
Abjad Documentation

Release 2.6

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CONTENTS

1	Abjad?	3
1.1	Abjad extends LilyPond	3
1.2	Abjad extends Python	3
1.3	What next?	4
1.4	Mailing lists	4
2	Installation	5
2.1	Abjad depends on Python	5
2.2	Abjad depends on LilyPond	5
2.3	Installing the current packaged version of Abjad with <code>easy_install</code>	5
2.4	Installing the current packaged version of Abjad from the Python Package Index	6
2.5	After install	6
2.6	Note for Linux users	6
3	Version history	7
3.1	Abjad 2.6	7
3.2	Abjad 2.5	11
3.3	Abjad 2.4	11
3.4	Abjad 2.3	12
3.5	Abjad 2.2	13
3.6	Abjad 2.1	13
3.7	Abjad 2.0	13
3.8	Abjad 1.1.1	15
3.9	Abjad 1.1.0	15
3.10	Abjad 1.0.1055	16
3.11	Abjad 1.0.1022	16
4	Bartók: <i>Mikrokosmos</i>	17
4.1	The score	17
4.2	The measures	17
4.3	The notes	18
4.4	The details	19
5	Ferneyhough: <i>Unsichtbare Farben</i>	23
5.1	The proportions	23
5.2	The transforms	23
5.3	The rhythms	24
5.4	The score	24
6	Ligeti: <i>Désordre</i>	27

6.1	The cell	28
6.2	The measure	29
6.3	The staff	30
6.4	The score	30
7	Mozart: <i>Musikalisches Würfelspiel</i>	33
7.1	The materials	33
7.2	The structure	39
7.3	The score	40
7.4	The document	42
8	Leaf, Container, Spanner, Mark	45
8.1	Example 1	46
8.2	Example 2	47
9	Working with component parentage	49
9.1	Improper parentage	49
9.2	Proper parentage	49
9.3	Parentage attributes	50
10	Working with threads	51
10.1	What is a thread?	51
10.2	What are threads for?	52
10.3	Coda	54
11	Understanding LilyPond grobs	57
11.1	Grobs control typography	57
11.2	Grobs can be overridden	57
11.3	Check the LilyPond docs	58
12	Understanding Abjad overrides	59
12.1	Grob-override component plug-ins	59
12.2	Grob proxies	59
12.3	Dot-chained override syntax	60
13	Time signature marks by example	61
14	Annotations	71
14.1	Creating annotations	71
14.2	Attaching annotations to a component	71
14.3	Getting the annotations attached to a component	71
14.4	Detaching annotations from a component one at a time	72
14.5	Detaching all annotations attached to a component at once	72
14.6	Inspecting the component to which an annotation is attached	72
14.7	Inspecting annotation name	72
14.8	Inspecting annotation value	72
15	Articulations	73
15.1	Creating articulations	73
15.2	Attaching articulations to a leaf	73
15.3	Attaching articulations to many notes and chords at once	73
15.4	Getting the articulations attached to a leaf	74
15.5	Detaching articulations from a leaf one at a time	74
15.6	Detaching all articulations attached to a leaf at once	74
15.7	Inspecting the leaf to which an articulation is attached	74

15.8	Understanding the interpreter display of an articulation that is not attached to a leaf	75
15.9	Understanding the interpreter display of an articulation that is attached to a leaf	75
15.10	Understanding the string representation of an articulation	76
15.11	Inspecting the LilyPond format of an articulation	76
15.12	Controlling whether an articulation appears above or below the staff	76
15.13	Getting and setting the name of an articulation	77
15.14	Copying articulations	77
15.15	Comparing articulations	78
15.16	Overriding attributes of the LilyPond script grob	78
16	Chords	79
16.1	Making chords from a LilyPond input string	79
16.2	Making chords from chromatic pitch numbers and duration	79
16.3	Getting all the written pitches of a chord at once	79
16.4	Getting the written pitches of a chord one at a time	79
16.5	Adding one pitch to a chord at a time	80
16.6	Adding many pitches to a chord at once	80
16.7	Deleting pitches from a chord	81
16.8	Formatting chords	81
16.9	Working with note heads	81
16.10	Working with empty chords	82
17	Containers	83
17.1	Creating containers	83
17.2	Inspecting music	83
17.3	Inspecting length	83
17.4	Inspecting duration	84
17.5	Adding one component to the end of a container	84
17.6	Adding many components to the end of a container	84
17.7	Finding the index of a component	84
17.8	Inserting a component by index	84
17.9	Removing a component by index	85
17.10	Removing a component by reference	85
17.11	Naming containers	85
17.12	Understanding { } and << >> in LilyPond	86
17.13	Understanding sequential and parallel containers	87
17.14	Changing sequential and parallel containers	88
17.15	Overriding containers	88
17.16	Overriding containers' contents	89
17.17	Removing container overrides	90
18	Durations	91
18.1	Introduction	91
18.2	Assignability	91
18.3	Prolation	92
18.4	Duration types	93
18.5	Duration initialization	96
18.6	LilyPond multipliers	97
18.7	Duration interfaces compared	98
19	Instrument marks	99
19.1	Creating instrument marks	99
19.2	Attaching instrument marks to a component	99
19.3	Getting the instrument mark attached to a component	99
19.4	Getting the instrument in effect for a component	100

19.5	Detaching instrument marks from a component one at a time	100
19.6	Detaching all instrument marks attached to a component at once	100
19.7	Inspecting the component to which an instrument mark is attached	101
19.8	Inspecting the instrument name of an instrument mark	101
19.9	Inspecting the short instrument name of an instrument mark	101
20	I/O	103
20.1	Reopening Abjad PDFs	103
20.2	Looking at LilyPond output	103
20.3	Looking at the LilyPond log	104
21	LilyPond command marks	105
21.1	Creating LilyPond command marks	105
21.2	Attaching LilyPond command marks to Abjad components	105
21.3	Getting the LilyPond command marks attached to an Abjad component	106
21.4	Detaching LilyPond command marks from components one at a time	106
21.5	Detaching all LilyPond command marks attached to a component at once	106
21.6	Inspecting the component to which a LilyPond command mark is attached	107
21.7	Getting and setting the command name of a LilyPond command mark	107
21.8	Copying LilyPond commands	107
21.9	Comparing LilyPond command marks	108
22	LilyPond comments	109
22.1	Creating LilyPond comments	109
22.2	Attaching LilyPond comments to leaves	109
22.3	Attaching LilyPond comments to containers	109
22.4	Getting the LilyPond comments attached to a component	110
22.5	Detaching LilyPond comments from a component one at a time	110
22.6	Detaching all LilyPond comments attached to a component at once	111
22.7	Inspecting the component to which a LilyPond comment is attached	111
22.8	Inspecting contents string of a LilyPond comment	111
23	LilyPond files	113
23.1	Making LilyPond files	113
23.2	Inspecting file output	113
23.3	Setting default paper size	113
23.4	Setting global staff size	114
24	Measures	115
24.1	Understanding measures in LilyPond	115
24.2	Understanding measures in Abjad	115
24.3	Creating measures	116
24.4	Working with dynamic measures	116
24.5	Adding music to dynamic measures	116
24.6	Removing music from dynamic measures	117
24.7	Setting the denominator of dynamic measures	117
24.8	Suppressing the meter of dynamic measures	117
24.9	Working with anonymous measures	117
24.10	Adding music to anonymous measures	118
24.11	Removing music from anonymous measures	118
25	Notes	119
25.1	Making notes from a string	119
25.2	Making notes from chromatic pitch number and duration	119
25.3	Getting the written pitch of notes	119

25.4	Changing the written pitch of notes	119
25.5	Getting the duration attributes of notes	120
25.6	Changing the written duration of notes	120
25.7	Overriding notes	121
25.8	Removing note overrides	122
26	Pitches	123
26.1	Creating pitches	123
26.2	Inspecting the name of a pitch	123
26.3	Inspecting the octave of a pitch	123
26.4	Working with pitch deviation	123
26.5	Sorting pitches	124
26.6	Comparing pitches	124
26.7	Converting one type of pitch to another	125
26.8	Converting pitches to pitch-classes	125
26.9	Copying pitches	125
26.10	Accidental abbreviations	126
26.11	Chromatic pitch numbers	126
26.12	Diatonic pitch numbers	127
26.13	Octave designation	128
26.14	Accidental spelling	128
27	Working with lists of numbers	131
28	Rests	133
28.1	Making rests from strings	133
28.2	Making rests from durations	133
28.3	Getting the duration attributes of rests	133
28.4	Changing the written duration of rests	134
29	Scores	135
29.1	Creating scores	135
29.2	Inspecting score music	135
29.3	Inspecting score length	135
29.4	Inspecting score duration	135
29.5	Adding one component to the bottom of a score	136
29.6	Finding the index of a score component	136
29.7	Removing a score component by index	136
29.8	Removing a score component by reference	137
29.9	Testing score containment	137
29.10	Naming scores	137
30	Spanners	139
30.1	Overriding spanners	139
30.2	Overriding the components to which spanners attach	140
30.3	Removing spanner overrides	140
31	Staves	143
31.1	Creating staves	143
31.2	Inspecting staff music	143
31.3	Inspecting staff length	143
31.4	Inspecting staff duration	143
31.5	Adding one component to the end of a staff	144
31.6	Adding many components to the end of a staff	144
31.7	Finding the index of a staff component	144

31.8	Removing a staff component by index	144
31.9	Removing a staff component by reference	145
31.10	Naming staves	145
31.11	Forcing context	145
32	Tuplets	147
32.1	Making a tuplet from a LilyPond input string	147
32.2	Making a tuplet from a list of other Abjad components	147
32.3	Understanding the interpreter display of a tuplet	147
32.4	Understanding the string representation of a tuplet	148
32.5	Inspecting the LilyPond format of a tuplet	148
32.6	Inspecting the music in a tuplet	148
32.7	Inspecting a tuplet’s leaves	148
32.8	Getting the length of a tuplet	149
32.9	Getting the duration attributes of a tuplet	149
32.10	Understanding rhythmic augmentation and diminution	149
32.11	Understanding binary and nonbinary tuplets	149
32.12	Adding one component to the end of a tuplet	150
32.13	Adding many components to the end of a tuplet	150
32.14	Finding the index of a component in a tuplet	150
32.15	Removing a tuplet component by index	150
32.16	Removing a tuplet component by reference	151
32.17	Overriding attributes of the LilyPond tuplet number grob	151
32.18	Overriding attributes of the LilyPond tuplet bracket grob	151
33	Voices	153
33.1	Making a voice from a LilyPond input string	153
33.2	Making a voice from a list of other Abjad components	153
33.3	Understanding the <code>repr</code> of a voice	153
33.4	Inspecting the LilyPond format of a voice	154
33.5	Inspecting the music in a voice	154
33.6	Inspecting a voice’s leaves	154
33.7	Getting the length of a voice	154
33.8	Getting the duration attributes of a voice	154
33.9	Adding one component to the end of a voice	155
33.10	Adding many components to the end of a voice	155
33.11	Finding the index of a component in a voice	155
33.12	Removing a voice component by index	156
33.13	Removing a voice component by reference	156
33.14	Naming voices	156
33.15	Changing the context of a voice	157
34	Codebase	159
34.1	How the Abjad codebase is laid out	159
34.2	Removing prebuilt versions of Abjad before you check out	159
34.3	Installing the development version	160
35	Docs	163
35.1	How the Abjad docs are laid out	163
35.2	Installing Sphinx	163
35.3	Removing old builds of the docs	164
35.4	Generating the Abjad API	164
35.5	Building the HTML docs	164
35.6	Building a PDF of the docs	165
35.7	Building a coverage report	166

35.8	Building other versions of the docs	167
35.9	Inserting images with <code>abjad-book</code>	167
35.10	Updating Sphinx	167
36	Tests	169
36.1	Automated regression?	169
36.2	Running the battery	169
36.3	Reading test output	170
36.4	Writing tests	170
36.5	Test files start with <code>test_</code>	170
36.6	Avoiding name conflicts	170
36.7	Updating <code>py.test</code>	170
36.8	Running <code>doctest</code> on the <code>tools</code> directory	171
37	Scripts	173
37.1	Searching the Abjad codebase with <code>abj-grep</code>	173
37.2	Removing old <code>*.pyc</code> files with <code>abj-rmpycs</code>	174
37.3	Updating your development copy of Abjad with <code>abj-update</code>	174
37.4	Counting lines of code with <code>count-source-lines</code>	174
37.5	Global search-and-replace with <code>replace-in-files</code>	174
37.6	Adding new development scripts	175
38	Using <code>abjad-book</code>	177
38.1	HTML with embedded Abjad	177
38.2	LaTeX with embedded Abjad	178
38.3	Using <code>abjad-book</code> on ReST documents	180
38.4	Using <code>[hide = True]</code>	180
39	Timing code	181
40	Profiling code	183
41	Memory consumption	185
42	Class attributes	187
43	Using slots	189
44	Coding standards	191
45	From Trevor and Víctor	195
46	Why MIDI is not enough	197
46.1	A very brief overview of MIDI	197
46.2	Limitations of MIDI from the point of view of score modeling	197
46.3	Written note durations vs. MIDI delta-times	198
46.4	Written note pitch vs. MIDI note-on	198
46.5	Conclusion	198
47	Why LilyPond is right for Abjad	199
47.1	Nested tuplets works out of the box	199
47.2	Broken tuplets work out of the box	199
47.3	Nonbinary meters work out of the box	200
47.4	Lilypond models the musical measure correctly	200

48 LilyPond template gallery	203
48.1 Default LilyPond layout	203
48.2 lagos.ly	203
48.3 oedo.ly	204
48.4 tangiers.ly	204
48.5 tirnaveni.ly	205
49 LilyPond text alignment	207
49.1 Default alignment	207
49.2 TextScript #'self-alignment-X	207
49.3 TextScript #'X-offset	208
50 Bibliography	209
51 Abjad API	211
51.1 Abjad API	211
Bibliography	809
Index	811

Abjad helps composers build up complex pieces of music notation in an iterative and incremental way. Use Abjad to create a symbolic representation of all the notes, rests, staves, tuplets, beams and slurs in any score. Because Abjad extends the Python programming language, you can use Abjad to make systematic changes to your music as you work. And because Abjad wraps the powerful LilyPond music notation package, you can use Abjad to control the typographic details of the symbols on the page.



Start here

ABJAD?

Abjad is an interactive software system designed to help composers build up complex pieces of music notation in an iterative and incremental way. Use Abjad to create a symbolic representation of all the notes, rests, staves, tuplets, beams and slurs in any score. Because Abjad extends the Python programming language, you can use Abjad to make systematic changes to your music as you work. And because Abjad wraps the powerful LilyPond music notation package, you can use Abjad to control the typographic details of the symbols on the page.

1.1 Abjad extends LilyPond

[LilyPond](#) is an open-source music notation package invented by Han-Wen Nienhuys and Jan Niewenhuizen and extended by an international team of developers and musicians. LilyPond differs from other music engraving programs in a number of ways. LilyPond separates musical content from page layout. LilyPond affords typographic control over almost everything. And LilyPond implements a powerfully correct model of the musical score.

You can start working with Abjad right away because Abjad creates LilyPond files for you automatically. But you will work with Abjad faster and more effectively if you understand the structure of the LilyPond files Abjad creates. For this reason we recommend new users spend a couple of days learning LilyPond first.

Start by reading about [text input](#) in LilyPond. Then work the [LilyPond tutorial](#). You can test your understanding of LilyPond by using the program to engrave of a Bach chorale. Use a grand staff and include slurs, fermatas and so on. Once you can engrave a chorale in LilyPond you'll understand the way Abjad works with LilyPond behind the scenes.

1.2 Abjad extends Python

[Python](#) is an open-source programming language invented by Guido van Rossum and further developed by a team of programmers working in many countries around the world. Python is used to provision servers, process text, develop distributed systems and do much more besides. The dynamic language and interpreter features of Python are similar to Ruby while the syntax of Python resembles C, C++ and Java.

To get the most out of Abjad you need to know (or learn) the basics of programming in Python. Abjad extends Python because it makes no sense to reinvent the wheel modern programming languages have developed to find, sort, store, model and encapsulate information. Abjad simply piggy-backs on the ways of doing these things that Python provides. So to use Abjad effectively you need to know the way these things are done in Python.

Start with the [Python tutorial](#). The tutorial is structured in 15 chapters and you should work through the first 12. This will take a day or two and you'll be able to use all the information you read in the Python tutorial in Abjad. If you're an experienced programmer you should skip chapters 1 - 3 but read 4 - 12. When you're done you can give yourself the equivalent of the chorale test suggested above. First open a file and define a couple of classes and functions in it. Then open a second file and write some code to first import and then do stuff with the classes and functions you

defined in the first file. Once you can easily do this without looking at the Python docs you'll be in a much better position to work with Abjad.

1.3 What next?

The most important parts of Abjad are the interlocking objects that structure the system. Read about the way Abjad models pitch, duration, leaves, containers, spanners and marks in the *Abjad reference manual*.

But note that important parts of the system are missing from the manual. The reason for this is that we completed the Abjad API months before we started the manual. This means that classes and functions you look up in the API may not yet be documented in the manual. The reference manual will eventually document all parts of the system. But until then check the API if the manual doesn't yet have what you need.

Once you understand the basics about how to work with Abjad you should spend some time with the *Abjad API*. The API documents all the functionality available in the system. Abjad comprises about 153,000 lines of code. About half of these implement the automated tests that check the correctness of Abjad. The rest of the code implements 39 packages comprising 197 classes and 941 functions. All of these are documented in the API.

1.4 Mailing lists

As you begin working with Abjad please be in touch.

Questions, comments and contributions are welcomed from composers everywhere.

Questions or comments? Join the [abjad-user](#) list.

Want to contribute? Join the [abjad-devel](#) list.

INSTALLATION

2.1 Abjad depends on Python

You must have Python 2.5, 2.6 or 2.7 installed to run Abjad.

Abjad does not yet support the Python 3.x series of releases.

To check the version of Python installed on your computer type the following:

```
python --version
```

You can download different versions of Python at <http://www.python.org>.

2.2 Abjad depends on LilyPond

You must have LilyPond 2.12 or greater installed for Abjad to work properly.

You can download LilyPond at <http://www.lilypond.org>.

After you have installed LilyPond you should type the following to see if LilyPond is callable from your commandline:

```
lilypond --version
```

If LilyPond is not callable from your commandline you should add the location of the LilyPond executable to your PATH environment variable.

If you are new to working with the commandline you should use Google to get a basic introduction to editing your profile and setting environment variables.

2.3 Installing the current packaged version of Abjad with easy_install

There are different ways to install Python packages on your computer. One of the most direct ways is with `easy_install`.

If you have `easy_install` installed on your computer then you can install Abjad with this command:

```
sudo easy_install -U abjad
```

Python will install Abjad in the site packages directory on your computer and you'll be ready to start using the system.

If you do not have `easy_install` installed on your computer then you should follow the instructions below to install the current packaged version of Abjad from the Python Package Index.

2.4 Installing the current packaged version of Abjad from the Python Package Index

If you do not have `easy_install` installed on your computer you should follow these steps to install the current packaged version of Abjad from the Python Package Index:

1. Download the current release of Abjad from <http://pypi.python.org/pypi/Abjad>.
2. Unarchive the downloaded file. Under MacOS and Windows you can double click the archived file.
Under Linux execute the following command with `x.y` replaced by the current release of Abjad:

```
tar xzvf Abjad-x.y.tar.gz
```
3. Change into the directory created in step 2:

```
cd Abjad-x.y
```
4. Run the following under MacOS or Linux:

```
sudo python setup.py install
```
5. Or run this command under Windows after starting up a command shell with administrator privileges:

```
setup.py install
```

These commands will cause Python to install Abjad in your site packages directory. You'll then be ready to start using Abjad.

2.5 After install

When first run, Abjad creates an `.abjad` directory in your own `$HOME` directory. In `$HOME/.abjad` you will find the Abjad configuration file: `config.py`. Here you can tell Abjad about your preferred PDF file viewer, MIDI player, your preferred LilyPond language, etc. All relevant variables have defaults that you can change to suit your needs. In Linux, for example, you might want to set your `pdfviewer` to `evince` and your `MIDIplayer` to `tiMIDiTY`.

`config.py` is a regular Python file, so you should make sure the file follows Python syntax.

2.6 Note for Linux users

Abjad defaults to `xdg-open` to display PDF files using your default PDF viewer. Most Linux distributions now come with `xdg-utils` installed.

If you do not have `xdg-utils` installed, you can download it from <http://www.portland.freedsektop.org>.

Alternatively you can set the `pdfviewer` variable in `$HOME/.abjad/config` to your favorite PDF viewer.

VERSION HISTORY

3.1 Abjad 2.6

Released 2012-01-29. Built from r4977.

- Added top-level `decorators` directory with `requires` decorator. The `requires` decorator renders the following two function definitions equivalent:

```
from abjad.decorators import requires
```

```
@requires(int)
def foo(x):
    return x ** 2
```

```
def foo(x):
    assert isinstance(x, int)
    return x ** 2
```

- Added new classes to `scoretools`:

```
scoretools.InstrumentationSpecifier
scoretools.Performer
```

- Added `scoretools.list_performer_names()`:

```
abjad> for name in scoretools.list_performer_names()[:10]:
...     name
...
'accordionist'
'bassist'
'bassoonist'
'cellist'
'clarinetist'
'flutist'
'guitarist'
'harpist'
'harpsichordist'
'hornist'
```

- Added `scoretools.list_primary_performer_names()`.
- Added `measuretools.measure_to_one_line_input_string()`:

```
abjad> measure = Measure((3, 4), "c4 d4 e4")
```

```
abjad> measure
Measure(3/4, [c4, d4, e4])

abjad> measuretools.measure_to_one_line_input_string(measure)
"Measure((3, 4), 'c4 d4 e4')"
```

- Added new classes to instrumenttools:

```
SopraninoSaxophone
SopranoSaxophone
AltoSaxophone
TenorSaxophone
BaritoneSaxophone
BassSaxophone
ContrabassSaxophone
```

```
ClarinetInA
```

```
AltoTrombone
BassTrombone
```

```
Harpsichord
```

- Added known untuned percussion:

```
abjad> for name in instrumenttools.UntunedPercussion.known_untuned_percussion[:10]:
...     print name
...
agogô
anvil
bass drum
bongo drums
cabasa
cajón
castanets
caxixi
claves
conga drums
```

- Added `_Instrument.get_default_performer_name()`:

```
abjad> bassoon = instrumenttools.Bassoon()

abjad> bassoon.get_default_performer_name()
'bassoonist'
```

- Added `_Instrument.get_performer_names()`:

```
abjad> bassoon.get_performer_names()
['instrumentalist', 'reed player', 'double reed player', 'bassoonist']
```

- Added read / write `_Instrument.pitch_range`:

```
abjad> marimba.pitch_range = (-24, 36)
abjad> marimba.pitch_range
PitchRange(' [C2, C7]')
```

- Added read-only `_Instrument.traditional_pitch_range`:

```
abjad> marimba = instrumenttools.Marimba()
abjad> marimba.traditional_pitch_range
PitchRange(' [F2, C7]')
```

- Added `instrumenttools.list_instruments()`:

```
abjad> for instrument_name in instrumenttools.list_instrument_names()[:10]:
...     instrument_name
...
'accordion'
'alto flute'
'alto saxophone'
'alto trombone'
'clarinet in B-flat'
'baritone saxophone'
'bass clarinet'
'bass flute'
'bass saxophone'
'bass trombone'
```

- Added other functions to `instrumenttools`:

```
instrumenttools.list_primary_instrument_names()
instrumenttools.list_secondary_instrument_names()
```

- Added new class to `lilypondfiletools`:

```
ContextBlock
```

- Added `pitchtools.is_symbolic_pitch_range_string()`:

```
abjad> pitchtools.is_symbolic_pitch_range_string(' [A0, C8]')
True
```

- Added `pitchtools.pitch_class_octave_number_string_to_chromatic_pitch_name()`:

```
abjad> pitchtools.pitch_class_octave_number_string_to_chromatic_pitch_name('A#4')
"as"
```

- Added `pitchtools.symbolic_accidental_string_to_alphabetic_accidental_string_abbreviation`:

```
abjad> pitchtools.alphabetic_accidental_abbreviation_to_symbolic_accidental_string('tqs')
'#+'
```

- Added other new functions to `pitchtools`:

```
pitchtools.alphabetic_accidental_abbreviation_to_symbolic_accidental_string()
pitchtools.is_symbolic_accidental_string()
pitchtools.is_pitch_class_octave_number_string()
```

- Added `iotools.string_to_strict_directory_name()`:

```
abjad> iotools.string_to_strict_directory_name('Déja vu')
'deja_vu'
```

- Added `iotools.strip_diacritics_from_binary_string()`:

```
abjad> binary_string = 'Dvořák'
abjad> iotools.strip_diacritics_from_binary_string(binary_string)
'Dvorak'
```

- Added other new functions to `iotools`:

```
iotoools.capitalize_string_start()
iotoools.is_space_delimited_lowercamelcase_string()
iotoools.is_underscore_delimited_lowercamelcase_package_name()
iotoools.is_underscore_delimited_lowercamelcase_string()
iotoools.is_lowercamelcase_string()
iotoools.is_uppercamelcase_string()
iotoools.space_delimited_lowercase_to_uppercamelcase()
iotoools.uppercamelcase_to_space_delimited_lowercase()
iotoools.uppercamelcase_to_underscore_delimited_lowercase()
```

- Added new functions to mathtools:

```
mathtools.is_positive_integer_power_of_two()
mathtools.is_integer_equivalent_expr()
```

- Added sequence type-checking predicates:

```
chordtools.all_are_chords()
containertools.all_are_containers()
durationtools.all_are_duration_tokens()
durationtools.all_are_durations()
gracetools.all_are_grace_containers()
leaftools.all_are_leaves()
markuptools.all_are_markup()
measuretools.all_are_measures()
notetools.all_are_notes()
pitcharraytools.all_are_pitch_arrays()
pitchtools.all_are_named_chromatic_pitch_tokens()
resttools.all_are_rests()
scoretools.all_are_scores()
sievetoools.all_are_residue_class_expressions()
skiptools.all_are_skips()
spannertools.all_are_spanners()
stafftools.all_are_staves()
tupletoools.all_are_tuplets()
```

- Extended NamedChromaticPitch to allow initialization from pitch-class / octave number strings:

```
abjad> pitchtools.NamedChromaticPitch('C#2')
NamedChromaticPitch('cs,')
```

- Extended PitchRange to allow initialization from symbolic pitch range strings:

```
abjad> pitchtools.PitchRange('[A0, C8]')
PitchRange('[A0, C8]')
```

- Extended PitchRange to allow initialization from pitch-class / octave number strings:

```
abjad> pitchtools.PitchRange('A0', 'C8')
PitchRange('[A0, C8]')
```

- Extended leaftools.is_bar_line_crossing_leaf() to work when no explicit time signature mark is found.
- Extended Markup to be able to function as a top-level LilyPondFile element.
- Extended instruments with is_primary and is_secondary attributes.
- Extended instruments with instrument_name and instrument_name_markup attributes.
- Extended instruments with short_instrument_name and short_instrument_name_markup attributes.

- Extended `iotools.write_expr_to_ly()` and `iotools.write_expr_to_pdf()` with 'tagline' keyword.
- Extended `replace-in-files` script to skip `.text`, `.ly` and `.txt` files.
- Renamed `Accidental.symbolic_string` to `Accidental.symbolic_accidental_string`.
- Renamed `Accidental.alphabetic_string` to `Accidental.alphabetic_accidental_abbreviation`.
- Fixed bug in `iotools.play()`.
- Fixed bug in `quantizationtools` regarding quantizing a stream of `QEvents` directly.

3.2 Abjad 2.5

Released 2011-09-22. Built from r4803.

- Added `get_leaf_in_expr_with_minimum_prolated_duration()` function to `leafertools`.
- Added `get_leaf_in_expr_with_maximum_prolated_duration()` function to `leafertools`.
- Added `are_relatively_prime()` function to `mathtools`.
- Added `CyclicTree` class to `sequencetools`.
- Added `get_next_n_nodes_at_level(n, level)` method to `sequencetools.Tree`.
- Extended `spanners` to sort by repr.
- Renamed `lilyfiletools` to `lilypondfiletools`.
- Renamed `lilyfiletools.LilyFile` to `lilypondfiletools.LilyPondFile`.
- Renamed `lilyfiletools.make_basic_lily_file()` to `lilypondfiletools.make_basic_lilypond_file`.

Note that the three renames change user syntax. Composers working with the `lilypondfiletools` module should update their score code.

3.3 Abjad 2.4

Released 2011-09-12. Built from r4769.

- Added Mozart Musikalisches Wuerfelspiel.

Ein Musikalisches Wuerfelspiel

W. A. Mozart (maybe?)



- Added new `Tree` class to `sequencetools` to work with sequences whose elements have been grouped into arbitrarily many levels of containment.
- Added new `BarLine` class to `marktools` package.
- Added new `HorizontalBracketSpanner` to `spannertools` package.
- Improved `schemetools.SchemePair` handling.
- Extended `LilyPondFile` blocks with double underscore-delimited attributes.

3.4 Abjad 2.3

Released 2011-09-04. Built from r4747.

Filled out the API for working with marks:

```
marktools.attach_articulations_to_components_in_expr()
marktools.detach_articulations_attached_to_component()
marktools.get_articulations_attached_to_component()
marktools.get_articulation_attached_to_component()
marktools.is_component_with_articulation_attached()
```

These five type of functions are now implemented for the following marks:

```
marktools.Annotation
marktools.Articulation
marktools.LilyPondCommandMark
marktools.LilyPondComment
marktools.StemTremolo
```

The same type of functions are likewise implemented for the following context marks:

```
contextttools.ClefMark
contextttools.DynamicMark
contextttools.InstrumentMark
contextttools.KeySignatureMark
contextttools.StaffChangeMark
contextttools.TempoMark
contextttools.TimeSignatureMark
```

- Extended `Container.extend()` to allow for LilyPond input strings. You can now say `container.extend("c'4 d'4 e'4 f'4")`.
- Added public `parent` attribute to all components. You can now say `note.parent`. The attribute is read-only.
- Added `cfgtools.list_package_dependency_version()`.
- Added `py.test` and `Sphinx` dependencies to the Abjad package.
- Added LilyPond command mark chapter to reference manual
- Renamed `cfgtools` to `configurationtools`.
- Renamed `durtools` to `durationtools`.
- Renamed `metertools` to `timesignaturetools`.
- Renamed `seqtools` to `sequencetools`.
- Renamed `Mark.attach_mark()` to `Mark.attach()`.

- Renamed `Mark.detach_mark()` to `Mark.detach()`.
- Renamed `marktools.Comment` to `marktools.LilyPondComment`. This matches `marktools.LilyPondCommandMark`.
- Removed `contexttools.TimeSignatureMark(3, 8)` initialization. You must now say `contexttools.TimeSignatureMark((3, 8))` instead. This parallels the initialization syntax for rests, skips and measures.

3.5 Abjad 2.2

Released 2011-08-30. Built from r4677.

- Added articulations chapter to reference manual.
- Reordered the way in which Abjad determines the value of the `HOME` environment variable.
- Updated `scr/devel/replace-in-files` to avoid image files.
- Updated `iotools.log()` to call operating-specific text editor.

3.6 Abjad 2.1

Released 2011-08-21. Built from r4655.

- Updated instrument mark `repr` to display target context when instrument mark is attached.
- Extended `scr/abj` and `scr/abjad` to display Abjad version and revision numbers on startup.

3.7 Abjad 2.0

Released 2011-08-17. Built from r4638.

Abjad 2.0 is the first public release of Abjad in more than two years. The new release of the system more than doubles the number of classes, functions and packages available in Abjad.

- The API has been cleaned up and completely reorganized. Features have been organized into a collection of 39 different libraries:

<code>cfgtools/</code>	<code>instrumenttools/</code>	<code>mathtools/</code>	<code>resttools/</code>	<code>tempotools/</code>
<code>chordtools/</code>	<code>intervaltreertools/</code>	<code>measuretools/</code>	<code>schemetools/</code>	<code>threadtools/</code>
<code>componenttools/</code>	<code>iotools/</code>	<code>metertools/</code>	<code>scoretools/</code>	<code>tietools/</code>
<code>containertools/</code>	<code>layouttools/</code>	<code>musicxmltools/</code>	<code>seqtools/</code>	<code>tonalitytools/</code>
<code>contexttools/</code>	<code>leaftools/</code>	<code>notetools/</code>	<code>sievetools/</code>	<code>tuplettools/</code>
<code>durtools/</code>	<code>lilyfiletools/</code>	<code>pitcharraytools/</code>	<code>skiptools/</code>	<code>verticalitytools/</code>
<code>gracetools/</code>	<code>marktools/</code>	<code>pitchtools/</code>	<code>spannertools/</code>	<code>voicetools/</code>
<code>importtools/</code>	<code>markuptools/</code>	<code>quantizationtools/</code>	<code>stafftools/</code>	

- The name of almost every function in the public API has been changed to better indication what the function does. While this has the effect of making Abjad 2.0 largely non-backwards compatible with code written in Abjad 1.x, the longer and much more explicit function names in Abjad 2.0 make code used to structure complex scores dramatically easier to maintain and understand.
- The `contexttools`, `instrumenttools`, `intervaltreertools`, `lilyfiletools`, `marktools`, `pitcharraytools`, `quantizationtools`, `sievetools`, `tonalitytools` and `verticalitytools` packages are completely new.

- The classes implemented in the `contexttools` and `marktools` packages provide an object-oriented interfaces to clefs, time signatures, key signatures, articulations, tempo marks and other symbols stuck to the outside of the hierarchical score tree. The classes implemented in `contexttools` and `marktools` model information outside the score tree much the way that the classes implemented in `spannertools` implement object-oriented interfaces to beams, brackets, hairpins, glissandi and other line-like symbols.
- The `instrumenttools` package provides an object-oriented model of most of the conventional instruments of the orchestra.
- The `intervalreetools` package implements a custom way of working with chunks of score during composition.
- The `lilyfiletools` package implements an object-oriented interface to arbitrarily structured LilyPond input files.
- The `pitcharraytools` package implements an object-oriented way of composing with pitches, pitch-classes and other pitch-related objects independent of rhythmic context.
- The experimental `quantizationtools` package implements classes and functions for quantizing rhythmic events.
- The `sievetools` package implements an object-oriented interface to the basics of Xenakis's system of sieves.
- The `tonalitytools` package implements classes and methods to model the basics of functional harmonic analysis.
- The `verticalitytools` package provides vertical-moment-based iteration and analysis of any score.
- The `pitchtools` package has grown considerably in size and functionality. Classes now exist to model named and numbered chromatic pitches (and pitch-classes), named and numbered diatonic pitches (and pitch-classes), melodic and harmonic diatonic intervals (and interval-classes), melodic and harmonic chromatic intervals (and interval-classes), as well as ordered segments and unordered sets of these and related objects. The package contains dozens of functions to create, inspect, iterate, analyze and transpose these classes and their collections.
- The old `listtools` package has been renamed `seqtools`.
- Dozens of new functions for cutting, pasting, partitioning, breaking, arranging and reordering score components have been added to the system. See the new functions in `componenttools`, `containertools`, `leaftools`, `measuretools` and `scoretools` for details.
- The core component classes modeling notes, rests, chords, tuplets, measures, voices, staves and scores have been reimplemented to consume dramatically less memory, making it much easier to work with arrays of hundreds and thousands of components.
- Abjad core formatting logic has been optimized to make the formatting of scores with hundreds or thousands of events take much less time than before.
- The component duration interfaces have been replaced by more straightforward read-only component attributes.
- Added Ferneyhough Unsichbare Farben example.



3.8 Abjad 1.1.1

- More complete documentation.
- The configuration file `config` changed to pure Python `config.py`. The file now supports more settings previously read as environment variables. All user settings are now found in this file. Users no longer need to set environment variables.
- Some new classes
 - `_HistoryInterface`. Use the `_HistoryInterface` to apply attributes to any component in score that will be completely ignored by Abjad. Think of the `_HistoryInterface` as a private user namespace.
 - `_NoteColumnInterface` to handle the LilyPond `NoteColumn` grob.
 - `_SpanBarInterface`. See API for details.
 - `InvisibleStaff()` staff.
 - `Moment` utility class to model the Abjad representation of the LilyPond moment.
- New Spanners
 - `TempoProportional` spanner.
- More than a dozen new tools added.

3.9 Abjad 1.1.0

- Many structure transform tools added. See the `abjad.tools.*` in the *Abjad API* package.

- Construction, transformation, manipulation and all other tools now grouped cleanly into packages.
- New `abjad-book` application available. Use `abjad-book` to interpret Abjad code blocks embedded in HTML, LaTeX and reST documents.

3.10 Abjad 1.0.1055

Changes to the public interface:

- Abjad now models ties exclusively with the Tie spanner. The old `_TieInterface._set` attribute is now deprecated.
- You can no longer say `t.tie = True` or `t.tie = False`, for leaf `t`. You must structurally span `t` as `Tie(t)` instead.
- New public properties in `_SpannerReceptor`: `chain`, `parented`, `count`.
- New public helpers:
 - `construct.notes_curve()`
 - `durationtools.rationalize()`
 - `iterate.tie_chains()`
 - `list_helpers()`
 - `mathtools.interpolate_divide()`
 - `measuretools.concentrate()`
 - `measuretools.scale_and_remeter()`
 - `measuretools.spin()`
 - `play()`
- Grace note `append()` and `extend()` no longer throw errors.

3.11 Abjad 1.0.1022

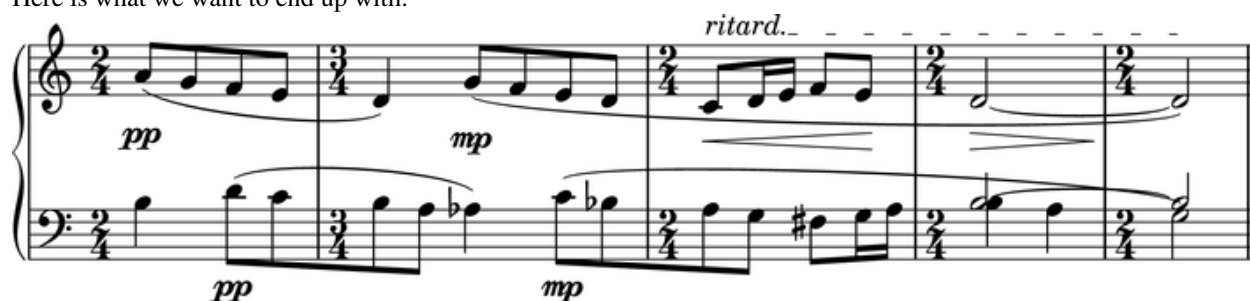
- First public release of Abjad.

Examples

BARTÓK: *MIKROKOSMOS*

This example reconstructs the last five measures of Bartók's "Wandering" from *Mikrokosmos*, volume III. The end result is just a few measures long but covers the basic features you'll use most often in Abjad.

Here is what we want to end up with:



4.1 The score

We'll construct the fragment top-down from containers to notes. We could have done it the other way around but it will be easier to keep the big picture in mind this way. Later, you can rebuild the example bottom-up as an exercise.

First let's create an empty score with a pair of staves connected by a brace:

```
abjad> score = Score([])
abjad> piano_staff = scoretools.PianoStaff([])
abjad> upper_staff = Staff([])
abjad> lower_staff = Staff([])

abjad> piano_staff.append(upper_staff)
abjad> piano_staff.append(lower_staff)
abjad> score.append(piano_staff)
```

Here we create an empty score and assign it to the `score` variable. Then we create an empty piano staff assigned to the `piano_staff` variable and two empty staves assigned to the `upper_staff` and `lower_staff` variables. Finally, we append the two staves to the piano staff and the piano staff to the score.

4.2 The measures

Now let's add some measures to our score:

```

abjad> m1 = Measure((2, 4), [])
abjad> m2 = Measure((3, 4), [])
abjad> m3 = Measure((2, 4), [])
abjad> m4 = Measure((2, 4), [])
abjad> m5 = Measure((2, 4), [])

abjad> upper_measures = [m1, m2, m3, m4, m5]
abjad> lower_measures = componenttools.copy_components_and_covered_spanners(upper_measures)

abjad> upper_staff.extend(upper_measures)
abjad> lower_staff.extend(lower_measures)

```

The lower measures are copies of the upper measures.

Note that we add lists of measures to staves with `extend()`. This is because `extend()` is used for adding many objects to an iterable at once while `append()` is used to add only one object at a time.

4.3 The notes

Now let's add some notes. We begin with the upper staff:

```

abjad> upper_measures[0].extend([Note(i, (1, 8)) for i in [9, 7, 5, 4]])

abjad> upper_measures[1].extend(notetools.make_notes([2, 7, 5, 4, 2], [(1, 4)] + [(1, 8)] * 4))

abjad> notes = notetools.make_notes([0, 2, 4, 5, 4], [(1, 8), (1, 16), (1, 16), (1, 8), (1, 8)])
abjad> upper_measures[2].extend(notes)

abjad> upper_measures[3].append(Note("d'2"))

abjad> upper_measures[4].append(Note("d'2"))

```

Now let's add notes to the lower staff. This will be a more intricate process than that needed for the upper staff. We added notes directly to the measures of the upper staff. But this will not be possible for the lower staff because of the simultaneous voices the lower staff contains.

We add notes to the lower staff measure by measure:

```

abjad> main_voice_m1 = Voice("b4 d'8 c'8")
abjad> main_voice_m1.name = 'main_voice'
abjad> lower_measures[0].append(main_voice_m1)

abjad> main_voice_m2 = Voice("b8 a8 af4 c'8 bf8")
abjad> main_voice_m2.name = 'main_voice'
abjad> lower_measures[1].append(main_voice_m2)

abjad> main_voice_m3 = Voice("a8 g8 fs8 gl6 a16")
abjad> main_voice_m3.name = 'main_voice'
abjad> lower_measures[2].append(main_voice_m3)

```

Notice that we give the same name to the three voices contained in the first three measures of the lower staff.

It is in the last two measures of the lower staff where Bartók writes two voices at once. We'll name the second of these two voices the *appendix_voice*:

```

abjad> appendix_voice_m4 = Voice([Note("b2")])
abjad> appendix_voice_m4.name = 'appendix_voice'
abjad> lilypond_command_mark = marktools.LilyPondCommandMark('voiceOne')
abjad> lilypond_command_mark.attach(appendix_voice_m4)

abjad> main_voice_m4 = Voice("b4 a4")
abjad> main_voice_m4.name = 'main_voice'
abjad> lilypond_command_mark = marktools.LilyPondCommandMark('voiceTwo')
abjad> lilypond_command_mark.attach(main_voice_m4)

abjad> container = Container([appendix_voice_m4, main_voice_m4])
abjad> container.is_parallel = True
abjad> lower_measures[3].append(container)

```

The LilyPond `\voiceOne` and `\voiceTwo` commands determine the direction of the stems in different voices.

Note that we must put both voices in a parallel container because they occur at the same time in the score. We do this by creating an Abjad container and then setting the `is_parallel` attribute of the container to true.

We now do a similar thing for the last measure:

```

abjad> appendix_voice_m5 = Voice("b2")
abjad> appendix_voice_m5.name = 'appendix_voice'
abjad> lilypond_command_mark = marktools.LilyPondCommandMark('voiceOne')
abjad> lilypond_command_mark.attach(appendix_voice_m5)

abjad> main_voice_m5 = Voice("g2")
abjad> main_voice_m5.name = 'main_voice'
abjad> lilypond_command_mark = marktools.LilyPondCommandMark('voiceTwo')
abjad> lilypond_command_mark.attach(main_voice_m5)

abjad> container = Container([appendix_voice_m5, main_voice_m5])
abjad> container.is_parallel = True
abjad> lower_measures[4].append(container)

```

Here's our work so far:

```
abjad> show(score)
```



4.4 The details

Ok, let's add the details. First, notice that the bottom staff has a treble clef just like the top staff. Let's change that:

```
abjad> contexttools.ClefMark('bass')(lower_staff)
```

Now let's add dynamic marks. For the top staff, we'll add them to the first note of the first measure and the second note of the second measure. For the bottom staff, we'll add dynamic markings to the second note of the first measure and the fourth note of the second measure.

```
abjad> contexttools.DynamicMark('pp')(upper_measures[0][0])
abjad> contexttools.DynamicMark('mp')(upper_measures[1][1])
abjad> contexttools.DynamicMark('pp')(lower_measures[0][0][1])
abjad> contexttools.DynamicMark('mp')(lower_measures[1][0][3])
```

Let's add a double bar to the end of the piece:

```
abjad> bar_line = marktools.BarLine('.')
abjad> bar_line.attach(lower_staff.leaves[-1])
```

And see how things are coming out:

```
abjad> show(score)
```



Notice that the beams of the eighth and sixteenth notes appear as you would usually expect: grouped by beat. We get this for free thanks to LilyPond's default beaming algorithm. But this is not the way Bartók notated the beams. Let's set the beams as Bartók did with some crossing the bar lines:

```
abjad> spannertools.BeamSpanner(upper_measures[0])
abjad> spannertools.BeamSpanner(lower_staff.leaves[1:5])
abjad> spannertools.BeamSpanner(lower_staff.leaves[6:10])

abjad> show(score)
```



Now some slurs:

```
abjad> spannertools.SlurSpanner(upper_staff.leaves[0:5])
abjad> spannertools.SlurSpanner(upper_staff.leaves[5:])
abjad> spannertools.SlurSpanner(lower_staff.leaves[1:6])
abjad> spannertools.SlurSpanner(lower_staff.leaves[6:13] + (main_voice_m4, main_voice_m5))
```

Hairpins:

```
abjad> spannertools.CrescendoSpanner(upper_staff.leaves[-7:-2])
abjad> spannertools.DecrescendoSpanner(upper_staff.leaves[-2:])
```

A ritardando marking above the last seven notes of the upper staff:

```
abjad> text_spanner = spannertools.TextSpanner(upper_staff.leaves[-7:])
abjad> text_spanner.override.text_spanner.bound_details__left__text = markuptools.Markup('ritard.')
```

And ties connecting the last two notes in each staff:

```
abjad> tietools.TieSpanner(upper_staff[-2:])  
abjad> tietools.TieSpanner([appendix_voice_m4[0], appendix_voice_m5[0]])
```

The final result:

```
abjad> show(score)
```



FERNEYHOUGH: *UNSICHTBARE FARBEN*

Mikhail Malt analyzes the rhythmic materials of Ferneyhough’s *Unsichtbare Farben* in *The OM Composer’s Book 2*.

Malt explains that Ferneyhough used OpenMusic to create an “exhaustive catalogue of rhythmic cells” such that:

1. They are subdivided into two pulses, with proportions from 1/1 to 1/11.
2. The second pulse is subdivided successively by 1, 2, 3, 4, 5 and 6.

Let’s recreate Malt’s results in Abjad.

5.1 The proportions

First we define proportions:

```
abjad> proportions = [(1, n) for n in range(1, 11 + 1)]

abjad> proportions
[(1, 1), (1, 2), (1, 3), (1, 4), (1, 5), (1, 6), (1, 7), (1, 8), (1, 9), (1, 10), (1, 11)]
```

5.2 The transforms

Then we make aliases to give shorter names to two functions with long names:

```
abjad> make_tuplet = tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_encourage_c
abjad> tie_chain_to_tuplet = tietools.tie_chain_to_diminished_tuplet_with_proportions_and_encourage_c
```

And then define a helper function:

```
def divide_tuplet(tuplet, n):
    last_tie_chain = tietools.get_tie_chain(tuplet[-1])
    proportions = n * [1]
    new = tie_chain_to_tuplet(last_tie_chain, proportions)
    return new
```

5.3 The rhythms

We set the duration of each tuplet equal to a quarter note:

```
abjad> duration = Fraction(1, 4)
```

And then we make the rhythms:

```
for proportion in proportions:
    tuplets = []
    for n in range(1, 6 + 1):
        tuplet = make_tuplet(duration, proportion)
        divide_tuplet(tuplet, n)
        tuplets.append(tuplet)
    staff.extend(tuplets)
```

5.4 The score

Finally we make the score:

```
abjad> staff = stafftools.RhythmicStaff(music)
abjad> score = Score([staff])
abjad> lilypond_file = lilyfiletools.make_basic_lilypond_file(score)
```

Configure containers:

```
abjad> contexttools.TimeSignatureMark((1, 4))(staff)
abjad> score.override.bar_number.transparent = True
abjad> score.set.proportional_notation_duration = schemetools.SchemeMoment(1, 56)
abjad> score.set.tuplet_full_length = True
abjad> score.override.spacing_spanner.uniform_stretching = True
abjad> score.override.spacing_spanner.strict_note_spacing = True
abjad> score.override.tuplet_bracket.padding = 2
abjad> score.override.tuplet_bracket.staff_padding = 4
abjad> score.override.tuplet_number.text = schemetools.SchemeFunction('tuplet-number::calc-fraction-t')
abjad> score.override.time_signature.stencil = False
abjad> score.override.bar_line.stencil = False
```

Configure the LilyPond file:

```
abjad> lilypond_file.default_paper_size = '11x17', 'portrait'
abjad> lilypond_file.global_staff_size = 12
abjad> lilypond_file.layout_block.indent = 0
abjad> lilypond_file.layout_block.ragged_right = True
abjad> lilypond_file.paper_block.ragged_bottom = True
abjad> space = schemetools.SchemePair('space', 18)
abjad> stretchability = schemetools.SchemePair('stretchability', 0)
abjad> vector = schemetools.SchemeVector(space, stretchability)
abjad> lilypond_file.paper_block.between_system_spacing = vector
```

And show the result:

```
abjad> show(lilypond_file)
```


6.1 The cell

Before plunging into the code, observe the following characteristic of the *cell*:

1. It is composed of two layers: the top one which is an octave “chord” and the bottom one which is a straight eighth note run.
2. The total duration of the *cell* can vary, and is always the sum of the eight note runs.
3. The eight note runs are always stem down while the octave “chord” is always stem up.
4. The eight note runs are always beamed together and slurred, and the first two notes always have the dynamic markings ‘f’ ‘p’.

The two “layers” of the *cell* we will model with two Voices inside a parallel Container. The top Voice will hold the octave “chord” while the lower Voice will hold the eighth note run. First the eighth notes:

```
abjad> pitches = [1, 2, 3]
abjad> notes = notetools.make_notes(pitches, [(1, 8)])
abjad> spannertools.BeamSpanner(notes)
abjad> spannertools.SlurSpanner(notes)
abjad> contexttools.DynamicMark('f')(notes[0])
abjad> contexttools.DynamicMark('p')(notes[1])

abjad> voice_lower = Voice(notes)
abjad> voice_lower.name = 'rh_lower'
abjad> marktools.LilyPondCommandMark('voiceTwo')(voice_lower)
```

The notes belonging to the eighth note run are first beamed and slurred. Then we add the dynamic marks to the first two notes, and finally we put them inside a Voice. After naming the voice we number it 2 so that the stems of the notes point down.

Now we construct the octave:

```
abjad> import math
abjad> n = int(math.ceil(len(pitches) / 2.))
abjad> chord = Chord([pitches[0], pitches[0] + 12], (n, 8))
abjad> marktools.Articulation('>')(chord)

abjad> voice_higher = Voice([chord])
abjad> voice_higher.name = 'rh_higher'
abjad> marktools.LilyPondCommandMark('voiceOne')(voice_higher)
```

The duration of the chord is half the duration of the running eighth notes if the duration of the running notes is divisible by two. Otherwise the duration of the chord is the next integer greater than this half. We add the articulation marking and finally add the Chord to a Voice, to which we set the number to 1, forcing the stem to always point up.

Finally we combine the two voices in a parallel Container:

```
abjad> p = Container([voice_lower, voice_higher])
abjad> p.is_parallel = True
```

This results in the complete *Désordre cell*:



Because this *cell* appears over and over again, we want to reuse this code to generate any number of these *cells*. We here encapsulate it in a function that will take only a list of pitches:

```
def desordre_cell(pitches):
    '''The function constructs and returns a *Désordre cell*.
       - 'pitches' is a list of numbers or, more generally, pitch tokens.
    '''
    notes = [Note(p, (1, 8)) for p in pitches]
    spannertools.BeamSpanner(notes)
    spannertools.SlurSpanner(notes)
    contextttools.DynamicMark('f')(notes[0])
    contextttools.DynamicMark('p')(notes[1])
    v_lower = Voice(notes)
    v_lower.name = 'rh_lower'
    marktools.LilyPondCommandMark('voiceTwo')(v_lower)

    n = int(math.ceil(len(pitches) / 2.))
    chord = Chord([pitches[0], pitches[0] + 12], (n, 8))
    marktools.Articulation('>')(chord)
    v_higher = Voice([chord])
    v_higher.name = 'rh_higher'
    marktools.LilyPondCommandMark('voiceOne')(v_higher)
    p = Container([v_lower, v_higher])
    p.is_parallel = True
    # make all 1/8 beats breakable
    for n in v_lower.leaves[:-1]:
        n.bar_line.kind = ''
    return p
```

Now we can call this function to create any number of *cells*. That was actually the hardest part of reconstructing the opening of Ligeti's *Désordre*. Because the repetition of patters occurs also at the level of measures and staves, we will now define functions to create these other higher level constructs.

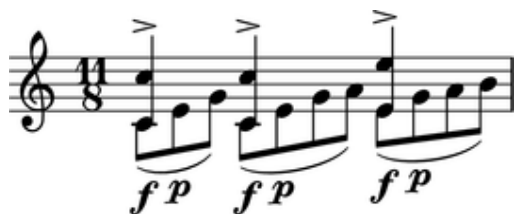
6.2 The measure

We define a function to create a measure from a list of lists of numbers:

```
def measure_build(pitches):
    '''Constructs a measure composed of *Désordre cells*.
       - 'pitches' is a list of lists of number (e.g., [[1, 2, 3], [2, 3, 4]])
       The function returns a DynamicMeasure.
    '''
    result = DynamicMeasure([])
    for seq in pitches:
        result.append(desordre_cell(seq))
```

The function is very simple. It simply creates a `DynamicMeasure` and then populates it with *cells* that are created internally with the function previously defined. The function takes a list *pitches* which is actually a list of lists of pitches (e.g., `[[1, 2, 3], [2, 3, 4]]`). The list of lists of pitches is iterated to create each of the *cells* to be appended to the `DynamicMeasures`. We could have defined the function to take ready made *cells* directly, but we are building the hierarchy of functions so that we can pass simple lists of lists of numbers to generate the full structure. To construct a Ligeti measure we would call the function like so:

```
abjad> measure = measure_build([[0, 4, 7], [0, 4, 7, 9], [4, 7, 9, 11]])
abjad> show(Staff([measure]))
```



6.3 The staff

Now we move up to the next level, the staff:

```
def staff_build(pitches):
    '''Returns a Staff containing DynamicMeasures.'''
    result = Staff([])
    for seq in pitches:
        measure = measure_build(seq)
        result.append(measure)
    return result
```

The function again takes a plain list as argument. The list must be a list of lists (for measures) of lists (for cells) of pitches. The function simply constructs the Ligeti measures internally by calling our previously defined function and puts them inside a Staff. As with measures, we can now create full measure sequences with this new function:

```
abjad> pitches = [[[-1, 4, 5], [-1, 4, 5, 7, 9]], [[0, 7, 9], [-1, 4, 5, 7, 9]]]
abjad> staff = staff_build(pitches)
abjad> show(staff)
```



6.4 The score

Finally a function that will generate the whole opening section of the piece *Désordre*:

```
def desordre_build(pitches):
    '''Returns a complete PianoStaff with Ligeti music!'''
    assert len(pitches) == 2
    piano = PianoStaff([])
    # build the music...
    for hand in pitches:
        seq = staff_build(hand)
        piano.append(seq)
    # set clef and key signature to left hand staff...
    piano[1].clef.forced = stafftools.Clef('bass')
    piano[1].key_signature.forced = tonalitytools.KeySignature('b', 'major')
    return piano
```

The function creates a PianoStaff, constructs Staves with Ligeti music and appends these to the empty PianoStaff. Finally it sets the clef and key signature of the lower staff to match the original score. The argument of the function is

a list of length 2, depth 3. The first element in the list corresponds to the upper staff, the second to the lower staff.

The final result:

```
abjad> top = [[[-1, 4, 5], [-1, 4, 5, 7, 9]], [[0, 7, 9], [-1, 4, 5, 7, 9]], [[2, 4, 5, 7, 9], [0, 5, 7, 9]], [[-1, 4, 5, 7, 9], [0, 5, 7, 9]]]
abjad> bottom = [[[-9, -4, -2], [-9, -4, -2, 1, 3]], [[-6, -2, 1], [-9, -4, -2, 1, 3]], [[-4, -2, 1, 3], [-9, -4, -2, 1, 3]], [[-4, -2, 1, 3], [-9, -4, -2, 1, 3]]]
abjad>
abjad> desordre = desordre_build([top, bottom])
abjad> show(desordre)
```



Now that we have the redundant aspect of the piece compactly expressed and encapsulated, we can play around with it by changing the sequence of pitches.

Note: In order for each staff to carry its own sequence of independent measure changes, LilyPond requires some special setting up prior to rendering. Specifically, one must move the *Timing_translator* from the score level to the level of staves. In this example we used the ‘tirnaveni’ template, which is configured to do just that. You may want to study this template (in the “templates” directory of the abjad distribution). Refer to the LilyPond documentation on [Polymetric notation](#) to learn all about how this works.

MOZART: *MUSIKALISCHES WÜRFELSPIEL*

Mozart’s dice game is a method for aleatorically generating sixteen-measure-long minuets. For each measure, two six-sided dice are rolled, and the sum of the dice used to look up a measure number in one of two tables (one for each half of the minuet). The measure number then locates a single measure from a collection of musical fragments. The fragments are concatenated together, and “music” results.

Implementing the dice game in a composition environment is somewhat akin to (although also somewhat more complicated than) the ubiquitous `hello world program` which every programming language uses to demonstrate its basic syntax.

Note: The musical dice game in question (*k516f*) has long been attributed to Mozart, albeit inconclusively. Its actual provenance is a musicological problem with which we are unconcerned here.

7.1 The materials

At the heart of the dice game is a large collection, *or corpus*, of musical fragments. Each fragment is a single 3/8 measure, consisting of a treble voice and a bass voice. Traditionally, these fragments are stored in a “score”, or “table of measures”, and located via two tables of measure numbers, which act as lookups, indexing into that collection.

Duplicate measures in the original corpus are common. Notably, the 8th measure - actually a pair of measures represent the first and second alternate ending of the first half of the minuet - are always identical. The last measure of the piece is similarly limited - there are only two possibilities rather than the usual eleven (for the numbers 2 to 12, being all the possible sums of two 6-sided dice).

How might we store this corpus compactly?

Some basic musical information in Abjad can be stored as strings, rather than actual collections of class instances. Abjad can parse simple LilyPond strings via `abjad.tools.iotools.parse_lilypond_input_string()`, which interprets a subset of LilyPond syntax, and understands basic concepts like notes, chords, rests and skips, as well as beams, slurs, ties, and articulations.

```
lily_string = "c'4 ( d'4 <cs' e'>8 ) -. r8 <g' b' d''>4 ^\marcato ~ <g' b' d''>1"
abjad> parsed_result = iotools.parse_lilypond_input_string(lily_string)
LilyPond file written to 'mozart-parsing-example.ly' ...
abjad> show(parsed_result)
```

WOLFGANG AMADEUS MOZART

Musikalisches Würfelspiel

Table of Measure Numbers

Part One

	I	II	III	IV	V	VI	VII	VIII
2	96	22	141	41	105	122	11	30
3	32	6	128	63	146	46	134	81
4	69	95	158	13	153	55	110	24
5	40	17	113	85	161	2	159	100
6	148	74	163	45	80	97	36	107
7	104	157	27	167	154	68	118	91
8	152	60	171	53	99	133	21	127
9	119	84	114	50	140	86	169	94
10	98	142	42	156	75	129	62	123
11	3	87	165	61	135	47	147	33
12	54	130	10	103	28	37	106	5

Part Two

	I	II	III	IV	V	VI	VII	VIII
2	70	121	26	9	112	49	109	14
3	117	39	126	56	174	18	116	83
4	66	139	15	132	73	58	145	79
5	90	176	7	34	67	160	52	170
6	25	143	64	125	76	136	1	93
7	138	71	150	29	101	162	23	151
8	16	155	57	175	43	168	89	172
9	120	88	48	166	51	115	72	111
10	65	77	19	82	137	38	149	8
11	102	4	31	164	144	59	173	78
12	35	20	108	92	12	124	44	131

Table of Measures



Figure 7.1: Part of a pen-and-paper implementation from the 20th century.



So, instead of storing our musical information as Abjad components, we'll represent each fragment in the corpus as a pair of strings: one representing the bass voice contents, and the other representing the treble. This pair of strings can be packaged together into a collection. For this implementation, we'll package them into a dictionary. Python dictionaries are cheap, and often provide more clarity than lists; the composer does not have to rely on remembering a convention for what data should appear in which position in a list - they can simply label that data semantically. In our musical dictionary, the treble voice will use the key 't' and the bass voice will use the key 'b'.

```
abjad> fragment = {'t': "g''8 ( e''8 c''8 )", 'b': '<c e>4 r8'}
```

Instead of relying on measure number tables to find our fragments - as in the original implementation, we'll package our fragment dictionaries into a list of lists of fragment dictionaries. That is to say, each of the sixteen measures in the piece will be represented by a list of fragment dictionaries. Furthermore, the 8th measure, which breaks the pattern, will simply be a list of two fragment dictionaries. Structuring our information in this way lets us avoid using measure number tables entirely; Python's list-indexing affordances will take care of that for us. The complete corpus looks like this:

```
measures = [
    [ # measure 1 choices
        {'b': 'c4 r8', 't': "e''8 c''8 g'8"},
        {'b': '<c e>4 r8', 't': "g'8 c''8 e''8"},
        {'b': '<c e>4 r8', 't': "g''8 ( e''8 c''8 )"},
        {'b': '<c e>4 r8', 't': "c''16 b'16 c''16 e''16 g'16 c''16"},
        {'b': '<c e>4 r8', 't': "c''16 b'16 c''16 g'16 e''16 c''16"},
        {'b': 'c4 r8', 't': "e'16 d'16 e'16 g'16 c'16 g'16"},
        {'b': '<c e>4 r8', 't': "g'8 f'16 e'16 d'16 c'16"},
        {'b': '<c e>4 r8', 't': "e'16 c'16 g'16 e'16 c'16 g'16"},
        {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "c'8 g'8 e'8"},
        {'b': '<c e>4 r8', 't': "g'8 c'8 e'8"},
        {'b': 'c8 c8 c8', 't': "<e' c''>8 <e' c''>8 <e' c''>8"},
    ],
    [ # measure 2 choices
        {'b': 'c4 r8', 't': "e''8 c''8 g'8"},
        {'b': '<c e>4 r8', 't': "g'8 c''8 e''8"},
        {'b': '<c e>4 r8', 't': "g'8 e''8 c''8"},
        {'b': '<e g>4 r8', 't': "c'16 g'16 c'16 e'16 g'16 c'16"},
        {'b': '<c e>4 r8', 't': "c'16 b'16 c'16 g'16 e'16 c'16"},
        {'b': 'c4 r8', 't': "e'16 d'16 e'16 g'16 c'16 g'16"},
        {'b': '<c e>4 r8', 't': "g'8 f'16 e'16 d'16 c'16"},
        {'b': '<c e>4 r8', 't': "c'16 g'16 e'16 c'16 g'16 e'16"},
        {'b': '<c e>4 r8', 't': "c'8 g'8 e'8"},
        {'b': '<c e>4 <c g>8', 't': "g'8 c'8 e'8"},
        {'b': 'c8 c8 c8', 't': "<e' c''>8 <e' c''>8 <e' c''>8"},
    ],
    [ # measure 3 choices
        {'b': '<b, g>4 g,8', 't': "d'16 e'16 f'16 d'16 c'16 b'16"},
        {'b': 'g,4 r8', 't': "b'8 d'8 g'8"},
        {'b': 'g,4 r8', 't': "b'8 d'16 b'16 a'16 g'16"},
        {'b': '<g b>4 r8', 't': "f'8 d'8 b'8"},
        {'b': '<b, d>4 r8', 't': "g'16 f'16 g'16 d'16 b'16 g'16"},
        {'b': '<g b>4 r8', 't': "f'16 e'16 f'16 d'16 c'16 b'16"},
        {'b': '<g, g>4 <b, g>8', 't': "b'16 c'16 d'16 e'16 f'16 d'16"},
        {'b': 'g8 g8 g8', 't': "<b' d''>8 <b' d''>8 <b' d''>8"},
        {'b': 'g,4 r8', 't': "b'16 c'16 d'16 b'16 a'16 g'16"},
    ]
]
```

```

    {'b': 'b,4 r8', 't': "d''8 ( b'8 g'8 )"},
    {'b': 'g4 r8', 't': "b'16 a'16 b'16 c''16 d''16 b'16"},
],
[ # measure 4 choices
    {'b': '<c e>4 r8', 't': "c''16 b'16 c''16 e''16 g'8"},
    {'b': 'c4 r8', 't': "e''16 c''16 b'16 c''16 g'8"},
    {'b': '<e g>4 r8', 't': "c''8 ( g'8 e'8 )"},
    {'b': '<e g>4 r8', 't': "c''8 e''8 g'8"},
    {'b': '<e g>4 r8', 't': "c''16 b'16 c''16 g'16 e'16 c'16"},
    {'b': '<c e>4 r8', 't': "c''8 c''16 d''16 e''8"},
    {'b': 'c4 r8', 't': "<c' e''>8 <c' e''>16 <d' f''>16 <e' g''>8"},
    {'b': '<e g>4 r8', 't': "c''8 e''16 c''16 g'8"},
    {'b': '<e g>4 r8', 't': "c''16 g'16 e''16 c''16 g''8"},
    {'b': '<e g>4 r8', 't': "c''8 e''16 c''16 g''8"},
    {'b': '<e g>4 r8', 't': "c''16 e''16 c''16 g'16 e'8"},
],
[ # measure 5 choices
    {'b': 'c4 r8', 't': "fs''8 a''16 fs''16 d''16 fs''16"},
    {'b': 'c8 c8 c8', 't': "<fs' d''>8 <d' fs''>8 <fs' a''>8"},
    {'b': 'c4 r8', 't': "d''16 a'16 fs''16 d''16 a''16 fs''16"},
    {'b': 'c8 c8 c8', 't': "<fs' d''>8 <fs' d''>8 <fs' d''>8"},
    {'b': 'c4 r8', 't': "d''8 a'8 ^\\turn fs''8"},
    {'b': 'c4 r8', 't': "d''16 cs''16 d''16 fs''16 a''16 fs''16"},
    {'b': '<c a>4 <c a>8', 't': "fs''8 a''8 d''8"},
    {'b': '<c fs>8 <c fs>8 <c a>8', 't': "a'8 a'16 d''16 fs''8"},
    {'b': 'c8 c8 c8', 't': "<d' fs''>8 <d' fs''>8 <d' fs''>8"},
    {'b': '<c d>8 <c d>8 <c d>8', 't': "fs''8 fs''16 d''16 a''8"},
    {'b': '<c a>4 r8', 't': "fs''16 d''16 a'16 a''16 fs''16 d''16"},
],
[ # measure 6 choices
    {'b': '<b, d>8 <b, d>8 <b, d>8', 't': "g''16 fs''16 g''16 b''16 d''8"},
    {'b': '<b, d>4 r8', 't': "g''8 b''16 g''16 d''16 b'16"},
    {'b': '<b, d>4 r8', 't': "g''8 b''8 d''8"},
    {'b': '<b, g>4 r8', 't': "a'8 fs'16 g'16 b'16 g'16"},
    {'b': '<b, d>4 <b, g>8', 't': "g''16 fs''16 g''16 d''16 b'16 g'16"},
    {'b': 'b,4 r8', 't': "g''8 b''16 g''16 d''16 g'16"},
    {'b': '<b, g>4 r8', 't': "d''8 g'16 d''16 b'16 d'16"},
    {'b': '<b, g>4 r8', 't': "d''8 d'16 g'16 b'8"},
    {'b': '<b, d>8 <b, d>8 <b, g>8', 't': "a'16 g'16 fs''16 g'16 d''8"},
    {'b': '<b, d>4 r8', 't': "g''8 g'16 d'16 b'8"},
    {'b': '<b, d>4 r8', 't': "g''16 b''16 g''16 d'16 b'8"},
],
[ # measure 7 choices
    {'b': 'c8 d8 d,8', 't': "e''16 c''16 b'16 a'16 g'16 fs'16"},
    {'b': 'c8 d8 d,8', 't': "a'16 e''16 <b' d''>16 <a' c''>16 <g' b'>16 <fs' a'>16"},
    {'b': 'c8 d8 d,8', 't': "<b' d''>16 ( <a' c''>16 ) <a' c''>16 ( <g' b'>16 ) <g' b'>16 ( <fs' a'>16 )"},
    {'b': 'c8 d8 d,8', 't': "e''16 g''16 d''16 c''16 b'16 a'16"},
    {'b': 'c8 d8 d,8', 't': "a'16 e''16 d''16 g''16 fs''16 a''16"},
    {'b': 'c8 d8 d,8', 't': "e''16 a''16 g''16 b''16 fs''16 a''16"},
    {'b': 'c8 d8 d,8', 't': "c''16 e''16 g''16 d''16 a'16 fs''16"},
    {'b': 'c8 d8 d,8', 't': "e''16 g''16 d''16 g'16 a'16 fs''16"},
    {'b': 'c8 d8 d,8', 't': "e''16 c''16 b'16 g'16 a'16 fs'16"},
    {'b': 'c8 d8 d,8', 't': "e''16 c''16 b''16 g''16 a''16 fs''16"},
    {'b': 'c8 d8 d,8', 't': "a'8 d''16 c''16 b'16 a'16"},
],
[ # measure 8 choices (always using both)
    {'b': 'g,8 g16 f16 e16 d16', 't': "<g' b' d'' g''>4 r8"},
    {'b': 'g,8 b16 g16 fs16 e16', 't': "<g' b' d'' g''>4 r8"}],

```

```

],
[ # measure 9 choices
  {'b': 'd4 c8', 't': "fs''8 a''16 fs''16 d''16 fs''16"},
  {'b': '<d fs>4 r8', 't': "d''16 a'16 d''16 fs''16 a''16 fs''16"},
  {'b': '<d a>8 <d fs>8 <c d>8', 't': "fs''8 a''8 fs''8"},
  {'b': '<c a>4 <c a>8', 't': "fs''16 a''16 d''16 a''16 fs''16 a''16"},
  {'b': 'd4 c8', 't': "d'16 fs'16 a'16 d''16 fs''16 a''16"},
  {'b': 'd,16 d16 cs16 d16 c16 d16', 't': "<a' d'' fs''>8 fs''4 ^\\tr"},
  {'b': '<d fs>4 <c fs>8', 't': "a''8 ( fs''8 d''8 )"},
  {'b': '<d fs>4 <c fs>8', 't': "d''8 a''16 fs''16 d''16 a'16"},
  {'b': '<d fs>4 r8', 't': "d''16 a'16 d''8 fs''8"},
  {'b': '<c a>4 <c a>8', 't': "fs''16 d''16 a'8 fs''8"},
  {'b': '<d fs>4 <c a>8', 't': "a'8 d''8 fs''8"},
],
[ # measure 10 choices
  {'b': '<b, g>4 r8', 't': "g''8 b''16 g''16 d''8"},
  {'b': 'b,16 d16 g16 d16 b,16 g,16', 't': "g''8 g'8 g'8"},
  {'b': 'b,4 r8', 't': "g''16 b''16 g''16 b''16 d''8"},
  {'b': '<b, d>4 <b, d>8', 't': "a''16 g''16 b''16 g''16 d''16 g''16"},
  {'b': '<b, d>4 <b, d>8', 't': "g''8 d''16 b'16 g'8"},
  {'b': '<b, d>4 <b, d>8', 't': "g''16 b''16 d''16 b''16 g''8"},
  {'b': '<b, d>4 r8', 't': "g''16 b''16 g''16 d''16 b'16 g'16"},
  {'b': '<b, d>4 <b, d>8', 't': "g''16 d''16 g''16 b''16 g''16 d''16"},
  {'b': '<b, d>4 <b, g>8', 't': "g''16 b''16 g''8 d''8"},
  {'b': 'g,16 b,16 g8 b,8', 't': "g''8 d''4 ^\\tr"},
  {'b': 'b,4 r8', 't': "g''8 b''16 d''16 d''8"},
],
[ # measure 11 choices
  {'b': 'c16 e16 g16 e16 c'16 c16', 't': "<c'' e''>8 <c'' e''>8 <c'' e''>8"},
  {'b': 'e4 e16 c16', 't': "c''16 g'16 c''16 e''16 g''16 <c'' e''>16"},
  {'b': '<c g>4 <c e>8', 't': "e''8 g''16 e''16 c''8"},
  {'b': '<c g>4 r8', 't': "e''16 c''16 e''16 g''16 c''16 g''16"},
  {'b': '<c g>4 <c g>8', 't': "e''16 g''16 c''16 g''16 e''16 c''16"},
  {'b': 'c16 b,16 c16 d16 e16 fs16', 't': "<g' c'' e''>8 e''4 ^\\tr"},
  {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "e''8 c''8 g'8"},
  {'b': '<c g>4 <c e>8', 't': "e''8 c''16 e''16 g''16 c''16"},
  {'b': '<c g>4 <c e>8', 't': "e''16 c''16 e''8 g''8"},
  {'b': '<c g>4 <c g>8', 't': "e''16 c''16 g'8 e''8"},
  {'b': '<c g>4 <c e>8', 't': "e''8 ( g''8 c''8 )"},
],
[ # measure 12 choices
  {'b': 'g4 g,8', 't': "<c'' e''>8 <b' d''>8 r8"},
  {'b': '<g, g>4 g8', 't': "d''16 b'16 g'8 r8"},
  {'b': 'g8 g,8 r8', 't': "<c'' e''>8 <b' d''>16 <g' b'>16 g'8"},
  {'b': 'g4 r8', 't': "e''16 c''16 d''16 b'16 g'8"},
  {'b': 'g8 g,8 r8', 't': "g''16 e''16 d''16 b'16 g'8"},
  {'b': 'g4 g,8', 't': "b'16 d''16 g''16 d''16 b'8"},
  {'b': 'g8 g,8 r8', 't': "e''16 c''16 b'16 d''16 g''8"},
  {'b': '<g b>4 r8', 't': "d''16 b''16 g''16 d''16 b'8"},
  {'b': '<b, g>4 <b, d>8', 't': "d''16 b'16 g'8 g''8"},
  {'b': 'g16 fs16 g16 d16 b,16 g,16', 't': "d''8 g'4"},
],
[ # measure 13 choices
  {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "e''8 c''8 g'8"},
  {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "g'8 c''8 e''8"},
  {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "g''8 e''8 c''8"},
  {'b': '<c e>4 <c e>8', 't': "c''16 b'16 c''16 e''16 g'16 c''16"},
  {'b': '<c e>4 <c g>8', 't': "c''16 b''16 c''16 g''16 e''16 c''16"},

```

```

        {'b': '<c g>4 <c e>8', 't': "e''16 d''16 e''16 g''16 c''16 g''16"},
        {'b': '<c e>4 r8', 't': "g''8 f''16 e''16 d''16 c''16"},
        {'b': '<c e>4 r8', 't': "c''16 g'16 e''16 c''16 g''16 e''16"},
        {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "c''8 g'8 e''8"},
        {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "g''8 c''8 e''8"},
        {'b': 'c8 c8 c8', 't': "<e' c''>8 <e' c''>8 <e' c''>8"}],
    ],
    [ # measure 14 choices
        {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "e''8 ( c''8 g'8 )"},
        {'b': '<c e>4 <c g>8', 't': "g'8 ( c''8 e''8 )"},
        {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "g''8 e''8 c''8"},
        {'b': '<c e>4 <c e>8', 't': "c''16 b'16 c''16 e''16 g'16 c''16"},
        {'b': '<c e>4 r8', 't': "c''16 b'16 c''16 g''16 e''16 c''16"},
        {'b': '<c g>4 <c e>8', 't': "e''16 d''16 e''16 g''16 c''16 g''16"},
        {'b': '<c e>4 <e g>8', 't': "g''8 f''16 e''16 d''16 c''16"},
        {'b': '<c e>4 r8', 't': "c''16 g'16 e''16 c''16 g''16 e''16"},
        {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "c''8 g'8 e''8"},
        {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "g''8 c''8 e''8"},
        {'b': 'c8 c8 c8', 't': "<e' c''>8 <e' c''>8 <e' c''>8"}],
    ],
    [ # measure 15 choices
        {'b': "<f a>4 <g d'>8", 't': "d''16 f''16 d''16 f''16 b'16 d''16"},
        {'b': 'f4 g8', 't': "d''16 f''16 a''16 f''16 d''16 b'16"},
        {'b': 'f4 g8', 't': "d''16 f''16 a'16 d''16 b'16 d''16"},
        {'b': 'f4 g8', 't': "d''16 ( cs''16 ) d''16 f''16 g'16 b'16"},
        {'b': 'f8 d8 g8', 't': "f''8 d''8 g''8"},
        {'b': 'f16 e16 d16 e16 f16 g16', 't': "f''16 e''16 d''16 e''16 f''16 g''16"},
        {'b': 'f16 e16 d8 g8', 't': "f''16 e''16 d''8 g''8"},
        {'b': 'f4 g8', 't': "f''16 e''16 d''16 c''16 b'16 d''16"},
        {'b': 'f4 g8', 't': "f''16 d''16 a'8 b'8"},
        {'b': 'f4 g8', 't': "f''16 a''16 a'8 b'16 d''16"},
        {'b': 'f4 g8', 't': "a'8 f''16 d''16 a'16 b'16"}],
    ],
    [ # measure 16 choices
        {'b': 'c8 g,8 c,8', 't': "c''4 r8"},
        {'b': 'c4 c,8', 't': "c''8 c'8 r8"}],
    ],
]

```

We can then use the `parse_lilypond_input_string()` function we saw earlier to “build” the treble and bass components of a measure like this:

```

def build_one_mozart_measure(measure_dict):
    # parse the contents of a measure definition dictionary
    treble = iotools.parse_lilypond_input_string(measure_dict['t'])
    bass = iotools.parse_lilypond_input_string(measure_dict['b'])
    return treble, bass

```

```

my_measure_dict = {'b': 'c4 ^\tr r8', 't': "e''8 ( c''8 g'8 )"}
abjad> treble, bass = build_one_mozart_measure(my_measure_dict)
abjad> f(treble)
{
    e''8 (
    c''8
    g'8 )
}
abjad> f(bass)
{

```



```

        c4 ^\tr
        r8
    }

```

7.2 The structure

After storing all of the musical fragments into a corpus, concatenating those elements into a musical structure is relatively trivial. We'll use the `choice()` function from Python's *random* module. `random.choice()` randomly selects one element from an input list.

```

abjad> import random
abjad> my_list = [1, 'b', 3]
abjad> my_result = [random.choice(my_list) for i in range(20)]
abjad> print my_result
[1, 3, 3, 3, 1, 1, 1, 'b', 3, 'b', 1, 'b', 'b', 1, 3, 'b', 3, 1, 'b', 1]

```

Our corpus is a list comprising sixteen sublists, one for each measure in the minuet. To build our musical structure, we can simply iterate through the corpus and call *choice* on each sublist, appending the chosen results to another list. The only catch is that the *eighth* measure of our minuet is actually the first-and-second-ending for the repeat of the first phrase. The sublist of the corpus for measure eight contains *only* the first and second ending definitions, and both of those measures should appear in the final piece, always in the same order. We'll have to intercept that sublist while we iterate through the corpus and apply some different logic.

The easiest way to intercept measure eight is to use the Python builtin *enumerate*, which allows you to iterate through a collection while also getting the index of each element in that collection:

```

def choose_mozart_measures( ):
    chosen_measures = [ ]
    for i, choices in enumerate(measures):
        if i == 7: # get both alternative endings for mm. 8
            chosen_measures.extend(choices)
        else:
            choice = random.choice(choices)
            chosen_measures.append(choice)
    return chosen_measures

```

Note: In *choose_mozart_measures* we test for index 7, rather than 8, because list indices count from 0 instead of 1.

The result will be a *seventeen*-item-long list of measure definitions:

```

abjad> choices = choose_mozart_measures( )
abjad> for i, measure in enumerate(choices): print i, measure
0 {'b': '<c e>4 r8', 't': "e''16 c''16 g''16 e''16 c'''16 g''16"}
1 {'b': 'c8 c8 c8', 't': "<e' c''>8 <e' c''>8 <e' c''>8"}
2 {'b': 'g,4 r8', 't': "b'8 d''8 g''8"}
3 {'b': '<e g>4 r8', 't': "c''16 g'16 e''16 c''16 g''8"}
4 {'b': 'c4 r8', 't': "d''8 a'8 ^\\turn fs''8"}
5 {'b': '<b, g>4 r8', 't': "a'8 fs'16 g'16 b'16 g''16"}
6 {'b': 'c8 d8 d,8', 't': "e''16 a''16 g''16 b''16 fs''16 a''16"}
7 {'b': 'g,8 g16 f16 e16 d16', 't': "<g' b' d'' g''>4 r8"}
8 {'b': 'g,8 b16 g16 fs16 e16', 't': "<g' b' d'' g''>4 r8"}
9 {'b': 'd4 c8', 't': "d'16 fs'16 a'16 d''16 fs''16 a''16"}
10 {'b': '<b, d>4 <b, g>8', 't': "g''16 b''16 g''8 d''8"}
11 {'b': '<c g>4 <c g>8', 't': "e''16 g''16 c'''16 g''16 e''16 c''16"}
12 {'b': 'g4 g,8', 't': "b'16 d''16 g''16 d''16 b'8"}

```

```
13 {'b': 'c8 c8 c8', 't': "<e' c''>8 <e' c''>8 <e' c''>8"}
14 {'b': '<c e>16 g16 <c e>16 g16 <c e>16 g16', 't': "e''8 ( c''8 g'8 )"}
15 {'b': 'f4 g8', 't': "f''16 d''16 a'8 b'8"}
16 {'b': 'c8 g,8 c,8', 't': "c''4 r8"}
```

7.3 The score

Now that we have our raw materials, and a way to organize them, we can start building our score. The tricky part here is figuring out how to implement LilyPond’s repeat structure in Abjad. LilyPond structures its repeats something like this:

```
\repeat volta n {
    music to be repeated
}

\alternative {
    { ending 1 }
    { ending 2 }
    { ending n }
}

...music after the repeat...
```

What you see above is really just two containers, each with a little text (“repeat volta n” and “alternative”) prepended to their opening curly brace. To create that structure in Abjad, we’ll need to use the `LilyPondCommandMark` class, which allows you to place LilyPond commands like “break” relative to any score component:

```
abjad> con = Container("c'4 d'4 e'4 f'4")
abjad> marktools.LilyPondCommandMark('before-the-container', 'before')(con)
abjad> marktools.LilyPondCommandMark('after-the-container', 'after')(con)
abjad> marktools.LilyPondCommandMark('opening-of-the-container', 'opening')(con)
abjad> marktools.LilyPondCommandMark('closing-of-the-container', 'closing')(con)
abjad> marktools.LilyPondCommandMark('to-the-right-of-a-note', 'right')(con[2])
abjad> f(con)
\before-the-container
{
    \opening-of-the-container
    c'4
    d'4
    e'4 \to-the-right-of-a-note
    f'4
    \closing-of-the-container
}
\after-the-container
```

Notice the second argument to each `LilyPondCommandMark` above, like *before* and *closing*. These are format slot indications, which control where the command is placed in the LilyPond code relative to the score element it is attached to. To mimic LilyPond’s repeat syntax, we’ll have to create two `LilyPondCommandMark` instances, both using the “before” format slot, insuring that their command is placed before their container’s opening curly brace.

Now let’s take a look at the code that puts our score together:

```
def build_mozart_piano_staff( ):
    treble_staff = Staff([ ])
    bass_staff = Staff([ ])
```

```

# select the measures to use
choices = choose_mozart_measures( )

# create and populate the volta containers
treble_volta = Container([ ])
bass_volta = Container([ ])
for choice in choices[:7]:
    treble, bass = build_one_mozart_measure(choice)
    treble_volta.append(treble)
    bass_volta.append(bass)

# add marks to the volta containers
marktools.LilyPondCommandMark('repeat volta 2', 'before')(treble_volta)
marktools.LilyPondCommandMark('repeat volta 2', 'before')(bass_volta)

# add the volta containers to our staves
treble_staff.append(treble_volta)
bass_staff.append(bass_volta)

# create and populate the alternative ending containers
treble_alternative = Container([ ])
bass_alternative = Container([ ])
for choice in choices[7:9]:
    treble, bass = build_one_mozart_measure(choice)
    treble_alternative.append(treble)
    bass_alternative.append(bass)

# add marks to the alternative containers
marktools.LilyPondCommandMark('alternative', 'before')(treble_alternative)
marktools.LilyPondCommandMark('alternative', 'before')(bass_alternative)

# add the alternative containers to our staves
treble_staff.append(treble_alternative)
bass_staff.append(bass_alternative)

# create the remaining measures
for choice in choices[9:]:
    treble, bass = build_one_mozart_measure(choice)
    treble_staff.append(treble)
    bass_staff.append(bass)

# add meter
contexttools.TimeSignatureMark((3, 8))(treble_staff)

# add bass clef
contexttools.ClefMark('bass')(bass_staff)

# add the final double bar line at the end of each final measure
marktools.BarLine('|.') (treble_staff[-1])
marktools.BarLine('|.') (bass_staff[-1])

# combine into a PianoStaff
piano_staff = scoretools.PianoStaff([treble_staff, bass_staff])

# add an instrument name via contexttools.InstrumentMark
contexttools.InstrumentMark('Katzenklavier', 'kk.',
    target_context = scoretools.PianoStaff)(piano_staff)

```

```
return piano_staff
```

```
abjad> piano_staff = build_mozart_piano_staff( )
LilyPond file written to 'mozart-piano-staff.ly' ...
abjad> show(piano_staff)
```



Note: Our instrument name got cut off! Looks like we need to do a little formatting. Keep reading...

7.4 The document

As you can see above, we’ve now got our randomized minuet. However, we can still go a bit further. LilyPond provides a wide variety of settings for controlling the overall *look* of a musical document, often through its *header*, *layout* and *paper* blocks. Abjad, in turn, gives us object-oriented access to these settings through the its *lilypondfiletools* module.

We’ll use `abjad.tools.lilypondfiletools.make_basic_lilypond_file()` to wrap our `PianoStaff` inside a `LilyPondFile` instance. From there we can access the other “blocks” of our document to add a title, a composer’s name, change the global staff size, paper size, staff spacing and so forth.

```
def build_mozart_lily(piano_staff):

    # wrap the PianoStaff with a LilyPondFile
    lily = lilypondfiletools.make_basic_lilypond_file(piano_staff)

    # create some markup to use in our header block
    title = markuptools.Markup('\bold \sans "Ein Musikalisches Wuerfelspiel"')
    composer = schemetools.SchemeString("W. A. Mozart (maybe?)")

    # change various settings
    lily.global_staff_size = 12
    lily.header_block.title = title
    lily.header_block.composer = composer
    lily.layout_block.ragged_right = True
```

```

lily.paper_block.markup_system_spacing__basic_distance = 8
lily.paper_block.paper_width = 180

return lily

abjad> lily = build_mozart_lily(piano_staff)
abjad> print lily
LilyPondFile(PianoStaff<<2>>)

abjad> print lily.header_block
HeaderBlock(2)
abjad> f(lily.header_block)
\header {
  composer = #"W. A. Mozart (maybe?)"
  title = \markup { \bold \sans "Ein Musikalisches Wuerfelspiel" }
}

abjad> print lily.layout_block
LayoutBlock(1)
abjad> f(lily.layout_block)
\layout {
  ragged-right = ##t
}

abjad> print lily.paper_block
PaperBlock(2)
abjad> f(lily.paper_block)
\paper {
  markup-system-spacing #'basic-distance = #20
  paper-width = #180
}

```

And now the final result:

LilyPond file written to 'mozart-lily.ly' ...
 abjad> show(lily)

Ein Musikalisches Wuerfelspiel

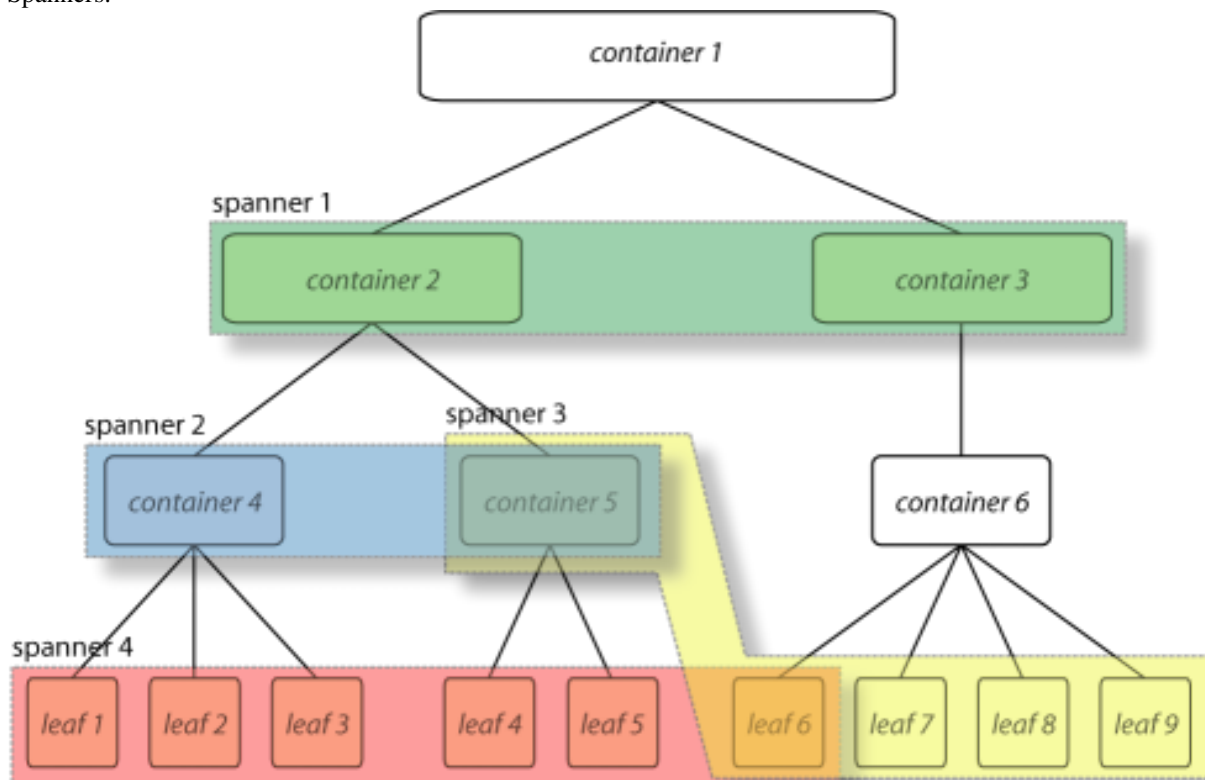
W. A. Mozart (maybe?)

Tutorials

LEAF, CONTAINER, SPANNER, MARK

At the heart of Abjad's Symbolic Score-Control lies a powerful model that we call the Leaf Container Spanner Mark, or LCSM, model of the musical score.

The LCSM model can be schematically visualized as a superposition of two complementary and completely independent layers of structure: a *tree* that includes the Containers and the Leaves, and a layer of free floating *connectors* or Spanners.



There can be any number of Spanners, they may overlap, and they may connect to different levels of the tree hierarchy. The spanner attach to the elements of the tree, so a tree structure must exist for spanners to be made manifest.

8.1 Example 1

To understand the whys and hows of the LCSM model implemented in Abjad, it is probably easier to base the discussion on concrete musical examples. Let's begin with a simple and rather abstract musical fragment: a measure with nested tuplets.



What we see in this little fragment is a measure with 4/4 meter, 14 notes and four tuplet brackets prolating the notes. The three bottom tuplets (with ratios 5:4, 3:2, 5:4) prolates all but the last note. The topmost tuplet prolates all the notes in the measure and combines with the bottom three tuplets to doubly prolates all but the last note. The topmost tuplet as thus prolates three tuplets, each of which in turn prolates a group of notes. We can think of a tuplet as *containing* notes or other tuplets or both. Thus, in our example, the topmost tuplet contains three tuplets and a half note. Each of the tuplets contained by the topmost tuplet in turn contains five, three, and five notes respectively. If we add the measure, then we have a measure that contains a tuplet that contains tuplets that contain notes. The structure of the measure with nested tuplets as we have just described it has two important properties:

1. It is a *hierarchical* structure.
2. It follows *exclusive membership*, meaning that each element in the hierarchy (a note, a tuplet or a measure) has one and only one *parent*. In other words a single note is not contained in more than one tuplet simultaneously, and no one tuplet is contained in more than one other tuplet at the same time.

What we are describing here is a tree, and it is the structure of Abjad *containers*.

While this tree structure seem like the right way to represent the relationships between the elements of a score, it is not enough. Consider the tuplet example again with the following beaming alternatives:

Beaming alternative 1:



Beaming alternative 2:



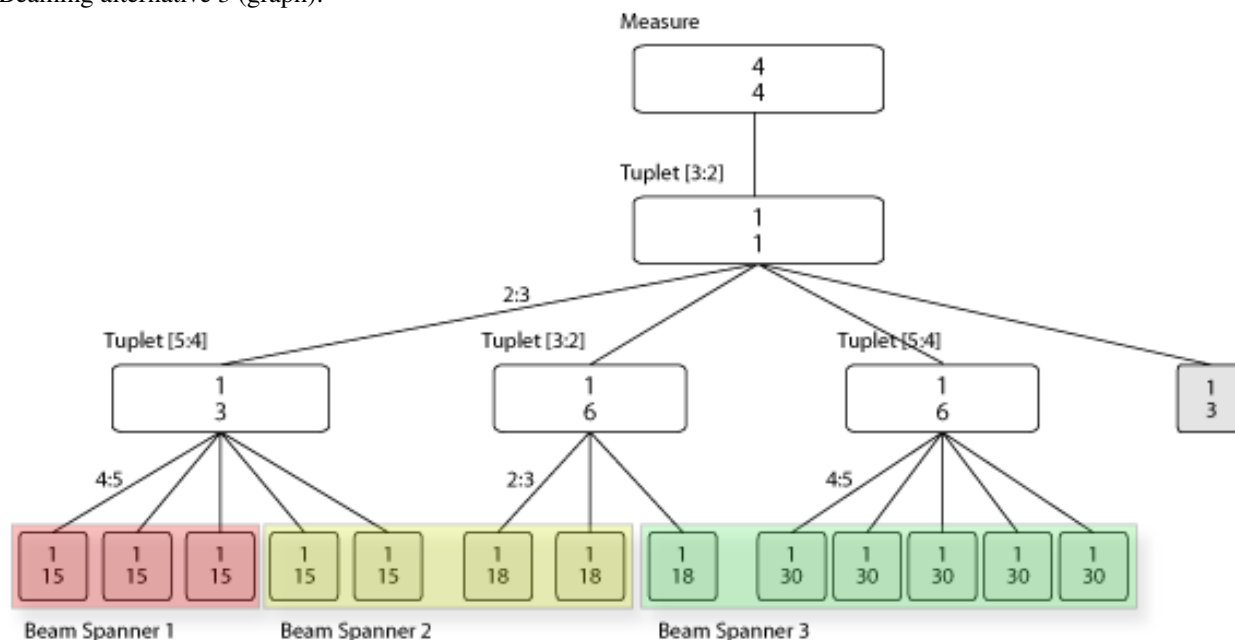
Beaming alternative 3:



Clearly the beaming of notes can be totally independent from the tuplet groupings. Beaming across tuplet groups implies beaming across nodes in the tree structure, which means that the beams do not adhere to the *exclusive (parent-hood) membership* characteristic of the tree. Beams must then be modeled independently as a separate and complementary structure. These are the Abjad *spanners*.

Below we have the score of our tuplet example with alternative beaming and its the Leaf-Container-Spanner graph. Notice that the colored blocks represent spanners.

Beaming alternative 3 (graph):



8.2 Example 2

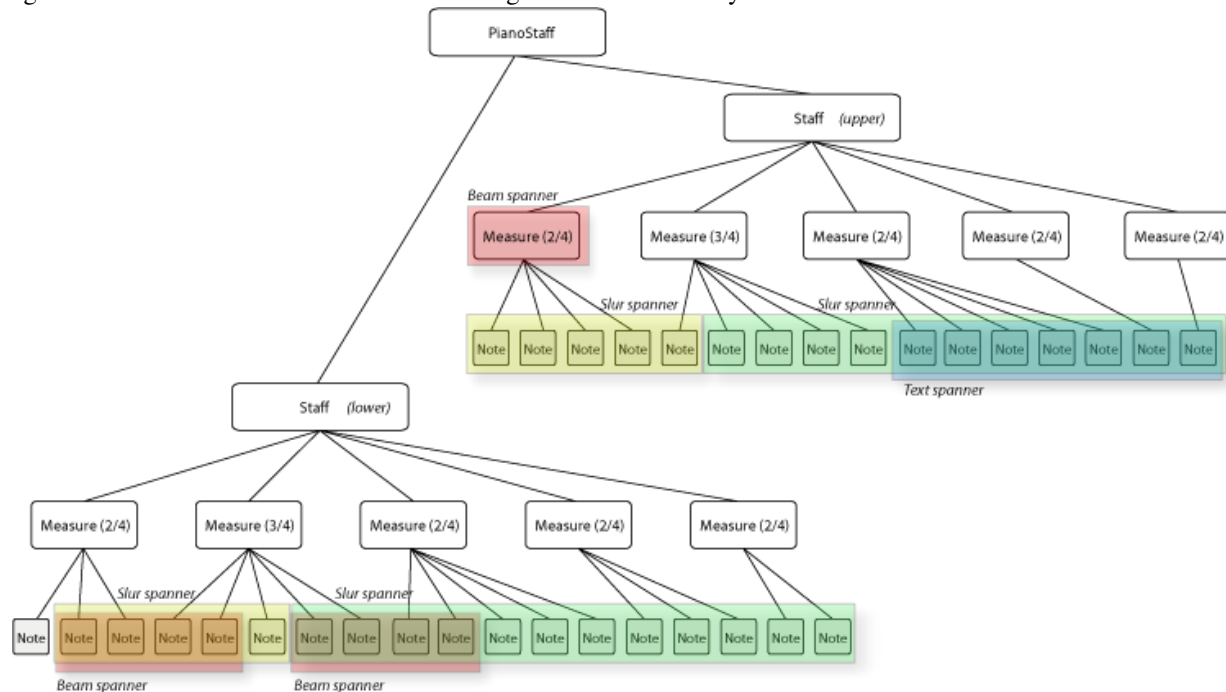
As a second example let's look at the last five measures of Bartók's *Wandering* from *Mikrokosmos* vol. III. As simple as it may seem, these five measures carry with them a lot of information pertaining to musical notation.



Note: Please refer to the [Bartok example](#) for a step by step construction of the musical fragment and its full Abjad code.

There are many musical signs of different types on the pages: notes, dynamic markings, clefs, staves, slurs, etc. These signs are structurally related to each other in different ways. Let's start by looking at the larger picture. The piano piece is written in two staves. As is customary, the staves are graphically grouped with a large curly brace attaching to them at the beginning or each system. Notice that each staff has a variety of signs associated with it. There are notes printed on the staff lines as well as meter indications and bar lines. Each note, for example, is in one and only one staff. A note is never in two staves at the same time. This is also true for measures. A measure in the top staff is not simultaneously drawn on the top staff and the bottom staff. It is better to think of each staff as having its own set of measures. Notice also that the notes in each staff fall within the region of one and only one measure, i.e. measures seem to contain notes. There is not one note that is at once in two measures (this is standard practice in musical notation, but it need not always be the case.)

As we continue describing the relationships between the musical signs in the page, we begin to discover a certain structure, or a convenient way of structuring the score for conceptualization and manipulation. All the music in a piano score seems to be written in what we might call a *staff group*. The staff group is *composed of* two staves. Each staff in turn appears to be composed of a series or measures, and each measure is composed of a series of notes. So again we find that the score structure can be organized hierarchically as a tree. This tree structure looks like this:

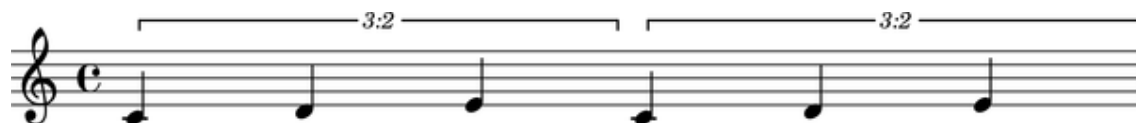


Notice again though that there are elements in the score that imply and require a different kind of grouping. The two four eighth-note runs in the lower staff are beamed together across the bar line and, based on our tree structure, across tree nodes. So do the slurs, the dynamics markings and the ritardando indication at the top of the score. As we have seen in the tuplets example, all these groups running across the tree structure can be defined with *spanners*.

WORKING WITH COMPONENT PARENTAGE

Many score objects contain other score objects.

```
abjad> tuplet = Tuplet(Fraction(2, 3), "c'4 d'4 e'4")
abjad> staff = Staff(2 * tuplet)
abjad> score = Score([staff])
abjad> show(score)
```



Abjad uses the idea of parentage to model the way objects contain each other.

9.1 Improper parentage

The improper parentage of the first note in score begins with the note itself:

```
abjad> note = score.leaves[0]
Note("c'4")

abjad> componenttools.get_improper_parentage_of_component(note)
(Note("c'4"), Tuplet(2/3, [c'4, d'4, e'4]), Staff{2}, Score<<1>>)
```

9.2 Proper parentage

The proper parentage of the note begins with only the immediate parent of the note:

```
abjad> componenttools.get_proper_parentage_of_component(note)
(Tuplet(2/3, [c'4, d'4, e'4]), Staff{2}, Score<<1>>)
```

Note: the length of the improper parentage of any component equals the length of the proper parentage of the component plus 1.

9.3 Parentage attributes

Use component tools to find score depth:

```
abjad> componenttools.component_to_score_depth(note)
3
```

Or score root:

```
abjad> componenttools.component_to_score_root(note)
Score<<1>>
```

Or to find whether a component has no (proper) parentage at all:

```
abjad> componenttools.is_orphan_component(note)
False
```

WORKING WITH THREADS

10.1 What is a thread?

A thread is a structural relationship binding a set of strictly sequential voice-level components.

Threads may be explicitly defined via voice instances:

```
abjad> v = Voice()
```

Or they may exist implicitly in certain score constructs in the absence of voice containers:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
```

Two contiguous voices must have the same name in order to be part of the same thread.

Here a thread does **not** exist between notes in different voices:

```
abjad> v_one = Voice("c'16 d'16 e'16 f'16")
abjad> v_two = Voice("c'8 d'8")
abjad> staff = Staff([v_one, v_two])
abjad> f(staff)
\new Staff {
    \new Voice {
        c'16
        d'16
        e'16
        f'16
    }
    \new Voice {
        c'8
        d'8
    }
}
```

Here a thread does exist:

```
abjad> v_one.name = 'flute'
abjad> v_two.name = 'flute'
abjad> f(staff)
\new Staff {
    \context Voice = "flute" {
        c'16
        d'16
        e'16
        f'16
    }
}
```

```
}
\context Voice = "flute" {
  c'8
  d'8
}
}
```

10.2 What are threads for?

Consider the following situation:



Are the two eighth notes in the second half of the measure the continuation of the ascending line in the first half, or is it the quarter note? Is the very last *C* the continuation of the top melodic line or is it the *A*? The stems might suggest an answer, but for Abjad, stem direction is not structural. What path should Abjad take to traverse this little score from the first note to the last *A*? This same problem appears when trying to apply spanners to parallel structures. Thus, threads are important in both score navigation and the application of spanners. In fact, threads are a requirement for spanner application.

In Abjad, the ambiguity is resolved through the explicit use of named voices.

The musical fragment above is constructed with the following code:

```
abjad> vA = Voice(notetools.make_notes([5, 7, 9, 11], [(1, 8)] * 4))
abjad> vB = Voice(notetools.make_notes([12, 11, 9], [(1, 8), (1, 8), (1, 4)]))
abjad> vC = Voice(Note(12, (1, 4)) * 2)
abjad> marktools.LilyPondCommandMark('voiceOne')(vA[0])
abjad> marktools.LilyPondCommandMark('voiceOne')(vB[0])
abjad> marktools.LilyPondCommandMark('voiceTwo')(vC[0])
abjad> p = Container([vB, vC])
abjad> p.is_parallel = True
abjad> staff = Staff([vA, p])
```



There's a staff that sequentially contains a voice and a parallel container. The container in turn holds two voices running simultaneously.

It is now clear from the code that the last *A* belongs with the two descending eighth notes. But there's still no indication about a relationship of continuity between the first voice in the sequence (*vA*) and any of the two following voices. Note that, while the LilyPond voice number commands setting may suggest that *vA* and *vB* belong together, this is not the case. The LilyPond voice number commands simply set the direction of stems in printed output.

To see this more clearly, suppose we want to add a slur spanner starting on the first note and ending on one of the last simultaneous notes. To attach the slur spanner to the voices we could try either:

```
abjad> spannertools.SlurSpanner([vA, vB])
```

or

```
abjad> spannertools.SlurSpanner([vA, vC])
```

But both raise a contiguity error. Abjad needs to see an explicit connection between either vA and vB or between vA and vC .

Observe the behavior of the `iterate_thread_forward_in_expr()` iterator on the *staff*:

```
::
```

```
abjad> from abjad.tools import threadtools
abjad> vA_thread_signature = threadtools.component_to_thread_signature(vA)
abjad> notes = threadtools.iterate_thread_forward_in_expr(staff, Note, vA_thread_signature)
abjad> print list(notes)
[Note("f'8"), Note("g'8"), Note("a'8"), Note("b'8")]
```

```
abjad> vB_thread_signature = threadtools.component_to_thread_signature(vB)
abjad> notes = threadtools.iterate_thread_forward_in_expr(staff, Note, vB_thread_signature)
abjad> print list(notes)
[Note("c''8"), Note("b'8"), Note("a'4")]
```

```
abjad> vC_thread_signature = threadtools.component_to_thread_signature(vC)
abjad> notes = threadtools.iterate_thread_forward_in_expr(staff, Note, vC_thread_signature)
abjad> print list(notes)
[Note("c''4"), Note("c''4")]
```

In each case we are passing a different **thread signature** to the `iterate_thread_forward_in_expr()` iterator, so each case returns a different list of notes.

We can see that the thread signature of each voice is indeed different by printing it:

```
abjad> vA_thread_signature = threadtools.component_to_thread_signature(vA)
abjad> vA_thread_signature
<      root: Staff-8112592 (8112592) *      score: * staffgroup: *      staff: Staff-8112592 *

abjad> vB_thread_signature = threadtools.component_to_thread_signature(vB)
abjad> vB_thread_signature
<      root: Staff-8108496 (8108496) *      score: * staffgroup: *      staff: Staff-8108496 *

abjad> vC_thread_signature = threadtools.component_to_thread_signature(vC)
abjad> vC_thread_signature
<      root: Staff-8108496 (8108496) *      score: * staffgroup: *      staff: Staff-8108496 *
```

And by comparing them with the binary equality operator:

```
abjad> vA_thread_signature == vB_thread_signature
False
abjad> vA_thread_signature == vC_thread_signature
False
abjad> vB_thread_signature == vC_thread_signature
False
```

To allow Abjad to treat the content of, say, voices vA and vB as belonging together, we explicitly define a thread between them. To do this all we need to do is give both voices the same name:

```
abjad> vA.name = 'piccolo'
abjad> vB.name = 'piccolo'
```

Now vA and vB and all their content belong to the same thread:

```
abjad> vA_thread_signature == vB_thread_signature
False
```

Note how the thread signatures have changed:

```

abjad> vA_thread_signature = threadtools.component_to_thread_signature(vA)
abjad> print vA_thread_signature
      root: Staff-8108496 (8108496)
      score:
staffgroup:
  staff: Staff-8108496
  voice: Voice-piccolo
  self: Voice-piccolo

abjad> vB_thread_signature = threadtools.component_to_thread_signature(vB)
abjad> print vB_thread_signature
      root: Staff-8108496 (8108496)
      score:
staffgroup:
  staff: Staff-8108496
  voice: Voice-piccolo
  self: Voice-piccolo

abjad> vC_thread_signature = threadtools.component_to_thread_signature(vC)
abjad> print vC_thread_signature
      root: Staff-8108496 (8108496)
      score:
staffgroup:
  staff: Staff-8108496
  voice: Voice-8108384
  self: Voice-8108384

```

And how the `threadtools.iterate_thread_forward_in_expr()` function returns all the notes belonging to both `vA` and `vB` when passing it the full staff and the thread signature of `vA`:

```

abjad> notes = threadtools.iterate_thread_forward_in_expr(staff, Note, vA_thread_signature)
abjad> print list(notes)
[Note("f'8"), Note("g'8"), Note("a'8"), Note("b'8"), Note("c'8"), Note("b'8"), Note("a'4")]

```

Now the slur spanner can be applied to voices `vA` and `vB`:

```

abjad> spannertools.SlurSpanner([vA, vB])

```

or directly to the notes returned by the `iterate_thread_forward_in_expr()` iteration tool, which are the notes belonging to both `vA` and `vB`:

```

abjad> notes = threadtools.iterate_thread_forward_in_expr(staff, Note, vA_thread_signature)
abjad> spannertools.SlurSpanner(list(notes))

```

```

abjad> show(staff)

```



10.3 Coda

We could have constructed this score in a simpler way with only two voices, one of them starting with a LilyPond skip:


```
abjad> vX = Voice(notetools.make_notes([5, 7, 9, 11, 12, 11, 9], [(1, 8)] * 6 + [(1, 4)]))
abjad> vY = Voice([skiptools.Skip((2, 4))] + Note(12, (1, 4)) * 2)
abjad> marktools.LilyPondCommandMark('voiceOne')(vX[0])
abjad> marktools.LilyPondCommandMark('voiceTwo')(vY[0])
abjad> staff = Staff([vX, vY])
abjad> staff.is_parallel = True
```



UNDERSTANDING LILYPOND GROBS

LilyPond models music notation as a collection of graphic objects or grobs.

11.1 Grobs control typography

LilyPond grobs control the typographic details of the score:

```
\new Staff {  
  c'4 (  
  d'4 )  
  e'4 (  
  f'4 )  
  g'4 (  
  a'4 )  
  g'2  
}
```



In the example above LilyPond creates a grob for every printed glyph. This includes the clef and time signature as well as the note heads, stems and slurs. If the example included beams, articulations or an explicit key signature then LilyPond would create grobs for those as well.

11.2 Grobs can be overridden

You can change the appearance of LilyPond grobs with grob overrides:

```
\new Staff \with {  
  \override NoteHead #'color = #red  
  \override StaffSymbol #'color = #blue  
  \override Stem #'color = #red  
} {  
  c'4 (  
  d'4 )  
  e'4 (  
  f'4 )  
  g'4 (  
  a'4 )  
}
```



11.3 Check the LilyPond docs

New grobs are added to LilyPond from time to time.

For a complete list of LilyPond grobs see the [LilyPond documentation](#).

UNDERSTANDING ABJAD OVERRIDES

12.1 Grob-override component plug-ins

All Abjad containers have a grob-override plug-in:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4 g'4 a'4 g'2")

abjad> staff.override.staff_symbol.color = 'blue'

abjad> staff.override
LilyPondGrobOverrideComponentPlugIn(staff_symbol__color = 'blue')
```

All Abjad leaves have a grob-override plug-in, too:

```
abjad> leaf = staff[-1]

abjad> leaf.override.note_head.color = 'red'
abjad> leaf.override.stem.color = 'red'

abjad> leaf.override
LilyPondGrobOverrideComponentPlugIn(note_head__color = 'red', stem__color = 'red')
```

And so do Abjad spanners:

```
abjad> slur = spannertools.SlurSpanner(staff[:])

abjad> slur.override.slur.color = 'red'

abjad> slur.override
LilyPondGrobOverrideComponentPlugIn(slur__color = 'red')
```

12.2 Grob proxies

Grob-override plug-ins contain grob proxies:

```
abjad> leaf.override.note_head
LilyPondGrobProxy(color = 'red')

abjad> leaf.override.stem
LilyPondGrobProxy(color = 'red')
```

12.3 Dot-chained override syntax

The's dot-chained grob override syntax shown here results from the special way that the Abjad grob-override plug-in and grob proxy set and get their attributes.

TIME SIGNATURE MARKS BY EXAMPLE

In this tutorial is to take a deeper look at what happens when we attach time signature marks to staves and other score components. To work through the tutorial, enter each of the examples into the Abjad interpreter and study what comes back. At the end of the tutorial you'll understand how time signature marks are created. You'll also understand how the states of different objects change when time signature marks are attached and detached.

First we start by creating a staff full of notes:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4 g'2")
```

If we ask the Abjad interpreter about our staff reference Abjad will respond with the interpreter display of the object:

```
abjad> staff
Staff{5}
```

The 5 in `Staff{5}` shows that the staff contains 5 top-level components. The curly braces in `Staff{5}` show that the contents of the staff are to be read sequentially through time rather than in parallel.

Before we get to time signature marks let's take a moment and examine the state of the staff we've created. We can motivate this a bit by asking two questions:

1. what time signature is currently in effect for the staff we have just created?
2. **what is the time signature currently in effect for** the five notes contained within the staff we have just created?

The answer to both questions is the same: there is no time signature currently in effect for either our staff or for the five notes it contains.

We can see that this is the case with tools from the API:

```
abjad> contexttools.get_effective_time_signature(staff) is None
True
```

And:

```
abjad> for leaf in staff:
...     contexttools.get_effective_time_signature(leaf) is None
...
True
True
True
True
True
```

If we want, we can iterate both the staff and its leaves at one and the same time like this:

```
abjad> for component in componenttools.iterate_components_forward_in_expr(staff):
...     component, contexttools.get_effective_time_signature(component)
...
(Staff{5}, None)
(Note("c'4"), None)
(Note("d'4"), None)
(Note("e'4"), None)
(Note("f'4"), None)
(Note("g'2"), None)
```

This confirms the answer to our questions that there is not yet any time signature in effect for any component in our staff because we have not yet attached a time signature mark to any component in our staff.

So what happens if we format our staff and send it off to LilyPond to render as a PDF? Will LilyPond render the staff with a time signature? Without a time signature? Will LilyPond refuse to render the example at all?

We find out like this:

```
abjad> show(staff)
```



It turns out LilyPond defaults to a time signature of 4/4.

What's important to note here is that because we have not yet attached a time signature mark any component in our staff Abjad says “no effective time signature here” while LilyPond says “OK, I’ll default to 4/4 so we can get on with rendering your music.”

We can further confirm that this is the case by asking Abjad for the LilyPond format of our staff:

```
abjad> f(staff)
\new Staff {
    c'4
    d'4
    e'4
    f'4
    g'2
}
```

The LilyPond format of our staff contains no LilyPond `\time` command. This is, again, because we have not yet attached a time signature mark to any component in our staff.

We can no practice attaching and detaching time signature marks to different components in our staff and study what happens as we do.

We’ll start with 3/4.

The easiest thing to do is to attach a time signature mark to the staff itself.

We’ll do this in two separate steps and study each step to understand exactly what’s going on.

First, we create a 3/4 time signature mark:

```
abjad> time_signature_mark = contexttools.TimeSignatureMark((3, 4))
```

If we ask the Abjad interpreter for the interpreter display of our time signature mark we get the following:

```
abjad> time_signature_mark
TimeSignatureMark((3, 4))
```


All this tells us is that we have in fact created a 3/4 time signature mark. Nothing too exciting yet. At this point our 3/4 time signature is not yet attached to anything. We could say that the “state” of our time signature mark is “unattached.” And we can see this like so:

```
abjad> time_signature_mark.start_component is None
True
```

What does it mean for a time signature mark to have ‘start_component’ equal to none? It means that the time signature isn’t yet attached to any score component anywhere.

So now we attach our time signature mark to our staff:

```
abjad> time_signature_mark.attach(staff)
TimeSignatureMark((3, 4))(Staff{5})
```

Abjad responds immediately by returning the time signature mark we have just attached.

Notice that our time signature mark’s repr has changed. The repr of our 3/4 time signature mark now includes the repr of the staff to which we have just attached the time signature mark. That is to say that the repr of our time signature mark is `statat`.

Our time signature mark has transitioned from an “unattached” state to an “attached” state. We can see this like so:

```
abjad> time_signature_mark.start_component
Staff{5}
```

And our staff has likewise transitioned from a state of having no effective time signature to a state of having an effective time signature:

```
abjad> contexttools.get_effective_time_signature(staff)
TimeSignatureMark((3, 4))(Staff{5})
```

And what about the leaves inside our staff? Do the leaves now “know” that they are governed by a 3/4 time signature?

Indeed they do:

```
abjad> for leaf in staff.leaves:
...     leaf, contexttools.get_effective_time_signature(leaf)
...
(Note("c'4"), TimeSignatureMark((3, 4))(Staff{5}))
(Note("d'4"), TimeSignatureMark((3, 4))(Staff{5}))
(Note("e'4"), TimeSignatureMark((3, 4))(Staff{5}))
(Note("f'4"), TimeSignatureMark((3, 4))(Staff{5}))
(Note("g'2"), TimeSignatureMark((3, 4))(Staff{5}))
```

So to briefly resume:

What we just did was to:

1. create a time signature mark
2. attach the time signature to a score component

This 2-step pattern is always the same when dealing with context marks: create then attach.

(We will find out later that there are short-cuts for different parts of this process. Right now we’ve chosen to create in a first step and attach in a second step so that we can examine the changing states of the objects involved.)

Before moving on let’s look at the PDF corresponding to our staff:

```
abjad> show(staff)
```



And let's confirm what we see in the PDF in the staff's format:

```
abjad> f(staff)
\new Staff {
    \time 3/4
    c' 4
    d' 4
    e' 4
    f' 4
    g' 2
}
```

The staff's format now contains a LilyPond `\time` command because we have attached an Abjad time signature mark to the staff.

What we've just been through above will cover over 80% of what you'll ever wind up doing with time signature marks: creating them and attaching them directly to staves. But what if we wanna get rid of a time signature mark? Or what if the time signature will be changing all over the place? We cover those cases next.

Detaching a time signature mark is easy:

```
abjad> time_signature_mark.detach()
TimeSignatureMark((3, 4))
```

The Abjad returns the mark we have just detached. And, observing the repr of the time signature mark, we see that the time signature mark has again changed state: the time signature mark has transitioned from attached to unattached. We confirm this like so:

```
abjad> time_signature_mark.start_component is None
True
```

And also like so:

```
abjad> contexttools.get_effective_time_signature(staff) is None
True
```

Yup: our time signature mark knows nothing about our staff. And vice versa. This is good.

So now what if we want to set up a time signature of 2/4? That fits our music, too.

We have a couple of options.

We can simply create and attach a new time signature mark:

```
abjad> duple_time_signature_mark = contexttools.TimeSignatureMark((2, 4))
abjad> duple_time_signature_mark.attach(staff)
TimeSignatureMark((2, 4)) (Staff{5})

abjad> f(staff)
\new Staff {
    \time 2/4
    c' 4
    d' 4
    e' 4
    f' 4
    g' 2
}
```

```
abjad> show(staff)
```



Yup. That works.

On the other hand, we could simply reuse our previous 3/4 time signature mark.

To do this we'll first detach our 2/4 time signature mark ...

```
abjad> duple_time_signature_mark.detach()
```

```
abjad> duple_time_signature_mark.detach()
TimeSignatureMark((2, 4))
```

... confirm that our staff is now time signatureless ...

```
abjad> contexttools.get_effective_time_signature(staff) is None
True
```

```
abjad> f(staff)
```

```
\new Staff {
    c'4
    d'4
    e'4
    f'4
    g'2
}
```

... reattach our previous 3/4 time signature ...

```
abjad> time_signature_mark.attach(staff)
```

```
abjad> time_signature_mark.attach(staff)
TimeSignatureMark((4, 4)) (Staff{5})
```

... change the numerator of our time signature mark ...

```
abjad> time_signature_mark.numerator = 2
```

... and check to make sure that everything is as it should be:

```
abjad> contexttools.get_effective_time_signature(staff)
TimeSignatureMark((2, 4)) (Staff{5})
abjad> time_signature_mark.start_component
Staff{5}
```

```
abjad> f(staff)
```

```
\new Staff {
    \time 2/4
    c'4
    d'4
    e'4
    f'4
    g'2
}
```

```
abjad> show(staff)
```



And everything works as it should.

To change to, for example, 4/4 we change just change the time signature mark's numerator again:

```
abjad> time_signature_mark.numerator = 4
```

```
abjad> f(staff)
\new Staff {
    \time 4/4
    c'4
    d'4
    e'4
    f'4
    g'2
}
```

But what if our time signature has a 2/4 pick-up?

The LilyPond command for pick-ups is `\partial`. Abjad time signature marks implement this as a read / write attribute:

```
abjad> time_signature_mark.partial = Duration(2, 4)
```

```
abjad> f(staff)
\new Staff {
    \partial 2
    \time 4/4
    c'4
    d'4
    e'4
    f'4
    g'2
}
```

```
abjad> show(staff)
```



And what if time signature changes all over the place?

We'll use the trivial example of a measure in 4/4 followed by a measure in 2/4.

To do this we will need two time signature marks.

We've already got a 4/4 time signature mark attached to our staff:

```
abjad> f(staff)
\new Staff {
    \partial 2
    \time 4/4
    c'4
    d'4
    e'4
```

```

        f'4
        g'2
    }

```

Let's get rid of the pick-up:

```
abjad> time_signature_mark.partial = None
```

```

abjad> f(staff)
\new Staff {
    \time 4/4
    c'4
    d'4
    e'4
    f'4
    g'2
}

```

Now what about the 2/4 time signature mark?

We create it in the usual way:

```

abjad> duple_time_signature_mark = contexttools.TimeSignatureMark((2, 4))
abjad> duple_time_signature_mark
TimeSignatureMark((2, 4))

```

But should we attach it? We can't attach our 2/4 time signature to our staff because we've already attached our 4/4 time signature to our staff. And it only makes sense to attach one time signature to any given score component.

Observe that we've built our score in a very straightforward way: we have a single staff that contains a (flat) sequence of notes. This means that we have only one choice for where to attach the new 2/4 time signature mark. And that is one the $g'2$ that comes on the downbeat of the second measure. We do that like this:

```
abjad> duple_time_signature_mark.attach(staff[4])
```

```

abjad> duple_time_signature_mark.attach(staff[4])
TimeSignatureMark((2, 4))(g'2)

```

```

abjad> f(staff)
\new Staff {
    \time 4/4
    c'4
    d'4
    e'4
    f'4
    \time 2/4
    g'2
}

```

```
abjad> show(staff)
```



And everything works as we would like.

Incidentally, `staff[4]` means the component sitting at index 4 inside our staff. Using the interpreter we can verify that this is $g'2$:

```
abjad> staff[4]
Note("g' 2")
```

Depending on how we had chosen to build our staff we would have had more options for where to attach our 2/4 time signature mark. If, for example, we had chosen to populate our staff with a series of measures then it's possible we could have attached our 2/4 time signature to a measure instead of a note.

That covers the vast majority of things you'll do with time signature marks.

But before we stop we should mention another useful API function and then talk about some short-cuts.

First an API function to detach ALL context marks attaching to a component:

We call the function a first time:

```
abjad> contexttools.detach_context_marks_attached_to_component(staff)
(TimeSignatureMark((4, 4)),)
```

```
abjad> f(staff)
\new Staff {
    c' 4
    d' 4
    e' 4
    f' 4
    \time 2/4
    g' 2
}
```

And then a second time:

```
:: abjad> contexttools.detach_context_marks_attached_to_component(staff[4]) (TimeSignatureMark((2, 4)),)
```

```
abjad> f(staff)
\new Staff {
    c' 4
    d' 4
    e' 4
    f' 4
    g' 2
}
```

Now there are now context marks of any sort attached to our staff or to the notes in our staff.

Be careful with this function, though: it removes *all* context marks. So even though we just used the function to remove time signature marks, it also would have removed any clef marks or tempo marks if we had had those attached to our score, too.

And now for the short-cuts:

Our staff currently has no time signature marks attached:

```
abjad> f(staff)
\new Staff {
    c' 4
    d' 4
    e' 4
    f' 4
    g' 2
}
```

So to recreate our 3/4 time signature we can do this ...

```
abjad> time_signature_mark = contexttools.TimeSignatureMark((3, 4))
```

... and then use a short-cut to avoid calling `time_signature_mark.attach()` like this:

```
abjad> time_signature_mark(staff)
TimeSignatureMark((3, 4))(Staff{5})
```

```
abjad> f(staff)
\new Staff {
    \time 3/4
    c'4
    d'4
    e'4
    f'4
    g'2
}
```

What's going on here is that all context marks implement the special `__call__()` method as a short-cut for `attach()`. What is the special `__call__()` method? The `__call__()` method is what makes a function, class or any other Python object callable. The statement `time_signature_mark(staff)` has parentheses in it because the time signature mark is callable; and the time signature mark is callable because all context marks implement the special `__call__()` method.

Note too that all context marks understand an *empty call* as a short-cut for `detach()`. Like this:

```
abjad> time_signature_mark()
TimeSignatureMark((3, 4))
```

```
abjad> f(staff)
\new Staff {
    c'4
    d'4
    e'4
    f'4
    g'2
}
```

The empty call made against the time signature mark causes the time signature mark to detach from its start component.

The fact that context marks implement the special `__call__()` method as a short-cut for `attach()` means that context marks can be created and attached in a single line:

```
abjad> contexttools.TimeSignatureMark((2, 4))(staff)
TimeSignatureMark((2, 4))(Staff{5})
```

```
abjad> f(staff)
\new Staff {
    \time 2/4
    c'4
    d'4
    e'4
    f'4
    g'2
}
```

What's going on here?

What's going on is that `contexttools.TimeSignatureMark((2, 4))` creates a time signature mark in the usual way and that – immediately after this – the newly created time signature mark is available for us to call it against our staff.

This last short-cut form of ...

```
abjad> contexttools.TimeSignatureMark((2, 4))(staff)
```

... is the usual way that you will see context marks of all sorts presented in the docs.

Reference manual

ANNOTATIONS

Annotate components with user-specific information for future use.

Annotations do not impact formatting.

14.1 Creating annotations

Use mark tools to create annotations:

```
abjad> annotation = marktools.Annotation('special pitch', pitchtools.NamedChromaticPitch('bs'))

abjad> annotation
Annotation('special pitch', NamedChromaticPitch('bs'))
```

14.2 Attaching annotations to a component

Attach annotations to any component with `attach()`:

```
abjad> note = Note("c'4")
abjad> annotation.attach(note)

abjad> annotation
Annotation('special pitch', NamedChromaticPitch('bs'))(c'4)

abjad> another_annotation = marktools.Annotation('special pitch', pitchtools.NamedChromaticPitch('bs'))
abjad> another_annotation.attach(note)

abjad> another_annotation
Annotation('special pitch', NamedChromaticPitch('bs'))(c'4)
```

14.3 Getting the annotations attached to a component

Use mark tools to get all the annotations attached to a component:

```
abjad> marktools.get_annotations_attached_to_component(note)
(Annotation('special pitch', NamedChromaticPitch('bs'))(c'4), Annotation('special pitch', NamedChromaticPitch('bs'))(c'4))
```

14.4 Detaching annotations from a component one at a time

Use `detach()` to detach annotations from a component one at a time:

```
abjad> annotation.detach()

abjad> annotation
Annotation('special pitch', NamedChromaticPitch('bs'))
```

14.5 Detaching all annotations attached to a component at once

Or use mark tools to detach all annotations attached to a component at once:

```
abjad> print marktools.detach_annotations_attached_to_component(note)
(Annotation('special pitch', NamedChromaticPitch('bs')),)

abjad> marktools.get_annotations_attached_to_component(note)
()
```

14.6 Inspecting the component to which an annotation is attached

Use `start_component` to inspect the component to which an annotation is attached:

```
abjad> annotation.attach(note)

abjad> annotation.start_component
Note("c'4")
```

14.7 Inspecting annotation name

Use `name` to get the name of any annotation:

```
abjad> annotation.name
'special pitch'
```

14.8 Inspecting annotation value

And use `value` to get the value of any annotation:

```
abjad> annotation.value
NamedChromaticPitch('bs')
```

ARTICULATIONS

Articulations model staccati, marcati, tenuti and other symbols. Articulations attach notes, rests or chords.

15.1 Creating articulations

Use `marktools` to create articulations:

```
articulation = marktools.Articulation('turn')

abjad> articulation
Articulation('turn')
```

15.2 Attaching articulations to a leaf

Use `attach()` to attach articulations to a leaf:

```
abjad> staff = Staff([])
abjad> key_signature = contexttools.KeySignatureMark('g', 'major')
abjad> key_signature.attach(staff)
time_signature = contexttools.TimeSignatureMark((2, 4), partial = Duration(1, 8))
abjad> time_signature.attach(staff)

abjad> staff.extend("d'8 f'8 a'8 d''8 f''8 gs'4 r8 e'8 gs'8 b'8 e''8 gs''8 a'4")

abjad> articulation.attach(staff[5])

abjad> show(staff)
```



(The example is based on Haydn's piano sonata number 42, Hob. XVI/27.)

15.3 Attaching articulations to many notes and chords at once

Use `marktools` to attach articulations to many notes and chords at one time:

```
abjad> marktools.attach_articulations_to_notes_and_chords_in_expr(staff[:6], ['.'])
```

```
abjad> show(staff)
```



15.4 Getting the articulations attached to a leaf

Use `marktools` to get the articulations attached to a leaf:

```
abjad> marktools.get_articulations_attached_to_component(staff[5])  
(Articulation('turn')(gs'4), Articulation('.') (gs'4))
```

15.5 Detaching articulations from a leaf one at a time

Detach articulations by hand with `detach()`:

```
abjad> articulation.detach()
```

```
abjad> articulation  
-\turn
```

```
abjad> show(staff)
```



15.6 Detaching all articulations attached to a leaf at once

Use `marktools` to detach all articulations attached to a leaf at once:

```
abjad> staff[0]  
Note("d'8")
```

```
abjad> marktools.detach_articulations_attached_to_component(staff[0])
```

```
abjad> show(staff)
```



15.7 Inspecting the leaf to which an articulation is attached

Use `start_component` to inspect the component to which an articulation is attached:

'staccato' tells you the articulation's name.

'^' tells you the articulation's direction string.

(a"4) tells you the component to which the articulation is attached.

If you set the direction string of the articulation to none then the direction will no longer appear:

```
abjad> articulation.direction_string = None
```

```
abjad> articulation
Articulation('staccato')(a'4)
```

15.10 Understanding the string representation of an articulation

The string representation of an articulation comprises two parts:

```
abjad> str(articulation)
'\staccato'
```

– tells you the articulation's direction string.

staccato tells you the articulation's name.

15.11 Inspecting the LilyPond format of an articulation

Get the LilyPond input format of an articulation with `format`:

```
abjad> articulation.format
'\staccato'
```

Use `f()` as a short-cut to print the LilyPond format of an articulation:

```
abjad> f(articulation)
-\staccato
```

15.12 Controlling whether an articulation appears above or below the staff

Set `direction_string` to '^' to force an articulation to appear above the staff:

```
abjad> articulation.direction_string = '^'
```

```
abjad> show(staff)
```



Set `direction_string` to '_' to force an articulation to appear below the staff:

```
abjad> articulation.direction_string = '_'
```

```
abjad> show(staff)
```



Set `direction_string` to `none` to allow LilyPond to position an articulation automatically:

```
abjad> articulation.direction_string = None
```

```
abjad> show(staff)
```



15.13 Getting and setting the name of an articulation

Set the `name` of an articulation to change the symbol an articulation prints:

```
abjad> articulation.name = 'staccatissimo'
```

```
abjad> show(staff)
```



15.14 Copying articulations

Use `copy.copy()` to copy an articulation:

```
abjad> import copy
```

```
abjad> articulation_copy_1 = copy.copy(articulation)
```

```
abjad> articulation_copy_1
Articulation('staccatissimo')
```

```
abjad> articulation_copy_1.attach(staff[1])
```

```
abjad> show(staff)
```



Or use `copy.deepcopy()` to do the same thing.

15.15 Comparing articulations

Articulations compare equal with equal direction names and direction strings:

```
abjad> articulation.name
'staccatissimo'
abjad> articulation.direction_string
None

abjad> articulation_copy_1.name
'staccatissimo'
abjad> articulation_copy_1.direction_string
None

abjad> articulation == articulation_copy_1
True
```

Otherwise articulations do not compare equal.

15.16 Overriding attributes of the LilyPond script grob

Override attributes of the LilyPond script grob like this:

```
abjad> staff.override.script.color = 'red'

abjad> f(staff)
\new Staff \with {
    \override Script #'color = #red
} {
    \key g \major
    \partial 8
    \time 2/4
    d'8
    f'8 -\staccatissimo -\staccato
    a'8 -\staccato
    d''8 -\staccato
    f''8 -\staccato
    gs'4 -\staccato
    r8
    e'8
    gs'8
    b'8
    e''8
    gs''8
    a'4 -\staccatissimo -\turn
}
```

```
abjad> show(staff)
```



See the LilyPond documentation for a list of script grob attributes available.

CHORDS

16.1 Making chords from a LilyPond input string

You can make chords from a LilyPond input string:

```
abjad> chord = Chord("<c' d' bf'>4")
```

```
abjad> show(chord)
```



16.2 Making chords from chromatic pitch numbers and duration

You can also make chords from chromatic pitch numbers and duration:

```
abjad> chord = Chord([0, 2, 10], Duration(1, 4))
```

```
abjad> show(chord)
```



16.3 Getting all the written pitches of a chord at once

You can get all the written pitches of a chord at one time:

```
abjad> chord.written_pitches  
(NamedChromaticPitch("c'"), NamedChromaticPitch("d'"), NamedChromaticPitch("bf'"))
```

Abjad returns a read-only tuple of named chromatic pitches.

16.4 Getting the written pitches of a chord one at a time

You can get the written pitches of a chord one at a time:

```
abjad> chord.written_pitches[0]
NamedChromaticPitch("c' ")
```

Chords index the pitch they contain starting from 0 (just like tuples and lists).

16.5 Adding one pitch to a chord at a time

Use `append()` to add one note to a chord.

You can add a pitch to a chord with a chromatic pitch number:

```
abjad> chord.append(9)
```

```
abjad> show(chord)
```



Or you can add a pitch to a chord with a chromatic pitch name:

```
abjad> chord.append("df' ")
```

```
abjad> show(chord)
```



Chords sort their pitches every time you add a new one.

This means you can add pitches to your chord in any order.

16.6 Adding many pitches to a chord at once

Use `extend()` to add many pitches to a chord.

You can use chromatic pitch numbers:

```
abjad> chord.extend([3, 4, 14])
```

```
abjad> show(chord)
```



Or you can use chromatic pitch names:

```
abjad> chord.extend(["g' ", "af' "])
```

```
abjad> show(chord)
```

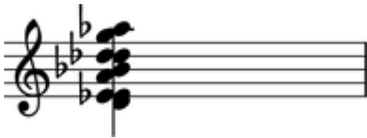


16.7 Deleting pitches from a chord

Delete pitches from a chord with `del()`:

```
abjad> del(chord[0])
```

```
abjad> show(chord)
```



```
abjad> del(chord[0])
```

```
abjad> show(chord)
```



Negative indices work too:

```
abjad> del(chord[-1])
```

```
abjad> show(chord)
```



16.8 Formatting chords

Get the LilyPond input format of any Abjad object with `format`:

```
abjad> chord.format
<ef' e' a' bf' df'' d'' g''>4
```

Use `f()` as a short-cut to print the LilyPond input format of any Abjad object:

```
abjad> f(chord)
<ef' e' a' bf' df'' d'' g''>4
```

16.9 Working with note heads

Most of the time you will work with the pitches of a chord. But you can get the note heads of a chord, too:

```
abjad> chord.note_heads
(NoteHead("ef'"), NoteHead("e'"), NoteHead("a'"), NoteHead("bf'"), NoteHead("df''"), NoteHead("d''"))
```

This is useful when you want to apply LilyPond overrides to note heads in a chord one at a time:

```
abjad> chord[2].tweak.color = 'red'
abjad> chord[3].tweak.color = 'blue'
abjad> chord[4].tweak.color = 'green'
```

```
abjad> f(chord)
<
    ef'
    e'
    \tweak #'color #red
    a'
    \tweak #'color #blue
    bf'
    \tweak #'color #green
    df''
    d''
    g''
>4
```

```
abjad> show(chord)
```



16.10 Working with empty chords

Abjad allows empty chords:

```
abjad> chord = Chord([], Duration(1, 4))
Chord('<>4')
```

Abjad formats empty chords, too:

```
abjad> f(chord)
<>4
```

But if you pass empty chords to `show()` LilyPond will complain because empty chords don't constitute valid LilyPond input.

When you are done working with an empty chord you can add pitches back into it chord in any of the ways described above:

```
abjad> chord.extend(["gf'", "df''", "g''"])
```

```
abjad> show(chord)
```



CONTAINERS

17.1 Creating containers

Create a container with components:

```
abjad> container = Container([Note("ds'16"), Note("cs'16"), Note("e'16"), Note("c'16")])
```

```
abjad> show(container)
```



Or with a note-entry string:

```
abjad> container = Container("ds'16 cs'16 e'16 c'16 d'2 ~ d'8")
```

```
abjad> show(container)
```



17.2 Inspecting music

Return the components in a container with `music`:

```
abjad> container.music
(Note("ds'16"), Note("cs'16"), Note("e'16"), Note("c'16"), Note("d'2"), Note("d'8"))
```

Or with a special call to `__getslice__`:

```
abjad> container[:]
[Note("ds'16"), Note("cs'16"), Note("e'16"), Note("c'16"), Note("d'2"), Note("d'8")]
```

17.3 Inspecting length

Get the length of a container with `len()`:

```
abjad> len(container)
6
```

17.4 Inspecting duration

Contents duration equals the sum of the duration of everything inside the container:

```
abjad> container.contents_duration
Duration(7, 8)
```

17.5 Adding one component to the end of a container

Add one component to the end of a container with `append`:

```
abjad> container.append(Note("af' 32"))

abjad> show(container)
```



17.6 Adding many components to the end of a container

Add many components to the end of a container with `extend`:

```
abjad> container.extend([Note("c' ' 32"), Note("a' 32")])

abjad> show(container)
```



17.7 Finding the index of a component

Find the index of a component with `index`:

```
abjad> note = container[7]

abjad> container.index(note)
7
```

17.8 Inserting a component by index

Insert a component by index with `insert`:


```
abjad> f(score)
\new Score <<
  \new StaffGroup <<
    \context Staff = "Flute" {
      c'8
      d'8
      e'8
      f'8
    }
    \context Staff = "Violin" {
      c'8
      d'8
      e'8
      f'8
    }
  >>
>>
```

And make it easy to retrieve containers later:

```
abjad> componenttools.get_first_component_in_expr_with_name(score, 'Flute')
Staff-"Flute">{4}
```

But container names do not appear in notational output:

```
abjad> show(score)
```



17.12 Understanding { } and << >> in LilyPond

LilyPond uses curly { } braces to wrap a stream of musical events that are to be engraved one after the other:

```
\new Voice {
  e''4
  f''4
  g''4
  g''4
  f''4
  e''4
  d''4
  d''4 \fermata
}
```



LilyPond uses skeleton << >> braces to wrap two or more musical expressions that are to be played at the same time:


```

\new Staff <<
  \new Voice {
    \voiceOne
    e''4
    f''4
    g''4
    g''4
    f''4
    e''4
    d''4
    d''4 \fermata
  }
  \new Voice {
    \voiceTwo
    c''4
    c''4
    b'4
    c''4
    c''8
    b'8
    c''4
    b'4
    b'4 \fermata
  }
>>

```



The examples above are both LilyPond input.

The most common use of LilyPond { } is to group a potentially long stream of notes and rests into a single expression.

The most common use of LilyPond << >> is to group a relatively smaller number of note lists together polyphonically.

17.13 Understanding sequential and parallel containers

Abjad implements LilyPond { } and << >> in the container `is_parallel` attribute.

Some containers set `is_parallel` to false at initialization:

```

staff = Staff([])
staff.is_parallel
False

```

Other containers set `is_parallel` to true:

```

score = Score([])
score.is_parallel
True

```

17.14 Changing sequential and parallel containers

Set `is_parallel` by hand as necessary:

```
voice_1 = Voice(r"e''4 f''4 g''4 g''4 f''4 e''4 d''4 d''4  ermata")
voice_2 = Voice(r"c''4 c''4 b'4 c''4 c''8 b'8 c''4 b'4 b'4  ermata")
abjad> staff = Staff([voice_1, voice_2])
abjad> staff.is_parallel = True
abjad> marktools.LilyPondCommandMark('voiceOne')(voice_1)
abjad> marktools.LilyPondCommandMark('voiceTwo')(voice_2)
abjad> show(staff)
```



The staff in the example above is set to parallel after initialization to create a type of polyphonic staff:

```
abjad> f(staff)
\new Staff <<
  \new Voice {
    \voiceOne
    e''4
    f''4
    g''4
    g''4
    f''4
    e''4
    d''4
    d''4 -\fermata
  }
  \new Voice {
    \voiceTwo
    c''4
    c''4
    b'4
    c''4
    c''8
    b'8
    c''4
    b'4
    b'4 -\fermata
  }
>>
```

17.15 Overriding containers

The symbols below are black with fixed thickness and predetermined spacing:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4 g'4 a'4 g'2")
abjad> slur_1 = spannertools.SlurSpanner(staff[:2])
abjad> slur_2 = spannertools.SlurSpanner(staff[2:4])
abjad> slur_3 = spannertools.SlurSpanner(staff[4:6])
```

```
abjad> f(staff)
\new Staff {
    c'4 (
    d'4 )
    e'4 (
    f'4 )
    g'4 (
    a'4 )
    g'2
}
```

```
abjad> show(staff)
```



But you can override LilyPond grobs to change the look of Abjad containers:

```
abjad> staff.override.staff_symbol.color = 'blue'
```

```
abjad> f(staff)
\new Staff \with {
    \override StaffSymbol #'color = #blue
} {
    c'4 (
    d'4 )
    e'4 (
    f'4 )
    g'4 (
    a'4 )
    g'2
}
```

```
abjad> show(staff)
```



17.16 Overriding containers' contents

You can override LilyPond grobs to change the look of containers' contents, too:

```
abjad> staff.override.note_head.color = 'red'
abjad> staff.override.stem.color = 'red'
```

```
abjad> f(staff)
\new Staff \with {
    \override NoteHead #'color = #red
    \override StaffSymbol #'color = #blue
    \override Stem #'color = #red
} {
    c'4 (
    d'4 )
}
```

```

e'4 (
f'4 )
g'4 (
a'4 )
g'2
}

```

```
abjad> show(staff)
```



17.17 Removing container overrides

Delete grob overrides you no longer want:

```
abjad> del(staff.override.staff_symbol)
```

```

abjad> f(staff)
\new Staff \with {
  \override NoteHead #'color = #red
  \override Stem #'color = #red
} {
  c'4 (
  d'4 )
  e'4 (
  f'4 )
  g'4 (
  a'4 )
  g'2
}

```

```
abjad> show(staff)
```



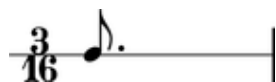
DURATIONS

18.1 Introduction

Abjad publishes information about many durated score objects.

Notes, rests, chords and skips carry some duration attributes:

```
abjad> note = Note(0, (3, 16))
abjad> measure = Measure((3, 16), [note])
abjad> staff = stafftools.RhythmicStaff([measure])
abjad> note.written_duration
Duration(3, 16)
```



Tuplets, measures, voices, staves and the other containers carry duration attributes, too:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(3, 16), Note(0, (1, 16)) * 5)
abjad> measure = Measure((3, 16), [tuplet])
abjad> staff = stafftools.RhythmicStaff([measure])
abjad> tuplet.multiplier
Duration(3, 5)
```



The next chapters document core duration concepts in Abjad.

18.2 Assignability

Western notation readily admits rational values like $1/4$. But values like $1/5$ notate only with tuplet brackets or special time signatures. Abjad formalizes the difference between rationals like $1/4$ and $1/5$ in the definition of rational assignability.

Rational values n/d are assignable when and only when numerator n is of the form $k(2^u - j)$ and denominator d is of the form 2^v . In this definition u and v must be nonnegative integers, k must be a positive integer, and j must be either 0 or 1.

Abjad initializes notes, rests and chords with assignable durations only.

18.3 Prolation

Abjad uses **prolation** as a cover term for rhythmic augmentation and diminution. Augmentation increases the duration of notes, rests and chords. Diminution does the opposite. Western notation employs tuplet brackets and special types of time signature to effect prolation.

18.3.1 Tuplet prolation

Tuplets prolate their contents:

```
abjad> tuplet = Tuplet(Fraction(5, 4), 4 * Note("c'8"))
abjad> staff = stafftools.RhythmicStaff([Measure((5, 8), [tuplet])])
abjad> spannertools.BeamSpanner(tuplet)
abjad> show(staff)
```



```
abjad> note = tuplet[0]
abjad> note.written_duration
Duration(1, 8)

abjad> note.prolation
Fraction(5, 4)

abjad> note.prolated_duration
Duration(5, 32)
```

Notes here with written duration 1/8 carry prolation factor 5/4 and prolated duration 5/32.

18.3.2 Meter prolation

Time signatures in western notation usually carry a denominator equal to a nonnegative integer power of 2. Abjad calls these conventional meters **binary meters**. Denominators equal to integers other than integer powers of 2 are also possible. Such **nonbinary meters** rhythmically diminish the contents of the measures they govern:

```
abjad> measure = Measure((4, 10), Note(0, (1, 8)) * 4)
abjad> spannertools.BeamSpanner(measure)
abjad> staff = stafftools.RhythmicStaff([measure])
```



```
abjad> note = staff.leaves[0]
abjad> note.prolation
Fraction(4, 5)

abjad> note.prolated_duration
Duration(1, 8)

abjad> note.prolation
Fraction(4, 5)
```

```
abjad> note.prolated_duration
Duration(1, 10)
```

Notes here with written duration $1/8$ carry prolation factor $4/5$ and prolated duration $1/10$.

18.3.3 The prolation chain

Tuplets nest and combine freely with different types of meter. When two or more **prolation donors** conspire, the prolation factor they collectively bestow on leaf-level music equals the cumulative product of all prolation factors in the **prolation chain**. All durated components carry a prolation chain:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(4, 8), Note(0, (1, 16)) * 7)
abjad> spannertools.BeamSpanner(tuplet)
abjad> measure = Measure((4, 10), [tuplet])
abjad> staff = stafftools.RhythmicStaff([measure])
```



```
abjad> measure.multiplier
Fraction(4, 5)
```

```
abjad> note = measure.leaves[0]
abjad> note.prolation
Duration(32, 35)
```

```
abjad> note.prolated_duration
Duration(2, 35)
```

Notes here with written duration $1/16$ carry prolated duration $2/35$.

Note: Western notation does not recognize tuplet brackets carrying one-to-one ratios. Such **trivial tuplets** may, however, be useful during different stages of composition, and Abjad allows them for that reason. Trivial tuplets carry **zero prolation**. Zero-prolated tuplets neither augment nor diminish the music they contain.

Note: Abjad implements one of two competing nonbinary **meter-interpretation schemes**. The first, **implicit meter-interpretation** given here, follows, for example, Ferneyhough, in that nonbinary meters prolate the contents of the measures they govern implicitly, ie, without recourse to tuplet brackets. The second, **explicit meter-interpretation**, which we find in, for example, Sciarrino, insists instead on the presence of some tuplet bracket, usually engraved in some broken or incomplete way. The implicit meter-interpretation that Abjad implements differs from the explicit meter-interpretation native to LilyPond. Abjad will eventually implement both implicit and explicit meter-interpretation, settable on a container-by-container basis.

Note: Nonbinary meter n/d rhythmically diminishes the contents of the measure it governs by a factor j/k , with $k=d$, and with j equal to the greatest integer power of 2 less than d . That is, $j=2^{**int(\log_2(d))}$.

18.4 Duration types

Abjad publishes duration information about all score components.

18.4.1 Written duration

Abjad uses **written duration** to refer to the face value of notes, rests and chords prior to prolation. Abjad written duration corresponds to the informal names most frequently used when talking about note duration.

These sixteenth notes are worth a sixteenth of a whole note:

```
abjad> measure = Measure((5, 16), Note(0, (1, 16)) * 5)
abjad> spannertools.BeamSpanner(measure)
abjad> staff = stafftools.RhythmicStaff([measure])
abjad> note = measure[0]
abjad> note.written_duration
Duration(1, 16)
```



These sixteenth notes are worth more than a sixteenth of a whole note:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(5, 16), Note(0, (1, 16)) * 4)
abjad> spannertools.BeamSpanner(tuplet)
abjad> measure = Measure((5, 16), [tuplet])
abjad> staff = stafftools.RhythmicStaff([measure])
abjad> note = tuplet[0]
abjad> note.written_duration
Duration(1, 16)
```



The notes in these examples are ‘sixteenth notes’ that carry different prolated durations. Abjad written duration captures the fact that the note heads and flag counts of the two examples match.

Written duration is a user-assignable rational number. Users can assign and reassign the written duration of notes, rests and chords at initialization and at any time during the life of the note, rest or chord. Written durations must be assignable; see the chapter on *assignability* for details. Note that Abjad containers do not carry written duration.

18.4.2 Prolated duration

Prolation refers to the duration-scaling effects of tuplets and special types of time signature. Prolation is a way of thinking about the contribution that musical structure makes to the duration of score objects. All durated Abjad objects carry a prolated duration. Prolated duration is an emergent property of notes, tuplets and other durated objects. The prolated duration of notes, rests and chords equals the product of the written duration and prolation of those objects. The prolated duration of tuplets, measures and other containers equals the the container’s duration interface multiplied by the container’s prolation.

18.4.3 Contents duration

Abjad defines the **contents duration** of tuplets, measures, voices, staves and other containers equal to the sum of the **preprolated duration** of each of the elements in the container.

The measure here contains two eighth notes and tuplet. These elements carry preprolated durations equal to 1/8, 1/8 and 2/8, respectively:


```
abjad> notes = Note(0, (1, 8)) * 2
abjad> spannertools.BeamSpanner(notes)
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), Note(0, (1, 8)) * 3)
abjad> spannertools.BeamSpanner(tuplet)
abjad> measure = Measure((4, 8), notes + [tuplet])
abjad> staff = stafftools.RhythmicStaff([measure])
abjad> measure.contents_duration
Duration(1, 2)
```



The contents duration of the measure here equals $1/8 + 1/8 + 2/8 = 4/8$.

18.4.4 Target duration

Abjad defines the target duration of fixed-duration tuplets equal to composer-settable duration to which the tuplet prolates its contents.

This fixed-duration tuplet carries a target duration equal to $4/8$:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(4, 8), Note(0, (1, 8)) * 5)
abjad> spannertools.BeamSpanner(tuplet)
abjad> measure = Measure((4, 8), [tuplet])
abjad> staff = stafftools.RhythmicStaff([measure])
abjad> print tuplet.contents_duration
5/8
abjad> tuplet.target_duration
Duration(1, 2)
```



The tuplet contents sum to $5/8$. But tuplet target duration always equals $4/8$.

18.4.5 Multiplied duration

Abjad defines the multiplied duration of notes, rests and chords equal to the product of written duration and leaf multiplier.

The first two notes below carry leaf multipliers equal to $2/1$:

```
abjad> notes = Note(0, (1, 16)) * 4
abjad> notes[0].duration_multiplier = Fraction(2, 1)
abjad> notes[1].duration_multiplier = Fraction(2, 1)
abjad> measure = Measure((3, 8), notes)
abjad> spannertools.BeamSpanner(measure)
abjad> staff = stafftools.RhythmicStaff([measure])
abjad> note = measure[0]
abjad> note.written_duration
Duration(1, 16)
```



```
abjad> note.duration_multiplier
Fraction(2, 1)
```

```
abjad> note.written_duration * note.duration_multiplier
Duration(1, 8)
abjad> note.multiplied_duration
Duration(1, 8)
```

The written duration of these first two notes equals 1/16 and so the multiplied duration of these first two notes equals $1/16 * 2/1 = 1/8$.

18.5 Duration initialization

Durated Abjad classes initialize duration from arguments in the form (n, d) with numerator n and denominator d .

```
abjad> note = Note(0, (3, 16))
```



Durated classes include notes, rests, chords, skips, tuplets and measures.

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), Note(0, (1, 8)) * 3)
abjad> spannertools.BeamSpanner(tuplet)
```



Abjad restricts notes, rests, chords and skips to durations like 3/16 that can be written with dots, beams and flags without ties or brackets. Abjad allows arbitrary positive durations like 5/8 for tuplets and measures.

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(5, 8), Note(0, (1, 8)) * 4)
abjad> spannertools.BeamSpanner(tuplet)
```



Abjad supports breves.

```
abjad> note = Note(0, (2, 1))
```



And longas.

```
abjad> note = Note(0, (4, 1))
```



Note: The restriction that the written durations of notes, rests, chords and skips be expressible with some combination of dots, flags and beams without recourse to ties and brackets generalizes to the condition of `note_head` assignability.

Values (n, d) are `note_head`-assignable when and only when (1) d is a nonnegative integer power of 2; (2) n is either a nonnegative integer power of 2 or is a nonnegative integer power of 2, minus 1; and (3) n/d is less than or equal to 8. Condition (3) captures the fact that LilyPond provides no glyph with greater duration than the maxima (equal to eight whole notes).

Note: Integer forms like 4 as a substitute for $(4, 1)$ in `Note(0, (4, 1))` are undocumented but allowed.

Note: Abjad allows maxima `note_heads` as in `Note(0, (8, 1))`. LilyPond implements a *maxima* command but does not supply a corresponding glyph for the `note_head`.

18.6 LilyPond multipliers

LilyPond provides an asterisk `*` operator to scale the durations of notes, rests and chords by arbitrarily positive rational values. LilyPond multipliers are invisible and generate no typographic output of their own. However, while independent from the typographic output, LilyPond multipliers do factor in in calculations of duration and time.

Abjad implements LilyPond multipliers as the settable `duration.multiplier` attribute of notes, rests and chords.

```
abjad> note = Note("c'4")
abjad> note.duration_multiplier = Fraction(1, 2)
abjad> note.duration_multiplier
Fraction(1, 2)
```

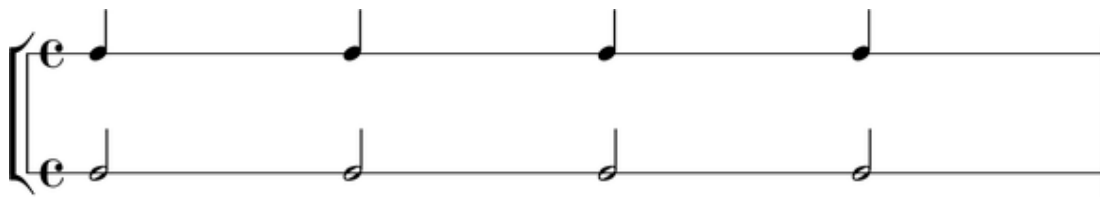
```
abjad> f(note)
c'4 * 1/2
```

Abjad also implements a `duration.multiplied` attribute to examine the duration of a note, rest or chord as affected by the multiplier.

```
abjad> note.multiplied_duration
Duration(1, 8)
```

LilyPond multipliers give the half notes here multiplied durations equal to a quarter note.

```
abjad> notes = Note("c'4") * 4
abjad> multiplied_note = Note(0, (1, 2))
abjad> multiplied_note.duration_multiplier = Fraction(1, 2)
abjad> multiplied_notes = multiplied_note * 4
abjad> top = stafftools.RhythmicStaff(notes)
abjad> bottom = stafftools.RhythmicStaff(multiplied_notes)
abjad> staves = scoretools.StaffGroup([top, bottom])
```



Note: Abjad models multiplication fundamentally differently than prolation. See the chapter on *Prolation* for more information.

Note: The LilyPond multiplication `*` operator differs from the Abjad multiplication `*` operator. LilyPond multiplication scales duration of LilyPond notes, rests and chords. Abjad multiplication copies Abjad containers and leaves.

18.7 Duration interfaces compared

type	core	leaf	container	measure	tuplet	fd tuple	fm tuple
contents	–	–	R	R	R	R	R
multiplied	–	R	–	–	–	R	R
multiplier	–	RW	–	R	R	R	RW
preprolated	R	R	R	R	R	R	R
prolated	R	R	R	R	R	R	R
prolation	R	R	R	R	R	R	R
target	–	–	–	–	–	RW	–
written	–	RW	–	–	–	–	–

The table contains a total of only four settable duration attributes, divided among only three classes. Durated Abjad classes offer up many read-only duration attributes but very few read-write duration attributes.

All classes carry all three prolation-related attributes because all classes can nest inside containers. It is possible, for example, to nest an entire voice within a fixed-duration tuple.

Note: Leaf multipliers and tuple multipliers differ.

INSTRUMENT MARKS

Instrument marks appear as markup in the left margin of your score.

19.1 Creating instrument marks

Use `contexttools` to create instrument marks:

```
abjad> instrument_mark = contexttools.InstrumentMark('Violin ', 'Vn. ')

abjad> instrument_mark
InstrumentMark('Violin ', 'Vn. ')
```

19.2 Attaching instrument marks to a component

Use `attach()` to attach any mark to a component:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4")

abjad> instrument_mark.attach(staff)

abjad> show(staff)
```



19.3 Getting the instrument mark attached to a component

Use `contexttools` to get the instrument mark attached to a component:

```
abjad> contexttools.get_instrument_mark_attached_to_component(staff)
InstrumentMark('Violin ', 'Vn. ')(Staff{4})
```

19.4 Getting the instrument in effect for a component

Or to get the instrument currently in effect for a component:

```
abjad> contexttools.get_effective_instrument(staff[1])
InstrumentMark('Violin ', 'Vn. ') (Staff{4})
```

19.5 Detaching instrument marks from a component one at a time

Use `detach()` to detach instrument marks from a component one at a time:

```
abjad> instrument_mark.detach()

abjad> instrument_mark
InstrumentMark('Violin ', 'Vn. ')

abjad> show(staff)
```



19.6 Detaching all instrument marks attached to a component at once

Or use `contexttools` to detach instrument marks all at once:

```
abjad> instrument_mark = contexttools.InstrumentMark('Violin ', 'Vn. ')
abjad> instrument_mark.attach(staff)

abjad> instrument_mark
InstrumentMark('Violin ', 'Vn. ') (Staff{4})

abjad> show(staff)
```



```
abjad> contexttools.detach_instrument_marks_attached_to_component(staff)

abjad> instrument_mark
InstrumentMark('Violin ', 'Vn. ')

abjad> show(staff)
```



19.7 Inspecting the component to which an instrument mark is attached

Use `start_component` to inspect the component to which an instrument mark is attached:

```
abjad> instrument_mark = contexttools.InstrumentMark('Flute ', 'Fl. ')
abjad> instrument_mark.attach(staff)

abjad> show(staff)
```



```
abjad> instrument_mark.start_component
Staff{4}
```

19.8 Inspecting the instrument name of an instrument mark

Use `instrument_name_markup` to get the instrument name of any instrument mark:

```
abjad> instrument_mark.instrument_name_markup
Markup('Flute ')
```

19.9 Inspecting the short instrument name of an instrument mark

And use `short_instrument_name_markup` to get the short instrument name of any instrument mark:

```
abjad> instrument_mark.short_instrument_name_markup
Markup('Fl. ')
```


20.1 Reopening Abjad PDFs

After you build a piece of notation and open with `show()` you will usually close the resulting PDF and continue working, changing your output notation in an iterative and incremental way.

```
abjad> staff = Staff(construct.scale(8))
abjad> show(staff)
```

But what if you need to go back and open the resulting PDF again? Abjad provides `pdf()` for precisely this purpose. Type the following at the Abjad prompt to open the most recent PDF written by Abjad.

```
abjad> pdf()
```

If you want to open not the next-to-most recent PDF generated by Abjad, pass in a `-1`. And for the next-to-next-to-most recent, pass in a `-2`, and so on.

20.2 Looking at LilyPond output

Abjad generates a LilyPond `.ly` file for every Abjad expression that you build and `show()`. To look at these LilyPond `.ly` files that Abjad builds behind the scenes, use `ly()`.

```
abjad> ly()

% Abjad revision 2362
% 2009-06-25 10:30

\version "2.12.2"
\include "english.ly"
\include "/Users/trevorbaca/Documents/abjad/trunk/abjad/scm/abjad.scm"

\new Staff {
  c'8
  d'8
  e'8
  f'8
  g'8
  a'8
  b'8
  c''8
}
```

Abjad opens the LilyPond `.ly` file in your favorite text editor.

These LilyPond `.ly` files that Abjad generates all have the same basic structure. The current version of Abjad and the date appear first, followed by the mandatory LilyPond version string and LilyPond directives for English note names and the default Abjad `.scm` file. The remainder of the file is reserved for the LilyPond input code corresponding to the expression you just built in Abjad.

When you are done looking at the LilyPond `.ly` file quit your text editor to return to the Abjad interpreter.

20.3 Looking at the LilyPond log

If things go wrong when you call `show()` or one of the other Abjad functions that call LilyPond behind the scenes, it may be helpful to examine the output that LilyPond writes to the LilyPond log.

```
abjad> log()
```

```
GNU LilyPond 2.12.2
Processing '1420.ly'
Parsing...
Interpreting music...
Preprocessing graphical objects...
Finding the ideal number of pages...
Fitting music on 1 page...
Drawing systems...
Layout output to '1420.ps'...
Converting to './1420.pdf'...
```

This is the normal output that LilyPond generates every time you call the program behind. When you are done looking at the LilyPond log, quit your text editor to return to the Abjad interpreter.

LILYPOND COMMAND MARKS

LilyPond command marks allow you to attach arbitrary LilyPond commands to Abjad score components.

21.1 Creating LilyPond command marks

Use `marktools` to create LilyPond command marks:

```
abjad> lilypond_command_mark = marktools.LilyPondCommandMark('bar "||"', 'after')

abjad> lilypond_command_mark
LilyPondCommandMark('bar "||"')
```

21.2 Attaching LilyPond command marks to Abjad components

Use `attach()` to attach a LilyPond command mark to any Abjad component:

```
abjad> import copy
abjad> staff = Staff([])
abjad> key_signature = contexttools.KeySignatureMark('f', 'major')
abjad> key_signature.attach(staff)
abjad> staff.extend(iotools.parse_lilypond_input_string("d''16 ( c''16 fs''16 g''16 )"))
abjad> staff.extend(iotools.parse_lilypond_input_string("f''16 ( e''16 d''16 c''16 )"))
abjad> staff.extend(iotools.parse_lilypond_input_string("cs''16 ( d''16 f''16 d''16 )"))
abjad> staff.extend(iotools.parse_lilypond_input_string("a'8 b'8"))
abjad> staff.extend(iotools.parse_lilypond_input_string("d''16 ( c''16 fs''16 g''16 )"))
abjad> staff.extend(iotools.parse_lilypond_input_string("f''16 ( e''16 d''16 c''16 )"))
abjad> staff.extend(iotools.parse_lilypond_input_string("cs''16 ( d''16 f''16 d''16 )"))
abjad> staff.extend(iotools.parse_lilypond_input_string("a'8 b'8 c''2"))

abjad> lilypond_command_mark.attach(staff[-2])

abjad> show(staff)
```



21.3 Getting the LilyPond command marks attached to an Abjad component

Use `marktools` to get the `lilypond_command_marks` attached to a leaf:

```
abjad> marktools.get_lilypond_command_marks_attached_to_component(staff[-2])
(LilyPondCommandMark('bar "||"' (b'8),)
```

21.4 Detaching LilyPond command marks from components one at a time

Use `detach()` to detach LilyPond command marks one at a time:

```
abjad> lilypond_command_mark.detach()
```

```
abjad> lilypond_command_mark
LilyPondCommandMark('bar "||"')
```

```
abjad> show(staff)
```



21.5 Detaching all LilyPond command marks attached to a component at once

Use `marktools` to detach all LilyPond command marks attached to a component at once:

```
abjad> lilypond_command_mark_1 = marktools.LilyPondCommandMark('bar "||"', 'closing')
abjad> lilypond_command_mark_1.attach(staff[-2])
```

```
abjad> lilypond_command_mark_2 = marktools.LilyPondCommandMark('bar "||"', 'closing')
abjad> lilypond_command_mark_2.attach(staff[-16])
```

```
abjad> show(staff)
```



```
abjad> marktools.detach_lilypond_command_marks_attached_to_component(staff[-16])
```

```
abjad> show(staff)
```



21.6 Inspecting the component to which a LilyPond command mark is attached

Use `start_component` to inspect the component to which a LilyPond command mark is attached:

```
abjad> lilypond_command_mark = marktools.LilyPondCommandMark('bar "||"', 'closing')
abjad> lilypond_command_mark.attach(staff[-2])
```

```
abjad> show(staff)
```



```
abjad> lilypond_command_mark.start_component
Note("b'8")
```

21.7 Getting and setting the command name of a LilyPond command mark

Set the `command_name` of a LilyPond command mark to change the LilyPond command a LilyPond command mark prints:

```
abjad> lilypond_command_mark.command_name = 'bar "|."'
```

```
abjad> show(staff)
```



21.8 Copying LilyPond commands

Use `copy.copy()` to copy a LilyPond command mark:

```
abjad> import copy
```

```
abjad> lilypond_command_mark_copy_1 = copy.copy(lilypond_command_mark)
```

```
abjad> lilypond_command_mark_copy_1
LilyPondCommandMark('bar "|. "')
```

```
abjad> lilypond_command_mark_copy_1.attach(staff[-1])
```

```
abjad> show(staff)
```



Or use `copy.deepcopy()` to do the same thing.

21.9 Comparing LilyPond command marks

LilyPond command marks compare equal with equal command names:

```
abjad> lilypond_command_mark.command_name
'bar "|"'
```

```
abjad> lilypond_command_mark_copy_1.command_name
'bar "|"'
```

```
abjad> lilypond_command_mark == lilypond_command_mark_copy_1
True
```

Otherwise LilyPond command marks do not compare equal.

LILYPOND COMMENTS

LilyPond comments begin with the % sign. Abjad models LilyPond comments as marks.

22.1 Creating LilyPond comments

Use `marktools` to create LilyPond comments:

```
abjad> comment_1 = marktools.LilyPondComment('This is a LilyPond comment before a note.', 'before')

abjad> comment_1
LilyPondComment('This is a LilyPond comment before a note.')
```

22.2 Attaching LilyPond comments to leaves

Attach LilyPond comments to a note, rest or chord with `attach()`:

```
abjad> note = Note("cs''4")
abjad> show(note)
```



```
abjad> comment_1.attach(note)

abjad> f(note)
% This is a LilyPond comment before a note.
cs''4
```

You can add LilyPond comments before, after or to the right of any leaf.

22.3 Attaching LilyPond comments to containers

Use `attach()` to attach LilyPond comments to a container:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> show(staff)
```



```
abjad> staff_comment_1 = marktools.LilyPondComment('Here is a LilyPond comment before the staff.', 'before')
abjad> staff_comment_2 = marktools.LilyPondComment('Here is a LilyPond comment in the staff opening.', 'opening')
abjad> staff_comment_3 = marktools.LilyPondComment('Here is another LilyPond comment in the staff opening.', 'opening')
abjad> staff_comment_4 = marktools.LilyPondComment('LilyPond comment in the staff closing.', 'closing')
abjad> staff_comment_5 = marktools.LilyPondComment('LilyPond comment after the staff.', 'after')

abjad> staff_comment_1.attach(staff)
abjad> staff_comment_2.attach(staff)
abjad> staff_comment_3.attach(staff)
abjad> staff_comment_4.attach(staff)
abjad> staff_comment_5.attach(staff)

abjad> f(staff)
% Here is a LilyPond comment before the staff.
\new Staff {
    % Here is a LilyPond comment in the staff opening.
    % Here is another LilyPond comment in the staff opening.
    c'8
    d'8
    e'8
    f'8
    % LilyPond comment in the staff closing.
}
% LilyPond comment after the staff.
```

You can add LilyPond comments before, after, in the opening or in the closing of any container.

22.4 Getting the LilyPond comments attached to a component

Use `marktools` to get all the LilyPond comments attached to a component:

```
abjad> marktools.get_lilypond_comments_attached_to_component(note)
(LilyPondComment('This is a LilyPond comment before a note.')(cs''4),)
```

Abjad returns a tuple of zero or more LilyPond comments.

22.5 Detaching LilyPond comments from a component one at a time

Use `detach()` to detach LilyPond comments from a component one at a time:

```
abjad> comment_1 = marktools.get_lilypond_comments_attached_to_component(note)[0]

abjad> comment_1.detach()
LilyPondComment('This is a LilyPond comment before a note.')

abjad> f(note)
cs''4
```


22.6 Detaching all LilyPond comments attached to a component at once

Or use `marktools` to detach all LilyPond comments attached to a component at once:

```
abjad> for comment in marktools.get_lilypond_comments_attached_to_component(staff): print comment
LilyPondComment('Here is a LilyPond comment before the staff.')(Staff{4})
LilyPondComment('Here is a LilyPond comment in the staff opening.')(Staff{4})
LilyPondComment('Here is another LilyPond comment in the staff opening.')(Staff{4})
LilyPondComment('LilyPond comment in the staff closing.')(Staff{4})
LilyPondComment('LilyPond comment after the staff.')(Staff{4})

abjad> marktools.detach_lilypond_comments_attached_to_component(staff)

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}
```

22.7 Inspecting the component to which a LilyPond comment is attached

Use `start_component` to inspect the component to which a LilyPond comment is attached:

```
abjad> comment_1.attach(note)

abjad> comment_1.start_component
Note("cs' '4")
```

22.8 Inspecting contents string of a LilyPond comment

Use `contents_string` to inspect the written contents of a LilyPond comment:

```
abjad> comment_1.contents_string
'This is a LilyPond comment before a note.'
```


LILYPOND FILES

23.1 Making LilyPond files

Make a basic LilyPond input file with the `lilyfiletools` package:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> lilypond_file = lilyfiletools.make_basic_lilypond_file(staff)

abjad> lilypond_file
LilyPondFile(Staff{4})
```

23.2 Inspecting file output

LilyPond input files that you create this way come equipped with many attributes that appear in file output:

```
abjad> f(lilypond_file)
% Abjad revision 4746
% 2011-09-04 17:36

\version "2.15.9"
\include "english.ly"
\include "/Users/trevorbaca/Documents/abjad/trunk/abjad/cfg/abjad.scm"

\score {
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
}
```

23.3 Setting default paper size

Set default LilyPond paper size like this:

```
abjad> lilypond_file.default_paper_size = '11x17', 'landscape'
```

```
abjad> f(lilypond_file)
% Abjad revision 4746
% 2011-09-04 17:36

\version "2.15.9"
\include "english.ly"
\include "/Users/trevorbaca/Documents/abjad/trunk/abjad/cfg/abjad.scm"

#(set-default-paper-size "11x17" 'landscape)

\score {
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
}
```

23.4 Setting global staff size

Set global staff size like this:

```
abjad> lilypond_file.global_staff_size = 16

abjad> f(lilypond_file)
% Abjad revision 4746
% 2011-09-04 17:36

\version "2.15.9"
\include "english.ly"
\include "/Users/trevorbaca/Documents/abjad/trunk/abjad/cfg/abjad.scm"

#(set-default-paper-size "11x17" 'landscape)
#(set-global-staff-size 16)

\score {
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
}
```

MEASURES

24.1 Understanding measures in LilyPond

In LilyPond you specify time signatures by hand and LilyPond creates measures automatically:

```
\new Staff {  
  \time 3/8  
  c'8  
  d'8  
  e'8  
  d'8  
  e'8  
  f'8  
  \time 2/4  
  g'4  
  e'4  
  f'4  
  d'4  
  c'2  
}
```



Here LilyPond creates five measures from two time signatures. This happens because behind-the-scenes LilyPond time-keeping tells the program when measures start and stop and how to draw the barlines that come between them.

24.2 Understanding measures in Abjad

Measures are optional in Abjad, too, and you may omit them in favor of time signatures:

```
abjad> staff = Staff("c'8 d'8 e'8 d'8 e'8 f'8 g'4 e'4 f'4 d'4 c'2")  
  
abjad> contexttools.TimeSignatureMark((3, 8))(staff)  
abjad> contexttools.TimeSignatureMark((2, 4))(staff[6])  
  
abjad> show(staff)
```



But you may also include explicit measures in the Abjad scores you build. The following sections explain how.

24.3 Creating measures

Create a measure with a meter and music:

```
abjad> measure = Measure((3, 8), "c'8 d'8 e'8")
```

```
abjad> f(measure)
{
    \time 3/8
    c'8
    d'8
    e'8
}
```

```
abjad> show(measure)
```



24.4 Working with dynamic measures

Dynamic measures adjust their time signatures on the fly as you add and remove music.

Create dynamic measures without a time signature:

```
abjad> measure = measuretools.DynamicMeasure("c'8 d'8 e'8")
```

```
abjad> show(measure)
```



24.5 Adding music to dynamic measures

Add music to dynamic measures the same as to all containers:

```
abjad> measure.extend([Note("fs'8"), Note("gs'8")])
```

```
abjad> show(measure)
```



24.6 Removing music from dynamic measures

Remove music from dynamic measures the same as with other containers:

```
abjad> del(measure[1:3])
```

```
abjad> show(measure)
```



24.7 Setting the denominator of dynamic measures

You can set the denominator of dynamic measures to any integer power of 2:

```
abjad> measure.denominator = 32
```

```
abjad> show(measure)
```



24.8 Suppressing the meter of dynamic measures

You can temporarily suppress the meter of dynamic measures:

```
abjad> measure.suppress_meter = True
```

```
abjad> f(measure)
```

```
{
    c' 8
    fs' 8
    gs' 8
}
```

LilyPond will engrave the last active meter.

24.9 Working with anonymous measures

Anonymous determine their time signatures on the fly and then hide them at format time.

Create anonymous measures without a time signature:

```
abjad> measure = measuretools.AnonymousMeasure("c' 8 d' 8 e' 8")
```

```
abjad> show(measure)
```



24.10 Adding music to anonymous measures

Add music to anonymous measures the same as to other containers:

```
abjad> measure.extend([Note("fs'8"), Note("gs'8")])
```

```
abjad> show(measure)
```



24.11 Removing music from anonymous measures

Remove music from anonymous measure the same as from other containers:

```
abjad> del(measure[1:3])
```

```
abjad> show(measure)
```



NOTES

25.1 Making notes from a string

You can make notes from string:

```
abjad> note = Note("c' 4")
```

```
abjad> show(note)
```



25.2 Making notes from chromatic pitch number and duration

You can also make notes from chromatic pitch number and duration:

```
abjad> note = Note(0, Duration(1, 4))
```

```
abjad> show(note)
```



(You even use `Note("c' 4")` to create notes with numbers alone.)

25.3 Getting the written pitch of notes

You can get the written pitch of notes:

```
abjad> note.written_pitch  
NamedChromaticPitch("c' ")
```

25.4 Changing the written pitch of notes

And you can change the written pitch of notes:

```
abjad> note.written_pitch = "cs' "
```



(You can use `note.written_pitch = 1` to change pitch with numbers, too.)

25.5 Getting the duration attributes of notes

Get the written duration of notes like this:

```
abjad> note.written_duration
Duration(1, 4)
```

Which is usually the same as preprolated duration:

```
abjad> note.preprolated_duration
Duration(1, 4)
```

And prolated duration:

```
abjad> note.prolated_duration
Duration(1, 4)
```

Except for notes inside a tuplet:

```
abjad> tuplet = Tuplet(Fraction(2, 3), [Note("c'4"), Note("d'4"), Note("e'4")])
```

```
abjad> show(tuplet)
```



```
abjad> note = tuplet[0]
```

Tupletted notes carry written duration:

```
abjad> note.written_duration
Duration(1, 4)
```

Prolation:

```
abjad> note.prolation
Fraction(2, 3)
```

And prolated duration that is the product of the two:

```
abjad> note.prolated_duration
Duration(1, 6)
```

25.6 Changing the written duration of notes

You can change the written duration of notes:

```
abjad> tuplet[0].written_duration = Duration(1, 8)
abjad> tuplet[1].written_duration = Duration(1, 8)
abjad> tuplet[2].written_duration = Duration(1, 8)
```

```
abjad> show(tuplet)
```



Other duration attributes are read-only.

25.7 Overriding notes

The notes below are black with fixed thickness and predetermined spacing:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4 g'4 a'4 g'2")
abjad> slur_1 = spannertools.SlurSpanner(staff[:2])
abjad> slur_2 = spannertools.SlurSpanner(staff[2:4])
abjad> slur_3 = spannertools.SlurSpanner(staff[4:6])
```

```
abjad> f(staff)
```

```
\new Staff {
    c'4 (
    d'4 )
    e'4 (
    f'4 )
    g'4 (
    a'4 )
    g'2
}
```

```
abjad> show(staff)
```



But you can override LilyPond grobs to change the look of notes, rests and chords:

```
abjad> staff[-1].override.note_head.color = 'red'
abjad> staff[-1].override.stem.color = 'red'
```

```
abjad> f(staff)
```

```
\new Staff {
    c'4 (
    d'4 )
    e'4 (
    f'4 )
    g'4 (
    a'4 )
    \once \override NoteHead #'color = #red
    \once \override Stem #'color = #red
    g'2
}
```

```
abjad> show(staff)
```



25.8 Removing note overrides

Delete grob overrides you no longer want:

```
abjad> del(staff[-1].override.stem)
```

```
abjad> f(staff)
\new Staff {
    c'4 (
    d'4 )
    e'4 (
    f'4 )
    g'4 (
    a'4 )
    \once \override NoteHead #'color = #red
    g'2
}
```

```
abjad> show(staff)
```



PITCHES

Named chromatic pitches are the everyday pitches attached to notes and chords:

```
abjad> note = Note("cs''8")

abjad> note.written_pitch
NamedChromaticPitch("cs''")
```

26.1 Creating pitches

Use pitch tools to create named chromatic pitches:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs''")

abjad> named_chromatic_pitch
NamedChromaticPitch("cs''")
```

26.2 Inspecting the name of a pitch

Use `str()` to get the name of named chromatic pitches:

```
abjad> str(named_chromatic_pitch)
cs''
```

26.3 Inspecting the octave of a pitch

Get the octave number of named chromatic pitches with `octave_number`:

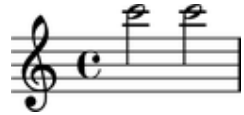
```
abjad> named_chromatic_pitch.octave_number
5
```

26.4 Working with pitch deviation

Use deviation to model the fact that two pitches differ by a fraction of a semitone:

```
abjad> note_1 = Note(24, (1, 2))
abjad> note_2 = Note(24, (1, 2))
abjad> staff = Staff([note_1, note_2])
```

```
abjad> show(staff)
```



```
abjad> note_2.written_pitch = pitchtools.NamedChromaticPitch(24, deviation = -31)
```

The pitch of the the first note is greater than the pitch of the second:

```
abjad> note_1.written_pitch > note_2.written_pitch
True
```

Use markup to include indications of pitch deviation in your score:

```
abjad> markuptools.Markup(note_2.written_pitch.deviation_in_cents, 'up')(note_2)
```



26.5 Sorting pitches

Named chromatic pitches sort by octave, diatonic pitch-class and accidental, in that order:

```
abjad> pitchtools.NamedChromaticPitch('es') < pitchtools.NamedChromaticPitch('ff')
True
```

26.6 Comparing pitches

Compare named chromatic pitches to each other:

```
abjad> named_chromatic_pitch_1 = pitchtools.NamedChromaticPitch("c'")
abjad> named_chromatic_pitch_2 = pitchtools.NamedChromaticPitch("d'")
```

```
abjad> named_chromatic_pitch_1 == named_chromatic_pitch_2
False
```

```
abjad> named_chromatic_pitch_1 != named_chromatic_pitch_2
True
```

```
abjad> named_chromatic_pitch_1 > named_chromatic_pitch_2
False
```

```
abjad> named_chromatic_pitch_1 < named_chromatic_pitch_2
True
```

```
abjad> named_chromatic_pitch_1 >= named_chromatic_pitch_2
False
```

```
abjad> named_chromatic_pitch_1 <= named_chromatic_pitch_2
True
```

26.7 Converting one type of pitch to another

Convert any named chromatic pitch to a named diatonic pitch:

```
abjad> named_chromatic_pitch.named_diatonic_pitch
NamedDiatonicPitch("c'")
```

To a numbered chromatic pitch:

```
abjad> named_chromatic_pitch.numbered_chromatic_pitch
NumberedChromaticPitch(13)
```

Or to a numbered diatonic pitch:

```
abjad> named_chromatic_pitch.numbered_diatonic_pitch
NumberedDiatonicPitch(7)
```

26.8 Converting pitches to pitch-classes

Convert any named chromatic pitch to a named chromatic pitch-class:

```
abjad> named_chromatic_pitch.named_chromatic_pitch_class
NamedChromaticPitchClass('cs')
```

To a named diatonic pitch-class:

```
abjad> named_chromatic_pitch.named_diatonic_pitch_class
NamedDiatonicPitchClass('c')
```

To a numbered chromatic pitch-class:

```
abjad> named_chromatic_pitch.numbered_chromatic_pitch_class
NumberedChromaticPitchClass(1)
```

Or to a numbered diatonic pitch-class:

```
abjad> named_chromatic_pitch.numbered_diatonic_pitch_class
NumberedDiatonicPitchClass(0)
```

26.9 Copying pitches

Use `copy.copy()` to copy named chromatic pitches:

```
abjad> import copy

abjad> copy.copy(named_chromatic_pitch)
NamedChromaticPitch("cs'")
```

Or use `copy.deepcopy()` to do the same thing.

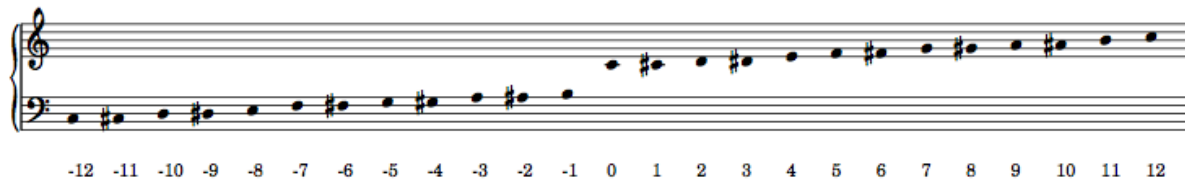
26.10 Accidental abbreviations

Abjad abbreviates accidentals according to the LilyPond `english.ly` module:

accidental name	abbreviation
quarter sharp	‘qs’
quarter flat	‘qf’
sharp	‘s’
flat	‘f’
three-quarters sharp	‘tqs’
three-quarters flat	‘tqf’
double sharp	‘ss’
double flat	‘ff’

26.11 Chromatic pitch numbers

Abjad numbers chromatic pitches by semitone with middle C set equal to 0:



The code to generate this table is as follows:

```
score, treble_staff, bass_staff = scoretools.make_empty_piano_score()
duration = Fraction(1, 32)

treble = measuretools.AnonymousMeasure([])
bass = measuretools.AnonymousMeasure([])

treble_staff.append(treble)
bass_staff.append(bass)

pitches = range(-12, 12 + 1)

configurationtools.set_default_accidental_spelling('sharps')

for i in pitches:
    note = Note(i, duration)
    rest = Rest(duration)
    clef = pitchtools.suggest_clef_for_named_chromatic_pitches([note.pitch])
    if clef == contexttools.ClefMark('treble'):
        treble.append(note)
        bass.append(rest)
    else:
        treble.append(rest)
        bass.append(note)
    diatonic_pitch_number = str(note.pitch.numbered_chromatic_pitch)
    markuptools.Markup(diatonic_pitch_number, 'down')(bass[-1])

score.override.rest.transparent = True
score.override.stem.stencil = False
```



```
show(score, 'paris.ly')
```

26.12 Diatonic pitch numbers

Abjad numbers diatonic pitches by staff space with middle C set equal to 0:



The code to generate this table is as follows:

```
score, treble_staff, bass_staff = scoretools.make_empty_piano_score()
duration = Fraction(1, 32)

treble = measuretools.AnonymousMeasure([])
bass = measuretools.AnonymousMeasure([])

treble_staff.append(treble)
bass_staff.append(bass)

pitches = []
diatonic_pitches = [0, 2, 4, 5, 7, 9, 11]

pitches.extend([-24 + x for x in diatonic_pitches])
pitches.extend([-12 + x for x in diatonic_pitches])
pitches.extend([0 + x for x in diatonic_pitches])
pitches.extend([12 + x for x in diatonic_pitches])
pitches.append(24)
configurationtools.set_default_accidental_spelling('sharps')

for i in pitches:
    note = Note(i, duration)
    rest = Rest(duration)
    clef = pitchtools.suggest_clef_for_named_chromatic_pitches([note.pitch])
    if clef == contexttools.ClefMark('treble'):
        treble.append(note)
        bass.append(rest)
    else:
        treble.append(rest)
        bass.append(note)
    diatonic_pitch_number = abs(note.pitch.numbered_diatonic_pitch)
    markuptools.Markup(diatonic_pitch_number, 'down')(bass[-1])

score.override.rest.transparent = True
score.override.stem.stencil = False

show(score, 'paris.ly')
```

26.13 Octave designation

Abjad designates octaves with both numbers and ticks:

Octave notation	Tick notation
C7	c'','',''
C6	c'','','
C5	c'',''
C4	c''
C3	c'
C2	c,
C1	c,,

26.14 Accidental spelling

Abjad chooses between enharmonic spellings at pitch-initialization according to the following table:

Chromatic pitch-class number	Chromatic pitch-class name (default)
0	C
1	C#
2	D
3	Eb
4	E
5	F
6	F#
7	G
8	Gb
9	A
10	Bb
11	B

```
abjad> staff = Staff([Note(n, (1, 8)) for n in range(12)])
abjad> show(staff)
```



Use pitch tools to respell with sharps:

```
abjad> pitchtools.respell_named_chromatic_pitches_in_expr_with_sharps(staff)
abjad> show(staff)
```



Or flats:

```
abjad> pitchtools.respell_named_chromatic_pitches_in_expr_with_flats(staff)
abjad> show(staff)
```



WORKING WITH LISTS OF NUMBERS

Python provides a built-in `list` class that you can use to carry around almost anything. The examples here show how to create a list of numbers and then do things with the numbers in the list.

Create a list with square brackets.

```
abjad> my_list = [23, 7, 10, 18, 13, 20, 3, 2, 18, 9, 14, 3]
abjad> my_list
[23, 7, 10, 18, 13, 20, 3, 2, 18, 9, 14, 3]
```

Use `len()` to find the number of elements in any list.

```
abjad> len(my_list)
12
```

Use `append()` to add one element to a list.

```
abjad> my_list.append(5)
abjad> my_list
[23, 7, 10, 18, 13, 20, 3, 2, 18, 9, 14, 3, 5]
```

Use `extend()` to extend one list with the contents of another.

```
abjad> my_other_list = [19, 11, 4, 10, 12]
abjad> my_list.extend(my_other_list)
abjad> my_list
[23, 7, 10, 18, 13, 20, 3, 2, 18, 9, 14, 3, 5, 19, 11, 4, 10, 12]
```

Use `reverse()` to reverse the elements in a list.

```
abjad> my_list.reverse()
abjad> my_list
[12, 10, 4, 11, 19, 5, 3, 14, 9, 18, 2, 3, 20, 13, 18, 10, 7, 23]
```

You can return a single value from a list with a numeric index.

```
abjad> my_list[0]
12
abjad> my_list[1]
10
abjad> my_list[2]
4
```

You can return many values from a list with slice notation.

```
abjad> my_list[:4]
[12, 10, 4, 11]
```

More information on these and all other operations defined on the built-in Python `list` is available in the [Python tutorial](#).

RESTS

28.1 Making rests from strings

You can make rests from a string:

```
abjad> rest = Rest('r8')
```

```
abjad> show(rest)
```



28.2 Making rests from durations

You can also make rests from a duration:

```
abjad> rest = Rest(Duration(1, 4))
```

```
abjad> show(rest)
```



(You can even use `Rest((1, 8))` to make rests from a duration pair.)

28.3 Getting the duration attributes of rests

Get the written duration of rests like this:

```
abjad> rest.written_duration  
Duration(1, 4)
```

Which is usually the same as preprolated duration:

```
abjad> rest.preprolated_duration  
Duration(1, 4)
```

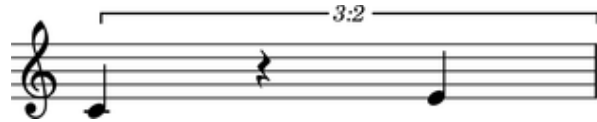
And prolated duration:

```
abjad> rest.prolated_duration
Duration(1, 4)
```

Except for rests inside a tuplet:

```
abjad> tuplet = Tuplet(Fraction(2, 3), [Note("c'4"), Rest('r4'), Note("e'4")])
```

```
abjad> show(tuplet)
```



```
abjad> rest = tuplet[1]
```

Tupletted rests carry written duration:

```
abjad> rest.written_duration
Duration(1, 4)
```

Prolation:

```
abjad> rest.prolation
Fraction(2, 3)
```

And prolated duration that is the product of the two:

```
abjad> rest.prolated_duration
Duration(1, 6)
```

28.4 Changing the written duration of rests

You can change the written duration of notes and rests:

```
abjad> tuplet[0].written_duration = Duration(1, 8)
abjad> tuplet[1].written_duration = Duration(1, 8)
abjad> tuplet[2].written_duration = Duration(1, 8)
```

```
abjad> show(tuplet)
```



Other duration attributes are read-only.

SCORES

29.1 Creating scores

Create a score like this:

```
abjad> treble_staff_1 = Staff("e'4 d'4 e'4 f'4 g'1")
abjad> treble_staff_2 = Staff("c'2. b8 a8 b1")

abjad> score = Score([treble_staff_1, treble_staff_2])

abjad> show(score)
```



29.2 Inspecting score music

Return score components with `music`:

```
abjad> score.music
(Staff{5}, Staff{4})
```

29.3 Inspecting score length

Get score length with `len()`:

```
abjad> len(score)
2
```

29.4 Inspecting score duration

Score contents duration is equal to the duration of the longest component in score:

```
abjad> score.contents_duration
Duration(2, 1)
```

29.5 Adding one component to the bottom of a score

Add one component to the bottom of a score with `append`:

```
abjad> bass_staff = Staff("g4 f4 e4 d4 d1")
abjad> contexttools.ClefMark('bass')(bass_staff)
```

```
abjad> score.append(bass_staff)
```

```
abjad> show(score)
```



29.6 Finding the index of a score component

Find the index of a score component with `index`:

```
abjad> score.index(treble_staff_1)
0
```

29.7 Removing a score component by index

Use `pop` to remove a score component by index:

```
abjad> score.pop(1)
```

```
abjad> show(score)
```



29.8 Removing a score component by reference

Remove a score component by reference with `remove`:

```
abjad> score.remove(treble_staff_1)
```

```
abjad> show(score)
```



29.9 Testing score containment

Use `in` to find out whether a score contains a given component:

```
abjad> treble_staff_1 in score
False
```

```
abjad> treble_staff_2 in score
False
```

```
abjad> bass_staff in score
True
```

29.10 Naming scores

You can name Abjad scores:

```
abjad> score.name = 'Example Score'
```

Score names appear in LilyPond input:

```
abjad> f(score)
\context Score = "Example Score" <<
  \new Staff {
    \clef "bass"
    g4
    f4
    e4
    d4
    d1
  }
>>
```

But do not appear in notational output:

```
abjad> show(score)
```



SPANNERS

30.1 Overriding spanners

The symbols below are black with fixed thickness and predetermined spacing:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4 g'4 a'4 g'2")
abjad> slur_1 = spannertools.SlurSpanner(staff[:2])
abjad> slur_2 = spannertools.SlurSpanner(staff[2:4])
abjad> slur_3 = spannertools.SlurSpanner(staff[4:6])
```

```
abjad> f(staff)
\new Staff {
    c'4 (
    d'4 )
    e'4 (
    f'4 )
    g'4 (
    a'4 )
    g'2
}
```

```
abjad> show(staff)
```



But you can override LilyPond grobs to change the look of spanners:

```
abjad> slur_1.override.slur.color = 'red'
abjad> slur_3.override.slur.color = 'red'
```

```
abjad> f(staff)
\new Staff {
    \override Slur #'color = #red
    c'4 (
    d'4 )
    \revert Slur #'color
    e'4 (
    f'4 )
    \override Slur #'color = #red
    g'4 (
    a'4 )
}
```

```
\revert Slur #'color
g'2
}
```

```
abjad> show(staff)
```



30.2 Overriding the components to which spanners attach

You can override LilyPond grobs to change spanners' contents:

```
abjad> slur_2.override.slur.color = 'blue'
abjad> slur_2.override.note_head.color = 'blue'
abjad> slur_2.override.stem.color = 'blue'
```

```
abjad> f(staff)
\new Staff {
  \override Slur #'color = #red
  c'4 (
  d'4 )
  \revert Slur #'color
  \override NoteHead #'color = #blue
  \override Slur #'color = #blue
  \override Stem #'color = #blue
  e'4 (
  f'4 )
  \revert NoteHead #'color
  \revert Slur #'color
  \revert Stem #'color
  \override Slur #'color = #red
  g'4 (
  a'4 )
  \revert Slur #'color
  g'2
}
```

```
abjad> show(staff)
```



30.3 Removing spanner overrides

Delete grob overrides you no longer want:

```
abjad> del(slur_1.override.slur)
abjad> del(slur_3.override.slur)
```

```
abjad> f(staff)
\new Staff {
    c'4 (
    d'4 )
    \override NoteHead #'color = #blue
    \override Slur #'color = #blue
    \override Stem #'color = #blue
    e'4 (
    f'4 )
    \revert NoteHead #'color
    \revert Slur #'color
    \revert Stem #'color
    g'4 (
    a'4 )
    g'2
}
```

```
abjad> show(staff)
```



STAVES

31.1 Creating staves

Create staves like this:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'4 c''1")
```

```
abjad> show(staff)
```



31.2 Inspecting staff music

Return staff components with `music`:

```
abjad> staff.music  
(Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8"), Note("g'8"), Note("a'8"), Note("b'4"), Note("c''1"))
```

31.3 Inspecting staff length

Get staff length with `len()`:

```
abjad> len(staff)  
8
```

31.4 Inspecting staff duration

Staff contents durations equals the sum of staff components' duration:

```
abjad> staff.contents_duration  
Duration(2, 1)
```

31.5 Adding one component to the end of a staff

Add one component to the end of a staff with `append`:

```
abjad> staff.append(Note("d' '2"))
```

```
abjad> show(staff)
```



31.6 Adding many components to the end of a staff

Add many components to the end of a staff with `extend`:

```
abjad> notes = [Note("e' '8"), Note("d' '8"), Note("c' '4")]
```

```
abjad> staff.extend(notes)
```

```
abjad> show(staff)
```



31.7 Finding the index of a staff component

Find staff component index with `index`:

```
abjad> notes[0]  
Note("e' '8")
```

```
abjad> staff.index(notes[0])  
9
```

31.8 Removing a staff component by index

Use `pop` to remove a staff component by index:

```
abjad> staff[8]  
Note("d' '2")
```

```
abjad> staff.pop(8)
```

```
abjad> show(staff)
```




```
abjad> staff.context
'CustomUserStaff'

abjad> f(staff)
\context CustomUserStaff = "Example Staff" {
    c' 8
    d' 8
    e' 8
    f' 8
    g' 8
    a' 8
    b' 4
    c'' 1
    e'' 8
    d'' 8
}
```

Force context when you have defined a new LilyPond context.

TUPLETS

32.1 Making a tuplet from a LilyPond input string

You can make an Abjad tuplet from a multiplier and a LilyPond input string:

```
abjad> tuplet = Tuplet(Fraction(2, 3), "c'8 d'8 e'8")
```

```
abjad> show(tuplet)
```



32.2 Making a tuplet from a list of other Abjad components

You can also make a tuplet from a multiplier and a list of other Abjad components:

```
abjad> leaves = [Note("fs'8"), Note("g'8"), Rest('r8')]
```

```
abjad> tuplet = Tuplet(Fraction(2, 3), leaves)
```

```
abjad> show(tuplet)
```



32.3 Understanding the interpreter display of a tuplet

The interpreter display of an Abjad tuplet contains three parts:

```
abjad> tuplet
Tuplet(2/3, [fs'8, g'8, r8])
```

`Tuplet` tells you the tuplet's class.

`2/3` tells you the tuplet's multiplier.

The list `[fs'8, g'8, r8]` shows the top-level components the tuplet contains.

32.4 Understanding the string representation of a tuplet

The string representation of a tuplet contains four parts:

```
abjad> print tuplet
{* 3:2 fs'8, g'8, r8 *}
```

Curly braces { and } indicate that the tuplet's music is interpreted sequentially instead of in parallel.

The asterisks * denote a fixed-multiplier tuplet.

3 : 2 tells you the tuplet's ratio.

The remaining arguments show the top-level components of tuplet.

32.5 Inspecting the LilyPond format of a tuplet

Get the LilyPond input format of any Abjad object with `format`:

```
abjad> tuplet.format
"\times 2/3 {\n\tfs'8\n\tg'8\n\tr8\n}"
```

Use `f()` as a short-cut to print the LilyPond format of any Abjad object:

```
abjad> f(tuplet)
\times 2/3 {
    fs'8
    g'8
    r8
}
```

32.6 Inspecting the music in a tuplet

Get the music in any Abjad container with `music`:

```
abjad> tuplet.music
(Note("fs'8"), Note("g'8"), Rest('r8'))
```

Abjad returns a read-only tuple of components.

32.7 Inspecting a tuplet's leaves

Get the leaves in any Abjad container with `leaves`:

```
abjad> tuplet.leaves
(Note("fs'8"), Note("g'8"), Rest('r8'))
```

Abjad returns a read-only tuple of leaves.

32.8 Getting the length of a tuplet

Get the length of any Abjad container with `len()`:

```
abjad> len(tuplet)
3
```

The length of every Abjad container is defined equal to the number of top-level components present in the container.

32.9 Getting the duration attributes of a tuplet

You set the multiplier of a tuplet at initialization:

```
abjad> tuplet.multiplier
Fraction(2, 3)
```

The contents durations of a tuplet equals the sum of written durations of the components in the tuplet:

```
abjad> tuplet.contents_duration
Duration(3, 8)
```

The multiplied duration of a tuplet equals the product of the tuplet's multiplier and the tuplet's contents duration:

```
abjad> tuplet.multiplied_duration
Duration(1, 4)
```

32.10 Understanding rhythmic augmentation and diminution

A tuplet with a multiplier less than 1 constitutes a type of rhythmic diminution:

```
abjad> tuplet.multiplier
Fraction(2, 3)

abjad> tuplet.is_diminution
True
```

A tuplet with a multiplier greater than 1 is a type of rhythmic augmentation:

```
abjad> tuplet.is_augmentation
False
```

32.11 Understanding binary and nonbinary tuplets

A tuplet is considered binary if the numerator of the tuplet multiplier is an integer power of 2:

```
abjad> tuplet.multiplier
Fraction(2, 3)

abjad> tuplet.is_binary
True
```

Other tuplets are nonbinary:

```
abjad> tuplet.is_nonbinary
False
```

32.12 Adding one component to the end of a tuplet

Add one component to the end of a tuplet with `append`:

```
abjad> tuplet.append(Note("e'4."))
```

```
abjad> show(tuplet)
```



32.13 Adding many components to the end of a tuplet

Add many components to the end of a tuplet with `extend`:

```
abjad> notes = [Note("fs'8"), Note("e'8"), Note("d'8"), Note("c'4.")]
abjad> tuplet.extend(notes)
```

```
abjad> show(tuplet)
```



32.14 Finding the index of a component in a tuplet

Find the index of a component in a tuplet with `index()`:

```
abjad> notes[1]
Note("e'8")
```

```
abjad> tuplet.index(notes[1])
5
```

32.15 Removing a tuplet component by index

Use `pop()` to remove a tuplet component by index:

```
abjad> tuplet[7]
Note("c'4.")
```

```
abjad> tuplet.pop(7)
```

```
abjad> show(tuplet)
```




32.16 Removing a tuplet component by reference

Remove tuplet components by reference with `remove()`:

```
abjad> tuplet.remove(tuplet[3])
```

```
abjad> show(tuplet)
```



32.17 Overriding attributes of the LilyPond tuplet number grob

Override attributes of the LilyPond tuplet number grob like this:

```
abjad> tuplet.override.tuplet_number.text = schemetools.SchemeFunction('tuplet-number::calc-fraction-
abjad> tuplet.override.tuplet_number.color = 'red'
```

```
abjad> f(tuplet)
\override TupletNumber #'color = #red
\override TupletNumber #'text = #tuplet-number::calc-fraction-text
\times 2/3 {
  fs'8
  g'8
  r8
  fs'8 [
  e'8
  d'8 ]
}
\revert TupletNumber #'color
\revert TupletNumber #'text
```

```
abjad> show(tuplet)
```



See the LilyPond docs for lists of grob attributes available.

32.18 Overriding attributes of the LilyPond tuplet bracket grob

Override attributes of the LilyPond tuplet bracket grob like this:

```
abjad> tuplet.override.tuplet_bracket.color = 'red'
```

```
abjad> f(tuplet)
\override TupletBracket #'color = #red
\override TupletNumber #'color = #red
\override TupletNumber #'text = #tuplet-number::calc-fraction-text
\times 2/3 {
    fs'8
    g'8
    r8
    fs'8 [
    e'8
    d'8 ]
}
\revert TupletBracket #'color
\revert TupletNumber #'color
\revert TupletNumber #'text
```

```
abjad> show(tuplet)
```



See the LilyPond docs for lists of grob attributes available.

VOICES

33.1 Making a voice from a LilyPond input string

You can make an Abjad voice from a LilyPond input string:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8 g'8 a'8 b'4 c''1")
```

```
abjad> show(voice)
```



33.2 Making a voice from a list of other Abjad components

You can also make a voice from a list of other Abjad components:

```
abjad> components = [Tuplet(Fraction(2, 3), "c'4 d'4 e'4"), Note("f'2"), Note("g'1")]
```

```
abjad> voice = Voice(components)
```

```
abjad> show(voice)
```



33.3 Understanding the repr of a voice

The repr of an Abjad voice contains three parts:

```
abjad> voice
Voice{3}
```

Voice tells you the voice's class.

3 tells you the voice's length (which is the number of top-level components the voice contains).

Curly braces { and } tell you that the music inside the voice is interpreted sequentially rather than in parallel.

33.4 Inspecting the LilyPond format of a voice

Get the LilyPond input format of any Abjad object with `format`:

```
abjad> voice.format
"\new Voice {\n\t\times 2/3 {\n\t\t\tc'4\n\t\t\td'4\n\t\t\te'4\n\t\t}\n\t\tf'2\n\t\tg'1\n}"
```

Use `f()` as a short-cut to print the LilyPond format of any Abjad object:

```
abjad> f(voice)
\nnew Voice {
  \times 2/3 {
    c'4
    d'4
    e'4
  }
  f'2
  g'1
}
```

33.5 Inspecting the music in a voice

Get voice components with `music`:

```
abjad> voice.music
(Tuplet(2/3, [c'4, d'4, e'4]), Note("f'2"), Note("g'1"))
```

Abjad returns a read-only tuple of components.

33.6 Inspecting a voice's leaves

Get the leaves in a voice with `leaves`:

```
abjad> voice.leaves
(Note("c'4"), Note("d'4"), Note("e'4"), Note("f'2"), Note("g'1"))
```

Abjad returns a read-only tuple of leaves.

33.7 Getting the length of a voice

Get voice length with `len()`:

```
abjad> len(voice)
3
```

The length of a voice is defined equal to the number of top-level components the voice contains.

33.8 Getting the duration attributes of a voice

The contents durations of a voice equals the sum of durations of the components in the voice:

```
abjad> voice.contents_duration
Duration(2, 1)
```

The preprolated duration of a voice is usually equal to the voice's contents duration:

```
abjad> voice.preprolated_duration
Duration(2, 1)
```

The prolated duration of a voice is usually equal to the voice's contents duration, too:

```
abjad> voice.preprolated_duration
Duration(2, 1)
```

Only when you nest a very small voice inside a tuplet will the prolated and preprolated duration of a voice differ.

Voices that are not nested inside a tuplet carry a prolation of 1:

```
abjad> voice.prolation
Fraction(1, 1)
```

All voice duration attributes are read-only.

33.9 Adding one component to the end of a voice

Add one component to the end of a voice with `append`:

```
abjad> voice.append(Note("af' 2"))

abjad> show(voice)
```



33.10 Adding many components to the end of a voice

Add many components to the end of a voice with `extend`:

```
abjad> notes = [Note("g' 4"), Note("f' 4")]
abjad> voice.extend(notes)

abjad> show(voice)
```



33.11 Finding the index of a component in a voice

Find the index of a component in a voice with `index()`:

```
abjad> notes[0]
Note("g' 4")
```

```
abjad> voice.index(notes[0])  
4
```

33.12 Removing a voice component by index

Use `pop()` to remove a voice component by index:

```
abjad> voice[5]  
Note("f'4")  
  
abjad> voice.pop(5)  
  
abjad> show(voice)
```



33.13 Removing a voice component by reference

Remove voice components by reference with `remove()`:

```
abjad> voice.remove(voice[-1])  
  
abjad> show(voice)
```



33.14 Naming voices

You can name Abjad voices:

```
abjad> voice.name = 'Upper Voice'
```

Voice names appear in LilyPond input:

```
abjad> f(voice)  
\context Voice = "Upper Voice" {  
  \times 2/3 {  
    c'4  
    d'4  
    e'4  
  }  
  f'2  
  g'1  
  af'2  
}
```

But not in notational output:

```
abjad> show(voice)
```



33.15 Changing the context of a voice

The context of a voice is set to 'Voice' by default:

```
abjad> voice.context
'Voice'
```

But you can change the context of a voice if you want:

```
abjad> voice.context = 'SpeciallyDefinedVoice'
```

```
abjad> voice.context
'SpeciallyDefinedVoice'
```

```
abjad> f(voice)
\context SpeciallyDefinedVoice = "Upper Voice" {
    \times 2/3 {
        c' 4
        d' 4
        e' 4
    }
    f' 2
    g' 1
    af' 2
}
```

Change the context of a voice when you have defined a new LilyPond context based on a LilyPond voice.

Developer documentation

CODEBASE

34.1 How the Abjad codebase is laid out

The Abjad codebase comprises twelve top-level directories.

```
abjad$ ls
__init__.py  cfg          core          docs          interfaces  scr          tools
book        checks      demos        exceptions   opt         templates
```

Of these, it is in the `tools` directory that the bulk of the musical reasoning implemented in Abjad resides.

```
abjad$ ls tools/
__init__.py      importtools      markuptools      quantizationtools  stafftools
configurationtools  instrumenttools  mathtools      resttools          tempotools
chordtools       intervaltretools  measuretools    schemetools        threadtools
componenttools   iotools          timesignaturetools  scoretools          tietools
containertools  layouttools      musicxmltools    sequencetools      tonalitytools
contexttools     leaftools        notetools        sievetools          tuplettools
durationtools    lilyfiletools    pitcharraytools  skiptools           verticalitytools
gracetools       marktools        pitchtools       spannertools        voicetools
```

The remaining sections of this chapter cover the topics necessary to familiarize developers coming to the project for the first time.

34.2 Removing prebuilt versions of Abjad before you check out

If you'd like to be at the cutting edge of the Abjad development then you should check out from Google Code and tell Python and your operating system about Abjad. You can do this by following the steps below.

But before you do this you should realize that there are two ways to get Abjad up and running on your computer. The first way is by downloading a compressed version of Abjad from the [Python Package Index](#). You probably did this when you first discovered Abjad and started to use the system. The second way is by following the steps below to check out a copy of the most recent version of the Abjad repository hosted on Google Code. If you already have a version of Abjad running on your computer but you haven't yet followed the steps below to check out from Google Code, then you probably downloaded a compressed version of Abjad from the Python Package Index.

Before you check out from Google Code you should remove all prebuilt versions of Abjad from your machine. The reason you need to do this is that having both a prebuilt version of Abjad and a Subversion-managed version of Abjad on your machine can confuse your operating system and lead to weird results when you try to start Abjad.

You remove prebuilt versions of Abjad resident on your computer by finding your site packages directory and removing the so-called Abjad 'egg' that Python has installed there. After you remove the Abjad egg from your site packages

directory you will also need to remove the `abj`, `abjad` and `abjad-book` scripts from `/usr/local/bin` or from the directory that is equivalent to `/usr/local/bin` under your operating system.

First note the version of Python you're currently running.

```
$ python --version
Python 2.6.1
```

This is important because you may have more than one version of Python installed on your machine. (Which tends especially to be the case if you're running a Apple's OS X.)

Then note that the site packages directory is a part of your filesystem into which Python installs third-party Python packages like Abjad. The location of the site packages directory varies from one operating system to the next and you may have to Google to find the exact location of the site packages directory on your machine. Under OS X you can check `/Library/Python/2.x/site-packages/`. Under Linux the site packages directory is usually `/usr/lib/python2.x/site-packages`.

Once you've found your site packages directory you can list its contents to see if Python has installed an Abjad egg in it.

```
site-packages$ ls
Abjad-2.0-py2.6.egg      Sphinx-1.0.7-py2.6.egg  py-1.3.4-py2.6.egg
Jinja2-2.5-py2.6.egg    docutils-0.7-py2.6.egg  py-1.4.0-py2.6.egg
Pygments-1.3.1-py2.6.egg easy-install.pth        py-1.4.4-py2.6.egg
README                  guppy                   pytest-2.0.0-py2.6.egg
Sphinx-1.0.1-py2.6.egg  guppy-0.1.9-py2.6.egg-info pytest-2.1.0-py2.6.egg
Sphinx-1.0.4-py2.6.egg  py-1.3.1-py2.6.egg
```

Remove any Abjad eggs Python has installed in your site packages directory.

After you've done this you should check `/usr/local/bin` or equivalent to see if the `abj`, `abjad` or `abjad-book` scripts are installed there.

```
bin$ ls
abj      abjad      abjad-book
```

Remove any of the three scripts you find installed there so that you can use the new versions of the scripts you will download from Google Code instead.

```
bin$ sudo rm abj*
```

Now proceed to the steps below to check out from Google Code.

34.3 Installing the development version

Follow the steps listed above to remove prebuilt versions of Abjad from your machine. Then follow the steps below to check out from Google Code.

1. Make sure Subversion is installed on your machine.

```
svn --version
```

If Subversion responds then it is already installed. Otherwise visit the [Subversion](#) website.

2. Check out a copy of the main line of the Abjad codebase.

```
svn checkout http://abjad.googlecode.com/svn/abjad/trunk abjad-trunk
```

3. Add the abjad trunk directory to your `PYTHONPATH` environment variable.

```
export PYTHONPATH="/path/to/abjad-trunk:$PYTHONPATH
```

4. Alternatively you may symlink your Python site packages directory to the abjad trunk directory.

```
ln -s /path/to/abjad-trunk /path/to/site-package/abjad
```

5. Finally, add `abjad-trunk/scr/` to your `PATH` environment variable.

```
export PATH="/path/to/abjad-trunk/scr:$PATH
```

You will then be able to run Abjad with the ```abjad``` command.

You now have a copy of the main line of the most recent version of the Abjad repository checked out to your machine.

DOCS

The reST-based sources for the Abjad documentation are included in their entirety in every installation of Abjad. You may add to and edit these reST-based sources as soon as you install Abjad. However, to build human-readable HTML or PDF versions of the docs you will first need to download and install Sphinx.

The remaining sections of this chapter describe how the Abjad docs are laid out and how to build the docs with Sphinx.

35.1 How the Abjad docs are laid out

The source files for the Abjad docs are included in the `docs` directory of every Abjad install. The `docs` directory contains everything required to build HTML, PDF and other versions of the Abjad docs.

```
abjad$ ls docs/
Makefile      _templates  chapters    index.rst   scr
_static       _themes     conf.py     make.bat
```

The bulk of the Abjad docs live in `docs/chapters`. The chapter directories mirror the main sections on Abjad documentation. What you'll find as you inspect the chapter directories are a collection of `.rst` files organized into groups. The `.rst` extension identifies files written in restructured text.

One example:

```
abjad$ ls docs/chapters/appendices/glossary
index.rst
```

35.2 Installing Sphinx

Sphinx is the automated documentation system used by Python, Abjad and [other projects](#) implemented in Python. Because Sphinx is not included in the Python standard library you will probably need to download and install it.

First check to see if Sphinx is already installed on your machine.

```
$ sphinx-build --version
```

If Sphinx responds then the program is already installed on your machine. Otherwise visit the [Sphinx](#) website.

35.3 Removing old builds of the docs

After installing Sphinx, change to the Abjad `docs` directory and use the Sphinx makefile to remove any existing `docs/_build` directory prior to making a new build of the docs.

```
abjad$ cd docs

docs$ make clean
rm -rf _build/*
```

35.4 Generating the Abjad API

The `docs/scr` directory includes a script to generate the Abjad API. Run this script before building the Abjad docs for the first time.

```
docs$ scr/make-abjad-api
Building TOC tree ...
Now making Sphinx TOC ...

... Done.

Now building the HTML docs ...

sphinx-build -b html -d _build/doctrees . _build/html
Running Sphinx v1.0.7
loading pickled environment... done

... (many lines omitted) ...

Build finished. The HTML pages are in _build/html.
```

Rerun `make-abjad-api` any time you add or remove a public class, method or function from the codebase.

35.5 Building the HTML docs

Change to the Abjad `docs` directory and run `make html`.

```
abjad$ cd docs

docs$ make html
sphinx-build -b html -d _build/doctrees . _build/html
Running Sphinx v1.0.7
loading pickled environment... not found
building [html]: targets for 568 source files that are out of date
updating environment: 568 added, 0 changed, 0 removed
reading sources... [ 13%] chapters/api/debug/debugghandlertoregators
reading sources... [ 37%] chapters/api/tools/clonewp/by_leaf_counts_with_parenta
reading sources... [ 38%] chapters/api/tools/clonewp/by_leaf_range_with_parentag
reading sources... [ 38%] chapters/api/tools/componenttools/get_duration_crosser
reading sources... [ 38%] chapters/api/tools/componenttools/get_duration_preprol
reading sources... [ 39%] chapters/api/tools/componenttools/get_le_duration_prol

... (many more lines omitted) ...
```

```
writing output... [ 85%] chapters/api/tools/spannertools/give_attached_to_childr
writing output... [ 95%] chapters/fundamentals/duration/interfaces_compared/inde
writing output... [100%] index /indexdexexexng/indexxxdexindex
writing additional files... genindex modindex search
copying images... done
copying static files... done
dumping search index... done
dumping object inventory... done
build succeeded.
```

Build finished. The HTML pages are in `_build/html`.

You will then find the complete HTML version of the docs in `docs/_build/html`.

```
docs$ ls _build/
doctrees html
```

The output from Sphinx is verbose the first time you build the docs. On sequent builds, Sphinx reports changes only.

```
docs$ make html
sphinx-build -b html -d _build/doctrees . _build/html
Running Sphinx v1.0.7
loading pickled environment... done
building [html]: targets for 1 source files that are out of date
updating environment: 0 added, 1 changed, 0 removed
reading sources... [100%] chapters/devel/documentation/index
looking for now-outdated files... none found
pickling environment... done
checking consistency... done
preparing documents... done
writing output... [100%] index ation/index
writing additional files... genindex modindex search
copying static files... done
dumping search index... done
dumping object inventory... done
build succeeded.
```

Build finished. The HTML pages are in `_build/html`.

35.6 Building a PDF of the docs

Building a PDF of the docs is a two-step process. First you build a LaTeX version of the docs. Then you typeset the LaTeX docs as a PDF.

First change to the Abjad docs directory.

```
abjad$ docs
```

Then make LaTeX sources of the docs.

```
docs$ make latex
sphinx-build -b latex -d _build/doctrees . _build/latex
Running Sphinx v1.0.7
loading pickled environment... done
building [latex]: all documents
updating environment: 0 added, 0 changed, 0 removed
looking for now-outdated files... none found
```

```
processing Abjad.tex... index chapters/start_here/abjad/index chapters/examples/bartok...
(... many lines omitted ...)
...ndices/pitch_conventions/images/example-3.png chapters/examples/ligeti/images/desordre.jpg
copying TeX support files... done
build succeeded.
```

Build finished; the LaTeX files are in `_build/latex`.
Run `'make all-pdf'` or `'make all-ps'` in that directory to run these through `(pdf)latex`.

Now follow the instructions provided by Sphinx and change to the LaTeX build directory.

```
docs$ cd _build/latex/
```

Then make a PDF version of the docs from the LaTeX sources.

```
latex$ make all-pdf

pdflatex 'Abjad.tex'
This is pdfTeXk, Version 3.141592-1.40.3 (Web2C 7.5.6)
  %&-line parsing enabled.
entering extended mode
(./Abjad.tex
LaTeX2e <2005/12/01>
Babel <v3.8h> and hyphenation patterns for english, usenglishmax, dumylang, noh
ypheation, arabic, basque, bulgarian, coptic, welsh, czech, slovak, german, ng
erman, danish, esperanto, spanish, catalan, galician, estonian, farsi, finnish,

(... many lines omitted ...)
```

The resulting docs will appear as `Abjad.pdf` in the LaTeX build directory you're currently in.

35.7 Building a coverage report

Change to the Abjad docs directory and call `sphinx-build` explicitly with the coverage builder, source directory and target directory.

```
docs$ sphinx-build -b coverage . _build/coverage
Making output directory...
Running Sphinx v1.0.7
loading pickled environment... not found
building [coverage]: coverage overview
updating environment: 568 added, 0 changed, 0 removed
reading sources... [ 37%] chapters/api/tools/clonewp/by_leaf_counts_with_parenta
reading sources... [ 38%] chapters/api/tools/clonewp/by_leaf_range_with_parentag
reading sources... [ 38%] chapters/api/tools/componenttools/get_duration_crosser

... (many lines omitted) ...

reading sources... [ 85%] chapters/api/tools/spannertools/withdraw_from_containe
reading sources... [ 95%] chapters/fundamentals/duration/interfaces_compared/ind
reading sources... [100%] index t/indexdexexexng/indexxxdexindex
looking for now-outdated files... none found
pickling environment... done
checking consistency... done
build succeeded.
```


The coverage report is now available in the `docs/_build/coverage` directory.

```
docs$ ls _build/
coverage doctrees html
```

35.8 Building other versions of the docs

Examine the Sphinx makefile in the Abjad `docs/` directory or change to the `docs/` directory and type `make` with no arguments to see a list of the other versions of the Abjad docs that are available to build.

```
docs$ make
Please use 'make <target>' where <target> is one of
  html          to make standalone HTML files
  dirhtml       to make HTML files named index.html in directories
  pickle        to make pickle files
  json          to make JSON files
  htmlhelp      to make HTML files and a HTML help project
  qthelp        to make HTML files and a qthelp project
  latex         to make LaTeX files, you can set PAPER=a4 or PAPER=letter
  changes       to make an overview of all changed/added/deprecated items
  linkcheck     to check all external links for integrity
  doctest       to run all doctests embedded in the documentation (if enabled)
```

35.9 Inserting images with `abjad-book`

Use *abjad-book* to insert snippets of notation in the docs you write in reST.

Embed Abjad code between open and close `<abjad>` `</abjad>` tags in your `.rst.raw` sourcefile and then call `abjad-book` to create a pure `.rst` file.

```
abjad-book foo.rst.raw foo.rst
```

```
Parsing file ...
Rendering "example-1.ly" ...
Rendering "example-2.ly" ...
```

You will need to build the HTML docs again to see your work.

```
make html
```

35.10 Updating Sphinx

It is important periodically to update your version of Sphinx. If you used `easy_install` to install Sphinx then the usual command to update Sphinx is this:

```
$ sudo easy_install -U Sphinx
```

This will usually work. But if Sphinx fails to update then it may be because you have multiple versions of Python installed on your computer. (This tends especially to be the case under Apple's OS X.)

To get around this first note the version of Python you're currently running:

```
$ python --version  
Python 2.6.1
```

Then use a version-explicit form of `easy_install` to update Sphinx:

```
$ sudo easy_install-2.6 -U Sphinx
```

TESTS

Abjad includes an extensive battery of tests. Abjad is in a state of rapid development and extension. Major refactoring efforts are common every six to eight months and are likely to remain so for several years. And yet Abjad continues to allow the creation of complex pieces of fully notated score in the midst of these changes. We believe this is due to the extensive coverage provided by the automated regression battery described in the following sections.

36.1 Automated regression?

A battery is any collection of tests. Regression tests differ from other types of test in that they are designed to be run again and again during many different stages of the development process. Regression tests help ensure that the system continues to function correctly as developers make changes to it. An automated regression battery is one that can be run automatically by some sort of driver with minimal manual intervention.

Several different test drivers are now in use in the Python community. Abjad uses `py.test`. The `py.test` distribution is not included in the Python standard library, so one of the first thing new contributors to Abjad should do is download and install `py.test`, and then run the existing battery.

36.2 Running the battery

Change to the directory where you have Abjad installed. Then run `py.test`.

```
abjad$ py.test
===== test session starts =====
platform darwin -- Python 2.6.1 -- pytest-2.1.0
collected 4235 items

core/LilyPondContextProxy/test/test_LilypondContextProxy__eq__.py .
core/LilyPondContextProxy/test/test_LilypondContextProxy__repr__.py .
core/LilyPondContextProxy/test/test_LilypondContextProxy__setattr__.py ..

... (many lines omitted) ...

tools/voicetools/test/test_voicetools_iterate_semantic_voices_forward_in_expr.py .
tools/voicetools/test/test_voicetools_iterate_voices_backward_in_expr.py .
tools/voicetools/test/test_voicetools_iterate_voices_forward_in_expr.py .

===== 4235 passed in 127.06 seconds =====
```

Abjad r4629 includes 4235 tests.

36.3 Reading test output

`py.test` crawls the entire directory structure from which you call it, running tests in alphabetical order. `py.test` prints the total number of tests per file in square brackets and prints test results as a single `.` dot for success or else an `F` for failure.

36.4 Writing tests

Project check-in standards ask that tests accompany all code committed to the Abjad repository. If you add a new function, class or method to Abjad, you should add a new test file for that function, class or method. If you fix or extend an existing function, class or method, you should find the existing test file that covers that code and then either add a completely new test to the test file or else update an existing test already present in the test file.

36.5 Test files start with `test_`

When `py.test` first starts up it crawls the entire directory structure from which you call it prior to running a single test. As `py.test` executes this preflight work, it looks for any files beginning or ending with the string `test` and then collects and alphabetizes these. Only after making such a catalog of tests does `py.test` begin execution. This collect-and-cache behavior leads to the important point about naming, below.

36.6 Avoiding name conflicts

Note that the names of **test functions** must be absolutely unique across the entire directory structure on which you call `py.test`. You must never share names between test functions. For example, you must not have two tests named `test_grob_handling_01()` **even if both tests live in different test files**. That is, a test named `test_grob_handling_01()` living in the file `test_accidental_grob_handling.py` and a second test named `test_grob_handling_01()` living in the file `test_notehead_grob_handling.py` will conflict with the each other when `py.test` runs. And, unfortunately, **“py.test is silent about such conflicts when it runs**. That is, should you run `py.test` with the duplicate naming situation described here, what will happen is that `py.test` will correctly run and report results for the **first** such test it finds. However, when `py.test` encounters the second like-named test, `py.test` will incorrectly report cached results for the **first** test rather than the second. The take-away is to include some sort of namespacing indicators in every test name and not to be afraid of long test names. The `test_grob_handling_01()` example given here fixes easily when the two tests rename to `test_accidental_grob_handling_01()` and `test_notehead_grob_handling_01()`.

36.7 Updating `py.test`

It is important periodically to update `py.test`.

The usual command to do this is:

```
$ sudo easy_install -U pytest
```

Note that `pytest` is here spelled without the intervening period.

36.8 Running doctest on the `tools` directory

The Python standard library includes the `doctest` module as way of checking the correctness of examples included in Python docstrings. The module searches for instances of the Python interpreter prompt `'>>>'` and executes any code that follows. Abjad docs display the Abjad prompt `'abjad>'` instead of the Python prompt. This means that all instances of the Abjad prompt must be changed to Python prompts before running `doctest` on the Abjad codebase. Three scripts in `abjad/scr/devel` help do this.

First change to the subdirectory of the Abjad source tree on which you'd like to run `doctest`. Then run these scripts:

```
replace-abjad-prompts-with-python-prompts
```

```
run-doctest-on-all-modules-in-tree
```

```
replace-python-prompts-with-abjad-prompts
```

After running `run-doctest-on-all-modules-in-tree` you can inspect the results that come back from `doctest` and make any fixes as required.

SCRIPTS

The `abjad/scr/devel` directory contains scripts for Abjad developers. Add `abjad/scr/devel` to your PATH to use the scripts described below.

```
abjad$ ls scr/devel
abj-grep
abj-grp
abj-rmpycs
abj-src-grp
abj-test-grp
abj-update
capitalize-test-file-names
conjoin-multiline-import-statements
count-source-lines
count-tools
duplicate-test-file
find-and-fix-manual-class-package-initializers
find-duplicate-module-names
find-duplicate-tool-module-names
find-import-as-statements
find-local-import-statements
find-lower-camel-case-definitions
find-lower-camel-case-modules
find-manual-class-loads-in-initializers
find-misnamed-private-modules
find-missing-test-modules
find-module-headers
find-modules-with-chevrons
find-multifunction-modules
find-multiline-import-statements
find-nonalphabetized-module-headers
find-nontrivial-subdirectories
find-public-helpers-without-docstrings
find-undocumented-tools
fix-nonalphabetized-module-headers
fix-test-case-block-comments
fix-test-case-names
fix-test-case-numbers
format-lilypond-context-names-with-underscores
list-private-modules
rebuild-docs
reindent-3-spaces-as-4
reindent-4-spaces-as-3
reindent-spaces-variably
remove-tmp-out-directories
rename-public-helper
replace-abjad-prompts-with-python-prompts
replace-in-files
replace-python-prompts-with-abjad-prompts
run-doctest-on-all-modules-in-tree
```

37.1 Searching the Abjad codebase with `abj-grep`

Abjad provides a wrapper around UNIX `grep` in the form of `abj-grep`. Use this script to recursively search the entire Abjad codebase, leaving out non-human-readable files, files located in special `.svn` Subversion subdirectories, and all files in the `abjad/documentation` directories. You can run `abj-grep` from any directory on your system; you needn't be in the Abjad source directories when you call `abj-grep`.

```
$ abj-grep 'is_assignable('
leaf/duration.py:111:         if not durationtools.is_assignable(rational):
tempo/indication.py:67:         assert durationtools.is_assignable(arg)
tools/check/are_scalable.py:12:         if not durationtools.is_assignable(candidate_duration):
tools/durationtools/is_assignable.py:5: def is_assignable(duration):
tools/durationtools/prolated_to_written.py:2: from abjad.tools.durationtools.is_assignable import is_a
```

```
tools/durationtools/prolated_to_written.py:15:     if is_assignable(prolated_duration):
tools/tietools/duration_change.py:28:     if durationtools.is_assignable(new_written_duration):
tools/tupletttools/contents_scale.py:30:     if durationtools.is_assignable(multiplier):
```

37.2 Removing old *.pyc files with `abj-rmpycs`

See the section on `abj-update` below for the reasons that it is a good idea to periodically remove the byte-compiled *.pyc files that Python generates for its own use behind the scenes. Abjad supplies `abj-rmpycs` to delete all the *.pyc in the Abjad codebase, leaving other *.pyc on your system untouched.

37.3 Updating your development copy of Abjad with `abj-update`

The normal way of updating your working copy of a Subversion repository is with the `svn update` or `svn up` command. You can update your working copy of Abjad in the usual way with `svn up`. But Abjad supplies an `abj-update` script as a wrapper around the usual Subversion update commands. In addition to updating your working copy of Abjad, `abj-update` populates the `abjad/.version` file with the most recent revision number of the system, and then removes all *.pyc files from your Abjad install. The benefits here are twofold. First, Abjad adds the most recent revision number of the system to all .ly files that you generate when working with Abjad. If you do not update the Abjad version file on a regular basis, the headers in your Abjad-generated .ly files will list the wrong version of the system. Second, as is the case in working with any substantial Python codebase, it is a good idea to periodically remove the byte-compiled *.pyc files that Python creates for its own use. The reason for this is inadvertant name aliasing. That is, if there was previously a module named `foo.py` somewhere in the system and if Python had at some point imported the module and created `foo.pyc` as a byproduct, this .pyc file will remain on the filesystem even if you later decide to remove, or rename, the source `foo.py` module. This lead to confusion because days or weeks after `foo.py` has been removed, Python will still find `foo.pyc` and seem to make the contents of `foo.py` available from beyond the grave. Updating with `abj-update` takes care of these two situations.

37.4 Counting lines of code with `count-source-lines`

Run `count-source-lines` for a count of lines of count divided between source and test files.

```
abjad$ count-source-lines

source_modules: 1703
test_modules:   1812

source_lines:   73942
test_lines:     76636

total lines:    150578
test-to-source ratio is 1 : 1
```

The script is directory-dependent so you can run it any the entire Abjad codebase or any subdirectory of the codebase.

37.5 Global search-and-replace with `replace-in-files`

You probably won't need to use `replace-in-files` very often. But if you are making changes to Abjad that will cause some name, such as `FooBar`, to be globally changed everywhere in the Abjad codebase to, say to `foo_bar`,

then you can use `replace-in-files` to save lots of time.

```
$ replace-in-files --help
```

Usage:

```
replace-in-files DIR OLD_TEXT NEW_TEXT [CONFIRM=true/false]
```

Crawl directory DIR and read every file in it recursively.
Replace OLD_TEXT with NEW_TEXT in each file.

Set CONFIRM to `'false'` to replace without prompting.

37.6 Adding new development scripts

If you write and then find yourself using a certain script over and over again when you're developing new code for Abjad, consider contributing back to the project so we can include your script in the next public release of Abjad. Scripts in the the Abjad script directories end with no file extension and try to be as OS-portable as possible, which usually means writing the script in Python, rather than your operating system's shell, and relying heavily on Python's `os` module.

USING ABJAD-BOOK

`abjad-book` is an independent application included in every installation of Abjad. `abjad-book` allows you to write Abjad code in the middle of documents written in HTML, LaTeX or ReST. We created `abjad-book` to help us document Abjad. Our work on `abjad-book` was inspired by `lilypond-book`, which does for LilyPond much what `abjad-book` does for Abjad.

38.1 HTML with embedded Abjad

To see `abjad-book` in action, open a file and write some HTML by hand. Add some Abjad code to your HTML between open and close `<abjad>` `</abjad>` tags.

```
<html>

<p>This is an <b>HTML</b> document.</p>

<p>The code is standard hypertext mark-up.</p>

<p>Here is some music notation generated automatically by Abjad:</p>

<abjad>
v = Voice(construct.scale(8))
Beam(v)
write_ly(v, 'abjad-book-1') <hide
show(v)
</abjad>

<p>And here is more ordinary <b>HTML</b>.</p>

</html>
```

Save your the file with the name `example.html.raw`. You now have an HTML file with embedded Abjad code.

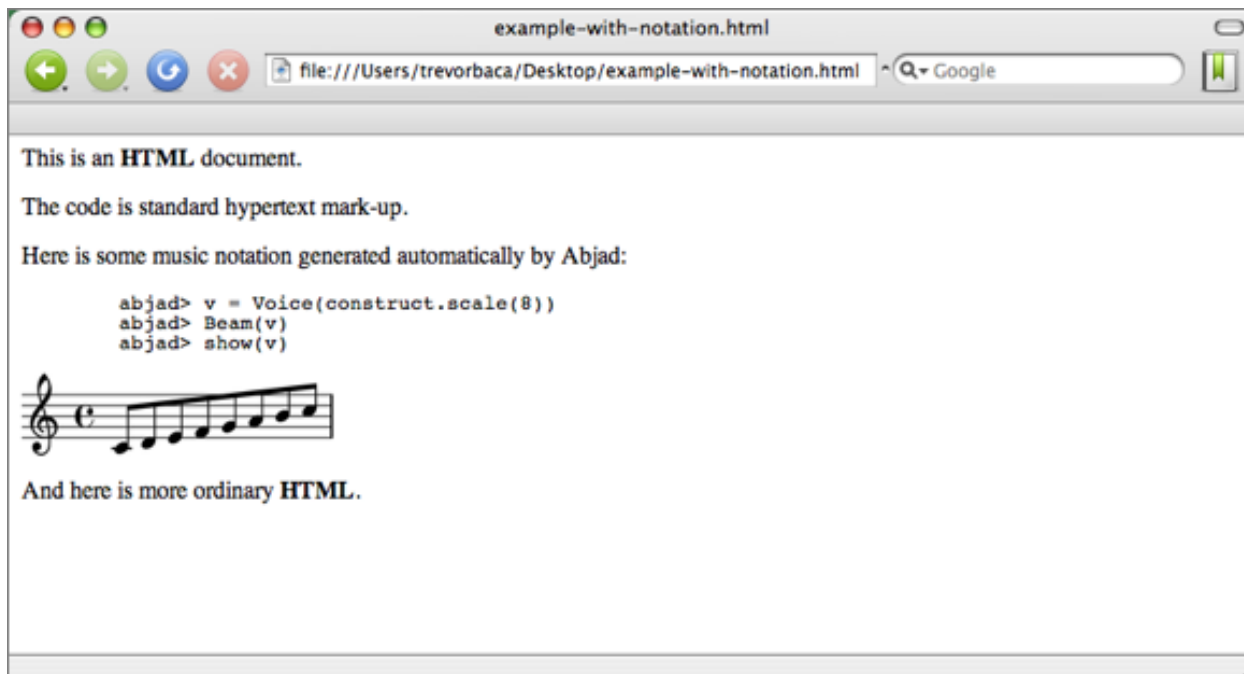
In the terminal, call `abjad-book` on `example.html.raw`.

```
$ abjad-book example.html.raw example.html
```

```
Parsing file...
Rendering "abjad-book-1.ly"...
```

The application opens `example.html.raw`, finds all Abjad code between `<abjad>` `</abjad>` tags, executes it, and then creates and inserts image files of music notation accordingly.

Open `example.html` with your browser.



That’s all there is to it. `abjad-book` lets you open a file and type HTML by hand with Abjad sandwiched between the special `<abjad>` `</abjad>` tags described here. Run `abjad-book` on such a hybrid file to create pure HTML with images of music notation created by Abjad.

Note: `abjad-book` makes use of ImageMagick’s `convert` application to crop and scale PNG images generated for HTML and ReST documents. For LaTeX documents, `abjad-book` uses `pdftocrop` for cropping PDFs.

38.2 LaTeX with embedded Abjad

You can use `abjad-book` to insert Abjad code and score excerpts into any LaTeX you create. Type the sample code below into a file.

```
\documentclass{article}
\usepackage{graphicx}
\usepackage{listings}
\begin{document}
```

This is a standard LaTeX document with embedded Abjad.

The code below creates an Abjad measure and then prints the measure format string.

```
<abjad>
measure = RigidMeasure((5, 8), construct.scale(5))
print measure.format
</abjad>
```

This next bit of code knows about the measure we defined earlier. This code renders the measure as a PDF using a template suitable for inclusion in LaTeX documents.

```
<abjad>
write_ly(measure, 'abjad-book-1', 'oedo') <hide
</abjad>
```

And this is the end of the our sample LaTeX document.

```
\end{document}
```

Save your file with the name `example.tex.raw`. You now have a LaTeX file with embedded Abjad code.

In the terminal, call `abjad-book` on `example.tex.raw`.

```
$ abjad-book example.tex.raw example.tex
```

```
Processing 'example.tex.raw'. Will write output to 'example.tex'...
Parsing file...
Rendering "abjad-book-1.ly"...
```

The application open `example.tex.raw`, finds all code between Abjad tags, executes it, and then creates and inserts Abjad interpreter output and PDF files of music notation. You can view the contents of the next LaTeX file `abjad-book` has created.

```
\documentclass{article}
\usepackage{graphicx}
\usepackage{listings}
\begin{document}
```

This is a standard LaTeX document with embedded Abjad.

The code below creates an Abjad measure and then prints the measure format string.

```
\begin{lstlisting}[basicstyle=\footnotesize, tabsize=4, showtabs=false, showspace=false]
  abjad> measure = RigidMeasure((5, 8), construct.scale(5))
  abjad> print measure.format
  {
    \time 5/8
    c'8
    d'8
    e'8
    f'8
    g'8
  }
\end{lstlisting}
```

This next bit of code knows about the measure we defined earlier. This code renders the measure as a PDF using a template suitable for inclusion in LaTeX documents.

```
\includegraphics{images/abjad-book-1.pdf}
```

And this is the end of the our sample LaTeX document.

```
\end{document}
```

You can now process the file `example.tex` just like any other LaTeX file, using `pdflatex` or `TexShop` or whatever LaTeX compilation program you normally use on your computer.

```
$ pdflatex example.tex
```

```
This is pdfTeX, Version 3.141592-1.40.3 (Web2C 7.5.6)
  %&-line parsing enabled.
entering extended mode
...
```

And then open the resulting PDF.

38.3 Using abjad-book on ReST documents

You can call `abjad-book` on ReST documents, too. Follow the examples given here for HTML and LaTeX documents and modify accordingly.

38.4 Using `[hide = True]`

You can add `[hide = True]` to any `abjad-book` example to show only music notation.

```
<abjad>[hide = True]
staff = Staff(construct.scale(8))
write_ly(staff, 'staff-example', 'oedo')
</abjad>
```

TIMING CODE

You can time code with Python's built-in `timeit` module:

```
from abjad import *
import timeit

timer = timeit.Timer('Note(0, (1, 4))', 'from __main__ import Note')
print timer.timeit(1000)

0.225436925888
```

These results show that 1000 notes take 0.23 seconds to create.

Other Python timing modules are available for download on the public Internet.

PROFILING CODE

Profile code with `profile_expr()` in the `iotools` package:

```
abjad> iotools.profile_expr('Note(0, (1, 4))')
Sun Aug 14 16:50:36 2011      _tmp_abj_profile

      327 function calls (312 primitive calls) in 0.001 CPU seconds

Ordered by: cumulative time
List reduced from 96 to 12 due to restriction <12>

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
      1   0.000    0.000    0.001    0.001 <string>:1(<module>)
      1   0.000    0.000    0.001    0.001 Note.py:18(__init__)
      1   0.000    0.000    0.001    0.001 Note.py:133(fset)
      1   0.000    0.000    0.001    0.001 NoteHead.py:18(__init__)
      1   0.000    0.000    0.001    0.001 NoteHead.py:121(fset)
      1   0.000    0.000    0.001    0.001 NamedChromaticPitch.py:28(__new__)
      1   0.000    0.000    0.000    0.000 _Leaf.py:18(__init__)
      1   0.000    0.000    0.000    0.000 chromatic_pitch_name_to_diatonic_pitch_numbe
      1   0.000    0.000    0.000    0.000 octave_tick_string_to_octave_number.py:4(oct
      1   0.000    0.000    0.000    0.000 re.py:134(match)
      1   0.000    0.000    0.000    0.000 re.py:227(_compile)
      1   0.000    0.000    0.000    0.000 sre_compile.py:501(compile)
```

These results show 327 function calls to create a note.

The `profile_expr()` function wraps the Python `cProfile` and `pstats` modules.

MEMORY CONSUMPTION

You can examine memory consumption with tools included in the `guppy` module:

```
from guppy import hpy
hp = hpy()
hp.setrelheap()
notes = [Note(0, (1, 4)) for x in range(1000)]
h = hp.heap()
print h
```

Partition of a set of 11024 objects. Total size = 586364 bytes.

Index	Count	%	Size	% Cumulative	% Kind (class / dict of class)
0	1000	9	124000	21	124000 21 abjad.tools.notetools.Note.Note.Note
1	1004	9	116464	20	240464 41 __builtin__.set
2	2003	18	76300	13	316764 54 list
3	1000	9	52000	9	368764 63 abjad.tools.pitchtools.NamedChromaticPitch.NamedChromaticPitch.NamedChromaticPitch
4	1000	9	44000	8	412764 70 abjad.interfaces._OffsetInterface._OffsetInterface._OffsetInterface
5	1000	9	44000	8	456764 78 abjad.tools.notetools.NoteHead.NoteHead.NoteHead
6	1000	9	40000	7	496764 85 0x23add0
7	1000	9	32000	5	528764 90 abjad.interfaces.ParentageInterface.ParentageInterface.ParentageInterface
8	1011	9	28568	5	557332 95 str
9	1000	9	28000	5	585332 100 abjad.interfaces._NavigationInterface._NavigationInterface._NavigationInterface

<6 more rows. Type e.g. `'_.more'` to view.>

These results show 586K for 1000 notes.

You must download `guppy` from the public Internet because the module is not included in the Python standard library.

CLASS ATTRIBUTES

Consider the definition of this class:

```
class FooWithInstanceAttribute(object):

    def __init__(self):
        self.constants = (
            'red', 'orange', 'yellow', 'green',
            'blue', 'indigo', 'violet',
        )
```

1000 objects consume 176k:

```
from guppy import hpy
hp = hpy()
hp.setrelheap()
objects = [FooWithInstanceAttribute() for x in range(1000)]
h = hp.heap()
print h
```

Partition of a set of 2004 objects. Total size = 176536 bytes.

Index	Count	%	Size	% Cumulative	% Kind (class / dict of class)
0	1000	50	140000	79	140000 79 dict of __main__.FooWithInstanceAttribute
1	1000	50	32000	18	172000 97 __main__.FooWithInstanceAttribute
2	1	0	4132	2	176132 100 list
3	1	0	348	0	176480 100 types.FrameType
4	1	0	44	0	176524 100 __builtin__.weakref
5	1	0	12	0	176536 100 int

But consider the definition of this class:

```
class FooWithSharedClassAttribute(object):

    def __init__(self):
        pass

    self.constants = (
        'red', 'orange', 'yellow', 'green',
        'blue', 'indigo', 'violet',
    )
```

1000 objects consume only 36k:

```
from guppy import hpy
hp = hpy()
hp.setrelheap()
```

```
objects = [FooWithClassAttribute() for x in range(1000)]
h = hp.heap()
print h
```

Partition of a set of 1004 objects. Total size = 36536 bytes.

Index	Count	%	Size	% Cumulative	% Kind (class / dict of class)
0	1000	100	32000	88	32000 88 __main__.FooWithClassAttribute
1	1	0	4132	11	36132 99 list
2	1	0	348	1	36480 100 types.FrameType
3	1	0	44	0	36524 100 __builtin__.weakref
4	1	0	12	0	36536 100 int

Objects that share class attributes between them can consume less memory than objects that don't. But consider the usual provisions between class attributes and instance attributes when implementing custom classes. Class attributes make sense when objects will never modify the attribute in question. Class attributes also make sense when objects will modify the attribute in question and will desire to change the attribute in question for all other like objects at the same time. Probably best to use instance attributes in most other cases.

USING SLOTS

Consider the definition of this class:

```
class Foo(object)

    def __init__(self, a, b, c):
        self.a = a
        self.b = b
        self.c = c
```

1000 objects consume 176k:

```
from guppy import hpy
hp = hpy()
hp.setrelheap()
objects = [Foo(1, 2, 3) for x in range(1000)]
h = hp.heap()
print h
```

Partition of a set of 2004 objects. Total size = 176536 bytes.

Index	Count	%	Size	% Cumulative	% Kind (class / dict of class)
0	1000	50	140000	79	140000 79 dict of __main__.FooWithInstanceAttribute
1	1000	50	32000	18	172000 97 __main__.FooWithInstanceAttribute
2	1	0	4132	2	176132 100 list
3	1	0	348	0	176480 100 types.FrameType
4	1	0	44	0	176524 100 __builtin__.weakref
5	1	0	12	0	176536 100 int

But consider the definition of this class:

```
class FooWithSlots(object):

    __slots__ = ('a', 'b', 'c')
    def __init__(self, a, b, c):
        self.a = a
        self.b = b
        self.c = c
```

1000 objects consume only 40k:

```
from guppy import hpy
hp = hpy()
hp.setrelheap()
objects = [FooWithSlots(1, 2, 3) for x in range(1000)]
h = hp.heap()
print h
```

Partition of a set of 1004 objects. Total size = 40536 bytes.

Index	Count	%	Size	% Cumulative	% Kind (class / dict of class)
0	1000	100	36000	89	36000 89 <code>__main__.Bar</code>
1	1	0	4132	10	40132 99 <code>list</code>
2	1	0	348	1	40480 100 <code>types.FrameType</code>
3	1	0	44	0	40524 100 <code>__builtin__.weakref</code>
4	1	0	12	0	40536 100 <code>int</code>

The example here confirms the Python Reference Manual 3.4.2.4: “By default, instances of both old and new-style classes have a dictionary for attribute storage. This wastes space for objects having very few instance variables. The space consumption can become acute when creating large numbers of instances.”

CODING STANDARDS

Indent with spaces, not with tabs. Use four spaces at a time:

```
def foo(x, y):  
    return x + y
```

Introduce comments with one pound sign and a single space:

```
# comment before foo  
def foo(x, y):  
    return x + y
```

Favor early imports at the head of each module. Only one `import` per line:

```
from foo import x  
from foo import y  
from foo import z
```

Include two blank lines after `import` statements before the rest of the module:

```
from foo import x  
from foo import y  
from foo import z
```

```
class Foo(object):  
    ...  
    ...
```

Wrap docstrings with triple apostrophes and align like this:

```
def foo(x, y):  
    '''This is the first line of the foo docstring.  
       This is the second line of the foo docstring.  
       And this is the last line of the foo docstring.  
    '''
```

Use paired apostrophes to delimit strings:

```
s = 'foo'
```

Use paired quotation marks to delimit strings within a string:

```
s = 'foo and "bar"'
```

Name classes in upper camelcase:

```
def FooBar(object):  
    ...  
    ...
```

Name bound methods in underscore-delimited lowercase:

```
def Foo(object):  
  
    def bar_blah(self):  
        ...  
  
    def bar_baz(self):  
        ...
```

Name module-level functions in underscore-delimited lowercase:

```
def foo_bar():  
    ...  
  
def foo_blah():  
    ...
```

Separate bound method definitions with a single empty line:

```
class FooBar(object):  
  
    def __init__(self, x, y):  
        ...  
  
    def bar_blah(self):  
        ...  
  
    def bar_baz(self):  
        ...
```

Organize the definitions of core classes into the five following major sections plus initialization:

```
class FooBar(object):  
  
    def __init__(self, x, y):  
        ...  
  
    ### OVERLOADS ###  
  
    def __repr__(self):  
        ...  
  
    def __str__(self):  
        ...  
  
    ### PRIVATE ATTRIBUTES ###  
  
    @property  
    def _foo(self):  
        ...  
  
    ### PUBLIC ATTRIBUTES ###  
  
    @property  
    def bar(self):
```

```
...

### PRIVATE METHODS ###

def _blah(self, x, y):
    ...

### PUBLIC METHODS ###

def baz(self, z):
    ...
```

Precede private class attributes with a single underscore:

```
class FooBar(object):

    ### PRIVATE ATTRIBUTES ###

    @property
    def _foo(self):
        ...

    ### PRIVATE METHODS ###

    def _blah(self, x, y):
        ...
```

Alphabetize method names.

Use < less-than signs in preference to greater-than signs:

```
if x < y < z:
    ...
```

Limit lines to 110 characters and use \ to break lines where necessary.

Eliminate trivial slice indices. Use `s[:4]` instead of `s[0:4]`.

Do not abbreviate variable names.

Name variables that represent a list or other collection of objects in the plural.

Implement only one class per module.

Implement only one function per module.

Author one `py.test` test file for every module-level function.

Author one `py.test` test file for every bound method in the public interface of a class.

Appendices

FROM TREVOR AND VÍCTOR

We are composers Trevor Bača and Víctor Adán, creators of Abjad, and our earliest collaborative work dates back to shared undergraduate years in Austin. It was the mid- to late-90s and we found ourselves interested in ways of building up ever larger sets of musical materials in our scores, with ever greater amounts of musical information.

Our work then began with pitch formalization, creating materials in C and then writing the results as MIDI to hear what we'd created. Turns out that this is a fairly common gateway into materials generation for many composers, and so it was for us. Probably this was, and is, due to the ever present availability of MIDI and, to a lesser extent, CSound. But even back then it was clear to us to finding ways to embody other aspects of the musical score – from nested rhythms to the different approaches to the musical measure to the arbitrarily complex structures possible with overlapping musical voices – would require a wholly different level of consideration, and different development techniques as well.

As an example, consider flat lists of floating-point values. This basic data structure, together with the constant need some type of quantification or rounding, feeds much of most composers' work with CSound, pd and the like. It is a good thing, therefore, that essentially all modern programming languages include tools for manipulating flat lists of floats out of the box, or in the standard library. But what happens when you want to think of pitch as something much more than integers for core values with, perhaps, floats for microtones? What if you want to work with pitches as fully-fledged objects? Objects capable of carrying arbitrarily large sets of attributes and values? Objects that might group together, first into sets, and then into larger assemblages, and then into still larger complexes of pitch information loaded, or even overloaded, with cross-relationships or textural implications? Carrying this surplus of information about pitch, or the potential uses of pitch, in data structures limited to, or centered around, the list-of-floats paradigm then becomes a burden.

And what of working with rhythms not only as offset values, as implied by the list-of-floats approach, but as arbitrarily nested, stretched, compressed and stacked sets of values, as allowed by the tupleting and measure structures of conventional score? A different approach is needed.

There was, and still is, no reason to believe that general purpose programming languages and development tools should come readily supplied with the objects and methods most suitable for composerly applications. And this means that the attributes of a domain-specific language that will best meet the needs of composers interested in working formally with the full complement of capabilities in traditional score remains an open question.

We continued our work in score formalization independently until 2005, Trevor in a system that would come to be called Lascaux, and Víctor in a system dubbed Cuepatlahto. We experimented with C, Mathematica and Matlab as the core programming languages driving our systems before settling independently on Python, Víctor out of experience at MIT, where he was working on his masters at the Media Lab with Berry Vercoe, and Trevor out of the working necessities of a professional developer and engineer.

We passed through independent experiences using Finale, Sibelius, Leland Smith's SCORE, and even Adobe Illustrator as the notational rendering engines for Lascaux and Cuepatlahto. Through all of this, both systems were designed to tackle a shared set of problems. These included:

1. The difficulty involved in transcribing larger scale and highly parameterized gestures and textures into traditional Western notation.

2. The general inflexibility of closed, commercial music notation software packages.
3. The relative inability of objects on the printed page in conventional score to point to each other — or, indeed, to other objects or ideas outside the printed page — in ways rich enough to help capture, model and develop long-range, nonlocal relationships throughout our scores.

After collaborating on a joint paper describing the two systems, and after discussing collaborative design and implementation at length, both online and in weekends' long review of our respective codebases, we decided to combine our efforts into a single, unified project. That project is now Abjad.

In our work on Abjad we strive to develop a powerful and flexible symbolic system. We picked the phrase 'formalized score control', or FSC, as a nod to Xenakis, who was so far ahead in so many ways, and also to highlight our primary project goal: to bring the full power of modern programming languages, and tools in mathematics, text processing, pattern recognition, and modular, iterative and incremental development to bear on all parts of the compositional process.

WHY MIDI IS NOT ENOUGH

Given that Abjad models written musical score, it might seem odd for MIDI to be even mentioned in this manual. Yet, until fairly recently, MIDI has played a role (sometimes tangential, other times fundamental) in a variety of software tools related to music notation and engraving.

46.1 A very brief overview of MIDI

MIDI (Musical Instrument Digital Interface) was first introduced in 1981 by Dave Smith, the founder of Sequential Circuits. The original purpose of MIDI was to allow the communication between different electronic musical instruments; more specifically, to allow one device to send **control** data to another device. Typical messages might be “note On” (play a *note*) “note Off” (turn off a *note*). A MIDI “note” message, for example, is composed of three bytes: the first byte (the Status byte) tells the device what kind of message this is (e.g. a Note On message). The second byte encodes key number (which key was pressed) and the third byte, velocity (how hard the key was pressed). It should be clear that a *Note* in this context means something very different than *Note* in the context of a traditional printed score. While the bias towards keyboard interfaces is clear in the definition of the MIDI Note control message, one can still give the MIDI note a more general use by reinterpreting “key number” as pitch and “velocity” as loudness, the usual perceptual correlates of these control changes as well as the most meaningful musical parameters in western music.

With the subsequent proliferation of music production software, the SMF (Standard Midi File) was introduced to allow the recording and storage of the control data from a MIDI stream. The SMF required a time stamp to keep track of when control messages took place. These are called “delta-times” in the SMF specification.

“The MTrk chunk type is where actual song data is stored. It is simply a stream of MIDI events (and non-MIDI events), preceded by delta-time values.”

In combination with the MIDI Note message, the addition of duration now allowed one to have a minimal but sufficient **machine** representation—a machine score—of music requiring only these parameters: duration, pitch and loudness. Such is the case of most piano music.

46.2 Limitations of MIDI from the point of view of score modeling

But, alas, there is much more information in a printed score that can not be practically encoded in a SMF. Common musical notions such as meter, clef, key signature, articulation, to name only a few, are ignored. A desire to include some of these concepts in MIDI is evident in the inclusion of some so called *meta-events*. From the SMF specification: “specifies non-MIDI information useful to this format or to sequencers.” Examples of *meta-events* are *Time Signature* and *Key Signature*. In addition to the semantic elements just mentioned, there are also the typographical elements (such as line thickness, spacing, color, fonts, etc.) that all printed scores carry. This extra layer of information is completely absent in a SMF. However, from the point of view of encoding a printed score, the main limitation of MIDI is not the lack musical features or the absence of typographical data, but the assumption that musical durations, pitches

and loudnesses can be each fully and efficiently encoded with integers or even fractions. In a printed score, this is not the case for any of them. MIDI encodes only *magnitudes*: time interval magnitudes, pitch interval magnitudes, velocity magnitudes. While these may be sufficient attributes for an automated piano performance, they are not all the attributes of notes in a printed score.

46.3 Written note durations vs. MIDI delta-times

Assume a fixed tempo has been set. Assume that all magnitudes are represented with (and limited to) rational numbers. A time interval magnitude $d = 1/4$ has an infinity of equivalent representations in terms of magnitude: $d = 1/4 = 1/8 * 2 = 1/8 + 1/16 * 2 \dots$ etc. So, for example, while equivalent in magnitude, these are not the same notated durations:

```
abjad> m1 = measuretools.AnonymousMeasure([Note("c'4")])
abjad> m2 = measuretools.AnonymousMeasure(Note(0, (1, 8)) * 2)
abjad> tietools.TieSpanner(m2)
abjad> m3 = measuretools.AnonymousMeasure([Note(0, (1, 8))] + Note(0, (1, 16)) * 2)
abjad> tietools.TieSpanner(m3)
abjad> r = stafftools.RhythmicStaff([m1, m2, m3])
abjad> iotools.write_expr_to_ly(r, 'MIDI-1')
```



46.4 Written note pitch vs. MIDI note-on

A similar thing happens with pitches. In MIDI, key (pitch) number 61 is a half tone above middle C. But how is this pitch to be notated? As a C sharp or a B flat?

```
abjad> m1 = measuretools.AnonymousMeasure([Note(1, (1, 4))])
abjad> m2 = measuretools.AnonymousMeasure([Note(('df', 4), (1, 4))])
abjad> r = Staff([m1, m2])
abjad> iotools.write_expr_to_ly(r, 'MIDI-2')
```



46.5 Conclusion

MIDI was not designed for score representation. MIDI is a simple communication protocol intended for real-time control. As such, it naturally lacks the adequate model to represent the full range of information found in printed scores.

WHY LILYPOND IS RIGHT FOR ABJAD

Early versions of Abjad wrote MIDI files for input to Finale and Sibelius. Later versions of Abjad wrote .pbx files for input into Leland Smith's SCORE. Over time we found LilyPond superior to Finale, Sibelius and SCORE.

47.1 Nested tuplets works out of the box

LilyPond uses a single construct to nest tuplets arbitrarily:

```
\new stafftools.RhythmicStaff {  
  \time 7/8  
  \times 7/8 {  
    c8.  
    \times 7/5 { c16 c16 c16 c16 c16 }  
    \times 3/5 { c8 c8 c8 c8 c8 }  
  }  
}  
  
abjad> staff = stafftools.RhythmicStaff([Measure((7, 8), [])])  
abjad> measure = staff[0]  
abjad> measure.append(Note('c8.'))  
abjad> measure.append(Tuplet(Fraction(7, 5), 5 * Note('c16')))  
abjad> spannertools.BeamSpanner(measure[-1])  
abjad> measure.append(Tuplet(Fraction(3, 5), 5 * Note('c8')))  
abjad> spannertools.BeamSpanner(measure[-1])  
abjad> Tuplet(Fraction(7, 8), measure.music)  
abjad> staff.override.tuplet_bracket.bracket_visibility = True  
abjad> staff.override.tuplet_bracket.padding = 1.6  
abjad> show(staff)
```



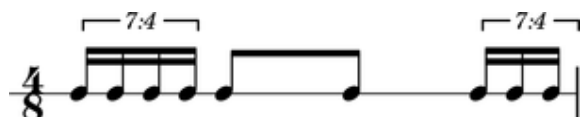
LilyPond's tuplet input syntax works the same as any other recursive construct.

47.2 Broken tuplets work out of the box

LilyPond engraves tupletted notes interrupted by nontupletted notes correctly:

```
\new Staff {
  \times 4/7 { c'16 c'16 c'16 c'16 }
  c'8 c'8
  \times 4/7 { c'16 c'16 c'16 }
}

abjad> t = Tuplet(Fraction(4, 7), Note(0, (1, 16)) * 4)
abjad> notes = Note(0, (1, 8)) * 2
abjad> u = Tuplet(Fraction(4, 7), Note(0, (1, 16)) * 3)
abjad> spannertools.BeamSpanner(t)
abjad> spannertools.BeamSpanner(notes)
abjad> spannertools.BeamSpanner(u)
abjad> measure = Measure((4, 8), [t] + notes + [u])
abjad> staff = stafftools.RhythmicStaff([measure])
abjad> show(staff)
```



47.3 Nonbinary meters work out of the box

The rhythm above rewrites with time signatures in place of tuplets:

```
\new Staff {
  \time 4/28 c'16 c'16 c'16 c'16 |
  \time 2/8 c'8 c'8 |
  \time 3/28 c'16 c'16 c'16 |
}

abjad> t = Measure((4, 28), Note(0, (1, 16)) * 4)
abjad> u = Measure((2, 8), Note(0, (1, 8)) * 2)
abjad> v = Measure((3, 28), Note(0, (1, 16)) * 3)
abjad> spannertools.BeamSpanner(t)
abjad> spannertools.BeamSpanner(u)
abjad> spannertools.BeamSpanner(v)
abjad> staff = stafftools.RhythmicStaff([t, u, v])
abjad> show(staff)
```



The time signatures 4/28 and 3/28 here have a denominator not equal to 4, 8, 16 or any other nonnegative integer power of two. Abjad calls such time signatures **nonbinary meters** and LilyPond engraves them correctly.

47.4 Lilypond models the musical measure correctly

Most engraving packages make the concept of the measure out to be more important than it should. We see evidence of this wherever an engraving package makes it difficult for either a long note or the notes of a tuplet to cross a barline. These difficulties come from working the idea of measure-as-container deep into object model of the package.

There is a competing way to model the musical measure that we might call the measure-as-background way of thinking about things. Western notation practice started absent any concept of the barline, introduced the idea gradually, and

has since retreated from the necessity of the convention. Engraving packages that pick out an understanding of the barline from the 18th or 19th centuries subscribe to the measure-as-container view of things and oversimplify the problem. One result of this is to render certain barline-crossing rhythmic figures either an inelegant hack or an outright impossibility. LilyPond eschews the measure-as-container model in favor of the measure-as-background model better able to handle both earlier and later notation practice.

LILYPOND TEMPLATE GALLERY

Abjad provides a number of score templates in the `abjad/templates` directory:

```
abjad> from abjad.tools import configurationtools
abjad> configurationtools.list_abjad_templates()
('coventry.ly', 'lagos.ly', 'oedo.ly', 'paris.ly', 'tangiers.ly', 'thebes.ly', 'tirnaveni.ly')
```

Templates provide header, layout, paper and grob settings for different types of score.

48.1 Default LilyPond layout

```
abjad> import random
abjad> pitches = [random.randrange(0, 25) for x in range(32)]
abjad> staff_1 = Staff([])
abjad> staff_2 = Staff([])
abjad> score = Score([staff_1, staff_2])
abjad> staff_1.extend([Note(x, (1, 8)) for x in pitches[:16]])
abjad> staff_2.extend([Note(x, (1, 8)) for x in pitches[16:]])
abjad> show(score)
```



48.2 `lagos.ly`

```
abjad> pitches = [random.randrange(0, 25) for x in range(32)]
abjad> staff_1 = Staff([])
abjad> staff_2 = Staff([])
abjad> score = Score([staff_1, staff_2])
abjad> staff_1.extend([Note(x, (1, 8)) for x in pitches[:16]])
abjad> staff_2.extend([Note(x, (1, 8)) for x in pitches[16:]])
abjad> show(score, template = 'lagos')
```



48.3 oedo.ly

```
abjad> pitches = [random.randrange(0, 25) for x in range(32)]
abjad> staff_1 = Staff([])
abjad> staff_2 = Staff([])
abjad> score = Score([staff_1, staff_2])
abjad> staff_1.extend([Note(x, (1, 8)) for x in pitches[:16]])
abjad> staff_2.extend([Note(x, (1, 8)) for x in pitches[16:]])
abjad> show(score, template = 'oedo')
```



48.4 tangiers.ly

```
abjad> pitches = [random.randrange(0, 25) for x in range(32)]
abjad> staff_1 = Staff([])
abjad> staff_2 = Staff([])
abjad> score = Score([staff_1, staff_2])
abjad> staff_1.extend([Note(x, (1, 8)) for x in pitches[:16]])
abjad> staff_2.extend([Note(x, (1, 8)) for x in pitches[16:]])
abjad> show(score, template = 'tangiers')
```



48.5 tirnaveni.ly

```
abjad> pitches = [random.randrange(0, 25) for x in range(32)]
abjad> staff_1 = Staff([])
abjad> staff_2 = Staff([])
abjad> score = Score([staff_1, staff_2])
abjad> staff_1.extend([Note(x, (1, 8)) for x in pitches[:16]])
abjad> staff_2.extend([Note(x, (1, 8)) for x in pitches[16:]])
abjad> show(score, template = 'tirnaveni')
```



LILYPOND TEXT ALIGNMENT

LilyPond provides many ways to position text.

49.1 Default alignment

LilyPond left-aligns markup relative to the left edge of note head by default.

```
abjad> notes = notetools.make_repeated_notes(1, Fraction(1, 4))
abjad> staff = stafftools.RhythmicStaff(notes)
abjad> leaves = staff.leaves
abjad> markuptools.Markup('XX', 'up')(leaves[0])
abjad> show(staff, 'thebes')
```



49.2 TextScript #'self-alignment-X

Use #'self-alignment-X to left-, center- or right-align markup relative to the left edge of note head.

Note: changes to #'self-alignment-X do not change the fact that markup positioning is by default relative to the LEFT edge of note head.

```
abjad> notes = notetools.make_repeated_notes(3, Fraction(1, 4))
abjad> staff = stafftools.RhythmicStaff(notes)
abjad> leaves = staff.leaves
abjad> markuptools.Markup('XX', 'up')(leaves[0])
abjad> leaves[0].override.text_script.self_alignment_X = 'left'
abjad> markuptools.Markup('XX', 'up')(leaves[1])
abjad> leaves[1].override.text_script.self_alignment_X = 'center'
abjad> markuptools.Markup('XX', 'up')(leaves[2])
abjad> leaves[2].override.text_script.self_alignment_X = 'right'
abjad> show(staff, 'thebes')
```



49.3 TextScript #'X-offset

Use #'X-offset to offset markup by some number of magic units in the horizontal direction.

Note: Specify #'X-offset arguments as numbers like #2.5. Do not specify #'X-offset arguments as direction constants like #right.

Note: changes to #'X-offset do not change the fact that markup positioning is by default relative to the LEFT edge of note head.

```
abjad> notes = notetools.make_repeated_notes(4, Fraction(1, 4))
abjad> staff = stafftools.RhythmicStaff(notes)
abjad> leaves = staff.leaves
abjad> markuptools.Markup('XX', 'up')(leaves[0])
abjad> leaves[0].override.text_script.X_offset = 0
abjad> markuptools.Markup('XX', 'up')(leaves[1])
abjad> leaves[1].override.text_script.X_offset = 2
abjad> markuptools.Markup('XX', 'up')(leaves[2])
abjad> leaves[2].override.text_script.X_offset = 4
abjad> markuptools.Markup('XX', 'up')(leaves[3])
abjad> leaves[3].override.text_script.X_offset = 6
abjad> show(staff, 'thebes')
```



BIBLIOGRAPHY

ABJAD API

51.1 Abjad API

51.1.1 Abjad composition packages

chordtools

chordtools.Chord

```
class abjad.tools.chordtools.Chord(*args, **kwargs)
    Bases: abjad.tools.leaftools._Leaf._Leaf._Leaf
```

Abjad model of a chord:

```
abjad> Chord([4, 13, 17], (1, 4))
Chord("<e' cs' ' f' '>4")
```

Return chord instance.

append (*note_head_token*)

Append *note_head_token* to chord:

```
abjad> chord = Chord([4, 13, 17], (1, 4))
abjad> chord
Chord("<e' cs' ' f' '>4")
```

```
abjad> chord.append(19)
abjad> chord
Chord("<e' cs' ' f' ' g' '>4")
```

Sort chord note heads automatically after append and return none.

clear ()

Clear chord:

```
abjad> chord = Chord("<e' cs' ' f' '>4")
abjad> chord
Chord("<e' cs' ' f' '>4")
```

```
abjad> chord.clear()
abjad> chord
Chord('<>4')
```

Return none.

extend (*note_head_tokens*)

Extend chord with *note_head_tokens*:

```
abjad> chord = Chord([4, 13, 17], (1, 4))
abjad> chord
Chord("<e' cs'' f''>4")

abjad> chord.extend([2, 12, 18])
abjad> chord
Chord("<d' e' c'' cs'' f'' fs''>4")
```

Sort chord note heads automatically after extend and return none.

fingered_pitches

Read-only fingered pitches:

```
abjad> staff = Staff("<c''' e'''>4 <d''' fs'''>4")
abjad> glockenspiel = instrumenttools.Glockenspiel()(staff)
abjad> instrumenttools.transpose_notes_and_chords_in_expr_from_sounding_pitch_to_fingered_pi

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Glockenspiel }
  \set Staff.shortInstrumentName = \markup { Gkspl. }
  <c' e'>4
  <d' fs'>4
}

abjad> staff[0].fingered_pitches
(NamedChromaticPitch("c'"), NamedChromaticPitch("e'"))
```

Return tuple of named chromatic pitches.

note_heads

Get read-only tuple of note heads in chord:

```
abjad> chord = Chord([7, 12, 16], (1, 4))
abjad> chord.note_heads
(NoteHead("g'"), NoteHead("c'"), NoteHead("e'"))
```

Set chord note heads from any iterable:

```
abjad> chord = Chord([7, 12, 16], (1, 4))
abjad> chord.note_heads = [0, 2, 6]
abjad> chord
Chord("<c' d' fs'>4")
```

pop (*i=-1*)

Remove note head at index *i* in chord:

```
abjad> chord = Chord([4, 13, 17], (1, 4))
abjad> chord
Chord("<e' cs'' f''>4")

abjad> chord.pop(1)
NoteHead("cs'")

abjad> chord
Chord("<e' f''>4")
```

Return note head.

remove(*note_head*)

Remove *note_head* from chord:

```
abjad> chord = Chord([4, 13, 17], (1, 4))
abjad> chord
Chord("<e' cs' f'>4")
```

```
abjad> chord.remove(chord[1])
abjad> chord
Chord("<e' f'>4")
```

Return none.

sounding_pitches

Read-only sounding pitches:

```
abjad> staff = Staff("<c' e'>4 <d' fs'>4")
abjad> glockenspiel = instrumenttools.Glockenspiel()(staff)
abjad> instrumenttools.transpose_notes_and_chords_in_expr_from_sounding_pitch_to_fingered_pi
```

```
abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Glockenspiel }
  \set Staff.shortInstrumentName = \markup { Gkspl. }
  <c' e'>4
  <d' fs'>4
}
```

```
abjad> staff[0].sounding_pitches
(NamedChromaticPitch("c'"), NamedChromaticPitch("e'"))
```

Return tuple of named chromatic pitches.

written_pitches

Get read-only tuple of pitches in chord:

```
abjad> chord = Chord([7, 12, 16], (1, 4))
abjad> chord.written_pitches
(NamedChromaticPitch("g'"), NamedChromaticPitch("c'"), NamedChromaticPitch("e'))
```

Set chord pitches from any iterable:

```
abjad> chord = Chord([7, 12, 16], (1, 4))
abjad> chord.written_pitches = [0, 2, 6]
abjad> chord
Chord("<c' d' fs'>4")
```

chordtools.all_are_chords

`abjad.tools.chordtools.all_are_chords(*args)`

New in version 2.6. True when *expr* is a sequence of Abjad chords:

```
abjad> chords = [Chord("<c' e' g'>4"), Chord("<c' f' a'>4")]
```

```
abjad> chordtools.all_are_chords(chords)
True
```

True when *expr* is an empty sequence:

```
abjad> chordtools.all_are_chords([])
True
```

Otherwise false:

```
abjad> chordtools.all_are_chords('foo')
False
```

Return boolean.

Function wraps `componenttools.all_are_components()`.

chordtools.arpeggiate_chord

`abjad.tools.chordtools.arpeggiate_chord(*args)`
 New in version 1.1. Arpeggiate *chord*:

```
abjad> chord = Chord("<c' d' ef'>8")

abjad> chordtools.arpeggiate_chord(chord)
[Note("c'8"), Note("d'8"), Note("ef'8")]
```

Arpeggiated notes inherit *chord* written duration.

Arpeggiated notes do not inherit other *chord* attributes.

Return list of newly constructed notes. Changed in version 2.0: renamed `chordtools.arpeggiate()` to `chordtools.arpeggiate_chord()`.

chordtools.change_defective_chord_to_note_or_rest

`abjad.tools.chordtools.change_defective_chord_to_note_or_rest(*args)`
 New in version 1.1. Change zero-length *chord* to rest:

```
abjad> chord = Chord([], (3, 16))

abjad> chord
Chord('<>8.')

abjad> chordtools.change_defective_chord_to_note_or_rest(chord)
Rest('r8.')
```

Change length-one chord to note:

```
abjad> chord = Chord("<cs'>8.")

abjad> chord
Chord("<cs'>8.")

abjad> chordtools.change_defective_chord_to_note_or_rest(chord)
Note("cs'8.")
```

Return chords with length greater than one unchanged:

```
abjad> chord = Chord("<c' c' cs'>8.")

abjad> chord
Chord("<c' c' cs'>8.")
```



```
abjad> chordtools.change_defective_chord_to_note_or_rest(chord)
Chord("<c' c'' cs''>8.")
```

Return notes unchanged:

```
abjad> note = Note("c'4")
```

```
abjad> note
Note("c'4")
```

```
abjad> chordtools.change_defective_chord_to_note_or_rest(note)
Note("c'4")
```

Return rests unchanged:

```
abjad> rest = Rest('r4')
```

```
abjad> rest
Rest('r4')
```

```
abjad> chordtools.change_defective_chord_to_note_or_rest(rest)
Rest('r4')
```

Return note, rest, chord or none. Changed in version 2.0: renamed `chordtools.cast_defective()` to `chordtools.change_defective_chord_to_note_or_rest()`.

chordtools.color_chord_note_heads_by_pitch_class_color_map

`abjad.tools.chordtools.color_chord_note_heads_by_pitch_class_color_map(*args)`

New in version 2.0. Color *chord* note heads by pitch-class *color_map*:

```
abjad> chord = Chord([12, 14, 18, 21, 23], (1, 4))
```

```
abjad> pitches = [[-12, -10, 4], [-2, 8, 11, 17], [19, 27, 30, 33, 37]]
```

```
abjad> colors = ['red', 'blue', 'green']
```

```
abjad> color_map = pitchtools.NumberedChromaticPitchClassColorMap(pitches, colors)
```

```
abjad> chordtools.color_chord_note_heads_by_pitch_class_color_map(chord, color_map)
Chord("<c'' d'' fs'' a'' b''>4")
```

```
abjad> f(chord)
```

```
<
  \tweak #'color #red
  c''
  \tweak #'color #red
  d''
  \tweak #'color #green
  fs''
  \tweak #'color #green
  a''
  \tweak #'color #blue
  b''
```

```
>4
```

Also works on notes:

```
abjad> note = Note("c'4")
```

```
abjad> chordtools.color_chord_note_heads_by_pitch_class_color_map(note, color_map)
Note("c' 4")
```

```
abjad> f(note)
\once \override NoteHead #'color = #red
c' 4
```

When *chord* is neither a chord nor note return *chord* unchanged:

```
abjad> staff = Staff([])

abjad> chordtools.color_chord_note_heads_by_pitch_class_color_map(staff, color_map)
Staff{}
```

Return *chord*. Changed in version 2.0: renamed `chordtools.color_note_heads_by_pc()` to `chordtools.color_chord_note_heads_by_pitch_class_color_map()`.

chordtools.divide_chord_by_chromatic_pitch_number

`abjad.tools.chordtools.divide_chord_by_chromatic_pitch_number(*args)`

New in version 1.1. Divide *chord* by chromatic *pitch* number:

```
abjad> chord = Chord(range(12), Duration(1, 4))

abjad> chord
Chord("<c' cs' d' ef' e' f' fs' g' af' a' bf' b'>4")
```

```
abjad> chordtools.divide_chord_by_chromatic_pitch_number(chord, pitchtools.NamedChromaticPitch(6))
(Chord("<fs' g' af' a' bf' b'>4"), Chord("<c' cs' d' ef' e' f'>4"))
```

Input *chord* may be a note, rest or chord but not a skip.

Zero-length parts return rests, length-one parts return notes and other parts return chords.

Return pair of newly constructed leaves. Changed in version 2.0: renamed `chordtools.split_by_pitch_number()` to `chordtools.divide_chord_by_chromatic_pitch_number()`.

chordtools.divide_chord_by_diatonic_pitch_number

`abjad.tools.chordtools.divide_chord_by_diatonic_pitch_number(*args)`

New in version 1.1. Divide *chord* by diatonic *pitch* number:

```
abjad> chord = Chord(range(12), Duration(1, 4))

abjad> chord
Chord("<c' cs' d' ef' e' f' fs' g' af' a' bf' b'>4")
```

```
abjad> chordtools.divide_chord_by_diatonic_pitch_number(chord, pitchtools.NamedChromaticPitch(6))
(Chord("<f' fs' g' af' a' bf' b'>4"), Chord("<c' cs' d' ef' e'>4"))
```

Input *chord* may be a note, rest or chord but not a skip.

Zero-length parts return as rests, length-one parts return as notes and other parts return as chords.

Return pair of newly constructed leaves. Changed in version 2.0: renamed `chordtools.split_by_altitude()` to `chordtools.divide_chord_by_diatonic_pitch_number()`.

chordtools.get_arithmetic_mean_of_chord

abjad.tools.chordtools.get_arithmetic_mean_of_chord(*args)

New in version 2.0. Get arithmetic mean of chromatic pitch number of pitches in *chord*:

```
abjad> chord = Chord("<g' c'' e''>4")
```

```
abjad> chordtools.get_arithmetic_mean_of_chord(chord)
11.666666666666666
```

Return none when *chord* is empty:

```
abjad> chord = Chord("< >4")
```

```
abjad> chordtools.get_arithmetic_mean_of_chord(chord) is None
True
```

Return number or none.

chordtools.get_note_head_from_chord_by_pitch

abjad.tools.chordtools.get_note_head_from_chord_by_pitch(*args)

New in version 2.0. Get note head from *chord* by *pitch*:

```
abjad> chord = Chord("<c'' d'' b''>4")
```

```
abjad> chordtools.get_note_head_from_chord_by_pitch(chord, 14)
NoteHead("d' ")
```

Raise missing note head error when *chord* contains no note head with pitch equal to *pitch*.

Raise extra note head error when *chord* contains more than one note head with pitch equal to *pitch*. Changed in version 2.0: renamed `chordtools.get_note_head()` to `chordtools.get_note_head_from_chord_by_pitch()`.

chordtools.iterate_chords_backward_in_expr

abjad.tools.chordtools.iterate_chords_backward_in_expr(*args)

New in version 2.0. Iterate chords backward in *expr*:

```
abjad> staff = Staff("<e' g' c''>8 a'8 r8 <d' f' b'>8 r2")
```

```
abjad> f(staff)
\new Staff {
  <e' g' c''>8
  a'8
  r8
  <d' f' b'>8
  r2
}
```

```
abjad> for chord in chordtools.iterate_chords_backward_in_expr(staff):
...     chord
Chord("<d' f' b'>8")
Chord("<e' g' c''>8")
```

Ignore threads.

Return generator.

chordtools.iterate_chords_forward_in_expr

`abjad.tools.chordtools.iterate_chords_forward_in_expr(*args)`

New in version 2.0. Iterate chords forward in *expr*:

```
abjad> staff = Staff("<e' g' c''>8 a'8 r8 <d' f' b'>8 r2")

abjad> f(staff)
\new Staff {
    <e' g' c''>8
    a'8
    r8
    <d' f' b'>8
    r2
}

abjad> for chord in chordtools.iterate_chords_forward_in_expr(staff):
...     chord
Chord("<e' g' c''>8")
Chord("<d' f' b'>8")
```

Ignore threads.

Return generator.

chordtools.yield_all_subchords_of_chord

`abjad.tools.chordtools.yield_all_subchords_of_chord(*args)`

New in version 2.0. Yield all subchords of *chord* in binary string order:

```
abjad> chord = Chord("<c' d' af' a'>4")

abjad> for subchord in chordtools.yield_all_subchords_of_chord(chord):
...     subchord
...
Rest('r4')
Note("c'4")
Note("d'4")
Chord("<c' d'>4")
Note("af'4")
Chord("<c' af'>4")
Chord("<d' af'>4")
Chord("<c' d' af'>4")
Note("a'4")
Chord("<c' a'>4")
Chord("<d' a'>4")
Chord("<c' d' a'>4")
Chord("<af' a'>4")
Chord("<c' af' a'>4")
Chord("<d' af' a'>4")
Chord("<c' d' af' a'>4")
```

Include empty chord as rest.

Return generator of newly constructed leaves. Changed in version 2.0: renamed `chordtools.subchords()` to `chordtools.yield_all_subchords_of_chord()`.

`chordtools.yield_groups_of_chords_in_sequence`

`abjad.tools.chordtools.yield_groups_of_chords_in_sequence(*args)`

New in version 2.0. Yield groups of chords in *sequence*:

```
abjad> staff = Staff("c'8 d'8 r8 r8 <e' g'>8 <f' a'>8 g'8 a'8 r8 r8 <b' d''>8 <c'' e''>8")

abjad> f(staff)
\new Staff {
    c'8
    d'8
    r8
    r8
    <e' g'>8
    <f' a'>8
    g'8
    a'8
    r8
    r8
    <b' d''>8
    <c'' e''>8
}

abjad> for chord in chordtools.yield_groups_of_chords_in_sequence(staff):
...     chord
...
(Chord("<e' g'>8"), Chord("<f' a'>8"))
(Chord("<b' d''>8"), Chord("<c'' e''>8"))
```

Return generator.

`componenttools`

`componenttools.all_are_components`

`abjad.tools.componenttools.all_are_components(expr, classes=None)`

New in version 1.1. True when elements in *expr* are all components:

```
abjad> componenttools.all_are_components(3 * Note("c'4"))
True
```

Otherwise false:

```
abjad> componenttools.all_are_components(['foo', 'bar'])
False
```

True when elements in *expr* are all *classes*:

```
abjad> componenttools.all_are_components(3 * Note("c'4"), classes = Note)
True
```

Otherwise false:

```
abjad> componenttools.all_are_components(['foo', 'bar'], classes = Note)
False
```

Return boolean.

componenttools.all_are_components_in_same_parent

abjad.tools.componenttools.all_are_components_in_same_parent(*expr*,
klassen=None, al-
low_orphans=True)

New in version 1.1. True when elements in *expr* are all components in same parent. Otherwise false:

```
abjad> staff = Staff(notetools.make_notes([12, 14, 16], [(1, 8)]))
abjad> componenttools.all_are_components_in_same_parent(staff.leaves)
True
```

True when elements in *expr* are all *klassen* in same parent. Otherwise false:

```
abjad> staff = Staff(notetools.make_notes([12, 14, 16], [(1, 8)]))
abjad> componenttools.all_are_components_in_same_parent(staff.leaves, klassen = (Note, ))
True
```

Return boolean.

componenttools.all_are_components_in_same_score

abjad.tools.componenttools.all_are_components_in_same_score(*expr*,
klassen=None, al-
low_orphans=True)

New in version 1.1. True when elements in *expr* are all components in same score. Otherwise false:

```
abjad> score = Score([Staff("c'8 d'8 e'8")])
abjad> componenttools.all_are_components_in_same_score(score.leaves)
True
```

True when elements in *expr* are all *klassen* in same score. Otherwise false:

```
abjad> score = Score([Staff("c'8 d'8 e'8")])
abjad> componenttools.all_are_components_in_same_score(score.leaves, klassen = (Note, ))
True
```

Return boolean.

componenttools.all_are_components_in_same_thread

abjad.tools.componenttools.all_are_components_in_same_thread(*expr*,
klassen=None, al-
low_orphans=True)

New in version 1.1. True when elements in *expr* are all components in same thread. Otherwise false:

```
abjad> voice = Voice("c'8 d'8 e'8")
abjad> componenttools.all_are_components_in_same_thread(voice.leaves)
True
```

True when elements in *expr* are all *klassen* in same thread. Otherwise false:

```
abjad> voice = Voice("c'8 d'8 e'8")
abjad> componenttools.all_are_components_in_same_thread(voice.leaves, klassen = Note)
True
```

Return boolean.

componenttools.all_are_components_scalable_by_multiplier

abjad.tools.componenttools.all_are_components_scalable_by_multiplier(*components*,
multiplier)

New in version 1.1. True when *components* are all scalable by *multiplier*:

```
abjad> components = [Note(0, (1, 8))]
abjad> componenttools.all_are_components_scalable_by_multiplier(components, Duration(3, 2))
True
```

Otherwise false:

```
abjad> components = [Note(0, (1, 8))]
abjad> componenttools.all_are_components_scalable_by_multiplier(components, Duration(2, 3))
False
```

Return boolean. Changed in version 2.0: renamed `durationtools.are_scalable()` to `componenttools.all_are_components_scalable_by_multiplier()`.

componenttools.all_are_contiguous_components

abjad.tools.componenttools.all_are_contiguous_components(*expr*, *klases=None*, *al-*
low_orphans=True)

New in version 1.1. True when elements in *expr* are all contiguous components. Otherwise false:

```
abjad> staff = Staff("c'8 d'8 e'8")
abjad> componenttools.all_are_contiguous_components(staff.leaves)
True
```

True when elements in *expr* are all contiguous *klases*. Otherwise false:

```
abjad> staff = Staff("c'8 d'8 e'8")
abjad> componenttools.all_are_contiguous_components(staff.leaves, klases = Note)
True
```

Return boolean.

componenttools.all_are_contiguous_components_in_same_parent

abjad.tools.componenttools.all_are_contiguous_components_in_same_parent(*expr*,
klases=None,
al-
low_orphans=True)

New in version 1.1. True when elements in *expr* are all contiguous components in same parent. Otherwise false:

```
abjad> staff = Staff("c'8 d'8 e'8")
abjad> componenttools.all_are_contiguous_components_in_same_parent(staff.leaves)
True
```

True when elements in *expr* are all contiguous *klases* in same parent. Otherwise false:

```
abjad> staff = Staff("c'8 d'8 e'8")
abjad> componenttools.all_are_contiguous_components_in_same_parent(staff.leaves, klases = Note)
True
```

Return boolean.

componenttools.all_are_contiguous_components_in_same_score

`abjad.tools.componenttools.all_are_contiguous_components_in_same_score`(*expr*,
klassen=None,
al-
low_orphans=True)

New in version 1.1. True when elements in *expr* are all contiguous components in same score. Otherwise false:

```
abjad> score = Score([Staff("c'8 d'8 e'8")])
abjad> componenttools.all_are_contiguous_components_in_same_score(score.leaves)
True
```

True when elements in *expr* are all contiguous *klassen* in same score. Otherwise false:

```
abjad> score = Score([Staff("c'8 d'8 e'8")])
abjad> componenttools.all_are_contiguous_components_in_same_score(score.leaves, klassen = Note)
True
```

Return boolean.

componenttools.all_are_contiguous_components_in_same_thread

`abjad.tools.componenttools.all_are_contiguous_components_in_same_thread`(*expr*,
klassen=None,
al-
low_orphans=True)

New in version 1.1. True when elements in *expr* are all contiguous components in same thread. Otherwise false:

```
abjad> staff = Staff("c'8 d'8 e'8")
abjad> componenttools.all_are_contiguous_components_in_same_thread(staff.leaves)
True
```

True when elements in *expr* are all contiguous *klassen* in same thread. Otherwise false:

```
abjad> staff = Staff("c'8 d'8 e'8")
abjad> componenttools.all_are_contiguous_components_in_same_thread(staff.leaves, klassen = Note)
True
```

Return boolean.

componenttools.all_are_orphan_components

`abjad.tools.componenttools.all_are_orphan_components`(*expr*)
New in version 2.0. True when *expr* is an iterable of zero or more orphan components.
Otherwise false.

componenttools.all_are_thread_contiguous_components

`abjad.tools.componenttools.all_are_thread_contiguous_components`(*expr*,
klassen=None,
al-
low_orphans=True)

New in version 1.1. True when elements in *expr* are all thread-contiguous components:


```

t = Voice(notetools.make_repeated_notes(4))
t.insert(2, Voice(notetools.make_repeated_notes(2)))
Container(t[:2])
Container(t[-2:])
pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)

\new Voice {
  {
    c'8
    d'8
  }
  \new Voice {
    e'8
    f'8
  }
  {
    g'8
    a'8
  }
}

assert _are_thread_contiguous_components(t[0:1] + t[-1:])
assert _are_thread_contiguous_components(t[0][:] + t[-1:])
assert _are_thread_contiguous_components(t[0:1] + t[-1][:])
assert _are_thread_contiguous_components(t[0][:] + t[-1][:])

```

Return boolean.

Thread-contiguous components are, by definition, spannable.

componenttools.component_to_parentage_signature

abjad.tools.componenttools.**component_to_parentage_signature**(*component*)

New in version 1.1. Change *component* to parentage signature:

```

abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> staff = Staff([tuplet])
abjad> note = staff.leaves[0]
abjad> print componenttools.component_to_parentage_signature(note)
    root: Staff-... (...)
    score:
staffgroup:
    staff: Staff-...
    voice:
    self: Note-...

```

Return parentage signature.

componenttools.component_to_pitch_and_rhythm_skeleton

abjad.tools.componenttools.**component_to_pitch_and_rhythm_skeleton**(*component*)

New in version 2.0. Change *component* to pitch and rhythm skeleton:

```

abjad> tuplet = Tuplet(Fraction(3, 4), "c'8 d'8 e'8 f'8")
abjad> measure = Measure((6, 16), [tuplet])
abjad> staff = Staff([measure])

```

```

abjad> score = Score(staff * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)

abjad> skeleton = componenttools.component_to_pitch_and_rhythm_skeleton(score)
abjad> print skeleton
Score([
  Staff([
    Measure((6, 16), [
      Tuplet(Fraction(3, 4), [
        Note(('c', 4), Duration(1, 8)),
        Note(('d', 4), Duration(1, 8)),
        Note(('e', 4), Duration(1, 8)),
        Note(('f', 4), Duration(1, 8))
      ])
    ])
  ]),
  Staff([
    Measure((6, 16), [
      Tuplet(Fraction(3, 4), [
        Note(('g', 4), Duration(1, 8)),
        Note(('a', 4), Duration(1, 8)),
        Note(('b', 4), Duration(1, 8)),
        Note(('c', 5), Duration(1, 8))
      ])
    ])
  ])
])

abjad> new = eval(skeleton)
abjad> new
Score<<2>>

abjad> f(new)
\new Score <<
  \new Staff {
    {
      \time 6/16
      \fraction \times 3/4 {
        c'8
        d'8
        e'8
        f'8
      }
    }
  }
  \new Staff {
    {
      \time 6/16
      \fraction \times 3/4 {
        g'8
        a'8
        b'8
        c''8
      }
    }
  }
>>

```

Return string.

componenttools.component_to_score_depth

abjad.tools.componenttools.**component_to_score_depth**(*component*)

New in version 1.1. Change *component* to score depth:

```

abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> staff = Staff([tuplet])
abjad> componenttools.component_to_score_depth(staff.leaves[0])
2

```

Return nonnegative integer.

componenttools.component_to_score_index

abjad.tools.componenttools.**component_to_score_index**(*component*)

New in version 2.0. Change *component* to score index:

```

abjad> staff_1 = Staff(tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_n
abjad> staff_2 = Staff([tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_
abjad> score = Score([staff_1, staff_2])
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> f(score)
\new Score <<
  \new Staff {
    \times 2/3 {
      c'8
      d'8
      e'8
    }
    \times 2/3 {
      f'8
      g'8
      a'8
    }
  }
  \new Staff {
    \times 2/3 {
      b'8
      c''8
      d''8
    }
  }
>>

abjad> for leaf in score.leaves:
...     leaf, componenttools.component_to_score_index(leaf)
...
(Note("c'8"), (0, 0, 0))
(Note("d'8"), (0, 0, 1))
(Note("e'8"), (0, 0, 2))
(Note("f'8"), (0, 1, 0))
(Note("g'8"), (0, 1, 1))
(Note("a'8"), (0, 1, 2))
(Note("b'8"), (1, 0, 0))
(Note("c''8"), (1, 0, 1))
(Note("d''8"), (1, 0, 2))

```

Return tuple of zero or more nonnegative integers.

componenttools.component_to_score_root

abjad.tools.componenttools.**component_to_score_root**(*component*)

New in version 1.1. Change *component* to score root:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> staff = Staff([tuplet])
abjad> note = staff.leaves[0]
abjad> componenttools.component_to_score_root(note)
Staff{1}
```

Return score root.

componenttools.component_to_tuplet_depth

abjad.tools.componenttools.**component_to_tuplet_depth**(*component*)

New in version 1.1. Change *component* to tuplet depth:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> staff = Staff([tuplet])
abjad> note = staff.leaves[0]

abjad> componenttools.component_to_tuplet_depth(note)
1

abjad> componenttools.component_to_tuplet_depth(tuplet)
0

abjad> componenttools.component_to_tuplet_depth(staff)
0
```

Return nonnegative integer.

componenttools.copy_and_partition_governed_component_subtree_by_leaf_counts

abjad.tools.componenttools.**copy_and_partition_governed_component_subtree_by_leaf_counts**(*container*, *leaf_counts*)

New in version 1.1. Copy *container* and partition copy according to *leaf_counts*:

```
abjad> voice = Voice(tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_note("c'8", 2)))
abjad> spannertools.BeamSpanner(voice[0].leaves)
BeamSpanner(c'8, c'8, c'8)
abjad> spannertools.BeamSpanner(voice[1].leaves)
BeamSpanner(c'8, c'8, c'8)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> f(voice)
\new Voice {
  \times 2/3 {
    c'8 [
      d'8
      e'8 ]
  }
  \times 2/3 {
    f'8 [
      g'8
      a'8 ]
  }
}
```

```

    }
}

abjad> first, second, third = componenttools.copy_and_partition_governed_component_subtree_by_lea

abjad> f(first)
\new Voice {
    \times 2/3 {
        c'8 [ ]
    }
}

abjad> f(second)
\new Voice {
    \times 2/3 {
        d'8 [
        e'8 ]
    }
}

abjad> f(third)
\new Voice {
    \times 2/3 {
        f'8 [
        g'8
        a'8 ]
    }
}

```

Set *leaf_counts* to an iterable of zero or more positive integers.

Return a list of parts equal in length to that of *leaf_counts*. Changed in version 2.0: renamed `clonewp.by_leaf_counts_with_parentage()` to `componenttools.copy_and_partition_governed_component_subtree_by_leaf_counts()`.

componenttools.copy_components_and_covered_spanners

`abjad.tools.componenttools.copy_components_and_covered_spanners(components, n=1)`

New in version 1.1. Clone *components* and covered spanners.

The *components* must be thread-contiguous.

Covered spanners are those spanners that cover *components*.

The steps taken in this function are as follows. Withdraw *components* from crossing spanners. Preserve spanners that *components* cover. Deep copy *components*. Reapply crossing spanners to source *components*. Return copied components with covered spanners.

```

abjad> voice = Voice(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> beam = spannertools.BeamSpanner(voice.leaves[:4])
abjad> f(voice)
\new Voice {
    {
        \time 2/8
        c'8 [
        d'8

```

```

    }
    {
        \time 2/8
        e'8
        f'8 ]
    }
    {
        \time 2/8
        g'8
        a'8
    }
}

abjad> result = componenttools.copy_components_and_covered_spanners(voice.leaves)
abjad> result
(Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8"), Note("g'8"), Note("a'8"))

abjad> new_voice = Voice(result)
abjad> f(new_voice)
\new Voice {
    c'8 [
    d'8
    e'8
    f'8 ]
    g'8
    a'8
}

abjad> voice.leaves[0] is new_voice.leaves[0]
False

```

Clone *components* a total of *n* times.

```

abjad> result = componenttools.copy_components_and_covered_spanners(voice.leaves[:2], n = 3)
abjad> result
(Note("c'8"), Note("d'8"), Note("c'8"), Note("d'8"), Note("c'8"), Note("d'8"))

abjad> new_voice = Voice(result)
abjad> f(new_voice)
\new Voice {
    c'8
    d'8
    c'8
    d'8
    c'8
    d'8
}

```

Changed in version 2.0: renamed `clone.covered()` to `componenttools.copy_components_and_covered_spanners()`
in version 2.0: renamed `componenttools.clone_components_and_covered_spanners()` to
`componenttools.copy_components_and_covered_spanners()`.

componenttools.copy_components_and_fracture_crossing_spanners

`abjad.tools.componenttools.copy_components_and_fracture_crossing_spanners` (*components*,
n=1)

New in version 1.1. Clone *components* and fracture crossing spanners.

The *components* must be thread-contiguous.

The steps this function takes are as follows. Deep copy *components*. Deep copy spanners that attach to any component in *components*. Fracture spanners that attach to components not in *components*. Return Python list of copied components.

```
abjad> voice = Voice(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> beam = spannertools.BeamSpanner(voice.leaves[:4])
abjad> f(voice)
\new Voice {
  {
    \time 2/8
    c'8 [
    d'8
  }
  {
    \time 2/8
    e'8
    f'8 ]
  }
  {
    \time 2/8
    g'8
    a'8
  }
}

abjad> result = componenttools.copy_components_and_fracture_crossing_spanners(voice.leaves[2:4])
abjad> result
(Note("e'8"), Note("f'8"))

abjad> new_voice = Voice(result)
abjad> f(new_voice)
\new Voice {
  e'8 [
  f'8 ]
}

abjad> voice.leaves[2] is new_voice.leaves[0]
False
```

Clone *components* a total of *n* times.

```
abjad> result = componenttools.copy_components_and_fracture_crossing_spanners(voice.leaves[2:4])
abjad> result
(Note("e'8"), Note("f'8"), Note("e'8"), Note("f'8"), Note("e'8"), Note("f'8"))

abjad> new_voice = Voice(result)
abjad> f(new_voice)
\new Voice {
  e'8 [
  f'8 ]
  e'8 [
  f'8 ]
  e'8 [
  f'8 ]
}
```

Changed in version 2.0: renamed `clone.fracture()` to `componenttools.copy_components_and_fracture_cr`

in version 2.0: renamed `componenttools.clone_components_and_fracture_crossing_spanners()` to `componenttools.copy_components_and_fracture_crossing_spanners()`.

componenttools.copy_components_and_immediate_parent_of_first_component

`abjad.tools.componenttools.copy_components_and_immediate_parent_of_first_component` (*components*)

New in version 1.1. Clone *components* and immediate parent of first component.

The *components* must be thread-contiguous.

Return in newly created container equal to type of first element in *components*.

If the parent of the first element in *components* is a tuplet then insure that the tuplet multiplier of the function output equals the tuplet multiplier of the parent of the first element in *components*.

```
abjad> voice = Voice(tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_note(
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> beam = spannertools.BeamSpanner(voice.leaves[:4])
abjad> f(voice)
\new Voice {
  \times 2/3 {
    c'8 [
    d'8
    e'8
  ]
  \times 2/3 {
    f'8 ]
    g'8
    a'8
  ]
  \times 2/3 {
    b'8
    c''8
    d''8
  ]
}
abjad> new_tuplet = componenttools.copy_components_and_immediate_parent_of_first_component(voice)
abjad> new_tuplet
FixedDurationTuplet(1/6, [c'8, d'8])
abjad> f(new_tuplet)
\times 2/3 {
  c'8 [
  d'8 ]
}
```

Parent-contiguity is not required. Thread-contiguous *components* suffice.

```
abjad> new_tuplet = componenttools.copy_components_and_immediate_parent_of_first_component(voice)
abjad> new_tuplet
FixedDurationTuplet(5/12, [c'8, d'8, e'8, f'8, g'8])
abjad> f(new_tuplet)
\times 2/3 {
  c'8 [
  d'8
  e'8
  f'8 ]
  g'8
}
```

Note: this function copies only the *immediate parent* of the first element in *components*. This function ignores any further parentage of *components* above the immediate parent of *components*.

Todo

this function should (but does not) copy marks that attach to *components* and to the immediate parent of the first component; extend function to do so.

Changed in version 2.0: renamed `clonewp.with_parent()` to `componenttools.copy_components_and_immediate_parent_of_first_component()`. Changed in version 2.0: renamed `componenttools.clone_components_and_immediate_parent_of_first_component()` to `componenttools.copy_components_and_immediate_parent_of_first_component()`.

componenttools.copy_components_and_remove_all_spanners

`abjad.tools.componenttools.copy_components_and_remove_all_spanners(components, n=1)`

New in version 1.1. Clone *components* and remove all spanners.

The *components* must be thread-contiguous.

The steps taken by this function are as follows. Withdraw all components at any level in *components* from spanners. Deep copy unspanned components in *components*. Reapply spanners to all components at any level in *components*.

```
abjad> voice = Voice(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> beam = spannertools.BeamSpanner(voice.leaves[:4])
abjad> f(voice)
\new Voice {
  {
    \time 2/8
    c'8 [
    d'8
  ]
  {
    \time 2/8
    e'8
    f'8 ]
  }
  {
    \time 2/8
    g'8
    a'8
  }
}

abjad> result = componenttools.copy_components_and_remove_all_spanners(voice.leaves[2:4])
abjad> result
(Note("e'8"), Note("f'8"))

abjad> new_voice = Voice(result)
abjad> f(new_voice)
\new Voice {
  e'8
```

```
f'8
}

abjad> voice.leaves[2] is new_voice.leaves[0]
False
```

Clone *components* a total of *n* times.

```
abjad> result = componenttools.copy_components_and_remove_all_spanners(voice.leaves[2:4], n = 3)
abjad> result
(Note("e'8"), Note("f'8"), Note("e'8"), Note("f'8"), Note("e'8"), Note("f'8"))

abjad> new_voice = Voice(result)
abjad> f(new_voice)
\new Voice {
    e'8
    f'8
    e'8
    f'8
    e'8
    f'8
}
```

Changed in version 2.0: renamed `clone.unspan()` to `componenttools.copy_components_and_remove_all_sp`
in version 2.0: renamed `componenttools.clone_components_and_remove_all_spanners()`
to `componenttools.copy_components_and_remove_all_spanners()`.

componenttools.copy_governed_component_subtree_by_leaf_range

```
abjad.tools.componenttools.copy_governed_component_subtree_by_leaf_range(component,
                                                                           start=0,
                                                                           stop=None)
```

New in version 1.1. Clone governed *component* subtree by leaf range.

Governed subtree means *component* together with children of *component*.

Leaf range refers to the sequential parentage of *component* from *start* leaf index to *stop* leaf index:

```
abjad> t = Staff([Voice(tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> f(t)
\new Staff {
    \new Voice {
        \times 2/3 {
            c'8
            d'8
            e'8
        }
        \times 2/3 {
            f'8
            g'8
            a'8
        }
    }
}
```

```
abjad> u = componenttools.copy_governed_component_subtree_by_leaf_range(t, 1, 5)
abjad> f(u)
```

```

\new Staff {
  \new Voice {
    \times 2/3 {
      d'8
      e'8
    }
    \times 2/3 {
      f'8
      g'8
    }
  }
}

```

Clone sequential containers in leaves' parentage up to the first parallel container in leaves' parentage.

Trim and shrink cloned containers as necessary.

When *stop* is none copy all leaves from *start* forward. Changed in version 2.0: renamed `clonewp.by_leaf_range_with_parentage()` to `componenttools.copy_governed_component_subtree_by_leaf_range()`. Changed in version 2.0: renamed `componenttools.clone_governed_component_subtree_by_leaf_range()` to `componenttools.copy_governed_component_subtree_by_leaf_range()`.

componenttools.copy_governed_component_subtree_from_prolated_offset_to

`abjad.tools.componenttools.copy_governed_component_subtree_from_prolated_offset_to` (*component*, *start*=0, *stop*=None)

New in version 1.1. Clone governed *component* subtree from *start* prolated duration to *stop* prolated duration.

Governed subtree refers to *component* together with the children of *component*:

```

abjad> voice = Voice(notetools.make_repeated_notes(2))
abjad> voice.append(tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_note(2)))
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> f(voice)
\new Voice {
  c'8
  d'8
  \times 2/3 {
    e'8
    f'8
    g'8
  }
}

abjad> new = componenttools.copy_governed_component_subtree_from_prolated_offset_to(voice, (0, 8))
abjad> f(new)
\new Voice {
  c'8
  d'8
  \times 2/3 {
    e'8
    f'16
  }
}

```

Raise contiguity error if asked to slice a parallel container.

```
abjad> staff = Staff(Voice("c'8 d'8") * 2)
abjad> staff.is_parallel = True
abjad> f(staff)
\new Staff <<
\new Voice {
    c'8
    d'8
}
\new Voice {
    c'8
    d'8
}
>>
```

Raise contiguity error when attempting to copy fleaves from parallel container.

But note that cases with `0 = start` work correctly:

```
abjad> new = componenttools.copy_governed_component_subtree_from_prolated_offset_to(voice, (0, 8))
abjad> f(new)
\new Voice {
    c'8
}
```

Cases with `0 < start` do not work correctly:

```
abjad> new = componenttools.copy_governed_component_subtree_from_prolated_offset_to(voice, (1, 8))
abjad> f(new)
\new Voice {
    c'8
    d'8
}
```

Create ad hoc tuplets as required:

```
abjad> voice = Voice([Note("c'4")])
abjad> new = componenttools.copy_governed_component_subtree_from_prolated_offset_to(voice, 0, (1, 1))
abjad> f(new)
\new Voice {
    \times 2/3 {
        c'8
    }
}
```

Function does NOT clone parentage of *component* when *component* is a leaf:

```
abjad> voice = Voice([Note("c'4")])
abjad> new_leaf = componenttools.copy_governed_component_subtree_from_prolated_offset_to(voice[0], 0, (1, 1))
abjad> f(new_leaf)
c'8
abjad> new_leaf._parentage.parent is None
True
```

Return (untrimmed_copy, first_dif, second_dif). Changed in version 2.0: renamed `componenttools.clone_governed_component_subtree_from_prolated_duration_to()` to `componenttools.copy_governed_component_subtree_from_prolated_offset_to()`.

componenttools.cut_component_at_prolated_duration

abjad.tools.componenttools.**cut_component_at_prolated_duration**(*component*, *pro-
lated_duration*)

New in version 2.0. Cut *component* at dotted *prolated_duration*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> componenttools.cut_component_at_prolated_duration(staff, Duration(1, 32))
abjad> f(staff)
\new Staff {
    c'16. [
    d'8
    e'8
    f'8 ]
}
```

Cut *component* at tied *prolated_duration*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> componenttools.cut_component_at_prolated_duration(staff, Duration(3, 64))
abjad> f(staff)
\new Staff {
    c'16 [ ~
    c'64
    d'8
    e'8
    f'8 ]
}
```

Cut *component* at nonbinary *prolated_duration*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> componenttools.cut_component_at_prolated_duration(staff, Duration(1, 24))
abjad> f(staff)
\new Staff {
    \times 2/3 {
        c'8 [
    ]
    d'8
    e'8
    f'8 ]
}
```

Return none.

componenttools.extend_in_parent_of_component_and_do_not_grow_spanners

abjad.tools.componenttools.**extend_in_parent_of_component_and_do_not_grow_spanners**(*component*, *com-
po-
nents*)

New in version 1.1. Extend *components* in parent of *component* and do not grow spanners:

```

abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8")]
abjad> t = Voice("c'8 d'8 e'8")
abjad> spannertools.BeamSpanner(t[:])
BeamSpanner(c'8, d'8, e'8)
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8")]
abjad> componenttools.extend_in_parent_of_component_and_do_not_grow_spanners(t[-1], notes)
[Note("e'8"), Note("c'8"), Note("d'8"), Note("e'8")]

abjad> print t.format
\new Voice {
    c'8 [
    d'8
    e'8 ]
    c'8
    d'8
    e'8
}

```

Return list of *component* and *components*. Changed in version 2.0: renamed `extend_in_parent()` to `extend_in_parent_of_component_and_do_not_grow_spanners()`.

componenttools.extend_in_parent_of_component_and_grow_spanners

`abjad.tools.componenttools.extend_in_parent_of_component_and_grow_spanners` (*component*, *new_components*)

New in version 2.0. Extend *new_components* in parent of *component* and grow spanners:

```

abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8")]
abjad> voice = Voice(notes)
abjad> spannertools.BeamSpanner(voice[:])
BeamSpanner(c'8, d'8, e'8)

abjad> f(voice)
\new Voice {
    c'8 [
    d'8
    e'8 ]
}

abjad> new_components = [Note("c'8"), Note("d'8"), Note("e'8")]
abjad> componenttools.extend_in_parent_of_component_and_grow_spanners(voice.leaves[-1], new_comp
[Note("e'8"), Note("c'8"), Note("d'8"), Note("e'8")]

abjad> f(voice)
\new Voice {
    c'8 [
    d'8
    e'8
    c'8
    d'8
    e'8 ]
}

```

Return *component* and *new_components* together in list.

componenttools.extend_left_in_parent_of_component_and_do_not_grow_spanners

abjad.tools.componenttools.**extend_left_in_parent_of_component_and_do_not_grow_spanners** (*component*, *new_components*)

New in version 1.1. Extend *components* left in parent of *component* and do not grow spanners:

```
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8")]
abjad> t = Voice(notes)
abjad> spannertools.BeamSpanner(t[:])
BeamSpanner(c'8, d'8, e'8)
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8")]
abjad> componenttools.extend_left_in_parent_of_component_and_do_not_grow_spanners(t[0], notes)
[Note("c'8"), Note("d'8"), Note("e'8"), Note("c'8")]

abjad> print t.format
\new Voice {
    c'8
    d'8
    e'8
    c'8 [
    d'8
    e'8 ]
}
```

Return *components* and *component* together in newly created list. Changed in version 2.0: renamed `extend_left_in_parent()` to `extend_left_in_parent_of_component_and_do_not_grow_spanners()`.

componenttools.extend_left_in_parent_of_component_and_grow_spanners

abjad.tools.componenttools.**extend_left_in_parent_of_component_and_grow_spanners** (*component*, *new_components*)

New in version 2.0. Extend *new_components* left in parent of *component* and grow spanners:

```
abjad> voice = Voice("c'8 d'8 e'8")
abjad> spannertools.BeamSpanner(voice[:])
BeamSpanner(c'8, d'8, e'8)

abjad> f(voice)
\new Voice {
    c'8 [
    d'8
    e'8 ]
}

abjad> new_components = 3 * Note(0, (1, 16))
abjad> componenttools.extend_left_in_parent_of_component_and_grow_spanners(voice[0], new_components)
[Note("c'16"), Note("c'16"), Note("c'16"), Note("c'8")]

abjad> f(voice)
\new Voice {
    c'16 [
    c'16
    c'16
    c'8
    d'8
}
```

```

    e'8 ]
}

```

Return *new_components* and *component* together in newly created list. Changed in version 2.0: renamed `splice_left()` to `componenttools.extend_left_in_parent_of_component_and_grow_spanners()`.

componenttools.get_component_start_offset

`abjad.tools.componenttools.get_component_start_offset(component)`

New in version 1.1. Get *component* start offset:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}

abjad> componenttools.get_component_start_offset(staff[1])
Offset(1, 8)

```

Return nonnegative fraction.

componenttools.get_component_start_offset_in_seconds

`abjad.tools.componenttools.get_component_start_offset_in_seconds(component)`

New in version 1.1. Get *component* start offset in seconds:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> score = Score([staff])
abjad> contexttools.TempoMark(Duration(1, 4), 52)(score)
TempoMark(4, 52)(Score<<1>>)
abjad> f(score) # doctest: +SKIP
\new Score <<
    \new Staff {
        \tempo 4=52
        c'8
        d'8
        e'8
        f'8
    }
>>

abjad> componenttools.get_component_start_offset_in_seconds(score.leaves[1])
Offset(15, 26)

```

Return nonnegative fraction.

componenttools.get_component_stop_offset

`abjad.tools.componenttools.get_component_stop_offset(component)`

New in version 1.1. Get *component* stop offset:


```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}

abjad> componenttools.get_component_stop_offset(staff[1])
Offset(1, 4)

```

Return positive fraction.

componenttools.get_component_stop_offset_in_seconds

`abjad.tools.componenttools.get_component_stop_offset_in_seconds(component)`
 New in version 1.1. Get *component* stop offset in seconds:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> score = Score([staff])
abjad> contexttools.TempoMark(Duration(1, 4), 52)(score)
TempoMark(4, 52)(Score<<1>>)
abjad> f(score) # doctest: +SKIP
\new Score <<
    \new Staff {
        \tempo 4=52
        c'8
        d'8
        e'8
        f'8
    }
>>

abjad> componenttools.get_component_stop_offset_in_seconds(score.leaves[1])
Offset(15, 13)

```

Return positive fraction.

componenttools.get_first_component_in_expr_with_name

`abjad.tools.componenttools.get_first_component_in_expr_with_name(expr, name)`
 New in version 1.1. Get first component in *expr* with *name*:

```

abjad> flute_staff = Staff("c'8 d'8 e'8 f'8")
abjad> flute_staff.name = 'Flute'
abjad> violin_staff = Staff("c'8 d'8 e'8 f'8")
abjad> violin_staff.name = 'Violin'
abjad> staff_group = scoretools.StaffGroup([flute_staff, violin_staff])
abjad> score = Score([staff_group])

abjad> componenttools.get_first_component_in_expr_with_name(score, 'Violin')
Staff-"Violin"{4}

```

Changed in version 2.0: Function returns first component found. Function previously returned tuple of all components found. Changed in version 2.0: renamed `scoretools.find()` to

`componenttools.get_first_component_in_expr_with_name()`. Changed in version 2.0: Removed *klass* and *context* keywords. Function operates only on component name.

`componenttools.get_first_component_with_name_in_improper_parentage_of_component`

`abjad.tools.componenttools.get_first_component_with_name_in_improper_parentage_of_component`

New in version 2.0. Get first component with *name* in improper parentage of *component*:

```
abjad> score = Score([Staff("c'4 d'4 e'4 f'4")])
abjad> score.name = 'The Score'

abjad> f(score)
\context Score = "The Score" <<
  \new Staff {
    c'4
    d'4
    e'4
    f'4
  }
>>

abjad> leaf = score.leaves[0]

abjad> componenttools.get_first_component_with_name_in_improper_parentage_of_component(leaf, 'The Score')
"The Score"<<1>>

abjad> componenttools.get_first_component_with_name_in_improper_parentage_of_component(leaf, 'The Score')
True
```

Return component or none.

`componenttools.get_first_component_with_name_in_proper_parentage_of_component`

`abjad.tools.componenttools.get_first_component_with_name_in_proper_parentage_of_component`

New in version 2.0. Get first component with *name* in proper parentage of *component*:

```
abjad> score = Score([Staff("c'4 d'4 e'4 f'4")])
abjad> score.name = 'The Score'

abjad> f(score)
\context Score = "The Score" <<
  \new Staff {
    c'4
    d'4
    e'4
    f'4
  }
>>

abjad> leaf = score.leaves[0]

abjad> componenttools.get_first_component_with_name_in_proper_parentage_of_component(leaf, 'The Score')
"The Score"<<1>>
```

```
abjad> componenttools.get_first_component_with_name_in_proper_parentage_of_component(leaf, 'foo')
True
```

Return component or none.

componenttools.get_first_instance_of_klass_in_improper_parentage_of_component

```
abjad.tools.componenttools.get_first_instance_of_klass_in_improper_parentage_of_component(component, klass)
```

New in version 2.0. Get first instance of *klass* in improper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> componenttools.get_first_instance_of_klass_in_improper_parentage_of_component(staff[0], Note("c'8"))
```

Return component or none.

componenttools.get_first_instance_of_klass_in_proper_parentage_of_component

```
abjad.tools.componenttools.get_first_instance_of_klass_in_proper_parentage_of_component(component, klass)
```

New in version 1.1. Get first instance of *klass* in proper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> componenttools.get_first_instance_of_klass_in_proper_parentage_of_component(staff[0], Staff{4})
```

Return component or none. Changed in version 2.0: renamed `componenttools.get_first()` to `componenttools.get_first_instance_of_klass_in_proper_parentage_of_component()`.

componenttools.get_improper_parentage_of_component

```
abjad.tools.componenttools.get_improper_parentage_of_component(component)
```

New in version 1.1. Get improper parentage of *component*:

```
abjad> tuplet = Tuplet(Fraction(2, 3), "c'8 d'8 e'8")
abjad> staff = Staff([tuplet])
abjad> note = staff.leaves[0]

abjad> componenttools.get_improper_parentage_of_component(note)
(Note("c'8"), Tuplet(2/3, [c'8, d'8, e'8]), Staff{1})
```

Return tuple of zero or more components.

componenttools.get_likely_multiplier_of_components

```
abjad.tools.componenttools.get_likely_multiplier_of_components(components)
```

New in version 2.0. Get likely multiplier of *components*:

```
abjad> staff = Staff("c'8.. d'8.. e'8.. f'8..")
abjad> f(staff)
\new Staff {
  c'8..
  d'8..
  e'8..
```

```

        f'8..
    }
    abjad> componenttools.get_likely_multiplier_of_components(staff[:])
    Duration(7, 4)

```

Return 1 when no multiplier is likely:

```

    abjad> staff = Staff("c'8 d'8 e'8 f'8")
    abjad> f(staff)
    \new Staff {
        c'8
        d'8
        e'8
        f'8
    }
    abjad> componenttools.get_likely_multiplier_of_components(staff[:])
    Duration(1, 1)

```

Return none when more than one multiplier is likely:

```

    abjad> staff = Staff(notetools.make_notes([0, 2, 4, 5], [(3, 16), (7, 32)]))
    abjad> f(staff)
    \new Staff {
        c'8.
        d'8..
        e'8.
        f'8..
    }
    abjad> componenttools.get_likely_multiplier_of_components(staff[:]) is None
    True

```

Return fraction or none.

componenttools.get_nth_component_in_expr

`abjad.tools.componenttools.get_nth_component_in_expr(expr, classes, n=0)`

New in version 1.1. Get component *n* in the *classes* of *expr*:

```

    abjad> staff = Staff([])
    abjad> durations = [Duration(n, 16) for n in range(1, 5)]
    abjad> notes = notetools.make_notes([0, 2, 4, 5], durations)
    abjad> rests = resttools.make_rests(durations)
    abjad> from abjad.tools import sequencetools
    abjad> leaves = sequencetools.interlace_sequences(notes, rests)
    abjad> staff.extend(leaves)

    abjad> print staff.format
    \new Staff {
        c'16
        r16
        d'8
        r8
        e'8.
        r8.
        f'4
        r4
    }

```

```

abjad> for n in range(4):
...     componenttools.get_nth_component_in_expr(staff, Note, n)
...
Note("c'16")
Note("d'8")
Note("e'8.")
Note("f'4")

abjad> for n in range(4):
...     componenttools.get_nth_component_in_expr(staff, Rest, n)
...
Rest('r16')
Rest('r8')
Rest('r8.')
Rest('r4')

abjad> componenttools.get_nth_component_in_expr(staff, Staff)
Staff{8}

```

Read right-to-left for negative values of n :

```

abjad> for n in range(3, -1, -1):
...     componenttools.get_nth_component_in_expr(staff, Rest, n)
...
Rest('r4')
Rest('r8.')
Rest('r8')
Rest('r16')

```

Return component or none. Changed in version 2.0: renamed `iterate.get_nth()` to `componenttools.get_nth_component_in_expr()`.

componenttools.get_nth_namesake_from_component

`abjad.tools.componenttools.get_nth_namesake_from_component(component, n)`

New in version 2.0. For positive n , return namesake to the right of *component*:

```

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> componenttools.get_nth_namesake_from_component(t[1], 1)
Note("e'8")

```

For negative n , return namesake to the left of *component*:

```

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> componenttools.get_nth_namesake_from_component(t[1], -1)
Note("c'8")

```

Return *component* when n is zero:

```

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> componenttools.get_nth_namesake_from_component(t[1], 0)
Note("d'8")

```

Return component or none.

componenttools.get_parent_and_start_stop_indices_of_components

`abjad.tools.componenttools.get_parent_and_start_stop_indices_of_components` (*components*)

New in version 1.1. Get parent and start / stop indices of *components*:

```
abjad> t = Staff("c'8 d'8 e'8 f'8 g'8 a'8")
abjad> print t.format
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
}

abjad> leaves = t[-2:]
abjad> leaves
[Note("g'8"), Note("a'8")]
abjad> componenttools.get_parent_and_start_stop_indices_of_components(leaves)
(Staff{6}, 4, 5)
```

Return parent / start index / stop index triple. Return parent as component or none. Return nonnegative integer start index and nonnegative index stop index. Changed in version 2.0: renamed `componenttools.get_with_indices()` to `componenttools.get_parent_and_start_stop_indices_of_components()`.

componenttools.get_proper_parentage_of_component

`abjad.tools.componenttools.get_proper_parentage_of_component` (*component*)

New in version 1.1. Get proper parentage of *component*:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> staff = Staff([tuplet])
abjad> note = staff.leaves[0]
abjad> componenttools.get_proper_parentage_of_component(note)
(FixedDurationTuplet(1/4, [c'8, d'8, e'8]), Staff{1})
```

Return tuple of zero or more components.

componenttools.is_beamable_component

`abjad.tools.componenttools.is_beamable_component` (*expr*)

New in version 1.1. True when *expr* is a beamable component. Otherwise false:

```
abjad> componenttools.is_beamable_component(Note(13, (1, 16)))
True
```

Return boolean.

componenttools.is_orphan_component

`abjad.tools.componenttools.is_orphan_component` (*component*)

New in version 1.1. True when *component* has no parent. Otherwise false:

```
abjad> note = Note("c'4")
abjad> componenttools.is_orphan_component(note)
True
```

Return boolean. Changed in version 2.0: renamed `componenttools.component_is_orphan()` to `componenttools.is_orphan_component()`.

componenttools.is_well_formed_component

`abjad.tools.componenttools.is_well_formed_component` (*expr*, *al-*
low_empty_containers=True)

New in version 1.1. True when *component* is well formed:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> componenttools.is_well_formed_component(staff)
True
```

Otherwise false:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> staff[1].written_duration = Duration(1, 4)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, d'4, e'8, f'8)
abjad> componenttools.is_well_formed_component(staff)
False
```

Beamed quarter notes are not well formed.

Return boolean.

componenttools.iterate_components_backward_in_expr

`abjad.tools.componenttools.iterate_components_backward_in_expr` (*expr*,
klass=<class
'ab-
jad.tools.componenttools._Component._C
start=0,
stop=None)

New in version 1.1. Iterate components backward in *expr*:

```
abjad> staff = Staff(tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_not
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(sta
abjad> f(staff)
\new Staff {
  \times 2/3 {
    c'8
    d'8
    e'8
  }
  \times 2/3 {
    f'8
    g'8
    a'8
  }
}
```

```
abjad> for x in componenttools.iterate_components_backward_in_expr(staff, Note):
...     x
...
Note("a'8")
Note("g'8")
Note("f'8")
Note("e'8")
Note("d'8")
Note("c'8")
```

New in version 2.0: optional *start* and *stop* keyword parameters.

```
abjad> for x in componenttools.iterate_components_backward_in_expr(staff, Note, start = 0, stop
...     x
...
Note("a'8")
Note("g'8")
Note("f'8")
Note("e'8")

abjad> for x in componenttools.iterate_components_backward_in_expr(staff, Note, start = 4):
...     x
...
Note("d'8")
Note("c'8")

abjad> for x in componenttools.iterate_components_backward_in_expr(staff, Note, start = 4, stop
...     x
...
Note("d'8")
Note("c'8")
```

This function is thread-agnostic. Changed in version 2.0: renamed `iterate.backwards()` to `componenttools.iterate_components_backward_in_expr()`.

componenttools.iterate_components_depth_first

```
abjad.tools.componenttools.iterate_components_depth_first(component,
                                                         capped=True,
                                                         unique=True,      for-
                                                         bid=None,          direc-
                                                         tion='left')
```

New in version 1.1. Iterate components depth-first from *component*.

Todo

Add usage examples.

Changed in version 2.0: renamed `iterate.depth_first()` to `componenttools.iterate_components_depth_first()`.

componenttools.iterate_components_forward_in_expr

```
abjad.tools.componenttools.iterate_components_forward_in_expr(expr,
                                                             klass=<class 'ab-
                                                             jad.tools.componenttools._Component._C
                                                             start=0,
                                                             stop=None)
```

New in version 1.1. Iterate components forward in *expr*:

```
abjad> container = Container(Voice(notetools.make_repeated_notes(2)) * 2)
abjad> container.is_parallel = True
abjad> container[0].name = 'voice 1'
abjad> container[1].name = 'vocie 2'
abjad> staff = Staff(container * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
    <<
        \context Voice = "voice 1" {
            c'8
            d'8
        }
        \context Voice = "vocie 2" {
            e'8
            f'8
        }
    >>
    <<
        \context Voice = "voice 1" {
            g'8
            a'8
        }
        \context Voice = "vocie 2" {
            b'8
            c''8
        }
    >>
}
abjad> for x in componenttools.iterate_components_forward_in_expr(staff, Note):
...     x
...
Note("c'8")
Note("d'8")
Note("e'8")
Note("f'8")
Note("g'8")
Note("a'8")
Note("b'8")
Note("c''8")
```

New in version 2.0: optional *start* and *stop* keyword parameters.

```
abjad> for x in componenttools.iterate_components_forward_in_expr(staff, Note, start = 0, stop =
...     x
...
Note("c'8")
Note("d'8")
Note("e'8")
Note("f'8")
```

```

abjad> for x in componenttools.iterate_components_forward_in_expr(staff, Note, start = 4):
...     x
...
Note("g'8")
Note("a'8")
Note("b'8")
Note("c''8")

abjad> for x in componenttools.iterate_components_forward_in_expr(staff, Note, start = 4, stop = 5):
...     x
...
Note("g'8")
Note("a'8")

```

This function is thread-agnostic. Changed in version 2.0: renamed `iterate.naive()` to `componenttools.iterate_components_forward_in_expr()`. Changed in version 2.0: *klass* now defaults to `_Component`.

`componenttools.iterate_namesakes_backward_from_component`

`abjad.tools.componenttools.iterate_namesakes_backward_from_component` (*component*,
start=0,
stop=None)

New in version 2.0. Iterate namesakes backward from *component*:

```

abjad> container = Container(Staff(notetools.make_repeated_notes(2)) * 2)
abjad> container.is_parallel = True
abjad> container[0].name = 'staff 1'
abjad> container[1].name = 'staff 2'
abjad> score = Score([])
abjad> score.is_parallel = False
abjad> score.extend(container * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> print score.format
\new Score {
  <<
    \context Staff = "staff 1" {
      c'8
      d'8
    }
    \context Staff = "staff 2" {
      e'8
      f'8
    }
  >>
  <<
    \context Staff = "staff 1" {
      g'8
      a'8
    }
    \context Staff = "staff 2" {
      b'8
      c''8
    }
  >>
}

```

```

abjad> for staff in componenttools.iterate_namesakes_backward_from_component(score[-1][0]):
...     print staff.format
...
\context Staff = "staff 1" {
    g'8
    a'8
}
\context Staff = "staff 1" {
    c'8
    d'8
}

```

Return generator.

componenttools.iterate_namesakes_forward_from_component

`abjad.tools.componenttools.iterate_namesakes_forward_from_component` (*component*,
start=0,
stop=None)

New in version 1.1. Iterate namesakes forward from *component*:

```

abjad> container = Container(Staff(notetools.make_repeated_notes(2)) * 2)
abjad> container.is_parallel = True
abjad> container[0].name = 'staff 1'
abjad> container[1].name = 'staff 2'
abjad> score = Score([])
abjad> score.is_parallel = False
abjad> score.extend(container * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> print score.format
\new Score {
    <<
        \context Staff = "staff 1" {
            c'8
            d'8
        }
        \context Staff = "staff 2" {
            e'8
            f'8
        }
    >>
    <<
        \context Staff = "staff 1" {
            g'8
            a'8
        }
        \context Staff = "staff 2" {
            b'8
            c''8
        }
    >>
}

abjad> for staff in componenttools.iterate_namesakes_forward_from_component(score[0][0]):
...     print staff.format
...
\context Staff = "staff 1" {

```

```

        c'8
        d'8
    }
    \context Staff = "staff 1" {
        g'8
        a'8
    }
}

```

Return generator.

componenttools.iterate_timeline_backward_from_component

`abjad.tools.componenttools.iterate_timeline_backward_from_component` (*expr*, *klass=None*)

New in version 2.0. Iterate timeline backward from *component*:

```

abjad> score = Score([])
abjad> score.append(Staff(notetools.make_repeated_notes(4, Duration(1, 4))))
abjad> score.append(Staff(notetools.make_repeated_notes(4)))
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'4
    d'4
    e'4
    f'4
  }
  \new Staff {
    g'8
    a'8
    b'8
    c''8
  }
>>
abjad> for leaf in componenttools.iterate_timeline_backward_from_component(score[1][2]):
...     leaf
...
Note("b'8")
Note("c'4")
Note("a'8")
Note("g'8")

```

Yield components sorted backward by score offset stop time.

Iterate leaves when *klass* is none.

Todo

optimize to avoid behind-the-scenes full-score traversal.

componenttools.iterate_timeline_backward_in_expr

`abjad.tools.componenttools.iterate_timeline_backward_in_expr` (*expr*, *klass=None*)

New in version 2.0. Iterate timeline backward in *expr*:

```
abjad> score = Score([])
abjad> score.append(Staff(notetools.make_repeated_notes(4, Duration(1, 4))))
abjad> score.append(Staff(notetools.make_repeated_notes(4)))
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'4
    d'4
    e'4
    f'4
  }
  \new Staff {
    g'8
    a'8
    b'8
    c''8
  }
>>
abjad> for leaf in componenttools.iterate_timeline_backward_in_expr(score):
...     leaf
...
Note("f'4")
Note("e'4")
Note("d'4")
Note("c''8")
Note("b'8")
Note("c'4")
Note("a'8")
Note("g'8")
```

Iterate leaves when *klass* is none.

Todo

optimize to avoid behind-the-scenes full-score traversal.

componenttools.iterate_timeline_forward_from_component

abjad.tools.componenttools.**iterate_timeline_forward_from_component**(*expr*,
 klass=None)

New in version 2.0. Iterate timeline forward from *component*:

```
abjad> score = Score([])
abjad> score.append(Staff(notetools.make_repeated_notes(4, Duration(1, 4))))
abjad> score.append(Staff(notetools.make_repeated_notes(4)))
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'4
    d'4
    e'4
    f'4
  }
  \new Staff {
```

```

        g'8
        a'8
        b'8
        c''8
    }
>>
abjad> for leaf in componenttools.iterate_timeline_forward_from_component(score[1][2]):
...     leaf
...
Note("b'8")
Note("c''8")
Note("e'4")
Note("f'4")

```

Iterate leaves when *klass* is none.

Todo

optimize to avoid behind-the-scenes full-score traversal.

componenttools.iterate_timeline_forward_in_expr

abjad.tools.componenttools.**iterate_timeline_forward_in_expr**(*expr*, *klass=None*)

New in version 2.0. Iterate timeline forward in *expr*:

```

abjad> score = Score([])
abjad> score.append(Staff(notetools.make_repeated_notes(4, Duration(1, 4))))
abjad> score.append(Staff(notetools.make_repeated_notes(4)))
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'4
    d'4
    e'4
    f'4
  }
  \new Staff {
    g'8
    a'8
    b'8
    c''8
  }
>>
abjad> for leaf in componenttools.iterate_timeline_forward_in_expr(score):
...     leaf
...
Note("c'4")
Note("g'8")
Note("a'8")
Note("d'4")
Note("b'8")
Note("c''8")
Note("e'4")
Note("f'4")

```

Iterate leaves when *klass* is none.

Todo

optimize to avoid behind-the-scenes full-score traversal.

componenttools.list_badly_formed_components_in_expr

`abjad.tools.componenttools.list_badly_formed_components_in_expr(expr, al-
low_empty_containers=True)`

New in version 1.1. List badly formed components in *expr*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> staff[1].written_duration = Duration(1, 4)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, d'4, e'8, f'8)
abjad> f(staff)
\new Staff {
    c'8 [
    d'4
    e'8
    f'8 ]
}
abjad> componenttools.list_badly_formed_components_in_expr(staff)
[Note("d'4")]
```

Beamed quarter notes are not well formed.

Return newly created list of zero or more components.

componenttools.list_improper_contents_of_component_that_cross_prolated_offset

`abjad.tools.componenttools.list_improper_contents_of_component_that_cross_prolated_offset(component)`

New in version 2.0. List improper contents of *component* that cross *prolated_offset*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
    e'8
    f'8
  }
}
```

Examples refer to the score above.

No components cross prolated offset 0:

```
abjad> componenttools.list_improper_contents_of_component_that_cross_prolated_offset(staff, 0)
[]
```

Staff, measure and leaf cross prolated offset 1/16:

```
abjad> componenttools.list_improper_contents_of_component_that_cross_prolated_offset(staff, Duration(1/16),
[Staff{2}, Measure(2/8, [c'8, d'8]), Note("c'8")])
```

Staff and measure cross prolated offset 1/8:

```
abjad> componenttools.list_improper_contents_of_component_that_cross_prolated_offset(staff, Duration(1/8),
[Staff{2}, Measure(2/8, [c'8, d'8])])
```

Staff crosses prolated offset 1/4:

```
abjad> componenttools.list_improper_contents_of_component_that_cross_prolated_offset(staff, Duration(1/4),
[Staff{2}])
```

No components cross prolated offset 99:

```
abjad> componenttools.list_improper_contents_of_component_that_cross_prolated_offset(staff, 99)
[]
```

Return list.

componenttools.list_leftmost_components_with_prolated_duration_at_most

`abjad.tools.componenttools.list_leftmost_components_with_prolated_duration_at_most` (*component*, *pro-
lated_duration*)

New in version 2.0. List leftmost components in *component* with prolated duration at most *prolated_duration*.

Return tuple of components[:i] together with the prolated duration of components[:i]:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> componenttools.list_leftmost_components_with_prolated_duration_at_most(voice[:], Duration(1/4),
([Note("c'8"), Note("d'8")], Duration(1, 4)))
```

Maximize i such that the prolated duration of components[:i] is no greater than *prolated_duration*.

Input *components* must be thread-contiguous.

Todo

implement `componenttools.list_leftmost_components_with_prolated_duration_at_least()`.

Todo

implement `componenttools.list_rightmost_components_with_prolated_duration_at_most()`.

Todo

implement `componenttools.list_rightmost_components_with_prolated_duration_at_least()`.

Changed in version 2.0: renamed `componenttools.get_le_duration_prolated()` to `componenttools.list_leftmost_components_with_prolated_duration_at_most()`.

componenttools.move_component_subtree_to_right_in_immediate_parent_of_component

abjad.tools.componenttools.**move_component_subtree_to_right_in_immediate_parent_of_component**

New in version 2.0. Move *component* subtree to right in immediate parent of *component*:

```
abjad> t = Voice("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(t[:2])
BeamSpanner(c'8, d'8)
abjad> spannertools.BeamSpanner(t[2:])
BeamSpanner(e'8, f'8)
abjad> f(t)
\new Voice {
    c'8 [
    d'8 ]
    e'8 [
    f'8 ]
}

abjad> componenttools.move_component_subtree_to_right_in_immediate_parent_of_component(t[1])
abjad> f(t)
\new Voice {
    c'8 [
    e'8 ]
    d'8 [
    f'8 ]
}
```

Return none.

Todo

add `n = 1` keyword to generalize flipped distance.

Todo

make `componenttools.move_component_subtree_to_right_in_immediate_parent_of_component()` work when spanners attach to children of component:

```
abjad> voice = Voice(tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_note(4, 'c')))
abjad> spannertools.BeamSpanner(voice.leaves[:4])
BeamSpanner(c'8, c'8, c'8, c'8)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> componenttools.move_component_subtree_to_right_in_immediate_parent_of_component(voice[0])
abjad> f(voice)
\new Voice {
    \times 2/3 {
        f'8 ]
        g'8
        a'8
    }
    \times 2/3 {
        c'8 [
        d'8
        e'8
    }
}
```

```
abjad> componenttools.is_well_formed_component(voice)
False
```

Preserve spanners. Changed in version 2.0: renamed `componenttools.flip()` to `componenttools.move_component_subtree_to_right_in_immediate_parent_of_component()`.

componenttools.move_parentage_and_spanners_from_components_to_components

```
abjad.tools.componenttools.move_parentage_and_spanners_from_components_to_components(donors,
re-
cip-
i-
ents)
```

New in version 1.1. Move parentage and spanners from *donors* to *recipients*.

Give everything from donors to recipients. Almost exactly the same as container `setitem` logic. This helper works with orphan donors. Container `setitem` logic can not work with orphan donors. Return donors. Changed in version 2.0: renamed `scoretools.bequeath()` to `componenttools.move_parentage_and_spanners_from_components_to_components()`.

componenttools.number_is_between_prolated_start_and_stop_offsets_of_component

```
abjad.tools.componenttools.number_is_between_prolated_start_and_stop_offsets_of_component(
c
H
n
```

New in version 2.0. True when *timepoint* is within the prolated duration of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> leaf = staff.leaves[0]
abjad> componenttools.number_is_between_prolated_start_and_stop_offsets_of_component(Duration(1,
True
abjad> componenttools.number_is_between_prolated_start_and_stop_offsets_of_component(Duration(1,
True
```

Otherwise false:

```
abjad> componenttools.number_is_between_prolated_start_and_stop_offsets_of_component(Duration(1,
False
```

Return boolean.

componenttools.number_is_between_start_and_stop_offsets_of_component_in_seconds

```
abjad.tools.componenttools.number_is_between_start_and_stop_offsets_of_component_in_seconds
```

New in version 2.0. True when *timepoint* is within the duration of *component* in seconds:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.TempoMark(Duration(1, 2), 60, target_context = Staff)(staff)
TempoMark(2, 60)(Staff{4})
```

```
abjad> leaf = staff.leaves[0]
abjad> componenttools.number_is_between_start_and_stop_offsets_of_component_in_seconds(0.1, leaf)
True
abjad> componenttools.number_is_between_start_and_stop_offsets_of_component_in_seconds(0.333, leaf)
True
```

Otherwise false:

```
abjad> componenttools.number_is_between_start_and_stop_offsets_of_component_in_seconds(0.5, staff)
False
```

Return boolean.

componenttools.partition_components_cyclically_by_durations_in_seconds_exactly_with_overhang

```
abjad.tools.componenttools.partition_components_cyclically_by_durations_in_seconds_exactly_with_overhang
```

New in version 1.1. Partition *components* cyclically by *durations_in_seconds* exactly with overhang.

componenttools.partition_components_cyclically_by_durations_in_seconds_exactly_without_overhang

```
abjad.tools.componenttools.partition_components_cyclically_by_durations_in_seconds_exactly_without_overhang
```

New in version 1.1. Partition *components* cyclically by *durations_in_seconds* exactly without overhang.

componenttools.partition_components_cyclically_by_durations_in_seconds_ge_with_overhang

```
abjad.tools.componenttools.partition_components_cyclically_by_durations_in_seconds_ge_with_overhang
```

New in version 1.1. Partition *components* cyclically by durations in seconds greater than or equal to *durations_in_seconds*, with overhang.

componenttools.partition_components_cyclically_by_durations_in_seconds_ge_without_overhang

```
abjad.tools.componenttools.partition_components_cyclically_by_durations_in_seconds_ge_without_overhang
```

New in version 1.1. Partition *components* cyclically by durations in seconds that are equal to or just greater than *durations_in_seconds*, without overhang.

`componenttools.partition_components_cyclically_by_durations_in_seconds_le_with_overhang`

`abjad.tools.componenttools.partition_components_cyclically_by_durations_in_seconds_le_with`

New in version 1.1. Partition *components* cyclically by durations in seconds equal to or just less than *durations_in_seconds*, with overhang.

`componenttools.partition_components_cyclically_by_durations_in_seconds_le_without_overhang`

`abjad.tools.componenttools.partition_components_cyclically_by_durations_in_seconds_le_with`

New in version 1.1. Partition *components* cyclically by durations in seconds that equal or are just less than *durations_in_seconds*, without overhang

`componenttools.partition_components_cyclically_by_prolated_durations_exactly_with_overhang`

`abjad.tools.componenttools.partition_components_cyclically_by_prolated_durations_exactly_w`

New in version 1.1. Partition *components* cyclically by *prolated_durations* exactly, with overhang.

`componenttools.partition_components_cyclically_by_prolated_durations_exactly_without_overhang`

`abjad.tools.componenttools.partition_components_cyclically_by_prolated_durations_exactly_w`

New in version 1.1. Partition *components* cyclically by *prolated_durations* exactly, without overhang.

`componenttools.partition_components_cyclically_by_prolated_durations_ge_with_overhang`

`abjad.tools.componenttools.partition_components_cyclically_by_prolated_durations_ge_with_ov`

New in version 1.1. Partition *components* cyclically by *prolated_durations* greater than or equal, with overhang:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 4)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
    e'8
    f'8
  }
}
```

```
\time 2/8
g'8
a'8
}
{
\time 2/8
b'8
c''8
}
}
```

```
abjad> groups = componenttools.partition_components_cyclically_by_prolated_durations_ge_with_ove
```

```
abjad> for group in groups:
...     group
...
[Note("c'8"), Note("d'8")]
[Note("e'8")]
[Note("f'8"), Note("g'8")]
[Note("a'8")]
[Note("b'8"), Note("c''8")]
```

Return list of lists.

Note: function works not just on components but on any durated objects including spanners.

componenttools.partition_components_cyclically_by_prolated_durations_ge_without_overhang

```
abjad.tools.componenttools.partition_components_cyclically_by_prolated_durations_ge_without
```

New in version 1.1. Partition *components* cyclically by prolated durations that equal or are just greater than *prolated_durations*, without overhang.

componenttools.partition_components_cyclically_by_prolated_durations_le_with_overhang

```
abjad.tools.componenttools.partition_components_cyclically_by_prolated_durations_le_with_ov
```

New in version 1.1. Partition *components* cyclically by prolated duration that equal or are just less than *prolated_durations*, with overhang.

componenttools.partition_components_cyclically_by_prolated_durations_le_without_overhang

```
abjad.tools.componenttools.partition_components_cyclically_by_prolated_durations_le_without
```

New in version 1.1. Partition *components* cyclically by prolated durations that equal or are just less than *prolated_durations*, without overhang.

componenttools.partition_components_once_by_durations_in_seconds_exactly_with_overhang

```
abjad.tools.componenttools.partition_components_once_by_durations_in_seconds_exactly_with_o
```

New in version 1.1. Partition *components* once by *durations_in_seconds* exactly, with overhang.

componenttools.partition_components_once_by_durations_in_seconds_exactly_without_overhang

```
abjad.tools.componenttools.partition_components_once_by_durations_in_seconds_exactly_witho
```

New in version 1.1. Partition *components* cyclically by *durations_in_seconds* exactly, without overhang.

componenttools.partition_components_once_by_durations_in_seconds_ge_with_overhang

```
abjad.tools.componenttools.partition_components_once_by_durations_in_seconds_ge_with_overh
```

New in version 1.1. Partition *components* once by durations in seconds that equal or are just greater than *durations_in_seconds*, with overhang.

componenttools.partition_components_once_by_durations_in_seconds_ge_without_overhang

```
abjad.tools.componenttools.partition_components_once_by_durations_in_seconds_ge_without_ov
```

New in version 1.1. Partition *components* once by durations in seconds that equal or are just greater than *durations_in_seconds*, without overhang.

componenttools.partition_components_once_by_durations_in_seconds_le_with_overhang

```
abjad.tools.componenttools.partition_components_once_by_durations_in_seconds_le_with_overh
```

New in version 1.1. Partition *components* once by durations in seconds that equal or are just less than *durations_in_seconds*, with overhang.

componenttools.partition_components_once_by_durations_in_seconds_le_without_overhang

```
abjad.tools.componenttools.partition_components_once_by_durations_in_seconds_le_without_ov
```

New in version 1.1. Partition *components* once by durations in seconds that equal or are just less than *durations_in_seconds*, without overhang.

componenttools.partition_components_once_by_prolated_durations_exactly_with_overhang

```
abjad.tools.componenttools.partition_components_once_by_prolated_durations_exactly_with_overhang
```

New in version 1.1. Partition *components* once by *prolated_durations* exactly, with overhang.

componenttools.partition_components_once_by_prolated_durations_exactly_without_overhang

```
abjad.tools.componenttools.partition_components_once_by_prolated_durations_exactly_without_overhang
```

New in version 1.1. Partition *components* once by *prolated_durations* exactly, without overhang.

componenttools.partition_components_once_by_prolated_durations_ge_with_overhang

```
abjad.tools.componenttools.partition_components_once_by_prolated_durations_ge_with_overhang
```

New in version 1.1. Partition *components* cyclically by prolated durations that equal or are just greater than *prolated_durations*, with overhang.

componenttools.partition_components_once_by_prolated_durations_ge_without_overhang

```
abjad.tools.componenttools.partition_components_once_by_prolated_durations_ge_without_overhang
```

New in version 1.1. Partition *components* cyclically by prolated durations that equal or are just greater than *prolated_durations*, without overhang.

componenttools.partition_components_once_by_prolated_durations_le_with_overhang

```
abjad.tools.componenttools.partition_components_once_by_prolated_durations_le_with_overhang
```

New in version 1.1. Partition *components* once by prolated durations that equal or are just less than *prolated_durations*, with overhang.

componenttools.partition_components_once_by_prolated_durations_le_without_overhang

```
abjad.tools.componenttools.partition_components_once_by_prolated_durations_le_without_overhang
```

New in version 1.1. Partition *components* once by prolated durations that equal or are just less than *prolated_durations*, without overhang.

componenttools.remove_component_subtree_from_score_and_spanners

```
abjad.tools.componenttools.remove_component_subtree_from_score_and_spanners(components)
```

New in version 1.1. Remove arbitrary *components* and children of *components* from score and spanners:

```

abjad> score = Voice(notetools.make_repeated_notes(2))
abjad> score.insert(1, Container(notetools.make_repeated_notes(2)))
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> spannertools.BeamSpanner(score.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> spannertools.GlissandoSpanner(score.leaves)
GlissandoSpanner(c'8, d'8, e'8, f'8)

abjad> f(score)
\new Voice {
  c'8 [ \glissando
  {
    d'8 \glissando
    e'8 \glissando
  }
  f'8 ]
}

```

Examples refer to the score above.

Remove one leaf from score:

```

abjad> componenttools.remove_component_subtree_from_score_and_spanners(score.leaves[1:2]) # doctest: +SKIP
(Note(d', 8),)

abjad> f(score) # doctest: +SKIP
\new Voice {
  c'8 [ \glissando
  {
    e'8 \glissando
  }
  f'8 ]
}

```

Remove contiguous leaves from score:

```

abjad> result = componenttools.remove_component_subtree_from_score_and_spanners(score.leaves[:2])
(Note(c', 8), Note(d', 8))

abjad> f(score) # doctest: +SKIP
\new Voice {
  {
    e'8 [ \glissando
  }
  f'8 ]
}

```

Remove noncontiguous leaves from score:

```

abjad> componenttools.remove_component_subtree_from_score_and_spanners([score.leaves[0], score.leaves[2]])
[Note(c', 8), Note(e', 8)]

abjad> f(score) # doctest: +SKIP
\new Voice {
  {
    d'8 [ \glissando
  }
  f'8 ]
}

```


Remove container from score:

```
abjad> result = componenttools.remove_component_subtree_from_score_and_spanners(score[1:2])
abjad> result # doctest: +SKIP
[{d'8, e'8}]

abjad> f(score) # doctest: +SKIP
\new Voice {
    c'8 [ \glissando
    f'8 ]
}
```

Withdraw *components* and children of *components* from spanners.

Return either tuple or list of *components* and children of *components*.

Todo

regularize return value of function.

Note: rename to `componenttools.remove_components_from_score_deep()`.

Changed in version 2.0: renamed `componenttools.detach()` to `componenttools.remove_component_subtree_from_score_and_spanners()`.

componenttools.replace_components_with_children_of_components

`abjad.tools.componenttools.replace_components_with_children_of_components(components)`
 New in version 1.1. Remove arbitrary *components* from score but retain children of *components* in score:

```
abjad> staff = Staff(Container(notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> spannertools.SlurSpanner(staff[:])
SlurSpanner({c'8, d'8}, {e'8, f'8})
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
    {
        c'8 [ (
        d'8
    }
    {
        e'8
        f'8 ] )
    }
}

abjad> componenttools.replace_components_with_children_of_components(staff[0:1])
[{}]
```

```
abjad> f(staff)
\new Staff {
    c'8 [ (
    d'8
```

```

    {
        e'8
        f'8 ] )
    }
}

```

Return *components*.

Note: should be renamed to `componenttools.remove_components_from_score_shallow()`

Changed in version 2.0: renamed `componenttools.slip()` to `componenttools.replace_components_with_children_of_components()`.

componenttools.report_component_format_contributions_as_string

`abjad.tools.componenttools.report_component_format_contributions_as_string(component, verbose=False)`

New in version 1.1. Report *component* format contributions as string.

Set *verbose* to True or False.

componenttools.split_component_at_prolated_duration_and_do_not_fracture_crossing_spanners

`abjad.tools.componenttools.split_component_at_prolated_duration_and_do_not_fracture_crossing_spanners(component, prolated_duration)`

New in version 1.1. Split *component* at *prolated_duration* and do not fracture crossing spanners.

Leave spanners untouched.

Return split parts:

```

abjad> t = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> spannertools.BeamSpanner(t[0])
BeamSpanner(|2/8(2)|)
abjad> spannertools.BeamSpanner(t[1])
BeamSpanner(|2/8(2)|)
abjad> spannertools.SlurSpanner(t.leaves)
SlurSpanner(c'8, d'8, e'8, f'8)
abjad> f(t)
\new Staff {
    {
        \time 2/8
        c'8 [ (
        d'8 ]
    }
    {
        \time 2/8
        e'8 [
        f'8 ] )
    }
}

```

```

abjad> halves = componenttools.split_component_at_prolated_duration_and_do_not_fracture_crossing
abjad> f(t)
\new Staff {
  {
    \time 2/8
    c'32 [ (
    c'16.
    d'8 ]
  }
  {
    \time 2/8
    e'8 [
    f'8 ] )
  }
}

```

Works on both leaves and containers. Changed in version 2.0: renamed `split.unfractured_at_duration()` to `componenttools.split_component_at_prolated_duration_and_do_not_fracture_crossing_spanners()`

`componenttools.split_component_at_prolated_duration_and_fracture_crossing_spanners`

`abjad.tools.componenttools.split_component_at_prolated_duration_and_fracture_crossing_spanners`

New in version 1.1. Split *component* at *prolated_duration* and fracture crossing spanners.

Return split parts:

```

abjad> t = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> spannertools.BeamSpanner(t[0])
BeamSpanner(|2/8(2)|)
abjad> spannertools.BeamSpanner(t[1])
BeamSpanner(|2/8(2)|)
abjad> spannertools.SlurSpanner(t.leaves)
SlurSpanner(c'8, d'8, e'8, f'8)
abjad> f(t)
\new Staff {
  {
    \time 2/8
    c'8 [ (
    d'8 ]
  }
  {
    \time 2/8
    e'8 [
    f'8 ] )
  }
}

halves = componenttools.split_component_at_prolated_duration_and_fracture_crossing_spanners(t.leaves)
\new Staff {
  {
    \time 2/8
    c'32 () [
    c'16. (

```

```

        d'8 ]
    }
    {
        \time 2/8
        e'8 [
        f'8 ] )
    }
}

```

Function works on both leaves and containers. Changed in version 2.0: renamed `split.fractured_at_duration()` to `componenttools.split_component_at_prolated_duration_and`

componenttools.split_components_cyclically_by_prolated_durations_and_do_not_fracture_crossing_spanners

`abjad.tools.componenttools.split_components_cyclically_by_prolated_durations_and_do_not_fracture_crossing_spanners`

New in version 1.1. Partition *components* cyclically by prolated *durations* and do not fracture spanners:

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> spannertools.BeamSpanner(staff[0])
BeamSpanner(|2/8(2)|)
abjad> spannertools.BeamSpanner(staff[1])
BeamSpanner(|2/8(2)|)
abjad> spannertools.SlurSpanner(staff.leaves)
SlurSpanner(c'8, d'8, e'8, f'8)
abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8 [ (
        d'8 ]
    }
    {
        \time 2/8
        e'8 [
        f'8 ] )
    }
}

abjad> durations = [Duration(3, 32)]
abjad> componenttools.split_components_cyclically_by_prolated_durations_and_do_not_fracture_crossing_spanners(
[[Note("c'16."), [Note("c'32"), Note("d'16")],
[Note("d'16"), Note("e'32")], [Note("e'16."), [Note("f'16."), [Note("f'32")]]]

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'16. [ (
        c'32
        d'16
        d'16 ]
    }
}

```

```
{
    \time 2/8
    e'32 [
    e'16.
    f'16.
    f'32 ] )
}
}
```

Return list of partitioned components. Changed in version 2.0:
renamed `partition.cyclic_unfractured_by_durations()` to
`componenttools.split_components_cyclically_by_prolated_durations_and_do_not_fracture_c`

componenttools.split_components_cyclically_by_prolated_durations_and_fracture_crossing_spanners

`abjad.tools.componenttools.split_components_cyclically_by_prolated_durations_and_fracture_c`

New in version 1.1. Partition *components* cyclically by prolated *durations* and fracture spanners:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> spannertools.BeamSpanner(staff[0])
BeamSpanner(|2/8(2)|)
abjad> spannertools.BeamSpanner(staff[1])
BeamSpanner(|2/8(2)|)
abjad> spannertools.SlurSpanner(staff.leaves)
SlurSpanner(c'8, d'8, e'8, f'8)
abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8 [ (
        d'8 ]
    }
    {
        \time 2/8
        e'8 [
        f'8 ] )
    }
}

abjad> durations = [Duration(3, 32)]
abjad> componenttools.split_components_cyclically_by_prolated_durations_and_fracture_crossing_sp
[[Note("c'16."), [Note("c'32"), Note("d'16")], [Note("d'16"), Note("e'32")],
[Note("e'16."), [Note("f'16."), [Note("f'32")]]]

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'16. ( ) [
        c'32 (
        d'16 )
        d'16 ] (
```

```

    }
    {
        \time 2/8
        e'32 ) [
        e'16. (
        f'16. )
        f'32 ] ( )
    }
}

```

Return list of partitioned components. Changed in version 2.0: renamed `partition.cyclic_fractured_by_durations()` to `componenttools.split_components_cyclically_`

componenttools.split_components_once_by_prolated_durations_and_do_not_fracture_crossing_spanners

`abjad.tools.componenttools.split_components_once_by_prolated_durations_and_do_not_fracture_cr`

New in version 1.1. Split *components* once by prolated *durations* and do not fracture crossing spanners:

```

abjad> t = Staff(Container(notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> spannertools.BeamSpanner(t[0])
BeamSpanner({c'8, d'8})
abjad> spannertools.BeamSpanner(t[1])
BeamSpanner({e'8, f'8})
abjad> spannertools.SlurSpanner(t.leaves)
SlurSpanner(c'8, d'8, e'8, f'8)
abjad> f(t)
\new Staff {
    {
        c'8 [ (
        d'8 ]
    }
    {
        e'8 [
        f'8 ] )
    }
}

abjad> durations = [Duration(1, 32), Duration(3, 32), Duration(5, 32)]
abjad> parts = componenttools.split_components_once_by_prolated_durations_and_do_not_fracture_cr

abjad> f(t)
\new Staff {
    {
        c'32 [ (
    }
    {
        c'16.
    }
    {
        d'8 ]
    }
}

```

```

        e'8 [
        f'8 ] )
    }
}

```

Changed in version 2.0: renamed `partition.unfractured_by_durations()` to `componenttools.split_components_once_by_prolated_durations_and_do_not_fracture_crossing`

componenttools.split_components_once_by_prolated_durations_and_fracture_crossing

`abjad.tools.componenttools.split_components_once_by_prolated_durations_and_fracture_crossing`

New in version 1.1. Split *components* once by prolated *durations* and fracture crossing spanners:

```

abjad> t = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> spannertools.BeamSpanner(t[0])
BeamSpanner(|2/8(2)|)
abjad> spannertools.BeamSpanner(t[1])
BeamSpanner(|2/8(2)|)
abjad> spannertools.SlurSpanner(t.leaves)
SlurSpanner(c'8, d'8, e'8, f'8)
abjad> f(t)
\new Staff {
    {
        \time 2/8
        c'8 [ (
        d'8 ]
    }
    {
        \time 2/8
        e'8 [
        f'8 ] )
    }
}

abjad> durations = [Duration(1, 32), Duration(3, 32), Duration(5, 32)]
abjad> parts = componenttools.split_components_once_by_prolated_durations_and_fracture_crossing
abjad> f(t)
\new Staff {
    {
        \time 1/32
        c'32 [ ] ( )
    }
    {
        \time 3/32
        c'16. [ ] ( )
    }
    {
        \time 4/32
        d'8 [ ] (
    }
    {
        \time 2/8

```

```
        e'8 [
        f'8 ] )
    }
}
```

Changed in version 2.0: renamed `partition.fractured_by_durations()` to `componenttools.split_components_once_by_prolated_durations_and_fracture_crossing_spann`

componenttools.sum_duration_of_components_in_seconds

`abjad.tools.componenttools.sum_duration_of_components_in_seconds(components)`

New in version 1.1. Sum duration of *components* in seconds:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> score = Score([Staff([tuplet])])
abjad> contexttools.TempoMark(Duration(1, 4), 48)(score)
TempoMark(4, 48)(Score<<1>>)
abjad> f(score) # doctest: +SKIP
\\new Score <<
  \\new Staff {
    \\times 2/3 {
      \\tempo 4=48
      c'8
      d'8
      e'8
    }
  }
>>
```

```
abjad> componenttools.sum_duration_of_components_in_seconds(tuplet[:])
Duration(5, 4)
```

Changed in version 2.0: renamed `durationtools.sum_seconds()` to `componenttools.sum_duration_of_components_in_seconds()`.

componenttools.sum_preprolated_duration_of_components

`abjad.tools.componenttools.sum_preprolated_duration_of_components(components)`

New in version 1.1. Sum preprolated duration of *components*:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> componenttools.sum_preprolated_duration_of_components(tuplet[:])
Duration(3, 8)
```

Return zero on empty iterable:

```
abjad> componenttools.sum_preprolated_duration_of_components([])
0
```

Raise contiguity error on nonparent-contiguous *components*:

```
abjad> t = Voice(tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_notes(3
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> f(t)
\\new Voice {
  \\times 2/3 {
    c'8
```



```

        d'8
        e'8
    }
    \times 2/3 {
        f'8
        g'8
        a'8
    }
}
abjad> componenttools.sum_preprolated_duration_of_components(t.leaves)
Duration(3, 4)

```

Changed in version 2.0: renamed `componenttools.get_duration_preprolated()` to `componenttools.sum_preprolated_duration_of_components()`.

componenttools.sum_prolated_duration_of_components

```

abjad.tools.componenttools.sum_prolated_duration_of_components(components)
    New in version 1.1. Sum prolated duration of components:

abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> f(tuplet)
\Times 2/3 {
    c'8
    d'8
    e'8
}
abjad> componenttools.sum_prolated_duration_of_components(tuplet[:])
Duration(1, 4)

```

Changed in version 2.0: renamed `durationtools.sum_prolated()` to `componenttools.sum_prolated_duration_of_components()`.

componenttools.tabulate_well_formedness_violations_in_expr

```

abjad.tools.componenttools.tabulate_well_formedness_violations_in_expr(expr,
    al-
    low_empty_containers=True)

```

New in version 1.1. Tabulate well-formedness violations in *expr*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> staff[1].written_duration = Duration(1, 4)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, d'4, e'8, f'8)
abjad> f(staff)
\new Staff {
    c'8 [
    d'4
    e'8
    f'8 ]
}

abjad> componenttools.tabulate_well_formedness_violations_in_expr(staff)
1 / 4 beamed quarter note
0 / 1 discontinuous spanner
0 / 5 duplicate i d

```

```

0 / 1 empty container
0 / 0 intermarked hairpin
0 / 0 misdurated measure
0 / 0 misfilled measure
0 / 4 mispitched tie
0 / 4 misrepresented flag
0 / 5 missing parent
0 / 0 nested measure
0 / 0 overlapping beam
0 / 0 overlapping glissando
0 / 0 overlapping octavation
0 / 0 short hairpin

```

Beamed quarter notes are not well formed.

componenttools.yield_components_grouped_by_preprolated_duration

`abjad.tools.componenttools.yield_components_grouped_by_preprolated_duration(components)`

New in version 2.0. Yield components grouped by preprolated duration:

```

abjad> notes = notetools.make_notes([0], [(1, 4), (1, 4), (1, 8), (1, 16), (1, 16), (1, 16)])
abjad> for x in componenttools.yield_components_grouped_by_preprolated_duration(notes):
...     x
...
(Note("c'4"), Note("c'4"))
(Note("c'8"),)
(Note("c'16"), Note("c'16"), Note("c'16"))

```

Return generator.

componenttools.yield_components_grouped_by_prolated_duration

`abjad.tools.componenttools.yield_components_grouped_by_prolated_duration(components)`

New in version 2.0. Yield *component* grouped by prolated duration:

```

abjad> notes = notetools.make_notes([0], [(1, 4), (1, 4), (1, 8), (1, 16), (1, 16), (1, 16)])
abjad> for x in componenttools.yield_components_grouped_by_prolated_duration(notes):
...     x
...
(Note("c'4"), Note("c'4"))
(Note("c'8"),)
(Note("c'16"), Note("c'16"), Note("c'16"))

```

Return generator.

componenttools.yield_groups_of_mixed_klasses_in_sequence

`abjad.tools.componenttools.yield_groups_of_mixed_klasses_in_sequence(sequence, klasses)`

New in version 2.0. Yield groups of mixed *klasses* in *sequence*:

```

abjad> staff = Staff("c'8 d'8 r8 r8 <e' g'>8 <f' a'>8 g'8 a'8 r8 r8 <b' d''>8 <c'' e''>8")

abjad> f(staff)
\new Staff {
    c'8

```

```

    d'8
    r8
    r8
    <e' g'>8
    <f' a'>8
    g'8
    a'8
    r8
    r8
    <b' d''>8
    <c'' e''>8
}

```

```

abjad> for group in componenttools.yield_groups_of_mixed_klasses_in_sequence(staff, (Note, Chord)):
...     group
(Note("c'8"), Note("d'8"))
(Chord("<e' g'>8"), Chord("<f' a'>8"), Note("g'8"), Note("a'8"))
(Chord("<b' d''>8"), Chord("<c'' e''>8"))

```

Return generator.

componenttools.yield_topmost_components_grouped_by_type

`abjad.tools.componenttools.yield_topmost_components_grouped_by_type(expr)`

New in version 2.0. Yield topmost components in *expr* grouped by type:

```

abjad> staff = Staff(leaftools.make_leaves([0, 2, 4, None, None, 5, 7], [(1, 8)]))
abjad> for x in componenttools.yield_topmost_components_grouped_by_type(staff):
...     x
...
(Note("c'8"), Note("d'8"), Note("e'8"))
(Rest('r8'), Rest('r8'))
(Note("f'8"), Note("g'8"))

```

Return generator.

componenttools.yield_topmost_components_of_klass_grouped_by_type

`abjad.tools.componenttools.yield_topmost_components_of_klass_grouped_by_type(expr, klass)`

New in version 2.0. Yield topmost components of *klass* in *expr* grouped by type:

```

abjad> staff = Staff(leaftools.make_leaves([0, 2, 4, None, None, 5, 7], [(1, 8)]))
abjad> for x in componenttools.yield_topmost_components_of_klass_grouped_by_type(staff, Note):
...     x
...
(Note("c'8"), Note("d'8"), Note("e'8"))
(Note("f'8"), Note("g'8"))

```

Return generator.

containertools

containertools.Cluster

class abjad.tools.containertools.**Cluster** (*music=None, **kwargs*)

Bases: abjad.tools.containertools.Container.Container Container New in version 1.1.

Abjad model of a tone cluster container:

```
abjad> cluster = containertools.Cluster("c'8 d'8 b'8")
```

```
abjad> cluster
Cluster(c'8, d'8, b'8)
```

```
abjad> f(cluster)
\makeClusters {
    c'8
    d'8
    b'8
}
```

Return cluster object.

containertools.Container

class abjad.tools.containertools.**Container** (*music=None, **kwargs*)

Bases: abjad.tools.componenttools._Component._Component._Component

Abjad model of a music container:

```
abjad> container = Container("c'8 d'8 e'8 f'8")
abjad> f(container)
{
    c'8
    d'8
    e'8
    f'8
}
```

Return container object.

append (*component*)

Append *component* to container:

```
abjad> container = Container("c'8 d'8 e'8")
abjad> beam = spannertools.BeamSpanner(container.music)
```

```
abjad> f(container)
{
    c'8 [
    d'8
    e'8 ]
}
```

```
abjad> container.append(Note("f'8"))
```

```
abjad> f(container)
{
    c'8 [
    d'8
    e'8 ]
```

```

        f'8
    }

```

Return none.

contents_duration

duration_in_seconds

extend(*expr*)

Extend *expr* against container:

```

abjad> container = Container("c'8 d'8 e'8")
abjad> beam = spannertools.BeamSpanner(container.music)

abjad> f(container)
{
    c'8 [
    d'8
    e'8 ]
}

abjad> container.extend([Note("cs'8"), Note("ds'8"), Note("es'8")])

abjad> f(container)
{
    c'8 [
    d'8
    e'8 ]
    cs'8
    ds'8
    es'8
}

```

Return none. New in version 2.3: *expr* may now be a LilyPond input string.

index(*component*)

Index *component* in container:

```

abjad> container = Container("c'8 d'8 e'8")

abjad> note = container[-1]
abjad> note
Note("e'8")

abjad> container.index(note)
2

```

Return nonnegative integer.

insert(*i*, *component*)

Insert *component* in container at index *i*:

```

abjad> container = Container("c'8 d'8 e'8")
abjad> beam = spannertools.BeamSpanner(container.music)

abjad> f(container)
{
    c'8 [
    d'8

```

```

        e'8 ]
    }

abjad> container.insert(1, Note("cs'8"))

abjad> f(container)
{
    c'8 [
    cs'8
    d'8
    e'8 ]
}
```

Return none.

is_parallel

Get parallel container:

```

abjad> container = Container([Voice("c'8 d'8 e'8"), Voice('g4.')]

abjad> f(container)
{
    \new Voice {
        c'8
        d'8
        e'8
    }
    \new Voice {
        g4.
    }
}

abjad> container.is_parallel
False
```

Return boolean.

Set parallel container:

```

abjad> container.is_parallel = True

abjad> f(container)
<<
    \new Voice {
        c'8
        d'8
        e'8
    }
    \new Voice {
        g4.
    }
>>
```

Return none.

leaves

Read-only tuple of leaves in container:

```

abjad> container = Container("c'8 d'8 e'8")
```

```
abjad> container.leaves
(Note("c'8"), Note("d'8"), Note("e'8"))
```

Return tuple of zero or more leaves.

music

Read-only tuple of components in container:

```
abjad> container = Container("c'8 d'8 e'8")

abjad> container.music
(Note("c'8"), Note("d'8"), Note("e'8"))
```

Return tuple or zero or more components.

pop (*i=-1*)

Pop component at index *i* from container:

```
abjad> container = Container("c'8 d'8 e'8")
abjad> beam = spannertools.BeamSpanner(container.music)

abjad> f(container)
{
    c'8 [
    d'8
    e'8 ]
}

abjad> container.pop(-1)
Note("e'8")

abjad> f(container)
{
    c'8 [
    d'8 ]
}
```

Return component.

preprolated_duration

remove (*component*)

Remove *component* from container:

```
abjad> container = Container("c'8 d'8 e'8")
abjad> beam = spannertools.BeamSpanner(container.music)

abjad> f(container)
{
    c'8 [
    d'8
    e'8 ]
}

abjad> note = container[-1]
abjad> note
Note("e'8")

abjad> container.remove(note)
```

```
abjad> f(container)
{
    c'8 [
    d'8 ]
}
```

Return none.

containertools.all_are_containers

`abjad.tools.containertools.all_are_containers(expr)`
 New in version 2.6. True when *expr* is a sequence of Abjad containers:

```
abjad> containers = 3 * Container("c'8 d'8 e'8")

abjad> containertools.all_are_containers(containers)
True
```

True when *expr* is an empty sequence:

```
abjad> containertools.all_are_containers([])
True
```

Otherwise false:

```
abjad> containertools.all_are_containers('foo')
False
```

Return boolean.

Function wraps `componenttools.all_are_components()`.

containertools.color_contents_of_container

`abjad.tools.containertools.color_contents_of_container(container, color)`
 New in version 2.0. Color contents of *container*:

```
abjad> measure = Measure((2, 8), "c'8 d'8")

abjad> containertools.color_contents_of_container(measure, 'red')
Measure(2/8, [c'8, d'8])

abjad> f(measure)
{
    \override Accidental #'color = #red
    \override Beam #'color = #red
    \override Dots #'color = #red
    \override NoteHead #'color = #red
    \override Rest #'color = #red
    \override Stem #'color = #red
    \override TupletBracket #'color = #red
    \override TupletNumber #'color = #red
    \time 2/8
    c'8
    d'8
    \revert Accidental #'color
    \revert Beam #'color
}
```



```

\revert Dots #'color
\revert NoteHead #'color
\revert Rest #'color
\revert Stem #'color
\revert TupletBracket #'color
\revert TupletNumber #'color
}

```

Return `none`. Changed in version 2.0: renamed `containertools.contents_color()` to `containertools.color_contents_of_container()`.

containertools.delete_contents_of_container

`abjad.tools.containertools.delete_contents_of_container(container)`

Delete contents of *container*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

abjad> containertools.delete_contents_of_container(staff)
[Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]

abjad> f(staff)
\new Staff {
}

```

Return *container* contents. Changed in version 2.0: renamed `containertools.contents_delete()` to `containertools.delete_contents_of_container()`.

containertools.delete_contents_of_container_starting_at_or_after_prolated_offset

`abjad.tools.containertools.delete_contents_of_container_starting_at_or_after_prolated_offset`

New in version 2.0. Delete contents of *container* starting at or after *prolated_offset*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

```

```
abjad> containertools.delete_contents_of_container_starting_at_or_after_prolated_offset(staff, D
Staff{1}
```

```
abjad> f(staff)
\new Staff {
    c'8 [ ]
}
```

Return *container*. Changed in version 2.0: renamed `containertools.contents_delete_starting_not_before_prolated_offset` to `containertools.delete_contents_of_container_starting_at_or_after_prolated_offset()`.

`containertools.delete_contents_of_container_starting_before_or_at_prolated_offset`

`abjad.tools.containertools.delete_contents_of_container_starting_before_or_at_prolated_offset`

New in version 2.0. Delete contents of *container* starting before or at *prolated_offset*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
```

```
abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}
```

```
abjad> containertools.delete_contents_of_container_starting_before_or_at_prolated_offset(staff,
Staff{2})
```

```
abjad> f(staff)
\new Staff {
    e'8 [
    f'8 ]
}
```

Return *container*. Changed in version 2.0: renamed `containertools.contents_delete_starting_not_after_prolated_offset` to `containertools.delete_contents_of_container_starting_before_or_at_prolated_offset()`.

`containertools.delete_contents_of_container_starting_strictly_after_prolated_offset`

`abjad.tools.containertools.delete_contents_of_container_starting_strictly_after_prolated_offset`

New in version 2.0. Delete contents of *container* starting strictly after *prolated_offset*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
```

```
abjad> f(staff)
\new Staff {
    c'8 [
```

```

    d'8
    e'8
    f'8 ]
}

```

```

abjad> containertools.delete_contents_of_container_starting_strictly_after_prolated_offset(staff,
Staff{2})

```

```

abjad> f(staff)
\new Staff {
    c'8 [
    d'8 ]
}

```

Return *container*. Changed in version 2.0: renamed `containertools.contents_delete_starting_after_prolated_offset` to `containertools.delete_contents_of_container_starting_strictly_after_prolated_offset()`

`containertools.delete_contents_of_container_starting_strictly_before_prolated_offset`

```

abjad.tools.containertools.delete_contents_of_container_starting_strictly_before_prolated_offset(container, offset)

```

New in version 2.0. Delete contents of *container* contents starting strictly before *prolated_offset*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)

```

```

abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

```

```

abjad> containertools.delete_contents_of_container_starting_strictly_before_prolated_offset(staff,
Staff{3})

```

```

abjad> f(staff)
\new Staff {
    d'8 [
    e'8
    f'8 ]
}

```

Return *container*. Changed in version 2.0: renamed `containertools.contents_delete_starting_before_prolated_offset` to `containertools.delete_contents_of_container_starting_strictly_before_prolated_offset()`

`containertools.eject_contents_of_container`

```

abjad.tools.containertools.eject_contents_of_container(container)

```

New in version 2.0. Eject contents of *container*:

```

abjad> container = Container("c'8 d'8 e'8 f'8")

```

```

abjad> f(container)
{
    c'8
    d'8
    e'8
    f'8
}

abjad> containertools.eject_contents_of_container(container)
[Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]

abjad> container
{}

abjad> f(container)
{
}

```

Return list of *container* contents.

containertools.fuse_like_named_contiguous_containers_in_expr

`abjad.tools.containertools.fuse_like_named_contiguous_containers_in_expr(expr)`

Fuse like-named contiguous containers in *expr*:

```

abjad> staff = Staff(Voice("c'8 c'8") * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> staff[0].name = 'soprano'
abjad> staff[1].name = 'soprano'

abjad> f(staff)
\new Staff {
    \context Voice = "soprano" {
        c'8
        d'8
    }
    \context Voice = "soprano" {
        e'8
        f'8
    }
}

abjad> containertools.fuse_like_named_contiguous_containers_in_expr(staff)
Staff{1}

abjad> f(staff)
\new Staff {
    \context Voice = "soprano" {
        c'8
        d'8
        e'8
        f'8
    }
}

```

Return *expr*. Changed in version 2.0: renamed `fuse.containers_by_reference()` to `containertools.fuse_like_named_contiguous_containers_in_expr()`.

containertools.get_element_starting_at_exactly_prolated_offset

`abjad.tools.containertools.get_element_starting_at_exactly_prolated_offset` (*container*, *prolated_offset*)

New in version 2.0. Get *container* element starting at exactly *prolated_offset*:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")

abjad> containertools.get_element_starting_at_exactly_prolated_offset(voice, Duration(6, 8))
Note("b'8")
```

Raise missing component error when no *container* element starts at exactly *prolated_offset*. Changed in version 2.0: renamed `containertools.get_element_starting_at_prolated_offset()` to `containertools.get_element_starting_at_exactly_prolated_offset()`.

containertools.get_first_container_in_improper_parentage_of_component

`abjad.tools.containertools.get_first_container_in_improper_parentage_of_component` (*component*)

New in version 2.0. Get first container in improper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}

abjad> containertools.get_first_container_in_improper_parentage_of_component(staff[1])
Staff{4}
```

Return container or none.

containertools.get_first_container_in_proper_parentage_of_component

`abjad.tools.containertools.get_first_container_in_proper_parentage_of_component` (*component*)

New in version 2.0. Get first container in proper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}

abjad> containertools.get_first_container_in_proper_parentage_of_component(staff[1])
Staff{4}
```

Return container or none.

containertools.get_first_element_starting_at_or_after_prolated_offset

`abjad.tools.containertools.get_first_element_starting_at_or_after_prolated_offset` (*container*, *pro-lated_offset*)

New in version 2.0. Get first *container* element starting at or after *prolated_offset*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> containertools.get_first_element_starting_at_or_after_prolated_offset(staff, Duration(1,
Note("d'8"))
```

Return component.

Return none when no *container* element starts at or after *prolated_offset*. Changed in version 2.0: renamed `containertools.get_leftmost_element_starting_not_before_prolated_offset()` to `containertools.get_first_element_starting_at_or_after_prolated_offset()`.

containertools.get_first_element_starting_before_or_at_prolated_offset

`abjad.tools.containertools.get_first_element_starting_before_or_at_prolated_offset` (*container*, *pro-lated_offset*)

New in version 2.0. Get first *container* element starting before or at *prolated_offset*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> containertools.get_first_element_starting_before_or_at_prolated_offset(staff, Duration(1,
Note("d'8"))
```

Return component.

Return none when no *container* element starts before or at *prolated_offset*. Changed in version 2.0: renamed `containertools.get_rightmost_element_starting_not_after_prolated_offset()` to `containertools.get_first_element_starting_before_or_at_prolated_offset()`.

containertools.get_first_element_starting_strictly_after_prolated_offset

`abjad.tools.containertools.get_first_element_starting_strictly_after_prolated_offset` (*container*, *pro-lated_of*)

New in version 2.0. Get first *container* element starting strictly after *prolated_offset*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> containertools.get_first_element_starting_strictly_after_prolated_offset(staff, Duration(
Note("e'8"))
```

Return component.

Return none when no *container* element starts strictly after *prolated_offset*. Changed in version 2.0: renamed `containertools.get_leftmost_element_starting_after_prolated_offset()` to `containertools.get_first_element_starting_strictly_after_prolated_offset()`.

containertools.get_first_element_starting_strictly_before_prolated_offset

abjad.tools.containertools.get_first_element_starting_strictly_before_prolated_offset(*container*, *prolated_offset*)

New in version 2.0. Get first *container* element starting strictly before *prolated_offset*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> containertools.get_first_element_starting_strictly_before_prolated_offset(staff, Duration(
Note("c'8"))
```

Return component.

Return none when *container* element starts strictly before *prolated_offset*. Changed in version 2.0: renamed `containertools.get_rightmost_element_starting_before_prolated_offset()` to `containertools.get_first_element_starting_strictly_before_prolated_offset()`.

containertools.insert_component_and_do_not_fracture_crossing_spanners

abjad.tools.containertools.insert_component_and_do_not_fracture_crossing_spanners(*container*, *i*, *component*)

New in version 2.0. Insert *component* into *container* at index *i* and do not fracture crossing spanners:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
  c'8 [
  d'8
  e'8
  f'8 ]
}

abjad> containertools.insert_component_and_do_not_fracture_crossing_spanners(staff, 1, Note("cs'8"))
Staff{5}

abjad> f(staff)
\new Staff {
  c'8 [
  cs'8
  d'8
  e'8
  f'8 ]
}
```

Return *container*. Changed in version 2.0: renamed `containertools.insert_and_do_not_fracture()` to `containertools.insert_component_and_do_not_fracture_crossing_spanners()`.

containertools.insert_component_and_fracture_crossing_spanners

`abjad.tools.containertools.insert_component_and_fracture_crossing_spanners` (*container*, *i*, *com-*
po-
nent)

Insert *component* into *container* at index *i* and fracture spanners:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

abjad> containertools.insert_component_and_fracture_crossing_spanners(staff, 1, Rest((1, 8)))
[(BeamSpanner(c'8, d'8, e'8, f'8), BeamSpanner(c'8), BeamSpanner(d'8, e'8, f'8)), (BeamSpanner(c'8, d'8, e'8, f'8), BeamSpanner(d'8, e'8, f'8))]

abjad> f(staff)
\new Staff {
    c'8 [ ]
    r8
    d'8 [
    e'8
    f'8 ]
}
```

Return list of fractured spanners. Changed in version 2.0: renamed `containertools.insert_and_fracture()` to `containertools.insert_component_and_fracture_crossing_spanners()`

containertools.iterate_containers_backward_in_expr

`abjad.tools.containertools.iterate_containers_backward_in_expr` (*expr*, *start=0*, *stop=None*)

New in version 2.0. Iterate containers backward in *expr*:

```
abjad> staff = Staff([Voice("c'8 d'8"), Voice("e'8 f'8 g'8")])
abjad> Tuplet(Fraction(2, 3), staff[1][:])
Tuplet(2/3, [e'8, f'8, g'8])
abjad> staff.is_parallel = True

abjad> f(staff)
\new Staff <<
    \new Voice {
        c'8
        d'8
    }
    \new Voice {
        \times 2/3 {
            e'8
            f'8
            g'8
        }
    }
}
```



```

        g'8
    }
}
>>

abjad> for x in containertools.iterate_containers_backward_in_expr(staff):
...     x
Staff<<2>>
Voice{1}
Tuplet(2/3, [e'8, f'8, g'8])
Voice{2}

```

Ignore threads.

Return generator.

containertools.iterate_containers_forward_in_expr

`abjad.tools.containertools.iterate_containers_forward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate containers forward in *expr*:

```

abjad> staff = Staff([Voice("c'8 d'8"), Voice("e'8 f'8 g'8")])
abjad> Tuplet(Fraction(2, 3), staff[1][:])
Tuplet(2/3, [e'8, f'8, g'8])
abjad> staff.is_parallel = True

abjad> f(staff)
\new Staff <<
  \new Voice {
    c'8
    d'8
  }
  \new Voice {
    \times 2/3 {
      e'8
      f'8
      g'8
    }
  }
>>

```

```

abjad> for x in containertools.iterate_containers_forward_in_expr(staff):
...     x
Staff<<2>>
Voice{2}
Voice{1}
Tuplet(2/3, [e'8, f'8, g'8])

```

Ignore threads.

Return generator.

containertools.move_parentage_children_and_spanners_from_components_to_empty_container

`abjad.tools.containertools.move_parentage_children_and_spanners_from_components_to_empty_container`

Move parentage, children and spanners from *components* to empty *container*:

```
abjad> voice = Voice(Container("c'8 c'8") * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> spannertools.BeamSpanner(voice.leaves)
BeamSpanner(c'8, d'8, e'8, f'8, g'8, a'8)

abjad> f(voice)
\new Voice {
  {
    c'8 [
    d'8
  ]
  {
    e'8
    f'8
  ]
  {
    g'8
    a'8 ]
  ]
}

abjad> tuplet = Tuplet(Fraction(3, 4), [])
abjad> containertools.move_parentage_children_and_spanners_from_components_to_empty_container(voice)

abjad> f(voice)
\new Voice {
  \fraction \times 3/4 {
    c'8 [
    d'8
    e'8
    f'8
  ]
  {
    g'8
    a'8 ]
  ]
}
```

Return `None`. Changed in version 2.0: renamed `scoretools.donate()` to `containertools.move_parentage_children_and_spanners_from_components_to_empty_container`

containertools.remove_empty_containers_in_expr

`abjad.tools.containertools.remove_empty_containers_in_expr(expr)`

Remove empty containers in *expr*:

```
abjad> staff = Staff(Container(notetools.make_repeated_notes(2)) * 4)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
```

```

abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner({c'8, d'8}, {e'8, f'8}, {g'8, a'8}, {b'8, c''8})
abjad> containertools.delete_contents_of_container(staff[1])
[Note("e'8"), Note("f'8")]
abjad> containertools.delete_contents_of_container(staff[-1])
[Note("b'8"), Note("c''8")]

abjad> f(staff)
\new Staff {
    {
        c'8 [
        d'8
    ]
    {
    }
    {
        g'8
        a'8 ]
    }
    {
    }
}

abjad> containertools.remove_empty_containers_in_expr(staff)

abjad> f(staff)
\new Staff {
    {
        c'8 [
        d'8
    ]
    {
        g'8
        a'8 ]
    }
}

```

Return `none`. Changed in version 2.0: renamed `containertools.remove_empty()` to `containertools.remove_empty_containers_in_expr()`.

containertools.repeat_contents_of_container

`abjad.tools.containertools.repeat_contents_of_container(container, total=2)`

New in version 1.1. Repeat contents of *container*:

```

abjad> staff = Staff("c'8 d'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8 ]
}

abjad> containertools.repeat_contents_of_container(staff, 3)
Staff{6}

```

```
abjad> f(staff)
\new Staff {
    c'8 [
    d'8 ]
    c'8 [
    d'8 ]
    c'8 [
    d'8 ]
}
```

Leave *container* unchanged when *total* is 1.

Empty *container* when *total* is 0.

Return *container*. Changed in version 2.0: renamed `containertools.contents_multiply()` to `containertools.repeat_contents_of_container()`.

containertools.repeat_last_n_elements_of_container

`abjad.tools.containertools.repeat_last_n_elements_of_container(container, n=1, total=2)`

New in version 1.1. Repeat last *n* elements of *container*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
```

```
abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}
```

```
abjad> containertools.repeat_last_n_elements_of_container(staff, n = 2, total = 3)
Staff{8}
```

```
abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
    e'8 [
    f'8 ]
    e'8 [
    f'8 ]
}
```

Return *container*. Changed in version 2.0: renamed `containertools.extend_cyclic()` to `containertools.repeat_last_n_elements_of_container()`.

containertools.replace_contents_of_target_container_with_contents_of_source_container

`abjad.tools.containertools.replace_contents_of_target_container_with_contents_of_source_container`

New in version 2.0. Replace contents of *target_container* with contents of *source_container*:

```

abjad> staff = Staff(Tuplet(Fraction(2, 3), "c'8 d'8 e'8") * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, ... [5] ..., c''8, d''8)

abjad> f(staff)
\new Staff {
  \times 2/3 {
    c'8 [
      d'8
      e'8
    ]
  }
  \times 2/3 {
    f'8
    g'8
    a'8
  }
  \times 2/3 {
    b'8
    c''8
    d''8 ]
  }
}

abjad> container = Container("c'8 d'8 e'8")
abjad> spannertools.SlurSpanner(container.leaves)
SlurSpanner(c'8, d'8, e'8)

abjad> f(container)
{
  c'8 (
    d'8
    e'8 )
}

abjad> containertools.replace_contents_of_target_container_with_contents_of_source_container(staff,
Tuplet(2/3, [c'8, d'8, e'8]))

abjad> f(staff)
\new Staff {
  \times 2/3 {
    c'8 [
      d'8
      e'8
    ]
  }
  \times 2/3 {
    c'8 (
      d'8
      e'8 )
    ]
  }
  \times 2/3 {
    b'8
    c''8
    d''8 ]
  }
}

```

Leave *source_container* empty:

```
abjad> container
{}
```

Return *target_container*.

containertools.replace_larger_left_half_of_elements_in_container_with_big_endian_rests

`abjad.tools.containertools.replace_larger_left_half_of_elements_in_container_with_big_endian_rests`

New in version 2.0. Replace larger left half of elements in *container* with big-endian rests:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8 d''8 e''8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8
    d''8
    e''8
}
```

```
abjad> containertools.replace_larger_left_half_of_elements_in_container_with_big_endian_rests(staff)
Staff{7}
```

```
abjad> f(staff)
\new Staff {
    r2
    r8
    a'8
    b'8
    c''8
    d''8
    e''8
}
```

Return *container*.

containertools.replace_larger_left_half_of_elements_in_container_with_little_endian_rests

`abjad.tools.containertools.replace_larger_left_half_of_elements_in_container_with_little_endian_rests`

New in version 2.0. Replace larger left half of elements in *container* with little-endian rests:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8 d''8 e''8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
```

```

    a'8
    b'8
    c''8
    d''8
    e''8
}

```

```

abjad> containertools.replace_larger_left_half_of_elements_in_container_with_little_endian_rests(
Staff{7})

```

```

abjad> f(staff)
\new Staff {
    r8
    r2
    a'8
    b'8
    c''8
    d''8
    e''8
}

```

Return *container*.

containertools.replace_larger_right_half_of_elements_in_container_with_big_endian_rests

`abjad.tools.containertools.replace_larger_right_half_of_elements_in_container_with_big_endian_rests(container)`

New in version 2.0. Replace larger right half of elements in *container* with big-endian rests:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8 d''8 e''8")

```

```

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8
    d''8
    e''8
}

```

```

abjad> containertools.replace_larger_right_half_of_elements_in_container_with_big_endian_rests(
Staff{7})

```

```

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    r2
    r8
}

```

Return *container*.

containertools.replace_larger_right_half_of_elements_in_container_with_little_endian_rests

`abjad.tools.containertools.replace_larger_right_half_of_elements_in_container_with_little_endian_rests`

New in version 2.0. Replace larger right half of elements in *container* with little-endian rests:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8 d''8 e''8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8
    d''8
    e''8
}
```

```
abjad> containertools.replace_larger_right_half_of_elements_in_container_with_little_endian_rests(
Staff{7})
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    r8
    r2
}
```

Return *container*.

containertools.replace_n_edge_elements_in_container_with_big_endian_rests

`abjad.tools.containertools.replace_n_edge_elements_in_container_with_big_endian_rests` (*container*, *n*)

New in version 2.0. Replace *n* edge elements in *container* with big-endian rests:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
}
```



```
abjad> containertools.replace_n_edge_elements_in_container_with_big_endian_rests(staff, -5)
Staff{3}
```

```
abjad> f(staff)
\new Staff {
    c'8
    r2
    r8
}
```

Return *container*. Changed in version 2.0: renamed `containertools.replace_first_n_elements_in_container` to `containertools.replace_n_edge_elements_in_container_with_big_endian_rests()`.

`containertools.replace_n_edge_elements_in_container_with_little_endian_rests`

`abjad.tools.containertools.replace_n_edge_elements_in_container_with_little_endian_rests(container, n)`

New in version 2.0. Replace *n* edge elements in *container* with little-endian rests:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
}
```

```
abjad> containertools.replace_n_edge_elements_in_container_with_little_endian_rests(staff, -5)
Staff{3}
```

```
abjad> f(staff)
\new Staff {
    c'8
    r8
    r2
}
```

Return *container*. Changed in version 2.0: renamed `containertools.replace_first_n_elements_in_container` to `containertools.replace_n_edge_elements_in_container_with_little_endian_rests()`.

`containertools.replace_n_edge_elements_in_container_with_rests`

`abjad.tools.containertools.replace_n_edge_elements_in_container_with_rests(container, n)`

New in version 2.0. Replace first *n* elements in *container* with big-endian rests:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
```

```

        e'8
        f'8
        g'8
        a'8
    }

```

```

abjad> containertools.replace_n_edge_elements_in_container_with_rests(staff, 5)
Staff{3}

```

```

abjad> f(staff)
\new Staff {
    r2
    r8
    a'8
}

```

Replace last n elements in *container* with little-endian rests:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8")

```

```

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
}

```

```

abjad> containertools.replace_n_edge_elements_in_container_with_rests(staff, -5)
Staff{3}

```

```

abjad> f(staff)
\new Staff {
    c'8
    r8
    r2
}

```

Return *container*. Changed in version 2.0: renamed `containertools.replace_first_n_elements_in_container` to `containertools.replace_n_edge_elements_in_container_with_rests()`.

`containertools.replace_smaller_left_half_of_elements_in_container_with_big_endian_rests`

`abjad.tools.containertools.replace_smaller_left_half_of_elements_in_container_with_big_endian_rests`
 New in version 2.0. Replace smaller left half of elements in *container* with big-endian rests:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8 d''8 e''8")

```

```

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8

```

```

        a'8
        b'8
        c''8
        d''8
        e''8
    }

abjad> containertools.replace_smaller_left_half_of_elements_in_container_with_big_endian_rests(
Staff{7}

abjad> f(staff)
\new Staff {
    r2
    r8
    a'8
    b'8
    c''8
    d''8
    e''8
}

```

Return *container*.

containertools.replace_smaller_left_half_of_elements_in_container_with_little_endian_rests

`abjad.tools.containertools.replace_smaller_left_half_of_elements_in_container_with_little_endian_rests`

New in version 2.0. Replace smaller left half of elements in *container* with little-endian rests:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8 d''8 e''8")

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8
    d''8
    e''8
}

abjad> containertools.replace_smaller_left_half_of_elements_in_container_with_little_endian_rests(
Staff{7}

abjad> f(staff)
\new Staff {
    r8
    r2
    a'8
    b'8
    c''8
    d''8
    e''8
}

```

Return *container*.

`containertools.replace_smaller_right_half_of_elements_in_container_with_big_endian_rests`

`abjad.tools.containertools.replace_smaller_right_half_of_elements_in_container_with_big_endian_rests`

New in version 2.0. Relace smaller right half of elements in *container* with big-endian rests:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8 d''8 e''8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8
    d''8
    e''8
}
```

```
abjad> containertools.replace_smaller_right_half_of_elements_in_container_with_big_endian_rests(
Staff{7})
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    r2
    r8
}
```

Return *container*.

`containertools.replace_smaller_right_half_of_elements_in_container_with_little_endian_rests`

`abjad.tools.containertools.replace_smaller_right_half_of_elements_in_container_with_little_endian_rests`

New in version 2.0. Replace smaller right half of elements in *container* with little-endian rests:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8 d''8 e''8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8
    d''8
}
```

```

        e'8
    }

abjad> containertools.replace_smaller_right_half_of_elements_in_container_with_little_endian_res
Staff{7}

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    r8
    r2
}

```

Return *container*.

containertools.report_container_modifications_as_string

`abjad.tools.containertools.report_container_modifications_as_string(container)`

Report *container* modifications as string:

```

abjad> container = Container("c'8 d'8 e'8 f'8")
abjad> container.override.note_head.color = 'red'
abjad> container.override.note_head.style = 'harmonic'

abjad> f(container)
{
    \override NoteHead #'color = #red
    \override NoteHead #'style = #'harmonic
    c'8
    d'8
    e'8
    f'8
    \revert NoteHead #'color
    \revert NoteHead #'style
}

abjad> string = containertools.report_container_modifications_as_string(container)

abjad> print string # doctest: +SKIP
{
    \override NoteHead #'color = #red
    \override NoteHead #'style = #'harmonic

    %%% 4 components omitted %%%

    \revert NoteHead #'color
    \revert NoteHead #'style
}

```

Return string.

containertools.reverse_contents_of_container

`abjad.tools.containertools.reverse_contents_of_container(container)`

New in version 1.1. Reverse contents of *container*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves[:2])
BeamSpanner(c'8, d'8)
abjad> spannertools.SlurSpanner(staff.leaves[2:])
SlurSpanner(e'8, f'8)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8 ]
    e'8 (
    f'8 )
}

abjad> containertools.reverse_contents_of_container(staff)
Staff{4}

abjad> f(staff) # doctest: +SKIP
\new Staff {
    f'8 (
    e'8 )
    d'8 [
    c'8 ]
}
```

Return *container*. Changed in version 2.0: renamed `containertools.contents_reverse()` to `containertools.reverse_contents_of_container()`.

containertools.scale_contents_of_container

`abjad.tools.containertools.scale_contents_of_container(container, multiplier)`

New in version 1.1. Scale contents of *container* by dot *multiplier*:

```
abjad> staff = Staff("c'8 d'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8 ]
}

abjad> containertools.scale_contents_of_container(staff, Duration(3, 2))
Staff{2}

abjad> f(staff)
\new Staff {
    c'8. [
    d'8. ]
}
```

Scale contents of *container* by tie *multiplier*:

```

abjad> staff = Staff("c'8 d'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8 ]
}

abjad> containertools.scale_contents_of_container(staff, Duration(5, 4))
Staff{4}

abjad> f(staff)
\new Staff {
    c'8 [ ~
    c'32
    d'8 ~
    d'32 ]
}

```

Scale contents of *container* by nonbinary *multiplier*:

```

abjad> staff = Staff("c'8 d'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8 ]
}

abjad> containertools.scale_contents_of_container(staff, Duration(4, 3))
Staff{2}

abjad> f(staff)
\new Staff {
    \times 2/3 {
        c'4 [
    }
    \times 2/3 {
        d'4 ]
    }
}

```

Return *container*. Changed in version 2.0: renamed `containertools.contents_scale()` to `containertools.scale_contents_of_container()`.

containertools.set_container_multiplier

`abjad.tools.containertools.set_container_multiplier(container, multiplier)`

Set *container multiplier*:

```

abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")

```

```

abjad> f(tuplet)
\times 2/3 {
    c'8
    d'8
    e'8
}

abjad> containertools.set_container_multiplier(tuplet, Duration(3, 4))

abjad> f(tuplet)
\fraction \times 3/4 {
    c'8
    d'8
    e'8
}

```

Return `none`. Changed in version 2.0: renamed `containertools.multiplier_set()` to `containertools.set_container_multiplier()`.

containertools.split_container_at_index_and_do_not_fracture_crossing_spanners

```

abjad.tools.containertools.split_container_at_index_and_do_not_fracture_crossing_spanners(

```

Split *container* at *index* and do not fracture crossing spanners:

```

abjad> voice = Voice(Measure((3, 8), "c'8 c'8 c'8") * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voi
abjad> beam = spannertools.BeamSpanner(voice[:])

abjad> f(voice)
\new Voice {
    {
        \time 3/8
        c'8 [
        d'8
        e'8
    }
    {
        \time 3/8
        f'8
        g'8
        a'8 ]
    }
}

abjad> containertools.split_container_at_index_and_do_not_fracture_crossing_spanners(voice[1], 1
(Measure(1/8, [f'8]), Measure(2/8, [g'8, a'8]))

abjad> f(voice)
\new Voice {
    {
        \time 3/8
        c'8 [
        d'8
        e'8
    }
}

```



```

    {
        \time 1/8
        f'8
    }
    {
        \time 2/8
        g'8
        a'8 ]
    }
}

```

Leave spanners and leaves untouched.

Resize resizable containers.

Preserve container multiplier.

Preserve meter denominator.

Return split parts. Changed in version 2.0: renamed `split.unfractured_at_index()` to `containertools.split_container_at_index_and_do_not_fracture_crossing_spanners()`.

containertools.split_container_at_index_and_fracture_crossing_spanners

`abjad.tools.containertools.split_container_at_index_and_fracture_crossing_spanners` (*container*, *index*)

Split *container* at *index* and fracture crossing spanners:

```

abjad> voice = Voice(tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 c'8 c'8") * 2)
abjad> tuplet = voice[1]
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voi
abjad> beam = spannertools.BeamSpanner(voice[:])

abjad> f(voice)
\new Voice {
    \times 2/3 {
        c'8 [
        d'8
        e'8
    }
    \times 2/3 {
        f'8
        g'8
        a'8 ]
    }
}

abjad> left, right = containertools.split_container_at_index_and_fracture_crossing_spanners(tupl

abjad> f(voice)
\new Voice {
    \times 2/3 {
        c'8 [
        d'8
        e'8
    }
    \times 2/3 {
        f'8 ]

```

```

    }
    \times 2/3 {
      g'8 [
      a'8 ]
    }
  }
}

```

Leave leaves untouched.

Create two new copies of *container*.

Empty *container* of original contents.

Return split parts. Changed in version 2.0: renamed `split.fractured_at_index()` to `containertools.split_container_at_index_and_fracture_crossing_spanners()`.

containertools.split_container_cyclically_by_counts_and_do_not_fracture_crossing_spanners

`abjad.tools.containertools.split_container_cyclically_by_counts_and_do_not_fracture_crossing_spanners`

Split *container* cyclically by *counts* and do not fracture crossing spanners:

```

abjad> container = Container("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
abjad> voice = Voice([container])
abjad> beam = spannertools.BeamSpanner(voice)
abjad> slur = spannertools.SlurSpanner(container)

```

```

abjad> f(voice)
\new Voice {
  {
    c'8 [ (
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8 ] )
  }
}

```

```

abjad> containertools.split_container_cyclically_by_counts_and_do_not_fracture_crossing_spanners
[[{c'8}], [{d'8, e'8, f'8}], [{g'8}], [{a'8, b'8, c''8}]]

```

```

abjad> f(voice)
\new Voice {
  {
    c'8 [ (
  }
  {
    d'8
    e'8
    f'8
  }
  {
    g'8
  }
  {

```

```

        a'8
        b'8
        c''8 ] )
    }
}

```

Return list of list-wrapped container pieces. Changed in version 2.0: renamed `partition.cyclic_unfractured_by_counts()` to `containertools.split_container_cyclically_by_counts_and_do_not_fracture_crossing_spanners`

containertools.split_container_cyclically_by_counts_and_fracture_crossing_spanners

`abjad.tools.containertools.split_container_cyclically_by_counts_and_fracture_crossing_spanners`

Split *container* cyclically by *counts* and fracture crossing spanners:

```

abjad> container = Container("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
abjad> voice = Voice([container])
abjad> beam = spannertools.BeamSpanner(voice)
abjad> slur = spannertools.SlurSpanner(container)

```

```

abjad> f(voice)
\new Voice {
  {
    c'8 [ (
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8 ] )
  }
}

```

```

abjad> containertools.split_container_cyclically_by_counts_and_fracture_crossing_spanners(container,
[[{c'8}], [{d'8, e'8, f'8}], [{g'8}], [{a'8, b'8, c''8}]]

```

```

abjad> f(voice)
\new Voice {
  {
    c'8 ( ) [
  }
  {
    d'8 (
    e'8
    f'8 )
  }
  {
    g'8 ( )
  }
  {
    a'8 (
    b'8
    c''8 ] )
  }
}

```

Return list of list-wrapped container pieces. Changed in version 2.0: renamed `partition.cyclic_fractured_by_counts()` to `containertools.split_container_cyclically_by_counts_and_fracture_crossing_spanners()`.

`containertools.split_container_once_by_counts_and_do_not_fracture_crossing_spanners`

`abjad.tools.containertools.split_container_once_by_counts_and_do_not_fracture_crossing_spanners`

Split *container* once by *counts* and do no fracture crossing spanners:

```
abjad> container = Container("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
abjad> voice = Voice([container])
abjad> beam = spannertools.BeamSpanner(voice)
abjad> slur = spannertools.SlurSpanner(container)
```

```
abjad> f(voice)
\new Voice {
  {
    c'8 [ (
      d'8
      e'8
      f'8
      g'8
      a'8
      b'8
      c''8 ] )
  }
}
```

```
abjad> containertools.split_container_once_by_counts_and_do_not_fracture_crossing_spanners(container,
[[{c'8}], [{d'8, e'8, f'8}], [{g'8, a'8, b'8, c''8}]]
```

```
abjad> f(voice)
\new Voice {
  {
    c'8 [ (
  }
  {
    d'8
    e'8
    f'8
  }
  {
    g'8
    a'8
    b'8
    c''8 ] )
  }
}
```

Return list of list-wrapped container pieces. Changed in version 2.0: renamed `partition.unfractured_by_counts()` to `containertools.split_container_once_by_counts_and_do_not_fracture_crossing_spanners()`.

containertools.split_container_once_by_counts_and_fracture_crossing_spanners

abjad.tools.containertools.**split_container_once_by_counts_and_fracture_crossing_spanners** (container, counts, fracture_crossing_spanners) *CO*

Split *container* once by *counts* and fracture crossing spanners:

```
abjad> container = Container("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
abjad> voice = Voice([container])
abjad> beam = spannertools.BeamSpanner(voice)
abjad> slur = spannertools.SlurSpanner(container)
```

```
abjad> f(voice)
\new Voice {
  {
    c'8 [ (
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8 ] )
  }
}
```

```
abjad> containertools.split_container_once_by_counts_and_fracture_crossing_spanners(container, [
[[{c'8}], [{d'8, e'8, f'8}], [{g'8, a'8, b'8, c''8}]]
```

```
abjad> f(voice)
\new Voice {
  {
    c'8 ( ) [
  }
  {
    d'8 (
    e'8
    f'8 )
  }
  {
    g'8 (
    a'8
    b'8
    c''8 ] )
  }
}
```

Return list of list-wrapped container pieces. Changed in version 2.0: renamed `partition.fractured_by_counts()` to `containertools.split_container_once_by_counts_and_fracture_crossing_spanners()`

contexttools

contexttools.ClefMark

class abjad.tools.contexttools.**ClefMark** (*arg*, *target_context=None*)

Bases: `abjad.tools.contexttools.ContextMark.ContextMark` New in version 2.0. Abjad model of a clef:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> contexttools.ClefMark('treble')(staff)
ClefMark('treble')(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "treble"
  c'8
  d'8
  e'8
  f'8
}
```

Clef marks target the staff context by default.

clef_name

Get clef name:

```
abjad> clef = contexttools.ClefMark('treble')
abjad> clef.clef_name
'treble'
```

Set clef name:

```
abjad> clef.clef_name = 'alto'
abjad> clef.clef_name
'alto'
```

Return string.

format

Read-only LilyPond format of clef:

```
abjad> clef = contexttools.ClefMark('treble')
abjad> clef.format
'\\clef "treble"'
```

Return string.

middle_c_position

Read-only middle-C position of clef:

```
abjad> clef = contexttools.ClefMark('treble')
abjad> clef.middle_c_position
-6
```

Return integer number of stafflines.

contexttools.ContextMark

class abjad.tools.contexttools.**ContextMark** (*target_context=None*)

Bases: abjad.tools.marktools.Mark.Mark.Mark New in version 2.0. Abstract class from which concrete context marks inherit:

```
abjad> note = Note("c'4")

abjad> contexttools.ContextMark()(note)
ContextMark()(c'4)
```

Context marks override `__call__` to attach to Abjad components.

Context marks implement `__slots__`.

attach (*start_component*)

Make sure no context mark of same type is already attached to start component.

detach ()

Detach mark:

```
abjad> note = Note("c'4")
abjad> context_mark = contexttools.ContextMark()(note)

abjad> context_mark.start_component
Note("c'4")

abjad> context_mark.detach()
ContextMark()

abjad> context_mark.start_component is None
True
```

Return context mark.

effective_context

Read-only reference to effective context of context mark:

```
abjad> note = Note("c'4")
abjad> context_mark = contexttools.ContextMark()(note)

abjad> context_mark.effective_context is None
True
```

Return context mark or none.

target_context

Read-only reference to target context of context mark:

```
abjad> note = Note("c'4")
abjad> context_mark = contexttools.ContextMark()(note)

abjad> context_mark.target_context is None
True
```

Return context mark or none.

contexttools.DynamicMark

class abjad.tools.contexttools.**DynamicMark** (*dynamic_name*, *target_context=None*)

Bases: abjad.tools.contexttools.ContextMark.ContextMark.ContextMark New in version 2.0. Abjad model of a dynamic mark:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> contexttools.DynamicMark('f')(staff[0])
DynamicMark('f')(c'8)

abjad> f(staff)
\new Staff {
  c'8 \f
```

```
d' 8
e' 8
f' 8
}
```

Dynamic marks target the staff context by default.

static composite_dynamic_name_to_steady_state_dynamic_name (*dynamic_name*)

Change composite *dynamic_name* to steady state dynamic name:

```
abjad> contexttools.DynamicMark.composite_dynamic_name_to_steady_state_dynamic_name('sfp')
'p'
```

Return string.

dynamic_name

Get dynamic name:

```
abjad> dynamic = contexttools.DynamicMark('f')
abjad> dynamic.dynamic_name
'f'
```

Set dynamic name:

```
abjad> dynamic.dynamic_name = 'p'
abjad> dynamic.dynamic_name
'p'
```

Return string.

static dynamic_name_to_dynamic_ordinal (*dynamic_name*)

Change *dynamic_name* to dynamic ordinal:

```
abjad> contexttools.DynamicMark.dynamic_name_to_dynamic_ordinal('fff')
4
```

Return integer.

static dynamic_ordinal_to_dynamic_name (*dynamic_ordinal*)

Change *dynamic_ordinal* to dynamic name:

```
abjad> contexttools.DynamicMark.dynamic_ordinal_to_dynamic_name(-5)
'pppp'
```

Return string.

format

Read-only LilyPond input format of dynamic mark:

```
abjad> dynamic_mark = contexttools.DynamicMark('f')
abjad> dynamic_mark.format
'\f'
```

Return string.

static is_dynamic_name (*arg*)

True when *arg* is dynamic name. False otherwise:

```
abjad> contexttools.DynamicMark.is_dynamic_name('f')
True
```

Return boolean.

contexttools.InstrumentMark

class abjad.tools.contexttools.**InstrumentMark**(*instrument_name*, *short_instrument_name*,
instrument_name_markup=None,
short_instrument_name_markup=None,
target_context=None)

Bases: abjad.tools.contexttools.ContextMark.ContextMark.ContextMark New in version 2.0. Abjad model of an instrument change:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> contexttools.InstrumentMark('Flute', 'Fl.')(staff)
InstrumentMark('Flute', 'Fl.')(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Flute }
  \set Staff.shortInstrumentName = \markup { Fl. }
  c'8
  d'8
  e'8
  f'8
}
```

Instrument marks target staff context by default.

default_instrument_name

Read-only default instrument name.

Return string.

default_short_instrument_name

Read-only default short instrument name.

Return string.

format

Read-only LilyPond input format of instrument mark:

```
abjad> instrument = contexttools.InstrumentMark('Flute', 'Fl.')
abjad> instrument.format
['\set Staff.instrumentName = \markup { Flute }', '\set Staff.shortInstrumentName = \markup
```

Return list.

instrument_name

Get instrument name:

```
abjad> instrument = contexttools.InstrumentMark('Flute', 'Fl.')
abjad> instrument.instrument_name
'Flute'
```

Set instrument name:

```
abjad> instrument.instrument_name = 'Alto Flute'
abjad> instrument.instrument_name
'Alto Flute'
```

Return string.

instrument_name_markup

Get instrument name:

```
abjad> instrument = contexttools.InstrumentMark('Flute', 'Fl.')
abjad> instrument.instrument_name_markup
Markup('Flute')
```

Set instrument name:

```
abjad> instrument.instrument_name_markup = 'Alto Flute'
abjad> instrument.instrument_name_markup
Markup('Alto Flute')
```

Return markup.

short_instrument_name

Get short instrument name:

```
abjad> instrument = contexttools.InstrumentMark('Flute', 'Fl.')
abjad> instrument.short_instrument_name
'Fl.'
```

Set short instrument name:

```
abjad> instrument.short_instrument_name = 'Alto Fl.'
abjad> instrument.short_instrument_name
'Alto Fl.'
```

Return string.

short_instrument_name_markup

Get short instrument name:

```
abjad> instrument = contexttools.InstrumentMark('Flute', 'Fl.')
abjad> instrument.short_instrument_name_markup
Markup('Fl.')
```

Set short instrument name:

```
abjad> instrument.short_instrument_name_markup = 'Alto Fl.'
abjad> instrument.short_instrument_name_markup
Markup('Alto Fl.')
```

Return markup.

contexttools.KeySignatureMark

class abjad.tools.contexttools.**KeySignatureMark** (*tonic, mode, target_context=None*)

Bases: abjad.tools.contexttools.ContextMark.ContextMark.ContextMark New in version 2.0. Abjad model of a key signature setting or key signature change:

```
abjad> staff = Staff("e'8 fs'8 gs'8 a'8")

abjad> contexttools.KeySignatureMark('e', 'major')(staff)
KeySignatureMark(NamedChromaticPitchClass('e'), Mode(major))(Staff{4})

abjad> f(staff)
\new Staff {
  \key e \major
  e'8
  fs'8
  gs'8
```

```

    a' 8
}

```

Key signature marks target staff context by default.

format

Read-only LilyPond format of key signature mark:

```

abjad> key_signature = contexttools.KeySignatureMark('e', 'major')
abjad> key_signature.format
'\\key e \\major'

```

Return string.

mode

Get mode of key signature:

```

abjad> key_signature = contexttools.KeySignatureMark('e', 'major')
abjad> key_signature.mode
Mode(major)

```

Set mode of key signature:

```

abjad> key_signature.mode = 'minor'
abjad> key_signature.mode
Mode(minor)

```

Return mode.

name

Read-only name of key signature:

```

abjad> key_signature = contexttools.KeySignatureMark('e', 'major')
abjad> key_signature.name
'E major'

```

Return string.

tonic

Get tonic of key signature:

```

abjad> key_signature = contexttools.KeySignatureMark('e', 'major')
abjad> key_signature.tonic
NamedChromaticPitchClass('e')

```

Set tonic of key signature:

```

abjad> key_signature.tonic = 'd'
abjad> key_signature.tonic
NamedChromaticPitchClass('d')

```

Return named chromatic pitch.

contexttools.StaffChangeMark

class `abjad.tools.contexttools.StaffChangeMark` (*staff*, *target_context=None*)

Bases: `abjad.tools.contexttools.ContextMark.ContextMark.ContextMark` New in version 2.0. Abjad model of a staff change:

```

abjad> piano_staff = scoretools.PianoStaff([])
abjad> rh_staff = Staff("c'8 d'8 e'8 f'8")
abjad> rh_staff.name = 'RHStaff'
abjad> lh_staff = Staff("s2")
abjad> lh_staff.name = 'LHStaff'
abjad> piano_staff.extend([rh_staff, lh_staff])

abjad> f(piano_staff)
\new PianoStaff <<
  \context Staff = "RHStaff" {
    c'8
    d'8
    e'8
    f'8
  }
  \context Staff = "LHStaff" {
    s2
  }
>>

abjad> contexttools.StaffChangeMark(lh_staff)(rh_staff[2])
StaffChangeMark(Staff-"LHStaff"{1})(e'8)

abjad> f(piano_staff)
\new PianoStaff <<
  \context Staff = "RHStaff" {
    c'8
    d'8
    \change Staff = LHStaff
    e'8
    f'8
  }
  \context Staff = "LHStaff" {
    s2
  }
>>

```

Staff change marks target staff context by default.

format

Read-only LilyPond format of staff change mark:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> staff.name = 'RHStaff'
abjad> staff_change = contexttools.StaffChangeMark(staff)
abjad> staff_change.format
'\change Staff = RHStaff'

```

Return string.

staff

Get staff of staff change mark:

```

abjad> rh_staff = Staff("c'8 d'8 e'8 f'8")
abjad> rh_staff.name = 'RHStaff'
abjad> staff_change = contexttools.StaffChangeMark(rh_staff)
abjad> staff_change.staff
Staff-"RHStaff"{4}

```

Set staff of staff change mark:

```

abjad> lh_staff = Staff("s2")
abjad> lh_staff.name = 'LHStaff'
abjad> staff_change.staff = lh_staff
abjad> staff_change.staff
Staff-"LHStaff"{1}

```

Return staff.

contexttools.TempoMark

class abjad.tools.contexttools.**TempoMark** (*args, **kwargs)

Bases: abjad.tools.contexttools.ContextMark.ContextMark.ContextMark New in version 2.0. Abjad model of a tempo indication:

```

abjad> score = Score([])
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> score.append(staff)

abjad> contexttools.TempoMark(Duration(1, 8), 52)(staff[0])
TempoMark(8, 52)(c'8)

abjad> f(score)
\new Score <<
  \tempo 8=52
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
>>

```

Tempo marks target **score** context by default.

duration

Get duration of tempo mark:

```

abjad> tempo = contexttools.TempoMark(Duration(1, 8), 52)
abjad> tempo.duration
Duration(1, 8)

```

Set duration of tempo mark:

```

abjad> tempo.duration = Duration(1, 4)
abjad> tempo.duration
Duration(1, 4)

```

Return duration.

format

Read-only LilyPond format of tempo mark:

```

abjad> tempo = contexttools.TempoMark(Duration(1, 8), 52)
abjad> tempo.format
'\tempo 8=52'

```

Return string.

quarters_per_minute

Read-only quarters per minute of tempo mark:

```
abjad> tempo = contexttools.TempoMark(Duration(1, 8), 52)
abjad> tempo.quarters_per_minute
Duration(104, 1)
```

Return fraction.

units_per_minute

Get units per minute of tempo mark:

```
abjad> tempo = contexttools.TempoMark(Duration(1, 8), 52)
abjad> tempo.units_per_minute
52
```

Set units per minute of tempo mark:

```
abjad> tempo.units_per_minute = 56
abjad> tempo.units_per_minute
56
```

Return number.

contexttools.TimeSignatureMark

class abjad.tools.contexttools.**TimeSignatureMark**(*args, **kwargs)

Bases: abjad.tools.contexttools.ContextMark.ContextMark.ContextMark New in version 2.0. Abjad model of a time signature:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> contexttools.TimeSignatureMark((4, 8))(staff[0])
TimeSignatureMark((4, 8))(c'8)

abjad> f(staff)
\new Staff {
  \time 4/8
  c'8
  d'8
  e'8
  f'8
}
```

Abjad time signature marks target **staff context** by default.

Initialize time signature marks to **score context** like this:

```
abjad> contexttools.TimeSignatureMark((4, 8), target_context = Score)
TimeSignatureMark((4, 8), target_context = Score)
```

Time signatures are immutable.

denominator

Get denominator of time signature mark:

```
abjad> time_signature = contexttools.TimeSignatureMark((3, 8))
abjad> time_signature
TimeSignatureMark((3, 8))
```

```
abjad> time_signature.denominator
8
```

Set denominator of time signature mark:

```
abjad> time_signature.denominator = 16
abjad> time_signature.denominator
16
```

Return integer.

duration

Read-only duration of time signature mark:

```
abjad> time_signature = contexttools.TimeSignatureMark((3, 8))
abjad> time_signature.duration
Duration(3, 8)
```

Return fraction.

format

Read-only LilyPond format of time signature mark:

```
abjad> time_signature = contexttools.TimeSignatureMark((3, 8))
abjad> time_signature.format
'\\time 3/8'
```

Return string.

is_nonbinary

Read-only indicator true when time signature mark is nonbinary:

```
abjad> time_signature = contexttools.TimeSignatureMark((3, 8))
abjad> time_signature.is_nonbinary
False
```

Return boolean.

multiplier

Read-only multiplier of time signature mark:

```
abjad> time_signature = contexttools.TimeSignatureMark((3, 8))
abjad> time_signature.multiplier
Fraction(1, 1)
```

Return fraction.

numerator

Get numerator of time signature mark:

```
abjad> time_signature = contexttools.TimeSignatureMark((3, 8))
abjad> time_signature.numerator
3
```

Set numerator of time signature mark:

```
abjad> time_signature.numerator = 4
abjad> time_signature.numerator
4
```

Set integer.

partial

Get partial measure pick-up of time signature mark:

```
abjad> time_signature = contexttools.TimeSignatureMark((3, 8), partial = Duration(1, 8))
abjad> time_signature.partial
Duration(1, 8)
```

Set partial measure pick-up of time signature mark:

```
abjad> time_signature.partial = Duration(1, 4)
abjad> time_signature.partial
Duration(1, 4)
```

Set fraction or none.

contexttools.detach_clef_marks_attached_to_component

`abjad.tools.contexttools.detach_clef_marks_attached_to_component` (*component*)

New in version 2.3. Detach clef marks attached to *component*:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4")
abjad> clef_mark = contexttools.ClefMark('treble')
abjad> clef_mark.attach(staff)
ClefMark('treble')(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "treble"
  c'4
  d'4
  e'4
  f'4
}

abjad> contexttools.detach_clef_marks_attached_to_component(staff)
(ClefMark('treble'),)

abjad> f(staff)
\new Staff {
  c'4
  d'4
  e'4
  f'4
}
```

Return tuple of zero or more clef marks.

contexttools.detach_context_marks_attached_to_component

`abjad.tools.contexttools.detach_context_marks_attached_to_component` (*component*,
klasses=(*<class*
'ab-
jad.tools.contexttools.ContextMan
)

New in version 2.0. Detach context marks attached to *component*:


```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> clef_mark = contexttools.ClefMark('treble')(staff)
abjad> dynamic_mark = contexttools.DynamicMark('p')(staff[0])
abjad> f(staff)
\new Staff {
    \clef "treble"
    c'8 \p
    d'8
    e'8
    f'8
}

abjad> contexttools.detach_context_marks_attached_to_component(staff[0])
(DynamicMark('p'),)

abjad> f(staff)
\new Staff {
    \clef "treble"
    c'8
    d'8
    e'8
    f'8
}

```

Return tuple of zero or context marks.

contexttools.detach_dynamic_marks_attached_to_component

`abjad.tools.contexttools.detach_dynamic_marks_attached_to_component(component)`

New in version 2.3. Detach dynamic marks attached to *component*:

```

abjad> staff = Staff("c'4 d'4 e'4 f'4")
abjad> dynamic_mark = contexttools.DynamicMark('p')
abjad> dynamic_mark.attach(staff[0])
DynamicMark('p')(c'4)

abjad> f(staff)
\new Staff {
    c'4 \p
    d'4
    e'4
    f'4
}

abjad> contexttools.detach_dynamic_marks_attached_to_component(staff[0])
(DynamicMark('p'),)

abjad> f(staff)
\new Staff {
    c'4
    d'4
    e'4
    f'4
}

```

Return tuple of zero or more dynamic marks.

contexttools.detach_instrument_marks_attached_to_component

`abjad.tools.contexttools.detach_instrument_marks_attached_to_component` (*component*)

New in version 2.1. Detach instrument marks attached to *component*:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4")
abjad> instrument_mark = contexttools.InstrumentMark('Violin ', 'Vn. ')
abjad> instrument_mark.attach(staff)
InstrumentMark('Violin ', 'Vn. ') (Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Violin }
  \set Staff.shortInstrumentName = \markup { Vn. }
  c'4
  d'4
  e'4
  f'4
}

abjad> contexttools.detach_instrument_marks_attached_to_component(staff)
(InstrumentMark('Violin ', 'Vn. '),)

abjad> f(staff)
\new Staff {
  c'4
  d'4
  e'4
  f'4
}
```

Return tuple of zero or more instrument marks.

contexttools.detach_key_signature_marks_attached_to_component

`abjad.tools.contexttools.detach_key_signature_marks_attached_to_component` (*component*)

New in version 2.3. Detach key signature marks attached to *component*:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4")
abjad> key_signature_mark = contexttools.KeySignatureMark('c', 'major')
abjad> key_signature_mark.attach(staff)
KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major)) (Staff{4})

abjad> f(staff)
\new Staff {
  \key c \major
  c'4
  d'4
  e'4
  f'4
}

abjad> contexttools.detach_key_signature_marks_attached_to_component(staff)
(KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major)),)

abjad> f(staff)
\new Staff {
```

```

    c'4
    d'4
    e'4
    f'4
}

```

Return tuple of zero or more key signature marks.

contexttools.detach_staff_change_marks_attached_to_component

`abjad.tools.contexttools.detach_staff_change_marks_attached_to_component` (*component*)

New in version 2.3. Detach staff change marks attached to *component*:

```

abjad> piano_staff = scoretools.PianoStaff([])
abjad> rh_staff = Staff("c'8 d'8 e'8 f'8")
abjad> rh_staff.name = 'RHStaff'
abjad> lh_staff = Staff("s2")
abjad> lh_staff.name = 'LHStaff'
abjad> piano_staff.extend([rh_staff, lh_staff])
abjad> contexttools.StaffChangeMark(lh_staff)(rh_staff[2])
StaffChangeMark(Staff-"LHStaff"{1})(e'8)

abjad> f(piano_staff)
\new PianoStaff <<
  \context Staff = "RHStaff" {
    c'8
    d'8
    \change Staff = LHStaff
    e'8
    f'8
  }
  \context Staff = "LHStaff" {
    s2
  }
>>

abjad> contexttools.detach_staff_change_marks_attached_to_component(rh_staff[2])
(StaffChangeMark(Staff-"LHStaff"{1}),)

```

Return tuple of zero or more staff change marks.

contexttools.detach_tempo_marks_attached_to_component

`abjad.tools.contexttools.detach_tempo_marks_attached_to_component` (*component*)

New in version 2.3. Detach tempo marks attached to *component*:

```

abjad> score = Score([])
abjad> staff = Staff("c'4 d'4 e'4 f'4")
abjad> score.append(staff)

abjad> tempo_mark = contexttools.TempoMark(Duration(1, 8), 52)
abjad> tempo_mark.attach(staff)
TempoMark(8, 52)(Staff{4})

abjad> f(score)
\new Score <<

```

```
\tempo 8=52
\new Staff {
    c'4
    d'4
    e'4
    f'4
}
>>

abjad> contexttools.detach_tempo_marks_attached_to_component(staff)
(TempoMark(8, 52),)

abjad> f(score)
\new Score <<
    \new Staff {
        c'4
        d'4
        e'4
        f'4
    }
>>
```

Return tuple of zero or more tempo marks.

contexttools.detach_time_signature_marks_attached_to_component

`abjad.tools.contexttools.detach_time_signature_marks_attached_to_component` (*component*)

New in version 2.0. Detach time signature marks attached to *component*:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4")
abjad> contexttools.TimeSignatureMark((4, 4))(staff[0])
TimeSignatureMark((4, 4))(c'4)

abjad> f(staff)
\new Staff {
    \time 4/4
    c'4
    d'4
    e'4
    f'4
}

abjad> contexttools.detach_time_signature_marks_attached_to_component(staff[0])
(TimeSignatureMark((4, 4)),)

abjad> f(staff)
\new Staff {
    c'4
    d'4
    e'4
    f'4
}
```

Return tuple of zero or more time signature marks.

contexttools.get_clef_mark_attached_to_component

`abjad.tools.contexttools.get_clef_mark_attached_to_component` (*component*)

New in version 2.3. Get clef mark attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('treble')(staff)
ClefMark('treble')(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "treble"
  c'8
  d'8
  e'8
  f'8
}

abjad> contexttools.get_clef_mark_attached_to_component(staff)
ClefMark('treble')(Staff{4})

```

Return clef mark.

Raise missing mark error when no clef mark attached to *component*.

contexttools.get_clef_marks_attached_to_component

`abjad.tools.contexttools.get_clef_marks_attached_to_component` (*component*)

New in version 2.3. Get clef marks attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('treble')(staff)
ClefMark('treble')(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "treble"
  c'8
  d'8
  e'8
  f'8
}

abjad> contexttools.get_clef_marks_attached_to_component(staff)
(ClefMark('treble')(Staff{4}),)

```

Return tuple of zero or more clef marks.

contexttools.get_context_mark_attached_to_component

`abjad.tools.contexttools.get_context_mark_attached_to_component` (*component*,

klaseses=(*<class*

'ab-

jad.tools.contexttools.ContextMark.Con

))

New in version 2.3. Get context mark attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('treble')(staff)
ClefMark('treble')(Staff{4})

abjad> f(staff)
\new Staff {
    \clef "treble"
    c'8
    d'8
    e'8
    f'8
}

abjad> contexttools.get_context_mark_attached_to_component(staff)
ClefMark('treble')(Staff{4})

```

Return context mark.

Raise missing mark error when no context mark attaches to *component*.

contexttools.get_context_marks_attached_to_any_improper_parent_of_component

`abjad.tools.contexttools.get_context_marks_attached_to_any_improper_parent_of_component` (*component*)
 New in version 2.0. Get all context marks attached to any improper parent of *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('treble')(staff)
ClefMark('treble')(Staff{4})
abjad> contexttools.DynamicMark('f')(staff[0])
DynamicMark('f')(c'8)

abjad> f(staff)
\new Staff {
    \clef "treble"
    c'8 \f
    d'8
    e'8
    f'8
}

abjad> contexttools.get_context_marks_attached_to_any_improper_parent_of_component(staff[0]) # d
set([DynamicMark('f')(c'8), ClefMark('treble')(Staff{4})])

```

Return unordered set of zero or more context marks. Changed in version 2.0: renamed `contexttools.get_all_context_marks_attached_to_any_improper_parent_of_component()` to `contexttools.get_context_marks_attached_to_any_improper_parent_of_component()`.

contexttools.get_context_marks_attached_to_component

`abjad.tools.contexttools.get_context_marks_attached_to_component` (*component*,
classes=(*<class*
 'ab-
 jad.tools.contexttools.ContextMark.Co
))

New in version 2.0. Get context marks attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('treble')(staff)
ClefMark('treble')(Staff{4})
abjad> contexttools.DynamicMark('p')(staff[0])
DynamicMark('p')(c'8)

abjad> f(staff)
\new Staff {
    \clef "treble"
    c'8 \p
    d'8
    e'8
    f'8
}

abjad> contexttools.get_context_marks_attached_to_component(staff[0])
(DynamicMark('p')(c'8),)

```

Return tuple of zero or more context marks. Changed in version 2.0: re-named `contexttools.get_context_marks_attached_to_component()` to `contexttools.get_context_marks_attached_to_component()`.

contexttools.get_dynamic_mark_attached_to_component

`abjad.tools.contexttools.get_dynamic_mark_attached_to_component(component)`

New in version 2.3. Get dynamic mark attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.DynamicMark('p')(staff[0])
DynamicMark('p')(c'8)

abjad> f(staff)
\new Staff {
    c'8 \p
    d'8
    e'8
    f'8
}

abjad> contexttools.get_dynamic_mark_attached_to_component(staff[0])
DynamicMark('p')(c'8)

```

Return dynamic mark.

Raise missing mark error when no dynamic mark attaches to *component*.

Raise extra mark error when more than one dynamic mark attaches to *component*.

contexttools.get_dynamic_marks_attached_to_component

`abjad.tools.contexttools.get_dynamic_marks_attached_to_component(component)`

New in version 2.0. Get dynamic marks attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.DynamicMark('p')(staff[0])
DynamicMark('p')(c'8)

```

```
abjad> f(staff)
\new Staff {
    c'8 \p
    d'8
    e'8
    f'8
}

abjad> contexttools.get_dynamic_marks_attached_to_component(staff[0])
(DynamicMark('p')(c'8),)
```

Return tuple of zero or more dynamic marks.

contexttools.get_effective_clef

`abjad.tools.contexttools.get_effective_clef(component)`

New in version 2.0. Get effective clef of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('treble')(staff)
ClefMark('treble')(Staff{4})

abjad> f(staff)
\new Staff {
    \clef "treble"
    c'8
    d'8
    e'8
    f'8
}

abjad> for note in staff:
...     print note, contexttools.get_effective_clef(note)
...
c'8 ClefMark('treble')(Staff{4})
d'8 ClefMark('treble')(Staff{4})
e'8 ClefMark('treble')(Staff{4})
f'8 ClefMark('treble')(Staff{4})
```

Return clef mark or none.

contexttools.get_effective_context_mark

`abjad.tools.contexttools.get_effective_context_mark(component, klass)`

New in version 2.0. Get effective context mark of *klass* from *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.TimeSignatureMark((4, 8))(staff)
TimeSignatureMark((4, 8))(Staff{4})

abjad> f(staff)
\new Staff {
    \time 4/8
    c'8
    d'8
    e'8
```



```

    f'8
}

abjad> contexttools.get_effective_context_mark(staff[0], contexttools.TimeSignatureMark)
TimeSignatureMark((4, 8))(Staff{4})

```

Return context mark or none.

contexttools.get_effective_dynamic

abjad.tools.contexttools.get_effective_dynamic(*component*)

New in version 2.0. Get effective dynamic of *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.DynamicMark('f')(staff[0])
DynamicMark('f')(c'8)

abjad> f(staff)
\new Staff {
    c'8 \f
    d'8
    e'8
    f'8
}

abjad> for note in staff:
...     print note, contexttools.get_effective_dynamic(note)
...
c'8 DynamicMark('f')(c'8)
d'8 DynamicMark('f')(c'8)
e'8 DynamicMark('f')(c'8)
f'8 DynamicMark('f')(c'8)

```

Return dynamic mark or none.

contexttools.get_effective_instrument

abjad.tools.contexttools.get_effective_instrument(*component*)

New in version 2.0. Get effective instrument of *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.InstrumentMark('Flute', 'Fl.')(staff)
InstrumentMark('Flute', 'Fl.')(Staff{4})

abjad> f(staff)
\new Staff {
    \set Staff.instrumentName = \markup { Flute }
    \set Staff.shortInstrumentName = \markup { Fl. }
    c'8
    d'8
    e'8
    f'8
}

abjad> for note in staff:
...     print note, contexttools.get_effective_instrument(note)

```

```
...
c'8 InstrumentMark('Flute', 'Fl.')(Staff{4})
d'8 InstrumentMark('Flute', 'Fl.')(Staff{4})
e'8 InstrumentMark('Flute', 'Fl.')(Staff{4})
f'8 InstrumentMark('Flute', 'Fl.')(Staff{4})
```

Return instrument mark or none.

contexttools.get_effective_key_signature

`abjad.tools.contexttools.get_effective_key_signature(component)`

New in version 2.0. Get effective key signature of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.KeySignatureMark('c', 'major')(staff)
KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major))(Staff{4})

abjad> f(staff)
\new Staff {
    \key c \major
    c'8
    d'8
    e'8
    f'8
}

abjad> for note in staff:
...     note, contexttools.get_effective_key_signature(note)
...
(Note("c'8"), KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major))(Staff{4}))
(Note("d'8"), KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major))(Staff{4}))
(Note("e'8"), KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major))(Staff{4}))
(Note("f'8"), KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major))(Staff{4}))
```

Return key signature mark or none.

contexttools.get_effective_staff

`abjad.tools.contexttools.get_effective_staff(component)`

New in version 2.0. Get effective staff of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> staff.name = 'First Staff'

abjad> f(staff)
\context Staff = "First Staff" {
    c'8
    d'8
    e'8
    f'8
}

abjad> for note in staff:
...     print note, contexttools.get_effective_staff(note)
...
c'8 Staff-"First Staff"{4}
d'8 Staff-"First Staff"{4}
```

```
e'8 Staff-"First Staff"{4}
f'8 Staff-"First Staff"{4}
```

Return staff or none.

contexttools.get_effective_tempo

abjad.tools.contexttools.get_effective_tempo(*component*)

New in version 2.0. Get effective tempo of *component*:

```
abjad> score = Score([])
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> score.append(staff)
abjad> contexttools.TempoMark(Duration(1, 8), 52)(staff[0])
TempoMark(8, 52)(c'8)

abjad> f(score)
\new Score <<
  \tempo 8=52
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
>>

abjad> for note in staff:
...     print note, contexttools.get_effective_tempo(note)
...
c'8 TempoMark(8, 52)(c'8)
d'8 TempoMark(8, 52)(c'8)
e'8 TempoMark(8, 52)(c'8)
f'8 TempoMark(8, 52)(c'8)
```

Return tempo mark or none.

contexttools.get_effective_time_signature

abjad.tools.contexttools.get_effective_time_signature(*component*)

New in version 2.0. Get effective time signature of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.TimeSignatureMark((4, 8))(staff)
TimeSignatureMark((4, 8))(Staff{4})

abjad> f(staff)
\new Staff {
  \time 4/8
  c'8
  d'8
  e'8
  f'8
}
```

```
abjad> for note in staff:
...     note, contexttools.get_effective_time_signature(note)
...
(Note("c'8"), TimeSignatureMark((4, 8))(Staff{4}))
(Note("d'8"), TimeSignatureMark((4, 8))(Staff{4}))
(Note("e'8"), TimeSignatureMark((4, 8))(Staff{4}))
(Note("f'8"), TimeSignatureMark((4, 8))(Staff{4}))
```

Return time signature mark or none.

contexttools.get_instrument_mark_attached_to_component

abjad.tools.contexttools.get_instrument_mark_attached_to_component(*component*)

New in version 2.1. Get instrument mark attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> violin = contexttools.InstrumentMark('Violin ', 'Vn. ')
abjad> violin.attach(staff)
InstrumentMark('Violin ', 'Vn. ')(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Violin }
  \set Staff.shortInstrumentName = \markup { Vn. }
  c'8
  d'8
  e'8
  f'8
}

abjad> contexttools.get_instrument_mark_attached_to_component(staff)
InstrumentMark('Violin ', 'Vn. ')(Staff{4})
```

Return instrument mark.

Raise missing mark error when no instrument mark attaches to *component*.

contexttools.get_instrument_marks_attached_to_component

abjad.tools.contexttools.get_instrument_marks_attached_to_component(*component*)

New in version 2.3. Get instrument marks attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.InstrumentMark('Flute', 'Fl.')(staff)
InstrumentMark('Flute', 'Fl.')(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Flute }
  \set Staff.shortInstrumentName = \markup { Fl. }
  c'8
  d'8
  e'8
  f'8
}
```

```
abjad> contexttools.get_instrument_marks_attached_to_component(staff)
(InstrumentMark('Flute', 'Fl.') (Staff{4}),)
```

Return tuple of zero or more instrument marks.

contexttools.get_key_signature_mark_attached_to_component

abjad.tools.contexttools.get_key_signature_mark_attached_to_component(*component*)

New in version 2.3. Get key signature mark attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.KeySignatureMark('c', 'major')(staff)
KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major)) (Staff{4})
```

```
abjad> f(staff)
\new Staff {
  \key c \major
  c'8
  d'8
  e'8
  f'8
}
```

```
abjad> contexttools.get_key_signature_mark_attached_to_component(staff)
KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major)) (Staff{4})
```

Return key signature mark.

Raise missing mark error when no key signature mark attaches to component.

contexttools.get_key_signature_marks_attached_to_component

abjad.tools.contexttools.get_key_signature_marks_attached_to_component(*component*)

New in version 2.3. Get key signature marks attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.KeySignatureMark('c', 'major')(staff)
KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major)) (Staff{4})
```

```
abjad> f(staff)
\new Staff {
  \key c \major
  c'8
  d'8
  e'8
  f'8
}
```

```
abjad> contexttools.get_key_signature_marks_attached_to_component(staff)
(KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major)) (Staff{4}),)
```

Return tuple of zero or more key signature marks.

contexttools.get_staff_change_mark_attached_to_component

abjad.tools.contexttools.get_staff_change_mark_attached_to_component(*component*)

New in version 2.3. Get staff change mark attached to *component*:

```
abjad> piano_staff = scoretools.PianoStaff([])
abjad> rh_staff = Staff("c'8 d'8 e'8 f'8")
abjad> rh_staff.name = 'RHStaff'
abjad> lh_staff = Staff("s2")
abjad> lh_staff.name = 'LHStaff'
abjad> piano_staff.extend([rh_staff, lh_staff])
abjad> contexttools.StaffChangeMark(lh_staff)(rh_staff[2])
StaffChangeMark(Staff-"LHStaff"{1})(e'8)
```

```
abjad> f(piano_staff)
\new PianoStaff <<
  \context Staff = "RHStaff" {
    c'8
    d'8
    \change Staff = LHStaff
    e'8
    f'8
  }
  \context Staff = "LHStaff" {
    s2
  }
>>
```

```
abjad> contexttools.get_staff_change_mark_attached_to_component(rh_staff[2])
StaffChangeMark(Staff-"LHStaff"{1})(e'8)
```

Return staff change mark.

Raise missing mark error when no staff change mark attaches to *component*.

contexttools.get_staff_change_marks_attached_to_component

abjad.tools.contexttools.get_staff_change_marks_attached_to_component(*component*)

New in version 2.3. Get staff change marks attached to *component*:

```
abjad> piano_staff = scoretools.PianoStaff([])
abjad> rh_staff = Staff("c'8 d'8 e'8 f'8")
abjad> rh_staff.name = 'RHStaff'
abjad> lh_staff = Staff("s2")
abjad> lh_staff.name = 'LHStaff'
abjad> piano_staff.extend([rh_staff, lh_staff])
abjad> contexttools.StaffChangeMark(lh_staff)(rh_staff[2])
StaffChangeMark(Staff-"LHStaff"{1})(e'8)
```

```
abjad> f(piano_staff)
\new PianoStaff <<
  \context Staff = "RHStaff" {
    c'8
    d'8
    \change Staff = LHStaff
    e'8
    f'8
  }
  }
```

```

    \context Staff = "LHStaff" {
      s2
    }
  >>

abjad> contexttools.get_staff_change_marks_attached_to_component(rh_staff[2])
(StaffChangeMark(Staff-"LHStaff"{1})(e'8),)

```

Return tuple of zero or more staff change marks.

contexttools.get_tempo_mark_attached_to_component

abjad.tools.contexttools.get_tempo_mark_attached_to_component(*component*)

New in version 2.3. Get tempo mark attached to *component*:

```

abjad> score = Score([])
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> score.append(staff)

abjad> contexttools.TempoMark(Duration(1, 8), 52)(staff)
TempoMark(8, 52)(Staff{4})

abjad> f(score)
\new Score <<
  \tempo 8=52
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
>>

abjad> contexttools.get_tempo_mark_attached_to_component(staff)
TempoMark(8, 52)(Staff{4})

```

Return tempo mark.

Raise missing mark error when no tempo mark attaches to *component*.

contexttools.get_tempo_marks_attached_to_component

abjad.tools.contexttools.get_tempo_marks_attached_to_component(*component*)

New in version 2.3. Get tempo marks attached to *component*:

```

abjad> score = Score([])
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> score.append(staff)

abjad> contexttools.TempoMark(Duration(1, 8), 52)(staff)
TempoMark(8, 52)(Staff{4})

abjad> f(score)
\new Score <<
  \tempo 8=52
  \new Staff {
    c'8

```

```

        d'8
        e'8
        f'8
    }
>>

```

```

abjad> contexttools.get_tempo_marks_attached_to_component(staff)
(TempoMark(8, 52) (Staff{4}),)

```

Return tuple of zero or more tempo marks.

contexttools.get_time_signature_mark_attached_to_component

abjad.tools.contexttools.get_time_signature_mark_attached_to_component(*component*)

New in version 2.0. Get time signature mark attached to *component*:

```

abjad> measure = Measure((4, 8), "c'8 d'8 e'8 f'8")

abjad> f(measure)
{
    \time 4/8
    c'8
    d'8
    e'8
    f'8
}

abjad> contexttools.get_time_signature_mark_attached_to_component(measure)
TimeSignatureMark((4, 8))(|4/8, c'8, d'8, e'8, f'8|)

```

Return time signature mark.

Raise missing mark error when no time signature mark attaches to *component*.

contexttools.get_time_signature_marks_attached_to_component

abjad.tools.contexttools.get_time_signature_marks_attached_to_component(*component*)

New in version 2.3. Get time signature marks attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.TimeSignatureMark((2, 4))(staff)
TimeSignatureMark((2, 4)) (Staff{4})

abjad> f(staff)
\new Staff {
    \time 2/4
    c'8
    d'8
    e'8
    f'8
}

abjad> contexttools.get_time_signature_marks_attached_to_component(staff)
(TimeSignatureMark((2, 4)) (Staff{4}),)

```

Return tuple of zero or more time_signature marks.

contexttools.is_component_with_clef_mark_attached

`abjad.tools.contexttools.is_component_with_clef_mark_attached(expr)`

New in version 2.3. True when *expr* is a component with clef mark attached:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('treble')(staff)
ClefMark('treble')(Staff{4})
```

```
abjad> f(staff)
\new Staff {
  \clef "treble"
  c'8
  d'8
  e'8
  f'8
}
```

```
abjad> contexttools.is_component_with_clef_mark_attached(staff)
True
```

False otherwise:

```
abjad> contexttools.is_component_with_clef_mark_attached(staff[0]) False
```

Return boolean.

contexttools.is_component_with_context_mark_attached

`abjad.tools.contexttools.is_component_with_context_mark_attached(expr,
klases=(<class
'ab-
jad.tools.contexttools.ContextMark.Co
))`

New in version 2.0. True when *expr* is a component with context mark of *klases* attached:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.TimeSignatureMark((4, 8))(staff[0])
TimeSignatureMark((4, 8))(c'8)
abjad> f(staff)
\new Staff {
  \time 4/8
  c'8
  d'8
  e'8
  f'8
}
abjad> contexttools.is_component_with_context_mark_attached(staff[0])
True
```

Otherwise false:

```
abjad> contexttools.is_component_with_context_mark_attached(staff)
False
```

Return boolean.

contexttools.is_component_with_dynamic_mark_attached

`abjad.tools.contexttools.is_component_with_dynamic_mark_attached(expr)`

New in version 2.3. True when *expr* is a component and has a dynamic mark attached:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.DynamicMark('p')(staff[0])
DynamicMark('p')(c'8)
```

```
abjad> f(staff)
\new Staff {
    c'8 \p
    d'8
    e'8
    f'8
}
```

```
abjad> contexttools.is_component_with_dynamic_mark_attached(staff[0])
True
```

Otherwise false:

```
abjad> contexttools.is_component_with_dynamic_mark_attached(staff)
False
```

Return boolean.

contexttools.is_component_with_instrument_mark_attached

`abjad.tools.contexttools.is_component_with_instrument_mark_attached(expr)`

New in version 2.3. True when *expr* is a component with instrument mark attached:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> violin = contexttools.InstrumentMark('Violin ', 'Vn. ')
abjad> violin.attach(staff)
InstrumentMark('Violin ', 'Vn. ')(Staff{4})
```

```
abjad> f(staff)
\new Staff {
    \set Staff.instrumentName = \markup { Violin }
    \set Staff.shortInstrumentName = \markup { Vn. }
    c'8
    d'8
    e'8
    f'8
}
```

```
abjad> contexttools.is_component_with_instrument_mark_attached(staff)
True
```

Otherwise false:

```
abjad> contexttools.is_component_with_instrument_mark_attached(staff[0])
False
```

Return boolean.

contexttools.is_component_with_key_signature_mark_attached

`abjad.tools.contexttools.is_component_with_key_signature_mark_attached(expr)`

New in version 2.3. True when *expr* is a component with key signature mark attached:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.KeySignatureMark('c', 'major')(staff)
KeySignatureMark(NamedChromaticPitchClass('c'), Mode(major))(Staff{4})
```

```
abjad> f(staff)
\new Staff {
    \key c \major
    c'8
    d'8
    e'8
    f'8
}
```

```
abjad> contexttools.is_component_with_key_signature_mark_attached(staff)
True
```

Otherwise false:

```
abjad> contexttools.is_component_with_key_signature_mark_attached(staff[0])
False
```

Return boolean.

contexttools.is_component_with_staff_change_mark_attached

`abjad.tools.contexttools.is_component_with_staff_change_mark_attached(expr)`

New in version 2.3. True when *expr* is a component with staff change mark attached:

```
abjad> piano_staff = scoretools.PianoStaff([])
abjad> rh_staff = Staff("c'8 d'8 e'8 f'8")
abjad> rh_staff.name = 'RHStaff'
abjad> lh_staff = Staff("s2")
abjad> lh_staff.name = 'LHStaff'
abjad> piano_staff.extend([rh_staff, lh_staff])
abjad> contexttools.StaffChangeMark(lh_staff)(rh_staff[2])
StaffChangeMark(Staff-"LHStaff"{1})(e'8)
```

```
abjad> f(piano_staff)
\new PianoStaff <<
    \context Staff = "RHStaff" {
        c'8
        d'8
        \change Staff = LHStaff
        e'8
        f'8
    }
    \context Staff = "LHStaff" {
        s2
    }
>>
```

```
abjad> contexttools.is_component_with_staff_change_mark_attached(rh_staff[2])
True
```

Otherwise false:

```
abjad> contexttools.is_component_with_staff_change_mark_attached(rh_staff)
False
```

Return boolean.

contexttools.is_component_with_tempo_mark_attached

`abjad.tools.contexttools.is_component_with_tempo_mark_attached(expr)`

New in version 2.3. True when *expr* is a component with tempo mark attached:

```
abjad> score = Score([])
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> score.append(staff)

abjad> contexttools.TempoMark(Duration(1, 8), 52)(staff)
TempoMark(8, 52)(Staff{4})

abjad> f(score)
\new Score <<
  \tempo 8=52
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
>>

abjad> contexttools.is_component_with_tempo_mark_attached(staff)
True
```

Otherwise false:

```
abjad> contexttools.is_component_with_tempo_mark_attached(staff[0])
False
```

Return boolean.

contexttools.is_component_with_time_signature_mark_attached

`abjad.tools.contexttools.is_component_with_time_signature_mark_attached(expr)`

New in version 2.0. True when *expr* is a component with time signature mark attached:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.TimeSignatureMark((4, 8))(staff[0])
TimeSignatureMark((4, 8))(c'8)

abjad> f(staff)
\new Staff {
  \time 4/8
  c'8
  d'8
  e'8
  f'8
}
```

```
abjad> contexttools.is_component_with_time_signature_mark_attached(staff[0])
True
```

Otherwise false:

```
abjad> contexttools.is_component_with_time_signature_mark_attached(staff)
False
```

Return boolean.

contexttools.iterate_contexts_backward_in_expr

```
abjad.tools.contexttools.iterate_contexts_backward_in_expr(expr, start=0,
                                                         stop=None)
```

New in version 2.0. Iterate contexts backward in *expr*:

```
abjad> staff = Staff([Voice("c'8 d'8"), Voice("e'8 f'8 g'8")])
abjad> Tuplet(Fraction(2, 3), staff[1][:])
Tuplet(2/3, [e'8, f'8, g'8])
abjad> staff.is_parallel = True
```

```
abjad> f(staff)
\new Staff <<
  \new Voice {
    c'8
    d'8
  }
  \new Voice {
    \times 2/3 {
      e'8
      f'8
      g'8
    }
  }
>>
```

```
abjad> for x in contexttools.iterate_contexts_backward_in_expr(staff):
...     x
Staff<<2>>
Voice{1}
Voice{2}
```

Ignore threads.

Return generator.

contexttools.iterate_contexts_forward_in_expr

```
abjad.tools.contexttools.iterate_contexts_forward_in_expr(expr, start=0,
                                                         stop=None)
```

New in version 2.0. Iterate contexts forward in *expr*:

```
abjad> staff = Staff([Voice("c'8 d'8"), Voice("e'8 f'8 g'8")])
abjad> Tuplet(Fraction(2, 3), staff[1][:])
Tuplet(2/3, [e'8, f'8, g'8])
abjad> staff.is_parallel = True
```

```

abjad> f(staff)
\new Staff <<
  \new Voice {
    c'8
    d'8
  }
  \new Voice {
    \times 2/3 {
      e'8
      f'8
      g'8
    }
  }
>>

abjad> for x in contexttools.iterate_contexts_forward_in_expr(staff):
...     x
Staff<<2>>
Voice{2}
Voice{1}

```

Ignore threads.

Return generator.

contexttools.set_accidental_style_on_sequential_contexts_in_expr

```

abjad.tools.contexttools.set_accidental_style_on_sequential_contexts_in_expr(expr,
                                                                              ac-
                                                                              ci-
                                                                              den-
                                                                              tal_style)

```

New in version 2.0. Set *accidental_style* for sequential semantic contexts in *expr*:

```

abjad> score = Score(Staff("c'8 d'8") * 2)
abjad> contexttools.set_accidental_style_on_sequential_contexts_in_expr(score, 'forget')

abjad> f(score)
\new Score <<
  \new Staff {
    #(set-accidental-style 'forget)
    c'8
    d'8
  }
  \new Staff {
    #(set-accidental-style 'forget)
    c'8
    d'8
  }
>>

```

Skip nonsemantic contexts.

Function looks like a hack but isn't. LilyPond uses the dedicated command shown here to set accidental style. This means that it is not possible to set accidental style on a top-level context like score with a single override.

gracetools

gracetools.Grace

class abjad.tools.gracetools.**Grace** (*music=None, kind='grace', **kwargs*)
 Bases: abjad.tools.containertools.Container.Container.Container

Abjad model of grace music:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(voice[:])
BeamSpanner(c'8, d'8, e'8, f'8)

abjad> f(voice)
\new Voice {
  c'8 [
  d'8
  e'8
  f'8 ]
}

abjad> grace_notes = [Note("c'16"), Note("d'16")]
abjad> gracetools.Grace(grace_notes, kind = 'grace')(voice[1])
Note("d'8")

abjad> f(voice)
\new Voice {
  c'8 [
  \grace {
    c'16
    d'16
  }
  d'8
  e'8
  f'8 ]
}

abjad> after_grace_notes = [Note("e'16"), Note("f'16")]
abjad> gracetools.Grace(after_grace_notes, kind = 'after')(voice[1])
Note("d'8")

abjad> f(voice)
\new Voice {
  c'8 [
  \grace {
    c'16
    d'16
  }
  \afterGrace
  d'8
  {
    e'16
    f'16
  }
  e'8
  f'8 ]
}
```

Grace objects are containers you can fill with notes, rests and chords.

Grace containers override the special `__call__` method.

Use `Grace()` to attach grace containers to nongrace notes, rests and chords.

detach()

Detach grace container from leaf:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> grace_container = gracetools.Grace([Note("cs'16")], kind = 'grace')
abjad> grace_container(staff[1])
Note("d'8")
abjad> f(staff)
\new Staff {
    c'8
    \grace {
        cs'16
    }
    d'8
    e'8
    f'8
}

abjad> grace_container.detach()
Grace()
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}
```

Return grace container.

kind

Get *kind* of grace container:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> gracetools.Grace([Note("cs'16")], kind = 'grace')(staff[1])
Note("d'8")
abjad> grace_container = staff[1].grace
abjad> grace_container.kind
'grace'
```

Return string.

Set *kind* of grace container:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> gracetools.Grace([Note("cs'16")], kind = 'grace')(staff[1])
Note("d'8")
abjad> grace_container = staff[1].grace
abjad> grace_container.kind = 'acciaccatura'
abjad> grace_container.kind
'acciaccatura'
```

Set string.

Valid options include `'after'`, `'grace'`, `'acciaccatura'`, `'appoggiatura'`.

gracetools.all_are_grace_containers

abjad.tools.gracetools.**all_are_grace_containers**(*expr*)

New in version 2.6. True when *expr* is a sequence of Abjad grace containers:

```

abjad> graces = [gracetools.Grace("<c' e' g'>4"), gracetools.Grace("<c' f' a'>4")]
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> grace_notes = [Note("c'16"), Note("d'16")]
abjad> grace_container = gracetools.Grace(grace_notes, kind = 'grace')
abjad> grace_container(voice[1])
Note("d'8")

```

```

abjad> f(voice)
\new Voice {
  c'8
  \grace {
    c'16
    d'16
  }
  d'8
  e'8
  f'8
}

```

```

abjad> gracetools.all_are_grace_containers([grace_container])
True

```

True when *expr* is an empty sequence:

```

abjad> gracetools.all_are_grace_containers([])
True

```

Otherwise false:

```

abjad> gracetools.all_are_grace_containers('foo')
False

```

Return boolean.

Function wraps `componenttools.all_are_components()`.

gracetools.detach_grace_containers_attached_to_leaf

abjad.tools.gracetools.**detach_grace_containers_attached_to_leaf**(*leaf*)

New in version 2.0. Detach grace containers attached to *leaf*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> grace_container = gracetools.Grace([Note("cs'16")], kind = 'grace')
abjad> grace_container(staff[1])
Note("d'8")

```

```

abjad> f(staff)
\new Staff {
  c'8
  \grace {
    cs'16
  }
  d'8
  e'8
}

```

```

        f'8
    }

abjad> gracetools.get_grace_containers_attached_to_leaf(staff[1])
(Grace(cs'16),)

abjad> gracetools.detach_grace_containers_attached_to_leaf(staff[1])
(Grace(),)

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}

abjad> gracetools.get_grace_containers_attached_to_leaf(staff[1])
()
```

Return tuple.

gracetools.get_grace_containers_attached_to_leaf

`abjad.tools.gracetools.get_grace_containers_attached_to_leaf(leaf)`

New in version 2.0. Get grace containers attached to leaf:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> gracetools.Grace([Note("cs'16")], kind = 'grace')(staff[1])
Note("d'8")
abjad> gracetools.Grace([Note("ds'16")], kind = 'after')(staff[1])
Note("d'8")

abjad> f(staff)
\new Staff {
    c'8
    \grace {
        cs'16
    }
    \afterGrace
    d'8
    {
        ds'16
    }
    e'8
    f'8
}

abjad> gracetools.get_grace_containers_attached_to_leaf(staff[1])
(Grace(cs'16), Grace(ds'16))
```

Return tuple.

gracetools.iterate_components_and_grace_containers_forward_in_expr

abjad.tools.gracetools.**iterate_components_and_grace_containers_forward_in_expr**(*expr*, *klass*)

Iterate components of *klass* forward in *expr*:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(voice[:])
BeamSpanner(c'8, d'8, e'8, f'8)

abjad> grace_notes = [Note("c'16"), Note("d'16")]
abjad> gracetools.Grace(grace_notes, kind = 'grace')(voice[1])
Note("d'8")

abjad> after_grace_notes = [Note("e'16"), Note("f'16")]
abjad> gracetools.Grace(after_grace_notes, kind = 'after')(voice[1])
Note("d'8")
```

```
abjad> f(voice)
\new Voice {
  c'8 [
    \grace {
      c'16
      d'16
    }
  \afterGrace
  d'8
  {
    e'16
    f'16
  }
  e'8
  f'8 ]
}
```

```
abjad> for note in gracetools.iterate_components_and_grace_containers_forward_in_expr(voice, Note):
...     note
...
Note("c'8")
Note("c'16")
Note("d'16")
Note("d'8")
Note("e'16")
Note("f'16")
Note("e'8")
Note("f'8")
```

Include grace leaves before main leaves.

Include grace leaves after main leaves. Changed in version 2.0: renamed `iterate.grace()` to `componenttools.iterate_components_and_grace_containers_forward_in_expr()`.

instrumenttools

instrumenttools.Accordion

class abjad.tools.instrumenttools.**Accordion**(*target_context=None*, ***kwargs*)

Bases: abjad.tools.instrumenttools._KeyboardInstrument._KeyboardInstrument, abjad.tools.instrumenttools._ReedInstrument._ReedInstrument

Abjad model of the accordion:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Accordion(target_context = Staff)(staff)
Accordion()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Accordion }
  \set Staff.shortInstrumentName = \markup { Acc. }
  c'8
  d'8
  e'8
  f'8
}
```

The accordion targets piano staff context by default.

instrumenttools.AltoFlute

class abjad.tools.instrumenttools.**AltoFlute**(**kwargs)
 Bases: abjad.tools.instrumenttools.Flute.Flute.Flute

Abjad model of the alto flute:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.AltoFlute()(staff)
AltoFlute()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Alto flute }
  \set Staff.shortInstrumentName = \markup { Alt. fl. }
  c'8
  d'8
  e'8
  f'8
}
```

The alto flute targets staff context by default.

instrumenttools.AltoSaxophone

class abjad.tools.instrumenttools.**AltoSaxophone**(**kwargs)
 Bases: abjad.tools.instrumenttools._Saxophone._Saxophone._Saxophone New in version 2.6. Abjad model of the alto saxophone:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.AltoSaxophone()(staff)
AltoSaxophone()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Alto saxophone }
```

```

\set Staff.shortInstrumentName = \markup { Alto sax. }
c'8
d'8
e'8
f'8
}

```

The alto saxophone is pitched in E-flat.

The alto saxophone targets staff context by default.

instrumenttools.AltoTrombone

class abjad.tools.instrumenttools.**AltoTrombone** (**kwargs)

Bases: abjad.tools.instrumenttools._Trombone._Trombone._Trombone New in version 2.0. Abjad model of the alto trombone:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('bass')(staff)
ClefMark('bass')(Staff{4})

abjad> instrumenttools.AltoTrombone()(staff)
AltoTrombone()(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "bass"
  \set Staff.instrumentName = \markup { Alto trombone }
  \set Staff.shortInstrumentName = \markup { Alt. trb. }
  c'8
  d'8
  e'8
  f'8
}

```

The tenor trombone targets staff context by default.

instrumenttools.BFlatClarinet

class abjad.tools.instrumenttools.**BFlatClarinet** (**kwargs)

Bases: abjad.tools.instrumenttools._Clarinet._Clarinet._Clarinet New in version 2.0. Abjad model of the B-flat clarinet:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.BFlatClarinet()(staff)
BFlatClarinet()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Clarinet in B-flat }
  \set Staff.shortInstrumentName = \markup { Cl. in B-flat }
  c'8
  d'8
  e'8
  f'8
}

```

The B-flat clarinet targets staff context by default.

instrumenttools.BaritoneSaxophone

```
class abjad.tools.instrumenttools.BaritoneSaxophone (**kwargs)
    Bases: abjad.tools.instrumenttools._Saxophone._Saxophone._Saxophone New in version 2.6. Abjad model of the baritone saxophone:

    abjad> staff = Staff("c'8 d'8 e'8 f'8")

    abjad> instrumenttools.BaritoneSaxophone()(staff)
    BaritoneSaxophone()(Staff{4})

    abjad> f(staff)
    \new Staff {
        \set Staff.instrumentName = \markup { Baritone saxophone }
        \set Staff.shortInstrumentName = \markup { Bar. sax. }
        c'8
        d'8
        e'8
        f'8
    }
```

The baritone saxophone is pitched in E-flat.

The baritone saxophone targets staff context by default.

instrumenttools.BassClarinet

```
class abjad.tools.instrumenttools.BassClarinet (**kwargs)
    Bases: abjad.tools.instrumenttools._Clarinet._Clarinet._Clarinet New in version 2.0. Abjad model of the bass clarinet:

    abjad> staff = Staff("c'8 d'8 e'8 f'8")

    abjad> instrumenttools.BassClarinet()(staff)
    BassClarinet()(Staff{4})

    abjad> f(staff)
    \new Staff {
        \set Staff.instrumentName = \markup { Bass clarinet }
        \set Staff.shortInstrumentName = \markup { Bass cl. }
        c'8
        d'8
        e'8
        f'8
    }
```

The bass clarinet targets staff context by default.

instrumenttools.BassFlute

```
class abjad.tools.instrumenttools.BassFlute (**kwargs)
    Bases: abjad.tools.instrumenttools.Flute.Flute.Flute New in version 2.0. Abjad model of the bass flute:
```

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.BassFlute()(staff)
BassFlute()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Bass flute }
  \set Staff.shortInstrumentName = \markup { Bass fl. }
  c'8
  d'8
  e'8
  f'8
}

```

The bass flute targets staff context by default.

instrumenttools.BassSaxophone

class abjad.tools.instrumenttools.**BassSaxophone** (**kwargs)
Bases: abjad.tools.instrumenttools._Saxophone._Saxophone._Saxophone New in version 2.6. Abjad model of the bass saxophone:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.BassSaxophone()(staff)
BassSaxophone()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Bass saxophone }
  \set Staff.shortInstrumentName = \markup { Bass sax. }
  c'8
  d'8
  e'8
  f'8
}

```

The bass saxophone is pitched in B-flat.

The bass saxophone targets staff context by default.

instrumenttools.BassTrombone

class abjad.tools.instrumenttools.**BassTrombone** (**kwargs)
Bases: abjad.tools.instrumenttools._Trombone._Trombone._Trombone New in version 2.0. Abjad model of the tenor trombone:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('bass')(staff)
ClefMark('bass')(Staff{4})

abjad> instrumenttools.BassTrombone()(staff)
BassTrombone()(Staff{4})

```

```
abjad> f(staff)
\new Staff {
  \clef "bass"
  \set Staff.instrumentName = \markup { Bass trombone }
  \set Staff.shortInstrumentName = \markup { Bass trb. }
  c'8
  d'8
  e'8
  f'8
}
```

The tenor trombone targets staff context by default.

instrumenttools.Bassoon

class abjad.tools.instrumenttools.**Bassoon** (**kwargs)

Bases: abjad.tools.instrumenttools._DoubleReedInstrument._DoubleReedInstrument._DoubleReedInstrument

New in version 2.0. Abjad model of the bassoon:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('bass')(staff)
ClefMark('bass')(Staff{4})
```

```
abjad> instrumenttools.Bassoon()(staff)
Bassoon()(Staff{4})
```

```
abjad> f(staff)
\new Staff {
  \clef "bass"
  \set Staff.instrumentName = \markup { Bassoon }
  \set Staff.shortInstrumentName = \markup { Bsn. }
  c'8
  d'8
  e'8
  f'8
}
```

The bassoon targets staff context by default.

instrumenttools.Cello

class abjad.tools.instrumenttools.**Cello** (**kwargs)

Bases: abjad.tools.instrumenttools._StringInstrument._StringInstrument._StringInstrument

New in version 2.0. Abjad model of the cello:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('bass')(staff)
ClefMark('bass')(Staff{4})
```

```
abjad> instrumenttools.Cello()(staff)
Cello()(Staff{4})
```

```
abjad> f(staff)
\new Staff {
  \clef "bass"
  \set Staff.instrumentName = \markup { Cello }
```



```

\set Staff.shortInstrumentName = \markup { Vc. }
c'8
d'8
e'8
f'8
}

```

The cello targets staff context by default.

instrumenttools.ClarinetInA

class abjad.tools.instrumenttools.**ClarinetInA**(**kwargs)

Bases: abjad.tools.instrumenttools._Clarinet._Clarinet._Clarinet New in version 2.6. Abjad model of the clarinet in A:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.ClarinetInA()(staff)
ClarinetInA()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Clarinet in A }
  \set Staff.shortInstrumentName = \markup { Cl. A \natural }
  c'8
  d'8
  e'8
  f'8
}

```

The clarinet in A targets staff context by default.

instrumenttools.Contrabass

class abjad.tools.instrumenttools.**Contrabass**(**kwargs)

Bases: abjad.tools.instrumenttools._StringInstrument._StringInstrument._StringInstrument New in version 2.0. Abjad model of the contrabass:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('bass')(staff)
ClefMark('bass')(Staff{4})

abjad> instrumenttools.Contrabass()(staff)
Contrabass()(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "bass"
  \set Staff.instrumentName = \markup { Contrabass }
  \set Staff.shortInstrumentName = \markup { Vb. }
  c'8
  d'8
  e'8
  f'8
}

```

The contrabass targets staff context by default.

instrumenttools.ContrabassClarinet

class abjad.tools.instrumenttools.**ContrabassClarinet** (**kwargs)
Bases: abjad.tools.instrumenttools._Clarinet._Clarinet._Clarinet New in version 2.6. Abjad model of the contrabass clarinet:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.ContrabassClarinet()(staff)
ContrabassClarinet()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Contrabass clarinet }
  \set Staff.shortInstrumentName = \markup { Cbass cl. }
  c'8
  d'8
  e'8
  f'8
}
```

The contrabass clarinet targets staff context by default.

instrumenttools.ContrabassFlute

class abjad.tools.instrumenttools.**ContrabassFlute** (**kwargs)
Bases: abjad.tools.instrumenttools.Flute.Flute.Flute New in version 2.0. Abjad model of the contrabass flute:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.ContrabassFlute()(staff)
ContrabassFlute()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Contrabass flute }
  \set Staff.shortInstrumentName = \markup { Cbass. fl. }
  c'8
  d'8
  e'8
  f'8
}
```

The contrabass flute targets staff context by default.

instrumenttools.ContrabassSaxophone

class abjad.tools.instrumenttools.**ContrabassSaxophone** (**kwargs)
Bases: abjad.tools.instrumenttools._Saxophone._Saxophone._Saxophone New in version 2.6. Abjad model of the bass saxophone:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.ContrabassSaxophone()(staff)
ContrabassSaxophone()(Staff{4})
```

```

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Contrabass saxophone }
  \set Staff.shortInstrumentName = \markup { Cbass. sax. }
  c'8
  d'8
  e'8
  f'8
}

```

The contrabass saxophone is pitched in E-flat.

The contrabass saxophone targets staff context by default.

instrumenttools.Contrabassoon

class abjad.tools.instrumenttools.**Contrabassoon** (**kwargs)

Bases: abjad.tools.instrumenttools.Bassoon.Bassoon.Bassoon New in version 2.0. Abjad model of the contrabassoon:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('bass')(staff)
ClefMark('bass')(Staff{4})

abjad> instrumenttools.Contrabassoon()(staff)
Contrabassoon()(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "bass"
  \set Staff.instrumentName = \markup { Contrabassoon }
  \set Staff.shortInstrumentName = \markup { Contrabsn. }
  c'8
  d'8
  e'8
  f'8
}

```

The contrabassoon targets staff context by default.

instrumenttools.EFlatClarinet

class abjad.tools.instrumenttools.**EFlatClarinet** (**kwargs)

Bases: abjad.tools.instrumenttools._Clarinet._Clarinet._Clarinet New in version 2.0. Abjad model of the E-flat clarinet:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.EFlatClarinet()(staff)
EFlatClarinet()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Clarinet in E-flat }
  \set Staff.shortInstrumentName = \markup { Cl. E-flat }
  c'8

```

```

        d'8
        e'8
        f'8
    }

```

The E-flat clarinet targets staff context by default.

instrumenttools.EnglishHorn

class abjad.tools.instrumenttools.**EnglishHorn** (**kwargs)

Bases: abjad.tools.instrumenttools.Oboe.Oboe.Oboe New in version 2.0. Abjad model of the English horn:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.EnglishHorn()(staff)
EnglishHorn()(Staff{4})

abjad> f(staff)
\new Staff {
    \set Staff.instrumentName = \markup { English horn }
    \set Staff.shortInstrumentName = \markup { Eng. hn. }
    c'8
    d'8
    e'8
    f'8
}

```

The English horn targets staff context by default.

instrumenttools.Flute

class abjad.tools.instrumenttools.**Flute** (**kwargs)

Bases: abjad.tools.instrumenttools._WindInstrument._WindInstrument._WindInstrument New in version 2.0. Abjad model of the flute:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Flute()(staff)
Flute()(Staff{4})

abjad> f(staff)
\new Staff {
    \set Staff.instrumentName = \markup { Flute }
    \set Staff.shortInstrumentName = \markup { Fl. }
    c'8
    d'8
    e'8
    f'8
}

```

The flute targets staff context by default.

instrumenttools.FrenchHorn

class abjad.tools.instrumenttools.**FrenchHorn** (**kwargs)
 Bases: abjad.tools.instrumenttools._BrassInstrument._BrassInstrument._BrassInstrument,
 abjad.tools.instrumenttools._WindInstrument._WindInstrument._WindInstrument
 New in version 2.0. Abjad model of the French horn:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.FrenchHorn() (staff)
FrenchHorn() (Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Horn }
  \set Staff.shortInstrumentName = \markup { Hn. }
  c'8
  d'8
  e'8
  f'8
}
```

The French horn targets staff context by default.

instrumenttools.Glockenspiel

class abjad.tools.instrumenttools.**Glockenspiel** (instrument_name=None,
 short_instrument_name=None, in-
 strument_name_markup=None,
 short_instrument_name_markup=None,
 target_context=None)
 Bases: abjad.tools.instrumenttools._PercussionInstrument._PercussionInstrument._PercussionInstrument
 New in version 2.0. Abjad model of the glockenspiel:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Glockenspiel() (staff)
Glockenspiel() (Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Glockenspiel }
  \set Staff.shortInstrumentName = \markup { Gkspl. }
  c'8
  d'8
  e'8
  f'8
}
```

The glockenspiel targets staff context by default.

instrumenttools.Guitar

class abjad.tools.instrumenttools.**Guitar** (**kwargs)
 Bases: abjad.tools.instrumenttools._StringInstrument._StringInstrument._StringInstrument
 New in version 2.0. Abjad model of the guitar:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Guitar()(staff)
Guitar()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Guitar }
  \set Staff.shortInstrumentName = \markup { Gt. }
  c'8
  d'8
  e'8
  f'8
}
```

The guitar targets staff context by default.

instrumenttools.Harp

class abjad.tools.instrumenttools.**Harp**(target_context=None, **kwargs)
Bases: abjad.tools.instrumenttools._StringInstrument._StringInstrument._StringInstrument
New in version 2.0. Abjad model of the harp:

```
abjad> piano_staff = scoretools.PianoStaff([Staff("c'8 d'8 e'8 f'8"), Staff("c'4 b4")])

abjad> instrumenttools.Harp()(piano_staff)
Harp()(PianoStaff<<2>>)

abjad> f(piano_staff) # doctest: +SKIP
\new PianoStaff <<
  \set PianoStaff.instrumentName = \markup { Harp }
  \set PianoStaff.shortInstrumentName = \markup { Hp. }
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
  \new Staff {
    c'4
    b4
  }
>>
```

The harp targets piano staff context by default.

instrumenttools.Harpsichord

class abjad.tools.instrumenttools.**Harpsichord**(target_context=None, **kwargs)
Bases: abjad.tools.instrumenttools._KeyboardInstrument._KeyboardInstrument._KeyboardInstrument
New in version 2.5. Abjad model of the harpsichord:

```
abjad> piano_staff = scoretools.PianoStaff([Staff("c'8 d'8 e'8 f'8"), Staff("c'4 b4")])

abjad> instrumenttools.Harpsichord()(piano_staff)
Harpsichord()(PianoStaff<<2>>)
```

```
abjad> f(piano_staff) # doctest: +SKIP
\new PianoStaff <<
  %%% \set Staff.instrumentName = \markup { Harpsichord } %%%
  %%% \set Staff.shortInstrumentName = \markup { Hpschd. } %%%
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
  \new Staff {
    c'4
    b4
  }
>>
```

The harpsichord targets piano staff context by default.

Return instrument.

instrumenttools.Marimba

```
class abjad.tools.instrumenttools.Marimba(instrument_name=None,
                                           short_instrument_name=None,      in-
                                           strument_name_markup=None,
                                           short_instrument_name_markup=None, tar-
                                           get_context=None)
```

Bases: abjad.tools.instrumenttools._PercussionInstrument._PercussionInstrument._PercussionInstrument

New in version 2.0. Abjad model of the marimba:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Marimba()(staff)
Marimba()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Marimba }
  \set Staff.shortInstrumentName = \markup { Mb. }
  c'8
  d'8
  e'8
  f'8
}
```

The marimba targets staff context by default.

instrumenttools.Oboe

```
class abjad.tools.instrumenttools.Oboe(**kwargs)
Bases: abjad.tools.instrumenttools._DoubleReedInstrument._DoubleReedInstrument._DoubleReedInstrument
New in version 2.0. Abjad model of the oboe:
```

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
```

```
abjad> instrumenttools.Oboe()(staff)
Oboe()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Oboe }
  \set Staff.shortInstrumentName = \markup { Ob. }
  c'8
  d'8
  e'8
  f'8
}
```

The oboe targets staff context by default.

instrumenttools.Piano

class `abjad.tools.instrumenttools.Piano` (*target_context=None*, ***kwargs*)
Bases: `abjad.tools.instrumenttools._KeyboardInstrument._KeyboardInstrument._KeyboardInstrument`
New in version 2.0. Abjad model of the piano:

```
abjad> piano_staff = scoretools.PianoStaff([Staff("c'8 d'8 e'8 f'8"), Staff("c'4 b4")])

abjad> instrumenttools.Piano()(piano_staff)
Piano()(PianoStaff<<2>>)

abjad> f(piano_staff) # doctest: +SKIP
\new PianoStaff <<
  \set PianoStaff.instrumentName = \markup { Piano }
  \set PianoStaff.shortInstrumentName = \markup { Pf. }
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
  \new Staff {
    c'4
    b4
  }
>>
```

The piano targets piano staff context by default.

instrumenttools.Piccolo

class `abjad.tools.instrumenttools.Piccolo` (***kwargs*)
Bases: `abjad.tools.instrumenttools.Flute.Flute.Flute` **New in version 2.0.** Abjad model of the piccolo:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Piccolo()(staff)
Piccolo()(Staff{4})
```



```

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Piccolo }
  \set Staff.shortInstrumentName = \markup { Picc. }
  c'8
  d'8
  e'8
  f'8
}

```

The piccolo targets staff context by default.

instrumenttools.SopraninoSaxophone

class abjad.tools.instrumenttools.**SopraninoSaxophone** (**kwargs)
 Bases: abjad.tools.instrumenttools._Saxophone._Saxophone._Saxophone New in version 2.6. Abjad model of the sopranino saxophone:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.SopraninoSaxophone()(staff)
SopraninoSaxophone()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Sopranino saxophone }
  \set Staff.shortInstrumentName = \markup { Sopranino sax. }
  c'8
  d'8
  e'8
  f'8
}

```

The sopranino saxophone is pitched in E-flat.

The sopranino saxophone targets staff context by default.

instrumenttools.SopranoSaxophone

class abjad.tools.instrumenttools.**SopranoSaxophone** (**kwargs)
 Bases: abjad.tools.instrumenttools._Saxophone._Saxophone._Saxophone New in version 2.6. Abjad model of the soprano saxophone:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.SopranoSaxophone()(staff)
SopranoSaxophone()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Soprano saxophone }
  \set Staff.shortInstrumentName = \markup { Sop. sax. }
  c'8
  d'8
  e'8
  f'8
}

```

The soprano saxophone is pitched in B-flat.

The soprano saxophone targets staff context by default.

instrumenttools.TenorSaxophone

class abjad.tools.instrumenttools.**TenorSaxophone** (**kwargs)

Bases: abjad.tools.instrumenttools._Saxophone._Saxophone._Saxophone New in version 2.6. Abjad model of the tenor saxophone:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.TenorSaxophone()(staff)
TenorSaxophone()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Tenor saxophone }
  \set Staff.shortInstrumentName = \markup { Ten. sax. }
  c'8
  d'8
  e'8
  f'8
}
```

The tenor saxophone is pitched in B-flat.

The tenor saxophone targets staff context by default.

instrumenttools.TenorTrombone

class abjad.tools.instrumenttools.**TenorTrombone** (**kwargs)

Bases: abjad.tools.instrumenttools._Trombone._Trombone._Trombone New in version 2.0. Abjad model of the tenor trombone:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('bass')(staff)
ClefMark('bass')(Staff{4})

abjad> instrumenttools.TenorTrombone()(staff)
TenorTrombone()(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "bass"
  \set Staff.instrumentName = \markup { Tenor trombone }
  \set Staff.shortInstrumentName = \markup { Ten. trb. }
  c'8
  d'8
  e'8
  f'8
}
```

The tenor trombone targets staff context by default.

instrumenttools.Trumpet

class abjad.tools.instrumenttools.**Trumpet** (**kwargs)
 Bases: abjad.tools.instrumenttools._BrassInstrument._BrassInstrument._BrassInstrument
 New in version 2.0. Abjad model of the trumpet:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Trumpet()(staff)
Trumpet()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Trumpet }
  \set Staff.shortInstrumentName = \markup { Tp. }
  c'8
  d'8
  e'8
  f'8
}
```

The trumpet targets staff context by default.

instrumenttools.Tuba

class abjad.tools.instrumenttools.**Tuba** (**kwargs)
 Bases: abjad.tools.instrumenttools._BrassInstrument._BrassInstrument._BrassInstrument
 New in version 2.0. Abjad model of the tuba:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('bass')(staff)
ClefMark('bass')(Staff{4})

abjad> instrumenttools.Tuba()(staff)
Tuba()(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "bass"
  \set Staff.instrumentName = \markup { Tuba }
  \set Staff.shortInstrumentName = \markup { Tb. }
  c'8
  d'8
  e'8
  f'8
}
```

The tuba targets staff context by default.

instrumenttools.UntunedPercussion

class abjad.tools.instrumenttools.**UntunedPercussion** (instrument_name=None,
 short_instrument_name=None,
 instrument_name_markup=None,
 short_instrument_name_markup=None,
 target_context=None)
 Bases: abjad.tools.instrumenttools._PercussionInstrument._PercussionInstrument._PercussionInstrument

New in version 2.0. Abjad model of untuned percussion:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.UntunedPercussion()(staff)
UntunedPercussion()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Untuned percussion }
  \set Staff.shortInstrumentName = \markup { Perc. }
  c'8
  d'8
  e'8
  f'8
}
```

Untuned percussion targets the staff context by default.

known_untuned_percussion = ['agog\xc3\xbf', 'anvil', 'bass drum', 'bongo drums', 'cabasa', 'caj\xc3\xbf', 'castanets']

instrumenttools.Vibraphone

class abjad.tools.instrumenttools.**Vibraphone**(*instrument_name=None*,
short_instrument_name=None, *instrument_name_markup=None*,
short_instrument_name_markup=None,
target_context=None)
Bases: abjad.tools.instrumenttools._PercussionInstrument._PercussionInstrument
 New in version 2.0. Abjad model of the vibraphone:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Vibraphone()(staff)
Vibraphone()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Vibraphone }
  \set Staff.shortInstrumentName = \markup { Vibr. }
  c'8
  d'8
  e'8
  f'8
}
```

The vibraphone targets staff context by default.

instrumenttools.Viola

class abjad.tools.instrumenttools.**Viola**(**kwargs)
Bases: abjad.tools.instrumenttools._StringInstrument._StringInstrument
 New in version 2.0. Abjad model of the viola:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('alto')(staff)
ClefMark('alto')(Staff{4})
```

```

abjad> instrumenttools.Viola()(staff)
Viola()(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "alto"
  \set Staff.instrumentName = \markup { Viola }
  \set Staff.shortInstrumentName = \markup { Va. }
  c'8
  d'8
  e'8
  f'8
}

```

The viola targets staff context by default.

instrumenttools.Violin

```

class abjad.tools.instrumenttools.Violin(**kwargs)
  Bases: abjad.tools.instrumenttools._StringInstrument._StringInstrument._StringInstrument
  New in version 2.0. Abjad model of the violin:

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Violin()(staff)
Violin()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Violin }
  \set Staff.shortInstrumentName = \markup { Vn. }
  c'8
  d'8
  e'8
  f'8
}

```

The violin targets staff context by default.

instrumenttools.Xylophone

```

class abjad.tools.instrumenttools.Xylophone(instrument_name=None,
                                             short_instrument_name=None,      in-
                                             instrument_name_markup=None,
                                             short_instrument_name_markup=None,  tar-
                                             get_context=None)
  Bases: abjad.tools.instrumenttools._PercussionInstrument._PercussionInstrument._PercussionInstrument
  New in version 2.0. Abjad model of the xylophone:

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> instrumenttools.Xylophone()(staff)
Xylophone()(Staff{4})

```

```
abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Xylophone }
  \set Staff.shortInstrumentName = \markup { Xyl. }
  c'8
  d'8
  e'8
  f'8
}
```

The xylophone targets staff context by default.

instrumenttools.default_instrument_name_to_instrument_class

`abjad.tools.instrumenttools.default_instrument_name_to_instrument_class` (*default_instrument_name*)
 New in version 2.5. Change *default_instrument_name* to class name:

```
abjad> instrumenttools.default_instrument_name_to_instrument_class('clarinet in E-flat')
<class 'abjad.tools.instrumenttools.EFlatClarinet.EFlatClarinet.EFlatClarinet'>
```

Return class.

When *default_instrument_name* matches no instrument class:

```
abjad> instrumenttools.default_instrument_name_to_instrument_class('foo') is None
True
```

Return none.

instrumenttools.iterate_notes_and_chords_in_expr_outside_traditional_instrument_ranges

`abjad.tools.instrumenttools.iterate_notes_and_chords_in_expr_outside_traditional_instrument`
 New in version 2.0. Iterate notes and chords in *expr* outside traditional instrument ranges:

```
abjad> staff = Staff("c'8 r8 <d fs>8 r8")
abjad> instrumenttools.Violin()(staff)
Violin()(Staff{4})

abjad> for note_or_chord in instrumenttools.iterate_notes_and_chords_in_expr_outside_traditional
...     note_or_chord
Chord('<d fs>8')
```

Return generator.

instrumenttools.list_instrument_names

`abjad.tools.instrumenttools.list_instrument_names` (*klases=None*)
 New in version 2.5. List instrument names:

```
abjad> for instrument_name in instrumenttools.list_instrument_names():
...     instrument_name
...
'accordion'
'alto flute'
'alto saxophone'
'alto trombone'
```

```

'clarinet in B-flat'
'baritone saxophone'
'bass clarinet'
'bass flute'
'bass saxophone'
'bass trombone'
'bassoon'
'cello'
'clarinet in A'
'contrabass'
'contrabass clarinet'
'contrabass flute'
'contrabass saxophone'
'contrabassoon'
'clarinet in E-flat'
'English horn'
'flute'
'horn'
'glockenspiel'
'guitar'
'harp'
'harpsichord'
'marimba'
'oboe'
'piano'
'piccolo'
'sopranino saxophone'
'soprano saxophone'
'tenor saxophone'
'tenor trombone'
'trumpet'
'tuba'
'untuned percussion'
'vibraphone'
'viola'
'violin'
'xylophone'

```

Return list.

instrumenttools.list_instruments

abjad.tools.instrumenttools.**list_instruments** (*klassen=None*)

New in version 2.5. List instruments in instrumenttools module:

```

abjad> for instrument in instrumenttools.list_instruments():
...     instrument
...
<class 'abjad.tools.instrumenttools.Accordion.Accordion.Accordion'>
<class 'abjad.tools.instrumenttools.AltoFlute.AltoFlute.AltoFlute'>
<class 'abjad.tools.instrumenttools.AltoSaxophone.AltoSaxophone.AltoSaxophone'>
<class 'abjad.tools.instrumenttools.AltoTrombone.AltoTrombone.AltoTrombone'>
<class 'abjad.tools.instrumenttools.BFlatClarinet.BFlatClarinet.BFlatClarinet'>
<class 'abjad.tools.instrumenttools.BaritoneSaxophone.BaritoneSaxophone.BaritoneSaxophone'>
<class 'abjad.tools.instrumenttools.BassClarinet.BassClarinet.BassClarinet'>
<class 'abjad.tools.instrumenttools.BassFlute.BassFlute.BassFlute'>
<class 'abjad.tools.instrumenttools.BassSaxophone.BassSaxophone.BassSaxophone'>

```

```
<class 'abjad.tools.instrumenttools.BassTrombone.BassTrombone.BassTrombone'>
<class 'abjad.tools.instrumenttools.Bassoon.Bassoon.Bassoon'>
<class 'abjad.tools.instrumenttools.Cello.Cello.Cello'>
<class 'abjad.tools.instrumenttools.ClarinetInA.ClarinetInA.ClarinetInA'>
<class 'abjad.tools.instrumenttools.Contrabass.Contrabass.Contrabass'>
<class 'abjad.tools.instrumenttools.ContrabassClarinet.ContrabassClarinet.ContrabassClarinet'>
<class 'abjad.tools.instrumenttools.ContrabassFlute.ContrabassFlute.ContrabassFlute'>
<class 'abjad.tools.instrumenttools.ContrabassSaxophone.ContrabassSaxophone.ContrabassSaxophone'>
<class 'abjad.tools.instrumenttools.Contrabassoon.Contrabassoon.Contrabassoon'>
<class 'abjad.tools.instrumenttools.EFlatClarinet.EFlatClarinet.EFlatClarinet'>
<class 'abjad.tools.instrumenttools.EnglishHorn.EnglishHorn.EnglishHorn'>
<class 'abjad.tools.instrumenttools.Flute.Flute.Flute'>
<class 'abjad.tools.instrumenttools.FrenchHorn.FrenchHorn.FrenchHorn'>
<class 'abjad.tools.instrumenttools.Glockenspiel.Glockenspiel.Glockenspiel'>
<class 'abjad.tools.instrumenttools.Guitar.Guitar.Guitar'>
<class 'abjad.tools.instrumenttools.Harp.Harp.Harp'>
<class 'abjad.tools.instrumenttools.Harpsichord.Harpsichord.Harpsichord'>
<class 'abjad.tools.instrumenttools.Marimba.Marimba.Marimba'>
<class 'abjad.tools.instrumenttools.Oboe.Oboe.Oboe'>
<class 'abjad.tools.instrumenttools.Piano.Piano.Piano'>
<class 'abjad.tools.instrumenttools.Piccolo.Piccolo.Piccolo'>
<class 'abjad.tools.instrumenttools.SopraninoSaxophone.SopraninoSaxophone.SopraninoSaxophone'>
<class 'abjad.tools.instrumenttools.SopranoSaxophone.SopranoSaxophone.SopranoSaxophone'>
<class 'abjad.tools.instrumenttools.TenorSaxophone.TenorSaxophone.TenorSaxophone'>
<class 'abjad.tools.instrumenttools.TenorTrombone.TenorTrombone.TenorTrombone'>
<class 'abjad.tools.instrumenttools.Trumpet.Trumpet.Trumpet'>
<class 'abjad.tools.instrumenttools.Tuba.Tuba.Tuba'>
<class 'abjad.tools.instrumenttools.UntunedPercussion.UntunedPercussion.UntunedPercussion'>
<class 'abjad.tools.instrumenttools.Vibraphone.Vibraphone.Vibraphone'>
<class 'abjad.tools.instrumenttools.Viola.Viola.Viola'>
<class 'abjad.tools.instrumenttools.Violin.Violin.Violin'>
<class 'abjad.tools.instrumenttools.Xylophone.Xylophone.Xylophone'>
```

Return list.

instrumenttools.list_primary_instruments

`abjad.tools.instrumenttools.list_primary_instruments()`

New in version 2.5. List primary instruments:

```
abjad> for primary_instrument in instrumenttools.list_primary_instruments():
...     primary_instrument
...
<class 'abjad.tools.instrumenttools.Accordion.Accordion.Accordion'>
<class 'abjad.tools.instrumenttools.AltoSaxophone.AltoSaxophone.AltoSaxophone'>
<class 'abjad.tools.instrumenttools.BFlatClarinet.BFlatClarinet.BFlatClarinet'>
<class 'abjad.tools.instrumenttools.Bassoon.Bassoon.Bassoon'>
<class 'abjad.tools.instrumenttools.Cello.Cello.Cello'>
<class 'abjad.tools.instrumenttools.Contrabass.Contrabass.Contrabass'>
<class 'abjad.tools.instrumenttools.Flute.Flute.Flute'>
<class 'abjad.tools.instrumenttools.FrenchHorn.FrenchHorn.FrenchHorn'>
<class 'abjad.tools.instrumenttools.Guitar.Guitar.Guitar'>
<class 'abjad.tools.instrumenttools.Harp.Harp.Harp'>
<class 'abjad.tools.instrumenttools.Harpsichord.Harpsichord.Harpsichord'>
<class 'abjad.tools.instrumenttools.Oboe.Oboe.Oboe'>
<class 'abjad.tools.instrumenttools.Piano.Piano.Piano'>
<class 'abjad.tools.instrumenttools.TenorTrombone.TenorTrombone.TenorTrombone'>
```



```
<class 'abjad.tools.instrumenttools.Trumpet.Trumpet.Trumpet'>
<class 'abjad.tools.instrumenttools.Tuba.Tuba.Tuba'>
<class 'abjad.tools.instrumenttools.Viola.Viola.Viola'>
<class 'abjad.tools.instrumenttools.Violin.Violin.Violin'>
```

Return list

instrumenttools.list_secondary_instruments

`abjad.tools.instrumenttools.list_secondary_instruments()`

New in version 2.5. List secondary instruments:

```
abjad> for secondary_instrument in instrumenttools.list_secondary_instruments():
...     secondary_instrument
...
<class 'abjad.tools.instrumenttools.AltoFlute.AltoFlute.AltoFlute'>
<class 'abjad.tools.instrumenttools.AltoTrombone.AltoTrombone.AltoTrombone'>
<class 'abjad.tools.instrumenttools.BaritoneSaxophone.BaritoneSaxophone.BaritoneSaxophone'>
<class 'abjad.tools.instrumenttools.BassClarinet.BassClarinet.BassClarinet'>
<class 'abjad.tools.instrumenttools.BassFlute.BassFlute.BassFlute'>
<class 'abjad.tools.instrumenttools.BassSaxophone.BassSaxophone.BassSaxophone'>
<class 'abjad.tools.instrumenttools.BassTrombone.BassTrombone.BassTrombone'>
<class 'abjad.tools.instrumenttools.ClarinetInA.ClarinetInA.ClarinetInA'>
<class 'abjad.tools.instrumenttools.ContrabassClarinet.ContrabassClarinet.ContrabassClarinet'>
<class 'abjad.tools.instrumenttools.ContrabassFlute.ContrabassFlute.ContrabassFlute'>
<class 'abjad.tools.instrumenttools.ContrabassSaxophone.ContrabassSaxophone.ContrabassSaxophone'>
<class 'abjad.tools.instrumenttools.Contrabassoon.Contrabassoon.Contrabassoon'>
<class 'abjad.tools.instrumenttools.EFlatClarinet.EFlatClarinet.EFlatClarinet'>
<class 'abjad.tools.instrumenttools.EnglishHorn.EnglishHorn.EnglishHorn'>
<class 'abjad.tools.instrumenttools.Glockenspiel.Glockenspiel.Glockenspiel'>
<class 'abjad.tools.instrumenttools.Marimba.Marimba.Marimba'>
<class 'abjad.tools.instrumenttools.Piccolo.Piccolo.Piccolo'>
<class 'abjad.tools.instrumenttools.SopraninoSaxophone.SopraninoSaxophone.SopraninoSaxophone'>
<class 'abjad.tools.instrumenttools.SopranoSaxophone.SopranoSaxophone.SopranoSaxophone'>
<class 'abjad.tools.instrumenttools.TenorSaxophone.TenorSaxophone.TenorSaxophone'>
<class 'abjad.tools.instrumenttools.UntunedPercussion.UntunedPercussion.UntunedPercussion'>
<class 'abjad.tools.instrumenttools.Vibraphone.Vibraphone.Vibraphone'>
<class 'abjad.tools.instrumenttools.Xylophone.Xylophone.Xylophone'>
```

Return list

instrumenttools.notes_and_chords_in_expr_are_on_expected_clefs

`abjad.tools.instrumenttools.notes_and_chords_in_expr_are_on_expected_clefs(expr, percussion_clef_is_allowed)`

New in version 2.0. True when notes and chords in *expr* are on expected clefs:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('treble')(staff)
ClefMark('treble')(Staff{4})
abjad> instrumenttools.Violin()(staff)
Violin()(Staff{4})
```

```
abjad> instrumenttools.notes_and_chords_in_expr_are_on_expected_clefs(staff)
True
```

False otherwise:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('alto')(staff)
ClefMark('alto')(Staff{4})
abjad> instrumenttools.Violin()(staff)
Violin()(Staff{4})

abjad> instrumenttools.notes_and_chords_in_expr_are_on_expected_clefs(staff)
False
```

Allow percussion clef when *percussion_clef_is_allowed* is true:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.ClefMark('percussion')(staff)
ClefMark('percussion')(Staff{4})
abjad> instrumenttools.Violin()(staff)
Violin()(Staff{4})

abjad> f(staff)
\new Staff {
  \clef "percussion"
  \set Staff.instrumentName = \markup { Violin }
  \set Staff.shortInstrumentName = \markup { Vn. }
  c'8
  d'8
  e'8
  f'8
}
```

```
abjad> instrumenttools.notes_and_chords_in_expr_are_on_expected_clefs(staff, percussion_clef_is_
True
```

Disallow percussion clef when *percussion_clef_is_allowed* is false:

```
abjad> instrumenttools.notes_and_chords_in_expr_are_on_expected_clefs(staff, percussion_clef_is_
False
```

Return boolean.

instrumenttools.notes_and_chords_in_expr_are_within_traditional_instrument_ranges

`abjad.tools.instrumenttools.notes_and_chords_in_expr_are_within_traditional_instrument_ranges`
 New in version 2.0. True when notes and chords in *expr* are within traditional instrument ranges:

```
abjad> staff = Staff("c'8 r8 <d' fs'>8 r8")
abjad> instrumenttools.Violin()(staff)
Violin()(Staff{4})

abjad> instrumenttools.notes_and_chords_in_expr_are_within_traditional_instrument_ranges(staff)
True
```

False otherwise:

```

abjad> staff = Staff("c'8 r8 <d fs>8 r8")
abjad> instrumenttools.Violin()(staff)
Violin()(Staff{4})

abjad> instrumenttools.notes_and_chords_in_expr_are_within_traditional_instrument_ranges(staff)
False

```

Return boolean.

instrumenttools.transpose_notes_and_chords_in_expr_from_fingered_pitch_to_sounding_pitch

abjad.tools.instrumenttools.**transpose_notes_and_chords_in_expr_from_fingered_pitch_to_sounding_pitch**
 New in version 2.0. Transpose notes and chords in *expr* from sounding pitch to fingered pitch:

```

abjad> staff = Staff("<c' e' g'>4 d'4 r4 e'4")
abjad> instrumenttools.BFlatClarinet()(staff)
BFlatClarinet()(Staff{4})

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Clarinet in B-flat }
  \set Staff.shortInstrumentName = \markup { Cl. in B-flat }
  <c' e' g'>4
  d'4
  r4
  e'4
}

abjad> for leaf in staff.leaves:
...   leaf.written_pitch_indication_is_at_sounding_pitch = False

abjad> instrumenttools.transpose_notes_and_chords_in_expr_from_fingered_pitch_to_sounding_pitch(staff)

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Clarinet in B-flat }
  \set Staff.shortInstrumentName = \markup { Cl. in B-flat }
  <bf d' f'>4
  c'4
  r4
  d'4
}

```

Return none.

instrumenttools.transpose_notes_and_chords_in_expr_from_sounding_pitch_to_fingered_pitch

abjad.tools.instrumenttools.**transpose_notes_and_chords_in_expr_from_sounding_pitch_to_fingered_pitch**
 New in version 2.0. Transpose notes and chords in *expr* from sounding pitch to fingered pitch:

```

abjad> staff = Staff("<c' e' g'>4 d'4 r4 e'4")
abjad> instrumenttools.BFlatClarinet()(staff)
BFlatClarinet()(Staff{4})

abjad> f(staff)
\new Staff {

```

```

\set Staff.instrumentName = \markup { Clarinet in B-flat }
\set Staff.shortInstrumentName = \markup { Cl. in B-flat }
<c' e' g'>4
d'4
r4
e'4
}

```

```
abjad> instrumenttools.transpose_notes_and_chords_in_expr_from_sounding_pitch_to_fingered_pitch()
```

```

abjad> f(staff)
\new Staff {
  \set Staff.instrumentName = \markup { Clarinet in B-flat }
  \set Staff.shortInstrumentName = \markup { Cl. in B-flat }
  <d' fs' a'>4
  e'4
  r4
  fs'4
}

```

Return none.

leaftools

leaftools.all_are_leaves

`abjad.tools.leaftools.all_are_leaves(expr)`

New in version 2.6. True when *expr* is a sequence of Abjad leaves:

```
abjad> leaves = [Note("c'4"), Rest('r4'), Note("d'4")]
```

```

abjad> leaftools.all_are_leaves(leaves)
True

```

True when *expr* is an empty sequence:

```

abjad> leaftools.all_are_leaves([])
True

```

Otherwise false:

```

abjad> leaftools.all_are_leaves('foo')
False

```

Return boolean.

Function wraps `componenttools.all_are_components()`.

leaftools.change_written_leaf_duration_and_preserve_preprolated_leaf_duration

`abjad.tools.leaftools.change_written_leaf_duration_and_preserve_preprolated_leaf_duration()`

New in version 1.1. Change *leaf* written duration to *written_duration* and preserve preprolated *leaf* duration:

```

abjad> note = Note("c'4")
abjad> note.written_duration
Duration(1, 4)

```

```

abjad> note.preprolated_duration
Duration(1, 4)

abjad> leaftools.change_written_leaf_duration_and_preserve_preprolated_leaf_duration(note, Duration(3, 16))
Note("c'8. * 4/3")

abjad> note.written_duration
Duration(3, 16)
abjad> note.preprolated_duration
Duration(1, 4)

```

Add LilyPond multiplier where necessary.

Return *leaf*. Changed in version 2.0: Renamed from `leaftools.duration_rewrite()`.
`leaftools.change_written_leaf_duration_and_preserve_preprolated_leaf_duration()`.

leaftools.color_leaf

`abjad.tools.leaftools.color_leaf(leaf, color)`

New in version 2.0. Color note:

```

abjad> note = Note("c'4")

abjad> leaftools.color_leaf(note, 'red')
Note("c'4")

abjad> f(note)
\once \override Accidental #'color = #red
\once \override Dots #'color = #red
\once \override NoteHead #'color = #red
c'4

```

Color rest:

```

abjad> rest = Rest('r4')

abjad> leaftools.color_leaf(rest, 'red')
Rest('r4')

abjad> f(rest)
\once \override Dots #'color = #red
\once \override Rest #'color = #red
r4

```

Color chord:

```

abjad> chord = Chord("<c' e' bf'>4")

abjad> leaftools.color_leaf(chord, 'red')
Chord("<c' e' bf'>4")

abjad> f(chord)
\once \override Accidental #'color = #red
\once \override Dots #'color = #red
\once \override NoteHead #'color = #red
<c' e' bf'>4

```

Return *leaf*.

leaftools.color_leaves_in_expr

`abjad.tools.leaftools.color_leaves_in_expr(expr, color)`

New in version 2.0. Color leaves in *expr*:

```
abjad> staff = Staff([Note(1, (3, 16)), Rest((3, 16)), skiptools.Skip((3, 16)), Chord([0, 1, 9],
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(cs'8., r8., s8., <c' cs' a'>8.)
abjad> f(staff)
\new Staff {
    cs'8. [
    r8.
    s8.
    <c' cs' a'>8. ]
}
```

```
abjad> leaftools.color_leaves_in_expr(staff, 'red')
```

```
abjad> f(staff)
\new Staff {
    \once \override Accidental #'color = #red
    \once \override Dots #'color = #red
    \once \override NoteHead #'color = #red
    cs'8. [
    \once \override Dots #'color = #red
    \once \override Rest #'color = #red
    r8.
    s8.
    \once \override Accidental #'color = #red
    \once \override Dots #'color = #red
    \once \override NoteHead #'color = #red
    <c' cs' a'>8. ]
}
```

Return none.

leaftools.copy_written_duration_and_multiplier_from_leaf_to_leaf

`abjad.tools.leaftools.copy_written_duration_and_multiplier_from_leaf_to_leaf(source_leaf, target_leaf)`

New in version 2.0. Copy written duration and multiplier from *source_leaf* to *target_leaf*:

```
abjad> note = Note("c'4")
abjad> note.duration_multiplier = Duration(1, 2)
abjad> rest = Rest((1, 64))
abjad> leaftools.copy_written_duration_and_multiplier_from_leaf_to_leaf(note, rest)
Rest('r4 * 1/2')
```

Return *target_leaf*.

leaftools.divide_leaf_meiotically

`abjad.tools.leaftools.divide_leaf_meiotically(leaf, n=2)`

New in version 1.1. Divide *leaf* meiotically *n* times:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

abjad> leaftools.divide_leaf_meiotically(staff[0], n = 4)

abjad> f(staff)
\new Staff {
    c'32 [
    c'32
    c'32
    c'32
    d'8
    e'8
    f'8 ]
}

```

Replace *leaf* with *n* new leaves.

Preserve parentage and spanners.

Allow divisions into only 1, 2, 4, 8, 16, ... and other nonnegative integer powers of 2.

Produce only leaves and never tuplets or other containers.

Return none.

leaftools.divide_leaves_in_expr_meiotically

`abjad.tools.leaftools.divide_leaves_in_expr_meiotically(expr, n=2)`

New in version 1.1. Divide leaves meiotically in *expr* *n* times:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

abjad> leaftools.divide_leaves_in_expr_meiotically(staff[2:], n = 4)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'32
    e'32
    e'32
}

```

```

    e' 32
    f' 32
    f' 32
    f' 32
    f' 32 ]
}

```

Replace every leaf in *expr* with *n* new leaves.

Preserve parentage and spanners.

Allow divisions into only 1, 2, 4, 8, 16, ... and other nonnegative integer powers of 2.

Produce only leaves and never tuplets or other containers.

Return none. Changed in version 2.0: renamed `leaftools.meiose()` to `leaftools.divide_leaves_in_expr_meiotically()`.

`leaftools.expr_has_leaf_with_dotted_written_duration`

`abjad.tools.leaftools.expr_has_leaf_with_dotted_written_duration(expr)`

New in version 2.0. True when *expr* has at least one leaf with dotted written duration:

```

abjad> notes = notetools.make_notes([0], [(1, 16), (2, 16), (3, 16)])
abjad> leaftools.expr_has_leaf_with_dotted_written_duration(notes)
True

```

False otherwise:

```

abjad> notes = notetools.make_notes([0], [(1, 16), (2, 16), (4, 16)])
abjad> leaftools.expr_has_leaf_with_dotted_written_duration(notes)
False

```

Return boolean.

`leaftools.fuse_leaves_big_endian`

`abjad.tools.leaftools.fuse_leaves_big_endian(leaves)`

New in version 1.1. Fuse thread-contiguous *leaves*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> leaftools.fuse_leaves_big_endian(staff[1:])
[Note("d'4.")]
abjad> f(staff)
\new Staff {
    c'8
    d'4.
}

```

Rewrite duration of first leaf in *leaves*.

Detach all leaves in *leaves* other than first leaf from score.

Return list of first leaf in *leaves*. Changed in version 2.0: renamed `fuse.leaves_by_reference()` to `leaftools.fuse_leaves_big_endian()`.

leaftools.fuse_leaves_in_container_once_by_counts_into_big_endian_notes

`abjad.tools.leaftools.fuse_leaves_in_container_once_by_counts_into_big_endian_notes` (*container*, *counts*)

New in version 1.1. Fuse leaves in *container* once by *counts* into big-endian notes.

leaftools.fuse_leaves_in_container_once_by_counts_into_big_endian_rests

`abjad.tools.leaftools.fuse_leaves_in_container_once_by_counts_into_big_endian_rests` (*container*, *counts*)

New in version 1.1. Fuse leaves in *container* once by *counts* into big-endian rests.

leaftools.fuse_leaves_in_container_once_by_counts_into_little_endian_notes

`abjad.tools.leaftools.fuse_leaves_in_container_once_by_counts_into_little_endian_notes` (*container*, *counts*)

New in version 1.1. Fuse leaves in *container* once by *counts* into little-endian notes.

leaftools.fuse_leaves_in_container_once_by_counts_into_little_endian_rests

`abjad.tools.leaftools.fuse_leaves_in_container_once_by_counts_into_little_endian_rests` (*container*, *counts*)

New in version 1.1. Fuse leaves in *container* once by *counts* into little-endian rests.

leaftools.fuse_leaves_in_tie_chain_by_immediate_parent_big_endian

`abjad.tools.leaftools.fuse_leaves_in_tie_chain_by_immediate_parent_big_endian` (*tie_chain*)

New in version 1.1. Fuse leaves in *tie_chain* by immediate parent:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> tietools.TieSpanner(staff.leaves)
TieSpanner(c'8, c'8, c'8, c'8)
abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8 ~
        c'8 ~
    }
    {
        \time 2/8
        c'8 ~
        c'8
    }
}

abjad> tie_chain = tietools.get_tie_chain(staff.leaves[0])
abjad> leaftools.fuse_leaves_in_tie_chain_by_immediate_parent_big_endian(tie_chain)
[[Note("c'4")], [Note("c'4")]]

abjad> f(staff)
\new Staff {
    {
        \time 2/8
```

```

        c'4 ~
    }
    {
        \time 2/8
        c'4
    }
}

```

Return list of fused notes by parent. Changed in version 2.0: renamed `fuse.leaves_in_tie_chain()` to `leaftools.fuse_leaves_in_tie_chain_by_immediate_parent_big_endian()`.

leaftools.fuse_tied_leaves_in_components_once_by_prolated_durations_without_overhang

`abjad.tools.leaftools.fuse_tied_leaves_in_components_once_by_prolated_durations_without_overhang`

New in version 1.1. Fuse tied leaves in *components* once by *prolated_durations* without overhang:

```

abjad> staff = Staff(notetools.make_repeated_notes(8))
abjad> tietools.TieSpanner(staff.leaves)
TieSpanner(c'8, c'8, c'8, c'8, c'8, c'8, c'8, c'8)
abjad> f(staff)
\new Staff {
    c'8 ~
    c'8 ~
    c'8 ~
    c'8 ~
    c'8 ~
    c'8 ~
    c'8 ~
    c'8 ~
}

```

```

abjad> leaftools.fuse_tied_leaves_in_components_once_by_prolated_durations_without_overhang(staff)

```

```

abjad> f(staff)
\new Staff {
    c'4. ~
    c'4. ~
    c'8 ~
    c'8
}

```

Return none. Changed in version 2.0: renamed `fuse.tied_leaves_by_prolated_durations()` to `leaftools.fuse_tied_leaves_in_components_once_by_prolated_durations_without_overhang()`.

leaftools.get_composite_offset_difference_series_from_leaves_in_expr

`abjad.tools.leaftools.get_composite_offset_difference_series_from_leaves_in_expr(expr)`

New in version 2.0. Get composite offset difference series from leaves in *expr*:

```

abjad> staff_1 = Staff([tuplettools.FixedDurationTuplet(Duration(4, 8), notetools.make_repeated_notes(4))])
abjad> staff_2 = Staff(notetools.make_repeated_notes(4))
abjad> score = Score([staff_1, staff_2])
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> f(score)

```

```

\new Score <<
  \new Staff {
    \fraction \times 4/3 {
      c'8
      d'8
      e'8
    }
  }
  \new Staff {
    f'8
    g'8
    a'8
    b'8
  }
>>
abjad> leaftools.get_composite_offset_difference_series_from_leaves_in_expr(score)
[Offset(1, 8), Offset(1, 24), Offset(1, 12), Offset(1, 12), Offset(1, 24), Offset(1, 8)]

```

Composite offset difference series defined equal to time intervals between unique start and stop offsets of leaves in *expr*.

Return list of fractions.

leaftools.get_composite_offset_series_from_leaves_in_expr

`abjad.tools.leaftools.get_composite_offset_series_from_leaves_in_expr(expr)`

New in version 2.0. Get composite offset series from leaves in *expr*:

```

abjad> staff_1 = Staff([tuplettools.FixedDurationTuplet(Duration(4, 8), notetools.make_repeated_
abjad> staff_2 = Staff(notetools.make_repeated_notes(4))
abjad> score = Score([staff_1, staff_2])
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(score)
abjad> f(score)
\new Score <<
  \new Staff {
    \fraction \times 4/3 {
      c'8
      d'8
      e'8
    }
  }
  \new Staff {
    f'8
    g'8
    a'8
    b'8
  }
>>
abjad> leaftools.get_composite_offset_series_from_leaves_in_expr(score)
[Offset(0, 1), Offset(1, 8), Offset(1, 6), Offset(1, 4), Offset(1, 3), Offset(3, 8), Offset(1, 2)

```

Equal to list of unique start and stop offsets of leaves in *expr*.

Return list of fractions.

leaftools.get_leaf_at_index_in_measure_number_in_expr

`abjad.tools.leaftools.get_leaf_at_index_in_measure_number_in_expr(expr, measure_number, leaf_index)`

New in version 2.0. Get leaf at *leaf_index* in *measure_number* in *expr*:

```
abjad> t = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> f(t)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 2/8
        e'8
        f'8
    }
    {
        \time 2/8
        g'8
        a'8
    }
}

abjad> leaftools.get_leaf_at_index_in_measure_number_in_expr(t, 2, 0)
Note("e'8")
```

Return leaf or none.

leaftools.get_leaf_in_expr_with_maximum_prolated_duration

`abjad.tools.leaftools.get_leaf_in_expr_with_maximum_prolated_duration(expr)`

New in version 2.5. Get leaf in *expr* with maximum prolated duration:

```
abjad> staff = Staff("c'4.. d'16 e'4.. f'16")

abjad> leaftools.get_leaf_in_expr_with_maximum_prolated_duration(staff)
Note("c'4..")
```

When two leaves in *expr* are both of equally maximal prolated duration, return the first leaf encountered in forward iteration.

Return none when *expr* contains no leaves:

```
abjad> leaftools.get_leaf_in_expr_with_maximum_prolated_duration([]) is None
True
```

Return leaf.

leaftools.get_leaf_in_expr_with_minimum_prolated_duration

`abjad.tools.leaftools.get_leaf_in_expr_with_minimum_prolated_duration(expr)`

New in version 2.5. Get leaf in *expr* with minimum prolated duration:

```
abjad> staff = Staff("c'4.. d'16 e'4.. f'16")
```

```
abjad> leaftools.get_leaf_in_expr_with_minimum_prolated_duration(staff)
Note("d'16")
```

When two leaves in *expr* are both of equally minimal prolated duration, return the first leaf encountered in forward iteration.

Return none when *expr* contains no leaves:

```
abjad> leaftools.get_leaf_in_expr_with_minimum_prolated_duration([]) is None
True
```

Return leaf.

leaftools.get_nth_leaf_in_expr

`abjad.tools.leaftools.get_nth_leaf_in_expr(expr, n=0)`

New in version 2.0. Get *n* th leaf in *expr*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
    e'8
    f'8
  }
  {
    \time 2/8
    g'8
    a'8
  }
}

abjad> for n in range(6):
...     leaftools.get_nth_leaf_in_expr(staff, n)
...
Note("c'8")
Note("d'8")
Note("e'8")
Note("f'8")
Note("g'8")
Note("a'8")
```

Read backwards for negative values of *n*.

```
abjad> leaftools.get_nth_leaf_in_expr(staff, -1)
Note("a'8")
```

Note: Because this function returns as soon as it finds instance *n* of *klases*, it is more efficient to call

`leaftools.get_nth_leaf_in_expr(expr, 0)` than `expr.leaves[0]`. It is likewise more efficient to call `leaftools.get_nth_leaf_in_expr(expr, -1)` than `expr.leaves[-1]`.

Return leaf of none.

leaftools.get_nth_leaf_in_thread_from_leaf

`abjad.tools.leaftools.get_nth_leaf_in_thread_from_leaf(leaf, n=0)`

New in version 2.0. Get *n* th leaf in thread from *leaf*:

```
abjad> staff = Staff(2 * Voice("c'8 d'8 e'8 f'8"))
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
    \new Voice {
        c'8
        d'8
        e'8
        f'8
    }
    \new Voice {
        g'8
        a'8
        b'8
        c''8
    }
}

abjad> for n in range(8):
...     print n, leaftools.get_nth_leaf_in_thread_from_leaf(staff[0][0], n)
...
0 c'8
1 d'8
2 e'8
3 f'8
4 None
5 None
6 None
7 None
```

Return leaf or none.

leaftools.is_bar_line_crossing_leaf

`abjad.tools.leaftools.is_bar_line_crossing_leaf(leaf)`

New in version 2.0. True when *leaf* crosses bar line:

```
abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> t[2].written_duration *= 2
abjad> contexttools.TimeSignatureMark((2, 8), partial = Duration(1, 8))(t[2])
TimeSignatureMark((2, 8), partial = Duration(1, 8))(e'4)
abjad> f(t)
\new Staff {
    c'8
    d'8
    \partial 8
```

```

        \time 2/8
        e'4
        f'8
    }
abjad> leaftools.is_bar_line_crossing_leaf(t.leaves[2])
True

```

Otherwise false:

```

abjad> leaftools.is_bar_line_crossing_leaf(t.leaves[3])
False

```

Return boolean.

leaftools.iterate_leaf_pairs_forward_in_expr

`abjad.tools.leaftools.iterate_leaf_pairs_forward_in_expr(expr)`

New in version 2.0. Iterate leaf pairs forward in *expr*:

```

abjad> score = Score([])
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8"), Note("g'4")]
abjad> score.append(Staff(notes))
abjad> notes = [Note(x, (1, 4)) for x in [-12, -15, -17]]
abjad> score.append(Staff(notes))
abjad> contexttools.ClefMark('bass')(score[1])
ClefMark('bass')(Staff{3})

abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8
    e'8
    f'8
    g'4
  }
  \new Staff {
    \clef "bass"
    c4
    a,4
    g,4
  }
>>

abjad> for pair in leaftools.iterate_leaf_pairs_forward_in_expr(score):
...     pair
(Note("c'8"), Note('c4'))
(Note("c'8"), Note("d'8"))
(Note('c4'), Note("d'8"))
(Note("d'8"), Note("e'8"))
(Note("d'8"), Note('a,4'))
(Note('c4'), Note("e'8"))
(Note('c4'), Note('a,4'))
(Note("e'8"), Note('a,4'))
(Note("e'8"), Note("f'8"))
(Note('a,4'), Note("f'8"))
(Note("f'8"), Note("g'4"))
(Note("f'8"), Note('g,4'))

```

```
(Note('a', 4'), Note("g' 4"))
(Note('a', 4'), Note('g', 4'))
(Note("g' 4"), Note('g', 4'))
```

Iterate leaf pairs left-to-right and top-to-bottom.

Return generator.

leaftools.iterate_leaves_backward_in_expr

abjad.tools.leaftools.**iterate_leaves_backward_in_expr**(*expr*, *start*=0, *stop*=None)

New in version 2.0. Iterate leaves backward in *expr*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 2/8
        e'8
        f'8
    }
    {
        \time 2/8
        g'8
        a'8
    }
}

abjad> for leaf in leaftools.iterate_leaves_backward_in_expr(staff):
...     leaf
...
Note("a'8")
Note("g'8")
Note("f'8")
Note("e'8")
Note("d'8")
Note("c'8")
```

Use the optional *start* and *stop* keyword parameters to control the indices of iteration.

```
abjad> for leaf in leaftools.iterate_leaves_backward_in_expr(staff, start = 3):
...     leaf
...
Note("e'8")
Note("d'8")
Note("c'8")

abjad> for leaf in leaftools.iterate_leaves_backward_in_expr(staff, start = 0, stop = 3):
...     leaf
...
Note("a'8")
```



```
Note("g'8")
Note("f'8")
```

```
abjad> for leaf in leaftools.iterate_leaves_backward_in_expr(staff, start = 2, stop = 4):
...     leaf
...
Note("f'8")
Note("e'8")
```

Ignore threads.

Return generator.

leaftools.iterate_leaves_forward_in_expr

`abjad.tools.leaftools.iterate_leaves_forward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate leaves forward in *expr*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 2/8
        e'8
        f'8
    }
    {
        \time 2/8
        g'8
        a'8
    }
}

abjad> for leaf in leaftools.iterate_leaves_forward_in_expr(staff):
...     leaf
...
Note("c'8")
Note("d'8")
Note("e'8")
Note("f'8")
Note("g'8")
Note("a'8")
```

Use the optional *start* and *stop* keyword parameters to control the start and stop indices of iteration.

```
abjad> for leaf in leaftools.iterate_leaves_forward_in_expr(staff, start = 3):
...     leaf
...
Note("f'8")
Note("g'8")
Note("a'8")
```

```

abjad> for leaf in leaftools.iterate_leaves_forward_in_expr(staff, start = 0, stop = 3):
...     leaf
...
Note("c'8")
Note("d'8")
Note("e'8")

abjad> for leaf in leaftools.iterate_leaves_forward_in_expr(staff, start = 2, stop = 4):
...     leaf
...
Note("e'8")
Note("f'8")

```

Ignore threads.

Return generator.

leaftools.iterate_notes_and_chords_backward_in_expr

`abjad.tools.leaftools.iterate_notes_and_chords_backward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate notes and chords backward in *expr*:

```

abjad> staff = Staff("<e' g' c''>8 a'8 r8 <d' f' b'>8 r2")

abjad> f(staff)
\new Staff {
    <e' g' c''>8
    a'8
    r8
    <d' f' b'>8
    r2
}

abjad> for leaf in leaftools.iterate_notes_and_chords_backward_in_expr(staff):
...     leaf
Chord("<d' f' b'>8")
Note("a'8")
Chord("<e' g' c''>8")

```

Ignore threads.

Return generator. Changed in version 2.0: renamed `pitchtools.iterate_notes_and_chords_backward_in_expr` to `leaftools.iterate_notes_and_chords_backward_in_expr()`.

leaftools.iterate_notes_and_chords_forward_in_expr

`abjad.tools.leaftools.iterate_notes_and_chords_forward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate notes and chords forward in *expr*:

```

abjad> staff = Staff("<e' g' c''>8 a'8 r8 <d' f' b'>8 r2")

abjad> f(staff)
\new Staff {
    <e' g' c''>8
    a'8

```

```

r8
<d' f' b'>8
r2
}

```

```

abjad> for leaf in leaftools.iterate_notes_and_chords_forward_in_expr(staff):
...     leaf
Chord("<e' g' c'>8")
Note("a'8")
Chord("<d' f' b'>8")

```

Ignore threads.

Return generator. Changed in version 2.0: renamed `pitchtools.iterate_notes_and_chords_forward_in_expr()` to `leaftools.iterate_notes_and_chords_forward_in_expr()`.

`leaftools.label_leaves_in_expr_with_inversion_equivalent_chromatic_interval_classes`

`abjad.tools.leaftools.label_leaves_in_expr_with_inversion_equivalent_chromatic_interval_classes`

New in version 2.0. Label leaves in *expr* with inversion-equivalent chromatic interval classes:

```

abjad> staff = Staff(notetools.make_notes([0, 25, 11, -4, -14, -13, 9, 10, 6, 5], [Duration(1, 8)
abjad> leaftools.label_leaves_in_expr_with_inversion_equivalent_chromatic_interval_classes(staff)
abjad> f(staff)
\new Staff {
    c'8 ^ \markup { 1 }
    cs''8 ^ \markup { 2 }
    b'8 ^ \markup { 2 }
    af8 ^ \markup { 2 }
    bf,8 ^ \markup { 1 }
    b,8 ^ \markup { 2 }
    a'8 ^ \markup { 1 }
    bf'8 ^ \markup { 4 }
    fs'8 ^ \markup { 1 }
    f'8
}

```

Return none.

`leaftools.label_leaves_in_expr_with_leaf_depth`

`abjad.tools.leaftools.label_leaves_in_expr_with_leaf_depth`(*expr*,
markup_direction='down')

New in version 1.1. Label leaves in *expr* with leaf depth:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8")
abjad> tuplettools.FixedDurationTuplet(Duration(2, 8), staff[-3:])
FixedDurationTuplet(1/4, [e'8, f'8, g'8])
abjad> leaftools.label_leaves_in_expr_with_leaf_depth(staff)
abjad> f(staff)
\new Staff {
    c'8 _ \markup { \small 1 }
    d'8 _ \markup { \small 1 }
    \times 2/3 {
        e'8 _ \markup { \small 2 }
        f'8 _ \markup { \small 2 }
    }
}

```

```

        g'8 _ \markup { \small 2 }
    }
}

```

Changed in version 2.0: renamed `label.leaf_depth()` to `leaftools.label_leaves_in_expr_with_leaf_dep`
 Return none.

leaftools.label_leaves_in_expr_with_leaf_durations

`abjad.tools.leaftools.label_leaves_in_expr_with_leaf_durations`(*expr*,
markup_direction='down')

New in version 1.1. Label leaves in *expr* with leaf durations:

```

abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(1, 4), "c'8 d'8 e'8")
abjad> leaftools.label_leaves_in_expr_with_leaf_durations(tuplet)
abjad> f(tuplet)
\times 2/3 {
    c'8 _ \markup { \column { \small 1/8 \small 1/12 } }
    d'8 _ \markup { \column { \small 1/8 \small 1/12 } }
    e'8 _ \markup { \column { \small 1/8 \small 1/12 } }
}

```

Label both written duration and prolated duration.

Return none.

leaftools.label_leaves_in_expr_with_leaf_indices

`abjad.tools.leaftools.label_leaves_in_expr_with_leaf_indices`(*expr*,
markup_direction='down')

New in version 2.0. Label leaves in *expr* with leaf indices:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> leaftools.label_leaves_in_expr_with_leaf_indices(staff)
abjad> f(staff)
\new Staff {
    c'8 _ \markup { \small 0 }
    d'8 _ \markup { \small 1 }
    e'8 _ \markup { \small 2 }
    f'8 _ \markup { \small 3 }
}

```

Return none.

leaftools.label_leaves_in_expr_with_leaf_numbers

`abjad.tools.leaftools.label_leaves_in_expr_with_leaf_numbers`(*expr*,
markup_direction='down')

New in version 1.1. Label leaves in *expr* with leaf numbers:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> leaftools.label_leaves_in_expr_with_leaf_numbers(staff)
abjad> f(staff)
\new Staff {
    c'8 _ \markup { \small 1 }
    d'8 _ \markup { \small 2 }
}

```

```
e'8 _ \markup { \small 3 }
f'8 _ \markup { \small 4 }
}
```

Number leaves starting from 1. Changed in version 2.0: renamed `label.leaf_numbers()` to `leaftools.label_leaves_in_expr_with_leaf_numbers()`. Return none.

leaftools.label_leaves_in_expr_with_melodic_chromatic_interval_classes

`abjad.tools.leaftools.label_leaves_in_expr_with_melodic_chromatic_interval_classes`(*expr*, *markup_direction*)

New in version 2.0. Label leaves in *expr* with melodic chromatic interval classes:

```
abjad> staff = Staff(notetools.make_notes([0, 25, 11, -4, -14, -13, 9, 10, 6, 5], [Duration(1, 8)
abjad> leaftools.label_leaves_in_expr_with_melodic_chromatic_interval_classes(staff)
abjad> f(staff)
\new Staff {
  c'8 ^ \markup { +1 }
  cs'''8 ^ \markup { -2 }
  b'8 ^ \markup { -2 }
  af8 ^ \markup { -10 }
  bf,8 ^ \markup { +1 }
  b,8 ^ \markup { +10 }
  a'8 ^ \markup { +1 }
  bf'8 ^ \markup { -4 }
  fs'8 ^ \markup { -1 }
  f'8
}
```

Return none.

leaftools.label_leaves_in_expr_with_melodic_chromatic_intervals

`abjad.tools.leaftools.label_leaves_in_expr_with_melodic_chromatic_intervals`(*expr*, *markup_direction*)

New in version 2.0. Label leaves in *expr* with melodic chromatic intervals:

```
abjad> staff = Staff(notetools.make_notes([0, 25, 11, -4, -14, -13, 9, 10, 6, 5], [Duration(1, 8)
abjad> leaftools.label_leaves_in_expr_with_melodic_chromatic_intervals(staff)
abjad> f(staff)
\new Staff {
  c'8 ^ \markup { +25 }
  cs'''8 ^ \markup { -14 }
  b'8 ^ \markup { -15 }
  af8 ^ \markup { -10 }
  bf,8 ^ \markup { +1 }
  b,8 ^ \markup { +22 }
  a'8 ^ \markup { +1 }
  bf'8 ^ \markup { -4 }
  fs'8 ^ \markup { -1 }
  f'8
}
```

Return none.

leaftools.label_leaves_in_expr_with_melodic_counterpoint_interval_classes

abjad.tools.leaftools.**label_leaves_in_expr_with_melodic_counterpoint_interval_classes**(*expr*, *markup*)

New in version 2.0. Label leaves in *expr* with melodic counterpoint interval classes:

```
abjad> staff = Staff(notetools.make_notes([0, 25, 11, -4, -14, -13, 9, 10, 6, 5], [Duration(1, 8)
abjad> leaftools.label_leaves_in_expr_with_melodic_counterpoint_interval_classes(staff)
abjad> f(staff)
\new Staff {
    c'8 ^ \markup { +8 }
    cs'''8 ^ \markup { -2 }
    b'8 ^ \markup { -2 }
    af8 ^ \markup { -7 }
    bf,8 ^ \markup { +1 }
    b,8 ^ \markup { +7 }
    a'8 ^ \markup { +2 }
    bf'8 ^ \markup { -4 }
    fs'8 ^ \markup { +1 }
    f'8
}
```

Return none.

leaftools.label_leaves_in_expr_with_melodic_counterpoint_intervals

abjad.tools.leaftools.**label_leaves_in_expr_with_melodic_counterpoint_intervals**(*expr*, *markup_direction*)

New in version 2.0. Label leaves in *expr* with melodic counterpoint intervals:

```
abjad> staff = Staff(notetools.make_notes([0, 25, 11, -4, -14, -13, 9, 10, 6, 5], [Duration(1, 8)
abjad> leaftools.label_leaves_in_expr_with_melodic_counterpoint_intervals(staff)
abjad> f(staff)
\new Staff {
    c'8 ^ \markup { +15 }
    cs'''8 ^ \markup { -9 }
    b'8 ^ \markup { -9 }
    af8 ^ \markup { -7 }
    bf,8 ^ \markup { 1 }
    b,8 ^ \markup { +14 }
    a'8 ^ \markup { +2 }
    bf'8 ^ \markup { -4 }
    fs'8 ^ \markup { 1 }
    f'8
}
```

Return none.

leaftools.label_leaves_in_expr_with_melodic_diatonic_interval_classes

abjad.tools.leaftools.**label_leaves_in_expr_with_melodic_diatonic_interval_classes**(*expr*, *markup_direction*)

New in version 2.0. Label leaves in *expr* with melodic diatonic interval classes:

```
abjad> staff = Staff(notetools.make_notes([0, 25, 11, -4, -14, -13, 9, 10, 6, 5], [Duration(1, 8)
abjad> leaftools.label_leaves_in_expr_with_melodic_diatonic_interval_classes(staff)
abjad> f(staff)
```

```

\new Staff {
  c'8 ^ \markup { +aug8 }
  cs'''8 ^ \markup { -M2 }
  b'8 ^ \markup { -aug2 }
  af8 ^ \markup { -m7 }
  bf,8 ^ \markup { aug1 }
  b,8 ^ \markup { +m7 }
  a'8 ^ \markup { +m2 }
  bf'8 ^ \markup { -dim4 }
  fs'8 ^ \markup { aug1 }
  f'8
}

```

Return none.

leaftools.label_leaves_in_expr_with_melodic_diatonic_intervals

abjad.tools.leaftools.**label_leaves_in_expr_with_melodic_diatonic_intervals**(*expr*,
markup_direction='up'

New in version 2.0. Label leaves in *expr* with melodic diatonic intervals:

```

abjad> staff = Staff(notetools.make_notes([0, 25, 11, -4, -14, -13, 9, 10, 6, 5], [Duration(1, 8)
abjad> leaftools.label_leaves_in_expr_with_melodic_diatonic_intervals(staff)
abjad> f(staff)
\new Staff {
  c'8 ^ \markup { +aug15 }
  cs'''8 ^ \markup { -M9 }
  b'8 ^ \markup { -aug9 }
  af8 ^ \markup { -m7 }
  bf,8 ^ \markup { +aug1 }
  b,8 ^ \markup { +m14 }
  a'8 ^ \markup { +m2 }
  bf'8 ^ \markup { -dim4 }
  fs'8 ^ \markup { -aug1 }
  f'8
}

```

Return none.

leaftools.label_leaves_in_expr_with_pitch_class_numbers

abjad.tools.leaftools.**label_leaves_in_expr_with_pitch_class_numbers**(*expr*,
*num-
ber=True,
color=False,
markup_direction='down'*

New in version 1.1. Label leaves in *expr* with pitch-class numbers:

```

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> leaftools.label_leaves_in_expr_with_pitch_class_numbers(t)
abjad> print t.format
\new Staff {
  c'8 _ \markup { \small 0 }
  d'8 _ \markup { \small 2 }
  e'8 _ \markup { \small 4 }
  f'8 _ \markup { \small 5 }
}

```

When `color = True` call `color_note_head_by_numbered_chromatic_pitch_class_color_map()`.

```
abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> leaftools.label_leaves_in_expr_with_pitch_class_numbers(t, color = True, number = False)
abjad> print t.format
\new Staff {
  \once \override NoteHead #'color = #(x11-color 'red)
  c'8
  \once \override NoteHead #'color = #(x11-color 'orange)
  d'8
  \once \override NoteHead #'color = #(x11-color 'ForestGreen)
  e'8
  \once \override NoteHead #'color = #(x11-color 'MediumOrchid)
  f'8
}
```

You can set *number* and *color* at the same time. Changed in version 2.0: renamed `label.leaf_pcs()` to `leaftools.label_leaves_in_expr_with_pitch_class_numbers()`. Return `none`.

leaftools.label_leaves_in_expr_with_pitch_numbers

`abjad.tools.leaftools.label_leaves_in_expr_with_pitch_numbers` (*expr*,
markup_direction='down')

New in version 1.1. Label leaves in *expr* with pitch numbers:

```
abjad> staff = Staff(leaftools.make_leaves([None, 12, [13, 14, 15], None], [(1, 4)]))
abjad> leaftools.label_leaves_in_expr_with_pitch_numbers(staff)
abjad> f(staff)
\new Staff {
  r4
  c''4 _ \markup { \small 12 }
  <cs'' d'' ef''>4 _ \markup { \column { \small 15 \small 14 \small 13 } }
  r4
}
```

Return `none`. Changed in version 2.0: renamed `label.leaf_pitch_numbers()` to `leaftools.label_leaves_in_expr_with_pitch_numbers()`.

leaftools.label_leaves_in_expr_with_prolated_leaf_duration

`abjad.tools.leaftools.label_leaves_in_expr_with_prolated_leaf_duration` (*expr*,
markup_direction='down')

New in version 1.1. Label leaves in *expr* with prolated leaf duration:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(1, 4), "c'8 d'8 e'8")
abjad> leaftools.label_leaves_in_expr_with_prolated_leaf_duration(tuplet)
abjad> f(tuplet)
\times 2/3 {
  c'8 _ \markup { \small 1/12 }
  d'8 _ \markup { \small 1/12 }
  e'8 _ \markup { \small 1/12 }
}
```

Return `none`.

leaftools.label_leaves_in_expr_with_tuplet_depth

abjad.tools.leaftools.**label_leaves_in_expr_with_tuplet_depth**(*expr*,
markup_direction='down')

New in version 1.1. Label leaves in *expr* with tuple depth:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8")
abjad> tuplettools.FixedDurationTuplet(Duration(2, 8), staff[-3:])
FixedDurationTuplet(1/4, [e'8, f'8, g'8])
abjad> leaftools.label_leaves_in_expr_with_tuplet_depth(staff)
abjad> f(staff)
\new Staff {
  c'8 _ \markup { \small 0 }
  d'8 _ \markup { \small 0 }
  \times 2/3 {
    e'8 _ \markup { \small 1 }
    f'8 _ \markup { \small 1 }
    g'8 _ \markup { \small 1 }
  }
}
```

Return `none`. Changed in version 2.0: renamed `label.leaf_depth_tuplet()` to `leaftools.label_leaves_in_expr_with_tuplet_depth()`.

leaftools.label_leaves_in_expr_with_written_leaf_duration

abjad.tools.leaftools.**label_leaves_in_expr_with_written_leaf_duration**(*expr*,
markup_direction='down')

New in version 1.1. Label leaves in *expr* with written leaf duration:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(1, 4), "c'8 d'8 e'8")
abjad> leaftools.label_leaves_in_expr_with_written_leaf_durations(tuplet)
abjad> f(tuplet)
\times 2/3 {
  c'8 _ \markup { \column { \small 1/8 \small 1/12 } }
  d'8 _ \markup { \column { \small 1/8 \small 1/12 } }
  e'8 _ \markup { \column { \small 1/8 \small 1/12 } }
}
```

Return `none`.

leaftools.leaf_to_augmented_tuplet_with_n_notes_of_equal_written_duration

abjad.tools.leaftools.**leaf_to_augmented_tuplet_with_n_notes_of_equal_written_duration**(*leaf*,
n)

New in version 2.0. Change *leaf* to augmented tuplet with *n* notes of equal written duration:

```
abjad> for n in range(1, 11):
...     note = Note(0, (3, 16))
...     tuplet = leaftools.leaf_to_augmented_tuplet_with_n_notes_of_equal_written_duration(note,
...     print tuplet
...
{@ 1:1 c'8. @}
{@ 1:1 c'16., c'16. @}
{@ 1:1 c'16, c'16, c'16 @}
{@ 1:1 c'32., c'32., c'32., c'32. @}
{@ 5:8 c'64., c'64., c'64., c'64., c'64. @}
```

```
{@ 1:1 c'32, c'32, c'32, c'32, c'32, c'32 @}
{@ 7:8 c'64., c'64., c'64., c'64., c'64., c'64., c'64. @}
{@ 1:1 c'64., c'64., c'64., c'64., c'64., c'64., c'64. @}
{@ 3:4 c'64, c'64, c'64, c'64, c'64, c'64, c'64, c'64 @}
{@ 5:8 c'128., c'128., c'128., c'128., c'128., c'128., c'128., c'128., c'128., c'128. @}
```

Return augmented fixed-duration tuplet.

leaftools.leaf_to_augmented_tuplet_with_proportions

abjad.tools.leaftools.leaf_to_augmented_tuplet_with_proportions(*leaf*, *proportions*)

New in version 2.0. Change *leaf* to augmented tuplet with *proportions*:

```
abjad> note = Note(0, (3, 16))
abjad> print leaftools.leaf_to_augmented_tuplet_with_proportions(note, [1])
{@ 1:1 c'8. @}
abjad> print leaftools.leaf_to_augmented_tuplet_with_proportions(note, [1, 2])
{@ 1:1 c'16, c'8 @}
abjad> print leaftools.leaf_to_augmented_tuplet_with_proportions(note, [1, 2, 2])
{@ 5:8 c'64., c'32., c'32. @}
abjad> print leaftools.leaf_to_augmented_tuplet_with_proportions(note, [1, 2, 2, 3])
{@ 2:3 c'64, c'32, c'32, c'32. @}
abjad> print leaftools.leaf_to_augmented_tuplet_with_proportions(note, [1, 2, 2, 3, 3])
{@ 11:12 c'64, c'32, c'32, c'32., c'32. @}
abjad> print leaftools.leaf_to_augmented_tuplet_with_proportions(note, [1, 2, 2, 3, 3, 4])
{@ 5:8 c'128, c'64, c'64, c'64., c'64., c'32 @}

```

Return augmented fixed-duration tuplet.

leaftools.leaf_to_diminished_tuplet_with_n_notes_of_equal_written_duration

abjad.tools.leaftools.leaf_to_diminished_tuplet_with_n_notes_of_equal_written_duration(*leaf*, *n*)

New in version 2.0. Change *leaf* to diminished tuplet with *n* notes of equal written duration:

```
abjad> for n in range(1, 11):
...     note = Note(0, (3, 16))
...     tuplet = leaftools.leaf_to_diminished_tuplet_with_n_notes_of_equal_written_duration(note, n)
...     print tuplet
...
{@ 1:1 c'8. @}
{@ 1:1 c'16., c'16. @}
{@ 1:1 c'16, c'16, c'16 @}
{@ 1:1 c'32., c'32., c'32., c'32. @}
{@ 5:4 c'32., c'32., c'32., c'32., c'32. @}
{@ 1:1 c'32, c'32, c'32, c'32, c'32, c'32 @}
{@ 7:4 c'32., c'32., c'32., c'32., c'32., c'32., c'32. @}
{@ 1:1 c'64., c'64., c'64., c'64., c'64., c'64., c'64., c'64. @}
{@ 3:2 c'32, c'32, c'32, c'32, c'32, c'32, c'32, c'32 @}
{@ 5:4 c'64., c'64., c'64., c'64., c'64., c'64., c'64., c'64., c'64., c'64. @}
```

Return diminished fixed-duration tuplet.

leaftools.leaf_to_diminished_tuplet_with_proportions

abjad.tools.leaftools.leaf_to_diminished_tuplet_with_proportions(*leaf*, *proportions*)

New in version 2.0. Change *leaf* to diminished tuplet with *proportions*:

```

abjad> note = Note(0, (3, 16))
abjad> print leaftools.leaf_to_diminished_tuplet_with_proportions(note, [1])
{@ 1:1 c'8. @}
abjad> print leaftools.leaf_to_diminished_tuplet_with_proportions(note, [1, 2])
{@ 1:1 c'16, c'8 @}
abjad> print leaftools.leaf_to_diminished_tuplet_with_proportions(note, [1, 2, 2])
{@ 5:4 c'32., c'16., c'16. @}
abjad> print leaftools.leaf_to_diminished_tuplet_with_proportions(note, [1, 2, 2, 3])
{@ 4:3 c'32, c'16, c'16, c'16. @}
abjad> print leaftools.leaf_to_diminished_tuplet_with_proportions(note, [1, 2, 2, 3, 3])
{@ 11:6 c'32, c'16, c'16, c'16., c'16. @}
abjad> print leaftools.leaf_to_diminished_tuplet_with_proportions(note, [1, 2, 2, 3, 3, 4])
{@ 5:4 c'64, c'32, c'32, c'32., c'32., c'16 @}

```

Return diminished fixed-duration tuplet.

leaftools.list_prolated_durations_of_leaves_in_expr

abjad.tools.leaftools.list_prolated_durations_of_leaves_in_expr(*expr*)

New in version 2.0. List prolated durations of leaves in *expr*:

```

abjad> staff = Staff(tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8") * 2)
abjad> leaftools.list_prolated_durations_of_leaves_in_expr(staff)
[Duration(1, 12), Duration(1, 12), Duration(1, 12), Duration(1, 12), Duration(1, 12), Duration(1, 12)]

```

Return list of fractions.

leaftools.list_written_durations_of_leaves_in_expr

abjad.tools.leaftools.list_written_durations_of_leaves_in_expr(*expr*)

New in version 2.0. List the written durations of leaves in *expr*:

```

abjad> staff = Staff(tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8") * 2)
abjad> leaftools.list_written_durations_of_leaves_in_expr(staff)
[Duration(1, 8), Duration(1, 8), Duration(1, 8), Duration(1, 8), Duration(1, 8), Duration(1, 8)]

```

Return list of fractions.

leaftools.make_leaves

abjad.tools.leaftools.make_leaves(*pitches*, *durations*, *direction*='big-endian', *tied_rests*=False)

New in version 1.1. Construct a list of notes, rests or chords.

Set *pitches* is a single pitch, or a list of pitches, or a tuple of pitches.

Integer pitches create notes.

```

abjad> leaftools.make_leaves([2, 4, 19], [(1, 4)])
[Note("d'4"), Note("e'4"), Note("g'4")]

```

Tuple pitches create chords.

```
abjad> leaftools.make_leaves([(0, 1, 2), (3, 4, 5), (6, 7, 8)], [(1, 4)])
[Chord("<c' cs' d'>4"), Chord("<ef' e' f'>4"), Chord("<fs' g' af'>4")]
```

Set *pitches* to a list of none to create rests.

```
abjad> leaftools.make_leaves([None, None, None, None], [(1, 8)])
[Rest('r8'), Rest('r8'), Rest('r8'), Rest('r8')]
```

You can mix and match pitch values.

```
abjad> leaftools.make_leaves([12, (1, 2, 3), None, 12], [(1, 4)])
[Note("c''4"), Chord("<cs' d' ef'>4"), Rest('r4'), Note("c''4")]
```

If the length of *pitches* is less than the length of *durations*, the function reads *durations* cyclically.

```
abjad> leaftools.make_leaves([13], [(1, 8), (1, 8), (1, 4), (1, 4)])
[Note("cs''8"), Note("cs''8"), Note("cs''4"), Note("cs''4")]
```

Set *durations* to a single duration, a list of duration, or a tuple of durations.

If the length of *durations* is less than the length of *pitches*, the function reads *pitches* cyclically.

```
abjad> leaftools.make_leaves([13, 14, 15, 16], [(1, 8)])
[Note("cs''8"), Note("d''8"), Note("ef''8"), Note("e''8")]
```

Duration values not of the form $m / 2^{**} n$ return leaves nested inside a fixed-multiplier tuplet.

```
abjad> leaftools.make_leaves([14], [(1, 12), (1, 12), (1, 12)])
[Tuplet(2/3, [d''8, d''8, d''8])]
```

Set *direction* to 'little-endian' to return tied leaf durations from least to greatest.

```
abjad> staff = Staff(leaftools.make_leaves([15], [(13, 16)], direction = 'little-endian'))
abjad> f(staff)
\new Staff {
    ef''16 ~
    ef''2.
}
```

Set *tied_rests* to true to return tied rests for durations like 5/16 and 9/16.

```
abjad> staff = Staff(leaftools.make_leaves([None], [(5, 16)], tied_rests = True))
abjad> f(staff)
\new Staff {
    r4 ~
    r16
}
```

Return list of leaves. Changed in version 2.0: renamed `construct.leaves()` to `leaftools.make_leaves()`.

leaftools.make_leaves_from_note_value_signal

```
abjad.tools.leaftools.make_leaves_from_note_value_signal(note_value_signal, de-
nominator_of_signal,
tied_rests=False)
```

New in version 2.0. Make leaves from *note_value_signal* and *denominator_of_signal*:

```
abjad> leaves = leaftools.make_leaves_from_note_value_signal([3, -3, 5, -5], 8)
abjad> staff = Staff(leaves)
```

```
abjad> f(staff)
\new Staff {
    c'4.
    r4.
    c'2 ~
    c'8
    r2
    r8
}
```

Interpret positive elements in *note_value_signal* as notes.

Interpret negative elements in *note_value_signal* as rests.

Set the pitch of all notes to middle C.

Return list of notes and / or rests.

leaftools.remove_initial_rests_from_sequence

`abjad.tools.leaftools.remove_initial_rests_from_sequence(sequence)`

New in version 2.0. Remove initial rests from *sequence*:

```
abjad> staff = Staff("r8 r8 c'8 d'8 r4 r4")
```

```
abjad> f(staff)
\new Staff {
    r8
    r8
    c'8
    d'8
    r4
    r4
}
```

```
abjad> leaftools.remove_initial_rests_from_sequence(staff)
[Note("c'8"), Note("d'8"), Rest('r4'), Rest('r4')]
```

```
abjad> f(staff)
\new Staff {
    r8
    r8
    c'8
    d'8
    r4
    r4
}
```

Return list.

leaftools.remove_leaf_and_shrink_durated_parent_containers

`abjad.tools.leaftools.remove_leaf_and_shrink_durated_parent_containers(leaf)`

New in version 1.1. Remove *leaf* and shrink durated parent containers:

```

abjad> measure = Measure((4, 8), tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(measure)
abjad> spannertools.BeamSpanner(measure.leaves)
BeamSpanner(c'8, d'8, e'8, f'8, g'8, a'8)
abjad> f(measure)
{
    \time 4/8
    \times 2/3 {
        c'8 [
        d'8
        e'8
    ]
    \times 2/3 {
        f'8
        g'8
        a'8 ]
    }
}

abjad> leaftools.remove_leaf_and_shrink_durated_parent_containers(measure.leaves[0])

abjad> f(measure)
{
    \time 5/12
    \scaleDurations #'(2 . 3) {
        {
            d'8 [
            e'8
        ]
        {
            f'8
            g'8
            a'8 ]
        }
    }
}

```

Return none.

leaftools.remove_outer_rests_from_sequence

`abjad.tools.leaftools.remove_outer_rests_from_sequence(sequence)`

New in version 2.0. Remove outer rests from *sequence*:

```

abjad> staff = Staff("r8 r8 c'8 d'8 r4 r4")

abjad> f(staff)
\new Staff {
    r8
    r8
    c'8
    d'8
    r4
    r4
}

```

```
abjad> leaftools.remove_outer_rests_from_sequence(staff)
[Note("c'8"), Note("d'8")]
```

```
abjad> f(staff)
\new Staff {
    r8
    r8
    c'8
    d'8
    r4
    r4
}
```

Return list.

leaftools.remove_terminal_rests_from_sequence

`abjad.tools.leaftools.remove_terminal_rests_from_sequence(sequence)`

New in version 2.0. Remove terminal rests from *sequence*:

```
abjad> staff = Staff("r8 r8 c'8 d'8 r4 r4")
```

```
abjad> f(staff)
\new Staff {
    r8
    r8
    c'8
    d'8
    r4
    r4
}
```

```
abjad> leaftools.remove_terminal_rests_from_sequence(staff)
[Rest('r8'), Rest('r8'), Note("c'8"), Note("d'8")]
```

```
abjad> f(staff)
\new Staff {
    r8
    r8
    c'8
    d'8
    r4
    r4
}
```

Return list.

leaftools.repeat_leaf_and_extend_spanners

`abjad.tools.leaftools.repeat_leaf_and_extend_spanners(leaf, total=1)`

New in version 1.1. Repeat *leaf* and extend spanners:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> f(staff)
```

```
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

abjad> leaftools.repeat_leaf_and_extend_spanners(staff[0], total = 3)

abjad> f(staff)
\new Staff {
    c'8 [
    c'8
    c'8
    d'8
    e'8
    f'8 ]
}
```

Preserve *leaf* written duration.

Preserve parentage and spanners.

Return none. Changed in version 2.0: renamed `leaftools.clone_and_splice_leaf()` to `leaftools.repeat_leaf_and_extend_spanners()`.

leaftools.repeat_leaves_in_expr_and_extend_spanners

`abjad.tools.leaftools.repeat_leaves_in_expr_and_extend_spanners(expr, total=1)`

New in version 1.1. Repeat leaves in *expr* and extend spanners:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

abjad> result = leaftools.repeat_leaves_in_expr_and_extend_spanners(staff[2:], total = 3)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    e'8
    e'8
    f'8
    f'8
    f'8 ]
}
```

Preserve leaf written durations.

Preserve parentage and spanners.

Return `none`. Changed in version 2.0: renamed `leaftools.multiply()` to `leaftools.repeat_leaves_in_expr_and_extend_spanners()`.

leaftools.scale_preprolated_leaf_duration

`abjad.tools.leaftools.scale_preprolated_leaf_duration(leaf, multiplier)`

New in version 1.1. Scale preprolated *leaf* leaf duration by dotted *multiplier*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> leaftools.scale_preprolated_leaf_duration(staff[1], Duration(3, 2))
[Note("d'8.")]
abjad> f(staff)
\new Staff {
    c'8 [
    d'8.
    e'8
    f'8 ]
}
```

Scale preprolated *leaf* duration by tied *multiplier*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> leaftools.scale_preprolated_leaf_duration(staff[1], Duration(5, 4))
[Note("d'8"), Note("d'32")]
abjad> f(staff)
\new Staff {
    c'8 [
    d'8 ~
    d'32
    e'8
    f'8 ]
}
```

Scale preprolated *leaf* duration by nonbinary *multiplier*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> leaftools.scale_preprolated_leaf_duration(staff[1], Duration(2, 3))
[Note("d'8")]
abjad> f(staff)
\new Staff {
    c'8 [
    \times 2/3 {
        d'8
    }
    e'8
    f'8 ]
}
```

Scale preprolated *leaf* duration by tied nonbinary *multiplier*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
```

```
abjad> leaftools.scale_preprolated_leaf_duration(staff[1], Duration(5, 6))
[Note("d'8"), Note("d'32")]
abjad> f(staff)
\new Staff {
  c'8 [
    \times 2/3 {
      d'8 ~
      d'32
    }
  e'8
  f'8 ]
}
```

Return *leaf*. Changed in version 2.0: renamed from `leaftools.duration_scale()`.
`leaftools.scale_preprolated_leaf_duration()`.

leaftools.set_preprolated_leaf_duration

`abjad.tools.leaftools.set_preprolated_leaf_duration(leaf, new_preprolated_duration)`

New in version 1.1. Set preprolated *leaf* duration:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> leaftools.set_preprolated_leaf_duration(staff[1], Duration(3, 16))
[Note("d'8.")]
abjad> f(staff)
\new Staff {
  c'8 [
    d'8.
    e'8
    f'8 ]
}
```

Set tied preprolated *leaf* duration:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> leaftools.set_preprolated_leaf_duration(staff[1], Duration(5, 32))
[Note("d'8"), Note("d'32")]
abjad> f(staff)
\new Staff {
  c'8 [
    d'8 ~
    d'32
    e'8
    f'8 ]
}
```

Set nonbinary preprolated *leaf* duration:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> leaftools.set_preprolated_leaf_duration(staff[1], Duration(1, 12))
[Note("d'8")]
abjad> f(staff)
```

```
\new Staff {
  c'8 [
    \times 2/3 {
      d'8
    }
  e'8
  f'8 ]
}
```

Set tied nonbinary preprolated *leaf* duration:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'8, d'8, e'8, f'8)
abjad> leaftools.set_preprolated_leaf_duration(staff[1], Duration(5, 48))
[Note("d'8"), Note("d'32")]
abjad> f(staff)
\new Staff {
  c'8 [
    \times 2/3 {
      d'8 ~
      d'32
    }
  e'8
  f'8 ]
}
```

Set preprolated *leaf* duration with LilyPond multiplier:

```
abjad> note = Note(0, (1, 8))
abjad> note.duration_multiplier = Duration(1, 2)
abjad> leaftools.set_preprolated_leaf_duration(note, Duration(5, 48))
[Note("c'8 * 5/6")]
abjad> f(note)
c'8 * 5/6
```

Return list of *leaf* and leaves newly tied to *leaf*. Changed in version 2.0: renamed `leaftools.change_leaf_preprolated_duration()` to `leaftools.set_preprolated_leaf_duration()`.

leaftools.show_leaves

`abjad.tools.leaftools.show_leaves` (*leaves*, *template=None*, *suppress_pdf=False*)

New in version 2.0. Show *leaves* in temporary piano staff score:

```
abjad> leaves = leaftools.make_leaves([None, 1, (-24, -22, 7, 21), None], (1, 4))
abjad> score = leaftools.show_leaves(leaves) # doctest: +SKIP
\new Score <<
  \new PianoStaff <<
    \context Staff = "treble" {
      \clef "treble"
      r4
      cs'4
      <g' a''>4
      r4
    }
    \context Staff = "bass" {
      \clef "bass"
```

```

        r4
        r4
        <c, d,>4
        r4
    }
    >>
>>

```

Useful when working with notes, rests, chords not yet added to score.

Return temporary piano staff score.

leaftools.split_leaf_at_prolated_duration_and_rest_right_half

abjad.tools.leaftools.**split_leaf_at_prolated_duration_and_rest_right_half**(*leaf*,
pro-
lated_duration)

New in version 1.1. Split *leaf* at *prolated_duration* and rest right half:

```

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.SlurSpanner(t[:])
SlurSpanner(c'8, d'8, e'8, f'8)
abjad> f(t)
\new Staff {
    c'8 (
    d'8
    e'8
    f'8 )
}

abjad> leaftools.split_leaf_at_prolated_duration_and_rest_right_half(t.leaves[1], (1, 32))
([Note("d'32")], [Note("d'16.")])

abjad> f(t)
\new Staff {
    c'8 (
    d'32
    r16.
    e'8
    f'8 )
}

```

Return list of leaves to left of *prolated_duration* together with list of leaves to right of *prolated_duration*. Changed in version 2.0: renamed `leaftools.shorten()` to `leaftools.split_leaf_at_prolated_duration_and_rest_right_half()`.

leaftools.yield_groups_of_mixed_notes_and_chords_in_sequence

abjad.tools.leaftools.**yield_groups_of_mixed_notes_and_chords_in_sequence**(*sequence*)
New in version 2.0. Yield groups of mixed notes and chords in *sequence*:

```

abjad> staff = Staff("c'8 d'8 r8 r8 <e' g'>8 <f' a'>8 g'8 a'8 r8 r8 <b' d''>8 <c'' e''>8")

abjad> f(staff)
\new Staff {
    c'8
    d'8

```

```

r8
r8
<e' g'>8
<f' a'>8
g'8
a'8
r8
r8
<b' d''>8
<c'' e''>8
}

```

```

abjad> for group in leaftools.yield_groups_of_mixed_notes_and_chords_in_sequence(staff):
...     group
...
(Note("c'8"), Note("d'8"))
(Chord("<e' g'>8"), Chord("<f' a'>8"), Note("g'8"), Note("a'8"))
(Chord("<b' d''>8"), Chord("<c'' e''>8"))

```

Return generator.

`lilypondfiletools`

`lilypondfiletools.AbjadRevisionToken`

class `abjad.tools.lilypondfiletools.AbjadRevisionToken`

Bases: `abjad.core._Immutable._Immutable._Immutable` New in version 2.0. Abjad version token:

```

abjad> lilypondfiletools.AbjadRevisionToken()
AbjadRevisionToken(Abjad revision ...)

```

Return Abjad version token.

format

Format contribution of Abjad version token:

```

abjad> lilypondfiletools.AbjadRevisionToken().format
'Abjad revision ...'

```

Return string.

`lilypondfiletools.BookBlock`

class `abjad.tools.lilypondfiletools.BookBlock`

Bases: `abjad.tools.lilypondfiletools._NonattributedBlock._NonattributedBlock._NonattributedBlock` New in version 2.0. Abjad model of LilyPond input file book block:

```

abjad> book_block = lilypondfiletools.BookBlock()

```

```

abjad> book_block
BookBlock()

```

```

abjad> f(book_block)
\book {}

```

Return book block.

lilypondfiletools.BookpartBlock

class abjad.tools.lilypondfiletools.**BookpartBlock**

Bases: abjad.tools.lilypondfiletools._NonattributedBlock._NonattributedBlock._NonattributedBlock

New in version 2.0. Abjad model of LilyPond input file bookpart block:

```
abjad> bookpart_block = lilypondfiletools.BookpartBlock()
```

```
abjad> bookpart_block
BookpartBlock()
```

```
abjad> f(bookpart_block)
\bookpart {}
```

Return bookpart block.

lilypondfiletools.ContextBlock

class abjad.tools.lilypondfiletools.**ContextBlock** (*context_name=None*)

Bases: abjad.tools.lilypondfiletools._AttributedBlock._AttributedBlock._AttributedBlock

New in version 2.5. Abjad model of LilyPond input file context block:

```
abjad> context_block = lilypondfiletools.ContextBlock()
```

```
abjad> context_block
ContextBlock()
```

```
abjad> context_block.context_name = 'Score'
abjad> context_block.override.bar_number.transparent = True
abjad> context_block.override.time_signature.break_visibility = schemetools.SchemeVariable('end-
abjad> context_block.set.proportionalNotationDuration = schemetools.SchemeMoment((1, 45))
```

```
abjad> f(context_block)
\context {
  \Score
  \override BarNumber #'transparent = ##t
  \override TimeSignature #'break-visibility = #end-of-line-invisible
  proportionalNotationDuration = #(ly:make-moment 1 45)
}
```

Return context block.

context_name

Read / write context name.

override

Read-only reference to LilyPond grob override component plug-in.

set

Read-only reference LilyPond context setting component plug-in.

lilypondfiletools.DateTimeToken

class abjad.tools.lilypondfiletools.**DateTimeToken**

Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Date time token:

```
abjad> lilypondfiletools.DateTimeToken()
DateTimeToken(...)
```

Return date / time token.

format

Format contribution of date time token:

```
abjad> lilypondfiletools.DateTimeToken().format
'...'
```

Return string.

`lilypondfiletools.HeaderBlock`

class `abjad.tools.lilypondfiletools.HeaderBlock`

Bases: `abjad.tools.lilypondfiletools._AttributedBlock._AttributedBlock._AttributedBlock`
 New in version 2.0. Abjad model of LilyPond input file header block:

```
abjad> header_block = lilypondfiletools.HeaderBlock()

abjad> header_block
HeaderBlock()

abjad> header_block.composer = markuptools.Markup('Josquin')
abjad> header_block.title = markuptools.Markup('Missa sexti tonus')

abjad> f(header_block)
\header {
  composer = \markup { Josquin }
  title = \markup { Missa sexti tonus }
}
```

Return header block.

`lilypondfiletools.LayoutBlock`

class `abjad.tools.lilypondfiletools.LayoutBlock`

Bases: `abjad.tools.lilypondfiletools._AttributedBlock._AttributedBlock._AttributedBlock`
 New in version 2.0. Abjad model of LilyPond input file layout block:

```
abjad> layout_block = lilypondfiletools.LayoutBlock()

abjad> layout_block
LayoutBlock()

abjad> layout_block.indent = 0
abjad> layout_block.ragged_right = True

abjad> f(layout_block)
\layout {
  indent = #0
  ragged-right = ##t
}
```

Return layout block.

context_blocks

Read-only list of context blocks:

```
abjad> layout_block = lilypondfiletools.LayoutBlock()

abjad> context_block = lilypondfiletools.ContextBlock('Score')
abjad> context_block.override.bar_number.transparent = True

abjad> context_block.override.time_signature.break_visibility = schemetools.SchemeVariable('
abjad> layout_block.context_blocks.append(context_block)

abjad> f(layout_block)
\layout {
  \context {
    \Score
    \override BarNumber #'transparent = ##t
    \override TimeSignature #'break-visibility = #end-of-line-invisible
  }
}
```

Return list.

contexts

DEPRECATED. USE CONTEXT_BLOCKS INSTEAD.

lilypondfiletools.LilyPondFile

class abjad.tools.lilypondfiletools.**LilyPondFile**

Bases: list New in version 2.0. Abjad model of LilyPond input file:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> lilypond_file = lilypondfiletools.make_basic_lilypond_file(staff)
abjad> lilypond_file.file_initial_user_comments.append('File construct as an example.')
abjad> lilypond_file.file_initial_user_comments.append('Parts shown here for positioning.')
abjad> lilypond_file.file_initial_user_includes.append('external-settings-file-1.ly')
abjad> lilypond_file.file_initial_user_includes.append('external-settings-file-2.ly')
abjad> lilypond_file.default_paper_size = 'letter', 'portrait'
abjad> lilypond_file.global_staff_size = 16
abjad> lilypond_file.header_block.composer = markuptools.Markup('Josquin')
abjad> lilypond_file.header_block.title = markuptools.Markup('Missa sexti tonus')
abjad> lilypond_file.layout_block.indent = 0
abjad> lilypond_file.layout_block.left_margin = 15
abjad> lilypond_file.paper_block.oddFooterMarkup = markuptools.Markup('The odd-page footer')
abjad> lilypond_file.paper_block.evenFooterMarkup = markuptools.Markup('The even-page footer')

abjad> f(lilypond_file) # doctest: +SKIP
% Abjad revision 3719
% 2010-09-24 09:01

% File construct as an example.
% Parts shown here for positioning.

\version "2.13.32"
\include "english.ly"
\include "/Users/trevorbaca/Documents/abjad/trunk/abjad/cfg/abjad.scm"

\include "external-settings-file-1.ly"
\include "external-settings-file-2.ly"
```



```

#(set-default-paper-size "letter" 'portrait)
#(set-global-staff-size 16)

\header {
  composer = \markup { Josquin }
  title = \markup { Missa sexti tonus }
}

\layout {
  indent = #0
  left-margin = #15
}

\paper {
  evenFooterMarkup = \markup { The even-page footer }
  oddFooterMarkup = \markup { The odd-page footer }
}

\new Staff {
  c'8
  d'8
  e'8
  f'8
}

```

default_paper_size

LilyPond default paper size.

file_initial_system_comments

Read-only list of file-initial system comments.

file_initial_system_includes

List of file-initial system include commands.

file_initial_user_comments

Read-only list of file-initial user comments.

file_initial_user_includes

List of file-initial user include commands.

format

Format-time contribution of LilyPond file.

global_staff_size

LilyPond global staff size.

lilypondfiletools.LilyPondLanguageToken**class abjad.tools.lilypondfiletools.LilyPondLanguageToken**

Bases: `abjad.core._Immutable._Immutable._Immutable` New in version 2.0. LilyPond language token:

```

abjad> lilypondfiletools.LilyPondLanguageToken()
LilyPondLanguageToken(\include "english.ly")

```

Return LilyPond language token.

format

Format contribution of LilyPond language token:

```
abjad> lilypondfiletools.LilyPondLanguageToken().format
'\include "english.ly"
```

Return string.

`lilypondfiletools.LilyPondVersionToken`

class `abjad.tools.lilypondfiletools.LilyPondVersionToken`

Bases: `abjad.core._Immutable._Immutable._Immutable` New in version 2.0. LilyPond version token:

```
abjad> lilypondfiletools.LilyPondVersionToken()
LilyPondVersionToken(\version "...")
```

Return LilyPond version token.

format

Format contribution of LilyPond version token:

```
abjad> lilypondfiletools.LilyPondVersionToken().format
'\version "..."
```

Return string.

`lilypondfiletools.MIDIBlock`

class `abjad.tools.lilypondfiletools.MIDIBlock`

Bases: `abjad.tools.lilypondfiletools._AttributedBlock._AttributedBlock._AttributedBlock` New in version 2.0. Abjad model of LilyPond input file MIDI block:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4")
abjad> score = Score([staff])
abjad> lilypond_file = lilypondfiletools.make_basic_lilypond_file(score)
```

```
abjad> lilypond_file.score_block.append(lilypondfiletools.MIDIBlock())
```

```
abjad> layout_block = lilypondfiletools.LayoutBlock()
abjad> layout_block.is_formatted_when_empty = True
abjad> lilypond_file.score_block.append(layout_block)
```

```
abjad> f(lilypond_file.score_block)
\score {
  \new Score <<
    \new Staff {
      c'4
      d'4
      e'4
      f'4
    }
  >>
  \midi {}
  \layout {}
}
```

MIDI blocks are formatted even when they are empty.

The example here appends MIDI and layout blocks to a score block. Doing this allows LilyPond to create both MIDI and PDF output from a single input file.

Read the LilyPond docs on LilyPond file structure for the details as to why this is the case.

`lilypondfiletools.PaperBlock`

class `abjad.tools.lilypondfiletools.PaperBlock`

Bases: `abjad.tools.lilypondfiletools._AttributedBlock._AttributedBlock._AttributedBlock`

New in version 2.0. Abjad model of LilyPond input file paper block:

```
abjad> paper_block = lilypondfiletools.PaperBlock()
```

```
abjad> paper_block
PaperBlock()
```

```
abjad> paper_block.print_page_number = True
abjad> paper_block.print_first_page_number = False
```

```
abjad> f(paper_block)
\paper {
  print-first-page-number = ##f
  print-page-number = ##t
}
```

Return paper block.

`minimal_page_breaking`

`lilypondfiletools.ScoreBlock`

class `abjad.tools.lilypondfiletools.ScoreBlock`

Bases: `abjad.tools.lilypondfiletools._NonattributedBlock._NonattributedBlock._NonattributedBlock`

New in version 2.0. Abjad model of LilyPond input file score block:

```
abjad> score_block = lilypondfiletools.ScoreBlock()
```

```
abjad> score_block
ScoreBlock()
```

```
abjad> f(score_block)
\score {}
```

Return score block.

`lilypondfiletools.make_basic_lilypond_file`

`abjad.tools.lilypondfiletools.make_basic_lilypond_file` (*music=None*)

New in version 2.0. Make basic LilyPond file with *music*:

```
abjad> score = Score([Staff("c'8 d'8 e'8 f'8")])
abjad> lilypond_file = lilypondfiletools.make_basic_lilypond_file(score)
abjad> lilypond_file.header_block.composer = markuptools.Markup('Josquin')
abjad> lilypond_file.layout_block.indent = 0
abjad> lilypond_file.paper_block.top_margin = 15
abjad> lilypond_file.paper_block.left_margin = 15
```

```
abjad> f(lilypond_file) # doctest: +SKIP
\header {
  composer = \markup { Josquin }
}

\layout {
  indent = #0
}

\paper {
  left-margin = #15
  top-margin = #15
}

\new Score <<
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
>>
```

Equip LilyPond file with header, layout and paper blocks.

Return LilyPond file.

marktools

marktools.Annotation

class abjad.tools.marktools.**Annotation**(*args)

Bases: abjad.tools.marktools.Mark.Mark Mark New in version 2.0. User-defined annotation:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
```

```
abjad> f(staff)
\new Staff {
  c'8
  d'8
  e'8
  f'8
}
```

```
abjad> marktools.Annotation('special pitch', pitchtools.NamedChromaticPitch('ds'))(staff[0])
Annotation('special pitch', NamedChromaticPitch('ds'))(c'8)
```

```
abjad> f(staff)
\new Staff {
  c'8
  d'8
  e'8
  f'8
}
```

Annotations contribute no formatting.

Annotations implement `__slots__`.

name

Get name of annotation:

```
abjad> annotation = marktools.Annotation('special_pitch', pitchtools.NamedChromaticPitch('ds'))
abjad> annotation.name
'special_pitch'
```

Set name of annotation:

```
abjad> annotation.name = 'revised special pitch'
abjad> annotation.name
'revised special pitch'
```

Set string.

value

Get value of annotation:

```
abjad> annotation = marktools.Annotation('special_pitch', pitchtools.NamedChromaticPitch('ds'))
abjad> annotation.value
NamedChromaticPitch('ds')
```

Set value of annotation:

```
abjad> annotation.value = pitchtools.NamedChromaticPitch('e')
abjad> annotation.value
NamedChromaticPitch('e')
```

Set arbitrary object.

marktools.Articulation

```
class abjad.tools.marktools.Articulation(*args)
    Bases: abjad.tools.marktools.Mark.Mark.Mark
```

Abjad model of musical articulation:

```
abjad> note = Note("c'4")

abjad> marktools.Articulation('staccato')(note)
Articulation('staccato')(c'4)
```

```
abjad> f(note)
c'4 -\staccato
```

Articulations implement `__slots__`.

direction_string

Get direction string of articulation:

```
abjad> articulation = marktools.Articulation('staccato')
abjad> articulation.direction_string is None
True
```

Set direction string of articulation:

```
abjad> articulation.direction_string = '^'
abjad> articulation.direction_string
'^'
```

Set string.

format

Read-only LilyPond format string of articulation:

```
abjad> articulation = marktools.Articulation('marcato', 'up')
abjad> articulation.format
'^\marcato'
```

Return string.

name

Get name of articulation:

```
abjad> articulation = marktools.Articulation('staccato', 'up')
abjad> articulation.name
'staccato'
```

Set name of articulation:

```
abjad> articulation.name = 'marcato'
abjad> articulation.name
'marcato'
```

Set string.

marktools.BarLine

class abjad.tools.marktools.**BarLine** (*bar_line_string='|'*)

Bases: abjad.tools.marktools.LilyPondCommandMark.LilyPondCommandMark.LilyPondCommandMark

New in version 2.4. Abjad model of bar line:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4")

abjad> bar_line = marktools.BarLine('|.') (staff[-1])

abjad> bar_line
BarLine('|.') (f'4)

abjad> f(staff)
\new Staff {
  c'4
  d'4
  e'4
  f'4
  \bar "|."
}
```

Return bar line.

bar_line_string

Get bar line string of bar line:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4")
abjad> bar_line = marktools.BarLine()(staff[-1])
abjad> bar_line.bar_line_string
'|'
```

Set bar line string of bar line:

```
abjad> bar_line.bar_line_string = '|.'
```

```
abjad> f(staff)
\new Staff {
    c'4
    d'4
    e'4
    f'4
    \bar "|."
}
```

Set string.

marktools.LilyPondCommandMark

class abjad.tools.marktools.**LilyPondCommandMark**(*args)

Bases: abjad.tools.marktools.Mark.Mark New in version 2.0. LilyPond command mark:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff.leaves)

abjad> lilypond_command = marktools.LilyPondCommandMark('slurDotted')(staff[0])

abjad> f(staff)
\new Staff {
    \slurDotted
    c'8 (
    d'8
    e'8
    f'8 )
}
```

Initialize LilyPond command marks from command name; or from command name with format slot; or from another LilyPond command mark; or from another LilyPond command mark with format slot.

LilyPond command marks implement `__slots__`.

command_name

Get command name of LilyPond command mark:

```
abjad> lilypond_command = marktools.LilyPondCommandMark('slurDotted')
abjad> lilypond_command.command_name
'slurDotted'
```

Set command name of LilyPond command mark:

```
abjad> lilypond_command.command_name = 'slurDashed'
abjad> lilypond_command.command_name
'slurDashed'
```

Set string.

format

Read-only LilyPond input format of LilyPond command mark:

```
abjad> note = Note("c'4")
abjad> lilypond_command = marktools.LilyPondCommandMark('slurDotted')(note)
abjad> lilypond_command.format
'\slurDotted'
```

Return string.

format_slot

New in version 2.3. Get format slot of LilyPond command mark:

```
abjad> note = Note("c'4")
abjad> lilypond_command = marktools.LilyPondCommandMark('break', 'after')
abjad> lilypond_command.format_slot
'after'
```

Set format slot of LilyPond command mark:

```
abjad> note = Note("c'4")
abjad> lilypond_command = marktools.LilyPondCommandMark('break', 'after')
abjad> lilypond_command.format_slot = 'before'
abjad> lilypond_command.format_slot
'before'
```

Set to 'before', 'after', 'opening', 'closing', 'right' or none.

marktools.LilyPondComment

class abjad.tools.marktools.**LilyPondComment** (*args)

Bases: abjad.tools.marktools.Mark.Mark.Mark New in version 2.0.Changed in version 2.3: Changed Comment to LilyPondComment. User-defined comment:

```
abjad> note = Note("c'4")

abjad> marktools.LilyPondComment('this is a comment')(note)
LilyPondComment('this is a comment')(c'4)

abjad> f(note)
% this is a comment
c'4
```

Initialize LilyPond comment from contents string; or contents string and format slot; or from other LilyPond comment; or from other LilyPond comment and format slot.

LilyPond comments implement `__slots__`.

contents_string

Get contents string of comment:

```
abjad> comment = marktools.LilyPondComment('comment contents string')
abjad> comment.contents_string
'comment contents string'
```

Set contents string of comment:

```
abjad> comment.contents_string = 'new comment contents string'
abjad> comment.contents_string
'new comment contents string'
```

Set string.

format

Read-only LilyPond input format of comment:

```
abjad> comment = marktools.LilyPondComment('this is a comment.')
abjad> comment.format
'% this is a comment.'
```

Return string.

format_slot

New in version 2.3. Get format slot of LilyPond comment:

```
abjad> note = Note("c'4")
abjad> lilypond_comment = marktools.LilyPondComment('comment')
abjad> lilypond_comment.format_slot
'before'
```

Set format slot of LilyPond comment:

```
abjad> note = Note("c'4")
abjad> lilypond_comment = marktools.LilyPondComment('comment')
abjad> lilypond_comment.format_slot = 'after'
abjad> lilypond_comment.format_slot
'after'
```

Set to 'before', 'after', 'opening', 'closing', 'right' or none.

marktools.Mark

class abjad.tools.marktools.**Mark** (*args)

Bases: object New in version 2.0. Abstract class from which concrete marks inherit:

```
abjad> note = Note("c'4")

abjad> marktools.Mark()(note)
Mark()(c'4)
```

Marks override `__call__` to attach to a note, rest or chord.

Marks implement `__slots__`.

attach (start_component)

Attach mark to *start_component*:

```
abjad> note = Note("c'4")
abjad> mark = marktools.Mark()

abjad> mark.attach(note)
Mark()(c'4)

abjad> mark.start_component
Note("c'4")
```

Return mark.

detach ()

Detach mark:

```
abjad> note = Note("c'4")
abjad> mark = marktools.Mark()(note)
```

```
abjad> mark.start_component
Note("c'4")

abjad> mark.detach()
Mark()

abjad> mark.start_component is None
True
```

Return mark.

start_component

Read-only reference to mark start component:

```
abjad> note = Note("c'4")
abjad> mark = marktools.Mark()(note)

abjad> mark.start_component
Note("c'4")
```

Return component or none.

marktools.StemTremolo

class abjad.tools.marktools.**StemTremolo**(*args)

Bases: abjad.tools.marktools.Mark.Mark New in version 2.0. Abjad model of stem tremolo:

```
abjad> note = Note("c'4")

abjad> marktools.StemTremolo(16)(note)
StemTremolo(16)(c'4)

abjad> f(note)
c'4 :16
```

Stem tremolos implement `__slots__`.

format

Read-only LilyPond format string:

```
abjad> stem_tremolo = marktools.StemTremolo(16)
abjad> stem_tremolo.format
':16'
```

Return string.

tremolo_flags

Get tremolo flags:

```
abjad> stem_tremolo = marktools.StemTremolo(16)
abjad> stem_tremolo.tremolo_flags
16
```

Set tremolo flags:

```
abjad> stem_tremolo.tremolo_flags = 32
abjad> stem_tremolo.tremolo_flags
32
```

Set integer.

marktools.attach_annotations_to_components_in_expr

abjad.tools.marktools.**attach_annotations_to_components_in_expr**(*expr*, *annotations*)

New in version 2.3. Attach *annotations* to components in *expr*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> annotation = marktools.Annotation('foo', 'bar')
abjad> marktools.attach_annotations_to_components_in_expr(staff.leaves, [annotation])

abjad> for x in staff:
...     print x, marktools.get_annotations_attached_to_component(x)
...
c'8 (Annotation('foo', 'bar')(c'8),)
d'8 (Annotation('foo', 'bar')(d'8),)
e'8 (Annotation('foo', 'bar')(e'8),)
f'8 (Annotation('foo', 'bar')(f'8),)
```

Return none.

marktools.attach_articulations_to_notes_and_chords_in_expr

abjad.tools.marktools.**attach_articulations_to_notes_and_chords_in_expr**(*expr*, *articulations*)

New in version 2.0. Attach *articulations* to notes and chords in *expr*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.attach_articulations_to_notes_and_chords_in_expr(staff, list('^.'))

abjad> f(staff)
\new Staff {
    c'8 -\marcato -\staccato
    d'8 -\marcato -\staccato
    e'8 -\marcato -\staccato
    f'8 -\marcato -\staccato
}
```

Return none.

marktools.attach_lilypond_command_marks_to_components_in_expr

abjad.tools.marktools.**attach_lilypond_command_marks_to_components_in_expr**(*expr*, *lilypond_command_marks*)

New in version 2.3. Attach *lilypond_command_marks* to components in *expr*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> lilypond_command_mark = marktools.LilyPondCommandMark('stemUp')
abjad> marktools.attach_lilypond_command_marks_to_components_in_expr(staff.leaves, [lilypond_command_mark])

abjad> f(staff)
\new Staff {
    \stemUp
    c'8
```

```

        \stemUp
        d'8
        \stemUp
        e'8
        \stemUp
        f'8
    }

```

Return none.

marktools.attach_lilypond_comments_to_components_in_expr

abjad.tools.marktools.**attach_lilypond_comments_to_components_in_expr**(*expr*,
lily-
pond_comments)

New in version 2.3. Attach *lilypond_comments* to components in *expr*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> lilypond_comment = marktools.LilyPondComment('foo', 'right')
abjad> marktools.attach_lilypond_comments_to_components_in_expr(staff.leaves, [lilypond_comment])

abjad> f(staff)
\new Staff {
    c'8 % foo
    d'8 % foo
    e'8 % foo
    f'8 % foo
}

```

Return none.

marktools.attach_stem_tremolos_to_notes_and_chords_in_expr

abjad.tools.marktools.**attach_stem_tremolos_to_notes_and_chords_in_expr**(*expr*,
stem_tremolos)

New in version 2.3. Attach *stem_tremolos* to notes and chords in *expr*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> stem_tremolo = marktools.StemTremolo(16)
abjad> marktools.attach_stem_tremolos_to_notes_and_chords_in_expr(staff, [stem_tremolo])

abjad> f(staff)
\new Staff {
    c'8 :16
    d'8 :16
    e'8 :16
    f'8 :16
}

```

Return none.

marktools.detach_annotations_attached_to_component

abjad.tools.marktools.**detach_annotations_attached_to_component**(*component*)

New in version 2.0. Detach annotations attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> marktools.Annotation('annotation 1')(staff[0])
Annotation('annotation 1')(c'8)
abjad> marktools.Annotation('annotation 2')(staff[0])
Annotation('annotation 2')(c'8)

abjad> f(staff)
\new Staff {
    c'8 (
    d'8
    e'8
    f'8 )
}

abjad> marktools.get_annotations_attached_to_component(staff[0])
(Annotation('annotation 1')(c'8), Annotation('annotation 2')(c'8))

abjad> marktools.detach_annotations_attached_to_component(staff[0])
(Annotation('annotation 1'), Annotation('annotation 2'))

abjad> marktools.get_annotations_attached_to_component(staff[0])
()
```

Return tuple or zero or more annotations detached.

marktools.detach_articulations_attached_to_component

abjad.tools.marktools.**detach_articulations_attached_to_component** (*component*)

New in version 2.0. Detach articulations attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> marktools.Articulation('^')(staff[0])
Articulation('^')(c'8)
abjad> marktools.Articulation('.')[staff[0])
Articulation('.')[c'8)

abjad> f(staff)
\new Staff {
    c'8 -\marcato -\staccato (
    d'8
    e'8
    f'8 )
}

abjad> marktools.get_articulations_attached_to_component(staff[0])
(Articulation('^')(c'8), Articulation('.')[c'8))

abjad> marktools.detach_articulations_attached_to_component(staff[0])
(Articulation('^'), Articulation('.')[c'8))

abjad> marktools.get_articulations_attached_to_component(staff[0])
()
```

Return tuple or zero or more articulations detached.

marktools.detach_lilypond_command_marks_attached_to_component

abjad.tools.marktools.**detach_lilypond_command_marks_attached_to_component** (*component*,
com-
mand_name=None)

New in version 2.0. Detach LilyPond command marks attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> marktools.LilyPondCommandMark('slurDotted')(staff[0])
LilyPondCommandMark('slurDotted')(c'8)
abjad> marktools.LilyPondCommandMark('slurUp')(staff[0])
LilyPondCommandMark('slurUp')(c'8)

abjad> f(staff)
\new Staff {
  \slurDotted
  \slurUp
  c'8 (
  d'8
  e'8
  f'8 )
}

abjad> marktools.detach_lilypond_command_marks_attached_to_component(staff[0])
(LilyPondCommandMark('slurDotted'), LilyPondCommandMark('slurUp'))

abjad> f(staff)
\new Staff {
  c'8 (
  d'8
  e'8
  f'8 )
}
```

Return tuple of zero or more marks detached.

marktools.detach_lilypond_comments_attached_to_component

abjad.tools.marktools.**detach_lilypond_comments_attached_to_component** (*component*)

New in version 2.0. Detach LilyPond comments attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> marktools.LilyPondComment('comment 1')(staff[0])
LilyPondComment('comment 1')(c'8)
abjad> marktools.LilyPondComment('comment 2')(staff[0])
LilyPondComment('comment 2')(c'8)

abjad> f(staff)
\new Staff {
  % comment 1
  % comment 2
  c'8 (
  d'8
  e'8
  f'8 )
}
```

```

abjad> marktools.detach_lilypond_comments_attached_to_component(staff[0])
(LilyPondComment('comment 1'), LilyPondComment('comment 2'))

abjad> f(staff)
\new Staff {
    c'8 (
    d'8
    e'8
    f'8 )
}

abjad> marktools.get_lilypond_comments_attached_to_component(staff[0])
()
```

Return tuple or zero or more LilyPond comments.

marktools.detach_marks_attached_to_component

`abjad.tools.marktools.detach_marks_attached_to_component(component)`

New in version 2.0. Detach marks attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> marktools.Articulation('^')(staff[0])
Articulation('^')(c'8)
abjad> marktools.LilyPondComment('comment 1')(staff[0])
LilyPondComment('comment 1')(c'8)
abjad> marktools.LilyPondCommandMark('slurUp')(staff[0])
LilyPondCommandMark('slurUp')(c'8)

abjad> f(staff)
\new Staff {
    % comment 1
    \slurUp
    c'8 -\marcato (
    d'8
    e'8
    f'8 )
}

abjad> marktools.get_marks_attached_to_component(staff[0])
(Articulation('^')(c'8), LilyPondComment('comment 1')(c'8), LilyPondCommandMark('slurUp')(c'8))

abjad> marktools.detach_marks_attached_to_component(staff[0])
(Articulation('^'), LilyPondComment('comment 1'), LilyPondCommandMark('slurUp'))

abjad> marktools.get_marks_attached_to_component(staff[0])
()
```

Return tuple or zero or more marks detached.

marktools.detach_noncontext_marks_attached_to_component

`abjad.tools.marktools.detach_noncontext_marks_attached_to_component(component)`

New in version 2.3. Detach noncontext marks attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.TimeSignatureMark((2, 4))(staff[0])
TimeSignatureMark((2, 4))(c'8)
abjad> marktools.Articulation('staccato')(staff[0])
Articulation('staccato')(c'8)

abjad> f(staff)
\new Staff {
  \time 2/4
  c'8 -\staccato
  d'8
  e'8
  f'8
}

abjad> marktools.detach_noncontext_marks_attached_to_component(staff[0])
(Articulation('staccato'),)

abjad> f(staff)
\new Staff {
  \time 2/4
  c'8
  d'8
  e'8
  f'8
}

```

Return tuple of noncontext marks.

marktools.detach_stem_tremolos_attached_to_component

abjad.tools.marktools.**detach_stem_tremolos_attached_to_component**(*component*)

New in version 2.0. Detach stem tremolos attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.StemTremolo(16)(staff[0])
StemTremolo(16)(c'8)

abjad> f(staff)
\new Staff {
  c'8 :16
  d'8
  e'8
  f'8
}

abjad> marktools.get_stem_tremolos_attached_to_component(staff[0])
(StemTremolo(16)(c'8),)

abjad> marktools.detach_stem_tremolos_attached_to_component(staff[0])
(StemTremolo(16),)

abjad> marktools.get_stem_tremolos_attached_to_component(staff[0])
()

```

Return tuple or zero or more stem tremolos detached.

marktools.get_annotation_attached_to_component

`abjad.tools.marktools.get_annotation_attached_to_component` (*component*)

New in version 2.0. Get exactly one annotation attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.Annotation('special information')(staff[0])
Annotation('special information')(c'8)

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}

abjad> marktools.get_annotation_attached_to_component(staff[0])
Annotation('special information')(c'8)

```

Return one annotation.

Raise missing mark error when no annotation is attached.

Raise extra mark error when more than one annotation is attached.

marktools.get_annotations_attached_to_component

`abjad.tools.marktools.get_annotations_attached_to_component` (*component*)

New in version 2.0. Get annotations attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.Annotation('annotation 1')(staff[0])
Annotation('annotation 1')(c'8)
abjad> marktools.Annotation('annotation 2')(staff[0])
Annotation('annotation 2')(c'8)

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}

abjad> marktools.get_annotations_attached_to_component(staff[0])
(Annotation('annotation 1')(c'8), Annotation('annotation 2')(c'8))

```

Return tuple of zero or more annotations.

marktools.get_articulation_attached_to_component

`abjad.tools.marktools.get_articulation_attached_to_component` (*component*)

New in version 2.0. Get exactly one articulation attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.Articulation('staccato')(staff[0])
Articulation('staccato')(c'8)

```

```
abjad> f(staff)
\new Staff {
    c'8 -\staccato
    d'8
    e'8
    f'8
}

abjad> marktools.get_articulation_attached_to_component(staff[0])
Articulation('staccato')(c'8)
```

Return one articulation.

Raise missing mark error when no articulation is attached.

Raise extra mark error when more than one articulation is attached.

marktools.get_articulations_attached_to_component

`abjad.tools.marktools.get_articulations_attached_to_component` (*component*)

New in version 2.0. Get articulations attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.Articulation('staccato')(staff[0])
Articulation('staccato')(c'8)
abjad> marktools.Articulation('marcato')(staff[0])
Articulation('marcato')(c'8)

abjad> f(staff)
\new Staff {
    c'8 -\marcato -\staccato
    d'8
    e'8
    f'8
}

abjad> marktools.get_articulations_attached_to_component(staff[0])
(Articulation('staccato')(c'8), Articulation('marcato')(c'8))
```

Return tuple of zero or more articulations.

marktools.get_lilypond_command_mark_attached_to_component

`abjad.tools.marktools.get_lilypond_command_mark_attached_to_component` (*component*)

New in version 2.0. Get exactly one LilyPond command mark attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.LilyPondCommandMark('stemUp')(staff[0])
LilyPondCommandMark('stemUp')(c'8)

abjad> f(staff)
\new Staff {
    \stemUp
    c'8
    d'8
    e'8
```

```
f'8
}
```

```
abjad> marktools.get_lilypond_command_mark_attached_to_component(staff[0])
LilyPondCommandMark('stemUp')(c'8)
```

Return one LilyPond command mark.

Raise missing mark error when no LilyPond command mark is attached.

Raise extra mark error when more than one LilyPond command mark is attached.

marktools.get_lilypond_command_marks_attached_to_component

```
abjad.tools.marktools.get_lilypond_command_marks_attached_to_component(component,
                                                                    com-
                                                                    mand_name=None)
```

New in version 2.0. Get LilyPond command marks attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> marktools.LilyPondCommandMark('slurDotted')(staff[0])
LilyPondCommandMark('slurDotted')(c'8)
abjad> marktools.LilyPondCommandMark('slurUp')(staff[0])
LilyPondCommandMark('slurUp')(c'8)

abjad> f(staff)
\new Staff {
  \slurDotted
  \slurUp
  c'8 (
  d'8
  e'8
  f'8 )
}

abjad> marktools.get_lilypond_command_marks_attached_to_component(staff[0])
(LilyPondCommandMark('slurDotted')(c'8), LilyPondCommandMark('slurUp')(c'8))
```

Return tuple of zero or more marks.

marktools.get_lilypond_comment_attached_to_component

```
abjad.tools.marktools.get_lilypond_comment_attached_to_component(component)
```

New in version 2.0. Get exactly one LilyPond comment attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.LilyPondComment('comment')(staff[0])
LilyPondComment('comment')(c'8)

abjad> f(staff)
\new Staff {
  % comment
  c'8
  d'8
  e'8
```

```
f'8
}
```

```
abjad> marktools.get_lilypond_comment_attached_to_component(staff[0])
LilyPondComment('comment')(c'8)
```

Return one LilyPond comment.

Raise missing mark error when no LilyPond comment is attached.

Raise extra mark error when more than one LilyPond comment is attached.

marktools.get_lilypond_comments_attached_to_component

abjad.tools.marktools.get_lilypond_comments_attached_to_component(*component*)

New in version 2.0. Get LilyPond comments attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> marktools.LilyPondComment('comment 1')(staff[0])
LilyPondComment('comment 1')(c'8)
abjad> marktools.LilyPondComment('comment 2')(staff[0])
LilyPondComment('comment 2')(c'8)

abjad> f(staff)
\new Staff {
    % comment 1
    % comment 2
    c'8 (
    d'8
    e'8
    f'8 )
}

abjad> marktools.get_lilypond_comments_attached_to_component(staff[0])
(LilyPondComment('comment 1')(c'8), LilyPondComment('comment 2')(c'8))
```

Return tuple of zero or more LilyPond comments.

marktools.get_mark_attached_to_component

abjad.tools.marktools.get_mark_attached_to_component(*component*)

New in version 2.0. Get exactly one mark attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.Mark()(staff[0])
Mark()(c'8)

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}
```

```
abjad> marktools.get_mark_attached_to_component(staff[0])
Mark()(c'8)
```

Return one mark.

Raise missing mark error when no mark is attached.

Raise extra mark error when more than one mark is attached.

marktools.get_marks_attached_to_component

`abjad.tools.marktools.get_marks_attached_to_component(component)`

New in version 2.0. Get all marks attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> comment_mark = marktools.LilyPondComment('beginning of note content')(staff[0])
abjad> marktools.LilyPondCommandMark('slurDotted')(staff[0])
LilyPondCommandMark('slurDotted')(c'8)

abjad> f(staff)
\new Staff {
    % beginning of note content
    \slurDotted
    c'8 (
    d'8
    e'8
    f'8 )
}

abjad> marktools.get_marks_attached_to_component(staff[0])
(LilyPondComment('beginning of note content')(c'8), LilyPondCommandMark('slurDotted')(c'8))
```

Return tuple of zero or more marks. Changed in version 2.0: re-named `marktools.get_all_marks_attached_to_component()` to `marktools.get_marks_attached_to_component()`.

marktools.get_noncontext_mark_attached_to_component

`abjad.tools.marktools.get_noncontext_mark_attached_to_component(component)`

New in version 2.0. Get exactly one noncontext_mark attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.Articulation('staccato')(staff[0])
Articulation('staccato')(c'8)

abjad> f(staff)
\new Staff {
    c'8 -\staccato
    d'8
    e'8
    f'8
}

abjad> marktools.get_noncontext_mark_attached_to_component(staff[0])
Articulation('staccato')(c'8)
```

Return one `noncontext_mark`.

Raise missing mark error when no `noncontext_mark` is attached.

Raise extra mark error when more than one `noncontext_mark` is attached.

marktools.get_noncontext_marks_attached_to_component

`abjad.tools.marktools.get_noncontext_marks_attached_to_component` (*component*)

New in version 2.0. Get noncontext marks attached to component:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> contexttools.TimeSignatureMark((2, 4))(staff[0])
TimeSignatureMark((2, 4))(c'8)
abjad> marktools.Articulation('staccato')(staff[0])
Articulation('staccato')(c'8)

abjad> f(staff)
\new Staff {
  \time 2/4
  c'8 -\staccato
  d'8
  e'8
  f'8
}

abjad> marktools.get_noncontext_marks_attached_to_component(staff[0])
(Articulation('staccato')(c'8),)
```

Return tuple of zero or more marks.

marktools.get_stem_tremolo_attached_to_component

`abjad.tools.marktools.get_stem_tremolo_attached_to_component` (*component*)

New in version 2.0. Get stem tremolo attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.StemTremolo(16)(staff[0])
StemTremolo(16)(c'8)

abjad> f(staff)
\new Staff {
  c'8 :16
  d'8
  e'8
  f'8
}

abjad> marktools.get_stem_tremolo_attached_to_component(staff[0])
StemTremolo(16)(c'8)
```

Raise missing mark error when no stem tremolo attaches to *component*.

Raise extra mark error when more than one stem tremolo attaches to *component*.

Return stem tremolo.

marktools.get_stem_tremolos_attached_to_component

abjad.tools.marktools.get_stem_tremolos_attached_to_component(*component*,
tremolo_flags=None)

New in version 2.3. Get stem tremolos attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.StemTremolo(16)(staff[0])
StemTremolo(16)(c'8)

abjad> f(staff)
\new Staff {
    c'8 :16
    d'8
    e'8
    f'8
}

abjad> marktools.get_stem_tremolos_attached_to_component(staff[0])
(StemTremolo(16)(c'8),)
```

Return tuple of zero or more stem tremolos.

marktools.get_value_of_annotation_attached_to_component

abjad.tools.marktools.get_value_of_annotation_attached_to_component(*component*,
name,
de-
fault_value=None)

New in version 2.0. Get value of annotation with *name* attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> marktools.Annotation('special dictionary', {})(staff[0])
Annotation('special dictionary', {})(c'8)

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}

abjad> marktools.get_value_of_annotation_attached_to_component(staff[0], 'special dictionary')
{}
```

Return arbitrary value of annotation.

Return *default_value* when no annotation with *name* is attached.

Raise extra mark error when more than one annotation with *name* is attached.

marktools.is_component_with_annotation_attached

`abjad.tools.marktools.is_component_with_annotation_attached`(*expr*, *annotation_name=None*, *annotation_value=None*)

New in version 2.3. True when *expr* is component with annotation attached:

```
abjad> note = Note("c'4")
abjad> marktools.Annotation('foo', 'bar')(note)
Annotation('foo', 'bar')(c'4)

abjad> marktools.is_component_with_annotation_attached(note)
True
```

False otherwise:

```
abjad> note = Note("c'4")

abjad> marktools.is_component_with_annotation_attached(note)
False
```

Return boolean.

marktools.is_component_with_articulation_attached

`abjad.tools.marktools.is_component_with_articulation_attached`(*expr*, *articulation_name=None*)

New in version 2.3. True when *expr* is component with articulation attached:

```
abjad> note = Note("c'4")
abjad> marktools.Articulation('staccato')(note)
Articulation('staccato')(c'4)

abjad> marktools.is_component_with_articulation_attached(note)
True
```

False otherwise:

```
abjad> note = Note("c'4")

abjad> marktools.is_component_with_articulation_attached(note)
False
```

Return boolean.

marktools.is_component_with_lilypond_command_mark_attached

`abjad.tools.marktools.is_component_with_lilypond_command_mark_attached`(*expr*, *command_name=None*)

New in version 2.0. True when *expr* is component with LilyPond command mark attached:

```
abjad> note = Note("c'4")
abjad> marktools.LilyPondCommandMark('stemUp')(note)
LilyPondCommandMark('stemUp')(c'4)
```



```
abjad> marktools.is_component_with_lilypond_command_mark_attached(note)
True
```

False otherwise:

```
abjad> note = Note("c'4")

abjad> marktools.is_component_with_lilypond_command_mark_attached(note)
False
```

Return boolean.

marktools.is_component_with_lilypond_comment_attached

`abjad.tools.marktools.is_component_with_lilypond_comment_attached(expr, comment_contents_string=None)`

New in version 2.3. True when *expr* is component with LilyPond comment mark attached:

```
abjad> note = Note("c'4")
abjad> marktools.LilyPondComment('comment here')(note)
LilyPondComment('comment here')(c'4)

abjad> marktools.is_component_with_lilypond_comment_attached(note)
True
```

False otherwise:

```
abjad> note = Note("c'4")

abjad> marktools.is_component_with_lilypond_comment_attached(note)
False
```

Return boolean.

marktools.is_component_with_mark_attached

`abjad.tools.marktools.is_component_with_mark_attached(expr)`

New in version 2.3. True when *expr* is component with mark attached:

```
abjad> note = Note("c'4")
abjad> marktools.Mark()(note)
Mark()(c'4)

abjad> marktools.is_component_with_mark_attached(note)
True
```

False otherwise:

```
abjad> note = Note("c'4")

abjad> marktools.is_component_with_mark_attached(note)
False
```

Return boolean.

marktools.is_component_with_noncontext_mark_attached

`abjad.tools.marktools.is_component_with_noncontext_mark_attached(expr)`

New in version 2.3. True when *expr* is component with noncontext mark attached:

```
abjad> note = Note("c'4")
abjad> marktools.Articulation('staccato')(note)
Articulation('staccato')(c'4)
```

```
abjad> marktools.is_component_with_noncontext_mark_attached(note)
True
```

False otherwise:

```
abjad> note = Note("c'4")

abjad> marktools.is_component_with_noncontext_mark_attached(note)
False
```

Return boolean.

marktools.is_component_with_stem_tremolo_attached

`abjad.tools.marktools.is_component_with_stem_tremolo_attached(expr, tremolo_flags=None)`

New in version 2.3. True when *expr* is component with LilyPond command mark attached:

```
abjad> note = Note("c'4")
abjad> marktools.StemTremolo(16)(note)
StemTremolo(16)(c'4)
```

```
abjad> marktools.is_component_with_stem_tremolo_attached(note)
True
```

False otherwise:

```
abjad> note = Note("c'4")

abjad> marktools.is_component_with_stem_tremolo_attached(note)
False
```

Return boolean.

markuptools

markuptools.Markup

class `abjad.tools.markuptools.Markup(arg, direction_string=None, style_string='backslash')`

Bases: `abjad.tools.marktools.Mark.Mark.Mark`

Abjad model of backslash-style LilyPond markup or Scheme-style LilyPond markup.

Initialize backslash-style markup from string:

```
abjad> markup = markuptools.Markup(r'\bold { "This is markup text." }')

abjad> markup
Markup('\bold { "This is markup text." }')
```

```
abjad> f(markup)
\markup { \bold { "This is markup text." } }
```

Initialize Scheme-style markup from string:

```
abjad> markup = markuptools.Markup("(markup #:draw-line '(0 . -1))", style_string = 'scheme')

abjad> markup
Markup("(markup #:draw-line '(0 . -1))")

abjad> f(markup)
#(markup #:draw-line '(0 . -1))
```

Initialize any markup from existing markup:

```
abjad> markup_1 = markuptools.Markup('foo', direction_string = 'up')
abjad> markup_2 = markuptools.Markup(markup_1, direction_string = 'down')

abjad> f(markup_1)
^ \markup { foo }

abjad> f(markup_2)
_ \markup { foo }
```

Attach markup to score components like this:

```
abjad> note = Note("c'4")

abjad> markup = markuptools.Markup(r'\bold { "This is markup text." }')

abjad> markup(note)
Markup('\bold { "This is markup text." }')

abjad> f(note)
c'4 \markup { \bold { "This is markup text." } }
```

Set *direction_string* to 'up', 'down', 'neutral' or none.

Set *style_string* to 'backslash' or 'scheme'.

Markup objects are immutable.

contents_string

Read-only contents string of markup:

```
abjad> markup = markuptools.Markup(r'\bold { "This is markup text." }')
abjad> markup.contents_string
'\bold { "This is markup text." }'
```

Return string

format

Read-only LilyPond format of markup:

```
abjad> markup = markuptools.Markup(r'\bold { "This is markup text." }')
abjad> markup.format
'\markup { \bold { "This is markup text." } }'
```

Return string.

markuptools.MarkupCommand

class abjad.tools.markuptools.**MarkupCommand**(*command, args, markup, is_braced=True*)

Bases: abjad.core._Immutable._Immutable._Immutable

Abjad model of a LilyPond markup command:

```
abjad> circle = markuptools.MarkupCommand('draw-circle', ['#2.5', '#0.1', '##f'], None)
abjad> square = markuptools.MarkupCommand('rounded-box', None, ['hello?'])
abjad> line = markuptools.MarkupCommand('line', None, [square, 'wow!'])
abjad> rotate = markuptools.MarkupCommand('rotate', ['#60'], [line])
abjad> combine = markuptools.MarkupCommand('combine', None, [rotate, circle], is_braced = False)
```

```
abjad> print combine
\combine \rotate #60 \line { \rounded-box hello? wow! } \draw-circle #2.5 #0.1 ##f
```

Insert markup command in markup to attach to score components:

```
abjad> note = Note("c'4")

abjad> markup = markuptools.Markup(combine)

abjad> markup(note)
Markup('\combine \rotate #60 \line { \rounded-box hello? wow! } \draw-circle #2.5 #0.1 ##f')

abjad> f(note)
c'4 \markup { \combine \rotate #60 \line { \rounded-box hello? wow! } \draw-circle #2.5 #0.1 ##f }
```

Markup commands are immutable.

args

Read-only tuple of markup command arguments.

command

Read-only string of markup command command-name.

format

Read-only format of markup command:

```
abjad> markup_command = markuptools.MarkupCommand('draw-circle', ['#2.5', '#0.1', '##f'], None)
abjad> markup_command.format
'\draw-circle #2.5 #0.1 ##f'
```

Return list of strings.

is_braced

Read-only boolean of markup command bracing.

markup

Read-only tuple of markup command's child markup.

report (*output='screen'*)

Report, in an indented human-readable format, the structure of a formatted MarkupCommand.

markuptools.all_are_markup

abjad.tools.markuptools.all_are_markup(*expr*)

New in version 2.6. True when *expr* is a sequence of Abjad markup:

```
abjad> markup = markuptools.Markup('some text')
```

```
abjad> markuptools.all_are_markup([markup])
True
```

True when *expr* is an empty sequence:

```
abjad> markuptools.all_are_markup([])
True
```

Otherwise false:

```
abjad> markuptools.all_are_markup('foo')
False
```

Return boolean.

markuptools.combine_markup_commands

`abjad.tools.markuptools.combine_markup_commands(*commands)`
Combine MarkupCommand and/or string objects.

LilyPond's 'combine' markup command can only take two arguments, so in order to combine more than two stencils, a cascade of 'combine' commands must be employed. *combine_markup_commands* simplifies this process.

```
abjad> from abjad.tools.markuptools import combine_markup_commands
abjad> from abjad.tools.markuptools import MarkupCommand

abjad> markup_a = MarkupCommand('draw-circle', ["#4", '#0.4', '##f'], None)
abjad> markup_b = MarkupCommand('filled-box', ["#(-4 . 4)", "#(-0.5 . 0.5)", '#1'], None)
abjad> markup_c = "some text"
abjad> combine_markup_commands(markup_a, markup_b, markup_c).report()
\combine
  \combine
    \draw-circle #4 #0.4 ##f
    \filled-box #'(-4 . 4) #'(-0.5 . 0.5) #1
    "some text"
```

Returns a MarkupCommand instance, or a string if that was the only argument.

markuptools.get_down_markup_attached_to_component

`abjad.tools.markuptools.get_down_markup_attached_to_component(component)`
New in version 2.0. Get down-markup attached to component:

```
abjad> chord = Chord([-11, 2, 5], (1, 4))
abjad> markuptools.Markup('UP', 'up')(chord)
Markup('UP', 'up')
abjad> markuptools.Markup('DOWN', 'down')(chord)
Markup('DOWN', 'down')

abjad> markuptools.get_down_markup_attached_to_component(chord)
(Markup('DOWN', 'down'),)
```

Return tuple of zero or more markup objects.

markuptools.get_markup_attached_to_component

`abjad.tools.markuptools.get_markup_attached_to_component(component)`

New in version 2.0. Get markup attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff[:])
abjad> markuptools.Markup('foo')(staff[0])
Markup('foo')
abjad> markuptools.Markup('bar')(staff[0])
Markup('bar')

abjad> f(staff)
\new Staff {
    c'8 - \markup { \column { foo bar } } (
    d'8
    e'8
    f'8 )
}

abjad> markuptools.get_markup_attached_to_component(staff[0])
(Markup('foo'), Markup('bar'))
```

Return tuple of zero or more markup objects.

markuptools.get_up_markup_attached_to_component

`abjad.tools.markuptools.get_up_markup_attached_to_component(component)`

New in version 2.0. Get up-markup attached to component:

```
abjad> chord = Chord([-11, 2, 5], (1, 4))
abjad> markuptools.Markup('UP', 'up')(chord)
Markup('UP', 'up')
abjad> markuptools.Markup('DOWN', 'down')(chord)
Markup('DOWN', 'down')

abjad> markuptools.get_up_markup_attached_to_component(chord)
(Markup('UP', 'up'),)
```

Return tuple of zero or more markup objects.

markuptools.make_big_centered_page_number_markup

`abjad.tools.markuptools.make_big_centered_page_number_markup(text=None)`

New in version 1.1. Make big centered page number markup:

```
abjad> markup = markuptools.make_big_centered_page_number_markup()

abjad> f(markup)
\markup {
    \fill-line {
        \bold \fontsize #3 \concat {
            \on-the-fly #print-page-number-check-first
            \fromproperty #'page:page-number-string } } }
```

Return markup. Changed in version 2.0: renamed `markuptools.big_centered_page_number()` to `markuptools.make_big_centered_page_number_markup()`.

markuptools.remove_markup_attached_to_component

`abjad.tools.markuptools.remove_markup_attached_to_component` (*component*)

New in version 2.0. Remove markup attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> slur = spannertools.SlurSpanner(staff[:])
abjad> markuptools.Markup('foo')(staff[0])
Markup('foo')
abjad> markuptools.Markup('bar')(staff[0])
Markup('bar')

abjad> f(staff)
\new Staff {
    c'8 - \markup { \column { foo bar } } (
    d'8
    e'8
    f'8 )
}

abjad> markuptools.remove_markup_attached_to_component(staff[0])
(Markup('foo'), Markup('bar'))

abjad> f(staff)
\new Staff {
    c'8 (
    d'8
    e'8
    f'8 )
}
```

Return tuple of zero or more markup objects.

markuptools.remove_markup_from_leaves_in_expr

`abjad.tools.markuptools.remove_markup_from_leaves_in_expr` (*expr*)

New in version 1.1. Remove markup from leaves in *expr*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> leaftools.label_leaves_in_expr_with_pitch_class_numbers(staff)
abjad> f(staff)
\new Staff {
    c'8 _ \markup { \small 0 }
    d'8 _ \markup { \small 2 }
    e'8 _ \markup { \small 4 }
    f'8 _ \markup { \small 5 }
}

abjad> markuptools.remove_markup_from_leaves_in_expr(staff)
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}
```

Return none. Changed in version 2.0: renamed `label.clear_leaves()` to `markuptools.remove_markup_from_leaves_in_expr()`.

measuretools

measuretools.AnonymousMeasure

class abjad.tools.measuretools.**AnonymousMeasure** (*music=None, **kwargs*)

Bases: abjad.tools.measuretools.DynamicMeasure.DynamicMeasure.DynamicMeasure
New in version 1.1. Dynamic measure with no time signature:

```
abjad> measure = measuretools.AnonymousMeasure("c'8 d'8 e'8 f'8")
```

```
abjad> f(measure)
{
    \override Staff.TimeSignature #'stencil = ##f
    \time 1/2
    c'8
    d'8
    e'8
    f'8
    \revert Staff.TimeSignature #'stencil
}
```

```
abjad> notes = [Note("c'8"), Note("d'8")]
abjad> measure.extend(notes)
```

```
abjad> f(measure)
{
    \override Staff.TimeSignature #'stencil = ##f
    \time 3/4
    c'8
    d'8
    e'8
    f'8
    c'8
    d'8
    \revert Staff.TimeSignature #'stencil
}
```

Return anonymous measure.

measuretools.DynamicMeasure

class abjad.tools.measuretools.**DynamicMeasure** (*music=None, **kwargs*)

Bases: abjad.tools.measuretools.Measure.Measure.Measure New in version 1.1. Measure sets meter dynamically to exactly equal contents duration:

```
abjad> measure = measuretools.DynamicMeasure("c'8 d'8 e'8")
```

```
abjad> measure
DynamicMeasure(3/8, [c'8, d'8, e'8])
```

```
abjad> f(measure)
{
    \time 3/8
    c'8
```



```

    d'8
    e'8
}

```

Return dynamic measure.

denominator

Get explicit denominator of dynamic measure:

```

abjad> measure = measuretools.DynamicMeasure("c'8 d'8 e'8 f'8")

abjad> measure.denominator is None
True

```

Set explicit denominator of dynamic measure:

```

abjad> measure.denominator = 8

abjad> f(measure)
{
    \time 4/8
    c'8
    d'8
    e'8
    f'8
}

```

Set positive integer or none.

extend (*expr*)

Extend dynamic measure:

```

abjad> measure = measuretools.DynamicMeasure("c'8 d'8 e'8")

abjad> f(measure)
{
    \time 3/8
    c'8
    d'8
    e'8
}

abjad> measure.extend([Note("f'8"), Note("g'8")])

abjad> f(measure)
{
    \time 5/8
    c'8
    d'8
    e'8
    f'8
    g'8
}

```

Return none.

preprolated_duration

suppress_meter

Get meter suppression indicator:

```
abjad> measure = measuretools.DynamicMeasure("c'8 d'8 e'8 f'8")
```

```
abjad> f(measure)
{
    \time 1/2
    c'8
    d'8
    e'8
    f'8
}
```

```
abjad> measure.suppress_meter
False
```

Set meter suppression indicator:

```
abjad> measure.suppress_meter = True
```

```
abjad> measure.suppress_meter
True
```

```
abjad> f(measure)
{
    c'8
    d'8
    e'8
    f'8
}
```

Set boolean.

measuretools.Measure

class abjad.tools.measuretools.**Measure** (*meter*, *music=None*, ***kwargs*)

Bases: abjad.tools.containertools.Container.Container New in version 1.1.

Abjad model of a measure:

```
abjad> measure = Measure((4, 8), "c'8 d'8 e'8 f'8")
```

```
abjad> measure
Measure(4/8, [c'8, d'8, e'8, f'8])
```

```
abjad> f(measure)
{
    \time 4/8
    c'8
    d'8
    e'8
    f'8
}
```

Return measure object.

is_binary

is_full

True when meter matches duration of measure:

```
abjad> measure = Measure((4, 8), "c'8 d'8 e'8 f'8")
```

```
abjad> measure.is_full
True
```

False otherwise:

```
abjad> measure = Measure((4, 8), "c'8 d'8 e'8")
```

```
abjad> measure.is_full
False
```

Return boolean.

is_nonbinary

is_overfull

New in version 1.1. True when prolated duration is greater than effective meter duration.

is_underfull

New in version 1.1. True when prolated duration is less than effective meter duration.

measure_number

multiplier

preprolated_duration

Measure contents duration times effective meter multiplier.

measuretools.all_are_measures

`abjad.tools.measuretools.all_are_measures(expr)`

New in version 2.6. True when *expr* is a sequence of Abjad measures:

```
abjad> measures = 3 * Measure((3, 4), "c'4 d'4 e'4")
```

```
abjad> measures
[Measure(3/4, [c'4, d'4, e'4]), Measure(3/4, [c'4, d'4, e'4]), Measure(3/4, [c'4, d'4, e'4])]
```

```
abjad> measuretools.all_are_measures(measures)
True
```

True when *expr* is an empty sequence:

```
abjad> measuretools.all_are_measures([])
True
```

Otherwise false:

```
abjad> measuretools.all_are_measures('foo')
False
```

Return boolean.

Function wraps `componenttools.all_are_components()`.

measuretools.append_spacer_skip_to_underfull_measure

`abjad.tools.measuretools.append_spacer_skip_to_underfull_measure(rigid_measure)`

New in version 1.1. Append spacer skip to underfull *measure*:

```

abjad> measure = Measure((4, 12), "c'8 d'8 e'8 f'8")
abjad> contexttools.detach_time_signature_marks_attached_to_component(measure)
(TimeSignatureMark((4, 12)),)
abjad> contexttools.TimeSignatureMark((5, 12))(measure)
TimeSignatureMark((5, 12))(|5/12, c'8, d'8, e'8, f'8|)
abjad> measure.is_underfull
True

```

```

abjad> measuretools.append_spacer_skip_to_underfull_measure(measure)
Measure(5/12, [c'8, d'8, e'8, f'8, s1 * 1/8])

```

```

abjad> f(measure)
{
    \time 5/12
    \scaleDurations #'(2 . 3) {
        c'8
        d'8
        e'8
        f'8
        s1 * 1/8
    }
}

```

Append nothing to nonunderfull *measure*.

Return *measure*. Changed in version 2.0: renamed `measuretools.make_measures_with_full_measure_spacer_skip` to `measuretools.append_spacer_skip_to_underfull_measure()`.

measuretools.append_spacer_skips_to_underfull_measures_in_expr

`abjad.tools.measuretools.append_spacer_skips_to_underfull_measures_in_expr(expr)`
 New in version 1.1. Append spacer skips to underfull measures in *expr*:

```

abjad> staff = Staff(Measure((3, 8), "c'8 d'8 e'8") * 3)
abjad> contexttools.detach_time_signature_marks_attached_to_component(staff[1])
(TimeSignatureMark((3, 8)),)
abjad> contexttools.TimeSignatureMark((4, 8))(staff[1])
TimeSignatureMark((4, 8))(|4/8, c'8, d'8, e'8|)
abjad> contexttools.detach_time_signature_marks_attached_to_component(staff[2])
(TimeSignatureMark((3, 8)),)
abjad> contexttools.TimeSignatureMark((5, 8))(staff[2])
TimeSignatureMark((5, 8))(|5/8, c'8, d'8, e'8|)
abjad> staff[1].is_underfull
True
abjad> staff[2].is_underfull
True

```

```

abjad> measuretools.append_spacer_skips_to_underfull_measures_in_expr(staff)
[Measure(4/8, [c'8, d'8, e'8, s1 * 1/8]), Measure(5/8, [c'8, d'8, e'8, s1 * 1/4])]

```

```

abjad> f(staff)
\new Staff {
    {
        \time 3/8
        c'8
        d'8
        e'8
    }
}

```

```

{
  \time 4/8
  c'8
  d'8
  e'8
  s1 * 1/8
}
{
  \time 5/8
  c'8
  d'8
  e'8
  s1 * 1/4
}
}

```

Return measures treated. Changed in version 2.0: renamed `measuretools.remedy_underfull_measures()` to `measuretools.append_spacer_skips_to_underfull_measures_in_expr()`.

measuretools.apply_beam_spanner_to_measure

`abjad.tools.measuretools.apply_beam_spanner_to_measure(measure)`

New in version 2.0. Apply beam spanner to *measure*:

```

abjad> measure = Measure((2, 8), "c'8 d'8")

abjad> f(measure)
{
  \time 2/8
  c'8
  d'8
}

abjad> measuretools.apply_beam_spanner_to_measure(measure)
BeamSpanner(|2/8(2)|)

abjad> f(measure)
{
  \time 2/8
  c'8 [
  d'8 ]
}

```

Return beam spanner.

measuretools.apply_beam_spanners_to_measures_in_expr

`abjad.tools.measuretools.apply_beam_spanners_to_measures_in_expr(expr)`

New in version 1.1. Apply beam spanners to measures in *expr*:

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> f(staff)
\new Staff {
  {

```

```

        \time 2/8
        c'8
        d'8
    }
    {
        \time 2/8
        e'8
        f'8
    }
}

abjad> measuretools.apply_beam_spanners_to_measures_in_expr(staff)
[BeamSpanner(|2/8(2)|), BeamSpanner(|2/8(2)|)]

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8 [
        d'8 ]
    }
    {
        \time 2/8
        e'8 [
        f'8 ]
    }
}

```

Return list of beams created. Changed in version 2.0: renamed `measuretools.beam()` to `measuretools.apply_beam_spanners_to_measures_in_expr()`.

measuretools.apply_complex_beam_spanner_to_measure

`abjad.tools.measuretools.apply_complex_beam_spanner_to_measure(measure)`

New in version 2.0. Apply complex beam spanner to *measure*:

```

abjad> measure = Measure((2, 8), "c'8 d'8")

abjad> f(measure)
{
    \time 2/8
    c'8
    d'8
}

abjad> measuretools.apply_complex_beam_spanner_to_measure(measure)
DulatedComplexBeamSpanner(|2/8(2)|)

abjad> f(measure)
{
    \time 2/8
    \set stemLeftBeamCount = #0
    \set stemRightBeamCount = #1
    c'8 [
    \set stemLeftBeamCount = #1
    \set stemRightBeamCount = #0

```

```

    d'8 ]
}

```

Return complex beam spanner.

measuretools.apply_complex_beam_spanners_to_measures_in_expr

abjad.tools.measuretools.**apply_complex_beam_spanners_to_measures_in_expr**(*expr*)

New in version 2.0. Apply complex beam spanners to measures in *expr*:

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)

```

```

abjad> f(staff)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
    e'8
    f'8
  }
}

```

```

abjad> measuretools.apply_complex_beam_spanners_to_measures_in_expr(staff)
[DuratedComplexBeamSpanner(|2/8(2)|), DuratedComplexBeamSpanner(|2/8(2)|)]

```

```

abjad> f(staff)
\new Staff {
  {
    \time 2/8
    \set stemLeftBeamCount = #0
    \set stemRightBeamCount = #1
    c'8 [
    \set stemLeftBeamCount = #1
    \set stemRightBeamCount = #0
    d'8 ]
  }
  {
    \time 2/8
    \set stemLeftBeamCount = #0
    \set stemRightBeamCount = #1
    e'8 [
    \set stemLeftBeamCount = #1
    \set stemRightBeamCount = #0
    f'8 ]
  }
}

```

Return list of beams created.

measuretools.apply_durated_complex_beam_spanner_to_measures

`abjad.tools.measuretools.apply_durated_complex_beam_spanner_to_measures(measures)`

New in version 1.1. Apply durated complex beam spanner to *measures*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
```

```
abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 2/8
        e'8
        f'8
    }
}
```

```
abjad> measures = staff[:]
abjad> measuretools.apply_durated_complex_beam_spanner_to_measures(measures)
DuratedComplexBeamSpanner(|2/8(2)|, |2/8(2)|)
```

```
abjad> f(staff)
\new Staff {
    {
        \time 2/8
        \set stemLeftBeamCount = #0
        \set stemRightBeamCount = #1
        c'8 [
        \set stemLeftBeamCount = #1
        \set stemRightBeamCount = #1
        d'8
    ]
    {
        \time 2/8
        \set stemLeftBeamCount = #1
        \set stemRightBeamCount = #1
        e'8
        \set stemLeftBeamCount = #1
        \set stemRightBeamCount = #0
        f'8 ]
    }
}
```

Set beam spanner durations to preprolated measure durations.

Return beam spanner created. Changed in version 2.0: renamed `measuretools.beam_together()`.

measuretools.apply_full_measure_tuplets_to_contents_of_measures_in_expr

`abjad.tools.measuretools.apply_full_measure_tuplets_to_contents_of_measures_in_expr(expr)`

New in version 2.0. Apply full-measure tuplets to contents of measures in *expr*:


```

abjad> staff = Staff([Measure((2, 8), "c'8 d'8"), Measure((3, 8), "e'8 f'8 g'8")])

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 3/8
        e'8
        f'8
        g'8
    }
}

abjad> measuretools.apply_full_measure_tuplets_to_contents_of_measures_in_expr(staff)

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        {
            c'8
            d'8
        }
    }
    {
        \time 3/8
        {
            e'8
            f'8
            g'8
        }
    }
}

```

Return none.

measuretools.color_measure

`abjad.tools.measuretools.color_measure(measure, color='red')`

New in version 2.0. Color *measure* with *color*:

```

abjad> measure = Measure((2, 8), "c'8 d'8")

abjad> f(measure)
{
    \time 2/8
    c'8
    d'8
}

abjad> measuretools.color_measure(measure, 'red')
Measure(2/8, [c'8, d'8])

```

```
abjad> f(measure)
{
  \override Beam #'color = #red
  \override Dots #'color = #red
  \override NoteHead #'color = #red
  \override Staff.TimeSignature #'color = #red
  \override Stem #'color = #red
  \time 2/8
  c'8
  d'8
  \revert Beam #'color
  \revert Dots #'color
  \revert NoteHead #'color
  \revert Staff.TimeSignature #'color
  \revert Stem #'color
}
```

Return colored *measure*.

Color names appear in LilyPond Learning Manual appendix B.5.

measuretools.color_nonbinary_measures_in_expr

`abjad.tools.measuretools.color_nonbinary_measures_in_expr(expr, color='red')`

New in version 2.0. Color nonbinary measures in *expr* with *color*:

```
abjad> staff = Staff(Measure((2, 8), "c'8 d'8") * 2)
abjad> measuretools.scale_measure_denominator_and_adjust_measure_contents(staff[1], 3)
Measure(3/12, [c'8., d'8.])
```

```
abjad> f(staff)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 3/12
    \scaleDurations #'(2 . 3) {
      c'8.
      d'8.
    }
  }
}
```

```
abjad> measuretools.color_nonbinary_measures_in_expr(staff, 'red')
[Measure(3/12, [c'8., d'8.])]
```

```
abjad> f(staff)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \override Beam #'color = #red
```

```

\override Dots #'color = #red
\override NoteHead #'color = #red
\override Staff.TimeSignature #'color = #red
\override Stem #'color = #red
\time 3/12
\scaleDurations #'(2 . 3) {
  c'8.
  d'8.
}
\revert Beam #'color
\revert Dots #'color
\revert NoteHead #'color
\revert Staff.TimeSignature #'color
\revert Stem #'color
}
}

```

Return list of measures colored.

Color names appear in LilyPond Learning Manual appendix B.5.

measuretools.comment_measures_in_container_with_measure_numbers

`abjad.tools.measuretools.comment_measures_in_container_with_measure_numbers(container)`

New in version 1.1. Comment measures in *container* with measure numbers:

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> measuretools.comment_measures_in_container_with_measure_numbers(staff)

abjad> f(staff)
\new Staff {
  % start measure 1
  {
    \time 2/8
    c'8
    d'8
  }
  % stop measure 1
  % start measure 2
  {
    \time 2/8
    e'8
    f'8
  }
  % stop measure 2
  % start measure 3
  {
    \time 2/8
    g'8
    a'8
  }
  % stop measure 3
}

```

Changed in version 2.0: renamed `label.measure_numbers()` to `measuretools.comment_measures_in_container_with_measure_numbers()`.

measuretools.extend_measures_in_expr_and_apply_full_measure_tuplets_to_measure_contents

abjad.tools.measuretools.**extend_measures_in_expr_and_apply_full_measure_tuplets_to_measure_contents**

New in version 2.0. Extend measures in *expr* with *supplement* and apply full-measure tuplets to contents of measures:

```
abjad> staff = Staff([Measure((2, 8), "c'8 d'8"), Measure((3, 8), "e'8 f'8 g'8")])

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 3/8
        e'8
        f'8
        g'8
    }
}

abjad> supplement = [Rest((1, 16))]
abjad> measuretools.extend_measures_in_expr_and_apply_full_measure_tuplets_to_measure_contents(supplement, staff)

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        \times 4/5 {
            c'8
            d'8
            r16
        }
    }
    {
        \time 3/8
        \fraction \times 6/7 {
            e'8
            f'8
            g'8
            r16
        }
    }
}
```

Return none.

measuretools.fill_measures_in_expr_with_big_endian_notes

abjad.tools.measuretools.**fill_measures_in_expr_with_big_endian_notes**(*expr*,
iterc-trl=None)

New in version 1.1. Fill measures in *expr* with big-endian notes.

measuretools.fill_measures_in_expr_with_full_measure_spacer_skips

```
abjad.tools.measuretools.fill_measures_in_expr_with_full_measure_spacer_skips(expr,
                                                                              iter-
                                                                              c-
                                                                              trl=None)
```

New in version 1.1. Fill measures in *expr* with full-measure spacer skips.

measuretools.fill_measures_in_expr_with_little_endian_notes

```
abjad.tools.measuretools.fill_measures_in_expr_with_little_endian_notes(expr,
                                                                           iter-
                                                                           c-
                                                                           trl=None)
```

New in version 1.1. Fill measures in *expr* with little-endian notes.

measuretools.fill_measures_in_expr_with_meter_denominator_notes

```
abjad.tools.measuretools.fill_measures_in_expr_with_meter_denominator_notes(expr,
                                                                               iter-
                                                                               c-
                                                                               trl=None)
```

New in version 1.1. Fill measures in *expr* with meter denominator notes:

```
abjad> staff = Staff([Measure((3, 4), []), Measure((3, 16), []), Measure((3, 8), [])])
abjad> measuretools.fill_measures_in_expr_with_meter_denominator_notes(staff)
```

```
abjad> f(staff)
\new Staff {
  {
    \time 3/4
    c'4
    c'4
    c'4
  }
  {
    \time 3/16
    c'16
    c'16
    c'16
  }
  {
    \time 3/8
    c'8
    c'8
    c'8
  }
}
```

Delete existing contents of measures in *expr*.

Return none.

measuretools.fill_measures_in_expr_with_repeated_notes

`abjad.tools.measuretools.fill_measures_in_expr_with_repeated_notes` (*expr*, *written_duration*, *iterc*, *trl=None*)

New in version 1.1. Fill measures in *expr* with repeated notes.

measuretools.fuse_contiguous_measures_in_container_cyclically_by_counts

`abjad.tools.measuretools.fuse_contiguous_measures_in_container_cyclically_by_counts` (*container*, *counts*, *mark=Fa*)

New in version 1.1. Fuse contiguous measures in *container* cyclically by *counts*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 5)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 2/8
        e'8
        f'8
    }
    {
        \time 2/8
        g'8
        a'8
    }
    {
        \time 2/8
        b'8
        c''8
    }
    {
        \time 2/8
        d''8
        e''8
    }
}

abjad> counts = (2, 1)
abjad> measuretools.fuse_contiguous_measures_in_container_cyclically_by_counts(staff, counts)

abjad> f(staff)
\new Staff {
    {
        \time 4/8
        c'8
        d'8
        e'8
```

```

        f'8
    }
    {
        \time 2/8
        g'8
        a'8
    }
    {
        \time 4/8
        b'8
        c''8
        d''8
        e''8
    }
}

```

Return none.

Set *mark* to true to mark fused measures for later reference. Changed in version 2.0: renamed `fuse.measures_by_counts_cyclic()` to `measuretools.fuse_contiguous_measures_in_container_cyclically_by_counts()`.

measuretools.fuse_measures

`abjad.tools.measuretools.fuse_measures` (*measures*)

New in version 1.1. Fuse *measures*:

```

abjad> staff = Staff(measuretools.make_measures_with_full_measure_spacer_skips([(1, 8), (2, 16)]))
abjad> measuretools.fill_measures_in_expr_with_repeated_notes(staff, Duration(1, 16))
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> spannertools.BeamSpanner(staff.leaves)
BeamSpanner(c'16, d'16, e'16, f'16)

```

```

abjad> f(staff)
\new Staff {
    {
        \time 1/8
        c'16 [
        d'16
    ]
    {
        \time 2/16
        e'16
        f'16 ]
    }
}

```

```

abjad> measuretools.fuse_measures(staff[:])
Measure(2/8, [c'16, d'16, e'16, f'16])

```

```

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'16 [
        d'16
        e'16
    ]
}

```

```

        f'16 ]
    }
}

```

Return new measure.

Allow parent-contiguous *measures*.

Allow outside-of-score *measures*.

Do not define measure fusion across intervening container boundaries.

Calculate best new time signature.

Instantiate new measure.

Give *measures* contents to new measure.

Give *measures* dominant spanners to new measure.

Give *measures* parentage to new measure.

Leave *measures* empty, unspanned and outside-of-score. Changed in version 2.0: renamed `fuse.measures_by_reference()` to `measuretools.fuse_measures()`.

measuretools.get_first_measure_in_improper_parentage_of_component

`abjad.tools.measuretools.get_first_measure_in_improper_parentage_of_component(component)`

New in version 2.0. Get first measure in improper parentage of *component*:

```

abjad> measure = Measure((2, 4), "c'8 d'8 e'8 f'8")
abjad> staff = Staff([measure])

```

```

abjad> f(staff)
\new Staff {
    {
        \time 2/4
        c'8
        d'8
        e'8
        f'8
    }
}

```

```

abjad> measuretools.get_first_measure_in_improper_parentage_of_component(staff.leaves[0])
Measure(2/4, [c'8, d'8, e'8, f'8])

```

Return measure or none.

measuretools.get_first_measure_in_proper_parentage_of_component

`abjad.tools.measuretools.get_first_measure_in_proper_parentage_of_component(component)`

New in version 2.0. Get first measure in proper parentage of *component*:

```

abjad> measure = Measure((2, 4), "c'8 d'8 e'8 f'8")
abjad> staff = Staff([measure])

```



```

abjad> f(staff)
\new Staff {
    {
        \time 2/4
        c'8
        d'8
        e'8
        f'8
    }
}

abjad> measuretools.get_first_measure_in_proper_parentage_of_component(staff.leaves[0])
Measure(2/4, [c'8, d'8, e'8, f'8])

```

Return measure or none.

measuretools.get_next_measure_from_component

`abjad.tools.measuretools.get_next_measure_from_component(component)`

New in version 1.1. Get next measure from *component*.

When *component* is voice, staff or other sequential context, and when *component* contains a measure, return first measure in *component*. This starts the process of forwards measure iteration.

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> measuretools.get_next_measure_from_component(staff)
Measure(2/8, [c'8, d'8])

```

When *component* is voice, staff or other sequential context, and when *component* contains no measure, raise missing measure error.

When *component* is a measure and there is a measure immediately following *component*, return measure immediately following component.

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> measuretools.get_prev_measure_from_component(staff[0]) is None
True

```

When *component* is a measure and there is no measure immediately following *component*, return None.

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> measuretools.get_prev_measure_from_component(staff[-1])
Measure(2/8, [c'8, d'8])

```

When *component* is a leaf and there is a measure in the parentage of *component*, return the measure in the parentage of *component*.

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> measuretools.get_prev_measure_from_component(staff.leaves[0])
Measure(2/8, [c'8, d'8])

```

When *component* is a leaf and there is no measure in the parentage of *component*, raise missing measure error. Changed in version 2.0: renamed `iterate.measure_next()` to `measuretools.get_next_measure_from_component()`.

measuretools.get_nth_measure_in_expr

abjad.tools.measuretools.get_nth_measure_in_expr(expr, n=0)

New in version 2.0. Get *n*th measure in *expr*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> f(staff)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
    e'8
    f'8
  }
  {
    \time 2/8
    g'8
    a'8
  }
}
```

Read forward for positive values of *n*.

```
abjad> for n in range(3):
...     measuretools.get_nth_measure_in_expr(staff, n)
...
Measure(2/8, [c'8, d'8])
Measure(2/8, [e'8, f'8])
Measure(2/8, [g'8, a'8])
```

Read backward for negative values of *n*.

```
abjad> for n in range(3, -1, -1):
...     measuretools.get_nth_measure_in_expr(staff, n)
...
Measure(2/8, [g'8, a'8])
Measure(2/8, [e'8, f'8])
Measure(2/8, [c'8, d'8])
```

Changed in version 2.0: renamed `iterate.get_nth_measure()` to `measuretools.get_nth_measure_in_expr()`.

measuretools.get_one_indexed_measure_number_in_expr

abjad.tools.measuretools.get_one_indexed_measure_number_in_expr(expr, measure_number)

New in version 2.0. Get one-indexed *measure_number* in *expr*:

```
abjad> t = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
```

```

abjad> f(t)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
    e'8
    f'8
  }
  {
    \time 2/8
    g'8
    a'8
  }
}
abjad> measuretools.get_one_indexed_measure_number_in_expr(t, 3)
Measure(2/8, [g'8, a'8])

```

Note that measures number from 1.

measuretools.get_prev_measure_from_component

`abjad.tools.measuretools.get_prev_measure_from_component(component)`

New in version 1.1. Get previous measure from *component*.

When *component* is voice, staff or other sequential context, and when *component* contains a measure, return last measure in *component*. This starts the process of backwards measure iteration.

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> measuretools.get_prev_measure_from_component(staff)
Measure(2/8, [e'8, f'8])

```

When *component* is voice, staff or other sequential context, and when *component* contains no measure, raise missing measure error.

When *component* is a measure and there is a measure immediately preceeding *component*, return measure immediately preceeding component.

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> measuretools.get_prev_measure_from_component(staff[-1])
Measure(2/8, [c'8, d'8])

```

When *component* is a measure and there is no measure immediately preceeding *component*, return None.

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> measuretools.get_prev_measure_from_component(staff[0]) is None
True

```

When *component* is a leaf and there is a measure in the parentage of *component*, return the measure in the parentage of *component*.

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)

```

```
abjad> measuretools.get_prev_measure_from_component(staff.leaves[0])
Measure(2/8, [c'8, d'8])
```

When *component* is a leaf and there is no measure in the parentage of *component*, raise missing measure error. Changed in version 2.0: renamed `iterate.measure_prev()` to `measuretools.get_prev_measure_from_component()`.

measuretools.iterate_measures_backward_in_expr

```
abjad.tools.measuretools.iterate_measures_backward_in_expr(expr, start=0, stop=None)
```

New in version 2.0. Iterate measures backward in *expr*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 2/8
        e'8
        f'8
    }
    {
        \time 2/8
        g'8
        a'8
    }
}

abjad> for measure in measuretools.iterate_measures_backward_in_expr(staff):
...     measure
...
Measure(2/8, [g'8, a'8])
Measure(2/8, [e'8, f'8])
Measure(2/8, [c'8, d'8])
```

Use the optional *start* and *stop* keyword parameters to control indices of iteration.

```
abjad> for measure in measuretools.iterate_measures_backward_in_expr(staff, start = 1):
...     measure
...
Measure(2/8, [e'8, f'8])
Measure(2/8, [c'8, d'8])

abjad> for measure in measuretools.iterate_measures_backward_in_expr(staff, start = 0, stop = 2):
...     measure
...
Measure(2/8, [g'8, a'8])
Measure(2/8, [e'8, f'8])
```

Changed in version 2.0: renamed `iterate.measures_backward_in()` to `measuretools.iterate_measures_backward_in_expr()`.

measuretools.iterate_measures_forward_in_expr

`abjad.tools.measuretools.iterate_measures_forward_in_expr` (*expr*, *start=0*, *stop=None*)

New in version 2.0. Iterate measures forward in *expr*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 2/8
        e'8
        f'8
    }
    {
        \time 2/8
        g'8
        a'8
    }
}

abjad> for measure in measuretools.iterate_measures_forward_in_expr(staff):
...     measure
...
Measure(2/8, [c'8, d'8])
Measure(2/8, [e'8, f'8])
Measure(2/8, [g'8, a'8])
```

Use the optional *start* and *stop* keyword parameters to control the start and stop indices of iteration.

```
abjad> for measure in measuretools.iterate_measures_forward_in_expr(staff, start = 1):
...     measure
...
Measure(2/8, [e'8, f'8])
Measure(2/8, [g'8, a'8])

abjad> for measure in measuretools.iterate_measures_forward_in_expr(staff, start = 0, stop = 2):
...     measure
...
Measure(2/8, [c'8, d'8])
Measure(2/8, [e'8, f'8])
```

Changed in version 2.0: renamed `iterate.measures_forward_in()` to `measuretools.iterate_measures_forward_in_expr()`.

measuretools.list_time_signatures_of_measures_in_expr

`abjad.tools.measuretools.list_time_signatures_of_measures_in_expr` (*components*)

New in version 2.0. List time signatures of measures in *expr*:

```

abjad> from abjad.tools import timesignaturetools

abjad> staff = Staff([Measure((2, 8), "c8 d8"), Measure((3, 8), "c8 d8 e8"), Measure((4, 8), "c8
abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c8
        d8
    }
    {
        \time 3/8
        c8
        d8
        e8
    }
    {
        \time 4/8
        c8
        d8
        e8
        f8
    }
}

abjad> measuretools.list_time_signatures_of_measures_in_expr(staff)
[TimeSignatureMark((2, 8))(|2/8, c8, d8|), TimeSignatureMark((3, 8))(|3/8, c8, d8, e8|), TimeSig

Return list of zero or more time signatures.      Changed in version 2.0: re-
named      measuretools.list_time_signatures_of_mesures_in_expr()      to
measuretools.list_time_signatures_of_measures_in_expr().

```

measuretools.make_measures_with_full_measure_spacer_skips

abjad.tools.measuretools.**make_measures_with_full_measure_spacer_skips**(*meters*)

New in version 1.1. Make measures with full-measure spacer skips from *meters*:

```

abjad> measures = measuretools.make_measures_with_full_measure_spacer_skips([(1, 8), (5, 16), (5
abjad> staff = Staff(measures)

abjad> f(staff)
\new Staff {
    {
        \time 1/8
        s1 * 1/8
    }
    {
        \time 5/16
        s1 * 5/16
    }
    {
        \time 5/16
        s1 * 5/16
    }
}

```

Return list of rigid measures. Changed in version 2.0: renamed `measuretools.make()` to `measuretools.make_measures_with_full_measure_spacer_skips()`.

measuretools.measure_to_one_line_input_string

`abjad.tools.measuretools.measure_to_one_line_input_string(measure)`

New in version 2.6. Change *measure* to one-line input string:

```
abjad> measure = Measure((4, 4), "c'4 d'4 e'4 f'4")

abjad> input_string = measuretools.measure_to_one_line_input_string(measure)

abjad> print input_string
Measure((4, 4), "c'4 d'4 e'4 f'4")

abjad> new_measure = eval(input_string)

abjad> new_measure
Measure(4/4, [c'4, d'4, e'4, f'4])

abjad> f(new_measure)
{
    \time 4/4
    c'4
    d'4
    e'4
    f'4
}
```

The purpose of this function is to create an evaluable string from simple measures.

Spanners, articulations and overrides not supported.

Return string.

measuretools.move_measure_prolation_to_full_measure_tuplet

`abjad.tools.measuretools.move_measure_prolation_to_full_measure_tuplet(expr)`

New in version 2.0. Move measure prolotion to full-measure tuplet.

Turn nonbinary measures into binary measures containing a single fixed-duration tuplet.

This is the inverse of `measuretools.move_prolation_of_full_measure_tuplet_to_meter_of_measure()`.

Note that not all nonbinary measures can be made binary.

Returns `None` because processes potentially many measures. Changed in version 2.0: renamed `measuretools.project()` to `measuretools.move_measure_prolation_to_full_measure_tuplet()`.

measuretools.move_prolation_of_full_measure_tuplet_to_meter_of_measure

`abjad.tools.measuretools.move_prolation_of_full_measure_tuplet_to_meter_of_measure(expr)`

New in version 1.1. Move prolotion of full-measure tuplet to meter of measure.

Measures usually become nonbinary as as result:

```
abjad> t = Measure((2, 8), [tupletools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")])
abjad> measuretools.move_prolation_of_full_measure_tuplet_to_meter_of_measure(t)
```

```
abjad> f(t)
{
    \time 3/12
    \scaleDurations #'(2 . 3) {
        c'8
        d'8
        e'8
    }
}
```

Return `none`. Changed in version 2.0: renamed `measuretools.subsume()` to `measuretools.move_prolation_of_full_measure_tuplet_to_meter_of_measure()`.

measuretools.multiply_contents_of_measures_in_expr

`abjad.tools.measuretools.multiply_contents_of_measures_in_expr(expr, n)`

New in version 1.1. Multiply contents $n - 1$ times and adjust meter of every measure in *expr*:

```
abjad> measure = Measure((3, 8), "c'8 d'8 e'8")
abjad> spannertools.BeamSpanner(measure.leaves)
BeamSpanner(c'8, d'8, e'8)
```

```
abjad> f(measure)
{
    \time 3/8
    c'8 [
    d'8
    e'8 ]
}
```

```
abjad> measuretools.multiply_contents_of_measures_in_expr(measure, 3)
```

```
abjad> f(measure)
{
    \time 9/8
    c'8 [
    d'8
    e'8 ]
    c'8 [
    d'8
    e'8 ]
    c'8 [
    d'8
    e'8 ]
}
```

Changed in version 2.0: renamed `measuretools.spin()` to `measuretools.multiply_contents_of_measures_in_expr()`.

measuretools.multiply_contents_of_measures_in_expr_and_scale_meter_denominators

abjad.tools.measuretools.**multiply_contents_of_measures_in_expr_and_scale_meter_denominators**

New in version 1.1. Multiply contents of measures in *expr* and scale meter denominators.

Expr may be any Abjad expression. Concentration_pairs a Python list of pairs, each of the form (spin_count, scalar_denominator). Both spin_count and scalar_denominator must be positive integers.

Iterate expr. For every measure in expr, spin measure by the spin_count element in concentration_pair and scale measure by 1/scalar_denominator element in concentration_pair.

Return Python list of transformed measures:

```
abjad> t = Measure((3, 16), notetools.make_repeated_notes(3, Duration(1, 16)))
abjad> print(measuretools.multiply_contents_of_measures_in_expr_and_scale_meter_denominators(t,
|9/48, c'32, c'32, c'32, c'32, c'32, c'32, c'32, c'32, c'32|)
```

```
abjad> t = Measure((3, 16), notetools.make_repeated_notes(3, Duration(1, 16)))
abjad> print(measuretools.multiply_contents_of_measures_in_expr_and_scale_meter_denominators(t,
|9/32, c'32, c'32, c'32, c'32, c'32, c'32, c'32, c'32, c'32|)
```

```
abjad> t = Measure((3, 16), notetools.make_repeated_notes(3, Duration(1, 16)))
abjad> print(measuretools.multiply_contents_of_measures_in_expr_and_scale_meter_denominators(t,
|9/16, c'16, c'16, c'16, c'16, c'16, c'16, c'16, c'16, c'16|)
```

Changed in version 2.0: renamed measuretools.concentrate() to measuretools.multiply_contents_of_measures_in_expr_and_scale_meter_denominators().

measuretools.pad_measures_in_expr_with_rests

abjad.tools.measuretools.**pad_measures_in_expr_with_rests**(*expr*, *front*, *back*, *splice=False*)

New in version 1.1. Pad measures in *expr* with rests.

Iterate all measures in *expr*. Insert rest with duration equal to *front* at beginning of each measure. Insert rest with duration equal to *back* at end of each measure.

Set *front* to a positive rational or none. Set *back* to a positive rational or none.

Note that this function is designed to help create regularly spaced charts and tables of musical materials. This function makes most sense when used on anonymous measures or dynamic measures.

```
abjad> t = Staff(measuretools.AnonymousMeasure("c'8 d'8") * 2)
abjad> front, back = Duration(1, 32), Duration(1, 64)
abjad> measuretools.pad_measures_in_expr_with_rests(t, front, back)
```

```
abjad> f(t)
\new Staff {
    {
        \override Staff.TimeSignature #'stencil = ##f
        \time 19/64
        r32
        c'8
        d'8
        r64
    }
}
```

```

        \revert Staff.TimeSignature #'stencil
    }
    {
        \override Staff.TimeSignature #'stencil = ##f
        \time 19/64
        r32
        c'8
        d'8
        r64
        \revert Staff.TimeSignature #'stencil
    }
}

```

Works when measures contain stacked voices:

```

abjad> measure = measuretools.DynamicMeasure(Voice(notetools.make_repeated_notes(2)) * 2)
abjad> measure.is_parallel = True
abjad> t = Staff(measure * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> measuretools.pad_measures_in_expr_with_rests(t, Duration(1, 32), Duration(1, 64))

abjad> f(t)
\new Staff {
    <<
        \time 19/64
        \new Voice {
            r32
            c'8
            d'8
            r64
        }
        \new Voice {
            r32
            e'8
            f'8
            r64
        }
    >>
    <<
        \time 19/64
        \new Voice {
            r32
            g'8
            a'8
            r64
        }
        \new Voice {
            r32
            b'8
            c''8
            r64
        }
    >>
}

```

Set the optional *splice* keyword to `True` to extend edge spanners over newly inserted rests:

```

abjad> t = measuretools.DynamicMeasure("c'8 d'8")
abjad> spannertools.BeamSpanner(t[:])

```

```

BeamSpanner(c'8, d'8)
abjad> measuretools.pad_measures_in_expr_with_rests(t, Duration(1, 32), Duration(1, 64), splice

abjad> f(t)
{
    \time 19/64
    r32 [
    c'8
    d'8
    r64 ]
}

```

Return none.

Raise value when *front* is neither a positive rational nor none.

Raise value when *back* is neither a positive rational nor none. Changed in version 2.0: renamed `layout.insert_measure_padding_rest()` to `measuretools.pad_measures_in_expr_with_rests()`.

measuretools.pad_measures_in_expr_with_skips

```

abjad.tools.measuretools.pad_measures_in_expr_with_skips(expr, front, back,
                                                         splice=False)

```

New in version 2.0. Pad measures in *expr* with skips.

Iterate all measures in *expr*. Insert skip with duration equal to *front* at beginning of each measure. Insert skip with duration equal to *back* at end of each measure.

Set *front* to a positive rational or none. Set *back* to a positive rational or none.

Note that this function is designed to help create regularly spaced charts and tables of musical materials. This function makes most sense when used on anonymous measures and dynamic measures.

```

abjad> t = Staff(measuretools.AnonymousMeasure("c'8 d'8") * 2)
abjad> front, back = Duration(1, 32), Duration(1, 64)
abjad> measuretools.pad_measures_in_expr_with_skips(t, front, back)

abjad> f(t)
\new Staff {
    {
        \override Staff.TimeSignature #'stencil = ##f
        \time 19/64
        s32
        c'8
        d'8
        s64
        \revert Staff.TimeSignature #'stencil
    }
    {
        \override Staff.TimeSignature #'stencil = ##f
        \time 19/64
        s32
        c'8
        d'8
        s64
        \revert Staff.TimeSignature #'stencil
    }
}

```

Works when measures contain stacked voices.

```
abjad> measure = measuretools.DynamicMeasure(Voice(notetools.make_repeated_notes(2)) * 2)
abjad> measure.is_parallel = True
abjad> t = Staff(measure * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> measuretools.pad_measures_in_expr_with_skips(t, Duration(1, 32), Duration(1, 64))

abjad> f(t)
\new Staff {
  <<
    \time 19/64
    \new Voice {
      s32
      c'8
      d'8
      s64
    }
    \new Voice {
      s32
      e'8
      f'8
      s64
    }
  >>
  <<
    \time 19/64
    \new Voice {
      s32
      g'8
      a'8
      s64
    }
    \new Voice {
      s32
      b'8
      c''8
      s64
    }
  >>
}
```

Set the optional *splice* keyword to True to extend edge spanners over newly inserted skips:

```
abjad> t = measuretools.DynamicMeasure("c'8 d'8")
abjad> spannertools.BeamSpanner(t[:])
BeamSpanner(c'8, d'8)
abjad> measuretools.pad_measures_in_expr_with_skips(t, Duration(1, 32), Duration(1, 64), splice

abjad> f(t)
{
  \time 19/64
  s32 [
  c'8
  d'8
  s64 ]
}
```

Return none.

Raise value error when *front* is neither a positive rational nor none.

Raise value error when *back* is neither a positive rational nor none. Changed in version 2.0: renamed `layout.insert_measure_padding_skip()` to `measuretools.pad_measures_in_expr_with_skips()`.

measuretools.pitch_array_row_to_measure

`abjad.tools.measuretools.pitch_array_row_to_measure` (*pitch_array_row*,
cell_duration_denominator=8)

New in version 2.0. Change *pitch_array_row* to measure with meter *pitch_array_row.width* over *cell_duration_denominator*:

```
abjad> from abjad.tools import pitcharraytools
abjad> array = pitcharraytools.PitchArray([
...     [1, (2, 1), ([-2, -1.5], 2)],
...     [(7, 2), (6, 1), 1]])

abjad> print array
[ ] [d'] [bf bqf  ]
[g'    ] [fs'    ] [ ]

abjad> measure = measuretools.pitch_array_row_to_measure(array.rows[0])

abjad> f(measure)
{
    \time 4/8
    r8
    d'8
    <bf bqf>4
}
```

Return measure.

measuretools.pitch_array_to_measures

`abjad.tools.measuretools.pitch_array_to_measures` (*pitch_array*,
cell_duration_denominator=8)

New in version 2.0. Change *pitch_array* to measures with meters *row.width* over *cell_duration_denominator* for each row in *pitch_array*:

```
abjad> from abjad.tools import pitcharraytools
abjad> array = pitcharraytools.PitchArray([
...     [1, (2, 1), ([-2, -1.5], 2)],
...     [(7, 2), (6, 1), 1]])

abjad> print array
[ ] [d'] [bf bqf  ]
[g'    ] [fs'    ] [ ]

abjad> measuretools.pitch_array_to_measures(array)
[Measure(4/8, [r8, d'8, <bf bqf>4]), Measure(4/8, [g'4, fs'8, r8])]
abjad> for measure in _:
...     f(measure)
...
{
    \time 4/8
```

```

        r8
        d'8
        <bf bqf>4
    }
    {
        \time 4/8
        g'4
        fs'8
        r8
    }

```

Return list of measures.

measuretools.replace_contents_of_measures_in_expr

abjad.tools.measuretools.**replace_contents_of_measures_in_expr**(*expr*,
new_contents)

New in version 1.1. Replace contents of measures in *expr* with *new_contents*:

```
abjad> staff = Staff(measuretools.make_measures_with_full_measure_spacer_skips([(1, 8), (3, 16)]))
```

```
abjad> f(staff)
\new Staff {
    {
        \time 1/8
        s1 * 1/8
    }
    {
        \time 3/16
        s1 * 3/16
    }
}

```

```
abjad> notes = [Note("c'16"), Note("d'16"), Note("e'16"), Note("f'16")]
abjad> measuretools.replace_contents_of_measures_in_expr(staff, notes)
[Measure(1/8, [c'16, d'16]), Measure(3/16, [e'16, f'16, s1 * 1/16])]

```

```
abjad> f(staff)
\new Staff {
    {
        \time 1/8
        c'16
        d'16
    }
    {
        \time 3/16
        e'16
        f'16
        s1 * 1/16
    }
}

```

Preserve duration of all measures.

Skip measures that are too small.

Pad extra space at end of measures with spacer skip.

If not enough measures raise stop iteration.

Return measures iterated. Changed in version 2.0: renamed `measuretools.override_contents()` to `measuretools.replace_contents_of_measures_in_expr()`.

`measuretools.report_meter_distribution_as_string`

`abjad.tools.measuretools.report_meter_distribution_as_string(expr)`

New in version 2.0. Report meter distribution of *expr* as string:

```
abjad> measuretools.report_meter_distribution_as_string(t) # doctest: +SKIP
'\t3/80\t2\n\t2/16\t73\n\t7/40\t1\n\t3/16\t20\n\t16/80\t1\n\t17/80\t1\n\t19/80\t1\n\t4/16\t73\n\t5/16\t62\n\t13/40\t1\n\t27/80\t1\n\t6/16\t12\n\t7/16\t16\n\t8/16\t13\n\t9/16\t15\n\t10/16\t4\n'
```

Return string.

`measuretools.scale_contents_of_measures_in_expr`

`abjad.tools.measuretools.scale_contents_of_measures_in_expr(expr, multiplier=1)`

New in version 2.0. Scale contents of measures in *expr* by *multiplier*.

Iterate *expr*. For every measure in *expr* first multiply the measure meter by *multiplier* and then scale measure contents to fit the new meter.

Extend `containertools.scale_contents_of_container()`.

Return none.

`measuretools.scale_measure_by_multiplier_and_adjust_meter`

`abjad.tools.measuretools.scale_measure_by_multiplier_and_adjust_meter(measure, multiplier=1)`

New in version 2.0. Scale *measure* by *multiplier* and adjust meter:

```
abjad> t = Measure((3, 8), "c'8 d'8 e'8")
abjad> measuretools.scale_measure_by_multiplier_and_adjust_meter(t, Duration(2, 3))
Measure(3/12, [c'8, d'8, e'8])
```

```
abjad> f(t)
{
  \time 3/12
  \scaleDurations #'(2 . 3) {
    c'8
    d'8
    e'8
  }
}
```

Return *measure*.

`measuretools.scale_measure_denominator_and_adjust_measure_contents`

`abjad.tools.measuretools.scale_measure_denominator_and_adjust_measure_contents(measure, new_denominator_factor)`

New in version 1.1. Change binary *measure* to nonbinary measure with *new_denominator_factor*:

```

abjad> measure = Measure((2, 8), "c'8 d'8")
abjad> spannertools.BeamSpanner(measure.leaves)
BeamSpanner(c'8, d'8)

abjad> f(measure)
{
    \time 2/8
    c'8 [
    d'8 ]
}

abjad> measuretools.scale_measure_denominator_and_adjust_measure_contents(measure, 3)
Measure(3/12, [c'8., d'8.])

abjad> f(measure)
{
    \time 3/12
    \scaleDurations #'(2 . 3) {
        c'8. [
        d'8. ]
    }
}

```

Treat *new_denominator_factor* like clever form of 1: 3/3 or 5/5 or 7/7, etc.

Preserve *measure* prolated duration.

Derive new *measure* multiplier.

Scale *measure* contents.

Pick best new meter. Changed in version 2.0: renamed `measuretools.change_binary_measure_to_nonbinary()` to `measuretools.scale_measure_denominator_and_adjust_measure_contents()`.

`measuretools.set_measure_denominator_and_adjust_numerator`

```

abjad.tools.measuretools.set_measure_denominator_and_adjust_numerator(measure,
                                                                    de-
                                                                    nom-
                                                                    ina-
                                                                    tor)

```

New in version 1.1. Set *measure* meter *denominator* and multiply meter numerator accordingly:

```

abjad> measure = Measure((3, 8), "c'8 d'8 e'8")
abjad> spannertools.BeamSpanner(measure.leaves)
BeamSpanner(c'8, d'8, e'8)

abjad> f(measure)
{
    \time 3/8
    c'8 [
    d'8
    e'8 ]
}

abjad> measuretools.set_measure_denominator_and_adjust_numerator(measure, 16)
Measure(6/16, [c'8, d'8, e'8])

```



```

abjad> f(measure)
{
    \time 6/16
    c'8 [
    d'8
    e'8 ]
}

```

Leave *measure* contents unchanged.

Return *measure*. Changed in version 2.0: renamed `measuretools.set_measure_denominator_and_multiply_num` to `measuretools.set_measure_denominator_and_adjust_numerator()`.

notetools

notetools.NaturalHarmonic

class `abjad.tools.notetools.NaturalHarmonic(*args)`

Bases: `abjad.tools.notetools.Note.Note`, `abjad.tools.notetools._Flageolet._Flageolet`

Abjad model of natural harmonic.

Initialize natural harmonic by hand:

```

abjad> notetools.NaturalHarmonic("cs'8.")
NaturalHarmonic(cs', 8.)

```

Initialize natural harmonic from note:

```

abjad> note = Note("cs'8.")

abjad> notetools.NaturalHarmonic(note)
NaturalHarmonic(cs', 8.)

```

Natural harmonics are immutable.

notetools.Note

class `abjad.tools.notetools.Note(*args, **kwargs)`

Bases: `abjad.tools.leaftools._Leaf._Leaf`

Abjad model of a note:

```

abjad> Note(13, (3, 16))
Note("cs''8.")

```

fingered_pitch

Read-only fingered pitch of note:

```

abjad> staff = Staff("d''8 e''8 f''8 g''8")
abjad> piccolo = instrumenttools.Piccolo()(staff)
abjad> instrumenttools.transpose_notes_and_chords_in_expr_from_sounding_pitch_to_fingered_pi

abjad> f(staff)
\new Staff {
    \set Staff.instrumentName = \markup { Piccolo }
    \set Staff.shortInstrumentName = \markup { Picc. }
    d'8
    e'8

```

```

        f'8
        g'8
    }

```

```

abjad> staff[0].fingered_pitch
NamedChromaticPitch("d'")

```

Return named chromatic pitch.

note_head

Get note head of note:

```

abjad> note = Note(13, (3, 16))
abjad> note.note_head
NoteHead("cs'")

```

Set note head of note:

```

abjad> note = Note(13, (3, 16))
abjad> note.note_head = 14
abjad> note
Note("d''8.")

```

sounding_pitch

Read-only sounding pitch of note:

```

abjad> staff = Staff("d''8 e''8 f''8 g''8")
abjad> piccolo = instrumenttools.Piccolo()(staff)

```

```

abjad> instrumenttools.transpose_notes_and_chords_in_expr_from_sounding_pitch_to_fingered_pi

```

```

abjad> f(staff)
\new Staff {
    \set Staff.instrumentName = \markup { Piccolo }
    \set Staff.shortInstrumentName = \markup { Picc. }
    d'8
    e'8
    f'8
    g'8
}
abjad> staff[0].sounding_pitch
NamedChromaticPitch("d'")

```

Return named chromatic pitch.

written_pitch

Get named pitch of note:

```

abjad> note = Note(13, (3, 16))
abjad> note.written_pitch
NamedChromaticPitch("cs'")

```

Set named pitch of note:

```

abjad> note = Note(13, (3, 16))
abjad> note.written_pitch = 14
abjad> note
Note("d''8.")

```

notetools.NoteHead

class abjad.tools.notetools.**NoteHead**(*args)
 Bases: abjad.core._UnaryComparator._UnaryComparator._UnaryComparator

Abjad model of a note head:

```
abjad> notetools.NoteHead(13)
NoteHead("cs' ' ")
```

Note heads are immutable.

format

Read-only LilyPond input format of note head:

```
abjad> note_head = notetools.NoteHead("cs' ' ")
abjad> note_head.format
"cs' ' "
```

Return string.

named_chromatic_pitch

Read-only named chromatic pitch equal to note head:

```
abjad> note_head = notetools.NoteHead("cs' ' ")
abjad> note_head.named_chromatic_pitch
NamedChromaticPitch("cs' ' ")
```

Return named chromatic pitch.

tweak

Read-only LilyPond tweak reservoir:

```
abjad> note_head = notetools.NoteHead("cs' ' ")
abjad> note_head.tweak
LilyPondTweakReservoir()
```

Return LilyPond tweak reservoir.

written_pitch

Get named pitch of note head:

```
abjad> note_head = notetools.NoteHead("cs' ' ")
abjad> note_head.written_pitch
NamedChromaticPitch("cs' ' ")
```

Set named pitch of note head:

```
abjad> note_head = notetools.NoteHead("cs' ' ")
abjad> note_head.written_pitch = "d' ' "
abjad> note_head.written_pitch
NamedChromaticPitch("d' ' ")
```

Set pitch token.

notetools.add_artificial_harmonic_to_note

abjad.tools.notetools.**add_artificial_harmonic_to_note**(note,
melodic_diatonic_interval=MelodicDiatonicInterval('
 Add artifical harmonic to *note* at *melodic_diatonic_interval*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
  c'8 [
  d'8
  e'8
  f'8 ]
}

abjad> notetools.add_artificial_harmonic_to_note(staff[0])
Chord("<c' f'>8")

abjad> f(staff)
\new Staff {
  <
    c'
    \tweak #'style #'harmonic
    f'
  >8 [
  d'8
  e'8
  f'8 ]
}

```

Create new artificial harmonic chord from *note*.

Move parentage and spanners from *note* to artificial harmonic chord.

Return artificial harmonic chord. Changed in version 2.0: renamed `harmonictools.add_artificial()` to `notetools.add_artificial_harmonic_to_note()`.

notetools.all_are_notes

`abjad.tools.notetools.all_are_notes(expr)`

New in version 2.6. True when *expr* is a sequence of Abjad notes:

```
abjad> notes = [Note("c'4"), Note("d'4"), Note("e'4")]
```

```
abjad> notetools.all_are_notes(notes)
True
```

True when *expr* is an empty sequence:

```
abjad> notetools.all_are_notes([])
True
```

Otherwise false:

```
abjad> notetools.all_are_notes('foo')
False
```

Return boolean.

Function wraps `componenttools.all_are_components()`.

notetools.color_note_head_by_numbered_chromatic_pitch_class_color_map

`abjad.tools.notetools.color_note_head_by_numbered_chromatic_pitch_class_color_map` (*pitch_carrier*)

Color *pitch_carrier* note head:

```
abjad> note = Note("c'4")
```

```
abjad> notetools.color_note_head_by_numbered_chromatic_pitch_class_color_map(note)
Note("c'4")
```

```
abjad> f(note)
\once \override NoteHead #'color = #(x11-color 'red)
c'4
```

Numbered chromatic pitch-class color map:

```
0: red
1: MediumBlue
2: orange
3: LightSlateBlue
4: ForestGreen
5: MediumOrchid
6: firebrick
7: DeepPink
8: DarkOrange
9: IndianRed
10: CadetBlue
11: SeaGreen
12: LimeGreen
```

Numbered chromatic pitch-class color map can not be changed.

Raise type error when *pitch_carrier* is not a pitch carrier.

Raise extra pitch error when *pitch_carrier* carries more than 1 note head.

Raise missing pitch error when *pitch_carrier* carries no note head.

Return *pitch_carrier*. Changed in version 2.0: renamed `pitchtools.color_by_pc()` to `notetools.color_note_head_by_numbered_chromatic_pitch_class_color_map()`. Changed in version 2.0: renamed `notetools.color_note_head_by_numeric_chromatic_pitch_class_color_map()` to `notetools.color_note_head_by_numbered_chromatic_pitch_class_color_map()`.

notetools.iterate_notes_backward_in_expr

`abjad.tools.notetools.iterate_notes_backward_in_expr` (*expr*, *start=0*, *stop=None*)

New in version 2.0. Yield right-to-left notes in *expr*:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
```

```

        e'8
        f'8
    }
    {
        \time 2/8
        g'8
        a'8
    }
}

```

```

abjad> for leaf in notetools.iterate_notes_backward_in_expr(staff):
...     leaf
...
Note("a'8")
Note("g'8")
Note("f'8")
Note("e'8")
Note("d'8")
Note("c'8")

```

Use optional *start* and *stop* keyword parameters to control indices of iteration:

```

abjad> for leaf in notetools.iterate_notes_backward_in_expr(staff, start = 3):
...     leaf
...
Note("e'8")
Note("d'8")
Note("c'8")

```

```

abjad> for leaf in notetools.iterate_notes_backward_in_expr(staff, start = 0, stop = 3):
...     leaf
...
Note("a'8")
Note("g'8")
Note("f'8")

```

```

abjad> for leaf in notetools.iterate_notes_backward_in_expr(staff, start = 2, stop = 4):
...     leaf
...
Note("f'8")
Note("e'8")

```

Return note generator. Changed in version 2.0: renamed `iterate.notes_backward_in()` to `notetools.iterate_notes_backward_in_expr()`.

notetools.iterate_notes_forward_in_expr

`abjad.tools.notetools.iterate_notes_forward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Yield left-to-right notes in *expr*:

```

abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 3)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
    {
        \time 2/8
        c'8
    }
}

```

```

        d'8
    }
    {
        \time 2/8
        e'8
        f'8
    }
    {
        \time 2/8
        g'8
        a'8
    }
}

abjad> for leaf in notetools.iterate_notes_forward_in_expr(staff):
...     leaf
...
Note("c'8")
Note("d'8")
Note("e'8")
Note("f'8")
Note("g'8")
Note("a'8")

```

Use optional *start* and *stop* keyword parameters to control start and stop indices of iteration:

```

abjad> for leaf in notetools.iterate_notes_forward_in_expr(staff, start = 3):
...     leaf
...
Note("f'8")
Note("g'8")
Note("a'8")

abjad> for leaf in notetools.iterate_notes_forward_in_expr(staff, start = 0, stop = 3):
...     leaf
...
Note("c'8")
Note("d'8")
Note("e'8")

abjad> for leaf in notetools.iterate_notes_forward_in_expr(staff, start = 2, stop = 4):
...     leaf
...
Note("e'8")
Note("f'8")

```

Return generator. Changed in version 2.0: renamed `iterate.notes_forward_in()` to `notetools.iterate_notes_forward_in_expr()`.

notetools.label_notes_in_expr_with_note_indices

`abjad.tools.notetools.label_notes_in_expr_with_note_indices`(*expr*,
markup_direction='down')

New in version 2.0. Label notes in *expr* with note indices:

```
abjad> staff = Staff("c'8 d'8 r8 r8 g'8 a'8 r8 c''8")
```

```
abjad> notetools.label_notes_in_expr_with_note_indices(staff)
```

```
abjad> f(staff)
\new Staff {
  c'8 _ \markup { \small 0 }
  d'8 _ \markup { \small 1 }
  r8
  r8
  g'8 _ \markup { \small 2 }
  a'8 _ \markup { \small 3 }
  r8
  c''8 _ \markup { \small 4 }
}
```

Return none.

notetools.make_accelerating_notes_with_lilypond_multipliers

```
abjad.tools.notetools.make_accelerating_notes_with_lilypond_multipliers(pitches,
                                                                           total,
                                                                           start,
                                                                           stop,
                                                                           exp='cosine',
                                                                           written=Duration(1,
                                                                           8))
```

Make accelerating notes with LilyPond multipliers:

```
abjad> notetools.make_accelerating_notes_with_lilypond_multipliers([1,2], (1, 2), (1, 4), (1, 8))
[Note("cs'8 * 113/64"), Note("d'8 * 169/128"), Note("cs'8 * 117/128")]
```

```
abjad> voice = Voice(_)
abjad> voice.prolated_duration
Duration(1, 2)
```

Set note pitches cyclically from *pitches*.

Return as many interpolation values as necessary to fill the *total* duration requested.

Interpolate durations from *start* to *stop*.

Set note durations to *written* duration times computed interpolated multipliers.

Return list of notes. Changed in version 2.0: renamed `construct.notes_curve()` to `notetools.make_accelerating_notes_with_lilypond_multipliers()`.

notetools.make_notes

```
abjad.tools.notetools.make_notes(pitches, durations, direction='big-endian')
```

Make notes according to *pitches* and *durations*.

Cycle through *pitches* when the length of *pitches* is less than the length of *durations*:

```
abjad> notetools.make_notes([0], [(1, 16), (1, 8), (1, 8)])
[Note("c'16"), Note("c'8"), Note("c'8")]
```

Cycle through *durations* when the length of *durations* is less than the length of *pitches*:


```
abjad> notetools.make_notes([0, 2, 4, 5, 7], [(1, 16), (1, 8), (1, 8)])
[Note("c'16"), Note("d'8"), Note("e'8"), Note("f'16"), Note("g'8")]
```

Create ad hoc tuplets for nonassignable durations:

```
abjad> notetools.make_notes([0], [(1, 16), (1, 12), (1, 8)])
[Note("c'16"), Tuplet(2/3, [c'8]), Note("c'8")]
```

Set *direction* to 'big-endian' to express tied values in decreasing duration:

```
abjad> notetools.make_notes([0], [(13, 16)], direction = 'big-endian')
[Note("c'2."), Note("c'16")]
```

Set *direction* to 'little-endian' to express tied values in increasing duration:

```
abjad> notetools.make_notes([0], [(13, 16)], direction = 'little-endian')
[Note("c'16"), Note("c'2.")]
```

Set *pitch*s to a single pitch or a sequence of pitches.

Set *durations* to a single duration or a list of durations.

Return list of newly constructed notes. Changed in version 2.0: renamed `construct.notes()` to `notetools.make_notes()`.

notetools.make_notes_with_multiplied_durations

```
abjad.tools.notetools.make_notes_with_multiplied_durations (pitch,          writ-
                                                             ten_duration, multi-
                                                             plied_durations)
```

New in version 2.0. Make *written_duration* notes with *pitch* and *multiplied_durations*:

```
abjad> notetools.make_notes_with_multiplied_durations(0, Duration(1, 4), [(1, 2), (1, 3), (1, 4)])
[Note("c'4 * 2"), Note("c'4 * 4/3"), Note("c'4 * 1"), Note("c'4 * 4/5")]
```

Useful for making spatially positioned notes.

Return list of notes.

notetools.make_percussion_note

```
abjad.tools.notetools.make_percussion_note (pitch, total_duration, max_note_duration=(1,
                                                                                          8))
```

Make percussion note:

```
abjad> notetools.make_percussion_note(2, (1, 4), (1, 8))
[Note("d'8"), Rest('r8')]
```

```
abjad> notetools.make_percussion_note(2, (1, 64), (1, 8))
[Note("d'64")]
```

```
abjad> notetools.make_percussion_note(2, (5, 64), (1, 8))
[Note("d'16"), Rest('r64')]
```

```
abjad> notetools.make_percussion_note(2, (5, 4), (1, 8))
[Note("d'8"), Rest('r1'), Rest('r8')]
```

Return list of newly constructed note followed by zero or more newly constructed rests.

Durations of note and rests returned will sum to *total_duration*.

Duration of note returned will be no greater than *max_note_duration*.

Duration of rests returned will sum to note duration taken from *total_duration*.

Useful for percussion music where attack duration is negligible and tied notes undesirable. Changed in version 2.0: renamed `construct.percussion_note()` to `notetools.make_percussion_note()`.

notetools.make_quarter_notes_with_lilypond_multipliers

`abjad.tools.notetools.make_quarter_notes_with_lilypond_multipliers` (*pitches*,
multiplied_durations)

New in version 2.0. Make quarter notes with *pitches* and *multiplied_durations*:

```
abjad> notetools.make_quarter_notes_with_lilypond_multipliers([0, 2, 4, 5], [(1, 4), (1, 5), (1, 6), (1, 7)],  
[Note("c'4 * 1"), Note("d'4 * 4/5"), Note("e'4 * 2/3"), Note("f'4 * 4/7")])
```

Read *pitches* cyclically where the length of *pitches* is less than the length of *multiplied_durations*:

```
abjad> notetools.make_quarter_notes_with_lilypond_multipliers([0], [(1, 4), (1, 5), (1, 6), (1, 7)],  
[Note("c'4 * 1"), Note("c'4 * 4/5"), Note("c'4 * 2/3"), Note("c'4 * 4/7")])
```

Read *multiplied_durations* cyclically where the length of *multiplied_durations* is less than the length of *pitches*:

```
abjad> notetools.make_quarter_notes_with_lilypond_multipliers([0, 2, 4, 5], [(1, 5)])  
[Note("c'4 * 4/5"), Note("d'4 * 4/5"), Note("e'4 * 4/5"), Note("f'4 * 4/5")]
```

Return list of zero or more newly constructed notes. Changed in version 2.0: renamed `construct.quarter_notes_with_multipliers()` to `notetools.make_quarter_notes_with_lilypond_multipliers()`.

notetools.make_repeated_notes

`abjad.tools.notetools.make_repeated_notes` (*count*, *duration*=*Duration(1, 8)*)

Make *count* repeated notes with note head-assignable *duration*:

```
abjad> notetools.make_repeated_notes(4)  
[Note("c'8"), Note("c'8"), Note("c'8"), Note("c'8")]
```

Make *count* repeated tie chains with tied *duration*:

```
abjad> notes = notetools.make_repeated_notes(2, (5, 16))  
abjad> voice = Voice(notes)
```

```
abjad> f(voice)  
\new Voice {  
  c'4 ~  
  c'16  
  c'4 ~  
  c'16  
}
```

Make ad hoc tuplet holding *count* repeated notes with nonbinary *duration*:

```
abjad> notetools.make_repeated_notes(3, (1, 12))
[Tuplet(2/3, [c'8, c'8, c'8])]
```

Set pitch of all notes created to middle C.

Return list of zero or more newly constructed notes or list of one newly constructed tuplet. Changed in version 2.0: renamed `construct.run()` to `notetools.make_repeated_notes()`.

notetools.make_repeated_notes_from_time_signature

```
abjad.tools.notetools.make_repeated_notes_from_time_signature(time_signature,
                                                                pitch="c")
```

New in version 2.0. Make repeated notes from *time_signature*:

```
abjad> notetools.make_repeated_notes_from_time_signature((5, 32))
[Note("c'32"), Note("c'32"), Note("c'32"), Note("c'32"), Note("c'32")]
```

Make repeated notes with *pitch* from *time_signature*:

```
abjad> notetools.make_repeated_notes_from_time_signature((5, 32), pitch = "d'")
[Note("d'32"), Note("d'32"), Note("d'32"), Note("d'32"), Note("d'32")]
```

Return list of notes.

notetools.make_repeated_notes_from_time_signatures

```
abjad.tools.notetools.make_repeated_notes_from_time_signatures(time_signatures,
                                                                pitch="c")
```

Make repeated notes from *time_signatures*:

```
notetools.make_repeated_notes_from_time_signatures([(2, 8), (3, 32)])
[[Note("c'8"), Note("c'8")], [Note("c'32"), Note("c'32"), Note("c'32")]]
```

Make repeated notes with *pitch* from *time_signatures*:

```
abjad> notetools.make_repeated_notes_from_time_signatures([(2, 8), (3, 32)], pitch = "d'")
[[Note("d'8"), Note("d'8")], [Note("d'32"), Note("d'32"), Note("d'32")]]
```

Return two-dimensional list of note lists.

Use `sequencetools.flatten_sequence()` to flatten output if required.

notetools.make_repeated_notes_with_shorter_notes_at_end

```
abjad.tools.notetools.make_repeated_notes_with_shorter_notes_at_end(pitch,
                                                                      written_duration,
                                                                      total_duration,
                                                                      prolation=Duration(1,
                                                                      1))
```

Make repeated notes with *pitch* and *written_duration* summing to *total_duration* under *prolation*:

```
abjad> voice = Voice(notetools.make_repeated_notes_with_shorter_notes_at_end(0, Duration(1, 16),
```

```
abjad> f(voice)
\new Voice {
    c'16
    c'16
    c'16
    c'16
}
```

Fill binary remaining duration with binary notes of lesser written duration:

```
abjad> voice = Voice(notetools.make_repeated_notes_with_shorter_notes_at_end(0, Duration(1, 16),

abjad> f(voice)
\new Voice {
    c'16
    c'16
    c'16
    c'16
    c'32
}
```

Fill nonbinary remaining duration with ad hoc tuplet:

```
abjad> voice = Voice(notetools.make_repeated_notes_with_shorter_notes_at_end(0, Duration(1, 16),

abjad> f(voice)
\new Voice {
    c'16
    c'16
    c'16
    c'16
    c'16
    c'16
    \times 4/5 {
        c'32
    }
}
```

Set *prolation* when constructing notes in a nonbinary measure.

Return list of newly constructed components. Changed in version 2.0: renamed `construct.note_train()` to `notetools.make_repeated_notes_with_shorter_notes_at_end()`.

notetools.yield_groups_of_notes_in_sequence

`abjad.tools.notetools.yield_groups_of_notes_in_sequence(sequence)`

New in version 2.0. Yield groups of notes in *sequence*:

```
abjad> staff = Staff("c'8 d'8 r8 r8 <e' g'>8 <f' a'>8 g'8 a'8 r8 r8 <b' d''>8 <c'' e''>8")

abjad> f(staff)
\new Staff {
    c'8
    d'8
    r8
    r8
    <e' g'>8
    <f' a'>8
```

```

    g'8
    a'8
    r8
    r8
    <b' d''>8
    <c'' e''>8
}

abjad> for note in notetools.yield_groups_of_notes_in_sequence(staff):
...     note
...
(Note("c'8"), Note("d'8"))
(Note("g'8"), Note("a'8"))

```

Return generator.

pitchtools

pitchtools.Accidental

class abjad.tools.pitchtools.**Accidental**

Bases: abjad.core._StrictComparator._StrictComparator._StrictComparator, abjad.core._Immutable._Immutable._Immutable New in version 2.0. Abjad model of the accidental:

```

abjad> pitchtools.Accidental('s')
Accidental('s')

```

Accidentals are immutable.

alphabetic_accidental_abbreviation

Read-only alphabetic string:

```

abjad> accidental = pitchtools.Accidental('s')
abjad> accidental.alphabetic_accidental_abbreviation
's'

```

Return string.

format

Read-only LilyPond input format of accidental:

```

abjad> accidental = pitchtools.Accidental('s')
abjad> accidental.format
's'

```

Return string.

is_adjusted

True for all accidentals equal to a nonzero number of semitones. False otherwise:

```

abjad> accidental = pitchtools.Accidental('s')
abjad> accidental.is_adjusted
True

```

Return boolean.

name

Read-only name of accidental:

```
abjad> accidental = pitchtools.Accidental('s')
abjad> accidental.name
'sharp'
```

Return string.

semitones

Read-only semitones of accidental:

```
abjad> accidental = pitchtools.Accidental('s')
abjad> accidental.semitones
1
```

Return number.

symbolic_accidental_string

Read-only symbolic string of accidental:

```
abjad> accidental = pitchtools.Accidental('s')
abjad> accidental.symbolic_accidental_string
'#'
```

Return string.

pitchtools.HarmonicChromaticInterval

class abjad.tools.pitchtools.**HarmonicChromaticInterval**

Bases: abjad.tools.pitchtools._ChromaticInterval._ChromaticInterval._ChromaticInterval,
 abjad.tools.pitchtools._HarmonicInterval._HarmonicInterval._HarmonicInterval
 New in version 2.0. Abjad model of harmonic chromatic interval:

```
abjad> pitchtools.HarmonicChromaticInterval(-14)
HarmonicChromaticInterval(14)
```

Harmonic chromatic intervals are immutable.

harmonic_chromatic_interval_class

Read-only harmonic chromatic interval-class:

```
abjad> harmonic_chromatic_interval = pitchtools.HarmonicChromaticInterval(14)
abjad> harmonic_chromatic_interval.harmonic_chromatic_interval_class
HarmonicChromaticIntervalClass(2)
```

Return harmonic chromatic interval-class.

pitchtools.HarmonicChromaticIntervalClass

class abjad.tools.pitchtools.**HarmonicChromaticIntervalClass**

Bases: abjad.tools.pitchtools._ChromaticIntervalClass._ChromaticIntervalClass._ChromaticIntervalClass,
 abjad.tools.pitchtools._HarmonicIntervalClass._HarmonicIntervalClass._HarmonicIntervalClass
 New in version 2.0. Abjad model of harmonic chromatic interval-class:

```
abjad> pitchtools.HarmonicChromaticIntervalClass(-14)
HarmonicChromaticIntervalClass(2)
```

Harmonic chromatic interval-classes are immutable.

pitchtools.HarmonicChromaticIntervalClassVector

class abjad.tools.pitchtools.**HarmonicChromaticIntervalClassVector** (*expr*)

Bases: abjad.tools.pitchtools._Vector._Vector._Vector New in version 2.0. Abjad model of harmonic chromatic interval-class vector:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8")
abjad> hcicv = pitchtools.HarmonicChromaticIntervalClassVector(staff)
abjad> print hcicv
0 1 3 2 1 2 0 1 0 0 0 0
```

Harmonic chromatic interval-class vector is quartertone-aware:

```
abjad> staff.append(Note(1.5, (1, 4)))
abjad> hcicv = pitchtools.HarmonicChromaticIntervalClassVector(staff)
abjad> print hcicv
0 1 3 2 1 2 0 1 0 0 0 0
1 1 1 1 0 1 0 0 0 0 0 0
```

Harmonic chromatic interval-class vectors are immutable.

has_none_of (*chromatic_interval_numbers*)

True when harmonic chromatic interval-class vector contains none of *chromatic_interval_numbers*. Otherwise false:

```
abjad> hcicv = pitchtools.HarmonicChromaticIntervalClassVector(Staff("c'8 d'8 e'8 f'8 g'8"))
abjad> hcicv.has_none_of([9, 10, 11])
True
```

Return boolean.

pitchtools.HarmonicChromaticIntervalSegment

class abjad.tools.pitchtools.**HarmonicChromaticIntervalSegment**

Bases: abjad.tools.pitchtools._IntervalSegment._IntervalSegment._IntervalSegment New in version 2.0. Abjad model of harmonic chromatic interval segment:

```
abjad> pitchtools.HarmonicChromaticIntervalSegment([10, -12, -13, -13.5])
HarmonicChromaticIntervalSegment(10, 12, 13, 13.5)
```

Harmonic chromatic interval segments are immutable.

pitchtools.HarmonicChromaticIntervalSet

class abjad.tools.pitchtools.**HarmonicChromaticIntervalSet**

Bases: abjad.tools.pitchtools._IntervalSet._IntervalSet._IntervalSet New in version 2.0. Abjad model of harmonic chromatic interval set:

```
abjad> pitchtools.HarmonicChromaticIntervalSet([10, -12, -13, -13, -13.5])
HarmonicChromaticIntervalSet(10, 12, 13, 13.5)
```

Harmonic chromatic interval sets are immutable.

harmonic_chromatic_interval_numbers

harmonic_chromatic_intervals

pitchtools.HarmonicCounterpointInterval

class abjad.tools.pitchtools.**HarmonicCounterpointInterval**

Bases: abjad.tools.pitchtools._CounterpointInterval._CounterpointInterval._CounterpointInterval

abjad.tools.pitchtools._HarmonicInterval._HarmonicInterval._HarmonicInterval

New in version 2.0. Abjad model of harmonic counterpoint interval:

```
abjad> pitchtools.HarmonicCounterpointInterval(-9)
HarmonicCounterpointInterval(9)
```

Harmonic counterpoint intervals are immutable.

harmonic_counterpoint_interval_class

pitchtools.HarmonicCounterpointIntervalClass

class abjad.tools.pitchtools.**HarmonicCounterpointIntervalClass**

Bases: abjad.tools.pitchtools._CounterpointIntervalClass._CounterpointIntervalClass._CounterpointIntervalClass

abjad.tools.pitchtools._HarmonicIntervalClass._HarmonicIntervalClass._HarmonicIntervalClass

New in version 2.0. Abjad model of harmonic counterpoint interval-class:

```
abjad> pitchtools.HarmonicCounterpointIntervalClass(-9)
HarmonicCounterpointIntervalClass(2)
```

Harmonic counterpoint interval-classes are immutable.

pitchtools.HarmonicDiatonicInterval

class abjad.tools.pitchtools.**HarmonicDiatonicInterval**

Bases: abjad.tools.pitchtools._DiatonicInterval._DiatonicInterval._DiatonicInterval,

abjad.tools.pitchtools._HarmonicInterval._HarmonicInterval._HarmonicInterval

New in version 2.0. Abjad model harmonic diatonic interval:

```
abjad> pitchtools.HarmonicDiatonicInterval('M9')
HarmonicDiatonicInterval('M9')
```

Harmonic diatonic intervals are immutable.

harmonic_counterpoint_interval

harmonic_diatonic_interval_class

melodic_diatonic_interval_ascending

melodic_diatonic_interval_descending

semitones

staff_spaces

pitchtools.HarmonicDiatonicIntervalClass

class abjad.tools.pitchtools.**HarmonicDiatonicIntervalClass**

Bases: abjad.tools.pitchtools._DiatonicIntervalClass._DiatonicIntervalClass._DiatonicIntervalClass

abjad.tools.pitchtools._HarmonicIntervalClass._HarmonicIntervalClass._HarmonicIntervalClass

New in version 2.0. Abjad model harmonic diatonic interval-class:


```
abjad> pitchtools.HarmonicDiatonicIntervalClass('-M9')
HarmonicDiatonicIntervalClass('M2')
```

Harmonic diatonic interval-classes are immutable.

invert()

Read-only inversion of harmonic diatonic interval-class:

```
abjad> hdic = pitchtools.HarmonicDiatonicIntervalClass('major', -9)
abjad> hdic.invert()
HarmonicDiatonicIntervalClass('m7')
```

Return harmonic diatonic interval-class.

pitchtools.HarmonicDiatonicIntervalClassSet

class abjad.tools.pitchtools.**HarmonicDiatonicIntervalClassSet**

Bases: abjad.tools.pitchtools._IntervalClassSet._IntervalClassSet._IntervalClassSet

New in version 2.0. Abjad model of harmonic diatonic interval-class set:

```
abjad> pitchtools.HarmonicDiatonicIntervalClassSet('m2 M2 m3 M3') # doctest: +SKIP
HarmonicDiatonicIntervalClassSet('m2 M2 m3 M3')
```

Harmonic diatonic interval-class sets are immutable.

harmonic_diatonic_interval_classes

pitchtools.HarmonicDiatonicIntervalSegment

class abjad.tools.pitchtools.**HarmonicDiatonicIntervalSegment**

Bases: abjad.tools.pitchtools._IntervalSegment._IntervalSegment._IntervalSegment

New in version 2.0. Abjad model of harmonic diatonic interval segment:

```
abjad> pitchtools.HarmonicDiatonicIntervalSegment('m2 M9 m3 M3')
HarmonicDiatonicIntervalSegment('m2 M9 m3 M3')
```

Harmonic diatonic interval segments are immutable.

harmonic_chromatic_interval_segment

melodic_chromatic_interval_segment

melodic_diatonic_interval_segment

pitchtools.HarmonicDiatonicIntervalSet

class abjad.tools.pitchtools.**HarmonicDiatonicIntervalSet**

Bases: abjad.tools.pitchtools._IntervalSet._IntervalSet._IntervalSet New in version 2.0. Abjad model of harmonic diatonic interval set:

```
abjad> pitchtools.HarmonicDiatonicIntervalSet('m2 m2 M2 M9')
HarmonicDiatonicIntervalSet('m2 M2 M9')
```

Harmonic diatonic interval sets are immutable.

harmonic_chromatic_interval_set

harmonic_diatonic_interval_numbers

harmonic_diatonic_intervals

pitchtools.InversionEquivalentChromaticIntervalClass

class abjad.tools.pitchtools.**InversionEquivalentChromaticIntervalClass**

Bases: abjad.tools.pitchtools._IntervalClass._IntervalClass._IntervalClass

New in version 2.0. Abjad model of inversion-equivalent chromatic interval-class:

```
abjad> pitchtools.InversionEquivalentChromaticIntervalClass(1)
InversionEquivalentChromaticIntervalClass(1)
```

Inversion-equivalent chromatic interval-classes are immutable.

inversion_equivalent_chromatic_interval_number

pitchtools.InversionEquivalentChromaticIntervalClassSegment

class abjad.tools.pitchtools.**InversionEquivalentChromaticIntervalClassSegment**

Bases: abjad.tools.pitchtools._IntervalClassSegment._IntervalClassSegment._IntervalClassSegment

New in version 2.0. Abjad model of inversion-equivalent chromatic interval-class segment:

```
abjad> pitchtools.InversionEquivalentChromaticIntervalClassSegment([2, 1, 0, 5.5, 6])
InversionEquivalentChromaticIntervalClassSegment(2, 1, 0, 5.5, 6)
```

Inversion-equivalent chromatic interval-class segments are immutable.

pitchtools.InversionEquivalentChromaticIntervalClassSet

class abjad.tools.pitchtools.**InversionEquivalentChromaticIntervalClassSet**

Bases: abjad.tools.pitchtools._IntervalClassSet._IntervalClassSet._IntervalClassSet

New in version 2.0. Abjad model of inversion-equivalent chromatic interval-class set:

```
abjad> pitchtools.InversionEquivalentChromaticIntervalClassSet([1, 1, 6, 2, 2])
InversionEquivalentChromaticIntervalClassSet(1, 2, 6)
```

Inversion-equivalent chromatic interval-class sets are immutable.

inversion_equivalent_chromatic_interval_class_numbers

inversion_equivalent_chromatic_interval_classes

pitchtools.InversionEquivalentChromaticIntervalClassVector

class abjad.tools.pitchtools.**InversionEquivalentChromaticIntervalClassVector** (*args,
**kwargs)

Bases: abjad.tools.pitchtools._Vector._Vector._Vector New in version 2.0. Abjad model of inversion-equivalent chromatic interval-class vector:

```
abjad> pitchtools.InversionEquivalentChromaticIntervalClassVector([1, 1, 6, 2, 2, 2])
InversionEquivalentChromaticIntervalClassVector(0 | 2 3 0 0 0 1)
```

Initialize by inversion-equivalent chromatic interval-class counts:

```
abjad> pitchtools.InversionEquivalentChromaticIntervalClassVector(counts = [2, 3, 0, 0, 0, 1])
InversionEquivalentChromaticIntervalClassVector(0 | 2 3 0 0 0 1)
```

Inversion-equivalent chromatic interval-class vectors are immutable.

pitchtools.InversionEquivalentDiatonicIntervalClass

class abjad.tools.pitchtools.**InversionEquivalentDiatonicIntervalClass**

Bases: abjad.tools.pitchtools._DiatonicIntervalClass._DiatonicIntervalClass._DiatonicIntervalClass

New in version 2.0. Abjad model of inversion-equivalent diatonic interval-class:

```
abjad> pitchtools.InversionEquivalentDiatonicIntervalClass('-m14')
InversionEquivalentDiatonicIntervalClass('M2')
```

Inversion-equivalent diatonic interval-classes are immutable.

pitchtools.InversionEquivalentDiatonicIntervalClassSegment

class abjad.tools.pitchtools.**InversionEquivalentDiatonicIntervalClassSegment**

Bases: abjad.tools.pitchtools._IntervalSegment._IntervalSegment._IntervalSegment

New in version 2.0. Abjad model of inversion-equivalent diatonic interval-class segment:

```
abjad> pitchtools.InversionEquivalentDiatonicIntervalClassSegment([('major', 2), ('major', 9), ('mi', 1)])
InversionEquivalentDiatonicIntervalClassSegment(M2, M2, m2, m2)
```

Inversion-equivalent diatonic interval-class segments are immutable.

is_tertian

True when all diatonic interval-classes in segment are tertian. Otherwise false:

```
abjad> dics = pitchtools.InversionEquivalentDiatonicIntervalClassSegment([('major', 3), ('mi', 1)])
abjad> dics.is_tertian
True
```

Return boolean.

pitchtools.InversionEquivalentDiatonicIntervalClassVector

class abjad.tools.pitchtools.**InversionEquivalentDiatonicIntervalClassVector**(*expr*)

Bases: abjad.tools.pitchtools._Vector._Vector._Vector New in version 2.0. Abjad model of inversion-equivalent diatonic interval-class vector:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8")
abjad> pitchtools.InversionEquivalentDiatonicIntervalClassVector(staff)
InversionEquivalentDiatonicIntervalClassVector(P1: 0, aug1: 0, m2: 1, M2: 3, aug2: 0, dim3: 0, m3: 0)
```

Inversion-equivalent diatonic interval-class vector are not quartertone-aware.

Inversion-equivalent diatonic interval-class vectors are immutable.

pitchtools.MelodicChromaticInterval

class abjad.tools.pitchtools.**MelodicChromaticInterval**

Bases: abjad.tools.pitchtools._ChromaticInterval._ChromaticInterval._ChromaticInterval, abjad.tools.pitchtools._MelodicInterval._MelodicInterval._MelodicInterval

New in version 2.0. Abjad model of melodic chromatic interval:

```
abjad> pitchtools.MelodicChromaticInterval(-14)
MelodicChromaticInterval(-14)
```

Melodic chromatic intervals are immutable.

chromatic_interval_number

Read-only chromatic interval number:

```
abjad> pitchtools.MelodicChromaticInterval(-14).chromatic_interval_number
-14
```

Return integer or float.

direction_number

Read-only numeric sign:

```
abjad> pitchtools.MelodicChromaticInterval(-14).direction_number
-1
```

Return integer.

harmonic_chromatic_interval

Read-only harmonic chromatic interval:

```
abjad> pitchtools.MelodicChromaticInterval(-14).harmonic_chromatic_interval
HarmonicChromaticInterval(14)
```

Return harmonic chromatic interval.

melodic_chromatic_interval_class

Read-only melodic chromatic interval-class:

```
abjad> pitchtools.MelodicChromaticInterval(-14).melodic_chromatic_interval_class
MelodicChromaticIntervalClass(-2)
```

Return melodic chromatic interval-class.

pitchtools.MelodicChromaticIntervalClass

class abjad.tools.pitchtools.**MelodicChromaticIntervalClass**

Bases: abjad.tools.pitchtools._ChromaticIntervalClass._ChromaticIntervalClass._ChromaticIntervalClass

abjad.tools.pitchtools._MelodicIntervalClass._MelodicIntervalClass._MelodicIntervalClass

New in version 2.0. Abjad model of melodic chromatic interval-class:

```
abjad> pitchtools.MelodicChromaticIntervalClass(-14)
MelodicChromaticIntervalClass(-2)
```

Melodic chromatic interval-classes are immutable.

pitchtools.MelodicChromaticIntervalClassSegment

class abjad.tools.pitchtools.**MelodicChromaticIntervalClassSegment**

Bases: abjad.tools.pitchtools._IntervalClassSegment._IntervalClassSegment._IntervalClassSegment

New in version 2.0. Abjad model of melodic chromatic interval-class segment:

```
abjad> pitchtools.MelodicChromaticIntervalClassSegment([-2, -14, 3, 5.5, 6.5])
MelodicChromaticIntervalClassSegment(-2, -2, +3, +5.5, +6.5)
```

Melodic chromatic interval-class segments are immutable.

pitchtools.MelodicChromaticIntervalClassVector

class abjad.tools.pitchtools.**MelodicChromaticIntervalClassVector** (*mcic_tokens*)

Bases: abjad.tools.pitchtools._Vector._Vector._Vector New in version 2.0. Abjad model of melodic chromatic interval-class vector:

```

abjad> print pitchtools.MelodicChromaticIntervalClassVector([-2, -14, 3, 5.5, 6.5])
. | . . 1 . . . | . . . . .
  | . 2 . . . | . . . . .
  | . . . . 1 | 1 . . . .
  | . . . . . | . . . . .

```

Melodic chromatic interval-class vectors are immutable.

pitchtools.MelodicChromaticIntervalSegment

class abjad.tools.pitchtools.**MelodicChromaticIntervalSegment**

Bases: abjad.tools.pitchtools._IntervalSegment._IntervalSegment._IntervalSegment New in version 2.0. Abjad model of melodic chromatic interval segment:

```

abjad> pitchtools.MelodicChromaticIntervalSegment([11, 13, 13.5, -2, 2.5])
MelodicChromaticIntervalSegment(+11, +13, +13.5, -2, +2.5)

```

Melodic chromatic interval segments are immutable.

harmonic_chromatic_interval_segment

melodic_chromatic_interval_class_segment

melodic_chromatic_interval_class_vector

melodic_chromatic_interval_numbers

slope

The slope of a melodic interval segment is the sum of its intervals divided by its length:

```

abjad> pitchtools.MelodicChromaticIntervalSegment([1, 2]).slope
Fraction(3, 2)

```

Return fraction.

spread

The maximum harmonic interval spanned by any combination of the intervals within a harmonic chromatic interval segment:

```

abjad> pitchtools.MelodicChromaticIntervalSegment([1, 2, -3, 1, -2, 1]).spread
HarmonicChromaticInterval(4)
abjad> pitchtools.MelodicChromaticIntervalSegment([1, 1, 1, 2, -3, -2]).spread
HarmonicChromaticInterval(5)

```

Return harmonic chromatic interval.

pitchtools.MelodicChromaticIntervalSet

class abjad.tools.pitchtools.**MelodicChromaticIntervalSet**

Bases: abjad.tools.pitchtools._IntervalSet._IntervalSet._IntervalSet New in version 2.0. Abjad model of melodic chromatic interval set:

```
abjad> pitchtools.MelodicChromaticIntervalSet([11, 11, 13.5, 13.5])
MelodicChromaticIntervalSet(+11, +13.5)
```

Melodic chromatic interval sets are immutable.

harmonic_chromatic_interval_set

melodic_chromatic_interval_numbers

melodic_chromatic_intervals

pitchtools.MelodicCounterpointInterval

class abjad.tools.pitchtools.**MelodicCounterpointInterval**

Bases: abjad.tools.pitchtools._CounterpointInterval._CounterpointInterval._CounterpointInterval

abjad.tools.pitchtools._MelodicInterval._MelodicInterval._MelodicInterval

New in version 2.0. Abjad model of melodic counterpoint interval:

```
abjad> pitchtools.MelodicCounterpointInterval(-9)
MelodicCounterpointInterval(-9)
```

Melodic counterpoint intervals are immutable.

direction_number

melodic_counterpoint_interval_class

pitchtools.MelodicCounterpointIntervalClass

class abjad.tools.pitchtools.**MelodicCounterpointIntervalClass**

Bases: abjad.tools.pitchtools._CounterpointIntervalClass._CounterpointIntervalClass._CounterpointIntervalClass

abjad.tools.pitchtools._MelodicIntervalClass._MelodicIntervalClass._MelodicIntervalClass

New in version 2.0. Abjad model of melodic counterpoint interval-class:

```
abjad> pitchtools.MelodicCounterpointIntervalClass(-9)
MelodicCounterpointIntervalClass(-2)
```

Melodic counterpoint interval-classes are immutable.

pitchtools.MelodicDiatonicInterval

class abjad.tools.pitchtools.**MelodicDiatonicInterval**

Bases: abjad.tools.pitchtools._DiatonicInterval._DiatonicInterval._DiatonicInterval,

abjad.tools.pitchtools._MelodicInterval._MelodicInterval._MelodicInterval

New in version 2.0. Abjad model of melodic diatonic interval:

```
abjad> pitchtools.MelodicDiatonicInterval('+M9')
MelodicDiatonicInterval('+M9')
```

Melodic diatonic intervals are immutable.

direction_number

direction_string

harmonic_chromatic_interval

harmonic_counterpoint_interval

```

harmonic_diatonic_interval
inversion_equivalent_chromatic_interval_class
melodic_chromatic_interval
melodic_counterpoint_interval
melodic_diatonic_interval_class
semitones
staff_spaces

```

pitchtools.MelodicDiatonicIntervalClass

class abjad.tools.pitchtools.**MelodicDiatonicIntervalClass**

Bases: abjad.tools.pitchtools._DiatonicIntervalClass._DiatonicIntervalClass._DiatonicIntervalClass
 abjad.tools.pitchtools._MelodicIntervalClass._MelodicIntervalClass._MelodicIntervalClass
 New in version 2.0. Abjad model of melodic diatonic interval-class:

```

abjad> pitchtools.MelodicDiatonicIntervalClass('-M9')
MelodicDiatonicIntervalClass('-M2')

```

Melodic diatonic interval-classes are immutable.

```

direction_number
direction_symbol
direction_word

```

pitchtools.MelodicDiatonicIntervalSegment

class abjad.tools.pitchtools.**MelodicDiatonicIntervalSegment**

Bases: abjad.tools.pitchtools._IntervalSegment._IntervalSegment._IntervalSegment
 New in version 2.0. Abjad model of melodic diatonic interval segment:

```

abjad> pitchtools.MelodicDiatonicIntervalSegment('M2 M9 -m3 -P4')
MelodicDiatonicIntervalSegment('+M2 +M9 -m3 -P4')

```

Melodic diatonic interval segments are immutable.

```

harmonic_chromatic_interval_segment
harmonic_diatonic_interval_segment
melodic_chromatic_interval_segment

```

pitchtools.MelodicDiatonicIntervalSet

class abjad.tools.pitchtools.**MelodicDiatonicIntervalSet**

Bases: abjad.tools.pitchtools._IntervalSet._IntervalSet._IntervalSet
 New in version 2.0. Abjad model of melodic diatonic interval set:

```

abjad> pitchtools.MelodicDiatonicIntervalSet('M2 M2 -m3 -P4')
MelodicDiatonicIntervalSet('-P4 -m3 +M2')

```

Melodic diatonic interval sets are immutable.

```

harmonic_chromatic_interval_set
harmonic_diatonic_interval_set
melodic_chromatic_interval_set
melodic_diatonic_interval_numbers
melodic_diatonic_intervals

```

pitchtools.NamedChromaticPitch

class abjad.tools.pitchtools.**NamedChromaticPitch**

Bases: abjad.tools.pitchtools._Pitch._Pitch._Pitch New in version 1.1. Abjad model of named chromatic pitch:

```

abjad> pitchtools.NamedChromaticPitch("cs' ' ")
NamedChromaticPitch("cs' ' ")

```

Named chromatic pitches are immutable.

accidental_spelling = 'mixed'

chromatic_pitch_class_name

Read-only chromatic pitch-class name:

```

abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_chromatic_pitch.chromatic_pitch_class_name
'cs'

```

Return string.

chromatic_pitch_class_number

Read-only chromatic pitch-class number:

```

abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_chromatic_pitch.chromatic_pitch_class_number
1

```

Return integer or float.

chromatic_pitch_name

Read-only chromatic pitch name:

```

abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_chromatic_pitch.chromatic_pitch_name
"cs' ' "

```

Return string.

chromatic_pitch_number

Read-only chromatic pitch-class number:

```

abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_chromatic_pitch.chromatic_pitch_number
13

```

Return integer or float.

deviation_in_cents

Read-only deviation of named chromatic pitch in cents:


```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_chromatic_pitch.deviation_in_cents is None
True
```

Return integer or none.

diatonic_pitch_class_name

Read-only diatonic pitch-class name:

```
abjad> named_diatonic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_diatonic_pitch.diatonic_pitch_class_name
'C'
```

Return string.

diatonic_pitch_class_number

Read-only diatonic pitch-class number:

```
abjad> named_diatonic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_diatonic_pitch.diatonic_pitch_class_number
0
```

Return integer.

diatonic_pitch_name

Read-only diatonic pitch name:

```
abjad> named_diatonic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_diatonic_pitch.diatonic_pitch_name
"C' ' "
```

Return string.

diatonic_pitch_number

Read-only diatonic pitch number:

```
abjad> named_diatonic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_diatonic_pitch.diatonic_pitch_number
7
```

Return integer.

format

Read-only LilyPond input format of named chromatic pitch:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_chromatic_pitch.format
"cs' ' "
```

Return string.

named_chromatic_pitch_class

Read-only named pitch-class:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs' ' ")
abjad> named_chromatic_pitch.named_chromatic_pitch_class
NamedChromaticPitchClass('cs')
```

Return named chromatic pitch-class.

named_diatonic_pitch

Read-only named diatonic pitch:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs'")
abjad> named_chromatic_pitch.named_diatonic_pitch
NamedDiatonicPitch("c'")
```

Return named diatonic pitch.

named_diatonic_pitch_class

Read-only named diatonic pitch-class:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs'")
abjad> named_chromatic_pitch.named_diatonic_pitch_class
NamedDiatonicPitchClass('c')
```

Return named diatonic pitch-class.

numbered_chromatic_pitch

Read-only numbered chromatic pitch from named chromatic pitch:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs'")
abjad> named_chromatic_pitch.numbered_chromatic_pitch_class
NumberedChromaticPitchClass(1)
```

Return numbered chromatic pitch-class.

numbered_chromatic_pitch_class

Read-only numbered pitch-class:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs'")
abjad> named_chromatic_pitch.numbered_chromatic_pitch_class
NumberedChromaticPitchClass(1)
```

Return numbered chromatic pitch-class.

numbered_diatonic_pitch

Read-only numbered diatonic pitch:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs'")
abjad> named_chromatic_pitch.numbered_diatonic_pitch
NumberedDiatonicPitch(7)
```

Return numbered diatonic pitch.

numbered_diatonic_pitch_class

Read-only numbered diatonic pitch:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs'")
abjad> named_chromatic_pitch.numbered_diatonic_pitch_class
NumberedDiatonicPitchClass(0)
```

Return numbered diatonic pitch-class.

octave_number

Read-only integer octave number:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs'")
abjad> named_chromatic_pitch.octave_number
5
```

Return integer.

pitch_class_octave_label

Read-only pitch-class / octave label:

```
abjad> named_chromatic_pitch = pitchtools.NamedChromaticPitch("cs' ")
abjad> named_chromatic_pitch.pitch_class_octave_label
'C#5'
```

Return string.

pitchtools.NamedChromaticPitchClass

class abjad.tools.pitchtools.**NamedChromaticPitchClass**

Bases: abjad.tools.pitchtools._PitchClass._PitchClass._PitchClass New in version 2.0. Abjad model of named chromatic pitch-class:

```
abjad> pitchtools.NamedChromaticPitchClass('cs')
NamedChromaticPitchClass('cs')
```

Named chromatic pitch-classes are immutable.

apply_accidental (*accidental*)

Apply *accidental*:

```
abjad> named_chromatic_pitch_class = pitchtools.NamedChromaticPitchClass('cs')
abjad> named_chromatic_pitch_class.apply_accidental('qs')
NamedChromaticPitchClass('ctqs')
```

Return named chromatic pitch-class.

numbered_chromatic_pitch_class

Read-only numbered chromatic pitch-class:

```
abjad> named_chromatic_pitch_class = pitchtools.NamedChromaticPitchClass('cs')
abjad> named_chromatic_pitch_class.numbered_chromatic_pitch_class
NumberedChromaticPitchClass(1)
```

Return numbered chromatic pitch-class.

transpose (*melodic_diatonic_interval*)

Transpose named chromatic pitch-class by *melodic_diatonic_interval*:

```
abjad> named_chromatic_pitch_class = pitchtools.NamedChromaticPitchClass('cs')
abjad> named_chromatic_pitch_class.transpose(pitchtools.MelodicDiatonicInterval('major', 2))
NamedChromaticPitchClass('ds')
```

Return named chromatic pitch-class.

pitchtools.NamedChromaticPitchClassSegment

class abjad.tools.pitchtools.**NamedChromaticPitchClassSegment**

Bases: abjad.tools.pitchtools._PitchClassSegment._PitchClassSegment._PitchClassSegment New in version 2.0. Abjad model of named chromatic pitch-class segment:

```
abjad> pitchtools.NamedChromaticPitchClassSegment(['gs', 'a', 'as', 'c', 'cs'])
NamedChromaticPitchClassSegment(['gs', 'a', 'as', 'c', 'cs'])
```

Named chromatic pitch-class segments are immutable.

inversion_equivalent_diatonic_interval_class_segment

is_equivalent_under_transposition (*arg*)

```

named_chromatic_pitch_class_set
named_chromatic_pitch_classes
numbered_chromatic_pitch_class_segment
numbered_chromatic_pitch_class_set
numbered_chromatic_pitch_classes
retrograde()
rotate(n)
transpose(melodic_diatonic_interval)

```

pitchtools.NamedChromaticPitchClassSet

class abjad.tools.pitchtools.**NamedChromaticPitchClassSet**

Bases: abjad.tools.pitchtools._PitchClassSet._PitchClassSet._PitchClassSet
 New in version 2.0. Abjad model of a named chromatic pitch-class set:

```

abjad> named_chromatic_pitch_class_set = pitchtools.NamedChromaticPitchClassSet(['gs', 'g', 'as']

abjad> named_chromatic_pitch_class_set
NamedChromaticPitchClassSet(['as', 'c', 'cs', 'g', 'gs'])

abjad> print named_chromatic_pitch_class_set
{as, c, cs, g, gs}

```

Named chromatic pitch-class sets are immutable.

inversion_equivalent_diatonic_interval_class_vector

named_chromatic_pitch_classes

Read-only named chromatic pitch-classes:

```

abjad> named_chromatic_pitch_class_set = pitchtools.NamedChromaticPitchClassSet(['gs', 'g',
abjad> named_chromatic_pitch_class_set.named_chromatic_pitch_classes # doctest: +SKIP
(NamedChromaticPitchClass('c'), NamedChromaticPitchClass('cs'), NamedChromaticPitchClass('g')

```

Return tuple.

numbered_chromatic_pitch_class_set

order_by(*npc_seg*)

transpose(*melodic_diatonic_interval*)

Transpose all npcs in self by melodic diatonic interval.

pitchtools.NamedChromaticPitchSegment

class abjad.tools.pitchtools.**NamedChromaticPitchSegment**

Bases: abjad.tools.pitchtools._PitchSegment._PitchSegment._PitchSegment
 New in version 2.0. Abjad model of a named chromatic pitch segment:

```

abjad> pitchtools.NamedChromaticPitchSegment(['bf', 'bqf', "fs'", "g'", 'bqf', "g'"])
NamedChromaticPitchSegment("bf bqf fs' g' bqf g'")

```

Named chromtic pitch segments are immutable.

chromatic_pitch_numbers

```

harmonic_chromatic_interval_class_segment
harmonic_chromatic_interval_segment
harmonic_diatonic_interval_class_segment
harmonic_diatonic_interval_segment
inflection_point_count
inversion_equivalent_chromatic_interval_class_segment
inversion_equivalent_chromatic_interval_class_set
inversion_equivalent_chromatic_interval_class_vector
local_maxima
local_minima
melodic_chromatic_interval_class_segment
melodic_chromatic_interval_segment
melodic_diatonic_interval_class_segment
melodic_diatonic_interval_segment
named_chromatic_pitch_class_vector
named_chromatic_pitch_set
named_chromatic_pitch_vector
named_chromatic_pitches
numbered_chromatic_pitch_class_segment
numbered_chromatic_pitch_class_set
transpose (melodic_interval)
    Transpose pitches in pitch segment by melodic interval and emit new pitch segment.

```

pitchtools.NamedChromaticPitchSet

class abjad.tools.pitchtools.**NamedChromaticPitchSet**

Bases: abjad.tools.pitchtools._PitchSet._PitchSet._PitchSet New in version 2.0. Abjad model of a named chromatic pitch set:

```

abjad> pitchtools.NamedChromaticPitchSet(['bf', 'bqf', "fs'", "g'", 'bqf', "g'"])
NamedChromaticPitchSet(['bf', 'bqf', "fs'", "g'"])

```

Named chromatic pitch sets are immutable.

```

chromatic_pitch_numbers
duplicate_pitch_classes
is_pitch_class_unique
named_chromatic_pitches
numbered_chromatic_pitch_class_set
numbered_chromatic_pitch_classes

```

transpose (*n*)
Transpose all pcs in self by n.

pitchtools.NamedChromaticPitchVector

class abjad.tools.pitchtools.**NamedChromaticPitchVector** (*pitch_tokens*)
Bases: abjad.tools.pitchtools._Vector._Vector._Vector New in version 2.0. Abjad model of named chromatic pitch vector:

```
abjad> named_chromatic_pitch_vector = pitchtools.NamedChromaticPitchVector(["c'", "c'", "cs'"])
```

```
abjad> named_chromatic_pitch_vector
NamedChromaticPitchVector(c': 2, cs': 3)
```

```
abjad> print named_chromatic_pitch_vector
NamedChromaticPitchVector(c': 2, cs': 3)
```

Named chromatic pitch vectors are immutable.

chromatic_pitch_numbers

named_chromatic_pitches

pitchtools.NamedDiatonicPitch

class abjad.tools.pitchtools.**NamedDiatonicPitch**
Bases: abjad.tools.pitchtools._DiatonicPitch._DiatonicPitch._DiatonicPitch New in version 2.0. Abjad model of a named diatonic pitch:

```
abjad> named_diatonic_pitch = pitchtools.NamedDiatonicPitch("c'")
```

```
abjad> named_diatonic_pitch
NamedDiatonicPitch("c'")
```

```
abjad> print named_diatonic_pitch
c'
```

Named diatonic pitches are immutable.

chromatic_pitch_class_name

Read-only chromatic pitch-class name:

```
abjad> pitchtools.NamedDiatonicPitch("c'").chromatic_pitch_class_name
'c'
```

Return string.

chromatic_pitch_class_number

Read-only chromatic pitch-class number:

```
abjad> pitchtools.NamedDiatonicPitch("c'").chromatic_pitch_class_number
0
```

Return integer.

chromatic_pitch_name

Read-only chromatic pitch name:

```
abjad> pitchtools.NamedDiatonicPitch("c'").chromatic_pitch_name
"c' "
```

Return string.

chromatic_pitch_number

Read-only chromatic pitch number:

```
abjad> pitchtools.NamedDiatonicPitch("c'").chromatic_pitch_number
12
```

Return integer.

diatonic_pitch_class_name

Read-only diatonic pitch-class name:

```
abjad> pitchtools.NamedDiatonicPitch("c'").diatonic_pitch_class_name
'c'
```

Return string.

diatonic_pitch_class_number

Read-only diatonic pitch-class number:

```
abjad> pitchtools.NamedDiatonicPitch("c'").diatonic_pitch_class_number
0
```

Return integer.

diatonic_pitch_name

Read-only diatonic pitch name:

```
abjad> pitchtools.NamedDiatonicPitch("c'").diatonic_pitch_name
"c' "
```

Return string.

diatonic_pitch_number

Read-only diatonic pitch number:

```
abjad> pitchtools.NamedDiatonicPitch("c'").diatonic_pitch_number
7
```

Return integer.

format

Read-only LilyPond input format of named diatonic pitch:

```
abjad> pitchtools.NamedDiatonicPitch("c'").format
"c' "
```

Return string.

named_chromatic_pitch

Read-only named chromatic pitch:

```
abjad> pitchtools.NamedDiatonicPitch("c'").named_chromatic_pitch
NamedChromaticPitch("c' ")
```

Return named chromatic pitch.

named_chromatic_pitch_class

Read-only named chromatic pitch-class:

```
abjad> pitchtools.NamedDiatonicPitch("c'").named_chromatic_pitch_class
NamedChromaticPitchClass('c')
```

Return named chromatic pitch-class.

named_diatonic_pitch_class

Read-only named diatonic pitch-class:

```
abjad> pitchtools.NamedDiatonicPitch("c'").named_diatonic_pitch_class
NamedDiatonicPitchClass('c')
```

Return named diatonic pitch-class.

numbered_chromatic_pitch

Read-only numbered chromatic pitch:

```
abjad> pitchtools.NamedDiatonicPitch("c'").numbered_chromatic_pitch
NumberedChromaticPitch(12)
```

Return numbered chromatic pitch.

numbered_chromatic_pitch_class

Read-only numbered chromatic pitch-class:

```
abjad> pitchtools.NamedDiatonicPitch("c'").numbered_chromatic_pitch_class
NumberedChromaticPitchClass(0)
```

Return numbered chromatic pitch-class.

numbered_diatonic_pitch

Read-only numbered diatonic pitch:

```
abjad> pitchtools.NamedDiatonicPitch("c'").numbered_diatonic_pitch
NumberedDiatonicPitch(7)
```

Return numbered diatonic pitch.

numbered_diatonic_pitch_class

Read-only numbered diatonic pitch-class:

```
abjad> pitchtools.NamedDiatonicPitch("c'").numbered_diatonic_pitch_class
NumberedDiatonicPitchClass(0)
```

Return numbered diatonic pitch-class.

pitchtools.NamedDiatonicPitchClass

class abjad.tools.pitchtools.**NamedDiatonicPitchClass**

Bases: abjad.tools.pitchtools._DiatonicPitchClass._DiatonicPitchClass._DiatonicPitchClass

New in version 2.0. Abjad model of a named diatonic pitch-class:

```
abjad> pitchtools.NamedDiatonicPitchClass('c')
NamedDiatonicPitchClass('c')
```

Named diatonic pitch-classes are immutable.

numbered_diatonic_pitch_class

Read-only numbered diatonic pitch-class from named diatonic pitch-class:


```

abjad> named_diatonic_pitch_class = pitchtools.NamedDiatonicPitchClass('c')
abjad> named_diatonic_pitch_class.numbered_diatonic_pitch_class
NumberedDiatonicPitchClass(0)

```

Return numbered diatonic pitch-class.

pitchtools.NumberedChromaticPitch

class `abjad.tools.pitchtools.NumberedChromaticPitch`

Bases: `abjad.tools.pitchtools._ChromaticPitch._ChromaticPitch._ChromaticPitch`,
`abjad.tools.pitchtools._NumberedPitch._NumberedPitch._NumberedPitch` **New in**
 version 2.0. Abjad model of a numbered chromatic pitch:

```

abjad> pitchtools.NumberedChromaticPitch(13)
NumberedChromaticPitch(13)

```

Numbered chromatic pitches are immutable.

apply_accidental (*accidental=None*)

Apply *accidental*:

```

abjad> pitchtools.NumberedChromaticPitch(13).apply_accidental('flat')
NumberedChromaticPitch(12)

```

Return numbered chromatic pitch.

chromatic_pitch_number

Read-only chromatic pitch-class number:

```

abjad> pitchtools.NumberedChromaticPitch(13).chromatic_pitch_number
13

```

Return integer or float.

diatonic_pitch_class_number

Read-only diatonic pitch-class number:

```

abjad> pitchtools.NumberedChromaticPitch(13).diatonic_pitch_class_number
0

```

Return integer.

diatonic_pitch_number

Read-only diatonic pitch-class number:

```

abjad> pitchtools.NumberedChromaticPitch(13).diatonic_pitch_number
7

```

Return integer.

transpose (*n=0*)

Transpose by *n* semitones:

```

abjad> pitchtools.NumberedChromaticPitch(13).transpose(1)
NumberedChromaticPitch(14)

```

Return numbered chromatic pitch.

pitchtools.NumberedChromaticPitchClass

class abjad.tools.pitchtools.**NumberedChromaticPitchClass**

Bases: abjad.tools.pitchtools._PitchClass._PitchClass._PitchClass New in version 2.0. Abjad model of a numbered chromatic pitch-class:

```
abjad> pitchtools.NumberedChromaticPitchClass(13)
NumberedChromaticPitchClass(1)
```

Numbered chromatic pitch-classes are immutable.

apply_accidental (*accidental=None*)

Emit new numbered chromatic pitch-class as sum of self and accidental.

invert ()

Invert pitch-class.

multiply (*n*)

Multiply pitch-class by *n*.

transpose (*n*)

Transpose pitch-class by *n*.

pitchtools.NumberedChromaticPitchClassColorMap

class abjad.tools.pitchtools.**NumberedChromaticPitchClassColorMap**

Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Abjad model of a numbered chromatic pitch-class color map:

```
abjad> chromatic_pitch_class_numbers = [[-8, 2, 10, 21], [0, 11, 32, 41], [15, 25, 42, 43]]
abjad> colors = ['red', 'green', 'blue']
abjad> pitchtools.NumberedChromaticPitchClassColorMap(chromatic_pitch_class_numbers, colors)
NumberedChromaticPitchClassColorMap([[-8, 2, 10, 21], [0, 11, 32, 41], [15, 25, 42, 43]], ['red',
```

Numbered chromatic pitch-class color maps are immutable.

colors

get (*key, alternative=None*)

pairs

pitch_iterables

twelve_tone_complete

twenty_four_tone_complete

pitchtools.NumberedChromaticPitchClassSegment

class abjad.tools.pitchtools.**NumberedChromaticPitchClassSegment**

Bases: abjad.tools.pitchtools._PitchClassSegment._PitchClassSegment._PitchClassSegment New in version 2.0. Abjad model of a numbered chromatic pitch-class segment:

```
abjad> pitchtools.NumberedChromaticPitchClassSegment([-2, -1.5, 6, 7, -1.5, 7])
NumberedChromaticPitchClassSegment([10, 10.5, 6, 7, 10.5, 7])
```

Numbered chromatic pitch-class segments are immutable.

alpha()

Morris alpha transform of numbered chromatic pitch-class segment:

```
numbered_chromatic_pitch_class_segment = pitchtools.NumberedChromaticPitchClassSegment([10,
numbered_chromatic_pitch_class_segment.alpha()
NumberedChromaticPitchClassSegment([11, 11.5, 7, 6, 11.5, 6])
```

Return numbered chromatic pitch-class segment.

inversion_equivalent_chromatic_interval_class_segment

Read-only inversion-equivalent chromatic interval-class segment:

```
numbered_chromatic_pitch_class_segment = pitchtools.NumberedChromaticPitchClassSegment([10,
numbered_chromatic_pitch_class_segment.inversion_equivalent_chromatic_interval_class_segment
InversionEquivalentChromaticIntervalClassSegment(0.5, 4.5, 1, 3.5, 3.5)
```

Return inversion-equivalent chromatic interval-class segment.

invert()

Invert numbered chromatic pitch-class segment:

```
numbered_chromatic_pitch_class_segment = pitchtools.NumberedChromaticPitchClassSegment([10,
numbered_chromatic_pitch_class_segment.invert()
NumberedChromaticPitchClassSegment([2, 1.5, 6, 5, 1.5, 5])
```

Return numbered chromatic pitch-class segment.

multiply(*n*)

Multiply numbered chromatic pitch-class segment by *n*:

```
numbered_chromatic_pitch_class_segment = pitchtools.NumberedChromaticPitchClassSegment([10,
numbered_chromatic_pitch_class_segment.multiply(5)
NumberedChromaticPitchClassSegment([2, 4.5, 6, 11, 4.5, 11])
```

Return numbered chromatic pitch-class segment.

numbered_chromatic_pitch_class_set

Read-only numbered chromatic pitch-class set from numbered chromatic pitch-class segment:

```
numbered_chromatic_pitch_class_segment = pitchtools.NumberedChromaticPitchClassSegment([10,
numbered_chromatic_pitch_class_segment.numbered_chromatic_pitch_class_set
NumberedChromaticPitchClassSet([6, 7, 10, 10.5])
```

Return numbered chromatic pitch-class set.

retrograde()

Retrograde of numbered chromatic pitch-class segment:

```
numbered_chromatic_pitch_class_segment = pitchtools.NumberedChromaticPitchClassSegment([10,
numbered_chromatic_pitch_class_segment.retrograde()
NumberedChromaticPitchClassSegment([7, 10.5, 7, 6, 10.5, 10])
```

Return numbered chromatic pitch-class segment.

rotate(*n*)

Rotate numbered chromatic pitch-class segment:

```
numbered_chromatic_pitch_class_segment = pitchtools.NumberedChromaticPitchClassSegment([10,
numbered_chromatic_pitch_class_segment.rotate(1)
NumberedChromaticPitchClassSegment([7, 10, 10.5, 6, 7, 10.5])
```

Return numbered chromatic pitch-class segment.

transpose (*n*)

Transpose numbered chromatic pitch-class segment:

```
numbered_chromatic_pitch_class_segment = pitchtools.NumberedChromaticPitchClassSegment([10,
numbered_chromatic_pitch_class_segment.transpose(10)
NumberedChromaticPitchClassSegment([8, 8.5, 4, 5, 8.5, 5])
```

Return numbered chromatic pitch-class segment.

pitchtools.NumberedChromaticPitchClassSet

class abjad.tools.pitchtools.**NumberedChromaticPitchClassSet**

Bases: abjad.tools.pitchtools._PitchClassSet._PitchClassSet._PitchClassSet

New in version 2.0. Abjad model of a numbered chromatic pitch-class set:

```
abjad> numbered_chromatic_pitch_class_set = pitchtools.NumberedChromaticPitchClassSet([-2, -1.5,
abjad> numbered_chromatic_pitch_class_set
NumberedChromaticPitchClassSet([6, 7, 10, 10.5])

abjad> print numbered_chromatic_pitch_class_set
{6, 7, 10, 10.5}
```

Numbered chromatic pitch-class sets are immutable.

inversion_equivalent_chromatic_interval_class_set

Read-only inversion-equivalent chromatic interval-class set:

```
abjad> numbered_chromatic_pitch_class_set = pitchtools.NumberedChromaticPitchClassSet([-2,
abjad> numbered_chromatic_pitch_class_set.inversion_equivalent_chromatic_interval_class_set
InversionEquivalentChromaticIntervalClassSet(0.5, 1, 3, 3.5, 4, 4.5)
```

Return inversion-equivalent chromatic interval-class set.

inversion_equivalent_chromatic_interval_class_vector

Read-only inversion-equivalent chromatic interval-class vector:

```
abjad> numbered_chromatic_pitch_class_set = pitchtools.NumberedChromaticPitchClassSet([-2, -
abjad> numbered_chromatic_pitch_class_set.inversion_equivalent_chromatic_interval_class_vect
InversionEquivalentChromaticIntervalClassVector(0 | 1 0 1 1 0 0 1 0 0 1 1 0)
```

Return inversion-equivalent chromatic interval-class vector.

invert ()

Invert numbered chromatic pitch-class set:

```
abjad> numbered_chromatic_pitch_class_set = pitchtools.NumberedChromaticPitchClassSet([-2, -
abjad> numbered_chromatic_pitch_class_set.invert()
NumberedChromaticPitchClassSet([1.5, 2, 5, 6])
```

Return numbered chromatic pitch-class set.

is_transposed_subset (*pcset*)

True when self is transposed subset of *pcset*. False otherwise:

```
abjad> pcset_1 = pitchtools.NumberedChromaticPitchClassSet([-2, -1.5, 6, 7, -1.5, 7])
abjad> pcset_2 = pitchtools.NumberedChromaticPitchClassSet([-2, -1.5, 6, 7, -1.5, 7, 7.5, 8])

abjad> pcset_1.is_transposed_subset(pcset_2)
True
```

Return boolean.

`is_transposed_superset` (*pcset*)

True when self is transposed superset of *pcset*. False otherwise:

```
abjad> pcset_1 = pitchtools.NumberedChromaticPitchClassSet([-2, -1.5, 6, 7, -1.5, 7])
abjad> pcset_2 = pitchtools.NumberedChromaticPitchClassSet([-2, -1.5, 6, 7, -1.5, 7, 7.5, 8])

abjad> pcset_2.is_transposed_superset(pcset_1)
True
```

Return boolean.

multiply (n)

Multiply numbered chromatic pitch-class set by n :

```
abjad> numbered_chromatic_pitch_class_set = pitchtools.NumberedChromaticPitchClassSet([-2, -
abjad> numbered_chromatic_pitch_class_set.multiply(5)
NumberedChromaticPitchClassSet([2, 4.5, 6, 11])
```

Return numbered chromatic pitch-class set.

`numbered_chromatic_pitch_classes`

Read-only numbered chromatic pitch-classes:

```
abjad> numbered_chromatic_pitch_class_set = pitchtools.NumberedChromaticPitchClassSet([-2, -
abjad> numbered_chromatic_pitch_class_set.numbered_chromatic_pitch_classes
(NumberedChromaticPitchClass(6), NumberedChromaticPitchClass(7), NumberedChromaticPitchClass
```

Return tuple.

prime_form

To be implemented.

transpose (n)

Transpose numbered chromatic pitch-class set by n :

```
abjad> numbered_chromatic_pitch_class_set = pitchtools.NumberedChromaticPitchClassSet([-2, -
abjad> numbered_chromatic_pitch_class_set.multiply(5)
NumberedChromaticPitchClassSet([2, 4.5, 6, 11])
```

Return numbered chromatic pitch-class set.

pitchtools.NumberedChromaticPitchClassVector

```
class abjad.tools.pitchtools.NumberedChromaticPitchClassVector(pitch_class_tokens)
```

Bases: `abjad.tools.pitchtools._Vector._Vector._Vector` New in version 2.0. Abjad model of numbered chromatic pitch-class vector:

```
abjad> numbered_chromatic_pitch_class_vector = pitchtools.NumberedChromaticPitchClassVector([13,
abjad> numbered_chromatic_pitch_class_vector
NumberedChromaticPitchClassVector(0 2 0 0 0 0 | 3 0 0 0 0 0 || 0 0 3 0 0 0 | 0 0 0 0 0 0)

abjad> print numbered_chromatic_pitch_class_vector
0 2 0 0 0 0 | 3 0 0 0 0 0
0 0 3 0 0 0 | 0 0 0 0 0 0
```

Numbered chromatic pitch-class vectors are immutable.

chromatic_pitch_class_numbers

Read-only chromatic pitch-class numbers from numbered chromatic pitch-class vector:

```
abjad> numbered_chromatic_pitch_class_vector = pitchtools.NumberedChromaticPitchClassVector(
abjad> numbered_chromatic_pitch_class_vector.chromatic_pitch_class_numbers
[1, 2.5, 6]
```

Return list.

numbered_chromatic_pitch_classes

Read-only numbered chromatic pitch-classes from numbered chromatic pitch-class vector:

```
abjad> numbered_chromatic_pitch_class_vector = pitchtools.NumberedChromaticPitchClassVector(
abjad> numbered_chromatic_pitch_class_vector.numbered_chromatic_pitch_classes
[NumberedChromaticPitchClass(2.5), NumberedChromaticPitchClass(1), NumberedChromaticPitchClass(6)]
```

Return list.

pitchtools.NumberedDiatonicPitch

class abjad.tools.pitchtools.NumberedDiatonicPitch

Bases: abjad.tools.pitchtools._DiatonicPitch._DiatonicPitch, abjad.tools.pitchtools._NumberedPitch._NumberedPitch. New in version 2.0. Abjad model of a numbered diatonic pitch:

```
abjad> pitchtools.NumberedDiatonicPitch(7)
NumberedDiatonicPitch(7)
```

Numbered diatonic pitches are immutable.

chromatic_pitch_number

Read-only chromatic pitch number:

```
abjad> pitchtools.NumberedDiatonicPitch(7).chromatic_pitch_number
12
```

Return integer.

diatonic_pitch_number

Read-only diatonic pitch number:

```
abjad> pitchtools.NumberedDiatonicPitch(7).diatonic_pitch_number
7
```

Return integer.

named_diatonic_pitch

Read-only named diatonic pitch:

```
abjad> pitchtools.NumberedDiatonicPitch(7).named_diatonic_pitch
NamedDiatonicPitch('c'')
```

Return named diatonic pitch.

named_diatonic_pitch_class

Read-only named diatonic pitch-class:

```
abjad> pitchtools.NumberedDiatonicPitch(7).named_diatonic_pitch_class
NamedDiatonicPitchClass('c')
```

Return named diatonic pitch-class.

numbered_diatonic_pitch_class

Read-only numbered diatonic pitch-class:

```
abjad> pitchtools.NumberedDiatonicPitch(7).numbered_diatonic_pitch_class
NumberedDiatonicPitchClass(0)
```

Return numbered diatonic pitch-class.

pitchtools.NumberedDiatonicPitchClass

class abjad.tools.pitchtools.**NumberedDiatonicPitchClass**

Bases: abjad.tools.pitchtools._NumberedPitchClass._NumberedPitchClass._NumberedPitchClass

abjad.tools.pitchtools._DiatonicPitchClass._DiatonicPitchClass._DiatonicPitchClass

New in version 2.0. Abjad model of a numbered diatonic pitch-class:

```
abjad> pitchtools.NumberedDiatonicPitchClass(0)
NumberedDiatonicPitchClass(0)
```

Numbered diatonic pitch-classes are immutable.

named_diatonic_pitch_class

Read-only named diatonic pitch-class from numbered diatonic pitch-class:

```
abjad> numbered_diatonic_pitch_class = pitchtools.NumberedDiatonicPitchClass(0)
abjad> numbered_diatonic_pitch_class.named_diatonic_pitch_class
NamedDiatonicPitchClass('c')
```

Return named diatonic pitch-class.

pitchtools.PitchRange

class abjad.tools.pitchtools.**PitchRange**(*args)

Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Abjad model of pitch range:

```
abjad> pitchtools.PitchRange(-12, 36)
PitchRange(' [C3, C7]')
```

Init from pitch numbers, pitch names, pitch instances or other pitch range objects.

Pitch ranges implement all six Python rich comparators.

Pitch ranges are immutable.

one_line_named_chromatic_pitch_repr

Read-only one-line named chromatic pitch repr of pitch of range:

```
abjad> pitch_range = pitchtools.PitchRange(-12, 36)
abjad> pitch_range.one_line_named_chromatic_pitch_repr
'[C3, C7]'
```

Return string.

one_line_numbered_chromatic_pitch_repr

Read-only one-line numbered chromatic pitch repr of pitch of range:

```
abjad> pitch_range = pitchtools.PitchRange(-12, 36)
abjad> pitch_range.one_line_numbered_chromatic_pitch_repr
'[-12, 36]'
```

Return string.

start_pitch

Read-only start pitch of range:

```
abjad> pitch_range = pitchtools.PitchRange(-12, 36)
abjad> pitch_range.start_pitch
NamedChromaticPitch('c')
```

Return pitch.

start_pitch_is_included_in_range

True when start pitch is included in range. Otherwise false:

```
abjad> pitch_range = pitchtools.PitchRange(-12, 36)
abjad> pitch_range.start_pitch_is_included_in_range
True
```

Return boolean.

stop_pitch

Read-only stop pitch of range:

```
abjad> pitch_range = pitchtools.PitchRange(-12, 36)
abjad> pitch_range.stop_pitch
NamedChromaticPitch("c' ' ' ' ")
```

Return pitch.

stop_pitch_is_included_in_range

True when stop pitch is included in range. Otherwise false:

```
abjad> pitch_range = pitchtools.PitchRange(-12, 36)
abjad> pitch_range.stop_pitch_is_included_in_range
True
```

Return boolean.

pitchtools.TwelveToneRow

class abjad.tools.pitchtools.TwelveToneRow

Bases: `abjad.tools.pitchtools.NumberedChromaticPitchClassSegment.NumberedChromaticPitchC`

New in version 2.0. Abjad model of twelve-tone row:

```
abjad> pitchtools.TwelveToneRow([0, 1, 11, 9, 3, 6, 7, 5, 4, 10, 2, 8])
TwelveToneRow([0, 1, 11, 9, 3, 6, 7, 5, 4, 10, 2, 8])
```

Twelve-tone rows validate pitch-classes at initialization.

Twelve-tone rows inherit canonical operators from numbered chromatic pitch-class segment.

Twelve-tone rows return numbered chromatic pitch-class segments on calls to `getslice`.

Twelve-tone rows are immutable.

pitchtools.all_are_chromatic_pitch_class_name_octave_number_pairs

`abjad.tools.pitchtools.all_are_chromatic_pitch_class_name_octave_number_pairs` (*expr*)

New in version 1.1. True when all elements of *expr* are pitch tokens. Otherwise false:


```
abjad> pitchtools.all_are_chromatic_pitch_class_name_octave_number_pairs([('c', 4), ('d', 4)], pi
True
```

Return boolean. Changed in version 2.0: renamed `pitchtools.is_pitch_token_collection()` to `pitchtools.all_are_chromatic_pitch_class_name_octave_number_pairs()`.

pitchtools.all_are_named_chromatic_pitch_tokens

`abjad.tools.pitchtools.all_are_named_chromatic_pitch_tokens(expr)`

New in version 2.6. True when *expr* is a sequence of named chromatic pitch tokens:

```
abjad> named_chromatic_pitch_tokens = [('c', 4), pitchtools.NamedChromaticPitch("a")]
```

```
abjad> pitchtools.all_are_named_chromatic_pitch_tokens(named_chromatic_pitch_tokens)
True
```

True when *expr* is an empty sequence:

```
abjad> pitchtools.all_are_named_chromatic_pitch_tokens([])
True
```

Otherwise false:

```
abjad> pitchtools.all_are_named_chromatic_pitch_tokens('foo')
False
```

Return boolean.

pitchtools.alphabetic_accidental_abbreviation_to_symbolic_accidental_string

`abjad.tools.pitchtools.alphabetic_accidental_abbreviation_to_symbolic_accidental_string(alp)`

New in version 2.5. Change *alphabetic_accidental_abbreviation* to symbolic accidental string:

```
abjad> pitchtools.alphabetic_accidental_abbreviation_to_symbolic_accidental_string('tqs')
'#+'
```

None when *alphabetic_accidental_abbreviation* is not a valid alphabetic accidental abbreviation.

Return string or none.

pitchtools.apply_accidental_to_named_chromatic_pitch

`abjad.tools.pitchtools.apply_accidental_to_named_chromatic_pitch(named_chromatic_pitch,
acciden-
tal=None)`

New in version 2.0. Apply *accidental* to *named_chromatic_pitch*:

```
abjad> pitch = pitchtools.NamedChromaticPitch("cs'")
abjad> pitchtools.apply_accidental_to_named_chromatic_pitch(pitch, 'f')
NamedChromaticPitch("c'")
```

Return new named pitch.

`pitchtools.apply_octavation_spanner_to_pitched_components`

`abjad.tools.pitchtools.apply_octavation_spanner_to_pitched_components` (*expr*,
ottava_numbered_diatonic_pitch,
quintade-
cisima_numbered_diatonic_pitch)

New in version 1.1. Apply octavation spanner to pitched components in *expr*:

```
abjad> t = Measure((4, 8), notetools.make_notes([24, 26, 27, 29], [(1, 8)]))
abjad> pitchtools.apply_octavation_spanner_to_pitched_components(t, ottava_numbered_diatonic_pitch)
OctavationSpanner(|4/8(4)|)
```

```
abjad> print t.format
{
    \time 4/8
    \ottava #1
    c'''8
    d'''8
    ef'''8
    f'''8
    \ottava #0
}
```

Apply octavation spanner according to the diatonic pitch number of the maximum pitch in *expr*.

Return octavation spanner.

`pitchtools.calculate_harmonic_chromatic_interval_class_from_pitch_carrier_to_pitch_carrier`

`abjad.tools.pitchtools.calculate_harmonic_chromatic_interval_class_from_pitch_carrier_to_pitch_carrier`

New in version 2.0. Calculate harmonic chromatic interval-class from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_harmonic_chromatic_interval_class_from_pitch_carrier_to_pitch_carrier
HarmonicChromaticIntervalClass(2)
```

Return harmonic chromatic interval-class.

`pitchtools.calculate_harmonic_chromatic_interval_from_pitch_carrier_to_pitch_carrier`

`abjad.tools.pitchtools.calculate_harmonic_chromatic_interval_from_pitch_carrier_to_pitch_carrier`

New in version 2.0. Calculate harmonic chromatic interval from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_harmonic_chromatic_interval_from_pitch_carrier_to_pitch_carrier(pitch_carrier_1, pitch_carrier_2)
HarmonicChromaticInterval(14)
```

Return harmonic chromatic interval.

`pitchtools.calculate_harmonic_counterpoint_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch`

`abjad.tools.pitchtools.calculate_harmonic_counterpoint_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch`

New in version 2.0. Calculate harmonic counterpoint interval-class from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_harmonic_counterpoint_interval_class_from_named_chromatic_pitch_to_n
HarmonicCounterpointIntervalClass(2)
```

Return harmonic counterpoint interval-class. Changed in version 2.0: renamed
`pitchtools.calculate_harmonic_counterpoint_interval_class_from_named_pchromatic_pitch_to`
to `pitchtools.calculate_harmonic_counterpoint_interval_class_from_named_chromatic_pitch_to`

pitchtools.calculate_harmonic_counterpoint_interval_from_named_chromatic_pitch_to_named_chromatic_pitch

```
abjad.tools.pitchtools.calculate_harmonic_counterpoint_interval_from_named_chromatic_pitch_to_n
```

New in version 2.0. Calculate harmonic counterpoint interval *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_harmonic_counterpoint_interval_from_named_chromatic_pitch_to_named_c
HarmonicCounterpointInterval(9)
```

Return harmonic counterpoint interval-class.

pitchtools.calculate_harmonic_diatonic_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch

```
abjad.tools.pitchtools.calculate_harmonic_diatonic_interval_class_from_named_chromatic_pitch_to_n
```

New in version 2.0. Calculate harmonic diatonic interval-class from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_harmonic_diatonic_interval_class_from_named_chromatic_pitch_to_named_c
HarmonicDiatonicIntervalClass('M2')
```

Return harmonic diatonic interval-class.

pitchtools.calculate_harmonic_diatonic_interval_from_named_chromatic_pitch_to_named_chromatic_pitch

```
abjad.tools.pitchtools.calculate_harmonic_diatonic_interval_from_named_chromatic_pitch_to_n
```

New in version 2.0. Calculate harmonic diatonic interval from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_harmonic_diatonic_interval_from_named_chromatic_pitch_to_named_chrom
HarmonicDiatonicInterval('M9')
```

Return harmonic diatonic interval.

pitchtools.calculate_melodic_chromatic_interval_class_from_pitch_carrier_to_pitch_carrier

```
abjad.tools.pitchtools.calculate_melodic_chromatic_interval_class_from_pitch_carrier_to_pitch
```

New in version 2.0. Calculate melodic chromatic interval-class from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_melodic_chromatic_interval_class_from_pitch_carrier_to_pitch_carrier
MelodicChromaticIntervalClass(+2)
```

Return melodic chromatic interval-class.

`pitchtools.calculate_melodic_chromatic_interval_from_pitch_carrier_to_pitch_carrier`

`abjad.tools.pitchtools.calculate_melodic_chromatic_interval_from_pitch_carrier_to_pitch_carrier`

New in version 2.0. Calculate melodic chromatic interval from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_melodic_chromatic_interval_from_pitch_carrier_to_pitch_carrier(pitch_carrier_1, pitch_carrier_2)
MelodicChromaticInterval(+14)
```

Return melodic chromatic interval.

`pitchtools.calculate_melodic_counterpoint_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch`

`abjad.tools.pitchtools.calculate_melodic_counterpoint_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch`

New in version 2.0. Calculate melodic counterpoint interval-class from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_melodic_counterpoint_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch(pitch_carrier_1, pitch_carrier_2)
MelodicCounterpointIntervalClass(+2)
```

Return melodic counterpoint interval-class.

`pitchtools.calculate_melodic_counterpoint_interval_from_named_chromatic_pitch_to_named_chromatic_pitch`

`abjad.tools.pitchtools.calculate_melodic_counterpoint_interval_from_named_chromatic_pitch_to_named_chromatic_pitch`

New in version 2.0. Calculate melodic counterpoint interval *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_melodic_counterpoint_interval_from_named_chromatic_pitch_to_named_chromatic_pitch(pitch_carrier_1, pitch_carrier_2)
MelodicCounterpointInterval(+9)
```

Return melodic counterpoint interval.

`pitchtools.calculate_melodic_diatonic_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch`

`abjad.tools.pitchtools.calculate_melodic_diatonic_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch`

New in version 2.0. Calculate melodic diatonic interval-class from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_melodic_diatonic_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch(pitch_carrier_1, pitch_carrier_2)
MelodicDiatonicIntervalClass('+M2')
```

Return melodic diatonic interval-class.

`pitchtools.calculate_melodic_diatonic_interval_from_named_chromatic_pitch_to_named_chromatic_pitch`

`abjad.tools.pitchtools.calculate_melodic_diatonic_interval_from_named_chromatic_pitch_to_named_chromatic_pitch`

New in version 2.0. Calculate melodic diatonic interval from *pitch_carrier_1* to *pitch_carrier_2*:

```
abjad> pitchtools.calculate_melodic_diatonic_interval_from_named_chromatic_pitch_to_named_chromatic_pitch(pitch_carrier_1, pitch_carrier_2)
MelodicDiatonicInterval('+M9')
```

Return melodic diatonic interval.

pitchtools.chromatic_pitch_class_name_to_chromatic_pitch_class_number

`abjad.tools.pitchtools.chromatic_pitch_class_name_to_chromatic_pitch_class_number` (*chromatic_pitch_class_name*)
 New in version 2.0. Change *chromatic_pitch_class_name* to chromatic pitch-class number:

```
abjad> pitchtools.chromatic_pitch_class_name_to_chromatic_pitch_class_number('cs')
1
```

Return chromatic pitch-class number.

pitchtools.chromatic_pitch_class_name_to_diatonic_pitch_class_name

`abjad.tools.pitchtools.chromatic_pitch_class_name_to_diatonic_pitch_class_name` (*chromatic_pitch_class_name*)
 New in version 2.0. Change *chromatic_pitch_class_name* to diatonic pitch-class name:

```
abjad> pitchtools.chromatic_pitch_class_name_to_diatonic_pitch_class_name('cs')
'c'
```

Return string.

pitchtools.chromatic_pitch_class_name_to_diatonic_pitch_class_name_alphabetic_accidental_abbreviation_pair

`abjad.tools.pitchtools.chromatic_pitch_class_name_to_diatonic_pitch_class_name_alphabetic_accidental_abbreviation_pair` (*chromatic_pitch_class_name*)
 New in version 1.1. Change *chromatic_pitch_class_name* to diatonic pitch-class name / alphabetic accidental abbreviation pair:

```
abjad> pitchtools.chromatic_pitch_class_name_to_diatonic_pitch_class_name_alphabetic_accidental_abbreviation_pair('cs', 's')
('c', 's')
```

Return pair of strings. Changed in version 2.0: renamed `pitchtools.name_to_letter_accidental()` to `pitchtools.chromatic_pitch_class_name_to_diatonic_pitch_class_name_alphabetic_accidental_abbreviation_pair()`.

pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name

`abjad.tools.pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name` (*chromatic_pitch_class_number*)
 New in version 1.1. Change *chromatic_pitch_class_number* to chromatic pitch-class name:

```
abjad> for n in range(0, 13):
...     pc = n / 2.0
...     pitch_name = pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name(pc)
...     print '%s    %s' % (pc, pitch_name)
...
0.0    c
0.5    cqs
1.0    cs
1.5    dqf
2.0    d
2.5    dqs
3.0    ef
3.5    eqf
4.0    e
4.5    eqs
5.0    f
5.5    fqs
6.0    fs
```

Return string. Changed in version 2.0: renamed `pitchtools.pc_to_pitch_name()` to `pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name()`.

`pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_flats`

`abjad.tools.pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_flats`

New in version 1.1. Change chromatic pitch-class number to chromatic pitch-class name with flats:

```
abjad> for n in range(13):
...     pc = n / 2.0
...     name = pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_flats(
...     print '%s    %s' % (pc, name)
...
0.0    c
0.5    dtqf
1.0    df
1.5    dqf
2.0    d
2.5    etqf
3.0    ef
3.5    eqf
4.0    e
4.5    fqf
5.0    f
5.5    gtqf
6.0    gf
```

Return string. Changed in version 2.0: renamed `pitchtools.pc_to_pitch_name_flats()` to `pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_flats()`.

`pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_sharps`

`abjad.tools.pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_sharps`

New in version 1.1. Change *chromatic_pitch_class_number* to chromatic pitch-class name with sharps:

```
abjad> for n in range(13):
...     pc = n / 2.0
...     name = pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_sharps(
...     print '%s    %s' % (pc, name)
...
0.0    c
0.5    cqs
1.0    cs
1.5    ctqs
2.0    d
2.5    dqs
3.0    ds
3.5    dtqs
4.0    e
4.5    eqs
5.0    f
5.5    fqs
6.0    fs
```

Return string. Changed in version 2.0: renamed `pitchtools.pc_to_pitch_name_sharps()` to `pitchtools.chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_sharps()`.

pitchtools.chromatic_pitch_class_number_to_diatonic_pitch_class_number

`abjad.tools.pitchtools.chromatic_pitch_class_number_to_diatonic_pitch_class_number` (*chromatic_pitch_class_number*)
New in version 2.0. Change *chromatic_pitch_class_number* to diatonic pitch-class number:

```
abjad> pitchtools.chromatic_pitch_class_number_to_diatonic_pitch_class_number(1)
0
```

Return integer.

pitchtools.chromatic_pitch_name_to_chromatic_pitch_class_name

`abjad.tools.pitchtools.chromatic_pitch_name_to_chromatic_pitch_class_name` (*chromatic_pitch_name*)
New in version 2.0. Change *chromatic_pitch_name* to chromatic pitch-class name:

```
abjad> pitchtools.chromatic_pitch_name_to_chromatic_pitch_class_name("cs' ")
'cs'
```

Return string.

pitchtools.chromatic_pitch_name_to_chromatic_pitch_class_number

`abjad.tools.pitchtools.chromatic_pitch_name_to_chromatic_pitch_class_number` (*chromatic_pitch_name*)
New in version 2.0. Change *chromatic_class_name* to chromatic pitch-class-number:

```
abjad> pitchtools.chromatic_pitch_name_to_chromatic_pitch_class_number("cs' ")
1
```

Return integer or float.

pitchtools.chromatic_pitch_name_to_chromatic_pitch_number

`abjad.tools.pitchtools.chromatic_pitch_name_to_chromatic_pitch_number` (*chromatic_pitch_name*)
New in version 2.0. Change *chromatic_pitch_name* to chromatic pitch number:

```
abjad> pitchtools.chromatic_pitch_name_to_chromatic_pitch_number("cs' ")
13
```

Return integer or float.

pitchtools.chromatic_pitch_name_to_diatonic_pitch_class_name

`abjad.tools.pitchtools.chromatic_pitch_name_to_diatonic_pitch_class_name` (*chromatic_pitch_name*)
New in version 2.0. Change *chromatic_pitch_name* to diatonic pitch name:

```
abjad> pitchtools.chromatic_pitch_name_to_diatonic_pitch_class_name("cs' ")
'c'
```

Return string.

pitchtools.chromatic_pitch_name_to_diatonic_pitch_class_number

`abjad.tools.pitchtools.chromatic_pitch_name_to_diatonic_pitch_class_number` (*chromatic_pitch_name*)
New in version 2.0. Change *chromatic_pitch_name* to diatonic pitch-class number:

```
abjad> pitchtools.chromatic_pitch_name_to_diatonic_pitch_class_number("cs'")
0
```

Return integer.

pitchtools.chromatic_pitch_name_to_diatonic_pitch_name

`abjad.tools.pitchtools.chromatic_pitch_name_to_diatonic_pitch_name(chromatic_pitch_name)`
 New in version 2.0. Change *chromatic_pitch_name* to diatonic pitch name:

```
abjad> pitchtools.chromatic_pitch_name_to_diatonic_pitch_name("cs'")
"c'"
```

Return string.

pitchtools.chromatic_pitch_name_to_diatonic_pitch_number

`abjad.tools.pitchtools.chromatic_pitch_name_to_diatonic_pitch_number(chromatic_pitch_name)`
 New in version 2.0. Change *chromatic_pitch_name* to diatonic pitch number:

```
abjad> pitchtools.chromatic_pitch_name_to_diatonic_pitch_number("cs'")
7
```

Return integer.

pitchtools.chromatic_pitch_name_to_octave_number

`abjad.tools.pitchtools.chromatic_pitch_name_to_octave_number(chromatic_pitch_name)`
 New in version 2.0. Change *chromatic_pitch_name* to octave number:

```
abjad> pitchtools.chromatic_pitch_name_to_octave_number('cs')
3
```

Return integer.

pitchtools.chromatic_pitch_names_string_to_named_chromatic_pitch_list

`abjad.tools.pitchtools.chromatic_pitch_names_string_to_named_chromatic_pitch_list(chromatic_p`
 New in version 2.0. Change *chromatic_pitch_names_string* to named chromatic pitch list:

```
abjad> pitchtools.chromatic_pitch_names_string_to_named_chromatic_pitch_list("cs, cs cs' cs'")
[NamedChromaticPitch('cs,'), NamedChromaticPitch('cs'), NamedChromaticPitch("cs'"), NamedChromat
```

Return list of named chromatic pitches.

pitchtools.chromatic_pitch_number_and_accidental_semitones_to_octave_number

`abjad.tools.pitchtools.chromatic_pitch_number_and_accidental_semitones_to_octave_number(chro`
 New in version 1.1. Change *chromatic_pitch_number* and *accidental_semitones* to octave number:


```
abjad> pitchtools.chromatic_pitch_number_and_accidental_semitones_to_octave_number(12, -2)
5
```

Return integer. Changed in version 2.0: renamed `pitchtools.pitch_number_and_accidental_semitones_to_octave_number()` to `pitchtools.chromatic_pitch_number_and_accidental_semitones_to_octave_number()`.

`pitchtools.chromatic_pitch_number_diatonic_pitch_class_name_to_alphabetic_accidental_abbreviation_octave_number`

```
abjad.tools.pitchtools.chromatic_pitch_number_diatonic_pitch_class_name_to_alphabetic_accidental_abbreviation_octave_number
```

New in version 1.1. Change *chromatic_pitch_number* and *diatonic_pitch_class_name* to alphabetic accidental abbreviation / octave number pair:

```
abjad> pitchtools.chromatic_pitch_number_diatonic_pitch_class_name_to_alphabetic_accidental_abbreviation_octave_number('ss', 5)
```

Return pair. Changed in version 2.0: renamed `pitchtools.number_letter_to_accidental_octave()` to `pitchtools.chromatic_pitch_number_diatonic_pitch_class_name_to_alphabetic_accidental_abbreviation_octave_number()`.

`pitchtools.chromatic_pitch_number_to_chromatic_pitch_class_number`

```
abjad.tools.pitchtools.chromatic_pitch_number_to_chromatic_pitch_class_number(chromatic_pitch_number)
```

New in version 2.0. Change *chromatic_pitch_number* to chromatic pitch-class number:

```
abjad> pitchtools.chromatic_pitch_number_to_chromatic_pitch_class_number(13)
1
```

Return integer or float.

`pitchtools.chromatic_pitch_number_to_chromatic_pitch_name`

```
abjad.tools.pitchtools.chromatic_pitch_number_to_chromatic_pitch_name(chromatic_pitch_number,
                                accidental_abbreviation='accidental',
                                spelling='mixed')
```

New in version 2.0. Change *chromatic_pitch_number* to chromatic pitch name:

```
abjad> pitchtools.chromatic_pitch_number_to_chromatic_pitch_name(13)
"cs' "
```

Return string.

`pitchtools.chromatic_pitch_number_to_diatonic_pitch_class_name_alphabetic_accidental_abbreviation_octave_number`

```
abjad.tools.pitchtools.chromatic_pitch_number_to_diatonic_pitch_class_name_alphabetic_accidental_abbreviation_octave_number
```

Change *chromatic_pitch_number* to diatonic pitch-class name / alphabetic accidental abbreviation / octave number triple:

```
abjad> pitchtools.chromatic_pitch_number_to_diatonic_pitch_class_name_alphabetic_accidental_abbreviations('c', 's', 5)
```

Return tuple. Changed in version 2.0: renamed `pitchtools.number_to_letter_accidental_octave()` to `pitchtools.chromatic_pitch_number_to_diatonic_pitch_class_name_alphabetic_accidental_abbreviations()`.

pitchtools.chromatic_pitch_number_to_diatonic_pitch_class_number

`abjad.tools.pitchtools.chromatic_pitch_number_to_diatonic_pitch_class_number(chromatic_pitch_number)`
New in version 2.0. Change *chromatic_pitch_number* to diatonic pitch-class number:

```
abjad> pitchtools.chromatic_pitch_number_to_diatonic_pitch_class_number(13)
0
```

Return integer.

pitchtools.chromatic_pitch_number_to_diatonic_pitch_number

`abjad.tools.pitchtools.chromatic_pitch_number_to_diatonic_pitch_number(chromatic_pitch_number)`
New in version 2.0. Change *chromatic_pitch_number* to diatonic pitch number:

```
abjad> pitchtools.chromatic_pitch_number_to_diatonic_pitch_number(13)
7
```

Return integer.

pitchtools.chromatic_pitch_number_to_octave_number

`abjad.tools.pitchtools.chromatic_pitch_number_to_octave_number(chromatic_pitch_number)`
New in version 1.1. Change *chromatic_pitch_number* to octave number:

```
abjad> pitchtools.chromatic_pitch_number_to_octave_number(13)
5
```

Return integer. Changed in version 2.0: renamed `pitchtools.pitch_number_to_octave()` to `pitchtools.chromatic_pitch_number_to_octave_number()`.

pitchtools.clef_and_staff_position_number_to_named_chromatic_pitch

`abjad.tools.pitchtools.clef_and_staff_position_number_to_named_chromatic_pitch(clef, staff_position_number)`
New in version 2.0. Change *clef* and *staff_position_number* to named chromatic pitch:

```
abjad> clef = contexttools.ClefMark('treble')
abjad> for n in range(-6, 6):
...     pitch = pitchtools.clef_and_staff_position_number_to_named_chromatic_pitch(clef, n)
...     print '%s\t%s\t%s' % (clef.clef_name, n, pitch)
treble    -6  c'
treble    -5  d'
treble    -4  e'
treble    -3  f'
treble    -2  g'
treble    -1  a'
treble     0  b'
treble     1  c''
```

```
treble 2 d''
treble 3 e''
treble 4 f''
treble 5 g''
```

Return named chromatic pitch.

pitchtools.diatonic_interval_number_and_chromatic_interval_number_to_melodic_diatonic_interval

`abjad.tools.pitchtools.diatonic_interval_number_and_chromatic_interval_number_to_melodic_diatonic_interval`

New in version 2.0. Change *diatonic_interval_number* and *chromatic_interval_number* to melodic diatonic interval:

```
abjad> pitchtools.diatonic_interval_number_and_chromatic_interval_number_to_melodic_diatonic_interval(2, 3)
MelodicDiatonicInterval('+m2')
```

Return melodic diatonic interval.

pitchtools.diatonic_pitch_class_name_to_chromatic_pitch_class_number

`abjad.tools.pitchtools.diatonic_pitch_class_name_to_chromatic_pitch_class_number` (*diatonic_pitch_class_name*)

New in version 1.1. Change *diatonic_pitch_class_name* to chromatic pitch-class number:

```
abjad> pitchtools.diatonic_pitch_class_name_to_chromatic_pitch_class_number('f')
5
```

Return integer.

pitchtools.diatonic_pitch_class_name_to_diatonic_pitch_class_number

`abjad.tools.pitchtools.diatonic_pitch_class_name_to_diatonic_pitch_class_number` (*diatonic_pitch_class_name*)

New in version 2.0. Change *diatonic_pitch_class_name* to diatonic pitch-class number:

```
abjad> pitchtools.diatonic_pitch_class_name_to_diatonic_pitch_class_number('c')
0
```

Return integer.

pitchtools.diatonic_pitch_class_number_to_chromatic_pitch_class_number

`abjad.tools.pitchtools.diatonic_pitch_class_number_to_chromatic_pitch_class_number` (*diatonic_pitch_class_number*)

New in version 2.0. Change *diatonic_pitch_class_number* to chromatic pitch-class number:

```
abjad> pitchtools.diatonic_pitch_class_number_to_chromatic_pitch_class_number(6)
11
```

Return nonnegative integer.

pitchtools.diatonic_pitch_class_number_to_diatonic_pitch_class_name

`abjad.tools.pitchtools.diatonic_pitch_class_number_to_diatonic_pitch_class_name` (*diatonic_pitch_class_number*)

New in version 2.0. Change *diatonic_pitch_class_number* to diatonic pitch-class name:

```
abjad> pitchtools.diatonic_pitch_class_number_to_diatonic_pitch_class_name(0)
'c'
```

Return string.

`pitchtools.diatonic_pitch_name_to_chromatic_pitch_class_name`

`abjad.tools.pitchtools.diatonic_pitch_name_to_chromatic_pitch_class_name` (*diatonic_pitch_name*)
New in version 2.0. Change *diatonic_pitch_name* to chromatic pitch-class name:

```
abjad> pitchtools.diatonic_pitch_name_to_chromatic_pitch_class_name("c' ' ")
'c'
```

Return string.

`pitchtools.diatonic_pitch_name_to_chromatic_pitch_class_number`

`abjad.tools.pitchtools.diatonic_pitch_name_to_chromatic_pitch_class_number` (*diatonic_pitch_name*)
New in version 2.0. Change *diatonic_pitch_name* to chromatic pitch-class number:

```
abjad> pitchtools.diatonic_pitch_name_to_chromatic_pitch_class_number("c' ' ")
0
```

Return integer.

`pitchtools.diatonic_pitch_name_to_chromatic_pitch_name`

`abjad.tools.pitchtools.diatonic_pitch_name_to_chromatic_pitch_name` (*diatonic_pitch_name*)
New in version 2.0. Change *diatonic_pitch_name* to chromatic pitch name:

```
abjad> pitchtools.diatonic_pitch_name_to_chromatic_pitch_name("c' ' ")
"c' ' "
```

Return string.

`pitchtools.diatonic_pitch_name_to_chromatic_pitch_number`

`abjad.tools.pitchtools.diatonic_pitch_name_to_chromatic_pitch_number` (*diatonic_pitch_name*)
New in version 2.0. Change *diatonic_pitch_name* to chromatic pitch number:

```
abjad> pitchtools.diatonic_pitch_name_to_chromatic_pitch_number("c' ' ")
12
```

Return integer.

`pitchtools.diatonic_pitch_name_to_diatonic_pitch_class_name`

`abjad.tools.pitchtools.diatonic_pitch_name_to_diatonic_pitch_class_name` (*diatonic_pitch_name*)
New in version 2.0. Change *diatonic_pitch_name* to diatonic pitch-class name:

```
abjad> pitchtools.diatonic_pitch_name_to_diatonic_pitch_class_name("c' ' ")
'c'
```

Return string.

pitchtools.diatonic_pitch_name_to_diatonic_pitch_class_number

`abjad.tools.pitchtools.diatonic_pitch_name_to_diatonic_pitch_class_number` (*diatonic_pitch_name*)
New in version 2.0. Change *diatonic_pitch_name* to diatonic pitch-class number:

```
abjad> pitchtools.diatonic_pitch_name_to_diatonic_pitch_class_number("c' ")
0
```

Return integer.

pitchtools.diatonic_pitch_name_to_diatonic_pitch_number

`abjad.tools.pitchtools.diatonic_pitch_name_to_diatonic_pitch_number` (*diatonic_pitch_name*)
New in version 2.0. Change *diatonic_pitch_name* to diatonic pitch number:

```
abjad> pitchtools.diatonic_pitch_name_to_diatonic_pitch_number("c' ")
7
```

Return integer.

pitchtools.diatonic_pitch_number_to_chromatic_pitch_number

`abjad.tools.pitchtools.diatonic_pitch_number_to_chromatic_pitch_number` (*diatonic_pitch_number*)
New in version 2.0. Change *diatonic_pitch_number* to chromatic pitch number:

```
abjad> pitchtools.diatonic_pitch_number_to_chromatic_pitch_number(7)
12
```

Return integer.

pitchtools.diatonic_pitch_number_to_diatonic_pitch_class_name

`abjad.tools.pitchtools.diatonic_pitch_number_to_diatonic_pitch_class_name` (*diatonic_pitch_number*)
New in version 2.0. Change *diatonic_pitch_number* to diatonic pitch-class name:

```
abjad> pitchtools.diatonic_pitch_number_to_diatonic_pitch_class_name(7)
'c'
```

Return string.

pitchtools.diatonic_pitch_number_to_diatonic_pitch_class_number

`abjad.tools.pitchtools.diatonic_pitch_number_to_diatonic_pitch_class_number` (*diatonic_pitch_number*)
New in version 2.0. Change *diatonic_pitch_number* to diatonic pitch-class number:

```
abjad> pitchtools.diatonic_pitch_number_to_diatonic_pitch_class_number(7)
0
```

Return nonnegative integer.

pitchtools.diatonic_pitch_number_to_diatonic_pitch_name

`abjad.tools.pitchtools.diatonic_pitch_number_to_diatonic_pitch_name` (*diatonic_pitch_number*)
New in version 2.0. Change *diatonic_pitch_number* to diatonic pitch name:

```
abjad> pitchtools.diatonic_pitch_number_to_diatonic_pitch_name(7)
"c' "
```

Return string.

`pitchtools.expr_has_duplicate_named_chromatic_pitch`

`abjad.tools.pitchtools.expr_has_duplicate_named_chromatic_pitch(expr)`

New in version 2.0. True when *expr* has duplicate named chromatic pitch. Otherwise false:

```
abjad> chord = Chord([13, 13, 14], (1, 4))
abjad> pitchtools.expr_has_duplicate_named_chromatic_pitch(chord)
True
```

Return boolean.

`pitchtools.expr_has_duplicate_numbered_chromatic_pitch_class`

`abjad.tools.pitchtools.expr_has_duplicate_numbered_chromatic_pitch_class(expr)`

New in version 2.0. True when *expr* has duplicate numbered chromatic pitch-class. Otherwise false:

```
abjad> chord = Chord([1, 13, 14], (1, 4))
abjad> pitchtools.expr_has_duplicate_numbered_chromatic_pitch_class(chord)
True
```

Return boolean. Changed in version 2.0: renamed `pitchtools.expr_has_duplicate_numeric_chromatic_pitch` to `pitchtools.expr_has_duplicate_numbered_chromatic_pitch_class()`.

`pitchtools.expr_to_melodic_chromatic_interval_segment`

`abjad.tools.pitchtools.expr_to_melodic_chromatic_interval_segment(expr)`

New in version 2.0. Change *expr* to melodic chromatic interval segment:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
abjad> pitchtools.expr_to_melodic_chromatic_interval_segment(staff)
MelodicChromaticIntervalSegment(+2, +2, +1, +2, +2, +2, +1)
```

Return melodic chromatic interval segment.

`pitchtools.get_named_chromatic_pitch_from_pitch_carrier`

`abjad.tools.pitchtools.get_named_chromatic_pitch_from_pitch_carrier(pitch_carrier)`

New in version 1.1. Get named chromatic pitch from *pitch_carrier*:

```
abjad> pitch = pitchtools.NamedChromaticPitch('df', 5)
abjad> pitch
NamedChromaticPitch("df' ")
abjad> pitchtools.get_named_chromatic_pitch_from_pitch_carrier(pitch)
NamedChromaticPitch("df' ")

abjad> note = Note(('df', 5), (1, 4))
abjad> note
Note("df' 4")
abjad> pitchtools.get_named_chromatic_pitch_from_pitch_carrier(note)
NamedChromaticPitch("df' ")
```

```

abjad> note = Note(('df', 5), (1, 4))
abjad> note.note_head
NoteHead("df'")
abjad> pitchtools.get_named_chromatic_pitch_from_pitch_carrier(note.note_head)
NamedChromaticPitch("df'")

abjad> chord = Chord([('df', 5)], (1, 4))
abjad> chord
Chord("<df'>4")
abjad> pitchtools.get_named_chromatic_pitch_from_pitch_carrier(chord)
NamedChromaticPitch("df'")

abjad> pitchtools.get_named_chromatic_pitch_from_pitch_carrier(13)
NamedChromaticPitch("cs'")

```

Raise missing pitch error when *pitch_carrier* carries no pitch.

Raise extra pitch error when *pitch_carrier* carries more than one pitch.

Return named chromatic pitch. Changed in version 2.0: renamed `pitchtools.get_pitch()` to `pitchtools.get_named_chromatic_pitch_from_pitch_carrier()`.

`pitchtools.get_numbered_chromatic_pitch_class_from_pitch_carrier`

`abjad.tools.pitchtools.get_numbered_chromatic_pitch_class_from_pitch_carrier(pitch_carrier)`
 New in version 2.0. Get numbered chromatic pitch-class from *pitch_carrier*:

```

abjad> note = Note("cs' 4")
abjad> pitchtools.get_numbered_chromatic_pitch_class_from_pitch_carrier(note)
NumberedChromaticPitchClass(1)

```

Raise missing pitch error on empty chords.

Raise extra pitch error on many-note chords.

Return numbered chromatic pitch-class. Changed in version 2.0: renamed `pitchtools.get_numeric_chromatic_pitch_class_from_pitch_carrier()` to `pitchtools.get_numbered_chromatic_pitch_class_from_pitch_carrier()`.

`pitchtools.insert_and_transpose_nested_subruns_in_chromatic_pitch_class_number_list`

`abjad.tools.pitchtools.insert_and_transpose_nested_subruns_in_chromatic_pitch_class_number_list`

New in version 1.1. Insert and transpose nested subruns in *chromatic_pitch_class_number_list* according to *subrun_indicators*:

```

abjad> notes = [Note(p, (1, 4)) for p in [0, 2, 7, 9, 5, 11, 4]]
abjad> subrun_indicators = [(0, [2, 4]), (4, [3, 1])]
abjad> pitchtools.insert_and_transpose_nested_subruns_in_chromatic_pitch_class_number_list(notes)

abjad> t = []
abjad> for x in notes:
...     try:
...         t.append(x.written_pitch.chromatic_pitch_number)
...     except AttributeError:
...         t.append([y.written_pitch.chromatic_pitch_number for y in x])

```

```
abjad> t
[0, [5, 7], 2, [4, 0, 6, 11], 7, 9, 5, [10, 6, 8], 11, [7], 4]
```

Set *subrun_indicators* to a list of zero or more (index, length_list) pairs.

For each (index, length_list) pair in *subrun_indicators* the function will read *index* mod len(notes) and insert a subrun of length length_list[0] immediately after notes[index], a subrun of length length_list[1] immediately after notes[index+1], and, in general, a subrun of length_list[i] immediately after notes[index+i], for $i < \text{length}(\text{length_list})$.

New subruns are wrapped with lists. These wrapper lists are designed to allow inspection of the structural changes to *notes* immediately after the function returns. For this reason most calls to this function will be followed by `notes = sequencetools.flatten_sequence(notes):`

```
abjad> from abjad.tools import sequencetools
abjad> notes = sequencetools.flatten_sequence(notes)
abjad> notes
[Note("c'4"), Note("f'4"), Note("g'4"), Note("d'4"), Note("e'4"), Note("c'4"), Note("fs'4"), Not
```

This function is designed to work on a built-in Python list of notes. This function is **not** designed to work on Abjad voices, staves or other containers because the function currently implements no spanner-handling. That is, this function is designed to be used during precomposition when other, similar abstract pitch transforms may be common.

Return list of integers and / or floats. Changed in version 2.0: renamed `pitchtools.insert_transposed_pc_subruns()` to `pitchtools.insert_and_transpose_nested_subruns()`

`pitchtools.instantiate_pitch_and_interval_test_collection`

```
abjad.tools.pitchtools.instantiate_pitch_and_interval_test_collection()
```

New in version 2.0. Instantiate pitch and interval test collection:

```
abjad> for x in pitchtools.instantiate_pitch_and_interval_test_collection(): x
...
HarmonicChromaticInterval(1)
HarmonicChromaticIntervalClass(1)
HarmonicCounterpointInterval(1)
HarmonicCounterpointIntervalClass(1)
HarmonicDiatonicInterval('M2')
HarmonicDiatonicIntervalClass('M2')
InversionEquivalentChromaticIntervalClass(1)
InversionEquivalentDiatonicIntervalClass('M2')
MelodicChromaticInterval(+1)
MelodicChromaticIntervalClass(+1)
MelodicCounterpointInterval(1)
MelodicCounterpointIntervalClass(+1)
MelodicDiatonicInterval('+M2')
MelodicDiatonicIntervalClass('+M2')
NamedChromaticPitch('c')
NamedChromaticPitchClass('c')
NamedDiatonicPitch('c')
NamedDiatonicPitchClass('c')
NumberedChromaticPitch(1)
NumberedChromaticPitchClass(1)
NumberedDiatonicPitch(1)
NumberedDiatonicPitchClass(1)
```

Use to test pitch and interval interface consistency.

Return list.

pitchtools.inventory_aggregate_subsets

`abjad.tools.pitchtools.inventory_aggregate_subsets()`

New in version 2.0. Inventory aggregate subsets:

```
abjad> U_star = pitchtools.inventory_aggregate_subsets()
abjad> len(U_star)
4096
abjad> for pcset in U_star[:20]:
...     pcset
NumberedChromaticPitchClassSet([])
NumberedChromaticPitchClassSet([0])
NumberedChromaticPitchClassSet([1])
NumberedChromaticPitchClassSet([0, 1])
NumberedChromaticPitchClassSet([2])
NumberedChromaticPitchClassSet([0, 2])
NumberedChromaticPitchClassSet([1, 2])
NumberedChromaticPitchClassSet([0, 1, 2])
NumberedChromaticPitchClassSet([3])
NumberedChromaticPitchClassSet([0, 3])
NumberedChromaticPitchClassSet([1, 3])
NumberedChromaticPitchClassSet([0, 1, 3])
NumberedChromaticPitchClassSet([2, 3])
NumberedChromaticPitchClassSet([0, 2, 3])
NumberedChromaticPitchClassSet([1, 2, 3])
NumberedChromaticPitchClassSet([0, 1, 2, 3])
NumberedChromaticPitchClassSet([4])
NumberedChromaticPitchClassSet([0, 4])
NumberedChromaticPitchClassSet([1, 4])
NumberedChromaticPitchClassSet([0, 1, 4])
```

There are 4096 subsets of the aggregate.

This is U^* in [Morris 1987].

Return list of numbered chromatic pitch-class sets.

pitchtools.inventory_inversion_equivalent_diatonic_interval_classes

`abjad.tools.pitchtools.inventory_inversion_equivalent_diatonic_interval_classes()`

New in version 2.0. Inventory inversion-equivalent diatonic interval-classes:

```
abjad> for dic in pitchtools.inventory_inversion_equivalent_diatonic_interval_classes():
...     dic
...
InversionEquivalentDiatonicIntervalClass('P1')
InversionEquivalentDiatonicIntervalClass('aug1')
InversionEquivalentDiatonicIntervalClass('m2')
InversionEquivalentDiatonicIntervalClass('M2')
InversionEquivalentDiatonicIntervalClass('aug2')
InversionEquivalentDiatonicIntervalClass('dim3')
InversionEquivalentDiatonicIntervalClass('m3')
InversionEquivalentDiatonicIntervalClass('M3')
InversionEquivalentDiatonicIntervalClass('dim4')
InversionEquivalentDiatonicIntervalClass('P4')
InversionEquivalentDiatonicIntervalClass('aug4')
```

There are 11 inversion-equivalent diatonic interval-classes.

It is an open question as to whether octaves should be included.

Return list of inversion-equivalent diatonic interval-classes.

pitchtools.is_alphabetic_accidental_abbreviation

`abjad.tools.pitchtools.is_alphabetic_accidental_abbreviation(expr)`

New in version 2.0. True when *expr* is an alphabetic accidental abbreviation. Otherwise false:

```
abjad> pitchtools.is_alphabetic_accidental_abbreviation('tqs')
True
```

The regex `^([s]{1,2}|[f]{1,2}|t?q?[fs])!?$` underlies this predicate.

Return boolean.

pitchtools.is_chromatic_pitch_class_name

`abjad.tools.pitchtools.is_chromatic_pitch_class_name(expr)`

New in version 2.0. True when *expr* is a chromatic pitch-class name. Otherwise false:

```
abjad> pitchtools.is_chromatic_pitch_class_name('fs')
True
```

The regex `^([a-g,A-G])((([s]{1,2}|[f]{1,2}|t?q?[fs])|)!)$` underlies this predicate.

Return boolean.

pitchtools.is_chromatic_pitch_class_name_octave_number_pair

`abjad.tools.pitchtools.is_chromatic_pitch_class_name_octave_number_pair(expr)`

New in version 1.1. True when *arg* has the form of a chromatic pitch-class / octave number pair. Otherwise false:

```
abjad> pitchtools.is_chromatic_pitch_class_name_octave_number_pair(('cs', 5))
True
```

Return boolean. Changed in version 2.0: renamed `pitchtools.is_pair()` to `pitchtools.is_chromatic_pitch_class_name_octave_number_pair()`.

pitchtools.is_chromatic_pitch_class_number

`abjad.tools.pitchtools.is_chromatic_pitch_class_number(expr)`

New in version 2.0. True *expr* is a chromatic pitch-class number. Otherwise false:

```
abjad> pitchtools.is_chromatic_pitch_class_number(1)
True
```

The chromatic pitch-class numbers are equal to the set `[0, 0.5, ..., 11, 11.5]`.

Return boolean.

pitchtools.is_chromatic_pitch_name

`abjad.tools.pitchtools.is_chromatic_pitch_name(expr)`

New in version 2.0. True *expr* is a chromatic pitch name. Otherwise false:

```
abjad> pitchtools.is_chromatic_pitch_name('c,')
True
```

The regex `^([a-g,A-G])((([s]{1,2}|[f]{1,2}|t?q?[f,s]|)!)?) (,+|'+|)|)$` underlies this predicate.

Return boolean.

pitchtools.is_chromatic_pitch_number

`abjad.tools.pitchtools.is_chromatic_pitch_number(expr)`

New in version 2.0. True *expr* is a chromatic pitch number. Otherwise false:

```
abjad> pitchtools.is_chromatic_pitch_number(13)
True
```

The chromatic pitch numbers are equal to the set of all integers in union with the set of all integers plus or minus 0.5.

Return boolean.

pitchtools.is_diatonic_pitch_class_name

`abjad.tools.pitchtools.is_diatonic_pitch_class_name(expr)`

New in version 2.0. True when *expr* is a diatonic pitch-class name. Otherwise false:

```
abjad> pitchtools.is_diatonic_pitch_class_name('c')
True
```

The regex `^[a-g,A-G]$` underlies this predicate.

Return boolean.

pitchtools.is_diatonic_pitch_class_number

`abjad.tools.pitchtools.is_diatonic_pitch_class_number(expr)`

New in version 2.0. True when *expr* is a diatonic pitch-class number. Otherwise false:

```
abjad> pitchtools.is_diatonic_pitch_class_number(0)
True
```

The diatonic pitch-class numbers are equal to the set `[0, 1, 2, 3, 4, 5, 6]`.

Return boolean.

pitchtools.is_diatonic_pitch_name

`abjad.tools.pitchtools.is_diatonic_pitch_name(expr)`

New in version 2.0. True when *expr* is a diatonic pitch name. Otherwise false:

```
abjad> pitchtools.is_diatonic_pitch_name("c' ")
True
```

The regex `(^[a-g,A-G])(, +|' +|)$` underlies this predicate.

Return boolean.

pitchtools.is_diatonic_pitch_number

`abjad.tools.pitchtools.is_diatonic_pitch_number(expr)`
New in version 2.0. True when *expr* is a diatonic pitch number. Otherwise false:

```
abjad> pitchtools.is_diatonic_pitch_number(7)
True
```

The diatonic pitch numbers are equal to the set of integers.

Return boolean.

pitchtools.is_diatonic_quality_abbreviation

`abjad.tools.pitchtools.is_diatonic_quality_abbreviation(expr)`
New in version 2.0. True when *expr* is a diatonic quality abbreviation. Otherwise false:

```
abjad> pitchtools.is_diatonic_quality_abbreviation('aug')
True
```

The regex `^M|m|P|aug|dim$` underlies this predicate.

Return boolean.

pitchtools.is_harmonic_diatonic_interval_abbreviation

`abjad.tools.pitchtools.is_harmonic_diatonic_interval_abbreviation(expr)`
New in version 2.0. True when *expr* is a harmonic diatonic interval abbreviation. Otherwise false:

```
abjad> pitchtools.is_harmonic_diatonic_interval_abbreviation('M9')
True
```

The regex `^(M|m|P|aug|dim)(\d+)$` underlies this predicate.

Return boolean.

pitchtools.is_melodic_diatonic_interval_abbreviation

`abjad.tools.pitchtools.is_melodic_diatonic_interval_abbreviation(expr)`
New in version 2.0. True when *expr* is a melodic diatonic interval abbreviation. Otherwise false:

```
abjad> pitchtools.is_melodic_diatonic_interval_abbreviation('+M9')
True
```

The regex `^([+,-]?)(M|m|P|aug|dim)(\d+)$` underlies this predicate.

Return boolean.

pitchtools.is_named_chromatic_pitch_token

`abjad.tools.pitchtools.is_named_chromatic_pitch_token(pitch_token)`

New in version 1.1. True when *pitch_token* has the form of an Abjad pitch token. Otherwise false:

```
abjad> pitchtools.is_named_chromatic_pitch_token('c', 4)
True
```

Return boolean. Changed in version 2.0: renamed `pitchtools.is_pitch_token()` to `pitchtools.is_named_chromatic_pitch_token()`.

pitchtools.is_octave_tick_string

`abjad.tools.pitchtools.is_octave_tick_string(expr)`

New in version 2.0. True when *expr* is an octave tick string. Otherwise false:

```
abjad> pitchtools.is_octave_tick_string(',,,')
True
```

The regex `^,+|'+|'$` underlies this predicate.

Return boolean.

pitchtools.is_pitch_carrier

`abjad.tools.pitchtools.is_pitch_carrier(expr)`

New in version 1.1. True when *expr* is an Abjad pitch, note, note-head of chord instance. Otherwise false:

```
abjad> note = Note("c'4")
abjad> pitchtools.is_pitch_carrier(note)
True
```

Return boolean. Changed in version 2.0: renamed `pitchtools.is_carrier()` to `pitchtools.is_pitch_carrier()`.

pitchtools.is_pitch_class_octave_number_string

`abjad.tools.pitchtools.is_pitch_class_octave_number_string(expr)`

New in version 2.5. True when *expr* is a pitch-class / octave number string. Otherwise false:

```
abjad> pitchtools.is_pitch_class_octave_number_string('C#2')
True
```

Quartertone accidentals are supported.

The regex `^([A-G])([#]{1,2}|[b]{1,2}|[#]?[+]|[b]?[~]|)([-]?[0-9]+)$` underlies this predicate.

Return boolean.

pitchtools.is_symbolic_accidental_string

`abjad.tools.pitchtools.is_symbolic_accidental_string(expr)`

New in version 2.5. True when *expr* is a symbolic accidental string. Otherwise false:

```
abjad> pitchtools.is_symbolic_accidental_string('#+')
True
```

True on empty string.

The regex `^([\#\{1,2\}|[b]\{1,2\}|[\#]?[+]|[b]?[~]|)\$` underlies this predicate.

Return boolean.

`pitchtools.is_symbolic_pitch_range_string`

`abjad.tools.pitchtools.is_symbolic_pitch_range_string(expr)`
 New in version 2.5. True when *expr* is a symbolic pitch range string. Otherwise false:

```
abjad> pitchtools.is_symbolic_pitch_range_string('[A0, C8]')
True
```

The regex that underlies this predicate matches against two comma-separated pitch indicators enclosed in some combination of square brackets and round parentheses.

Return boolean.

`pitchtools.iterate_named_chromatic_pitch_pairs_forward_in_expr`

`abjad.tools.pitchtools.iterate_named_chromatic_pitch_pairs_forward_in_expr(expr)`
 New in version 2.0. Iterate left-to-right, top-to-bottom named chromatic pitch pairs in *expr*:

```
abjad> score = Score([])
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8"), Note("g'4")]
abjad> score.append(Staff(notes))
abjad> notes = [Note(x, (1, 4)) for x in [-12, -15, -17]]
abjad> score.append(Staff(notes))
abjad> contexttools.ClefMark('bass')(score[1])
ClefMark('bass')(Staff{3})
```

```
abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8
    e'8
    f'8
    g'4
  }
  \new Staff {
    \clef "bass"
    c4
    a,4
    g,4
  }
>>
```

```
abjad> for pair in pitchtools.iterate_named_chromatic_pitch_pairs_forward_in_expr(score):
...     pair
...
(NamedChromaticPitch("c'"), NamedChromaticPitch('c'))
(NamedChromaticPitch("c'"), NamedChromaticPitch("d'"))
(NamedChromaticPitch('c'), NamedChromaticPitch("d'"))
```

```
(NamedChromaticPitch("d' "), NamedChromaticPitch("e' "))
(NamedChromaticPitch("d' "), NamedChromaticPitch('a, '))
(NamedChromaticPitch('c' ), NamedChromaticPitch("e' "))
(NamedChromaticPitch('c' ), NamedChromaticPitch('a, '))
(NamedChromaticPitch("e' "), NamedChromaticPitch('a, '))
(NamedChromaticPitch("e' "), NamedChromaticPitch("f' "))
(NamedChromaticPitch('a, '), NamedChromaticPitch("f' "))
(NamedChromaticPitch("f' "), NamedChromaticPitch("g' "))
(NamedChromaticPitch("f' "), NamedChromaticPitch('g, '))
(NamedChromaticPitch('a, '), NamedChromaticPitch("g' "))
(NamedChromaticPitch('a, '), NamedChromaticPitch('g, '))
(NamedChromaticPitch("g' "), NamedChromaticPitch('g, '))
```

Chords are handled correctly.

```
abjad> chord_1 = Chord([0, 2, 4], (1, 4))
abjad> chord_2 = Chord([17, 19], (1, 4))
abjad> staff = Staff([chord_1, chord_2])

abjad> f(staff)
\new Staff {
    <c' d' e'>4
    <f'' g''>4
}

abjad> for pair in pitchtools.iterate_named_chromatic_pitch_pairs_forward_in_expr(staff):
...     print pair
(NamedChromaticPitch("c' "), NamedChromaticPitch("d' "))
(NamedChromaticPitch("c' "), NamedChromaticPitch("e' "))
(NamedChromaticPitch("d' "), NamedChromaticPitch("e' "))
(NamedChromaticPitch("c' "), NamedChromaticPitch("f'' "))
(NamedChromaticPitch("c' "), NamedChromaticPitch("g'' "))
(NamedChromaticPitch("d' "), NamedChromaticPitch("f'' "))
(NamedChromaticPitch("d' "), NamedChromaticPitch("g'' "))
(NamedChromaticPitch("e' "), NamedChromaticPitch("f'' "))
(NamedChromaticPitch("e' "), NamedChromaticPitch("g'' "))
(NamedChromaticPitch("f'' "), NamedChromaticPitch("g'' "))
```

Return generator.

`pitchtools.list_chromatic_pitch_numbers_in_expr`

`abjad.tools.pitchtools.list_chromatic_pitch_numbers_in_expr(expr)`

New in version 2.0. List chromatic pitch numbers in *expr*:

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> pitchtools.list_chromatic_pitch_numbers_in_expr(tuplet)
(0, 2, 4)
```

Return tuple of zero or more numbers.

`pitchtools.list_harmonic_chromatic_intervals_in_expr`

`abjad.tools.pitchtools.list_harmonic_chromatic_intervals_in_expr(expr)`

New in version 2.0. List harmonic chromatic intervals in *expr*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> for interval in sorted(pitchtools.list_harmonic_chromatic_intervals_in_expr(staff)):
...     interval
...
HarmonicChromaticInterval(1)
HarmonicChromaticInterval(2)
HarmonicChromaticInterval(2)
HarmonicChromaticInterval(3)
HarmonicChromaticInterval(4)
HarmonicChromaticInterval(5)
```

Return unordered set.

`pitchtools.list_harmonic_diatonic_intervals_in_expr`

`abjad.tools.pitchtools.list_harmonic_diatonic_intervals_in_expr(expr)`

New in version 2.0. List harmonic diatonic intervals in *expr*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> for interval in sorted(pitchtools.list_harmonic_diatonic_intervals_in_expr(staff)):
...     interval
...
HarmonicDiatonicInterval('m2')
HarmonicDiatonicInterval('M2')
HarmonicDiatonicInterval('M2')
HarmonicDiatonicInterval('m3')
HarmonicDiatonicInterval('M3')
HarmonicDiatonicInterval('P4')
```

Return unordered set.

`pitchtools.list_inversion_equivalent_chromatic_interval_classes_pairwise_between_pitch_carriers`

`abjad.tools.pitchtools.list_inversion_equivalent_chromatic_interval_classes_pairwise_between`

New in version 2.0. List inversion-equivalent chromatic interval-classes pairwise between *pitch_carriers*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8
}
```

```
abjad> pitchtools.list_inversion_equivalent_chromatic_interval_classes_pairwise_between_pitch_carriers(staff)
[InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(1)]
```



```

abjad> pitchtools.list_inversion_equivalent_chromatic_interval_classes_pairwise_between_pitch_carriers(
[InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(1), InversionEquivalentChromaticIntervalClass(0)]

abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8"), Note("g'8"), Note("a'8"), Note("b'8"), Note("c''8")]
abjad> notes.reverse()
abjad> notes
[Note("c''8"), Note("b'8"), Note("a'8"), Note("g'8"), Note("f'8"), Note("e'8"), Note("d'8"), Note("c'8")]

abjad> pitchtools.list_inversion_equivalent_chromatic_interval_classes_pairwise_between_pitch_carriers(
[InversionEquivalentChromaticIntervalClass(1), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(1), InversionEquivalentChromaticIntervalClass(2)]

abjad> pitchtools.list_inversion_equivalent_chromatic_interval_classes_pairwise_between_pitch_carriers(
[InversionEquivalentChromaticIntervalClass(1), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(1), InversionEquivalentChromaticIntervalClass(2), InversionEquivalentChromaticIntervalClass(0)]

```

When `wrap = False` do not return `pitch_carriers[-1] - pitch_carriers[0]` as last in series.

When `wrap = True` do return `pitch_carriers[-1] - pitch_carriers[0]` as last in series.

Return list.

`pitchtools.list_melodic_chromatic_interval_numbers_pairwise_between_pitch_carriers`

`abjad.tools.pitchtools.list_melodic_chromatic_interval_numbers_pairwise_between_pitch_carriers`

New in version 1.1. List melodic chromatic interval numbers pairwise between *pitch_carriers*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
abjad> print staff.format
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'8
    a'8
    b'8
    c''8
}

abjad> pitchtools.list_melodic_chromatic_interval_numbers_pairwise_between_pitch_carriers(staff)
[2, 2, 1, 2, 2, 2, 1]

abjad> pitchtools.list_melodic_chromatic_interval_numbers_pairwise_between_pitch_carriers(staff,
[2, 2, 1, 2, 2, 2, 1, -12]

abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8"), Note("g'8"), Note("a'8"), Note("b'8"), Note("c''8")]
abjad> notes.reverse()
abjad> notes
[Note("c''8"), Note("b'8"), Note("a'8"), Note("g'8"), Note("f'8"), Note("e'8"), Note("d'8"), Note("c'8")]

```

```
abjad> pitchtools.list_melodic_chromatic_interval_numbers_pairwise_between_pitch_carriers(notes)
[-1, -2, -2, -2, -1, -2, -2]

abjad> pitchtools.list_melodic_chromatic_interval_numbers_pairwise_between_pitch_carriers(notes,
[-1, -2, -2, -2, -1, -2, -2, 12])
```

When `wrap = False` do not return `pitch_carriers[-1] - pitch_carriers[0]` as last in series.

When `wrap = True` do return `pitch_carriers[-1] - pitch_carriers[0]` as last in series.

Return list. Changed in version 2.0: renamed `pitchtools.get_signed_interval_series()` to `pitchtools.list_melodic_chromatic_interval_numbers_pairwise_between_pitch_carriers()`.

`pitchtools.list_named_chromatic_pitch_carriers_in_expr_sorted_by_numbered_chromatic_pitch_class`

`abjad.tools.pitchtools.list_named_chromatic_pitch_carriers_in_expr_sorted_by_numbered_chromatic_pitch_class`
 New in version 2.0. List named chromatic pitch carriers in *expr* sorted by numbered chromatic pitch-class:

```
abjad> chord = Chord([9, 11, 12, 14, 16], (1, 4))
abjad> notes = chordtools.arpeggiate_chord(chord)
abjad> pitchtools.list_named_chromatic_pitch_carriers_in_expr_sorted_by_numbered_chromatic_pitch_class(notes)
[Note("c'4"), Note("d'4"), Note("e'4"), Note("a'4"), Note("b'4")]
```

The elements in *pitch_carriers* are not changed in any way.

Return list. Changed in version 2.0: renamed `pitchtools.list_named_chromatic_pitch_carriers_in_expr_sorted_by_numbered_chromatic_pitch_class` to `pitchtools.list_named_chromatic_pitch_carriers_in_expr_sorted_by_numbered_chromatic_pitch_class`.

`pitchtools.list_named_chromatic_pitches_in_expr`

`abjad.tools.pitchtools.list_named_chromatic_pitches_in_expr` (*expr*)
 New in version 2.0. List named chromatic pitches in *expr*:

```
abjad> t = Staff("c'4 d'4 e'4 f'4")
abjad> beam = spannertools.BeamSpanner(t[:])
abjad> pitchtools.list_named_chromatic_pitches_in_expr(beam)
(NamedChromaticPitch("c'"), NamedChromaticPitch("d'"), NamedChromaticPitch("e'"), NamedChromaticPitch("f'))
```

Return tuple.

`pitchtools.list_numbered_chromatic_pitch_classes_in_expr`

`abjad.tools.pitchtools.list_numbered_chromatic_pitch_classes_in_expr` (*expr*)
 New in version 2.0. List numbered chromatic pitch-classes in *expr*:

```
abjad> chord = Chord([13, 14, 15], (1, 4))
abjad> pitchtools.list_numbered_chromatic_pitch_classes_in_expr(chord)
(NumberedChromaticPitchClass(1), NumberedChromaticPitchClass(2), NumberedChromaticPitchClass(3))
```

Works with notes, chords, defective chords.

Return tuple or zero or more numbered chromatic pitch-classes. Changed in version 2.0: renamed `pitchtools.list_numeric_chromatic_pitch_classes_in_expr()` to `pitchtools.list_numbered_chromatic_pitch_classes_in_expr()`.

`pitchtools.list_octave_transpositions_of_pitch_carrier_within_pitch_range`

`abjad.tools.pitchtools.list_octave_transpositions_of_pitch_carrier_within_pitch_range` (*pitch_carrier*, *pitch_range*)

New in version 1.1. List octave transpositions of *pitch_carrier* in *pitch_range*:

```
abjad> chord = Chord([0, 2, 4], (1, 4))
abjad> pitch_range = pitchtools.PitchRange(0, 48)
abjad> pitchtools.list_octave_transpositions_of_pitch_carrier_within_pitch_range(chord, pitch_range)
[Chord("<c' d' e'>4"), Chord("<c'' d'' e''>4"), Chord("<c''' d''' e'''>4"), Chord("<c'''' d'''' e''''>4")]
```

Return list of newly created *pitch_carrier* objects.

`pitchtools.list_ordered_named_chromatic_pitch_pairs_from_expr_1_to_expr_2`

`abjad.tools.pitchtools.list_ordered_named_chromatic_pitch_pairs_from_expr_1_to_expr_2` (*expr_1*, *expr_2*)

New in version 2.0. List ordered named chromatic pitch pairs from *expr_1* to *expr_2*:

```
abjad> chord_1 = Chord([0, 1, 2], (1, 4))
abjad> chord_2 = Chord([3, 4], (1, 4))
abjad> for pair in pitchtools.list_ordered_named_chromatic_pitch_pairs_from_expr_1_to_expr_2(chord_1, chord_2):
...     pair
(NamedChromaticPitch("c'"), NamedChromaticPitch("ef'"))
(NamedChromaticPitch("c'"), NamedChromaticPitch("e'"))
(NamedChromaticPitch("cs'"), NamedChromaticPitch("ef'"))
(NamedChromaticPitch("cs'"), NamedChromaticPitch("e'"))
(NamedChromaticPitch("d'"), NamedChromaticPitch("ef'"))
(NamedChromaticPitch("d'"), NamedChromaticPitch("e'"))
```

Return generator.

`pitchtools.list_unordered_named_chromatic_pitch_pairs_in_expr`

`abjad.tools.pitchtools.list_unordered_named_chromatic_pitch_pairs_in_expr` (*expr*)

New in version 2.0. List unordered named chromatic pitch pairs in *expr*:

```
abjad> for pair in pitchtools.list_unordered_named_chromatic_pitch_pairs_in_expr(Chord([0, 1, 2], (1, 4))):
...     pair
...
(NamedChromaticPitch("c'"), NamedChromaticPitch("cs'"))
(NamedChromaticPitch("c'"), NamedChromaticPitch("d'"))
(NamedChromaticPitch("c'"), NamedChromaticPitch("ef'"))
(NamedChromaticPitch("cs'"), NamedChromaticPitch("d'"))
(NamedChromaticPitch("cs'"), NamedChromaticPitch("ef'"))
(NamedChromaticPitch("d'"), NamedChromaticPitch("ef'"))
```

Return generator.

`pitchtools.make_n_middle_c_centered_pitches`

`abjad.tools.pitchtools.make_n_middle_c_centered_pitches` (*n*)

New in version 2.0. Make *n* middle-c centered pitches, where $0 < n$:

```
abjad> for p in pitchtools.make_n_middle_c_centered_pitches(5): p
NamedChromaticPitch('f')
NamedChromaticPitch('a')
NamedChromaticPitch("c' ")
NamedChromaticPitch("e' ")
NamedChromaticPitch("g' ")

abjad> for p in pitchtools.make_n_middle_c_centered_pitches(4): p
NamedChromaticPitch('g')
NamedChromaticPitch('b')
NamedChromaticPitch("d' ")
NamedChromaticPitch("f' ")
```

Return list of zero or more named chromatic pitches.

pitchtools.named_chromatic_pitch_and_clef_to_staff_position_number

`abjad.tools.pitchtools.named_chromatic_pitch_and_clef_to_staff_position_number` (*pitch*, *clef*)

New in version 2.0. Change named chromatic *pitch* and *clef* to staff position number:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
abjad> clef = contexttools.ClefMark('treble')
abjad> for note in staff:
...     written_pitch = note.written_pitch
...     number = pitchtools.named_chromatic_pitch_and_clef_to_staff_position_number(written_pitch,
...     print '%s\t%s' % (written_pitch, number)
c'      -6
d'      -5
e'      -4
f'      -3
g'      -2
a'      -1
b'       0
c''      1
```

Return integer.

pitchtools.named_chromatic_pitch_tokens_to_named_chromatic_pitches

`abjad.tools.pitchtools.named_chromatic_pitch_tokens_to_named_chromatic_pitches` (*pitch_tokens*)

New in version 2.0. Change named chromatic *pitch_tokens* to named chromatic pitches:

```
abjad> pitchtools.named_chromatic_pitch_tokens_to_named_chromatic_pitches([0, 2, ('ef', 4)])
[NamedChromaticPitch("c' "), NamedChromaticPitch("d' "), NamedChromaticPitch("ef' ")]
```

Return list of zero or more named chromatic pitches.

pitchtools.named_chromatic_pitches_to_harmonic_chromatic_interval_class_number_dictionary

`abjad.tools.pitchtools.named_chromatic_pitches_to_harmonic_chromatic_interval_class_number_dictionary`

New in version 1.1. Change named chromatic pitches to harmonic chromatic interval-class number dictionary:

```
abjad> chord = Chord([0, 2, 11], (1, 4))
abjad> vector = pitchtools.named_chromatic_pitches_to_harmonic_chromatic_interval_class_number_dictionary(chord)
```

```
abjad> vector
{0: 0, 1: 0, 2: 1, 3: 0, 4: 0, 5: 0, 6: 0, 7: 0, 8: 0, 9: 1, 10: 0, 11: 1}
```

Return dictionary. Changed in version 2.0: renamed `pitchtools.get_interval_vector()` to `pitchtools.named_chromatic_pitches_to_harmonic_chromatic_interval_class_number_dictionary`.

pitchtools.named_chromatic_pitches_to_inversion_equivalent_chromatic_interval_class_number_dictionary

`abjad.tools.pitchtools.named_chromatic_pitches_to_inversion_equivalent_chromatic_interval_class_number_dictionary`
 New in version 1.1. Change named chromatic *pitches* to inversion-equivalent chromatic interval-class number dictionary:

```
abjad> chord = Chord([0, 2, 11], (1, 4))
abjad> vector = pitchtools.named_chromatic_pitches_to_inversion_equivalent_chromatic_interval_class_number_dictionary[chord]
abjad> for i in range(7):
...     print '\t%s\t%s' % (i, vector[i])
...
0 0
1 1
2 1
3 1
4 0
5 0
6 0
```

Changed in version 2.0: works with quartertones. Return dictionary. Changed in version 2.0: renamed `pitchtools.get_interval_class_vector()` to `pitchtools.named_chromatic_pitches_to_inversion_equivalent_chromatic_interval_class_number_dictionary`.

pitchtools.octave_number_to_octave_tick_string

`abjad.tools.pitchtools.octave_number_to_octave_tick_string(octave_number)`
 New in version 2.0. Change *octave_number* to octave tick string:

```
abjad> for octave_number in range(-1, 9):
...     print "%s\t%s" % (octave_number, pitchtools.octave_number_to_octave_tick_string(octave_number))
...
-1 ,,,,
0 ,,,
1 ,,
2 ,
3
4 '
5 ''
6 '''
7 ,,,,
8 ,,,,,
```

Raise type error on noninteger input.

Return string.

pitchtools.octave_tick_string_to_octave_number

`abjad.tools.pitchtools.octave_tick_string_to_octave_number(tick_string)`
 New in version 2.0. Change *tick_string* to octave number:

```
abjad> pitchtools.octave_tick_string_to_octave_number("'")
4
```

Raise type error on nonstring input.

Raise value error on input not of tick string format.

Return integer.

`pitchtools.ordered_chromatic_pitch_class_numbers_are_within_ordered_chromatic_pitch_numbers`

`abjad.tools.pitchtools.ordered_chromatic_pitch_class_numbers_are_within_ordered_chromatic_p`

New in version 1.1. True if ordered *chromatic_pitch_class_numbers* are within ordered *chromatic_pitch_numbers*:

```
abjad> pcs = [2, 7, 10]
abjad> pitches = [6, 9, 12, 13, 14, 19, 22, 27, 28, 29, 32, 35]
abjad> pitchtools.ordered_chromatic_pitch_class_numbers_are_within_ordered_chromatic_pitch_numbers(pitches, pcs)
True
```

Return boolean. Changed in version 2.0: renamed `pitchtools.are_in_octave_order()` to `pitchtools.ordered_chromatic_pitch_class_numbers_are_within_ordered_chromatic_pitch_numbers()`.

`pitchtools.pentatonic_pitch_number_to_chromatic_pitch_number`

`abjad.tools.pitchtools.pentatonic_pitch_number_to_chromatic_pitch_number` (*pentatonic_scale_degree*, *transpose=1*, *phase=0*)

New in version 1.1. Changed *pentatonic_scale_degree* number to chromatic pitch number:

```
abjad> for pentatonic_scale_degree in range(9): # doctest: +SKIP
...     chromatic_pitch_number = pitchtools.pentatonic_pitch_number_to_chromatic_pitch_number(pentatonic_scale_degree)
...     print '%s\t%s' % (pentatonic_scale_degree, chromatic_pitch_number)
...
0 1
1 3
2 6
3 8
4 10
5 13
6 15
7 18
8 20
```

Pentatonic scale degrees may be negative:

```
abjad> for pentatonic_scale_degree in range(-1, -9, -1): # doctest: +SKIP
...     chromatic_pitch_number = pitchtools.pentatonic_pitch_number_to_chromatic_pitch_number(pentatonic_scale_degree)
...     print '%s\t%s' % (pentatonic_scale_degree, chromatic_pitch_number)
...
-1 -2
-2 -4
-3 -6
-4 -9
```

```
-5 -11
-6 -14
-7 -16
-8 -18
```

Return integer. Changed in version 2.0: renamed `pitchtools.pentatonic_to_chromatic()` to `pitchtools.pentatonic_pitch_number_to_chromatic_pitch_number()`.

pitchtools.permute_named_chromatic_pitch_carrier_list_by_twelve_tone_row

`abjad.tools.pitchtools.permute_named_chromatic_pitch_carrier_list_by_twelve_tone_row`(*pitches*, *row*)

New in version 2.0. Permute named chromatic pitch carrier list by twelve-tone *row*:

```
abjad> notes = notetools.make_notes([17, -10, -2, 11], [Duration(1, 4)])
abjad> row = pitchtools.TwelveToneRow([10, 0, 2, 6, 8, 7, 5, 3, 1, 9, 4, 11])
abjad> pitchtools.permute_named_chromatic_pitch_carrier_list_by_twelve_tone_row(notes, row)
[Note('bf4'), Note('d4'), Note("f'4"), Note("b'4")]
```

Function works by reference only. No objects are cloned.

Return list.

pitchtools.pitch_class_octave_number_string_to_chromatic_pitch_name

`abjad.tools.pitchtools.pitch_class_octave_number_string_to_chromatic_pitch_name`(*pitch_class_octave_number_string*)

New in version 2.5. Change *pitch_class_octave_number_string* to chromatic pitch name:

```
abjad> pitchtools.pitch_class_octave_number_string_to_chromatic_pitch_name('C#+2')
'ctqs,'
```

Return string.

pitchtools.register_chromatic_pitch_class_numbers_by_chromatic_pitch_number_aggregate

`abjad.tools.pitchtools.register_chromatic_pitch_class_numbers_by_chromatic_pitch_number_aggregate`(*pitch_class_numbers*, *chromatic_pitch_numbers*)

New in version 1.1. Register chromatic *pitch_class_numbers* by chromatic pitch-number *aggregate*:

```
abjad> pitchtools.register_chromatic_pitch_class_numbers_by_chromatic_pitch_number_aggregate(
...     [10, 0, 2, 6, 8, 7, 5, 3, 1, 9, 4, 11],
...     [10, 19, 20, 23, 24, 26, 27, 29, 30, 33, 37, 40])
[10, 24, 26, 30, 20, 19, 29, 27, 37, 33, 40, 23]
```

Return list of zero or more chromatic pitch numbers. Changed in version 2.0: renamed `pitchtools.registrate()` to `pitchtools.register_chromatic_pitch_class_numbers_by_chromatic_pitch_number_aggregate()`.

pitchtools.respell_named_chromatic_pitches_in_expr_with_flats

`abjad.tools.pitchtools.respell_named_chromatic_pitches_in_expr_with_flats`(*expr*)

New in version 1.1. Respell named chromatic pitches in *expr* with flats:

```

abjad> staff = Staff(notetools.make_repeated_notes(6))
abjad> pitchtools.set_ascending_named_chromatic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> f(staff)
\new Staff {
    c'8
    cs'8
    d'8
    ef'8
    e'8
    f'8
}

abjad> pitchtools.respell_named_chromatic_pitches_in_expr_with_flats(staff)

abjad> f(staff)
\new Staff {
    c'8
    df'8
    d'8
    ef'8
    e'8
    f'8
}

```

Return `none`. Changed in version 2.0: renamed `pitchtools.make_flat()` to `pitchtools.respell_named_chromatic_pitches_in_expr_with_flats()`.

pitchtools.respell_named_chromatic_pitches_in_expr_with_sharps

`abjad.tools.pitchtools.respell_named_chromatic_pitches_in_expr_with_sharps(expr)`

New in version 1.1. Respell named chromatic pitches in *expr* with sharps:

```

abjad> staff = Staff(notetools.make_repeated_notes(6))
abjad> pitchtools.set_ascending_named_chromatic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> f(staff)
\new Staff {
    c'8
    cs'8
    d'8
    ef'8
    e'8
    f'8
}

abjad> pitchtools.respell_named_chromatic_pitches_in_expr_with_sharps(staff)

abjad> f(staff)
\new Staff {
    c'8
    cs'8
    d'8
    ds'8
    e'8
    f'8
}

```


Return `none`. Changed in version 2.0: renamed `pitchtools.make_sharp()` to `pitchtools.respell_named_chromatic_pitches_in_expr_with_sharps()`.

`pitchtools.set_ascending_named_chromatic_pitches_on_nontied_pitched_components_in_expr`

`abjad.tools.pitchtools.set_ascending_named_chromatic_pitches_on_nontied_pitched_components_in_expr`

New in version 1.1. Set ascending named chromatic pitches on nontied pitched components in *expr*:

```
abjad> staff = Voice(notetools.make_notes(0, [(5, 32)] * 4))
abjad> pitchtools.set_ascending_named_chromatic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> f(staff)
\new Voice {
  c'8 ~
  c'32
  cs'8 ~
  cs'32
  d'8 ~
  d'32
  ef'8 ~
  ef'32
}
```

Used primarily in generating test file examples.

Return `none`. Changed in version 2.0: renamed `pitchtools.chromaticize()` to `pitchtools.set_ascending_named_chromatic_pitches_on_nontied_pitched_components_in_expr`

`pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr`

`abjad.tools.pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr`

New in version 1.1. Set ascending named diatonic pitches on nontied pitched components in *expr*:

```
abjad> staff = Staff(notetools.make_notes(0, [(5, 32)] * 4))
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)

abjad> f(staff)
\new Staff {
  c'8 ~
  c'32
  d'8 ~
  d'32
  e'8 ~
  e'32
  f'8 ~
  f'32
}
```

Used primarily in generating test file examples. New in version 2.0: Optional *key_signature* keyword argument. Return `none`. Changed in version 2.0: renamed `pitchtools.diatonicize()` to `pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr`

pitchtools.suggest_clef_for_named_chromatic_pitches

abjad.tools.pitchtools.**suggest_clef_for_named_chromatic_pitches** (*pitches*,
clefs=['treble',
 'bass'])

New in version 1.1. Suggest clef for named chromatic *pitches*:

```
abjad> staff = Staff(notetools.make_notes(range(-12, -6), [(1, 4)]))
abjad> pitchtools.suggest_clef_for_named_chromatic_pitches(staff)
ClefMark('bass')
```

Suggest clef based on minimal number of ledger lines.

Return clef mark. Changed in version 2.0: renamed `pitchtools.suggest_clef()` to `pitchtools.suggest_clef_for_named_chromatic_pitches()`.

pitchtools.symbolic_accidental_string_to_alphabetic_accidental_abbreviation

abjad.tools.pitchtools.**symbolic_accidental_string_to_alphabetic_accidental_abbreviation** (*symbolic_accidental_string*)

New in version 2.5. Change *symbolic_accidental_string* to alphabetic accidental abbreviation:

```
abjad> pitchtools.symbolic_accidental_string_to_alphabetic_accidental_abbreviation('#+')
'tqs'
```

None when *symbolic_accidental_string* is not a valid symbolic accidental string.

Return string or none.

pitchtools.transpose_chromatic_pitch_by_melodic_chromatic_interval_segment

abjad.tools.pitchtools.**transpose_chromatic_pitch_by_melodic_chromatic_interval_segment** (*pitch*,
segment)

New in version 2.0. Transpose chromatic *pitch* by melodic chromatic interval *segment*:

```
abjad> ncp = pitchtools.NumberedChromaticPitch(0)
abjad> mcis = pitchtools.MelodicChromaticIntervalSegment([0, -1, 2])
abjad> pitchtools.transpose_chromatic_pitch_by_melodic_chromatic_interval_segment(ncp, mcis)
[NumberedChromaticPitch(0), NumberedChromaticPitch(-1), NumberedChromaticPitch(1)]
```

Transpose by each interval in *segment* such that each transposition transposes the resulting pitch of the previous transposition.

Return list of numbered chromatic pitches.

pitchtools.transpose_chromatic_pitch_class_number_by_octaves_to_nearest_neighbor_of_chromatic_pitch_number

abjad.tools.pitchtools.**transpose_chromatic_pitch_class_number_by_octaves_to_nearest_neighbor_of_chromatic_pitch_number** (*pitch_class_number*)

New in version 1.1. Transpose *chromatic_pitch_class_number* by octaves to nearest neighbor of *chromatic_pitch_number*:

```
abjad> pitchtools.transpose_chromatic_pitch_class_number_by_octaves_to_nearest_neighbor_of_chromatic_pitch_number(16)
16
```

Resulting chromatic pitch number must be within one tritone of *pitch_number*.

Return integer or float. Changed in version 2.0: renamed `pitchtools.nearest_neighbor()` to `pitchtools.transpose_chromatic_pitch_class_number_by_octaves_to_nearest_neighbor_of_ch`

`pitchtools.transpose_chromatic_pitch_number_by_octave_transposition_mapping`

`abjad.tools.pitchtools.transpose_chromatic_pitch_number_by_octave_transposition_mapping(chromatic_pitch_number, mapping)`

New in version 1.1. Transpose *chromatic_pitch_number* by the some number of octaves up or down. Derive correct number of octaves from *mapping* where *mapping* is a list of (*range_spec*, *octave*) pairs and *range_spec* is, in turn, a (*start*, *stop*) pair suitable to pass to the built-in Python `range()` function:

```
abjad> mapping = [((-39, -13), 0), ((-12, 23), 12), ((24, 48), 24)]
```

The mapping given here comprises three (*range_spec*, *octave*) pairs. The first such pair is `((-39, -13), 0)` and can be read as follows: “any pitches between -39 and -13 should be transposed into the octave rooted at pitch 0.” The octave rooted at pitch 0 equals the twelve pitches `range(0, 0 + 12)` or `[0, 1, ..., 10, 11]`.

The second (*range_spec*, *octave*) pair is `((-12, 23), 12)` and can be read as “any pitches between -12 and 23 should be transposed into the octave rooted at pitch 12,” with the octave rooted at pitch 12 equal to the twelve pitches `range(12, 12 + 12)` or `[12, 13, ..., 22, 23]`.

The third and last (*range_spec*, *octave*) pair is `((24, 48), 24)` and can be read as “any pitches between 24 and 48 should be transposed to the octave rooted at 24,” with the octave rooted at 24 equal to the twelve pitches `range(24, 24, + 12)` or `[24, 25, ..., 34, 35]`.

The mapping given here divides the compass of the piano, from -39 to 48, into three disjunct subranges and then explains how to transpose pitches found in any of those three disjunct subranges. This means that, for example, all the f-sharps within the range of the piano now undergo a known transposition under *mapping* as defined here:

```
abjad> pitchtools.transpose_chromatic_pitch_number_by_octave_transposition_mapping(-30, mapping)
6
```

We verify that pitch -30 should map to pitch 6 by noticing that pitch -30 falls in the first of the three subranges defined by *mapping* from -39 to -13 and then noting that *mapping* sends pitches with that subrange to the octave rooted at pitch 0. The octave transposition of -30 that falls within the octave rooted at 0 is 6:

```
abjad> pitchtools.transpose_chromatic_pitch_number_by_octave_transposition_mapping(-18, mapping)
6
```

Likewise, *mapping* sends pitch -18 to pitch 6 because pitch -18 falls in the same subrange from -39 to -13 as did pitch -39 and so undergoes the same transposition to the octave rooted at 0.

In this way we can map all f-sharps from -39 to 48 according to *mapping*:

```
abjad> pitch_numbers = [-30, -18, -6, 6, 18, 30, 42]
abjad> for n in pitch_numbers:
...     n, pitchtools.transpose_chromatic_pitch_number_by_octave_transposition_mapping(n, mapping)
(-30, 6)
(-18, 6)
(-6, 18)
(6, 18)
(18, 18)
(30, 30)
(42, 30)
```

And so on.

Return chromatic pitch number. Changed in version 2.0: renamed
`pitchtools.send_pitch_number_to_octave()` to `pitchtools.transpose_chromatic_pitch_number_`

`pitchtools.transpose_named_chromatic_pitch_by_melodic_chromatic_interval_and_respell`

`abjad.tools.pitchtools.transpose_named_chromatic_pitch_by_melodic_chromatic_interval_and_re`

New in version 1.1. Transpose named chromatic pitch by *melodic_chromatic_interval* and respell *staff_spaces* above or below:

```
abjad> pitch = pitchtools.NamedChromaticPitch(0)
abjad> pitchtools.transpose_named_chromatic_pitch_by_melodic_chromatic_interval_and_respell(pitch,
NamedChromaticPitch("dtqf' ")
```

Return new named chromatic pitch. Changed in version 2.0: renamed
`pitchtools.staff_space_transpose()` to `pitchtools.transpose_named_chromatic_pitch_by_melo`

`pitchtools.transpose_pitch_carrier_by_melodic_interval`

`abjad.tools.pitchtools.transpose_pitch_carrier_by_melodic_interval` (*pitch_carrier*,
melodic_interval)

New in version 2.0. Transpose *pitch_carrier* by diatonic *melodic_interval*:

```
abjad> chord = Chord("<c' e' g'>4")

abjad> pitchtools.transpose_pitch_carrier_by_melodic_interval(chord, '+m2')
Chord("<df' f' af'>4")
```

Transpose *pitch_carrier* by chromatic *melodic_interval*:

```
abjad> chord = Chord("<c' e' g'>4")

abjad> pitchtools.transpose_pitch_carrier_by_melodic_interval(chord, 1)
Chord("<cs' f' af'>4")
```

Return non-pitch-carrying input unchanged:

```
abjad> rest = Rest('r4')

abjad> pitchtools.transpose_pitch_carrier_by_melodic_interval(rest, 1)
Rest('r4')
```

Return *pitch_carrier*.

`pitchtools.transpose_pitch_expr_into_pitch_range`

`abjad.tools.pitchtools.transpose_pitch_expr_into_pitch_range` (*pitch_expr*,
pitch_range)

New in version 2.0. Transpose *pitch_expr* into *pitch_range*:

```
abjad> pitchtools.transpose_pitch_expr_into_pitch_range([-2, -1, 13, 14], pitchtools.PitchRange(
[10, 11, 1, 2])
```

Return new *pitch_expr* object.

resttools

resttools.MultiMeasureRest

class abjad.tools.resttools.**MultiMeasureRest** (*args, **kwargs)

Bases: abjad.tools.resttools.Rest.Rest.Rest New in version 2.0. Abjad model of a multi-measure rest:

```
abjad> resttools.MultiMeasureRest((1, 4))
MultiMeasureRest('R4')
```

Multi-measure rests are immutable.

resttools.Rest

class abjad.tools.resttools.**Rest** (*args, **kwargs)

Bases: abjad.tools.leaftools._Leaf._Leaf._Leaf

Abjad model of a rest:

```
abjad> Rest((3, 16))
Rest('r8.')
```

resttools.all_are_rests

abjad.tools.resttools.**all_are_rests** (expr)

New in version 2.6. True when *expr* is a sequence of Abjad rests:

```
abjad> rests = [Rest('r4'), Rest('r4'), Rest('r4')]

```

```
abjad> resttools.all_are_rests(rests)
True
```

True when *expr* is an empty sequence:

```
abjad> resttools.all_are_rests([])
True
```

Otherwise false:

```
abjad> resttools.all_are_rests('foo')
False
```

Return boolean.

Function wraps componenttools.all_are_components().

resttools.is_lilypond_rest_string

abjad.tools.resttools.**is_lilypond_rest_string** (expr)

New in version 2.0. True when *expr* is a LilyPond rest string:

```
abjad> resttools.is_lilypond_rest_string('r4.. * 1/2')
True
```

Otherwise false:

```
abjad> resttools.is_lilypond_rest_string('text')
False
```

The regex `^(r|R)\s*(1|2|4|8|16|32|64|128|\breve|\longa|\maxima)\s*(\.*)\s*(*\s*(\d+(\d+|/\d+|` underlies this predicate.

Return boolean.

resttools.iterate_rests_backward_in_expr

`abjad.tools.resttools.iterate_rests_backward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate rests backward in *expr*:

```
abjad> staff = Staff("<e' g' c''>8 a'8 r8 <d' f' b'>8 r2")
```

```
abjad> f(staff)
\new Staff {
  <e' g' c''>8
  a'8
  r8
  <d' f' b'>8
  r2
}
```

```
abjad> for rest in resttools.iterate_rests_backward_in_expr(staff):
...     rest
Rest('r2')
Rest('r8')
```

Ignore threads.

Return generator.

resttools.iterate_rests_forward_in_expr

`abjad.tools.resttools.iterate_rests_forward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate rests forward in *expr*:

```
abjad> staff = Staff("<e' g' c''>8 a'8 r8 <d' f' b'>8 r2")
```

```
abjad> f(staff)
\new Staff {
  <e' g' c''>8
  a'8
  r8
  <d' f' b'>8
  r2
}
```

```
abjad> for rest in resttools.iterate_rests_forward_in_expr(staff):
...     rest
Rest('r8')
Rest('r2')
```

Ignore threads.

Return generator.

resttools.make_multi_measure_rests

abjad.tools.resttools.**make_multi_measure_rests**(*duration_tokens*)

New in version 2.0. Make multi-measure rests from *duration_tokens*:

```
abjad> resttools.make_multi_measure_rests([(4, 4), (7, 4)])
[MultiMeasureRest('R1'), MultiMeasureRest('R1..')]
```

Return list.

resttools.make_repeated_rests_from_time_signature

abjad.tools.resttools.**make_repeated_rests_from_time_signature**(*time_signature*)

New in version 2.0. Make repeated rests from *time_signature*:

```
abjad> resttools.make_repeated_rests_from_time_signature((5, 32))
[Rest('r32'), Rest('r32'), Rest('r32'), Rest('r32'), Rest('r32')]
```

Return list of newly constructed rests.

resttools.make_repeated_rests_from_time_signatures

abjad.tools.resttools.**make_repeated_rests_from_time_signatures**(*time_signatures*)

Make repeated rests from *time_signatures*:

```
resttools.make_repeated_rests_from_time_signatures([(2, 8), (3, 32)])
[[Rest('r8'), Rest('r8')], [Rest('r32'), Rest('r32'), Rest('r32')]]
```

Return two-dimensional list of newly constructed rest lists.

Use `sequencetools.flatten_sequence()` to flatten output if required.

resttools.make_rests

abjad.tools.resttools.**make_rests**(*duration_tokens*, *direction*='big-endian', *tied*=False)

New in version 1.1. Make rests.

Make big-endian rests:

```
abjad> resttools.make_rests([(5, 16), (9, 16)], direction = 'big-endian')
[Rest('r4'), Rest('r16'), Rest('r2'), Rest('r16')]
```

Make little-endian rests:

```
abjad> resttools.make_rests([(5, 16), (9, 16)], direction = 'little-endian')
[Rest('r16'), Rest('r4'), Rest('r16'), Rest('r2')]
```

Make tied rests:

```
abjad> voice = Voice(resttools.make_rests([(5, 16), (9, 16)], tied = True))

abjad> f(voice)
\new Voice {
    r4 ~
    r16
    r2 ~
    r16
}
```

Return list of rests. Changed in version 2.0: renamed `construct.rests()` to `resttools.make_rests()`.

`resttools.set_vertical_positioning_pitch_on_rest`

`abjad.tools.resttools.set_vertical_positioning_pitch_on_rest(rest, pitch)`

New in version 2.0. Set vertical positioning *pitch* on *rest*:

```
abjad> rest = Rest((1, 4))

abjad> resttools.set_vertical_positioning_pitch_on_rest(rest, "d'")
Rest('r4')

abjad> f(rest)
d''4 \rest
```

Raise type error when *rest* is not a rest.

Return *rest*.

`resttools.yield_groups_of_rests_in_sequence`

`abjad.tools.resttools.yield_groups_of_rests_in_sequence(sequence)`

New in version 2.0. Yield groups of rests in *sequence*:

```
abjad> staff = Staff("c'8 d'8 r8 r8 <e' g'>8 <f' a'>8 g'8 a'8 r8 r8 <b' d''>8 <c'' e''>8")

abjad> f(staff)
\new Staff {
    c'8
    d'8
    r8
    r8
    <e' g'>8
    <f' a'>8
    g'8
    a'8
    r8
    r8
    <b' d''>8
    <c'' e''>8
}

abjad> for rest in resttools.yield_groups_of_rests_in_sequence(staff):
...     rest
...
(Rest('r8'), Rest('r8'))
(Rest('r8'), Rest('r8'))
```

Return generator.

`schemetools`

`schemetools.SchemeAssociativeList`

`class abjad.tools.schemetools.SchemeAssociativeList`

Bases: `tuple`, `abjad.core._Immutable._Immutable._Immutable` New in version 2.0. Abjad

model of Scheme associative list:

```
abjad> schemetools.SchemeAssociativeList(('space', 2), ('padding', 0.5))
SchemeAssociativeList(SchemePair('space', 2), SchemePair('padding', 0.5))
```

Scheme associative lists are immutable.

format

LilyPond input format of Scheme associative list:

```
abjad> scheme_associative_list = schemetools.SchemeAssociativeList(('space', 2), ('padding', 0.5))
abjad> scheme_associative_list.format
"##((space . 2) (padding . 0.5))"
```

Return string.

schemetools.SchemeBoolean

class abjad.tools.schemetools.**SchemeBoolean**

Bases: abjad.core._Immutable._Immutable._Immutable

Abjad model of Scheme boolean:

```
abjad> schemetools.SchemeBoolean(True)
SchemeBoolean(True)
```

Scheme variables are immutable.

arg

format

LilyPond input format of Scheme boolean:

```
abjad> scheme_boolean = schemetools.SchemeBoolean(True)
abjad> scheme_boolean.format
'##t'
```

Return string.

schemetools.SchemeColor

class abjad.tools.schemetools.**SchemeColor**

Bases: abjad.core._StrictComparator._StrictComparator._StrictComparator, abjad.core._Immutable._Immutable._Immutable

Abjad model of Scheme color:

```
abjad> schemetools.SchemeColor('ForestGreen')
SchemeColor('ForestGreen')
```

Scheme colors are immutable.

color_name

format

LilyPond input format of Scheme color:

```
abjad> scheme_color = schemetools.SchemeColor('ForestGreen')
abjad> scheme_color.format
"#{x11-color 'ForestGreen}'"
```

Return string.

schemetools.SchemeFunction

class abjad.tools.schemetools.**SchemeFunction**

Bases: abjad.core._StrictComparator._StrictComparator._StrictComparator,
abjad.core._Immutable._Immutable._Immutable

Abjad model of Scheme function:

```
abjad> schemetools.SchemeFunction('magstep', -3)
SchemeFunction('magstep', -3)
```

Scheme functions are immutable.

format

LilyPond input format of Scheme function:

```
abjad> scheme_function = schemetools.SchemeFunction('magstep', -3)
abjad> scheme_function.format
'#(magstep -3)'
```

Return string.

schemetools.SchemeMoment

class abjad.tools.schemetools.**SchemeMoment**

Bases: abjad.core._StrictComparator._StrictComparator._StrictComparator,
abjad.core._Immutable._Immutable._Immutable

Abjad model of LilyPond moment:

```
abjad> schemetools.SchemeMoment(1, 68)
SchemeMoment(1, 68)
```

Initialize scheme moments with a single fraction, two integers or another scheme moment.

Scheme moments are immutable.

duration

Duration of scheme moment:

```
abjad> scheme_moment = schemetools.SchemeMoment(1, 68)
abjad> scheme_moment.duration
Fraction(1, 68)
```

Return duration.

format

LilyPond input format of scheme moment:

```
abjad> scheme_moment = schemetools.SchemeMoment(1, 68)
abjad> scheme_moment.format
'#(ly:make-moment 1 68)'
```

Return string.

schemetools.SchemeNumber

class abjad.tools.schemetools.**SchemeNumber**
 Bases: abjad.core._Immutable._Immutable._Immutable

Abjad model of Scheme number:

```
abjad> schemetools.SchemeNumber(1.1)
SchemeNumber(1.1...)
```

Scheme numbers are immutable.

format

LilyPond input format of Scheme number:

```
abjad> scheme_number = schemetools.SchemeNumber(1.1)
abjad> scheme_number.format
'#1.1'
```

Return string.

number

schemetools.SchemePair

class abjad.tools.schemetools.**SchemePair**
 Bases: tuple, abjad.core._Immutable._Immutable._Immutable

Abjad model of Scheme pair:

```
abjad> schemetools.SchemePair('spacing', 4)
SchemePair('spacing', 4)
```

Initialize Scheme pairs with a tuple, two separate values or another Scheme pair.

Scheme pairs are immutable.

format

LilyPond input format of Scheme pair:

```
abjad> scheme_pair = schemetools.SchemePair('spacing', 4)
abjad> scheme_pair.format
"#'(spacing . 4)"
```

Return string.

schemetools.SchemeString

class abjad.tools.schemetools.**SchemeString**
 Bases: abjad.core._StrictComparator._StrictComparator, abjad.core._Immutable._Immutable._Immutable

Abjad model of Scheme string:

```
abjad> schemetools.SchemeString('grace')
SchemeString('grace')
```

Scheme strings are immutable.

format

LilyPond input format of Scheme string:

```
abjad> scheme_string = schemetools.SchemeString('grace')
abjad> scheme_string.format
'#"grace"'
```

Return string.

schemetools.SchemeVariable

class abjad.tools.schemetools.**SchemeVariable**

Bases: abjad.core._StrictComparator._StrictComparator._StrictComparator,
abjad.core._Immutable._Immutable._Immutable

Abjad model of Scheme variable:

```
abjad> schemetools.SchemeVariable('grace')
SchemeVariable('grace')
```

Scheme variables are immutable.

format

LilyPond input format of Scheme variable:

```
abjad> scheme_variable = schemetools.SchemeVariable('UP')
abjad> scheme_variable.format
'#UP'
```

Return string.

schemetools.SchemeVector

class abjad.tools.schemetools.**SchemeVector**

Bases: tuple, abjad.core._Immutable._Immutable._Immutable New in version 2.0. Abjad
model of Scheme vector:

```
abjad> schemetools.SchemeVector(True, True, False)
SchemeVector(True, True, False)
```

Scheme vectors and Scheme vector constants differ in only their LilyPond input format.

Scheme vectors are immutable.

format

LilyPond input format of Scheme vector:

```
abjad> scheme_vector = schemetools.SchemeVector(True, True, False)
abjad> scheme_vector.format
'##' (#t #t #f)'
```

Return string.

schemetools.SchemeVectorConstant

class abjad.tools.schemetools.**SchemeVectorConstant**

Bases: tuple, abjad.core._Immutable._Immutable._Immutable New in version 2.0. Abjad
model of Scheme vector constant:

```
abjad> schemetools.SchemeVectorConstant(True, True, False)
SchemeVectorConstant(True, True, False)
```

Scheme vectors and Scheme vector constants differ in only their LilyPond input format.

Scheme vector constants are immutable.

format

LilyPond input format of scheme vector constant:

```
abjad> scheme_vector_constant = schemetools.SchemeVectorConstant(True, True, False)
abjad> scheme_vector_constant.format
"##(#t #t #f) "
```

Return string.

scoretools

scoretools.GrandStaff

class abjad.tools.scoretools.**GrandStaff** (*music*)

Bases: abjad.tools.scoretools.StaffGroup.StaffGroup.StaffGroup

Abjad model of grand staff:

```
abjad> staff_1 = Staff("c'4 d'4 e'4 f'4 g'1")
abjad> staff_2 = Staff("g2 f2 e1")

abjad> grand_staff = scoretools.GrandStaff([staff_1, staff_2])

abjad> f(grand_staff)
\new GrandStaff <<
  \new Staff {
    c'4
    d'4
    e'4
    f'4
    g'1
  }
  \new Staff {
    g2
    f2
    e1
  }
>>
```

Return grand staff.

scoretools.InstrumentationSpecifier

class abjad.tools.scoretools.**InstrumentationSpecifier** (*performers=None*)

Bases: object New in version 2.5. Abjad model of score instrumentation:

```
abjad> flute = scoretools.Performer('Flute')
abjad> flute.instruments.append(instrumenttools.Flute())
abjad> flute.instruments.append(instrumenttools.AltoFlute())
```

```

abjad> guitar = scoretools.Performer('Guitar')
abjad> guitar.instruments.append(instrumenttools.Guitar())

abjad> instrumentation_specifier = scoretools.InstrumentationSpecifier([flute, guitar])

abjad> instrumentation_specifier
InstrumentationSpecifier([Performer(name='Flute', instruments=[Flute(), AltoFlute()]), Performer

```

Return instrumentation specifier.

instrument_count

Read-only number of instruments in score:

```

abjad> instrumentation_specifier.instrument_count
3

```

Return nonnegative integer.

instruments

Read-only list of instruments derived from performers:

```

abjad> instrumentation_specifier.instruments
[Flute(), AltoFlute(), Guitar()]

```

Return list.

performer_count

Read-only number of performers in score:

```

abjad> instrumentation_specifier.performer_count
2

```

Return nonnegative integer.

performers

Read / write list of performers in score:

```

abjad> instrumentation_specifier.performers
[Performer(name='Flute', instruments=[Flute(), AltoFlute()]), Performer(name='Guitar', instr

```

Return list.

scoretools.Performer

class abjad.tools.scoretools.**Performer** (*name=None, instruments=None*)

Bases: object New in version 2.5. Abjad model of performer:

```

abjad> scoretools.Performer(name='flutist')
Performer(name='flutist')

```

The purpose of the class is to model things like flute I doubling piccolo and alto flute.

At present the class is a list of instruments.

instrument_count

Read-only number of instruments to be played by performer:

```

abjad> performer = scoretools.Performer('flutist')

```

```

abjad> performer.instruments.append(instrumenttools.Flute())
abjad> performer.instruments.append(instrumenttools.Piccolo())

abjad> performer.instrument_count
2

```

Return nonnegative integer

instruments

List of instruments to be played by performer:

```

abjad> performer = scoretools.Performer('flutist')

abjad> performer.instruments.append(instrumenttools.Flute())
abjad> performer.instruments.append(instrumenttools.Piccolo())

abjad> performer.instruments
[Flute(), Piccolo()]

```

Return list.

is_doubling

Is performer to play more than one instrument?

```

abjad> performer = scoretools.Performer('flutist')

abjad> performer.instruments.append(instrumenttools.Flute())
abjad> performer.instruments.append(instrumenttools.Piccolo())

abjad> performer.is_doubling
True

```

Return boolean.

likely_instruments_based_on_performer_name

New in version 2.5. Likely instruments based on performer name:

```

abjad> flutist = scoretools.Performer(name='flutist')
abjad> for likely_instrument in flutist.likely_instruments_based_on_performer_name:
...     likely_instrument
...
<class 'abjad.tools.instrumenttools.AltoFlute.AltoFlute.AltoFlute'>
<class 'abjad.tools.instrumenttools.BassFlute.BassFlute.BassFlute'>
<class 'abjad.tools.instrumenttools.ContrabassFlute.ContrabassFlute.ContrabassFlute'>
<class 'abjad.tools.instrumenttools.Flute.Flute.Flute'>
<class 'abjad.tools.instrumenttools.Piccolo.Piccolo.Piccolo'>

```

Return list.

make_performer_name_instrument_dictionary (*locale=None*)

New in version 2.5. Make performer name / instrument dictionary.

Return dictionary.

most_likely_instrument_based_on_performer_name

New in version 2.5. Most likely instrument based on performer name:

```

abjad> flutist = scoretools.Performer(name='flutist')
abjad> flutist.most_likely_instrument_based_on_performer_name
<class 'abjad.tools.instrumenttools.Flute.Flute.Flute'>

```

Return instrument class.

name

Score name of performer:

```
abjad> performer = scoretools.Performer('flutist')
```

```
abjad> performer.name
'flutist'
```

Return string.

scoretools.PianoStaff

class abjad.tools.scoretools.**PianoStaff**(*music*)

Bases: abjad.tools.scoretools.StaffGroup.StaffGroup.StaffGroup

Abjad model of piano staff:

```
abjad> staff_1 = Staff("c'4 d'4 e'4 f'4 g'1")
abjad> staff_2 = Staff("g2 f2 e1")
```

```
abjad> piano_staff = scoretools.PianoStaff([staff_1, staff_2])
```

```
abjad> f(piano_staff)
```

```
\new PianoStaff <<
```

```
  \new Staff {
```

```
    c'4
```

```
    d'4
```

```
    e'4
```

```
    f'4
```

```
    g'1
```

```
  }
```

```
  \new Staff {
```

```
    g2
```

```
    f2
```

```
    e1
```

```
  }
```

```
>>
```

Return piano staff.

scoretools.Score

class abjad.tools.scoretools.**Score**(*music=None, **kwargs*)

Bases: abjad.tools.contexttools._Context._Context._Context

Abjad model of a score:

```
abjad> staff_1 = Staff("c'8 d'8 e'8 f'8")
```

```
abjad> staff_2 = Staff("c'8 d'8 e'8 f'8")
```

```
abjad> score = Score([staff_1, staff_2])
```

```
abjad> f(score)
```

```
\new Score <<
```

```
  \new Staff {
```

```
    c'8
```

```
    d'8
```

```
    e'8
```



```

        f'8
    }
    \new Staff {
        c'8
        d'8
        e'8
        f'8
    }
>>

```

Return score object.

scoretools.StaffGroup

```

class abjad.tools.scoretools.StaffGroup(music=[], **kwargs)
    Bases: abjad.tools.contexttools._Context._Context._Context

    Abjad model of staff group:

    abjad> staff_1 = Staff("c'4 d'4 e'4 f'4 g'1")
    abjad> staff_2 = Staff("g2 f2 e1")

    abjad> staff_group = scoretools.StaffGroup([staff_1, staff_2])

    abjad> f(staff_group)
    \new StaffGroup <<
      \new Staff {
        c'4
        d'4
        e'4
        f'4
        g'1
      }
      \new Staff {
        g2
        f2
        e1
      }
    >>

```

Return staff group.

scoretools.add_double_bar_to_end_of_score

```

abjad.tools.scoretools.add_double_bar_to_end_of_score(score)
    New in version 2.0. Add double bar to end of score:

    abjad> staff = Staff("c'4 d'4 e'4 f'4")

    abjad> scoretools.add_double_bar_to_end_of_score(staff)
    BarLine('|.')(f'4)

    abjad> f(staff)
    \new Staff {
      c'4
      d'4

```

```

    e'4
    f'4
    \bar "|."
}

```

Return double bar.

scoretools.add_markup_to_end_of_score

`abjad.tools.scoretools.add_markup_to_end_of_score(score, markup, extra_offset=None)`

New in version 2.0. Add *markup* to end of *score*:

```

abjad> staff = Staff("c'4 d'4 e'4 f'4")
abjad> markup = r'\italic \right-column { "Bremen - Boston - Los Angeles." "Jul 2010 - May 2011." }'
abjad> markup = markuptools.Markup(markup, 'down')
abjad> scoretools.add_markup_to_end_of_score(staff, markup, (4, -2))
Markup('\italic \right-column { "Bremen - Boston - Los Angeles." "Jul 2010 - May 2011." }', 'down')

abjad> f(staff)
\new Staff {
    c'4
    d'4
    e'4
    \once \override TextScript #'extra-offset = #'(4 . -2)
    f'4 _ \markup { \italic \right-column { "Bremen - Boston - Los Angeles." "Jul 2010 - May 2011." } }
}

```

Return *markup*.

scoretools.all_are_scores

`abjad.tools.scoretools.all_are_scores(expr)`

New in version 2.6. True when *expr* is a sequence of Abjad scores:

```

abjad> score = Score([Staff([Note("c'4")])])

abjad> score
Score<<1>>

abjad> scoretools.all_are_scores([score])
True

```

True when *expr* is an empty sequence:

```

abjad> scoretools.all_are_scores([])
True

```

Otherwise false:

```

abjad> scoretools.all_are_scores('foo')
False

```

Return boolean.

Function wraps `componenttools.all_are_components()`.

scoretools.get_first_score_in_improper_parentage_of_component

`abjad.tools.scoretools.get_first_score_in_improper_parentage_of_component` (*component*)
 New in version 2.0. Get first score in improper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> score = Score([staff])

abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
>>

abjad> scoretools.get_first_score_in_improper_parentage_of_component(score.leaves[0])
Score<<1>>
```

Return score or none.

scoretools.get_first_score_in_proper_parentage_of_component

`abjad.tools.scoretools.get_first_score_in_proper_parentage_of_component` (*component*)
 New in version 2.0. Get first score in proper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> score = Score([staff])

abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
>>

abjad> scoretools.get_first_score_in_proper_parentage_of_component(score.leaves[0])
Score<<1>>
```

Return score or none.

scoretools.iterate_scores_backward_in_expr

`abjad.tools.scoretools.iterate_scores_backward_in_expr` (*expr*, *start=0*, *stop=None*)
 New in version 2.0. Iterate scores backward in *expr*:

```
abjad> score_1 = Score([Staff("c'8 d'8 e'8 f'8")])
abjad> score_2 = Score([Staff("c'1"), Staff("g'1")])
abjad> scores = [score_1, score_2]
```

```
abjad> for score in scoretools.iterate_scores_backward_in_expr(scores):
...     score
Score<<2>>
Score<<1>>
```

Ignore threads.

Return generator.

scoretools.iterate_scores_forward_in_expr

`abjad.tools.scoretools.iterate_scores_forward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate scores forward in *expr*:

```
abjad> score_1 = Score([Staff("c'8 d'8 e'8 f'8")])
abjad> score_2 = Score([Staff("c'1"), Staff("g'1")])
abjad> scores = [score_1, score_2]
```

```
abjad> for score in scoretools.iterate_scores_forward_in_expr(scores):
...     score
Score<<1>>
Score<<2>>
```

Ignore threads.

Return generator.

scoretools.list_performer_names

`abjad.tools.scoretools.list_performer_names(locale='en-us')`

New in version 2.5. List performer names:

```
abjad> for performer_name in scoretools.list_performer_names():
...     performer_name
...
'accordionist'
'bassist'
'bassoonist'
'cellist'
'clarinetist'
'flutist'
'guitarist'
'harpist'
'harpsichordist'
'hornist'
'oboist'
'percussionist'
'pianist'
'saxophonist'
'trombonist'
'trumpeter'
'tubist'
'vibraphonist'
'violinist'
'violist'
'xylophonist'
```

Available values for *locale* are 'en-us' and 'en-uk'.

scoretools.list_primary_performer_names

abjad.tools.scoretools.**list_primary_performer_names**()

New in version 2.5. List performer names:

```

abjad> for pair in scoretools.list_primary_performer_names():
...     pair
...
('accordionist', 'acc.')
('bassist', 'vb.')
('bassoonist', 'bsn.')
('cellist', 'vc.')
('clarinetist', 'cl. in B-flat')
('flutist', 'fl.')
('guitarist', 'gt.')
('harpist', 'hp.')
('harpsichordist', 'hpschd.')
('hornist', 'hn.')
('oboist', 'ob.')
('pianist', 'pf.')
('saxophonist', 'alto sax.')
('trombonist', 'ten. trb.')
('trumpeter', 'tp.')
('tubist', 'tb.')
('violinist', 'vn.')
('violist', 'va.')

```

Return list.

scoretools.make_empty_piano_score

abjad.tools.scoretools.**make_empty_piano_score**()

New in version 1.1. Make empty piano score:

```

abjad> score, treble, bass = scoretools.make_empty_piano_score()

abjad> f(score)
\new Score <<
  \new PianoStaff <<
    \context Staff = "treble" {
      \clef "treble"
    }
    \context Staff = "bass" {
      \clef "bass"
    }
  >>
>>

```

Return score, treble staff, bass staff. Changed in version 2.0: renamed
 scoretools.make_piano_staff() to scoretools.make_empty_piano_score().

scoretools.make_piano_score_from_leaves

abjad.tools.scoretools.**make_piano_score_from_leaves**(*leaves*, *low-est_treble_pitch*=*NamedChromaticPitch('b')*)

New in version 2.0. Make piano score from *leaves*:

```

abjad> notes = [Note(x, (1, 4)) for x in [-12, 37, -10, 2, 4, 17]]
abjad> score, treble_staff, bass_staff = scoretools.make_piano_score_from_leaves(notes)

abjad> f(score)
\new Score <<
  \new PianoStaff <<
    \context Staff = "treble" {
      \clef "treble"
      r4
      cs''''4
      r4
      d'4
      e'4
      f''4
    }
    \context Staff = "bass" {
      \clef "bass"
      c4
      r4
      d4
      r4
      r4
      r4
    }
  >>
>>

```

Return score, treble staff, bass staff.

scoretools.make_piano_sketch_score_from_leaves

abjad.tools.scoretools.**make_piano_sketch_score_from_leaves** (*leaves*, *low-est_treble_pitch*=*NamedChromaticPitch('b')*)

New in version 2.0. Make piano sketch score from *leaves*:

```

abjad> notes = notetools.make_notes([-12, -10, -8, -7, -5, 0, 2, 4, 5, 7], [(1, 4)])
abjad> score, treble_staff, bass_staff = scoretools.make_piano_sketch_score_from_leaves(notes)

abjad> f(score)
\new Score \with {
  \override BarLine #'stencil = ##f
  \override BarNumber #'transparent = ##t
  \override SpanBar #'stencil = ##f
  \override TimeSignature #'stencil = ##f
} <<
  \new PianoStaff <<
    \context Staff = "treble" {
      \clef "treble"
      #(set-accidental-style 'forget)
      r4
      r4
      r4
      r4
      r4
      c'4
      d'4
      e'4
    }
  >>
>>

```

```

        f'4
        g'4
    }
    \context Staff = "bass" {
        \clef "bass"
        #(set-accidental-style 'forget)
        c4
        d4
        e4
        f4
        g4
        r4
        r4
        r4
        r4
        r4
    }
>>
>>

```

Make time signatures and bar numbers transparent.

Do not print bar lines or span bars.

Set all staff accidental styles to forget.

Return score, treble staff, bass staff.

scoretools.make_pitch_array_score_from_pitch_arrays

`abjad.tools.scoretools.make_pitch_array_score_from_pitch_arrays` (*pitch_arrays*)

New in version 2.0. Make pitch-array score from *pitch_arrays*:

```

abjad> from abjad.tools import pitcharraytools

abjad> array_1 = pitcharraytools.PitchArray([
...     [1, (2, 1), ([-2, -1.5], 2)],
...     [(7, 2), (6, 1), 1]])

abjad> array_2 = pitcharraytools.PitchArray([
...     [1, 1, 1],
...     [1, 1, 1]])

abjad> score = scoretools.make_pitch_array_score_from_pitch_arrays([array_1, array_2])

abjad> f(score)
\new Score <<
  \new StaffGroup <<
    \new Staff {
      {
        \time 4/8
        r8
        d'8
        <bf bqf>4
      }
      {
        \time 3/8
        r8

```

```

        r8
        r8
    }
}
\new Staff {
    {
        \time 4/8
        g'4
        fs'8
        r8
    }
    {
        \time 3/8
        r8
        r8
        r8
    }
}
>>
>>

```

Create one staff per pitch-array row.

Return score.

skiptools

skiptools.Skip

class abjad.tools.skiptools.**Skip**(*args, **kwargs)
 Bases: abjad.tools.leaftools._Leaf._Leaf._Leaf

Abjad model of a LilyPond skip:

```

abjad> skiptools.Skip((3, 16))
Skip('s8.')

```

Return skip.

skiptools.all_are_skips

abjad.tools.skiptools.**all_are_skips**(expr)
 New in version 2.6. True when *expr* is a sequence of Abjad skips:

```

abjad> from abjad.tools import skiptools

abjad> skips = 3 * skiptools.Skip('s4')

abjad> skips
[Skip('s4'), Skip('s4'), Skip('s4')]

abjad> skiptools.all_are_skips(skips)
True

```

True when *expr* is an empty sequence:

```

abjad> skiptools.all_are_skips([])
True

```


Otherwise false:

```
abjad> skiptools.all_are_skips('foo')
False
```

Return boolean.

Function wraps `componenttools.all_are_components()`.

skiptools.iterate_skips_backward_in_expr

`abjad.tools.skiptools.iterate_skips_backward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate skips backward in *expr*:

```
abjad> staff = Staff("<e' g' c''>8 a'8 s8 <d' f' b'>8 s2")

abjad> f(staff)
\new Staff {
    <e' g' c''>8
    a'8
    s8
    <d' f' b'>8
    s2
}

abjad> for skip in skiptools.iterate_skips_backward_in_expr(staff):
...     skip
Skip('s2')
Skip('s8')
```

Ignore threads.

Return generator.

skiptools.iterate_skips_forward_in_expr

`abjad.tools.skiptools.iterate_skips_forward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate skips forward in *expr*:

```
abjad> staff = Staff("<e' g' c''>8 a'8 s8 <d' f' b'>8 s2")

abjad> f(staff)
\new Staff {
    <e' g' c''>8
    a'8
    s8
    <d' f' b'>8
    s2
}

abjad> for skip in skiptools.iterate_skips_forward_in_expr(staff):
...     skip
Skip('s8')
Skip('s2')
```

Ignore threads.

Return generator.

skiptools.make_repeated_skips_from_time_signature

`abjad.tools.skiptools.make_repeated_skips_from_time_signature(time_signature)`
 New in version 2.0. Make repeated skips from *time_signature*:

```
abjad> skiptools.make_repeated_skips_from_time_signature((5, 32))
[Skip('s32'), Skip('s32'), Skip('s32'), Skip('s32'), Skip('s32')]
```

Return list of skips.

skiptools.make_repeated_skips_from_time_signatures

`abjad.tools.skiptools.make_repeated_skips_from_time_signatures(time_signatures)`
 Make repeated skips from *time_signatures*:

```
skiptools.make_repeated_skips_from_time_signatures([(2, 8), (3, 32)])
[[Skip('s8'), Skip('s8')], [Skip('s32'), Skip('s32'), Skip('s32')]]
```

Return list of skip lists.

skiptools.make_skips_with_multiplied_durations

`abjad.tools.skiptools.make_skips_with_multiplied_durations(written_duration, multiplied_durations)`
 New in version 2.0. Make *written_duration* skips with *multiplied_durations*:

```
abjad> skiptools.make_skips_with_multiplied_durations(Duration(1, 4), [(1, 2), (1, 3), (1, 4), (1, 5)])
[Skip('s4 * 2'), Skip('s4 * 4/3'), Skip('s4 * 1'), Skip('s4 * 4/5')]
```

Useful for making invisible layout voices.

Return list of skips. Changed in version 2.0: renamed `construct.skips_with_multipliers()` to `skiptools.make_skips_with_multiplied_durations()`.

skiptools.replace_leaves_in_expr_with_skips

`abjad.tools.skiptools.replace_leaves_in_expr_with_skips(expr)`
 New in version 1.1. Replace leaves in *expr* with skips:

```
abjad> staff = Staff(Measure((2, 8), "c'8 d'8") * 2)
abjad> skiptools.replace_leaves_in_expr_with_skips(staff[0])
abjad> print staff.format
\new Staff {
  {
    \time 2/8
    s8
    s8
  }
  {
    \time 2/8
    c'8
    d'8
  }
}
```

Return none. Changed in version 2.0: renamed `leaftools.replace_leaves_with_skips_in()` to `skiptools.replace_leaves_in_expr_with_skips()`.

skiptools.yield_groups_of_skips_in_sequence

`abjad.tools.skiptools.yield_groups_of_skips_in_sequence(sequence)`

New in version 2.0. Yield groups of skips in *sequence*:

```
abjad> staff = Staff("c'8 d'8 s8 s8 <e' g'>8 <f' a'>8 g'8 a'8 s8 s8 <b' d''>8 <c'' e''>8")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    s8
    s8
    <e' g'>8
    <f' a'>8
    g'8
    a'8
    s8
    s8
    <b' d''>8
    <c'' e''>8
}
```

```
abjad> for skip in skiptools.yield_groups_of_skips_in_sequence(staff):
...     skip
...
(Skip('s8'), Skip('s8'))
(Skip('s8'), Skip('s8'))
```

Return generator.

spannertools

spannertools.BeamSpanner

class `abjad.tools.spannertools.BeamSpanner(components=None)`

Bases: `abjad.tools.spannertools.Spanner.Spanner.Spanner`

Abjad beam spanner:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'2")
```

```
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
    g'2
}
```

```
abjad> spannertools.BeamSpanner(staff[:4])
BeamSpanner(c'8, d'8, e'8, f'8)
```

```
abjad> f(staff)
\new Staff {
    c'8 [
    d'8
```

```

        e'8
        f'8 ]
        g'2
    }

```

Return beam spanner.

spannertools.BracketSpanner

class abjad.tools.spannertools.**BracketSpanner** (*components=None*)

Bases: abjad.tools.spannertools.TextSpanner.TextSpanner.TextSpanner

Abjad bracket spanner:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spannertools.BracketSpanner(staff[:])
BracketSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
    \override TextSpanner #'bound-details #'left #'text = #(markup #:draw-line '(0 . -1))
    \override TextSpanner #'bound-details #'left-broken #'text = ##f
    \override TextSpanner #'bound-details #'right #'text = #(markup #:draw-line '(0 . -1))
    \override TextSpanner #'bound-details #'right-broken #'text = ##f
    \override TextSpanner #'color = #red
    \override TextSpanner #'dash-fraction = #1
    \override TextSpanner #'staff-padding = #2
    \override TextSpanner #'thickness = #1.5
    c'8 \startTextSpan
    d'8
    e'8
    f'8 \stopTextSpan
    \revert TextSpanner #'bound-details #'left #'text
    \revert TextSpanner #'bound-details #'left-broken #'text
    \revert TextSpanner #'bound-details #'right #'text
    \revert TextSpanner #'bound-details #'right-broken #'text
    \revert TextSpanner #'color
    \revert TextSpanner #'dash-fraction
    \revert TextSpanner #'staff-padding
    \revert TextSpanner #'thickness
}

```

Render 1.5-unit thick solid red spanner.

Draw nibs at beginning and end of spanner.

Do not draw nibs at line breaks.

Return bracket spanner.

spannertools.ComplexBeamSpanner

class abjad.tools.spannertools.**ComplexBeamSpanner** (*components=None, lone=False*)

Bases: abjad.tools.spannertools.BeamSpanner.BeamSpanner.BeamSpanner

Abjad complex beam spanner:

```

abjad> staff = Staff("c'16 e'16 r16 f'16 g'2")

abjad> f(staff)
\new Staff {
    c'16
    e'16
    r16
    f'16
    g'2
}

abjad> spannertools.ComplexBeamSpanner(staff[:4])
ComplexBeamSpanner(c'16, e'16, r16, f'16)

abjad> f(staff)
\new Staff {
    \set stemLeftBeamCount = #0
    \set stemRightBeamCount = #2
    c'16 [
    \set stemLeftBeamCount = #2
    \set stemRightBeamCount = #2
    e'16 ]
    r16
    \set stemLeftBeamCount = #2
    \set stemRightBeamCount = #0
    f'16 [ ]
    g'2
}

```

Return complex beam spanner.

lone

Beam lone leaf and force beam nibs to left:

```

abjad> note = Note("c'16")

abjad> beam = spannertools.ComplexBeamSpanner([note], lone = 'left')

abjad> f(note)
\set stemLeftBeamCount = #2
\set stemRightBeamCount = #0
c'16 [ ]

```

Beam lone leaf and force beam nibs to right:

```

abjad> note = Note("c'16")

abjad> beam = spannertools.ComplexBeamSpanner([note], lone = 'right')

abjad> f(note)
\set stemLeftBeamCount = #0
\set stemRightBeamCount = #2
c'16 [ ]

```

Beam lone leaf and force beam nibs to both left and right:

```

abjad> note = Note("c'16")

```

```
abjad> beam = spannertools.ComplexBeamSpanner([note], lone = 'both')
```

```
abjad> f(note)
\set stemLeftBeamCount = #2
\set stemRightBeamCount = #2
c'16 [ ]
```

Beam lone leaf and accept LilyPond default nibs at both left and right:

```
abjad> note = Note("c'16")
```

```
abjad> beam = spannertools.ComplexBeamSpanner([note], lone = True)
```

```
abjad> f(note)
\set stemLeftBeamCount = #2
\set stemRightBeamCount = #2
c'16 [ ]
```

Do not beam lone leaf:

```
abjad> note = Note("c'16")
```

```
abjad> beam = spannertools.ComplexBeamSpanner([note], lone = False)
```

```
abjad> f(note)
c'16
```

Set to 'left', 'right', 'both', true or false as shown above.

Ignore this setting when spanner contains more than one leaf.

spannertools.CrescendoSpanner

class abjad.tools.spannertools.**CrescendoSpanner** (*components=None, include_rests=True*)
 Bases: abjad.tools.spannertools.HairpinSpanner.HairpinSpanner.HairpinSpanner

Abjad crescendo spanner that includes rests:

```
abjad> staff = Staff("r4 c'8 d'8 e'8 f'8 r4")
```

```
abjad> f(staff)
\new Staff {
    r4
    c'8
    d'8
    e'8
    f'8
    r4
}
```

```
abjad> spannertools.CrescendoSpanner(staff[:], include_rests = True)
CrescendoSpanner(r4, c'8, d'8, e'8, f'8, r4)
```

```
abjad> f(staff)
\new Staff {
    r4 \<
    c'8
    d'8
```

```

        e'8
        f'8
        r4 \!
    }

```

Abjad crescendo spanner that does not include rests:

```

abjad> staff = Staff("r4 c'8 d'8 e'8 f'8 r4")

abjad> f(staff)
\new Staff {
    r4
    c'8
    d'8
    e'8
    f'8
    r4
}

abjad> spannertools.CrescendoSpanner(staff[:], include_rests = False)
CrescendoSpanner(r4, c'8, d'8, e'8, f'8, r4)

abjad> f(staff)
\new Staff {
    r4
    c'8 \<
    d'8
    e'8
    f'8 \!
    r4
}

```

Return crescendo spanner.

spannertools.DecrescendoSpanner

class abjad.tools.spannertools.**DecrescendoSpanner** (*components=None*, *include_rests=True*) *in-*
Bases: abjad.tools.spannertools.HairpinSpanner.HairpinSpanner.HairpinSpanner

Abjad decrescendo spanner that includes rests:

```

abjad> staff = Staff("r4 c'8 d'8 e'8 f'8 r4")

abjad> f(staff)
\new Staff {
    r4
    c'8
    d'8
    e'8
    f'8
    r4
}

abjad> spannertools.DecrescendoSpanner(staff[:], include_rests = True)
DecrescendoSpanner(r4, c'8, d'8, e'8, f'8, r4)

```

```
abjad> f(staff)
\new Staff {
    r4 \>
    c'8
    d'8
    e'8
    f'8
    r4 \!
}
```

Abjad decrescendo spanner that does not include rests:

```
abjad> staff = Staff("r4 c'8 d'8 e'8 f'8 r4")

abjad> f(staff)
\new Staff {
    r4
    c'8
    d'8
    e'8
    f'8
    r4
}

abjad> spannertools.DecrescendoSpanner(staff[:], include_rests = False)
DecrescendoSpanner(r4, c'8, d'8, e'8, f'8, r4)

abjad> f(staff)
\new Staff {
    r4
    c'8 \>
    d'8
    e'8
    f'8 \!
    r4
}
```

Return decrescendo spanner.

spannertools.DuratedComplexBeamSpanner

class abjad.tools.spannertools.**DuratedComplexBeamSpanner** (*components=None, durations=None, span=1, lone=False*)

Bases: abjad.tools.spannertools.ComplexBeamSpanner.ComplexBeamSpanner.ComplexBeamSpanner

Abjad durated complex beam spanner:

```
staff = Staff("c'16 d'16 e'16 f'16")

durations = [Duration(1, 8), Duration(1, 8)]
beam = spannertools.DuratedComplexBeamSpanner(staff[:], durations, 1)

f(staff)
\new Staff {
    \set stemLeftBeamCount = #0
    \set stemRightBeamCount = #2
    c'16 [
```



```

\set stemLeftBeamCount = #2
\set stemRightBeamCount = #1
d'16
\set stemLeftBeamCount = #1
\set stemRightBeamCount = #2
e'16
\set stemLeftBeamCount = #2
\set stemRightBeamCount = #0
f'16 ]
}

```

Beam all beamable leaves in spanner explicitly.

Group leaves in spanner according to *durations*.

Span leaves between duration groups according to *span*.

Return durated complex beam spanner.

durations

Get spanner leaf group durations:

```

abjad> staff = Staff("c'16 d'16 e'16 f'16")
abjad> durations = [Duration(1, 8), Duration(1, 8)]
abjad> beam = spannertools.DuratedComplexBeamSpanner(staff[:], durations)
abjad> beam.durations
[Duration(1, 8), Duration(1, 8)]

```

Set spanner leaf group durations:

```

abjad> staff = Staff("c'16 d'16 e'16 f'16")
abjad> durations = [Duration(1, 8), Duration(1, 8)]
abjad> beam = spannertools.DuratedComplexBeamSpanner(staff[:], durations)
abjad> beam.durations = [Duration(1, 4)]
abjad> beam.durations
[Duration(1, 4)]

```

Set iterable.

span

Get top-level beam count:

```

abjad> staff = Staff("c'16 d'16 e'16 f'16")
abjad> durations = [Duration(1, 8), Duration(1, 8)]
abjad> beam = spannertools.DuratedComplexBeamSpanner(staff[:], durations, 1)
abjad> beam.span
1

```

Set top-level beam count:

```

abjad> staff = Staff("c'16 d'16 e'16 f'16")
abjad> durations = [Duration(1, 8), Duration(1, 8)]
abjad> beam = spannertools.DuratedComplexBeamSpanner(staff[:], durations, 1)
abjad> beam.span = 2
abjad> beam.span
2

```

Set nonnegative integer.

spannertools.DynamicTextSpanner

class abjad.tools.spannertools.**DynamicTextSpanner** (*components=None, mark=''*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad dynamic text spanner:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spannertools.DynamicTextSpanner(staff[:], 'f')
DynamicTextSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
  c'8 \f
  d'8
  e'8
  f'8
}
```

Format dynamic *mark* at first leaf in spanner.

Return dynamic text spanner.

mark

Get dynamic string:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> dynamic_text_spanner = spannertools.DynamicTextSpanner(staff[:], 'f')
abjad> dynamic_text_spanner.mark
'f'
```

Set dynamic string:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> dynamic_text_spanner = spannertools.DynamicTextSpanner(staff[:], 'f')
abjad> dynamic_text_spanner.mark = 'p'
abjad> dynamic_text_spanner.mark
'p'
```

Set string.

spannertools.GlissandoSpanner

class abjad.tools.spannertools.**GlissandoSpanner** (*components=None*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad glissando spanner:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spannertools.GlissandoSpanner(staff[:])
GlissandoSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
  c'8 \glissando
  d'8 \glissando
  e'8 \glissando
}
```

```
f'8
}
```

Format nonlast leaves in spanner with LilyPond glissando command.

Return glissando spanner.

spannertools.HairpinSpanner

class abjad.tools.spannertools.**HairpinSpanner**(*components=None*, *descriptor='<'*, *include_rests=True*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad hairpin spanner that includes rests:

```
abjad> staff = Staff("r4 c'8 d'8 e'8 f'8 r4")
```

```
abjad> f(staff)
\new Staff {
  r4
  c'8
  d'8
  e'8
  f'8
  r4
}
```

```
abjad> spannertools.HairpinSpanner(staff[:], 'p < f', include_rests = True)
HairpinSpanner(r4, c'8, d'8, e'8, f'8, r4)
```

```
abjad> f(staff)
\new Staff {
  r4 \< \p
  c'8
  d'8
  e'8
  f'8
  r4 \f
}
```

Abjad hairpin spanner that does not include rests:

```
abjad> staff = Staff("r4 c'8 d'8 e'8 f'8 r4")
```

```
abjad> f(staff)
\new Staff {
  r4
  c'8
  d'8
  e'8
  f'8
  r4
}
```

```
abjad> spannertools.HairpinSpanner(staff[:], 'p < f', include_rests = False)
HairpinSpanner(r4, c'8, d'8, e'8, f'8, r4)
```

```
abjad> f(staff)
\new Staff {
    r4
    c'8 \< \p
    d'8
    e'8
    f'8 \f
    r4
}
```

Return hairpin spanner.

include_rests

Get boolean hairpin rests setting:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> hairpin = spannertools.HairpinSpanner(staff[:], 'p < f', include_rests = True)
abjad> hairpin.include_rests
True
```

Set boolean hairpin rests setting:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> hairpin = spannertools.HairpinSpanner(staff[:], 'p < f', include_rests = True)
abjad> hairpin.include_rests = False
abjad> hairpin.include_rests
False
```

Set boolean.

static is_hairpin_shape_string(arg)

True when *arg* is a hairpin shape string. Otherwise false:

```
abjad> spannertools.HairpinSpanner.is_hairpin_shape_string('<')
True
```

Return boolean.

shape_string

Get hairpin shape string:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> hairpin = spannertools.HairpinSpanner(staff[:], 'p < f')
abjad> hairpin.shape_string
'<'
```

Set hairpin shape string:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> hairpin = spannertools.HairpinSpanner(staff[:], 'p < f')
abjad> hairpin.shape_string = '>'
abjad> hairpin.shape_string
'>'
```

Set string.

start_dynamic_string

Get hairpin start dynamic string:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> hairpin = spannertools.HairpinSpanner(staff[:], 'p < f')
```

```
abjad> hairpin.start_dynamic_string
'p'
```

Set hairpin start dynamic string:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> hairpin = spannertools.HairpinSpanner(staff[:], 'p < f')
abjad> hairpin.start_dynamic_string = 'mf'
abjad> hairpin.start_dynamic_string
'mf'
```

Set string.

stop_dynamic_string

Get hairpin stop dynamic string:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> hairpin = spannertools.HairpinSpanner(staff[:], 'p < f')
abjad> hairpin.stop_dynamic_string
'f'
```

Set hairpin stop dynamic string:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> hairpin = spannertools.HairpinSpanner(staff[:], 'p < f')
abjad> hairpin.stop_dynamic_string = 'mf'
abjad> hairpin.stop_dynamic_string
'mf'
```

Set string.

spannertools.HiddenStaffSpanner

class abjad.tools.spannertools.**HiddenStaffSpanner** (*components=None*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad hidden staff spanner:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spannertools.HiddenStaffSpanner(staff[:2])
HiddenStaffSpanner(c'8, d'8)

abjad> f(staff)
\new Staff {
  \stopStaff
  c'8
  d'8
  \startStaff
  e'8
  f'8
}
```

Hide staff behind leaves in spanner.

Return hidden staff spanner.

spannertools.HorizontalBracketSpanner

class abjad.tools.spannertools.**HorizontalBracketSpanner** (*components=None*)
Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner New in version 2.4. Abjad horizontal bracket spanner:

```
abjad> voice = Voice("c'4 d'4 e'4 f'4")
abjad> voice.engraver_consists.add('Horizontal_bracket_engraver')

abjad> horizontal_bracket_spanner = spannertools.HorizontalBracketSpanner(voice[:])

abjad> horizontal_bracket_spanner
HorizontalBracketSpanner(c'4, d'4, e'4, f'4)

abjad> f(voice)
\new Voice \with {
  \consists Horizontal_bracket_engraver
} {
  c'4 \startGroup
  d'4
  e'4
  f'4 \stopGroup
}
```

Return horizontal bracket spanner.

spannertools.MeasuredComplexBeamSpanner

class abjad.tools.spannertools.**MeasuredComplexBeamSpanner** (*components=None*,
lone=False, *span=1*)
Bases: abjad.tools.spannertools.ComplexBeamSpanner.ComplexBeamSpanner.ComplexBeamSpanner

Abjad measured complex beam spanner:

```
abjad> staff = Staff([Measure((2, 16), "c'16 d'16"), Measure((2, 16), "e'16 f'16")])

abjad> spannertools.MeasuredComplexBeamSpanner(staff.leaves)
MeasuredComplexBeamSpanner(c'16, d'16, e'16, f'16)

abjad> f(staff)
\new Staff {
  {
    \time 2/16
    \set stemLeftBeamCount = #0
    \set stemRightBeamCount = #2
    c'16 [
    \set stemLeftBeamCount = #2
    \set stemRightBeamCount = #1
    d'16
  ]
  {
    \time 2/16
    \set stemLeftBeamCount = #1
    \set stemRightBeamCount = #2
    e'16
    \set stemLeftBeamCount = #2
    \set stemRightBeamCount = #0
    f'16 ]
}
```

```
}
}
```

Beam leaves in spanner explicitly.

Group leaves by measures.

Format top-level *span* beam between measures.

Return measured complex beam spanner.

span

Get top-level beam count:

```
abjad> staff = Staff([Measure((2, 16), "c'16 d'16"), Measure((2, 16), "e'16 f'16")])
abjad> beam = spannertools.MeasuredComplexBeamSpanner(staff.leaves)
abjad> beam.span
1
```

Set top-level beam count:

```
abjad> staff = Staff([Measure((2, 16), "c'16 d'16"), Measure((2, 16), "e'16 f'16")])
abjad> beam = spannertools.MeasuredComplexBeamSpanner(staff.leaves)
abjad> beam.span = 2
abjad> beam.span
2
```

Set nonnegative integer.

spannertools.MetricGridSpanner

class abjad.tools.spannertools.**MetricGridSpanner** (*components=None, meters=None*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad metric grid spanner:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c'8")

abjad> spannertools.MetricGridSpanner(staff.leaves, meters = [(1, 8), (1, 4)])
MetricGridSpanner(c'8, d'8, e'8, f'8, g'8, a'8, b'8, c'8)

abjad> f(staff)
\new Staff {
  \time 1/8
  c'8
  \time 1/4
  d'8
  e'8
  \time 1/8
  f'8
  \time 1/4
  g'8
  a'8
  \time 1/8
  b'8
  \time 1/4
  c'8
}
```

Format leaves in spanner cyclically with *meters*.

Return metric grid spanner.

meters

Get metric grid meters:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c'8")
abjad> metric_grid_spanner = spannertools.MetricGridSpanner(staff.leaves, meters = [(1, 8)],
abjad> list(metric_grid_spanner.meters)
[(TimeSignatureMark((1, 8)), 0, False), (TimeSignatureMark((1, 4)), Duration(1, 8), False),
```

Set metric grid meters:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c'8")
abjad> metric_grid_spanner = spannertools.MetricGridSpanner(staff.leaves, meters = [(1, 8)],
abjad> metric_grid_spanner.meters = [Duration(1, 4)]
abjad> list(metric_grid_spanner.meters)
[(TimeSignatureMark((1, 4)), 0, False), (TimeSignatureMark((1, 4)), Duration(1, 4), True),
```

Set iterable.

split_on_bar()

Temporarily unavailable.

splitting_condition (*leaf*)

User-definable boolean function to determine whether leaf should be split:

```
abjad> voice = Voice("c'4 r4 c'4")

abjad> f(voice)
\new Voice {
    c'4
    r4
    c'4
}

abjad> def cond(leaf):
...     if not isinstance(leaf, Rest): return True
...     else: return False
abjad> metric_grid_spanner = spannertools.MetricGridSpanner(voice.leaves, [Duration(1, 8)])
abjad> metric_grid_spanner.splitting_condition = cond

abjad> metric_grid_spanner.split_on_bar()

abjad> f(voice)
\new Voice {
    \time 1/8
    c'8 ~
    c'8
    r4
    c'8 ~
    c'8
}
```

Function defaults to return true.

spannertools.MultipartBeamSpanner

class abjad.tools.spannertools.**MultipartBeamSpanner** (*components=None*)

Bases: abjad.tools.spannertools.BeamSpanner.BeamSpanner.BeamSpanner New in version 2.0. Abjad multipart beam spanner:

```
abjad> staff = Staff("c'8 d'8 e'4 f'8 g'8 r4")

abjad> spannertools.MultipartBeamSpanner(staff[:])
MultipartBeamSpanner(c'8, d'8, e'4, f'8, g'8, r4)

abjad> f(staff)
\new Staff {
  c'8 [
  d'8 ]
  e'4
  f'8 [
  g'8 ]
  r4
}
```

Avoid rests.

Avoid large-duration notes.

Return multipart beam spanner.

spannertools.OctavationSpanner

class abjad.tools.spannertools.**OctavationSpanner** (*components=None, start=0, stop=0*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad octavation spanner:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spanner = spannertools.OctavationSpanner(staff[:], start = 1)

abjad> f(staff)
\new Staff {
  \ottava #1
  c'8
  d'8
  e'8
  f'8
  \ottava #0
}
```

Return octavation spanner.

start

Get octavation start:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> octavation = spannertools.OctavationSpanner(staff[:], start = 1)
abjad> octavation.start
1
```

Set octavation start:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> octavation = spannertools.OctavationSpanner(staff[:], start = 1)
abjad> octavation.start
1
```

Set integer.

stop

Get octavation stop:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> octavation = spannertools.OctavationSpanner(staff[:], start = 2, stop = 1)
abjad> octavation.stop
1
```

Set octavation stop:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> octavation = spannertools.OctavationSpanner(staff[:], start = 2, stop = 1)
abjad> octavation.stop = 0
abjad> octavation.stop
0
```

Set integer.

spannertools.PhrasingSlurSpanner

class abjad.tools.spannertools.**PhrasingSlurSpanner** (*components=None*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad phrasing slur spanner:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spannertools.PhrasingSlurSpanner(staff[:])
PhrasingSlurSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
    c'8 \{
    d'8
    e'8
    f'8 \}
}
```

Return phrasing slur spanner.

spannertools.PianoPedalSpanner

class abjad.tools.spannertools.**PianoPedalSpanner** (*components=None*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad piano pedal spanner:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spannertools.PianoPedalSpanner(staff[:])
PianoPedalSpanner(c'8, d'8, e'8, f'8)
```

```

abjad> f(staff)
\new Staff {
  \set Staff.pedalSustainStyle = #'mixed
  c'8 \sustainOn
  d'8
  e'8
  f'8 \sustainOff
}

```

Return piano pedal spanner.

kind

Get piano pedal spanner kind:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.PianoPedalSpanner(staff[:])
abjad> spanner.kind
'sustain'

```

Set piano pedal spanner kind:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.PianoPedalSpanner(staff[:])
abjad> spanner.kind = 'sostenuto'
abjad> spanner.kind
'sostenuto'

```

Acceptable values 'sustain', 'sostenuto', 'corda'.

style

Get piano pedal spanner style:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.PianoPedalSpanner(staff[:])
abjad> spanner.style
'mixed'

```

Set piano pedal spanner style:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.PianoPedalSpanner(staff[:])
abjad> spanner.style = 'bracket'
abjad> spanner.style
'bracket'

```

Acceptable values 'mixed', 'bracket', 'text'.

spannertools.SlurSpanner

class abjad.tools.spannertools.**SlurSpanner** (*components=None*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad slur spanner:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spannertools.SlurSpanner(staff[:])
SlurSpanner(c'8, d'8, e'8, f'8)

```

```
abjad> f(staff)
\new Staff {
    c'8 (
    d'8
    e'8
    f'8 )
}
```

Return slur spanner.

spannertools.Spanner

class `abjad.tools.spannertools.Spanner` (*components=None*)
 Bases: `abjad.core._StrictComparator._StrictComparator`

Any type of notation object that stretches horizontally and encompasses some number of notes, rest, chords, tuplets, measures, voices or other Abjad components.

Beams, slurs, hairpins, trills, glissandi and piano pedal brackets all stretch horizontally on the page to encompass multiple notes and all implement as Abjad spanners. That is, these spanner all have an obvious graphic reality with definite start-, stop- and midpoints.

Abjad also implements a number of spanners of a different type, such as tempo and instrument spanners, which mark a group of notes, rests, chords or measures as carrying a certain tempo or being played by a certain instrument.

The spanner class described here abstracts the functionality that all such spanners, both graphic and nongraphic, share. This shared functionality includes methods to add, remove, inspect and test components governed by the spanner, as well as basic formatting properties. The other spanner classes, such as beam and glissando, all inherit from this class and receive the functionality implemented here.

append (*component*)

Add *component* to right of spanner.

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[:2])
abjad> spanner
Spanner(c'8, d'8)

abjad> spanner.append(voice[2])
abjad> spanner
Spanner(c'8, d'8, e'8)
```

Return none.

append_left (*component*)

Add *component* to left of spanner.

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[2:])
abjad> spanner
Spanner(e'8, f'8)

abjad> spanner.append_left(voice[1])
abjad> spanner
Spanner(d'8, e'8, f'8)
```

Return none.

clear()

Remove all components from spanner:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[:])
abjad> spanner
Spanner(c'8, d'8, e'8, f'8)

abjad> spanner.clear()
abjad> spanner
Spanner()
```

Return none.

components

Return read-only tuple of components in spanner.

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[:2])
abjad> spanner.components
(Note("c'8"), Note("d'8"))
```

Changed in version 1.1: Now returns an (immutable) tuple instead of a (mutable) list.

duration_in_seconds

Sum of duration of all leaves in spanner, in seconds.

extend(components)

Add iterable *components* to right of spanner:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[:2])
abjad> spanner
Spanner(c'8, d'8)

abjad> spanner.extend(voice[2:])
abjad> spanner
Spanner(c'8, d'8, e'8, f'8)
```

Return none.

extend_left(components)

Add iterable *components* to left of spanner:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[2:])
abjad> spanner
Spanner(e'8, f'8)

abjad> spanner.extend_left(voice[:2])
abjad> spanner
Spanner(c'8, d'8, e'8, f'8)
```

Return none.

fracture(i, direction='both')

Fracture spanner at *direction* of component at index *i*.

Valid values for *direction* are 'left', 'right' and 'both'.

Return original, left and right spanners.

```

abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(voice[:])
abjad> beam
BeamSpanner(c'8, d'8, e'8, f'8)

abjad> beam.fracture(1, direction = 'left')
(BeamSpanner(c'8, d'8, e'8, f'8), BeamSpanner(c'8), BeamSpanner(d'8, e'8, f'8))

abjad> print voice.format
\new Voice {
  c'8 [ ]
  d'8 [
  e'8
  f'8 ]
}
```

Return tuple.

fuse (*spanner*)

Fuse contiguous spanners.

Return new spanner.

```

abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> left_beam = spannertools.BeamSpanner(voice[:2])
abjad> right_beam = spannertools.BeamSpanner(voice[2:])

abjad> print voice.format
\new Voice {
  c'8 [
  d'8 ]
  e'8 [
  f'8 ]
}

abjad> left_beam.fuse(right_beam)
[(BeamSpanner(c'8, d'8), BeamSpanner(e'8, f'8), BeamSpanner(c'8, d'8, e'8, f'8))]
```

```

abjad> print voice.format
\new Voice {
  c'8 [
  d'8
  e'8
  f'8 ]
}
```

Todo

Return (immutable) tuple instead of (mutable) list.

index (*component*)

Return nonnegative integer index of *component* in spanner.

```

abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[2:])
abjad> spanner
Spanner(e'8, f'8)
```

```
abjad> spanner.index(voice[-2])
0
```

Return nonnegative integer.

leaves

Return read-only tuple of leaves in spanner.

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[:2])
abjad> spanner.leaves
(Note("c'8"), Note("d'8"))
```

Changed in version 1.1: Now returns an (immutable) tuple instead of a (mutable) list.

Note: When dealing with large, complex scores accessing this attribute can take some time. Best to make a local copy with `leaves = spanner.leaves` first. Or use spanner- specific iteration tools.

offset

New in version 1.1. Return read-only reference to spanner offset interface.

Spanner offset interface implements `start` and `stop` attributes.

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[2:])
abjad> spanner
Spanner(e'8, f'8)
```

```
abjad> spanner._offset.start
Offset(1, 4)
```

```
abjad> spanner._offset.stop
Offset(1, 2)
```

Return duration.

override

LilyPond grob override component plug-in.

pop()

Remove and return rightmost component in spanner.

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[:])
abjad> spanner
Spanner(c'8, d'8, e'8, f'8)
```

```
abjad> spanner.pop()
Note("f'8")
```

```
abjad> spanner
Spanner(c'8, d'8, e'8)
```

Return component.

pop_left()

Remove and return leftmost component in spanner.

```

abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.Spanner(voice[:])
abjad> spanner
Spanner(c'8, d'8, e'8, f'8)

abjad> spanner.pop_left()
Note("c'8")

abjad> spanner
Spanner(d'8, e'8, f'8)

```

Return component.

preprolated_duration

Sum of preprolated duration of all components in spanner.

prolated_duration

Sum of prolated duration of all components in spanner.

set

LilyPond context setting component plug-in.

written_duration

Sum of written duration of all components in spanner.

spannertools.StaffLinesSpanner

class abjad.tools.spannertools.**StaffLinesSpanner** (*components=None, arg=5*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad staff lines spanner:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spannertools.StaffLinesSpanner(staff[:2], 1)
StaffLinesSpanner(c'8, d'8)

abjad> f(staff)
\new Staff {
  \stopStaff
  \override Staff.StaffSymbol #'line-count = #1
  \startStaff
  c'8
  d'8
  \stopStaff
  \revert Staff.StaffSymbol #'line-count
  \startStaff
  e'8
  f'8
}

```

Staff lines spanner handles changing either the line-count or the line-positions property of the StaffSymbol grob, as well as automatically stopping and restarting the staff so that the change may take place.

Return staff lines spanner.

lines

Get staff lines spanner line count:


```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.StaffLinesSpanner(staff[:2], 1)
abjad> spanner.lines
1

```

Set staff lines spanner line count:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.StaffLinesSpanner(staff[:2], 1)
abjad> spanner.lines = 2
abjad> spanner.lines
2

```

Set integer.

spannertools.TextScriptSpanner

class abjad.tools.spannertools.**TextScriptSpanner** (*components=None*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner New in version 2.0. Abjad text script spanner:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spanner = spannertools.TextScriptSpanner(staff[:])
abjad> spanner.override.text_script.color = 'red'
abjad> markuptools.Markup(r'\italic { espressivo }', 'up')(staff[1])
Markup('\italic { espressivo }', 'up')

abjad> f(staff)
\new Staff {
  \override TextScript #'color = #red
  c'8
  d'8 ^ \markup { \italic { espressivo } }
  e'8
  f'8
  \revert TextScript #'color
}

```

Override LilyPond TextScript grob.

Return text script spanner.

spannertools.TextSpanner

class abjad.tools.spannertools.**TextSpanner** (*components=None*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner New in version 2.0. Abjad text spanner:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> text_spanner = spannertools.TextSpanner(staff[:])

abjad> markup = markuptools.Markup('(markup #:bold #:italic "foo")', style_string = 'scheme')
abjad> text_spanner.override.text_spanner.bound_details__left__text = markup
abjad> markup = markuptools.Markup("(markup #:draw-line '(0 . -1))", style_string = 'scheme')
abjad> text_spanner.override.text_spanner.bound_details__right__text = markup
abjad> text_spanner.override.text_spanner.dash_fraction = 1

```

```

abjad> f(staff)
\new Staff {
  \override TextSpanner #'bound-details #'left #'text = #(markup #:bold #:italic "foo")
  \override TextSpanner #'bound-details #'right #'text = #(markup #:draw-line '(0 . -1))
  \override TextSpanner #'dash-fraction = #1
  c'8 \startTextSpan
  d'8
  e'8
  f'8 \stopTextSpan
  \revert TextSpanner #'bound-details #'left #'text
  \revert TextSpanner #'bound-details #'right #'text
  \revert TextSpanner #'dash-fraction
}

```

Override LilyPond TextSpanner grob.

Return text spanner.

spannertools.TrillSpanner

class abjad.tools.spannertools.**TrillSpanner**(*components=None*)
Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad trill spanner:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> spannertools.TrillSpanner(staff[:])
TrillSpanner(c'8, d'8, e'8, f'8)

abjad> f(staff)
\new Staff {
  c'8 \startTrillSpan
  d'8
  e'8
  f'8 \stopTrillSpan
}

```

Override LilyPond TrillSpanner grob.

Return trill spanner.

pitch

Optional read / write pitch for pitched trills.

```

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> trill = spannertools.TrillSpanner(t[:2])
abjad> trill.pitch = pitchtools.NamedChromaticPitch('cs', 4)

abjad> f(t)
\new Staff {
  \pitchedTrill c'8 \startTrillSpan cs'
  d'8 \stopTrillSpan
  e'8
  f'8
}

```

Set pitch.

written_pitch

spannertools.all_are_spanners

`abjad.tools.spannertools.all_are_spanners(expr)`

New in version 2.6. True when *expr* is a sequence of Abjad spanners:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> spanner = spannertools.BeamSpanner(voice[:2])
```

```
abjad> spannertools.all_are_spanners([spanner])
True
```

True when *expr* is an empty sequence:

```
abjad> spannertools.all_are_spanners([])
True
```

Otherwise false:

```
abjad> spannertools.all_are_spanners('foo')
False
```

Return boolean.

spannertools.destroy_all_spanners_attached_to_component

`abjad.tools.spannertools.destroy_all_spanners_attached_to_component(component, klass=None)`

New in version 1.1. Destroy all spanners attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> trill = spannertools.TrillSpanner(staff)
abjad> f(staff)
\new Staff {
    c'8 [ ( \startTrillSpan
    d'8
    e'8
    f'8 ] ) \stopTrillSpan
}

abjad> spannertools.destroy_all_spanners_attached_to_component(staff[0])
abjad> f(staff)
\new Staff {
    c'8 \startTrillSpan
    d'8
    e'8
    f'8 \stopTrillSpan
}
```

Return none.

spannertools.find_index_of_spanner_component_at_score_offset

abjad.tools.spannertools.**find_index_of_spanner_component_at_score_offset** (*spanner*, *score_offset*)

Return index of component in ‘spanner’ that begins at exactly ‘score_offset’:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

abjad> spannertools.find_index_of_spanner_component_at_score_offset(beam, Duration(3, 8))
3
```

Raise spanner population error when no component in *spanner* begins at exactly *score_offset*. Changed in version 2.0: renamed `spannertools.find_index_at_score_offset()` to `spannertools.find_index_of_spanner_component_at_score_offset()`.

spannertools.find_spanner_component_starting_at_exactly_score_offset

abjad.tools.spannertools.**find_spanner_component_starting_at_exactly_score_offset** (*spanner*, *score_offset*)

Find *spanner* component starting at exactly *score_offset*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)

abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

abjad> spannertools.find_spanner_component_starting_at_exactly_score_offset(beam, Duration(3, 8))
Note("f'8")
```

When no *spanner* component starts at exactly *score_offset* return none.

Return *spanner* component or none. Changed in version 2.0: re-named `spannertools.find_component_at_score_offset()` to `spannertools.find_spanner_component_starting_at_exactly_score_offset()`.

spannertools.fracture_all_spanners_attached_to_component

abjad.tools.spannertools.**fracture_all_spanners_attached_to_component** (*component*, *direction*=‘both’, *klass*=None)

New in version 1.1. Fracture all spanners attached to *component* according to *direction*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> trill = spannertools.TrillSpanner(staff)
abjad> f(staff)
\new Staff {
    c'8 [ ( \startTrillSpan
    d'8
    e'8
    f'8 ] ) \stopTrillSpan
}

abjad> spannertools.fracture_all_spanners_attached_to_component(staff[1], 'right')
[(BeamSpanner(c'8, d'8, e'8, f'8), BeamSpanner(c'8, d'8), BeamSpanner(e'8, f'8)), (SlurSpanner(c'8, d'8, e'8, f'8))]

abjad> f(staff)
\new Staff {
    c'8 [ ( \startTrillSpan
    d'8 ] )
    e'8 [ (
    f'8 ] ) \stopTrillSpan
}

```

Set *direction* to left, right or both.

spannertools.fracture_spanners_that_cross_components

`abjad.tools.spannertools.fracture_spanners_that_cross_components(components)`

Fracture to the left of the leftmost component. Fracture to the right of the rightmost component. Do not fracture spanners of any components at higher levels of score. Do not fracture spanners of any components at lower levels of score. Return components.

Components must be thread-contiguous. Some spanners may copy during fracture. This helper is public-safe.

Example:

```

t = Staff(Container(notetools.make_repeated_notes(2)) * 3)
pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
spannertools.CrescendoSpanner(t)
spannertools.BeamSpanner(t[:])
spannertools.TrillSpanner(t.leaves)

\new Staff {
    {
        c'8 [ \< \startTrillSpan
        d'8
    }
    {
        e'8
        f'8
    }
    {
        g'8
        a'8 ] \! \stopTrillSpan
    }
}

spannertools.fracture_spanners_that_cross_components(t[1:2])

```

```
\new Staff {
  {
    c'8 [ \< \startTrillSpan
    d'8 ]
  }
  {
    e'8 [
    f'8 ]
  }
  {
    g'8 [
    a'8 ] \! \stopTrillSpan
  }
}
```

Changed in version 2.0: renamed `spannertools.fracture_crossing()` to `spannertools.fracture_spanners_that_cross_components()`.

`spannertools.get_beam_spanner_attached_to_component`

`abjad.tools.spannertools.get_beam_spanner_attached_to_component` (*component*)

New in version 2.0. Get the only beam spanner attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
```

```
abjad> f(staff)
\new Staff {
  c'8 [
  d'8
  e'8
  f'8 ]
}
```

```
abjad> spannertools.get_beam_spanner_attached_to_component(staff[0])
BeamSpanner(c'8, d'8, e'8, f'8)
```

```
abjad> _ is beam
True
```

Return beam spanner.

Raise missing spanner error when no beam spanner attached to *component*.

Raise extra spanner error when more than one beam spanner attached to *component*. Changed in version 2.0: renamed `beamtools.get_beam_spanner()` to `spannertools.get_beam_spanner_attached_to_component()`. Changed in version 2.0: renamed `beamtools.get_beam_spanner_attached_to_component()` to `spannertools.get_beam_spanner_attached_to_component()`.

`spannertools.get_nth_leaf_in_spanner`

`abjad.tools.spannertools.get_nth_leaf_in_spanner` (*spanner*, *idx*)

Get *nth* leaf in spanner, no matter how complicated the nesting situation. Changed in version 2.0: renamed `spannertools.get_nth_leaf()` to `spannertools.get_nth_leaf_in_spanner()`.

spannertools.get_spanners_attached_to_any_improper_child_of_component

`abjad.tools.spannertools.get_spanners_attached_to_any_improper_child_of_component` (*component*, *klass=None*)

New in version 2.0. Get all spanners attached to any improper children of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> first_slur = spannertools.SlurSpanner(staff.leaves[:2])
abjad> second_slur = spannertools.SlurSpanner(staff.leaves[2:])
abjad> trill = spannertools.TrillSpanner(staff)

abjad> f(staff)
\new Staff {
    c'8 [ ( \startTrillSpan
    d'8 )
    e'8 (
    f'8 ] ) \stopTrillSpan
}

abjad> len(spannertools.get_spanners_attached_to_any_improper_child_of_component(staff)) == 4
True
```

Get all spanners of *klass* attached to any proper children of *component*:

```
abjad> spanner_klass = spannertools.SlurSpanner
abjad> spannertools.get_spanners_attached_to_any_proper_child_of_component(staff, spanner_klass)
set([SlurSpanner(c'8, d'8), SlurSpanner(e'8, f'8)])
```

Get all spanners of any *klass* attached to any proper children of *component*:

```
abjad> spanner_klasses = (spannertools.SlurSpanner, spannertools.BeamSpanner)
abjad> spannertools.get_spanners_attached_to_any_proper_child_of_component(staff, spanner_klasses)
set([BeamSpanner(c'8, d'8, e'8, f'8), SlurSpanner(c'8, d'8), SlurSpanner(e'8, f'8)])
```

Return unordered set of zero or more spanners. Changed in version 2.0: renamed `spannertools.get_all_spanners_attached_to_any_improper_children_of_component()` to `spannertools.get_spanners_attached_to_any_improper_child_of_component()`.

spannertools.get_spanners_attached_to_any_improper_parent_of_component

`abjad.tools.spannertools.get_spanners_attached_to_any_improper_parent_of_component` (*component*, *klass=None*)

New in version 1.1. Get all spanners attached to improper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> trill = spannertools.TrillSpanner(staff)
abjad> f(staff)
\new Staff {
    c'8 [ ( \startTrillSpan
    d'8
    e'8
    f'8 ] ) \stopTrillSpan
}
```

```
abjad> spannertools.get_spanners_attached_to_any_improper_parent_of_component(staff[0]) # doctest
set([BeamSpanner(c'8, d'8, e'8, f'8), SlurSpanner(c'8, d'8, e'8, f'8), TrillSpanner({c'8, d'8, e
```

Return unordered set of zero or more spanners. Changed in version 2.0: renamed `spannertools.get_all_spanners_attached_to_improper_parentage_of_component()` to `spannertools.get_spanners_attached_to_any_improper_parent_of_component()`.

`spannertools.get_spanners_attached_to_any_proper_child_of_component`

`abjad.tools.spannertools.get_spanners_attached_to_any_proper_child_of_component`(*component*, *klass=None*)

New in version 2.0. Get all spanners attached to any proper children of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> first_slur = spannertools.SlurSpanner(staff.leaves[:2])
abjad> second_slur = spannertools.SlurSpanner(staff.leaves[2:])
abjad> trill = spannertools.TrillSpanner(staff)

abjad> f(staff)
\new Staff {
    c'8 [ ( \startTrillSpan
    d'8 )
    e'8 (
    f'8 ] ) \stopTrillSpan
}

abjad> len(spannertools.get_spanners_attached_to_any_proper_child_of_component(staff)) == 3
True
```

Get all spanners of *klass* attached to any proper children of *component*:

```
abjad> spanner_klass = spannertools.SlurSpanner
abjad> spannertools.get_spanners_attached_to_any_proper_child_of_component(staff, spanner_klass)
set([SlurSpanner(c'8, d'8), SlurSpanner(e'8, f'8)])
```

Get all spanners of any *klass* attached to any proper children of *component*:

```
abjad> spanner_klasses = (spannertools.SlurSpanner, spannertools.BeamSpanner)
abjad> spannertools.get_spanners_attached_to_any_proper_child_of_component(staff, spanner_klasses)
set([BeamSpanner(c'8, d'8, e'8, f'8), SlurSpanner(c'8, d'8), SlurSpanner(e'8, f'8)])
```

Return unordered set of zero or more spanners. Changed in version 2.0: renamed `spannertools.get_all_spanners_attached_to_any_proper_children_of_component()` to `spannertools.get_spanners_attached_to_any_proper_child_of_component()`.

`spannertools.get_spanners_attached_to_any_proper_parent_of_component`

`abjad.tools.spannertools.get_spanners_attached_to_any_proper_parent_of_component`(*component*, *klass=None*)

New in version 2.0. Get all spanners attached to any proper parent of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> trill = spannertools.TrillSpanner(staff)
abjad> f(staff)
```



```
\new Staff {
  c'8 [ ( \startTrillSpan
  d'8
  e'8
  f'8 ] ) \stopTrillSpan
}
```

```
abjad> spannertools.get_spanners_attached_to_any_proper_parent_of_component(staff[0])
set([TrillSpanner({c'8, d'8, e'8, f'8}))])
```

Return unordered set of zero or more spanners. Changed in version 2.0: renamed `spannertools.get_all_spanners_attached_to_any_proper_parent_of_component()` to `spannertools.get_spanners_attached_to_any_proper_parent_of_component()`.

spannertools.get_spanners_attached_to_component

`abjad.tools.spannertools.get_spanners_attached_to_component` (*component*,
klass=None)

New in version 2.0. Get all spanners attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> first_slur = spannertools.SlurSpanner(staff.leaves[:2])
abjad> second_slur = spannertools.SlurSpanner(staff.leaves[2:])
abjad> crescendo = spannertools.CrescendoSpanner(staff.leaves)
```

```
abjad> f(staff)
\new Staff {
  c'8 [ \< (
  d'8 )
  e'8 (
  f'8 ] \! )
}
```

```
abjad> spannertools.get_spanners_attached_to_component(staff.leaves[0]) # doctest: +SKIP
set([BeamSpanner(c'8, d'8, e'8, f'8), SlurSpanner(c'8, d'8), CrescendoSpanner(c'8, d'8, e'8, f'8)])
```

Get spanners of *klass* attached to *component*:

```
abjad> klass = spannertools.BeamSpanner
abjad> spannertools.get_spanners_attached_to_component(staff.leaves[0], klass) # doctest: +SKIP
set([BeamSpanner(c'8, d'8, e'8, f'8)])
```

Get spanners of any *klass* attached to *component*:

```
abjad> klassen = (spannertools.BeamSpanner, spannertools.SlurSpanner)
abjad> spannertools.get_spanners_attached_to_component(staff.leaves[0], klassen) # doctest: +SKIP
set([BeamSpanner(c'8, d'8, e'8, f'8), SlurSpanner(c'8, d'8)])
```

Return unordered set of zero or more spanners. Changed in version 2.0: re-named `spannertools.get_all_spanners_attached_to_component()` to `spannertools.get_spanners_attached_to_component()`.

spannertools.get_spanners_contained_by_components

`abjad.tools.spannertools.get_spanners_contained_by_components` (*components*)

Return unordered set of spanners contained within any component in list of thread-

contiguous components. Getter for `t.spanners.contained` across thread-contiguous components. Changed in version 2.0: renamed `spannertools.get_contained()` to `spannertools.get_spanners_contained_by_components()`.

`spannertools.get_spanners_covered_by_components`

`abjad.tools.spannertools.get_spanners_covered_by_components(components)`

Return unordered set of spanners completely contained within the time bounds of thread-contiguous components.

Compare ‘covered’ spanners with ‘contained’ spanners. Compare ‘covered’ spanners with ‘dominant’ spanners.

Changed in version 2.0: renamed `spannertools.get_covered()` to `spannertools.get_spanners_covered_by_components()`.

`spannertools.get_spanners_on_components_or_component_children`

`abjad.tools.spannertools.get_spanners_on_components_or_component_children(components)`

Return unordered set of all spanners attaching to any component in *components* or attaching to any of the children of any of the components in *components*. Changed in version 2.0: renamed `spannertools.get_attached()` to `spannertools.get_spanners_on_components_or_component_children()`.

`spannertools.get_spanners_that_cross_components`

`abjad.tools.spannertools.get_spanners_that_cross_components(components)`

Assert thread-contiguous components. Collect spanners that attach to any component in ‘components’. Return unordered set of crossing spanners. A spanner P crosses a list of thread-contiguous components C when P and C share at least one component and when it is the case that NOT ALL of the components in P are also in C. In other words, there is some intersection – but not total intersection – between the components of P and C.

Compare ‘crossing’ spanners with ‘covered’ spanners. Compare ‘crossing’ spanners with ‘dominant’ spanners. Compare ‘crossing’ spanners with ‘contained’ spanners. Compare ‘crossing’ spanners with ‘attached’ spanners. Changed in version 2.0: renamed `spannertools.get_crossing()` to `spannertools.get_spanners_that_cross_components()`.

`spannertools.get_spanners_that_dominate_component_pair`

`abjad.tools.spannertools.get_spanners_that_dominate_component_pair(left, right)`

Return Python list of (spanner, index) pairs. ‘left’ must be either an Abjad component or None. ‘right’ must be either an Abjad component or None.

If both ‘left’ and ‘right’ are components, then ‘left’ and ‘right’ must be thread-contiguous.

This is a special version of `spannertools.get_spanners_that_dominate_components()`. This version is useful for finding spanners that dominate a zero-length ‘crack’ between components, as in `t[2:2]`. Changed in version 2.0: renamed `spannertools.get_dominant_between()` to `spannertools.get_spanners_that_dominate_component_pair()`.

`spannertools.get_spanners_that_dominates_components`

`abjad.tools.spannertools.get_spanners_that_dominates_components(components)`

Return Python list of (spanner, index) pairs. Each (spanner, index) pair gives a spanner which dominates all components in ‘components’ together with the start-index at which spanner first encounters ‘components’.

Use this helper to ‘lift’ any and all spanners temporarily from ‘components’, perform some action to the underlying score tree, and then reattach all spanners to new score components.

This operation always leaves all expressions in tact. Changed in version 2.0: renamed `spannertools.get_dominant()` to `spannertools.get_spanners_that_dominates_components()`.

`spannertools.get_spanners_that_dominates_container_components_from_to`

`abjad.tools.spannertools.get_spanners_that_dominates_container_components_from_to(container, start, stop)`

Return Python list of (spanner, index) pairs. Each spanner dominates the components specified by slice with start index ‘start’ and stop index ‘stop’. Generalization of dominant spanner-finding functions for slices. This exists for slices like `t[2:2]` that are empty lists. Changed in version 2.0: renamed `spannertools.get_dominant_slice()` to `spannertools.get_spanners_that_dominates_container_components_from_to()`.

`spannertools.get_the_only_spanner_attached_to_any_improper_parent_of_component`

`abjad.tools.spannertools.get_the_only_spanner_attached_to_any_improper_parent_of_component`

New in version 1.1. Get the only spanner attached to any improper parent *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> trill = spannertools.TrillSpanner(staff)
abjad> f(staff)
\new Staff {
  c'8 [ ( \startTrillSpan
  d'8
  e'8
  f'8 ] ) \stopTrillSpan
}

abjad> print spannertools.get_the_only_spanner_attached_to_component(staff)
TrillSpanner({c'8, d'8, e'8, f'8})
```

Raise missing spanner error when no spanner attached to *component*.

Raise extra spanner error when more than one spanner attached to *component*.

Return a single spanner.

Note: function will usually be called with *klass* specifier set.

spannertools.get_the_only_spanner_attached_to_component

`abjad.tools.spannertools.get_the_only_spanner_attached_to_component` (*component*, *klass=None*)

New in version 1.1. Get the only spanner attached to *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> trill = spannertools.TrillSpanner(staff)
abjad> f(staff)
\new Staff {
    c'8 [ ( \startTrillSpan
    d'8
    e'8
    f'8 ] ) \stopTrillSpan
}

abjad> print spannertools.get_the_only_spanner_attached_to_component(staff)
TrillSpanner({c'8, d'8, e'8, f'8})
```

Raise missing spanner error when no spanner attached to *component*.

Raise extra spanner error when more than one spanner attached to *component*.

Return a single spanner.

Note: function will usually be called with *klass* specifier set.

spannertools.is_component_with_beam_spanner_attached

`abjad.tools.spannertools.is_component_with_beam_spanner_attached` (*expr*)

New in version 2.0. True when *expr* is component with beam spanner attached:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)

abjad> spannertools.is_component_with_beam_spanner_attached(staff[0])
True
```

Otherwise false:

```
abjad> note = Note("c'8")

abjad> spannertools.is_component_with_beam_spanner_attached(note)
False
```

Return boolean. Changed in version 2.0: renamed `beamtools.is_component_with_beam_spanner_attached()` to `spannertools.is_component_with_beam_spanner_attached()`.

spannertools.is_component_with_spanner_attached

`abjad.tools.spannertools.is_component_with_spanner_attached` (*expr*, *klass=None*)

New in version 2.0. True when *expr* is a component with spanner attached:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> f(staff)
\new Staff {
    c'8 [
    d'8
    e'8
    f'8 ]
}

abjad> spannertools.is_component_with_spanner_attached(staff[0])
True

```

Otherwise false:

```

abjad> spannertools.is_component_with_spanner_attached(staff)
False

```

When *klass* is not none then true when *expr* is a component with a spanner of *klass* attached.

Return true or false.

spannertools.iterate_components_backward_in_spanner

```

abjad.tools.spannertools.iterate_components_backward_in_spanner(spanner,
                                                                klass=<class
                                                                'ab-
                                                                jad.tools.componenttools._Component.

```

New in version 2.0. Yield components in *spanner* one at a time from left to right.

```

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> p = spannertools.BeamSpanner(t[2:])
abjad> notes = spannertools.iterate_components_backward_in_spanner(p, klass = Note)
abjad> for note in notes:
...     note
Note("f'8")
Note("e'8")

```

Changed in version 2.0: renamed `spannertools.iterate_components_backward()` to `spannertools.iterate_components_backward_in_spanner()`.

spannertools.iterate_components_forward_in_spanner

```

abjad.tools.spannertools.iterate_components_forward_in_spanner(spanner,
                                                                klass=<class
                                                                'ab-
                                                                jad.tools.componenttools._Component.

```

New in version 2.0. Yield components in *spanner* one at a time from left to right.

```

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> p = spannertools.BeamSpanner(t[2:])
abjad> notes = spannertools.iterate_components_forward_in_spanner(p, klass = Note)
abjad> for note in notes:
...     note
Note("e'8")
Note("f'8")

```

Changed in version 2.0: renamed `spannertools.iterate_components_forward()` to `spannertools.iterate_components_forward_in_spanner()`.

spannertools.make_covered_spanner_schema

`abjad.tools.spannertools.make_covered_spanner_schema(components)`

New in version 2.0. Make schema of spanners covered by *components*:

```
abjad> voice = Voice(Measure((2, 8), notetools.make_repeated_notes(2)) * 4)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> beam = spannertools.BeamSpanner(voice.leaves[:4])
abjad> slur = spannertools.SlurSpanner(voice[-2:])
```

```
abjad> f(voice)
\new Voice {
  {
    \time 2/8
    c'8 [
    d'8
  ]
  {
    \time 2/8
    e'8
    f'8 ]
  ]
  {
    \time 2/8
    g'8 (
    a'8
  ]
  {
    \time 2/8
    b'8
    c''8 )
  ]
}

abjad> spannertools.make_covered_spanner_schema([voice]) # doctest: +SKIP
{BeamSpanner(c'8, d'8, e'8, f'8): [2, 3, 5, 6], SlurSpanner(|2/8(2)|, |2/8(2)|): [7, 10]}
```

Return dictionary.

spannertools.make_dynamic_spanner_below_with_nib_at_right

`abjad.tools.spannertools.make_dynamic_spanner_below_with_nib_at_right(dynamic_text, components=None)`

New in version 2.0. Span *components* with text spanner. Position spanner below staff and configure with *dynamic_text*, solid line and upward-pointing nib at right.

```
abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.make_dynamic_spanner_below_with_nib_at_right('mp', t[:])
TextSpanner(c'8, d'8, e'8, f'8)
abjad> f(t)
\new Staff {
```

```

\override TextSpanner #'bound-details #'left #'text = \markup { \dynamic { mp } }
\override TextSpanner #'bound-details #'right #'text = #(markup #:draw-line '(0 . 1))
\override TextSpanner #'bound-details #'right-broken #'text = ##f
\override TextSpanner #'dash-fraction = #1
\override TextSpanner #'direction = #down
c'8 \startTextSpan
d'8
e'8
f'8 \stopTextSpan
\revert TextSpanner #'bound-details #'left #'text
\revert TextSpanner #'bound-details #'right #'text
\revert TextSpanner #'bound-details #'right-broken #'text
\revert TextSpanner #'dash-fraction
\revert TextSpanner #'direction
}

```

Changed in version 2.0: renamed `spanners.dynamic_spanner_below_with_nib_at_right()` to `spannertools.make_dynamic_spanner_below_with_nib_at_right()`.

`spannertools.make_solid_text_spanner_above_with_nib_at_right`

`abjad.tools.spannertools.make_solid_text_spanner_above_with_nib_at_right` (*left_text*, *com-*
po-
nents=None)

New in version 2.0. Span *components* with text spanner. Position spanner above staff and configure with *left_text*, solid line and downward-pointing nib at right.

```

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.make_solid_text_spanner_above_with_nib_at_right('foo', t[:])
TextSpanner(c'8, d'8, e'8, f'8)
abjad> f(t)
\new Staff {
  \override TextSpanner #'bound-details #'left #'text = \markup { foo }
  \override TextSpanner #'bound-details #'right #'text = #(markup #:draw-line '(0 . -1))
  \override TextSpanner #'bound-details #'right-broken #'text = ##f
  \override TextSpanner #'dash-fraction = #1
  \override TextSpanner #'direction = #up
  c'8 \startTextSpan
  d'8
  e'8
  f'8 \stopTextSpan
  \revert TextSpanner #'bound-details #'left #'text
  \revert TextSpanner #'bound-details #'right #'text
  \revert TextSpanner #'bound-details #'right-broken #'text
  \revert TextSpanner #'dash-fraction
  \revert TextSpanner #'direction
}

```

Changed in version 2.0: renamed `spanners.solid_text_spanner_above_with_nib_at_right()` to `spannertools.make_solid_text_spanner_above_with_nib_at_right()`.

spannertools.make_solid_text_spanner_below_with_nib_at_right

abjad.tools.spannertools.**make_solid_text_spanner_below_with_nib_at_right** (*left_text*, *components=**None*)

New in version 2.0. Span *components* with text spanner. Position spanner below staff and configure with *left_text*, solid line and upward-pointing nib at right.

```
abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> spannertools.make_solid_text_spanner_below_with_nib_at_right('foo', t[:])
TextSpanner(c'8, d'8, e'8, f'8)
abjad> f(t)
\new Staff {
  \override TextSpanner #'bound-details #'left #'text = \markup { foo }
  \override TextSpanner #'bound-details #'right #'text = #(markup #:draw-line '(0 . 1))
  \override TextSpanner #'bound-details #'right-broken #'text = ##f
  \override TextSpanner #'dash-fraction = #1
  \override TextSpanner #'direction = #down
  c'8 \startTextSpan
  d'8
  e'8
  f'8 \stopTextSpan
  \revert TextSpanner #'bound-details #'left #'text
  \revert TextSpanner #'bound-details #'right #'text
  \revert TextSpanner #'bound-details #'right-broken #'text
  \revert TextSpanner #'dash-fraction
  \revert TextSpanner #'direction
}
```

Changed in version 2.0: renamed `spanners.solid_text_spanner_below_with_nib_at_right()` to `spannertools.make_solid_text_spanner_below_with_nib_at_right()`.

spannertools.make_spanner_schema

abjad.tools.spannertools.**make_spanner_schema** (*components*)

New in version 2.0. Make schema of spanners contained by *components*:

```
abjad> voice = Voice(Measure((2, 8), notetools.make_repeated_notes(2)) * 4)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(voice)
abjad> beam = spannertools.BeamSpanner(voice.leaves[:4])
abjad> slur = spannertools.SlurSpanner(voice[-2:])

abjad> f(voice)
\new Voice {
  {
    \time 2/8
    c'8 [
    d'8
  ]
  {
    \time 2/8
    e'8
    f'8 ]
  }
  {
    \time 2/8
```



```

        g'8 (
        a'8
    }
    {
        \time 2/8
        b'8
        c''8 )
    }
}

abjad> spannertools.make_spanner_schema(voice.leaves[2:4])
{BeamSpanner(c'8, d'8, e'8, f'8): [0, 1]}
```

Return dictionary.

spannertools.move_spanners_from_component_to_children_of_component

`abjad.tools.spannertools.move_spanners_from_component_to_children_of_component` (*donor*)
 Give spanners attaching directly to donor to recipients. Usual use is to give attached spanners from parent to children, which is a composer-safe operation. Changed in version 2.0: renamed `spannertools.give_attached_to_children()` to `spannertools.move_spanners_from_component_to_children_of_component()`.

spannertools.report_as_string_format_contributions_of_all_spanners_attached_to_component

`abjad.tools.spannertools.report_as_string_format_contributions_of_all_spanners_attached_to_`

New in version 1.1. Report as string format contributions of all spanners attached to *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> trill = spannertools.TrillSpanner(staff)
abjad> f(staff)
\new Staff {
    c'8 [ ( \startTrillSpan
    d'8
    e'8
    f'8 ] ) \stopTrillSpan
}

abjad> spannertools.report_as_string_format_contributions_of_all_spanners_attached_to_component (
'BeamSpanner\n\t_right\n\t\t[\nSlurSpanner\n\t_right\n\t\t\t(\n'
```

Return string.

spannertools.report_as_string_format_contributions_of_all_spanners_attached_to_improper_parentage_of_comp

`abjad.tools.spannertools.report_as_string_format_contributions_of_all_spanners_attached_to_`

New in version 1.1. Report as string format contributions of all spanners attached to improper parentage of *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> beam = spannertools.BeamSpanner(staff.leaves)
abjad> slur = spannertools.SlurSpanner(staff.leaves)
abjad> trill = spannertools.TrillSpanner(staff)
abjad> f(staff)
\new Staff {
    c'8 [ ( \startTrillSpan
    d'8
    e'8
    f'8 ] ) \stopTrillSpan
}

abjad> spannertools.report_as_string_format_contributions_of_all_spanners_attached_to_component (
'BeamSpanner\n\t_right\n\t\t[\nSlurSpanner\n\t_right\n\t\t(\n'
```

Return string.

spannertools.withdraw_components_from_spanners_covered_by_components

`abjad.tools.spannertools.withdraw_components_from_spanners_covered_by_components(components)`
 Find every spanner covered by 'components'. Withdraw all components in 'components' from covered spanners. Return 'components'. The operation always leaves all score trees in tact. Changed in version 2.0: renamed `spannertools.withdraw_from_covered()` to `spannertools.withdraw_components_from_spanners_covered_by_components()`.

stafftools

stafftools.RhythmicStaff

class `abjad.tools.stafftools.RhythmicStaff(music=[], **kwargs)`
 Bases: `abjad.tools.stafftools.Staff.Staff.Staff`
 Abjad model of a rhythmic staff.

stafftools.Staff

class `abjad.tools.stafftools.Staff(music=None, **kwargs)`
 Bases: `abjad.tools.contexttools._Context._Context._Context`
 Abjad model of a staff:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}
```

Return staff object.

stafftools.all_are_staves

`abjad.tools.stafftools.all_are_staves(expr)`

New in version 2.6. True when *expr* is a sequence of Abjad staves:

```
abjad> staff = Staff("c'4 d'4 e'4 f'4")

abjad> stafftools.all_are_staves([staff])
True
```

True when *expr* is an empty sequence:

```
abjad> stafftools.all_are_staves([])
True
```

Otherwise false:

```
abjad> stafftools.all_are_staves('foo')
False
```

Return boolean.

Function wraps `componenttools.all_are_components()`.

stafftools.get_first_staff_in_improper_parentage_of_component

`abjad.tools.stafftools.get_first_staff_in_improper_parentage_of_component(component)`

New in version 2.0. Get first staff in improper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}

abjad> stafftools.get_first_staff_in_improper_parentage_of_component(staff[1])
Staff{4}
```

Return staff or none.

stafftools.get_first_staff_in_proper_parentage_of_component

`abjad.tools.stafftools.get_first_staff_in_proper_parentage_of_component(component)`

New in version 2.0. Get first staff in proper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")

abjad> f(staff)
\new Staff {
    c'8
    d'8
    e'8
    f'8
}
```

```
abjad> stafftools.get_first_staff_in_proper_parentage_of_component(staff[1])
Staff{4}
```

Return staff or none.

stafftools.iterate_staves_backward_in_expr

`abjad.tools.stafftools.iterate_staves_backward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate staves backward in *expr*:

```
abjad> score = Score(4 * Staff([]))

abjad> f(score)
\new Score <<
  \new Staff {
  }
  \new Staff {
  }
  \new Staff {
  }
  \new Staff {
  }
>>

abjad> for staff in stafftools.iterate_staves_backward_in_expr(score):
...     staff
...
Staff{}
Staff{}
Staff{}
Staff{}

Return generator.
```

stafftools.iterate_staves_forward_in_expr

`abjad.tools.stafftools.iterate_staves_forward_in_expr(expr, start=0, stop=None)`

New in version 2.0. Iterate staves forward in *expr*:

```
abjad> score = Score(4 * Staff([]))

abjad> f(score)
\new Score <<
  \new Staff {
  }
  \new Staff {
  }
  \new Staff {
  }
  \new Staff {
  }
>>

abjad> for staff in stafftools.iterate_staves_forward_in_expr(score):
...     staff
...

```

```
Staff{}
Staff{}
Staff{}
Staff{}
```

Return generator.

stafftools.make_invisible_staff

abjad.tools.stafftools.**make_invisible_staff**(*music*)

Staff constructor that hides meter, bar line and staff lines. Changed in version 2.0: Invisible staff class changed to invisible staff function.

stafftools.make_rhythmic_sketch_staff

abjad.tools.stafftools.**make_rhythmic_sketch_staff**(*music*)

Make rhythmic staff with transparent meter and transparent bar lines.

tietools

tietools.TieSpanner

class abjad.tools.tietools.**TieSpanner**(*music=None*)

Bases: abjad.tools.spannertools.Spanner.Spanner.Spanner

Abjad tie spanner:

```
abjad> staff = Staff(notetools.make_repeated_notes(4))
abjad> tietools.TieSpanner(staff[:])
TieSpanner(c'8, c'8, c'8, c'8)
abjad> f(staff)
\new Staff {
    c'8 ~
    c'8 ~
    c'8 ~
    c'8
}
```

Return tie spanner.

tietools.add_or_remove_tie_chain_notes_to_achieve_scaled_written_duration

abjad.tools.tietools.**add_or_remove_tie_chain_notes_to_achieve_scaled_written_duration**(*tie_ch*

Scale tie chain by multiplier. Wraps tie_chain_duration_change. Returns tie chain. Changed in version 2.0: renamed tietools.duration_scale() to tietools.add_or_remove_tie_chain_notes_to_achieve_scaled_written_duration().

*(tie_ch
mul-
ti-
plier)*

tietools.add_or_remove_tie_chain_notes_to_achieve_written_duration

`abjad.tools.tietools.add_or_remove_tie_chain_notes_to_achieve_written_duration(tie_chain, new_written_duration)`

Change the written duration of tie chain, adding and subtracting notes as necessary.

Return newly modified tie chain. Changed in version 2.0: renamed `tietools.duration_change()` to `tietools.add_or_remove_tie_chain_notes_to_achieve_written_duration()`.

tietools.apply_tie_spanner_to_leaf_pair

`abjad.tools.tietools.apply_tie_spanner_to_leaf_pair(left, right)`

Apply tie spanner to *left* leaf and *right* leaf:

```
abjad> staff = Staff(notetools.make_repeated_notes(4))
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'8)
abjad> f(staff)
\new Staff {
    c'8 ~
    c'8
    c'8
    c'8
}

abjad> tietools.apply_tie_spanner_to_leaf_pair(staff[1], staff[2])

abjad> f(staff)
\new Staff {
    c'8 ~
    c'8 ~
    c'8
    c'8
}
```

Handle existing tie spanners intelligently.

Return `None`. Changed in version 2.0: renamed `tietools.span_leaf_pair()` to `tietools.apply_tie_spanner_to_leaf_pair()`.

tietools.are_components_in_same_tie_spanner

`abjad.tools.tietools.are_components_in_same_tie_spanner(components)`

True if all components in list share same tie spanner, otherwise False. Changed in version 2.0: renamed `tietools.are_in_same_spanner()` to `tietools.are_components_in_same_tie_spanner()`.

tietools.get_leaves_in_tie_chain

`abjad.tools.tietools.get_leaves_in_tie_chain(tie_chain)`

Return Python list of leaves in tie chain.

tietools.get_preprolated_tie_chain_duration

`abjad.tools.tietools.get_preprolated_tie_chain_duration(tie_chain)`

Get sum of preprolated duration of all leaves in *tie_chain*.

Todo

write `tietools.get_preprolated_tie_chain_duration()` tests.

Changed in version 2.0: renamed `tietools.get_duration_preprolated()` to `tietools.get_preprolated_tie_chain_duration()`.

tietools.get_prolated_tie_chain_duration

`abjad.tools.tietools.get_prolated_tie_chain_duration(tie_chain)`

Return sum of prolated duration of all leaves in chain.

Todo

Write `tietools.get_prolated_tie_chain_duration()` tests.

Changed in version 2.0: renamed `tietools.get_duration_prolated()` to `tietools.get_prolated_tie_chain_duration()`. Changed in version 2.0: renamed `tietools.get_tie_chain_prolated_duration()` to `tietools.get_prolated_tie_chain_duration()`.

tietools.get_tie_chain

`abjad.tools.tietools.get_tie_chain(component)`

New in version 2.0. Get tie chain from *component*.

tietools.get_tie_chain_duration_in_seconds

`abjad.tools.tietools.get_tie_chain_duration_in_seconds(tie_chain)`

Return sum of seconds duration of all leaves in chain.

Todo

Write `tietools.get_tie_chain_duration_in_seconds()` tests.

Changed in version 2.0: renamed `tietools.get_duration_seconds()` to `tietools.get_tie_chain_duration_in_seconds()`.

tietools.get_tie_chains_in_expr

`abjad.tools.tietools.get_tie_chains_in_expr(components)`

This function returns all tie chains in components. A tie chain may not encompass all the leaves spanned by its corresponding Tie spanner, but only those found in the given list. i.e. the function returns the intersection between all the leaves spanned by all tie spanners touching the components given and the leaves found in the given components list. Changed in version 2.0: renamed `tietools.get_tie_chains()` to `tietools.get_tie_chains_in_expr()`.

tietools.get_written_tie_chain_duration

`abjad.tools.tietools.get_written_tie_chain_duration(tie_chain)`
Return sum of written duration of all leaves in chain.

tietools.group_leaves_in_tie_chain_by_immediate_parents

`abjad.tools.tietools.group_leaves_in_tie_chain_by_immediate_parents(tie_chain)`
Group leaves in *tie_chain* by immediate parent:

```
abjad> staff = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> tietools.TieSpanner(staff.leaves)
TieSpanner(c'8, c'8, c'8, c'8)
abjad> f(staff)
\new Staff {
  {
    \time 2/8
    c'8 ~
    c'8 ~
  }
  {
    \time 2/8
    c'8 ~
    c'8
  }
}

abjad> tie_chain = tietools.get_tie_chain(staff.leaves[0])
abjad> tietools.group_leaves_in_tie_chain_by_immediate_parents(tie_chain)
[[Note("c'8"), Note("c'8")], [Note("c'8"), Note("c'8")]]
```

Return list of leaf group lists. Changed in version 2.0: renamed `tietools.group_by_parent()` to `tietools.group_leaves_in_tie_chain_by_immediate_parents()`.

tietools.is_component_with_tie_spanner_attached

`abjad.tools.tietools.is_component_with_tie_spanner_attached(expr)`
New in version 2.0. True when *expr* is component with tie spanner attached:

```
abjad> staff = Staff(notetools.make_repeated_notes(4))
abjad> tietools.TieSpanner(staff[:])
TieSpanner(c'8, c'8, c'8, c'8)
abjad> f(staff)
\new Staff {
  c'8 ~
  c'8 ~
  c'8 ~
  c'8
}
abjad> tietools.is_component_with_tie_spanner_attached(staff)
False
```

Otherwise false:

```
abjad> staff = Staff(notetools.make_repeated_notes(4))
abjad> tietools.TieSpanner(staff[:])
TieSpanner(c'8, c'8, c'8, c'8)
```



```

abjad> f(staff)
\new Staff {
    c'8 ~
    c'8 ~
    c'8 ~
    c'8
}
abjad> tietools.is_component_with_tie_spanner_attached(staff[1])
True

```

Return boolean.

tietools.is_tie_chain

`abjad.tools.tietools.is_tie_chain(expr)`
 True when *expr* is a tie chain, otherwise False.

tietools.is_tie_chain_with_all_leaves_in_same_parent

`abjad.tools.tietools.is_tie_chain_with_all_leaves_in_same_parent(expr)`
 True when *expr* is a tie chain with all leaves in same parent.

That is, True when tie chain crosses no container boundaries, otherwise False.

Example:

```

abjad> t = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 2)
abjad> tietools.TieSpanner(t.leaves[1:3])
TieSpanner(c'8, c'8)

\new Staff {
    \time 2/8
    c'8
    c'8 ~
    \time 2/8
    c'8
    c'8
}

abjad> tie_chain = tietools.get_tie_chain(t.leaves[0])
abjad> assert tietools.is_tie_chain_with_all_leaves_in_same_parent(tie_chain)
abjad> tie_chain = tietools.get_tie_chain(t.leaves[1])
abjad> assert not tietools.is_tie_chain_with_all_leaves_in_same_parent(tie_chain)
abjad> tie_chain = tietools.get_tie_chain(t.leaves[2])
abjad> assert not tietools.is_tie_chain_with_all_leaves_in_same_parent(tie_chain)
abjad> tie_chain = tietools.get_tie_chain(t.leaves[3])
abjad> assert tietools.is_tie_chain_with_all_leaves_in_same_parent(tie_chain)

```

Changed in version 2.0: renamed `tietools.is_in_same_parent()` to `tietools.is_tie_chain_with_all_leaves_in_same_parent()`.

tietools.iterate_tie_chains_backward_in_expr

`abjad.tools.tietools.iterate_tie_chains_backward_in_expr(expr)`
 Yield right-to-left tie chains in *expr*:

```

abjad> notes = notetools.make_notes([0], [(5, 16), (1, 8), (1, 8), (5, 16)])
abjad> staff = Staff(notes)
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 16), staff[1:3])
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> print staff.format
\new Staff {
  c'4 ~
  \times 2/3 {
    c'16
    d'8
  }
  e'8
  f'4 ~
  f'16
}

abjad> for x in tietools.iterate_tie_chains_backward_in_expr(staff):
...     x
...
(Note("f'4"), Note("f'16"))
(Note("e'8"),)
(Note("d'8"),)
(Note("c'4"), Note("c'16"))

```

Note that one-note tie chains yield the same as other tie chains.

Note also that nested structures are no problem. Changed in version 2.0: renamed `iterate.tie_chains_backward_in()` to `tietools.iterate_tie_chains_backward_in_expr()`. Changed in version 2.0: renamed `iterate.tie_chains_backward_in_expr()` to `tietools.iterate_tie_chains_backward_in_expr()`.

tietools.iterate_tie_chains_forward_in_expr

`abjad.tools.tietools.iterate_tie_chains_forward_in_expr(expr)`

Yield left-to-right tie chains in *expr*:

```

abjad> notes = notetools.make_notes([0], [(5, 16), (1, 8), (1, 8), (5, 16)])
abjad> staff = Staff(notes)
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 16), staff[1:3])
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> print staff.format
\new Staff {
  c'4 ~
  \times 2/3 {
    c'16
    d'8
  }
  e'8
  f'4 ~
  f'16
}

abjad> for x in tietools.iterate_tie_chains_forward_in_expr(staff):
...     x
...
(Note("c'4"), Note("c'16"))
(Note("d'8"),)

```

```
(Note("e'8"),)
(Note("f'4"), Note("f'16"))
```

Note that one-note tie chains yield the same as other tie chains.

Note also that nested structures are no problem. Changed in version 2.0: renamed `iterate.tie_chains_forward_in()` to `tietools.iterate_tie_chains_forward_in_expr()`. Changed in version 2.0: renamed `iterate.tie_chains_forward_in_expr()` to `tietools.iterate_tie_chains_forward_in_expr()`.

tietools.iterate_topmost_tie_chains_and_components_forward_in_expr

`abjad.tools.tietools.iterate_topmost_tie_chains_and_components_forward_in_expr(expr)`

Yield the left-to-right, top-level contents of *expr* with chain-wrapped leaves.

```
abjad> t = Staff(notetools.make_notes(0, [(5, 32)] * 4))
abjad> t.insert(4, tuplettools.FixedDurationTuplet(Duration(2, 8), notetools.make_repeated_notes(
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> f(t)
\new Staff {
    c'8 ~
    c'32
    d'8 ~
    d'32
    \times 2/3 {
        e'8
        f'8
        g'8
    }
    a'8 ~
    a'32
    b'8 ~
    b'32
}

abjad> for x in tietools.iterate_topmost_tie_chains_and_components_forward_in_expr(t):
...     x
...
(Note("c'8"), Note("c'32"))
(Note("d'8"), Note("d'32"))
FixedDurationTuplet(1/4, [e'8, f'8, g'8])
(Note("a'8"), Note("a'32"))
(Note("b'8"), Note("b'32"))
```

Crossing ties raise `TieChainError`. Changed in version 2.0: renamed `iterate.chained_contents()` to `tietools.iterate_topmost_tie_chains_and_components_forward_in_expr()`. Changed in version 2.0: renamed `iterate.topmost_tie_chains_and_components_forward_in_expr()` to `tietools.iterate_topmost_tie_chains_and_components_forward_in_expr()`.

tietools.label_tie_chains_in_expr_with_prolated_tie_chain_duration

`abjad.tools.tietools.label_tie_chains_in_expr_with_prolated_tie_chain_duration(expr, markup_direction)`

Label tie chains in *expr* with prolated tie chain duration:

```

abjad> staff = Staff(notetools.make_repeated_notes(4))
abjad> tuplettools.FixedDurationTuplet(Duration(2, 8), staff[:3])
FixedDurationTuplet(1/4, [c'8, c'8, c'8])
abjad> tietools.TieSpanner(staff.leaves[:2])
TieSpanner(c'8, c'8)
abjad> tietools.TieSpanner(staff.leaves[2:])
TieSpanner(c'8, c'8)
abjad> tietools.label_tie_chains_in_expr_with_prolated_tie_chain_duration(staff)
abjad> f(staff)
\new Staff {
  \times 2/3 {
    c'8 _ \markup { \small 1/6 } ~
    c'8
    c'8 _ \markup { \small 5/24 } ~
  }
  c'8
}

```

Return none.

tietools.label_tie_chains_in_expr_with_tie_chain_durations

`abjad.tools.tietools.label_tie_chains_in_expr_with_tie_chain_durations`(*expr*,
markup_direction='down')

Label tie chains in *expr* with both written tie chain duration and prolated tie chain duration:

```

abjad> staff = Staff(notetools.make_repeated_notes(4))
abjad> tuplettools.FixedDurationTuplet(Duration(2, 8), staff[:3])
FixedDurationTuplet(1/4, [c'8, c'8, c'8])
abjad> tietools.TieSpanner(staff.leaves[:2])
TieSpanner(c'8, c'8)
abjad> tietools.TieSpanner(staff.leaves[2:])
TieSpanner(c'8, c'8)
abjad> tietools.label_tie_chains_in_expr_with_tie_chain_durations(staff)
abjad> f(staff)
\new Staff {
  \times 2/3 {
    c'8 _ \markup { \column { \small 1/4 \small 1/6 } } ~
    c'8
    c'8 _ \markup { \column { \small 1/4 \small 5/24 } } ~
  }
  c'8
}

```

Return none.

tietools.label_tie_chains_in_expr_with_written_tie_chain_duration

`abjad.tools.tietools.label_tie_chains_in_expr_with_written_tie_chain_duration`(*expr*,
markup_direction=)

Label tie chains in *expr* with written tie chain duration.:

```

abjad> staff = Staff(notetools.make_repeated_notes(4))
abjad> tuplettools.FixedDurationTuplet(Duration(2, 8), staff[:3])
FixedDurationTuplet(1/4, [c'8, c'8, c'8])
abjad> tietools.TieSpanner(staff.leaves[:2])
TieSpanner(c'8, c'8)

```

```

abjad> tietools.TieSpanner(staff.leaves[2:])
TieSpanner(c'8, c'8)
abjad> tietools.label_tie_chains_in_expr_with_written_tie_chain_duration(staff)
abjad> f(staff)
\new Staff {
  \times 2/3 {
    c'8 _ \markup { \small 1/4 } ~
    c'8
    c'8 _ \markup { \small 1/4 } ~
  }
  c'8
}

```

Return none.

tietools.remove_all_leaves_in_tie_chain_except_first

`abjad.tools.tietools.remove_all_leaves_in_tie_chain_except_first(tie_chain)`
 Detach all leaves of tie chain after the first. Unspan and return length-1 tie chain. Changed in version 2.0: renamed `tietools.truncate()` to `tietools.remove_all_leaves_in_tie_chain_except_first()`.

tietools.remove_tie_spanners_from_components_in_expr

`abjad.tools.tietools.remove_tie_spanners_from_components_in_expr(expr)`

Remove tie spanners components in *expr*:

```

abjad> staff = Staff("c'4 ~ c'16 d'4 ~ d'16")
abjad> f(staff)
\new Staff {
  c'4 ~
  c'16
  d'4 ~
  d'16
}

abjad> tietools.remove_tie_spanners_from_components_in_expr(staff[:])
[Note("c'4"), Note("c'16"), Note("d'4"), Note("d'16")]
abjad> f(staff)
\new Staff {
  c'4
  c'16
  d'4
  d'16
}

```

Return *expr*. Changed in version 2.0: renamed `componenttools.untie_shallow()` to `tietools.remove_tie_spanners_from_components_in_expr()`.

tietools.tie_chain_to_augmented_tuplet_with_proportions_and_avoid_dots

abjad.tools.tietools.**tie_chain_to_augmented_tuplet_with_proportions_and_avoid_dots** (*tie_chain*, *proportions*)

New in version 2.0. Divide *tie_chain* into fixed-duration tuplet according to arbitrary integer *proportions*.

Interpret *proportions* as a ratio. That is, reduce integers in *proportions* relative to each other.

Return non-trivial tuplet as augmentation.

Where `proportions[i] == 1` for `i < len(proportions)`, do not allow tupletted notes to carry dots.

```
abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_augmented_tuplet_with_proportions_and_avoid_dots(tie_chain, [1])
FixedDurationTuplet(3/16, [c'8])
abjad> f(staff)
\new Staff {
    \fraction \times 3/2 {
        c'8 [
    ]
    c'16 ]
}

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_augmented_tuplet_with_proportions_and_avoid_dots(tie_chain, [1, 2])
FixedDurationTuplet(3/16, [c'16, c'8])
abjad> f(staff)
\new Staff {
    {
        c'16 [
        c'8
    ]
    c'16 ]
}

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_augmented_tuplet_with_proportions_and_avoid_dots(tie_chain, [1, 2,
FixedDurationTuplet(3/16, [c'32, c'16, c'16])
abjad> f(staff)
\new Staff {
    \fraction \times 6/5 {
        c'32 [
        c'16
```

```

        c'16
    }
    c'16 ]
}

```

Changed in version 2.0: renamed `divide.tie_chain_into_arbitrary_augmentation_undotted()` to `tietools.tie_chain_to_augmented_tuplet_with_proportions_and_avoid_dots()`.

tietools.tie_chain_to_augmented_tuplet_with_proportions_and_encourage_dots

`abjad.tools.tietools.tie_chain_to_augmented_tuplet_with_proportions_and_encourage_dots` (*tie_c*

pro-
por-
tions

New in version 2.0. Divide *tie_chain* into fixed-duration tuplet according to arbitrary integer *proportions*.

Interpret *proportions* as a ratio. That is, reduce integers in *proportions* relative to each other.

Return non-trivial tuplet as augmentation.

Where `proportions[i] == 1` for `i < len(proportions)`, allow tupletted notes to carry dots.

```

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_augmented_tuplet_with_proportions_and_encourage_dots(tie_chain, [1, 1])
FixedDurationTuplet(3/16, [c'8.])
abjad> f(staff)
\new Staff {
    {
        c'8. [
    ]
    c'16 ]
}

```

```

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_augmented_tuplet_with_proportions_and_encourage_dots(tie_chain, [1, 1])
FixedDurationTuplet(3/16, [c'16, c'8])
abjad> f(staff)
\new Staff {
    {
        c'16 [
        c'8
    ]
    c'16 ]
}

```

```

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)

```

```

abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_augmented_tuplet_with_proportions_and_encourage_dots(tie_chain, [1,
FixedDurationTuplet(3/16, [c'64., c'32., c'32.])
abjad> f(staff)
\new Staff {
    \fraction \times 8/5 {
        c'64. [
            c'32.
            c'32.
        ]
    }
    c'16 ]
}

```

Changed in version 2.0: renamed `divide.tie_chain_into_arbitrary_augmentation_dotted()` to `tietools.tie_chain_to_augmented_tuplet_with_proportions_and_encourage_dots()`.

tietools.tie_chain_to_diminished_tuplet_with_proportions_and_avoid_dots

```

abjad.tools.tietools.tie_chain_to_diminished_tuplet_with_proportions_and_avoid_dots(tie_chain,
                                                                                   pro-
                                                                                   por-
                                                                                   tions)

```

New in version 2.0. Divide *tie_chain* into fixed-duration tuplet according to arbitrary integer *proportions*.

Interpret *proportions* as a ratio. That is, reduce integers in *proportions* relative to each other.

Return non-trivial tuplet as diminution.

Where `proportions[i] == 1` for `i < len(proportions)`, do not allow tupletted notes to carry dots.

```

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_diminished_tuplet_with_proportions_and_avoid_dots(tie_chain, [1])
FixedDurationTuplet(3/16, [c'4])
abjad> f(staff)
\new Staff {
    \fraction \times 3/4 {
        c'4 [
        ]
    }
    c'16 ]
}

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_augmented_tuplet_with_proportions_and_avoid_dots(tie_chain, [1, 2])
FixedDurationTuplet(3/16, [c'16, c'8])
abjad> f(staff)
\new Staff {

```



```

    {
        c'16 [
            c'8
        ]
    }
    c'16 ]
}

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_diminished_tuplet_with_proportions_and_avoid_dots(tie_chain, [1, 2,
FixedDurationTuplet(3/16, [c'16, c'8, c'8])
abjad> f(staff)
\new Staff {
    \fraction \times 3/5 {
        c'16 [
            c'8
            c'8
        ]
    }
    c'16 ]
}

```

Changed in version 2.0: renamed `divide.tie_chain_into_arbitrary_diminution_undotted()` to `tietools.tie_chain_to_diminished_tuplet_with_proportions_and_avoid_dots()`.

tietools.tie_chain_to_diminished_tuplet_with_proportions_and_encourage_dots

`abjad.tools.tietools.tie_chain_to_diminished_tuplet_with_proportions_and_encourage_dots` (*tie*

pro
por
tion

New in version 2.0. Divide *tie_chain* into fixed-duration tuplet according to arbitrary integer *proportions*.

Interpret *proportions* as a ratio. That is, reduce integers in *proportions* relative to each other.

Return non-trivial tuplet as diminution.

Where `proportions[i] == 1` for `i < len(proportions)`, allow tupletted notes to carry dots.

```

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_diminished_tuplet_with_proportions_and_encourage_dots(tie_chain, [1
FixedDurationTuplet(3/16, [c'8.])
abjad> f(staff)
\new Staff {
    {
        c'8. [
        ]
    }
    c'16 ]
}

```

```

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_diminished_tuplet_with_proportions_and_encourage_dots(tie_chain, [1
FixedDurationTuplet(3/16, [c'16, c'8])
abjad> f(staff)
\new Staff {
    {
        c'16 [
            c'8
        ]
    }
    c'16 ]
}

abjad> staff = Staff([Note(0, (1, 8)), Note(0, (1, 16)), Note(0, (1, 16))])
abjad> tietools.TieSpanner(staff[:2])
TieSpanner(c'8, c'16)
abjad> spannertools.BeamSpanner(staff[:])
BeamSpanner(c'8, c'16, c'16)
abjad> tie_chain = tietools.get_tie_chain(staff[0])
abjad> tietools.tie_chain_to_diminished_tuplet_with_proportions_and_encourage_dots(tie_chain, [1
FixedDurationTuplet(3/16, [c'32., c'16., c'16.])
abjad> f(staff)
\new Staff {
    \times 4/5 {
        c'32. [
            c'16.
            c'16.
        ]
    }
    c'16 ]
}

```

Changed in version 2.0: renamed `divide.tie_chain_into_arbitrary_diminution_dotted()` to `tietools.tie_chain_to_diminished_tuplet_with_proportions_and_encourage_dots()`.

tuplettools

tuplettools.FixedDurationTuplet

class abjad.tools.tuplettools.**FixedDurationTuplet** (*duration, music=None, **kwargs*)

Bases: abjad.tools.tuplettools.Tuplet.Tuplet.Tuplet

Abjad tuplet of fixed duration and variable multiplier:

```

abjad> tuplettools.FixedDurationTuplet(Fraction(2, 8), "c'8 d'8 e'8")
FixedDurationTuplet(1/4, [c'8, d'8, e'8])

```

Return fixed-duration tuplet.

multiplied_duration

multiplier

target_duration

trim (*start, stop='unused'*)

Trim fixed-duration tuplet elements from *start* to *stop*:

```

abjad> tuplet = tuplettools.FixedDurationTuplet(Fraction(2, 8), "c'8 d'8 e'8")
abjad> tuplet
FixedDurationTuplet(1/4, [c'8, d'8, e'8])

abjad> tuplet.trim(2)
abjad> tuplet
FixedDurationTuplet(1/6, [c'8, d'8])

```

Preserve fixed-duration tuplet multiplier.

Adjust fixed-duration tuplet duration.

Return none.

tuplettools.Tuplet

class abjad.tools.tuplettools.**Tuplet** (*multiplier*, *music=None*, ***kwargs*)

Bases: abjad.tools.containertools.Container.Container.Container

Abjad model of a tuplet:

```

abjad> tuplet = Tuplet(Fraction(2, 3), "c'8 d'8 e'8")
abjad> f(tuplet)
\times 2/3 {
    c'8
    d'8
    e'8
}

```

Return tuplet object.

force_fraction

Read / write boolean to force n:m fraction.

is_augmentation

True when multiplier is greater than 1. Otherwise false:

```

abjad> t = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> t.is_augmentation
False

```

Return boolean.

is_binary

True when multiplier numerator is power of two, otherwise False.

is_diminution

True when multiplier is less than 1. Otherwise false:

```

abjad> t = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> t.is_diminution
True

```

Return boolean.

is_invisible

Read / write boolean to render tuplet invisible.

is_nonbinary

is_trivial

True when tuplet multiplier is one, otherwise False.

multiplied_duration

multiplier

preferred_denominator

New in version 2.0. Integer denominator in terms of which tuplet fraction should format.

preprolated_duration

Duration prior to prolotion:

```
abjad> t = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> t.preprolated_duration
Duration(1, 4)
```

Return duration.

ratio

Tuplet multiplier formatted with colon as ratio.

tuplettools.all_are_tuplets

`abjad.tools.tuplettools.all_are_tuplets(expr)`

New in version 2.6. True when *expr* is a sequence of Abjad tuplets:

```
abjad> tuplet = Tuplet((2, 3), "c'8 d'8 e'8")

abjad> tuplettools.all_are_tuplets([tuplet])
True
```

True when *expr* is an empty sequence:

```
abjad> tuplettools.all_are_tuplets([])
True
```

Otherwise false:

```
abjad> tuplettools.all_are_tuplets('foo')
False
```

Return boolean.

Function wraps `componenttools.all_are_components()`.

tuplettools.beam_bottommost_tuplets_in_expr

`abjad.tools.tuplettools.beam_bottommost_tuplets_in_expr(expr)`

Beam bottommost tuplets in *expr*:

```
abjad> staff = Staff(3 * Tuplet(Fraction(2, 3), "c'8 d'8 e'8"))

f(staff)
\new Staff {
  \times 2/3 {
    c'8
    d'8
    e'8
  }
  \times 2/3 {
    c'8
```

```
        d'8
        e'8
    }
    \times 2/3 {
        c'8
        d'8
        e'8
    }
}

abjad> tuplettools.beam_bottommost_tuplets_in_expr(staff)

abjad> f(staff)
\new Staff {
    \times 2/3 {
        c'8 [
        d'8
        e'8 ]
    }
    \times 2/3 {
        c'8 [
        d'8
        e'8 ]
    }
    \times 2/3 {
        c'8 [
        d'8
        e'8 ]
    }
}
```

Return none.

tuplettools.change_augmented_tuplets_in_expr_to_diminished

`abjad.tools.tuplettools.change_augmented_tuplets_in_expr_to_diminished(tuplet)`
New in version 2.0. Multiply the written duration of the leaves in *tuplet* by the least power of 2 necessary to diminished *tuplet*.

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 4), "c'8 d'8 e'8")
abjad> tuplet
FixedDurationTuplet(1/2, [c'8, d'8, e'8])
abjad> tuplettools.change_augmented_tuplets_in_expr_to_diminished(tuplet)
FixedDurationTuplet(1/2, [c'4, d'4, e'4])
```

Todo

make work with nested tuplets.

Changed in version 2.0: renamed `tuplettools.augmentation_to_diminution()` to `tuplettools.change_augmented_tuplets_in_expr_to_diminished()`.

tuplettools.change_diminished_tuplets_in_expr_to_augmented

`abjad.tools.tuplettools.change_diminished_tuplets_in_expr_to_augmented(tuplet)`
New in version 2.0. Divide the written duration of the leaves in *tuplet* by the least power of 2 necessary to augment *tuplet*.

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> tuplet
FixedDurationTuplet(1/4, [c'8, d'8, e'8])
abjad> tuplettools.change_diminished_tuplets_in_expr_to_augmented(tuplet)
FixedDurationTuplet(1/4, [c'16, d'16, e'16])
```

Todo

make work with nested tuplets.

Changed in version 2.0: renamed `tuplettools.diminution_to_augmentation()` to `tuplettools.change_diminished_tuplets_in_expr_to_augmented()`.

tuplettools.fix_contents_of_tuplets_in_expr

`abjad.tools.tuplettools.fix_contents_of_tuplets_in_expr(tuplet)`
Scale *tuplet* contents by power of two if tuplet multiplier less than 1/2 or greater than 2. Return *tuplet*.

```
abjad> tuplet = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'4 d'4 e'4")
abjad> tuplet
FixedDurationTuplet(1/4, [c'4, d'4, e'4])
abjad> tuplettools.fix_contents_of_tuplets_in_expr(tuplet)
FixedDurationTuplet(1/4, [c'8, d'8, e'8])
```

Changed in version 2.0: renamed `tuplettools.contents_fix()` to `tuplettools.fix_contents_of_tuplets_in_expr()`.

tuplettools.fuse_tuplets

`abjad.tools.tuplettools.fuse_tuplets(tuplets)`
Fuse parent-contiguous *tuplets*:

```
abjad> t1 = tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8")
abjad> spannertools.BeamSpanner(t1[:])
BeamSpanner(c'8, d'8, e'8)
abjad> t2 = tuplettools.FixedDurationTuplet(Duration(2, 16), "c'16 d'16 e'16")
abjad> spannertools.SlurSpanner(t2[:])
SlurSpanner(c'16, d'16, e'16)
abjad> staff = Staff([t1, t2])
abjad> f(staff)
\new Staff {
  \times 2/3 {
    c'8 [
      d'8
      e'8 ]
  }
  \times 2/3 {
    c'16 (
      d'16
```

```

        e'16 )
    }
}

abjad> tuplettools.fuse_tuplets(staff[:])
FixedDurationTuplet(3/8, [c'8, d'8, e'8, c'16, d'16, e'16])

abjad> f(staff)
\new Staff {
  \times 2/3 {
    c'8 [
      d'8
      e'8 ]
    c'16 (
      d'16
      e'16 )
  }
}

```

Return new tuplet.

Fuse zero or more parent-contiguous *tuplets*.

Allow in-score *tuplets*.

Allow outside-of-score *tuplets*.

All *tuplets* must carry the same multiplier.

All *tuplets* must be of the same type. Changed in version 2.0: renamed `fuse.tuplets_by_reference()` to `tuplettools.fuse_tuplets()`.

tuplettools.get_first_tuplet_in_improper_parentage_of_component

`abjad.tools.tuplettools.get_first_tuplet_in_improper_parentage_of_component` (*component*)

New in version 2.0. Get first tuplet in improper parentage of *component*:

```

abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> Tuplet(Fraction(2, 3), staff[:3])
Tuplet(2/3, [c'8, d'8, e'8])

abjad> f(staff)
\new Staff {
  \times 2/3 {
    c'8
    d'8
    e'8
  }
  f'8
}

abjad> tuplettools.get_first_tuplet_in_improper_parentage_of_component(staff.leaves[1])
Tuplet(2/3, [c'8, d'8, e'8])

```

Return tuplet or none.

tuplettools.get_first_tuplet_in_proper_parentage_of_component

`abjad.tools.tuplettools.get_first_tuplet_in_proper_parentage_of_component` (*component*)
 New in version 2.0. Get first tuplet in proper parentage of *component*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> Tuplet(Fraction(2, 3), staff[:3])
Tuplet(2/3, [c'8, d'8, e'8])

abjad> f(staff)
\new Staff {
    \times 2/3 {
        c'8
        d'8
        e'8
    }
    f'8
}

abjad> tuplettools.get_first_tuplet_in_proper_parentage_of_component(staff.leaves[1])
Tuplet(2/3, [c'8, d'8, e'8])
```

Return tuplet or none.

tuplettools.is_proper_tuplet_multiplier

`abjad.tools.tuplettools.is_proper_tuplet_multiplier` (*multiplier*)

True when $1/2 < \text{multiplier} < 2$.

```
abjad> for n in range(17):
...     rational = Fraction(n, 8)
...     multiplier = tuplettools.is_proper_tuplet_multiplier(rational)
...     print '%s    %s' % (rational, multiplier)
...
0        False
1/8      False
1/4      False
3/8      False
1/2      False
5/8      True
3/4      True
7/8      True
1        True
9/8      True
5/4      True
11/8     True
3/2      True
13/8     True
7/4      True
15/8     True
2        False
```

This function models the idea that 4:3, 4:5, 4:6, 4:7 are valid tuplet multipliers while 4:2 and 4:8 aren't. Changed in version 2.0: renamed `durationtools.is_tuplet_multiplier()` to `tuplettools.is_proper_tuplet_multiplier()`.

tuplettools.iterate_tuplets_backward_in_expr

`abjad.tools.tuplettools.iterate_tuplets_backward_in_expr` (*expr*, *start=0*, *stop=None*)

New in version 2.0. Iterate tuplets backward in *expr*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
abjad> Tuplet(Fraction(2, 3), staff[:3])
Tuplet(2/3, [c'8, d'8, e'8])
abjad> Tuplet(Fraction(2, 3), staff[-3:])
Tuplet(2/3, [a'8, b'8, c''8])
```

```
abjad> f(staff)
```

```
\new Staff {
  \times 2/3 {
    c'8
    d'8
    e'8
  }
  f'8
  g'8
  \times 2/3 {
    a'8
    b'8
    c''8
  }
}
```

```
abjad> for tuplet in tuplettools.iterate_tuplets_backward_in_expr(staff):
...     tuplet
...
Tuplet(2/3, [a'8, b'8, c''8])
Tuplet(2/3, [c'8, d'8, e'8])
```

Return generator.

tuplettools.iterate_tuplets_forward_in_expr

`abjad.tools.tuplettools.iterate_tuplets_forward_in_expr` (*expr*, *start=0*, *stop=None*)

New in version 2.0. Iterate tuplets forward in *expr*:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8 g'8 a'8 b'8 c''8")
abjad> Tuplet(Fraction(2, 3), staff[:3])
Tuplet(2/3, [c'8, d'8, e'8])
abjad> Tuplet(Fraction(2, 3), staff[-3:])
Tuplet(2/3, [a'8, b'8, c''8])
```

```
abjad> f(staff)
```

```
\new Staff {
  \times 2/3 {
    c'8
    d'8
    e'8
  }
  f'8
  g'8
  \times 2/3 {
    a'8
```

Return generator.

```
abjad.tools.tuplettools.make_augmented_tuplet_from_duration_and_proportions_and_avoid_dots
```

Return fixed-duration tuplelet. Changed in version 2.0: renamed `divide.duration_into_arbitrary_augmentation_undotted()` to `tuplelettools.make_augmented_tuplelet_from_duration_and_proportions_and_avoid_dots()`.

```
abjad.tools.tuplettools.make_augmented_tuplet_from_duration_and_proportions_and_encourage_c
```

632 Chapter 51. Abjad API

```
abjad> print tuplettools.make_augmented_tuplet_from_duration_and_proportions_and_encourage_dots(
... Fraction(3, 16), [1, 1, 1, -1, -1])
{@ 5:8 c'64., c'64., c'64., r64., r64. @}
```

Interpret nonassignable *proportions* according to *direction*:

```
abjad> print tuplettools.make_augmented_tuplet_from_duration_and_proportions_and_encourage_dots(
... Fraction(3, 16), [5, -1, 5], direction = 'little-endian')
{@ 11:16 c'32..., r128., c'32... @}
```

Reduce *proportions* relative to each other.

Interpret negative *proportions* as rests.

Return	fixed-duration	tuplet.	Changed	in	version	2.0:	renamed
							to

```
divide.duration_into_arbitrary_augmentation_dotted()
tuplettools.make_augmented_tuplet_from_duration_and_proportions_and_encourage_dots().
```

tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_avoid_dots

```
abjad.tools.tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_avoid_dots
```

New in version 2.0. Make diminished tuplet from *duration* and nonzero integer *proportions*.

Return tupletted leaves strictly without dots when all *proportions* equal 1:

```
abjad> print tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_avoid_dots(
... Fraction(3, 16), [1, 1, 1, -1, -1])
{@ 5:3 c'16, c'16, c'16, r16, r16 @}
```

Allow tupletted leaves to return with dots when some *proportions* do not equal 1:

```
abjad> print tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_avoid_dots(
... Fraction(3, 16), [1, -2, -2, 3, 3])
{@ 11:6 c'32, r16, r16, c'16., c'16. @}
```

Interpret nonassignable *proportions* according to *direction*:

```
abjad> print tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_avoid_dots(
... Fraction(3, 16), [5, -1, 5], direction = 'little-endian')
{@ 11:6 c'32, c'8, r32, c'32, c'8 @}
```

Reduce *proportions* relative to each other.

Interpret negative *proportions* as rests.

Return	fixed-duration	tuplet.	Changed	in	version	2.0:	renamed
							to

```
divide.duration_into_arbitrary_diminution_undotted()
tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_avoid_dots().
```

tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_encourage_dots

abjad.tools.tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_encourage_dots

New in version 2.0. Make diminished tuplet from *duration* and *proportions* and encourage dots:

```
abjad> print tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_encourage_dots(
... Fraction(3, 16), [1, 1, 1, -1, -1])
{@ 5:4 c'32., c'32., c'32., r32., r32. @}
```

Interpret nonassignable *proportions* according to *direction*:

```
abjad> print tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_encourage_dots(
... Fraction(3, 16), [5, -1, 5], direction = 'little-endian')
{@ 11:8 c'16..., r64., c'16... @}
```

Reduce *proportions* relative to each other.

Interpret negative *proportions* as rests.

Return fixed-duration tuplet. Changed in version 2.0: renamed divide.duration_into_arbitrary_diminution_dotted() to tuplettools.make_diminished_tuplet_from_duration_and_proportions_and_encourage_dots().

tuplettools.make_tuplet_from_proportions_and_pair

abjad.tools.tuplettools.make_tuplet_from_proportions_and_pair(*l*, (*n*, *d*), *together=False*)

Divide (*n*, *d*) according to *l*.

Where no prololation is necessary, return container.

```
abjad> tuplettools.make_tuplet_from_proportions_and_pair([1], (7, 16))
{c'4..}
```

Where prololation is necessary, return fixed-duration tuplet.

```
abjad> tuplettools.make_tuplet_from_proportions_and_pair([1, 2], (7, 16))
FixedDurationTuplet(7/16, [c'8, c'4])
```

```
abjad> tuplettools.make_tuplet_from_proportions_and_pair([1, 2, 4], (7, 16))
FixedDurationTuplet(7/16, [c'16, c'8, c'4])
```

```
abjad> tuplettools.make_tuplet_from_proportions_and_pair([1, 2, 4, 1], (7, 16))
FixedDurationTuplet(7/16, [c'16, c'8, c'4, c'16])
```

```
abjad> tuplettools.make_tuplet_from_proportions_and_pair([1, 2, 4, 1, 2], (7, 16))
FixedDurationTuplet(7/16, [c'16, c'8, c'4, c'16, c'8])
```

```
abjad> tuplettools.make_tuplet_from_proportions_and_pair([1, 2, 4, 1, 2, 4], (7, 16))
FixedDurationTuplet(7/16, [c'16, c'8, c'4, c'16, c'8, c'4])
```

Note: function accepts a pair rather than a rational.

Note: function interprets *d* as tuplet denominator.

Changed in version 2.0: renamed `divide.pair()` to `tuplettools.make_tuplet_from_proportions_and_pair`

`tuplettools.move_prolation_of_tuplet_to_contents_of_tuplet_and_remove_tuplet`

`abjad.tools.tuplettools.move_prolation_of_tuplet_to_contents_of_tuplet_and_remove_tuplet(tuplet)`
 Scale tuplet contents and then bequeath in-score position of tuplet to contents.

Return orphaned tuplet emptied of all contents.

```
abjad> t = Staff(tuplettools.FixedDurationTuplet(Duration(3, 8), "c'8 d'8") * 2)
abjad> spannertools.BeamSpanner(t.leaves)
BeamSpanner(c'8, d'8, c'8, d'8)
abjad> print t.format
\new Staff {
  \fraction \times 3/2 {
    c'8 [
      d'8
    ]
  }
  \fraction \times 3/2 {
    c'8
    d'8 ]
  }
}

abjad> tuplettools.move_prolation_of_tuplet_to_contents_of_tuplet_and_remove_tuplet(t[0])
FixedDurationTuplet(3/8, [])
abjad> print t.format
\new Staff {
  c'8. [
  d'8.
  \fraction \times 3/2 {
    c'8
    d'8 ]
  }
}
```

Changed in version 2.0: renamed `tuplettools.subsume()` to `tuplettools.move_prolation_of_tuplet_to_contents_of_tuplet_and_remove_tuplet()`.

`tuplettools.remove_trivial_tuplets_in_expr`

`abjad.tools.tuplettools.remove_trivial_tuplets_in_expr(expr)`

Remove trivial tuplets in *expr*:

```
abjad> t = tuplettools.FixedDurationTuplet(Duration(1, 4), "c'8 d'8 e'8")
abjad> u = tuplettools.FixedDurationTuplet(Duration(1, 4), "c'8 d'8")
abjad> s = Staff([t, u])
abjad> len(s)
2

abjad> s[0]
FixedDurationTuplet(1/4, [c'8, d'8, e'8])
```

```

abjad> s[1]
FixedDurationTuplet(1/4, [c'8, d'8])

abjad> tuplettools.remove_trivial_tuplets_in_expr(s)
abjad> len(s)
3
abjad> s[0]
FixedDurationTuplet(1/4, [c'8, d'8, e'8])
abjad> s[1]
Note("c'8")
abjad> s[2]
Note("d'8")

abjad> f(s)
\new Staff {
  \times 2/3 {
    c'8
    d'8
    e'8
  }
  c'8
  d'8
}

```

Replace trivial tuplets with plain leaves.

Return `none`. Changed in version 2.0: renamed `tuplettools.slip_trivial()` to `tuplettools.remove_trivial_tuplets_in_expr()`.

tuplettools.scale_contents_of_tuplets_in_expr_by_multiplier

```

abjad.tools.tuplettools.scale_contents_of_tuplets_in_expr_by_multiplier(tuplet,
                                                                           mul-
                                                                           ti-
                                                                           plier)

```

Scale fixed-duration tuplet by multiplier. Preserve tuplet multiplier. Return tuplet.

tuplettools.set_denominator_of_tuplets_in_expr_to_at_least

```

abjad.tools.tuplettools.set_denominator_of_tuplets_in_expr_to_at_least(expr,
                                                                           n)

```

New in version 2.0. Set denominator of tuplets in *expr* to at least *n*:

```

abjad> tuplet = Tuplet(Fraction(3, 5), "c'4 d'8 e'8 f'4 g'2")

abjad> f(tuplet)
\fraction \times 3/5 {
  c'4
  d'8
  e'8
  f'4
  g'2
}

abjad> tuplettools.set_denominator_of_tuplets_in_expr_to_at_least(tuplet, 8)

```

```

abjad> f(tuplet)
\fraction \times 6/10 {
    c'4
    d'8
    e'8
    f'4
    g'2
}

```

Return none.

voicetools

voicetools.Voice

class abjad.tools.voicetools.**Voice** (*music=None, **kwargs*)
 Bases: abjad.tools.contexttools._Context._Context._Context

Abjad model of a voice:

```

abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> f(voice)
\new Voice {
    c'8
    d'8
    e'8
    f'8
}

```

Return voice object.

voicetools.all_are_voices

abjad.tools.voicetools.**all_are_voices** (*expr*)
 New in version 2.6. True when *expr* is a sequence of Abjad voices:

```

abjad> voice = Voice("c'4 d'4 e'4 f'4")

abjad> voicetools.all_are_voices([voice])
True

```

True when *expr* is an empty sequence:

```

abjad> voicetools.all_are_voices([])
True

```

Otherwise false:

```

abjad> voicetools.all_are_voices('foo')
False

```

Return boolean.

Function wraps `componenttools.all_are_components()`.

voicetools.get_first_voice_in_improper_parentage_of_component

`abjad.tools.voicetools.get_first_voice_in_improper_parentage_of_component` (*component*)
 New in version 2.0. Get first voice in improper parentage of *component*:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> staff = Staff([voice])

abjad> f(staff)
\new Staff {
    \new Voice {
        c'8
        d'8
        e'8
        f'8
    }
}

abjad> voicetools.get_first_voice_in_improper_parentage_of_component(staff.leaves[0])
Voice{4}
```

Return voice or none.

voicetools.get_first_voice_in_proper_parentage_of_component

`abjad.tools.voicetools.get_first_voice_in_proper_parentage_of_component` (*component*)
 New in version 2.0. Get first voice in proper parentage of *component*:

```
abjad> voice = Voice("c'8 d'8 e'8 f'8")
abjad> staff = Staff([voice])

abjad> f(staff)
\new Staff {
    \new Voice {
        c'8
        d'8
        e'8
        f'8
    }
}

abjad> voicetools.get_first_voice_in_proper_parentage_of_component(staff.leaves[0])
Voice{4}
```

Return voice or none.

voicetools.iterate_semantic_voices_backward_in_expr

`abjad.tools.voicetools.iterate_semantic_voices_backward_in_expr` (*expr*)
 New in version 2.0. Iterate semantic voices backward in *expr*:

```
abjad> measures = measuretools.make_measures_with_full_measure_spacer_skips([(3, 8), (5, 16), (5, 16)])
abjad> time_signature_voice = Voice(measures)
abjad> time_signature_voice.name = 'TimeSignatureVoice'
abjad> time_signature_voice.is_nonsemantic = True
abjad> music_voice = Voice("c'4. d'4 e'16 f'4 g'16")
abjad> music_voice.name = 'MusicVoice'
```



```

abjad> staff = Staff([time_signature_voice, music_voice])
abjad> staff.is_parallel = True

abjad> f(staff)
\new Staff <<
  \context Voice = "TimeSignatureVoice" {
    {
      \time 3/8
      s1 * 3/8
    }
    {
      \time 5/16
      s1 * 5/16
    }
    {
      \time 5/16
      s1 * 5/16
    }
  }
  \context Voice = "MusicVoice" {
    c'4.
    d'4
    e'16
    f'4
    g'16
  }
>>

abjad> for voice in voicetools.iterate_semantic_voices_backward_in_expr(staff):
...     voice
Voice-"MusicVoice"{5}

```

Return generator.

voicetools.iterate_semantic_voices_forward_in_expr

`abjad.tools.voicetools.iterate_semantic_voices_forward_in_expr(expr)`

New in version 2.0. Iterate semantic voices forward in *expr*:

```

abjad> measures = measuretools.make_measures_with_full_measure_spacer_skips([(3, 8), (5, 16), (5, 16)])
abjad> meter_voice = Voice(measures)
abjad> meter_voice.name = 'TimeSignatuerVoice'
abjad> meter_voice.is_nonsemantic = True
abjad> music_voice = Voice("c'4. d'4 e'16 f'4 g'16")
abjad> music_voice.name = 'MusicVoice'
abjad> staff = Staff([meter_voice, music_voice])
abjad> staff.is_parallel = True

abjad> f(staff)
\new Staff <<
  \context Voice = "TimeSignatuerVoice" {
    {
      \time 3/8
      s1 * 3/8
    }
    {
      \time 5/16

```

```

        s1 * 5/16
    }
    {
        \time 5/16
        s1 * 5/16
    }
}
\context Voice = "MusicVoice" {
    c'4.
    d'4
    e'16
    f'4
    g'16
}
>>

abjad> for voice in voicetools.iterate_semantic_voices_forward_in_expr(staff):
...     voice
Voice-"MusicVoice"{5}

```

Return generator.

voicetools.iterate_voices_backward_in_expr

abjad.tools.voicetools.**iterate_voices_backward_in_expr**(*expr*)

New in version 2.0. Iterate voices backward in *expr*:

```

abjad> voice_1 = Voice("c'8 d'8 e'8 f'8")
abjad> voice_2 = Voice("c'4 b4")
abjad> staff = Staff([voice_1, voice_2])
abjad> staff.is_parallel = True

abjad> f(staff)
\new Staff <<
  \new Voice {
    c'8
    d'8
    e'8
    f'8
  }
  \new Voice {
    c'4
    b4
  }
>>

abjad> for voice in voicetools.iterate_voices_backward_in_expr(staff):
...     voice
Voice{2}
Voice{4}

```

Return generator.

voicetools.iterate_voices_forward_in_expr

abjad.tools.voicetools.**iterate_voices_forward_in_expr**(*expr*)

New in version 2.0. Iterate voices forward in *expr*:

```

abjad> voice_1 = Voice("c'8 d'8 e'8 f'8")
abjad> voice_2 = Voice("c'4 b4")
abjad> staff = Staff([voice_1, voice_2])
abjad> staff.is_parallel = True

abjad> f(staff)
\new Staff <<
  \new Voice {
    c'8
    d'8
    e'8
    f'8
  }
  \new Voice {
    c'4
    b4
  }
>>

abjad> for voice in voicetools.iterate_voices_forward_in_expr(staff):
...     voice
Voice{4}
Voice{2}

```

Return generator.

51.1.2 Additional Abjad composition packages (load manually)

configurationtools

configurationtools.get_abjad_revision_string

abjad.tools.configurationtools.get_abjad_revision_string()

New in version 2.0. Get Abjad revision string:

```

abjad> configurationtools.get_abjad_revision_string() # doctest: +SKIP
'4392'

```

Return string.

configurationtools.get_abjad_version_string

abjad.tools.configurationtools.get_abjad_version_string()

New in version 2.0. Get Abjad version string:

```

abjad> from abjad.tools import configurationtools

abjad> configurationtools.get_abjad_version_string()
'2.6'

```

Return string.

configurationtools.get_lilypond_version_string

`abjad.tools.configurationtools.get_lilypond_version_string()`

New in version 2.0. Get LilyPond version string:

```
abjad> configurationtools.get_lilypond_version_string() # doctest: +SKIP
'2.13.61'
```

Return string.

configurationtools.get_python_version_string

`abjad.tools.configurationtools.get_python_version_string()`

New in version 2.0. Get Python version string:

```
abjad> from abjad.tools import configurationtools

abjad> configurationtools.get_python_version_string() # doctest: +SKIP
'2.6.1'
```

Return string.

configurationtools.list_abjad_environment_variables

`abjad.tools.configurationtools.list_abjad_environment_variables()`

New in version 1.1. List Abjad environment variables.

Return tuple of zero or more environment variable / setting pairs.

Abjad environment variables are defined in `abjad/cfg/cfg.py`. Changed in version 2.0: renamed `configurationtools.list_settings()` to `configurationtools.list_abjad_environment_variables()`.

configurationtools.list_abjad_templates

`abjad.tools.configurationtools.list_abjad_templates()`

New in version 2.0. List Abjad templates:

```
abjad> from abjad.tools import configurationtools

abjad> configurationtools.list_abjad_templates()
('coventry.ly', 'lagos.ly', 'oedo.ly', 'paris.ly', 'tangiers.ly', 'thebes.ly', 'tirnaveni.ly')
```

Return tuple of zero or more strings.

Abjad templates are housed in `abjad/templates`.

configurationtools.list_package_dependency_versions

`abjad.tools.configurationtools.list_package_dependency_versions()`

configurationtools.set_default_accidental_spelling

`abjad.tools.configurationtools.set_default_accidental_spelling(spelling='mixed')`

New in version 1.1. Set default accidental spelling to sharps:

```
abjad> from abjad.tools import configurationtools

abjad> configurationtools.set_default_accidental_spelling('sharps')

abjad> [Note(13, (1, 4)), Note(15, (1, 4))]
[Note("cs''4"), Note("ds''4")]
```

Set default accidental spelling to flats:

```
abjad> configurationtools.set_default_accidental_spelling('flats')

abjad> [Note(13, (1, 4)), Note(15, (1, 4))]
[Note("df''4"), Note("ef''4")]
```

Set default accidental spelling to mixed:

```
abjad> configurationtools.set_default_accidental_spelling()

abjad> [Note(13, (1, 4)), Note(15, (1, 4))]
[Note("cs''4"), Note("ef''4")]
```

Mixed is system default.

Mixed test case must appear last here for doc tests to check correctly.

Return none. Changed in version 2.0: renamed `pitchtools.change_default_accidental_spelling()` to `configurationtools.set_default_accidental_spelling()`.

durationtools

durationtools.Duration

class `abjad.tools.durationtools.Duration`

Bases: `fractions.Fraction` New in version 2.0. Abjad model of musical duration:

```
abjad> Duration(15, 16)
Duration(15, 16)
```

Durations inherit from built-in `Fraction`.

durationtools.Offset

class `abjad.tools.durationtools.Offset`

Bases: `abjad.tools.durationtools.Duration` New in version 2.0. Abjad model of offset value of musical time:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.Offset(121, 16)
Offset(121, 16)
```

Offset inherits from duration (which inherits from built-in `Fraction`).

durationtools.all_are_duration_tokens

`abjad.tools.durationtools.all_are_duration_tokens(expr)`
 New in version 2.6. True when *expr* is a sequence of Abjad duration tokens:

```
abjad> from abjad.tools import durationtools

abjad> duration_tokens = ['8.', (3, 16), Fraction(3, 16), Duration(3, 16)]

abjad> durationtools.all_are_duration_tokens(duration_tokens)
True
```

True when *expr* is an empty sequence:

```
abjad> durationtools.all_are_duration_tokens([])
True
```

Otherwise false:

```
abjad> durationtools.all_are_durations('foo')
False
```

Return boolean.

durationtools.all_are_durations

`abjad.tools.durationtools.all_are_durations(expr)`
 New in version 2.6. True when *expr* is a sequence of Abjad durations:

```
abjad> from abjad.tools import durationtools

abjad> durations = [Duration((3, 16)), Duration((4, 16))]

abjad> durationtools.all_are_durations(durations)
True
```

True when *expr* is an empty sequence:

```
abjad> durationtools.all_are_durations([])
True
```

Otherwise false:

```
abjad> durationtools.all_are_durations('foo')
False
```

Return boolean.

durationtools.assignable_rational_to_dot_count

`abjad.tools.durationtools.assignable_rational_to_dot_count(rational)`
 New in version 2.0. Change assignable *rational* to dot count:

```
abjad> from abjad.tools import durationtools

abjad> for n in range(1, 9):
...     try:
...         rational = Fraction(n, 16)
```

```

...         dot_count = durationtools.assignable_rational_to_dot_count(rational)
...         print '%s\t%s' % (rational, dot_count)
...     except AssignabilityError:
...         pass
...
1/16    0
1/8     0
3/16    1
1/4     0
3/8     1
7/16    2
1/2     0

```

Raise assignability error when *rational* not assignable.

Return nonnegative integer.

durationtools.assignable_rational_to_lilypond_duration_string

`abjad.tools.durationtools.assignable_rational_to_lilypond_duration_string(rational)`

New in version 2.0. Change assignable *rational* to LilyPond duration string:

```
abjad> from abjad.tools import durationtools
```

```
abjad> durationtools.assignable_rational_to_lilypond_duration_string(Fraction(3, 16))
'8.'
```

Raise assignability error when *rational* not assignable.

Return string.

durationtools.duration_pair_to_prolation_string

`abjad.tools.durationtools.duration_pair_to_prolation_string(pair)`

New in version 2.0. Change positive integer duration *pair* to colon-separated prolation string:

```
abjad> from abjad.tools import durationtools
```

```
abjad> durationtools.duration_pair_to_prolation_string((2, 3))
'3:2'
```

Return string.

durationtools.duration_token_to_big_endian_list_of_assignable_duration_pairs

`abjad.tools.durationtools.duration_token_to_big_endian_list_of_assignable_duration_pairs(duration_token)`

New in version 1.1. Change *duration_token* to big-endian tuple of assignable duration pairs:

```
abjad> from abjad.tools import durationtools
```

```
abjad> duration_tokens = [(n, 16) for n in range(10, 20)]
abjad> for duration_token in duration_tokens:
...     print duration_token, durationtools.duration_token_to_big_endian_list_of_assignable_dura
...
(10, 16) ((8, 16), (2, 16))
(11, 16) ((8, 16), (3, 16))

```

```
(12, 16) ((12, 16),)
(13, 16) ((12, 16), (1, 16))
(14, 16) ((14, 16),)
(15, 16) ((15, 16),)
(16, 16) ((16, 16),)
(17, 16) ((16, 16), (1, 16))
(18, 16) ((16, 16), (2, 16))
(19, 16) ((16, 16), (3, 16))
```

Return tuple of integer pairs. Changed in version 2.0: renamed `durationtools.token_decompose()` to `durationtools.duration_token_to_big_endian_list_of_assignable_duration_pairs()`.

durationtools.duration_token_to_duration_pair

`abjad.tools.durationtools.duration_token_to_duration_pair(duration_token)`

New in version 1.1. Change *duration_token* to duration pair:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.duration_token_to_duration_pair(Fraction(2, 4))
(1, 2)
```

New in version 2.0: Change LilyPond duration string to duration pair:

```
abjad> durationtools.duration_token_to_duration_pair('8.')
(3, 16)
```

Return pair. Changed in version 2.0: renamed `durationtools.token_unpack()` to `durationtools.duration_token_to_duration_pair()`.

durationtools.duration_token_to_rational

`abjad.tools.durationtools.duration_token_to_rational(duration_token)`

New in version 2.0. Change *duration_token* to rational:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.duration_token_to_rational((4, 16))
Fraction(1, 4)

abjad> durationtools.duration_token_to_rational('4.')
Fraction(3, 8)
```

Return fraction.

durationtools.duration_tokens_to_duration_pairs

`abjad.tools.durationtools.duration_tokens_to_duration_pairs(duration_tokens)`

New in version 2.0. Change *duration_tokens* to duration pairs:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.duration_tokens_to_duration_pairs([Fraction(2, 4), 3, '8.', (5, 16)])
[(1, 2), (3, 1), (3, 16), (5, 16)]
```

Return new object of *duration_tokens* type.

durationtools.duration_tokens_to_duration_pairs_with_least_common_denominator

`abjad.tools.durationtools.duration_tokens_to_duration_pairs_with_least_common_denominator(durations)`
New in version 2.0. Change *duration_tokens* to duration pairs with least common denominator:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.duration_tokens_to_duration_pairs_with_least_common_denominator([Fraction(2, 4),
[(8, 16), (48, 16), (3, 16), (5, 16)]
```

Return new object of *duration_tokens* type.

durationtools.duration_tokens_to_least_common_denominator

`abjad.tools.durationtools.duration_tokens_to_least_common_denominator(duration_tokens)`
New in version 2.0. Change *duration_tokens* to least common denominator:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.duration_tokens_to_least_common_denominator([Fraction(2, 4), 3, '8.', (5, 16),
16
```

Return positive integer.

durationtools.duration_tokens_to_rationals

`abjad.tools.durationtools.duration_tokens_to_rationals(duration_tokens)`
New in version 2.0. Change *duration_tokens* to rationals:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.duration_tokens_to_rationals([Fraction(2, 4), 3, '8.', (5, 16)])
[Fraction(1, 2), Fraction(3, 1), Fraction(3, 16), Fraction(5, 16)]
```

Return new object of *duration_tokens* type.

durationtools.group_duration_tokens_by_implied_prolation

`abjad.tools.durationtools.group_duration_tokens_by_implied_prolation(durations)`
New in version 1.1. Group *durations* by implied prolation:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.group_duration_tokens_by_implied_prolation([(1, 4), (1, 8), (1, 3), (1, 6)],
[[ (1, 4), (1, 8)], [(1, 3), (1, 6)], [(1, 4)]]
```

Return list of integer pair lists. Changed in version 2.0: renamed `durationtools.agglomerate_by_prolation()` to `durationtools.group_duration_tokens_by_implied_prolation()`

durationtools.is_assignable_rational

`abjad.tools.durationtools.is_assignable_rational(expr)`
New in version 1.1. True when *expr* is assignable rational. Otherwise false:

```

abjad> from abjad.tools import durationtools

abjad> for numerator in range(0, 16 + 1):
...     duration = Fraction(numerator, 16)
...     print '%s\t%s' % (duration, durationtools.is_assignable_rational(duration))
...
0      False
1/16   True
1/8    True
3/16   True
1/4    True
5/16   False
3/8    True
7/16   True
1/2    True
9/16   False
5/8    False
11/16  False
3/4    True
13/16  False
7/8    True
15/16  True
1      True

```

Return boolean. Changed in version 2.0: renamed `durationtools.is_assignable()` to `durationtools.is_assignable_rational()`.

durationtools.is_binary_rational

`abjad.tools.durationtools.is_binary_rational(rational)`

New in version 1.1. True when *rational* is of the form $1/2^{*n}$. Otherwise false:

```

abjad> from abjad.tools import durationtools

abjad> for n in range(1, 17): # doctest: +SKIP
...     rational = Fraction(1, n)
...     print '%s\t%s' % (rational, durationtools.is_binary_rational(rational))
...
1      True
1/2    True
1/3    False
1/4    True
1/5    False
1/6    False
1/7    False
1/8    True
1/9    False
1/10   False
1/11   False
1/12   False
1/13   False
1/14   False
1/15   False
1/16   True

```

Return boolean.

durationtools.is_duration_pair

`abjad.tools.durationtools.is_duration_pair(arg)`

New in version 1.1. True when *arg* has the form of a pair of integers that initialize a positive rational:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.is_duration_pair((5, 16))
True
```

Otherwise false:

```
abjad> durationtools.is_duration_pair((-5, 16))
False
```

Return boolean. Changed in version 2.0: renamed `durationtools.is_pair()` to `durationtools.is_duration_pair()`.

durationtools.is_duration_token

`abjad.tools.durationtools.is_duration_token(expr)`

New in version 2.0. True when *expr* has the form of an Abjad duration token:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.is_duration_token('8.')
True
```

Otherwise false:

```
abjad> durationtools.is_duration_token('foo')
False
```

Return boolean.

durationtools.is_lilypond_duration_name

`abjad.tools.durationtools.is_lilypond_duration_name(expr)`

New in version 2.0. True when *expr* is a LilyPond duration name:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.is_lilypond_duration_name('\\breve')
True
```

Otherwise false:

```
abjad> durationtools.is_lilypond_duration_name('foo')
False
```

The regex `^(\\breve|\\longa|\\maxima)$` underlies this predicate.

Return boolean.

durationtools.is_lilypond_duration_string

`abjad.tools.durationtools.is_lilypond_duration_string(expr)`

New in version 2.0. True when *expr* is a LilyPond duration string:

```
abjad> from abjad.tools import durationtools
```

```
abjad> durationtools.is_lilypond_duration_string('4.. * 1/2')
True
```

Otherwise false:

```
abjad> durationtools.is_lilypond_duration_string('foo')
False
```

The regex `^(1|2|4|8|16|32|64|128|\breve|\longa|\maxima)\s*(\.\s*)\s*(*\s*(\d+(\s*\d+)?))?$` underlies this predicate.

Return boolean.

durationtools.lilypond_duration_string_to_rational

```
abjad.tools.durationtools.lilypond_duration_string_to_rational(duration_string)
```

New in version 2.0. Change LilyPond *duration_string* to rational:

```
abjad> from abjad.tools import durationtools
```

```
abjad> durationtools.lilypond_duration_string_to_rational('8.')
Fraction(3, 16)
```

Return fraction.

durationtools.lilypond_duration_string_to_rational_list

```
abjad.tools.durationtools.lilypond_duration_string_to_rational_list(duration_string)
```

New in version 2.0. Change LilyPond *duration_string* to rational list:

```
abjad> from abjad.tools import durationtools
```

```
abjad> durationtools.lilypond_duration_string_to_rational_list('8.. 32 8.. 32')
[Fraction(7, 32), Fraction(1, 32), Fraction(7, 32), Fraction(1, 32)]
```

Return list of fractions.

durationtools.multiply_duration_pair

```
abjad.tools.durationtools.multiply_duration_pair(pair, multiplier)
```

New in version 1.1. Multiply duration *pair* by rational *multiplier*:

```
abjad> from abjad.tools import durationtools
```

```
abjad> durationtools.multiply_duration_pair((4, 8), Fraction(4, 5))
(16, 40)
```

Naive multiplication with no simplification of anything intended for certain types of meter multiplication.

Return integer pair. Changed in version 2.0: renamed `durationtools.pair_multiply_naive()` to `durationtools.multiply_duration_pair()`.

durationtools.multiply_duration_pair_and_reduce_factors

abjad.tools.durationtools.**multiply_duration_pair_and_reduce_factors**(*pair*,
multiplier)

New in version 1.1. Multiply *pair* by rational *multiplier* and reduce factors:

```
abjad> from abjad.tools import durationtools
```

```
abjad> durationtools.multiply_duration_pair_and_reduce_factors((4, 8), Fraction(2, 3))
(4, 12)
```

Intended for certain types of meter multiplication.

Return integer pair. Changed in version 2.0: renamed `durationtools.pair_multiply_reduce_factors()` to `durationtools.multiply_duration_pair_and_reduce_factors()`.

durationtools.multiply_duration_pair_and_try_to_preserve_numerator

abjad.tools.durationtools.**multiply_duration_pair_and_try_to_preserve_numerator**(*pair*,
multiplier)

New in version 1.1. Multiply duration *pair* by rational *multiplier* and try to preserve numerator:

```
abjad> from abjad.tools import durationtools
```

```
abjad> durationtools.multiply_duration_pair_and_try_to_preserve_numerator((9, 16), Fraction(2, 3))
(9, 24)
```

Intended for certain types of meter multiplication.

Return integer pair. Changed in version 2.0: renamed `durationtools.pair_multiply_constant_numerator()` to `durationtools.multiply_duration_pair_and_try_to_preserve_numerator()`.

durationtools.numeric_seconds_to_clock_string

abjad.tools.durationtools.**numeric_seconds_to_clock_string**(*seconds*)

New in version 2.0. Change numeric *seconds* to clock string:

```
abjad> from abjad.tools import durationtools
```

```
abjad> durationtools.numeric_seconds_to_clock_string(117)
'1\57''
```

Return string.

durationtools.numeric_seconds_to_escaped_clock_string

abjad.tools.durationtools.**numeric_seconds_to_escaped_clock_string**(*seconds*)

New in version 2.0. Change numeric *seconds* to escaped clock string:

```
abjad> from abjad.tools import durationtools
```

```

abjad> note = Note("c'4")
abjad> clock_string = durationtools.numeric_seconds_to_escaped_clock_string(117)
abjad> markuptools.Markup('%s' % clock_string, 'up')(note)
Markup('1\'57\'\'\'', 'up')

abjad> f(note)
c'4 ^ \markup { "1'57\'" }
```

Escape seconds indicator for output as LilyPond markup.

Return string.

`durationtools.positive_integer_to_implied_prolation_multiplier`

`abjad.tools.durationtools.positive_integer_to_implied_prolation_multiplier(n)`
 New in version 1.1. Change positive integer *n* to implied porlation multiplier:

```

abjad> from abjad.tools import durationtools

abjad> for denominator in range(1, 17): # doctest: +SKIP
...     multiplier = durationtools.positive_integer_to_implied_prolation_multiplier(denominator)
...     print '%s\t%s' % (denominator, multiplier)
...
1         1
2         1
3         2/3
4         1
5         4/5
6         2/3
7         4/7
8         1
9         8/9
10        4/5
11        8/11
12        2/3
13        8/13
14        4/7
15        8/15
16        1
```

Return positive fraction less than or equal to 1. Changed in version 2.0: renamed `durationtools.denominator_to_multiplier()` to `durationtools.positive_integer_to_implied_prolation_multiplier()`.

`durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator`

`abjad.tools.durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(r, n)`

Change *duration* to duration pair with multiple of specified *integer_denominator*:

```

abjad> from abjad.tools import durationtools

abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(1, 2)
```

```

abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(2, 4)
abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(4, 8)
abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(8, 16)

abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(3, 6)
abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(3, 6)
abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(6, 12)
abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(12, 24)

abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(5, 10)
abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(5, 10)
abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(10, 20)
abjad> durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator(Fr
(20, 40)

```

Return integer pair. Changed in version 2.0: renamed `durationtools.in_terms_of_binary_multiple()` to `durationtools.rational_to_duration_pair_with_multiple_of_specified_integer_denominator()`

`durationtools.rational_to_duration_pair_with_specified_integer_denominator`

`abjad.tools.durationtools.rational_to_duration_pair_with_specified_integer_denominator` (*durationtools.rational_to_duration_pair_with_specified_integer_denominator*)

New in version 1.1. Change *duration* to *duraiton* pair with specified *integer_denominator*:

```

abjad> from abjad.tools import durationtools

abjad> for n in range(1, 17):
...     rational = Fraction(n, 16)
...     pair = durationtools.rational_to_duration_pair_with_specified_integer_denominator(rational, 16)
...     print '%s\t%s' % (rational, pair)
...
1/16    (1, 16)
1/8     (2, 16)
3/16    (3, 16)
1/4     (4, 16)
5/16    (5, 16)
3/8     (6, 16)
7/16    (7, 16)
1/2     (8, 16)
9/16    (9, 16)
5/8     (10, 16)
11/16   (11, 16)
3/4     (12, 16)
13/16   (13, 16)
7/8     (14, 16)

```

```
15/16    (15, 16)
1         (16, 16)
```

Return integer pair. Changed in version 2.0: renamed `durationtools.in_terms_of()` to `durationtools.rational_to_duration_pair_with_specified_integer_denominator()`.

`durationtools.rational_to_equal_or_greater_assignable_rational`

`abjad.tools.durationtools.rational_to_equal_or_greater_assignable_rational(rational)`

New in version 1.1. Change *rational* to equal or greater assignable rational:

```
abjad> from abjad.tools import durationtools

abjad> for n in range(1, 17): # doctest: +SKIP
...     prolated = Fraction(n, 16)
...     written = durationtools.rational_to_equal_or_greater_assignable_rational(prolated)
...     print '%s/16\t%s' % (n, written)
...
1/16    1/16
2/16    1/8
3/16    3/16
4/16    1/4
5/16    3/8
6/16    3/8
7/16    7/16
8/16    1/2
9/16    3/4
10/16   3/4
11/16   3/4
12/16   3/4
13/16   7/8
14/16   7/8
15/16   15/16
16/16   1
```

Return fraction.

Function returns dotted and double dotted durations where possible. Changed in version 2.0: Fixed to produce monotonically increasing output in response to monotonically increasing input. Changed in version 2.0: renamed `durationtools.prolated_to_written_not_less_than()` to `durationtools.rational_to_equal_or_greater_assignable_rational()`.

`durationtools.rational_to_equal_or_greater_binary_rational`

`abjad.tools.durationtools.rational_to_equal_or_greater_binary_rational(rational)`

New in version 1.1. Change *rational* to equal to greater binary rational:

```
abjad> from abjad.tools import durationtools

abjad> for n in range(1, 17): # doctest: +SKIP
...     rational = Fraction(n, 16)
...     written_duration = durationtools.rational_to_equal_or_greater_binary_rational(rational)
...     print '%s/16\t%s' % (n, written_duration)
...
1/16    1/16
2/16    1/8
```



```

3/16    1/4
4/16    1/4
5/16    1/2
6/16    1/2
7/16    1/2
8/16    1/2
9/16    1
10/16   1
11/16   1
12/16   1
13/16   1
14/16   1
15/16   1
16/16   1

```

```

abjad> durationtools.rational_to_equal_or_greater_binary_rational(Fraction(1, 80))
Fraction(1, 64)

```

```

abjad> durationtools.rational_to_equal_or_greater_binary_rational(Fraction(17, 16))
Fraction(2, 1)

```

Use to find written duration of tupletted leaves.

Return fraction. Changed in version 2.0: renamed `durationtools.naive_prolated_to_written_not_less_than` to `durationtools.rational_to_equal_or_greater_binary_rational()`.

`durationtools.rational_to_equal_or_lesser_assignable_rational`

`abjad.tools.durationtools.rational_to_equal_or_lesser_assignable_rational(rational)`

New in version 1.1. Change *rational* to equal or lesser assignable rational:

```

abjad> from abjad.tools import durationtools

abjad> for n in range(1, 17): # doctest: +SKIP
...     rational = Fraction(n, 16)
...     written = durationtools.rational_to_equal_or_lesser_assignable_rational(rational)
...     print '%s/16\t%s' % (n, written)
...
1/16    1/16
2/16    1/8
3/16    3/16
4/16    1/4
5/16    1/4
6/16    3/8
7/16    7/16
8/16    1/2
9/16    1/2
10/16   1/2
11/16   1/2
12/16   3/4
13/16   3/4
14/16   7/8
15/16   15/16
16/16   1

```

Return fraction.

Function returns dotted and double dotted durations where possible. Changed in version 2.0: Fixed

to produce monotonically increasing output in response to monotonically increasing input. Changed in version 2.0: renamed `durationtools.prolated_to_written_not_greater_than()` to `durationtools.rational_to_equal_or_lesser_assignable_rational()`.

`durationtools.rational_to_equal_or_lesser_binary_rational`

`abjad.tools.durationtools.rational_to_equal_or_lesser_binary_rational(rational)`

New in version 1.1. Change *rational* to equal or lesser binary rational:

```
abjad> from abjad.tools import durationtools

abjad> for n in range(1, 17): # doctest: +SKIP
...     rational = Fraction(n, 16)
...     written_duration = durationtools.rational_to_equal_or_lesser_binary_rational(rational)
...     print '%s/16\t%s' % (n, written_duration)
...
1/16    1/16
2/16    1/8
3/16    1/8
4/16    1/4
5/16    1/4
6/16    1/4
7/16    1/4
8/16    1/2
9/16    1/2
10/16   1/2
11/16   1/2
12/16   1/2
13/16   1/2
14/16   1/2
15/16   1/2
16/16   1

abjad> durationtools.rational_to_equal_or_lesser_binary_rational(Fraction(1, 80))
Fraction(1, 128)
```

Return fraction.

Function intended to find written duration of notes inside tuplet. Changed in version 2.0: re-named `durationtools.naive_prolated_to_written_not_greater_than()` to `durationtools.rational_to_equal_or_lesser_binary_rational()`.

`durationtools.rational_to_flag_count`

`abjad.tools.durationtools.rational_to_flag_count(rational)`

New in version 2.0. Change *rational* to number of flags required to notate:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.rational_to_flag_count(Fraction(1, 32))
3
```

Return nonnegative integer.

durationtools.rational_to_fraction_string

`abjad.tools.durationtools.rational_to_fraction_string(rational)`

New in version 1.1. Change *rational* to fraction string:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.rational_to_fraction_string(Fraction(2, 4))
'1/2'
```

Return string.

durationtools.rational_to_prolation_string

`abjad.tools.durationtools.rational_to_prolation_string(rational)`

New in version 2.0. Change *rational* to prolotion string:

```
abjad> from abjad.tools import durationtools

abjad> generator = durationtools.yield_all_positive_rationals_in_cantor_diagonalized_order_unique
abjad> for n in range(16): # doctest: +SKIP
...     rational = generator.next()
...     prolotion_string = durationtools.rational_to_prolation_string(rational)
...     print '%s\\t%s' % (rational, prolotion_string)
...
1          1:1
2          1:2
1/2        2:1
1/3        3:1
3          1:3
4          1:4
3/2        2:3
2/3        3:2
1/4        4:1
1/5        5:1
5          1:5
6          1:6
5/2        2:5
4/3        3:4
3/4        4:3
2/5        5:2
```

Return string.

durationtools.rational_to_proper_fraction

`abjad.tools.durationtools.rational_to_proper_fraction(rational)`

New in version 2.0. Change *rational* to proper fraction:

```
abjad> from abjad.tools import durationtools

abjad> durationtools.rational_to_proper_fraction(Fraction(116, 8))
(14, Fraction(1, 2))
```

Return pair.

durationtools.rewrite_rational_under_new_tempo

`abjad.tools.durationtools.rewrite_rational_under_new_tempo` (*prolated_duration_1*,
tempo_mark_1,
tempo_mark_2)

New in version 2.0. Given *prolated_duration_1* governed by *tempo_mark_1*, return *prolated_duration_2* governed by *tempo_mark_2* such that *prolated_duration_1* and *prolated_duration_2* consume exactly the same amount of time in seconds.

Consider the two tempo indications below.

```
abjad> from abjad.tools import durationtools
```

```
abjad> tempo_mark_1 = contexttools.TempoMark(Duration(1, 4), 60)
```

```
abjad> tempo_mark_2 = contexttools.TempoMark(Duration(1, 4), 90)
```

The first tempo indication specifies quarter = 60 MM. The second tempo indication specifies quarter = 90 MM.

The second tempo is 1 1/2 times as fast as the first.

```
abjad> tempo_mark_2 / tempo_mark_1
Duration(3, 2)
```

An triplet eighth note at tempo 1 equals a regular eighth note at tempo 2.

```
abjad> durationtools.rewrite_rational_under_new_tempo(Duration(1, 12), tempo_mark_1, tempo_mark_2)
Duration(1, 8)
```

Conversely, a regular eighth note at tempo 1 equals a dotted sixteenth at tempo 2.

```
abjad> durationtools.rewrite_rational_under_new_tempo(Duration(1, 8), tempo_mark_1, tempo_mark_2)
Duration(3, 16)
```

Return fraction.

durationtools.yield_all_assignable_rationals_in_cantor_diagonalized_order

`abjad.tools.durationtools.yield_all_assignable_rationals_in_cantor_diagonalized_order` ()

New in version 2.0. Yield all assignable rationals in Cantor diagonalized order:

```
abjad> from abjad.tools import durationtools
```

```
abjad> generator = durationtools.yield_all_assignable_rationals_in_cantor_diagonalized_order()
```

```
abjad> for n in range(16):
```

```
...     generator.next()
```

```
...
```

```
Fraction(1, 1)
```

```
Fraction(2, 1)
```

```
Fraction(1, 2)
```

```
Fraction(3, 1)
```

```
Fraction(4, 1)
```

```
Fraction(3, 2)
```

```
Fraction(1, 4)
```

```
Fraction(6, 1)
```

```
Fraction(3, 4)
```

```
Fraction(7, 1)
```

```
Fraction(8, 1)
```

```
Fraction(7, 2)
```

```
Fraction(1, 8)
```

```
Fraction(7, 4)
Fraction(3, 8)
Fraction(12, 1)
```

Return fraction generator.

durationtools.yield_all_positive_integer_pairs_in_cantor_diagonalized_order

`abjad.tools.durationtools.yield_all_positive_integer_pairs_in_cantor_diagonalized_order()`
New in version 2.0. Yield all positive integer pairs in Cantor diagonalized order:

```
abjad> from abjad.tools import durationtools

abjad> generator = durationtools.yield_all_positive_integer_pairs_in_cantor_diagonalized_order()
abjad> for n in range(16):
...     generator.next()
...
(1, 1)
(2, 1)
(1, 2)
(1, 3)
(2, 2)
(3, 1)
(4, 1)
(3, 2)
(2, 3)
(1, 4)
(1, 5)
(2, 4)
(3, 3)
(4, 2)
(5, 1)
(6, 1)
```

Return pair generator.

durationtools.yield_all_positive_rationals_in_cantor_diagonalized_order

`abjad.tools.durationtools.yield_all_positive_rationals_in_cantor_diagonalized_order()`
New in version 2.0. Yield all positive rationals in Cantor diagonalized order:

```
abjad> from abjad.tools import durationtools

abjad> generator = durationtools.yield_all_positive_rationals_in_cantor_diagonalized_order()
abjad> for n in range(16):
...     generator.next()
...
Fraction(1, 1)
Fraction(2, 1)
Fraction(1, 2)
Fraction(1, 3)
Fraction(1, 1)
Fraction(3, 1)
Fraction(4, 1)
Fraction(3, 2)
Fraction(2, 3)
```

```
Fraction(1, 4)
Fraction(1, 5)
Fraction(1, 2)
Fraction(1, 1)
Fraction(2, 1)
Fraction(5, 1)
Fraction(6, 1)
```

Return fraction generator.

`durationtools.yield_all_positive_rationals_in_cantor_diagonalized_order_uniquely`

`abjad.tools.durationtools.yield_all_positive_rationals_in_cantor_diagonalized_order_uniquely`

New in version 2.0. Yield all positive rationals in Cantor diagonalized order uniquely:

```
abjad> from abjad.tools import durationtools

abjad> generator = durationtools.yield_all_positive_rationals_in_cantor_diagonalized_order_uniquely
abjad> for n in range(16):
...     generator.next()
...
Fraction(1, 1)
Fraction(2, 1)
Fraction(1, 2)
Fraction(1, 3)
Fraction(3, 1)
Fraction(4, 1)
Fraction(3, 2)
Fraction(2, 3)
Fraction(1, 4)
Fraction(1, 5)
Fraction(5, 1)
Fraction(6, 1)
Fraction(5, 2)
Fraction(4, 3)
Fraction(3, 4)
Fraction(2, 5)
```

Return fraction generator.

`durationtools.yield_all_prolation_rewrite_pairs_of_rational_in_cantor_diagonalized_order`

`abjad.tools.durationtools.yield_all_prolation_rewrite_pairs_of_rational_in_cantor_diagonalized_order`

New in version 2.0. Yield all prolation rewrite pairs of *prolated_duration* in Cantor diagonalized order.

Ensure written duration never less than *minimum_written_duration*.

The different ways to notate a prolated duration of $1/8$:

```
abjad> from abjad.tools import durationtools
```

```

abjad> pairs = durationtools.yield_all_prolation_rewrite_pairs_of_rational_in_cantor_diagonalize
abjad> for pair in pairs: pair
...
(Fraction(1, 1), Fraction(1, 8))
(Fraction(2, 3), Fraction(3, 16))
(Fraction(4, 3), Fraction(3, 32))
(Fraction(4, 7), Fraction(7, 32))
(Fraction(8, 7), Fraction(7, 64))
(Fraction(8, 15), Fraction(15, 64))
(Fraction(16, 15), Fraction(15, 128))
(Fraction(16, 31), Fraction(31, 128))

```

The different ways to notate a prolated duration of $1/12$.

```

abjad> pairs = durationtools.yield_all_prolation_rewrite_pairs_of_rational_in_cantor_diagonalize
abjad> for pair in pairs: pair
...
(Fraction(2, 3), Fraction(1, 8))
(Fraction(4, 3), Fraction(1, 16))
(Fraction(8, 9), Fraction(3, 32))
(Fraction(16, 9), Fraction(3, 64))
(Fraction(16, 21), Fraction(7, 64))
(Fraction(32, 21), Fraction(7, 128))
(Fraction(32, 45), Fraction(15, 128))

```

The different ways to notate a prolated duration of $5/48$.

```

abjad> pairs = durationtools.yield_all_prolation_rewrite_pairs_of_rational_in_cantor_diagonalize
abjad> for pair in pairs: pair
...
(Fraction(5, 6), Fraction(1, 8))
(Fraction(5, 3), Fraction(1, 16))
(Fraction(5, 9), Fraction(3, 16))
(Fraction(10, 9), Fraction(3, 32))
(Fraction(20, 21), Fraction(7, 64))
(Fraction(40, 21), Fraction(7, 128))
(Fraction(8, 9), Fraction(15, 128))

```

Return generator of paired fractions.

intervalreetools

intervalreetools.BoundedInterval

```

class abjad.tools.intervalreetools.BoundedInterval(*args)
    Bases: dict, abjad.core._Immutable._Immutable._Immutable
    A low / high pair, carrying some metadata.

    centroid
        Center point of low and high bounds.

    get_overlap_with_interval(interval)
        Return amount of overlap with interval.

    high
        High bound.

    is_contained_by_interval(interval)
        True if interval is contained by interval.

```

is_container_of_interval (*interval*)

True if interval contains *interval*.

is_overlapped_by_interval (*interval*)

True if interval is overlapped by *interval*.

is_tangent_to_interval (*interval*)

True if interval is tangent to *interval*.

low

Low bound.

magnitude

High bound minus low bound.

scale_by_rational (*rational*)

scale_to_rational (*rational*)

shift_by_rational (*rational*)

shift_to_rational (*rational*)

signature

Tuple of low bound and high bound.

split_at_rational (*rational*)

intervaltreetools.IntervalTree

class abjad.tools.intervaltreetools.**IntervalTree** (*intervals=[]*)

Bases: abjad.tools.intervaltreetools._RedBlackTree._RedBlackTree._RedBlackTree

An augmented red-black tree for storing and searching for intervals of time (rather than pitch).

This allows for the arbitrary placement of blocks of material along a time-line. While this functionality could be achieved with Python's built-in collections, this class reduces the complexity of the search process, such as locating overlapping intervals.

IntervalTrees can be instantiated without contents, or from a mixed collection of other IntervalTrees and / or BoundedIntervals. The input will be parsed recursively

```
abjad> from abjad.tools.intervaltreetools import IntervalTree
abjad> from abjad.tools.intervaltreetools import BoundedInterval
abjad> bi = BoundedInterval(0, 10)
abjad> tree = IntervalTree([bi])
```

bounds

The lowest and highest values of the tree returned as a BoundedInterval.

find_intervals_intersecting_or_tangent_to_interval (**args*)

find_intervals_intersecting_or_tangent_to_offset (*offset*)

find_intervals_starting_after_offset (*offset*)

find_intervals_starting_and_stopping_within_interval (**args*)

find_intervals_starting_at_offset (*offset*)

find_intervals_starting_before_offset (*offset*)

find_intervals_starting_or_stopping_at_offset (*offset*)

find_intervals_starting_within_interval (*args)
find_intervals_stopping_after_offset (offset)
find_intervals_stopping_at_offset (offset)
find_intervals_stopping_before_offset (offset)
find_intervals_stopping_within_interval (*args)
high
 The maximum high value of all intervals in the tree. Alias of high_max.
high_max
 The maximum high value of all intervals in the tree.
high_min
 The minimum high value of all intervals in the tree.
low
 The minimum low value of all intervals in the tree. Alias of low_min.
low_max
 The maximum low value of all intervals in the tree.
low_min
 The minimum low value of all intervals in the tree.
magnitude
 Absolute difference of the high and low values of the tree.

intervalreetools.all_are_intervals_or_trees_or_empty

abjad.tools.intervalreetools.**all_are_intervals_or_trees_or_empty** (input)
 Recursively test if all elements of *input* are BoundedIntervals or IntervalTrees. An empty result also return as True.

intervalreetools.all_intervals_are_contiguous

abjad.tools.intervalreetools.**all_intervals_are_contiguous** (intervals)
 True when all intervals in *intervals* are contiguous and non-overlapping.

intervalreetools.all_intervals_are_nonoverlapping

abjad.tools.intervalreetools.**all_intervals_are_nonoverlapping** (intervals)
 True when all intervals in *intervals* in tree are non-overlapping.

intervalreetools.calculate_density_of_attacks_in_interval

abjad.tools.intervalreetools.**calculate_density_of_attacks_in_interval** (intervals,
*in-
 ter-
 val*)
 Return a Fraction of number of attacks in *interval* over the magnitude of *interval*.

`intervaltreertools.calculate_density_of_releases_in_interval`

`abjad.tools.intervaltreertools.calculate_density_of_releases_in_interval` (*intervals*, *interval*)

Return a Fraction of the number of releases in *interval* divided by the magnitude of *interval*.

`intervaltreertools.calculate_depth_centroid_of_intervals`

`abjad.tools.intervaltreertools.calculate_depth_centroid_of_intervals` (*intervals*)

Return a weighted mean, such that the centroids of each interval in the depth tree of *intervals* are the values, and the depth of each interval in the depth tree of *intervals* are the weights.

`intervaltreertools.calculate_depth_centroid_of_intervals_in_interval`

`abjad.tools.intervaltreertools.calculate_depth_centroid_of_intervals_in_interval` (*intervals*, *interval*)

Return the weighted mean of the depth tree of *intervals* in *interval*, such that the centroids of each interval of the depth tree are the values, and the weights are the depths at each interval of the depth tree.

`intervaltreertools.calculate_depth_density_of_intervals`

`abjad.tools.intervaltreertools.calculate_depth_density_of_intervals` (*intervals*)

Return a Fraction, of the magnitude of each interval in the depth tree of *intervals*, multiplied by the depth at that interval, divided by the overall magnitude of *intervals*.

The depth density of a single interval is 1

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = BoundedInterval(0, 1)
abjad> b = BoundedInterval(0, 1)
abjad> c = BoundedInterval(Fraction(1, 2), 1)
abjad> intervaltreertools.calculate_depth_density_of_intervals(a)
Duration(1, 1)
abjad> intervaltreertools.calculate_depth_density_of_intervals([a, b])
Duration(2, 1)
abjad> intervaltreertools.calculate_depth_density_of_intervals([a, c])
Duration(3, 2)
abjad> intervaltreertools.calculate_depth_density_of_intervals([a, b, c])
Duration(5, 2)
```

Return fraction.

intervaltreertools.calculate_depth_density_of_intervals_in_interval

`abjad.tools.intervaltreertools.calculate_depth_density_of_intervals_in_interval` (*intervals*,
in-ter-val)

Return a Fraction, of the magnitude of each interval in the depth tree of *intervals* within *interval*, multiplied by the depth at that interval, divided by the overall magnitude of *intervals*.

intervaltreertools.calculate_mean_attack_of_intervals

`abjad.tools.intervaltreertools.calculate_mean_attack_of_intervals` (*intervals*)
Return Fraction of the average attack offset of *intervals*

intervaltreertools.calculate_mean_release_of_intervals

`abjad.tools.intervaltreertools.calculate_mean_release_of_intervals` (*intervals*)
Return a Fraction of the average release offset of *intervals*.

intervaltreertools.calculate_min_mean_and_max_depth_of_intervals

`abjad.tools.intervaltreertools.calculate_min_mean_and_max_depth_of_intervals` (*intervals*)
Return a 3-tuple of the minimum, mean and maximum depth of *intervals*. If *intervals* is empty, return None. “Mean” in this case is a weighted mean, where the magnitudes of the intervals in depth tree of *intervals* are the weights

intervaltreertools.calculate_min_mean_and_max_magnitude_of_intervals

`abjad.tools.intervaltreertools.calculate_min_mean_and_max_magnitude_of_intervals` (*intervals*)
Return a 3-tuple of the minimum, mean and maximum magnitude of all intervals in *intervals*. If *intervals* is empty, return None.

intervaltreertools.calculate_sustain_centroid_of_intervals

`abjad.tools.intervaltreertools.calculate_sustain_centroid_of_intervals` (*intervals*)
Return a weighted mean, such that the centroid of each interval in *intervals* are the values, and the weights are their magnitudes.

intervaltreertools.clip_interval_magnitudes_to_range

`abjad.tools.intervaltreertools.clip_interval_magnitudes_to_range` (*intervals*,
min=None,
max=None)

intervaltreertools.compute_depth_of_intervals

`abjad.tools.intervaltreertools.compute_depth_of_intervals` (*intervals*)
Compute a tree whose intervals represent the depth (level of overlap) in each boundary pair of *intervals*:

```

abjad> from abjad.tools.intervaltreetools import *
abjad> a = BoundedInterval(0, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 15)
abjad> tree = IntervalTree([a, b, c])
abjad> compute_depth_of_intervals(tree)
IntervalTree([
    BoundedInterval(Offset(0, 1), Offset(3, 1), {'depth': 1}),
    BoundedInterval(Offset(3, 1), Offset(6, 1), {'depth': 0}),
    BoundedInterval(Offset(6, 1), Offset(9, 1), {'depth': 1}),
    BoundedInterval(Offset(9, 1), Offset(12, 1), {'depth': 2}),
    BoundedInterval(Offset(12, 1), Offset(15, 1), {'depth': 1})
])

```

Return interval tree.

intervaltreetools.compute_depth_of_intervals_in_interval

`abjad.tools.intervaltreetools.compute_depth_of_intervals_in_interval(intervals, interval)`

Compute a tree whose intervals represent the depth (level of overlap) in each boundary pair of *intervals*, cropped within *interval*:

```

abjad> from abjad.tools.intervaltreetools import *
abjad> a = BoundedInterval(0, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 15)
abjad> tree = IntervalTree([a, b, c])
abjad> d = BoundedInterval(-1, 16)
abjad> compute_depth_of_intervals_in_interval(tree, d)
IntervalTree([
    BoundedInterval(Offset(-1, 1), Offset(0, 1), {'depth': 0}),
    BoundedInterval(Offset(0, 1), Offset(3, 1), {'depth': 1}),
    BoundedInterval(Offset(3, 1), Offset(6, 1), {'depth': 0}),
    BoundedInterval(Offset(6, 1), Offset(9, 1), {'depth': 1}),
    BoundedInterval(Offset(9, 1), Offset(12, 1), {'depth': 2}),
    BoundedInterval(Offset(12, 1), Offset(15, 1), {'depth': 1}),
    BoundedInterval(Offset(15, 1), Offset(16, 1), {'depth': 0})
])

```

Return interval tree.

intervaltreetools.compute_logical_and_of_intervals

`abjad.tools.intervaltreetools.compute_logical_and_of_intervals(intervals)`
 Compute the logical AND of a collection of intervals.

intervaltreetools.compute_logical_and_of_intervals_in_interval

`abjad.tools.intervaltreetools.compute_logical_and_of_intervals_in_interval(intervals, interval)`
 Compute the logical AND of a collection of intervals, cropped within *interval*.

intervalreetools.compute_logical_not_of_intervals

`abjad.tools.intervalreetools.compute_logical_not_of_intervals(intervals)`
Compute the logical NOT of some collection of intervals.

intervalreetools.compute_logical_not_of_intervals_in_interval

`abjad.tools.intervalreetools.compute_logical_not_of_intervals_in_interval(intervals, interval)`
Compute the logical NOT of some collection of intervals, cropped within *interval*.

intervalreetools.compute_logical_or_of_intervals

`abjad.tools.intervalreetools.compute_logical_or_of_intervals(intervals)`
Compute the logical OR of a collection of intervals.

intervalreetools.compute_logical_or_of_intervals_in_interval

`abjad.tools.intervalreetools.compute_logical_or_of_intervals_in_interval(intervals, interval)`
Compute the logical OR of a collection of intervals, cropped within *interval*.

intervalreetools.compute_logical_xor_of_intervals

`abjad.tools.intervalreetools.compute_logical_xor_of_intervals(intervals)`
Compute the logical XOR of a collections of intervals.

intervalreetools.compute_logical_xor_of_intervals_in_interval

`abjad.tools.intervalreetools.compute_logical_xor_of_intervals_in_interval(intervals, interval)`
Compute the logical XOR of a collections of intervals, cropped within *interval*.

intervalreetools.concatenate_trees

`abjad.tools.intervalreetools.concatenate_trees(trees, padding=0)`
Merge all trees in *trees*, offsetting each subsequent tree to start after the previous.

intervalreetools.explode_intervals_compactly

`abjad.tools.intervalreetools.explode_intervals_compactly(intervals)`
Explode the intervals in *intervals* into *n* non-overlapping trees, where *n* is the maximum depth of *intervals*.
Returns an array of *IntervalTree* instances.

The algorithm will attempt to insert the exploded intervals into the lowest-indexed resultant tree with free space.

`intervaltreertools.explode_intervals_into_n_trees_heuristically`

`abjad.tools.intervaltreertools.explode_intervals_into_n_trees_heuristically` (*intervals*, *n*)
 Explode *intervals* into *n* trees, avoiding overlap when possible, and distributing intervals so as to equalize density across the trees.

`intervaltreertools.explode_intervals_uncompactly`

`abjad.tools.intervaltreertools.explode_intervals_uncompactly` (*intervals*)
 Explode the intervals in *intervals* into *n* non-overlapping trees, where *n* is the maximum depth of *intervals*.
 Returns an array of *IntervalTree* instances.
 The algorithm will attempt to insert the exploded intervals cyclically, making its insertion attempt at the next resultant tree in the array, rather than always beginning its search from index 0.

`intervaltreertools.fuse_overlapping_intervals`

`abjad.tools.intervaltreertools.fuse_overlapping_intervals` (*intervals*)
 Fuse the overlapping intervals in *intervals* and return an *IntervalTree* of the result

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = BoundedInterval(0, 10)
abjad> b = BoundedInterval(5, 15)
abjad> c = BoundedInterval(15, 25)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreertools.fuse_overlapping_intervals(tree)
IntervalTree([
    BoundedInterval(Offset(0, 1), Offset(15, 1), {}),
    BoundedInterval(Offset(15, 1), Offset(25, 1), {})
])
```

Return interval tree.

`intervaltreertools.fuse_tangent_or_overlapping_intervals`

`abjad.tools.intervaltreertools.fuse_tangent_or_overlapping_intervals` (*intervals*)
 Fuse all tangent or overlapping intervals and return an *IntervalTree* of the result

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = BoundedInterval(0, 10)
abjad> b = BoundedInterval(5, 15)
abjad> c = BoundedInterval(15, 25)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreertools.fuse_tangent_or_overlapping_intervals(tree)
IntervalTree([
```

```
        BoundedInterval(Offset(0, 1), Offset(25, 1), {})
    ])
```

Return interval tree.

`intervaltreertools.get_all_unique_bounds_in_intervals`

`abjad.tools.intervaltreertools.get_all_unique_bounds_in_intervals(intervals)`

Return all unique starting and ending boundaries in *intervals*.

`intervaltreertools.group_overlapping_intervals_and_yield_groups`

`abjad.tools.intervaltreertools.group_overlapping_intervals_and_yield_groups(intervals)`

Group overlapping intervals in *intervals* and return tuples.

`intervaltreertools.group_tangent_or_overlapping_intervals_and_yield_groups`

`abjad.tools.intervaltreertools.group_tangent_or_overlapping_intervals_and_yield_groups(intervals)`

Group tangent or overlapping intervals in *intervals* and return tuples.

`intervaltreertools.make_monophonic_percussion_score_from_nonoverlapping_intervals`

`abjad.tools.intervaltreertools.make_monophonic_percussion_score_from_nonoverlapping_intervals(intervals)`

Create a monophonic percussion score from nonoverlapping interval collection *intervals*.

`intervaltreertools.make_polyphonic_percussion_score_from_nonoverlapping_trees`

`abjad.tools.intervaltreertools.make_polyphonic_percussion_score_from_nonoverlapping_trees(trees)`

Make a polyphonic percussion score from a collections of non-overlapping trees.

`intervaltreertools.mask_intervals_with_intervals`

`abjad.tools.intervaltreertools.mask_intervals_with_intervals(masked_intervals, mask_intervals)`

Clip or remove all intervals in *masked_intervals* outside of the bounds defined in *mask_intervals*, while maintaining *masked_intervals*' payload contents

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = BoundedInterval(0, 10, {'a': 1})
abjad> b = BoundedInterval(5, 15, {'b': 2})
abjad> tree = IntervalTree([a, b])
abjad> mask = BoundedInterval(4, 11)
abjad> intervaltreertools.mask_intervals_with_intervals(tree, mask)
IntervalTree([
```

```

        BoundedInterval(Offset(4, 1), Offset(10, 1), {'a': 1}),
        BoundedInterval(Offset(5, 1), Offset(11, 1), {'b': 2})
    ])

```

Return interval tree.

`intervaltreertools.resolve_overlaps_between_nonoverlapping_trees`

`abjad.tools.intervaltreertools.resolve_overlaps_between_nonoverlapping_trees(trees)`

Create a nonoverlapping `IntervalTree` from *trees*. Intervals in higher-indexed trees in *trees* only appear in part or whole where they do not overlap intervals from lower-indexed trees

```

abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = IntervalTree(BoundedInterval(0, 4, {'a': 1}))
abjad> b = IntervalTree(BoundedInterval(1, 5, {'b': 2}))
abjad> c = IntervalTree(BoundedInterval(2, 6, {'c': 3}))
abjad> d = IntervalTree(BoundedInterval(1, 3, {'d': 4}))
abjad> intervaltreertools.resolve_overlaps_between_nonoverlapping_trees([a, b, c, d])
IntervalTree([
    BoundedInterval(Offset(0, 1), Offset(4, 1), {'a': 1}),
    BoundedInterval(Offset(4, 1), Offset(5, 1), {'b': 2}),
    BoundedInterval(Offset(5, 1), Offset(6, 1), {'c': 3})
])

```

Return interval tree.

`intervaltreertools.resolve_overlaps_between_nonoverlapping_trees_excluding_remainders_less_than_rational`

`abjad.tools.intervaltreertools.resolve_overlaps_between_nonoverlapping_trees_excluding_remainders_less_than_rational(trees, rational)`

Create a nonoverlapping `IntervalTree` from *trees*. Intervals in higher-indexed trees in *trees* only appear in part or whole where they do not overlap intervals from lower-indexed trees, and then only where their magnitudes are equal to or greater than *rational*

```

abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = IntervalTree(BoundedInterval(0, 1, {'a': 1}))
abjad> b = IntervalTree(BoundedInterval(Fraction(1, 32), Fraction(33, 32), {'b': 2}))
abjad> c = IntervalTree(BoundedInterval(Fraction(1, 16), Fraction(17, 16), {'c': 3}))
abjad> intervaltreertools.resolve_overlaps_between_nonoverlapping_trees_excluding_remainders_less_than_rational([a, b, c], Fraction(1, 16))
IntervalTree([
    BoundedInterval(Offset(0, 1), Offset(1, 1), {'a': 1}),
    BoundedInterval(Offset(1, 1), Offset(17, 16), {'c': 3})
])

```

Return interval tree.

intervaltreertools.round_interval_bounds_to_nearest_multiple_of_rational

`abjad.tools.intervaltreertools.round_interval_bounds_to_nearest_multiple_of_rational` (*intervals*, *ratio-
tio-
nal*)

intervaltreertools.scale_aggregate_magnitude_by_rational

`abjad.tools.intervaltreertools.scale_aggregate_magnitude_by_rational` (*intervals*, *ratio-
nal*)

Scale the aggregate magnitude of all intervals in *intervals* by *rational*, maintaining the original low offset

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = BoundedInterval(-1, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 16)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreertools.scale_aggregate_magnitude_by_rational(tree, Fraction(1, 3))
IntervalTree([
    BoundedInterval(Offset(-1, 1), Offset(1, 3), {}),
    BoundedInterval(Offset(4, 3), Offset(10, 3), {}),
    BoundedInterval(Offset(7, 3), Offset(14, 3), {})
])
```

Return interval tree.

intervaltreertools.scale_aggregate_magnitude_to_rational

`abjad.tools.intervaltreertools.scale_aggregate_magnitude_to_rational` (*intervals*, *ratio-
nal*)

Scale the aggregate magnitude of all intervals in *intervals* to *rational*, maintaining the original low offset

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = BoundedInterval(-1, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 16)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreertools.scale_aggregate_magnitude_to_rational(tree, Fraction(16, 7))
IntervalTree([
    BoundedInterval(Offset(-1, 1), Offset(-55, 119), {}),
    BoundedInterval(Offset(-1, 17), Offset(89, 119), {}),
    BoundedInterval(Offset(41, 119), Offset(9, 7), {})
])
```

Return interval tree.

intervaltreertools.scale_interval_magnitudes_by_rational

`abjad.tools.intervaltreertools.scale_interval_magnitudes_by_rational` (*intervals*, *rational*)

Scale the magnitude of each interval in *intervals* by *rational*, maintaining their low offsets

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = BoundedInterval(-1, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 16)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreertools.scale_interval_magnitudes_by_rational(tree, Fraction(6, 5))
IntervalTree([
    BoundedInterval(Offset(-1, 1), Offset(19, 5), {}),
    BoundedInterval(Offset(6, 1), Offset(66, 5), {}),
    BoundedInterval(Offset(9, 1), Offset(87, 5), {})
])
```

Return interval tree.

intervaltreertools.scale_interval_magnitudes_to_rational

`abjad.tools.intervaltreertools.scale_interval_magnitudes_to_rational` (*intervals*, *rational*)

Scale the magnitude of each interval in *intervals* to *rational*, maintaining their low offsets

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = BoundedInterval(-1, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 16)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreertools.scale_interval_magnitudes_to_rational(tree, Fraction(1, 7))
IntervalTree([
    BoundedInterval(Offset(-1, 1), Offset(-6, 7), {}),
    BoundedInterval(Offset(6, 1), Offset(43, 7), {}),
    BoundedInterval(Offset(9, 1), Offset(64, 7), {})
])
```

Return interval tree.

intervaltreertools.scale_interval_offsets_by_rational

`abjad.tools.intervaltreertools.scale_interval_offsets_by_rational` (*intervals*, *rational*)

Scale the offset of each interval in *intervals* by *rational*, maintaining the lowest offset in *intervals*

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree
```

```

abjad> a = BoundedInterval(-1, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 16)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreetools.scale_interval_offsets_by_rational(tree, Fraction(4, 5))
IntervalTree([
    BoundedInterval(Offset(-1, 1), Offset(3, 1), {}),
    BoundedInterval(Offset(23, 5), Offset(53, 5), {}),
    BoundedInterval(Offset(7, 1), Offset(14, 1), {})
])

```

Return interval tree.

intervaltreetools.shift_aggregate_offset_by_rational

`abjad.tools.intervaltreetools.shift_aggregate_offset_by_rational` (*intervals*, *rational*)

Shift the aggregate offset of *intervals* by *rational*

```

abjad> from abjad.tools import intervaltreetools
abjad> from abjad.tools.intervaltreetools import BoundedInterval
abjad> from abjad.tools.intervaltreetools import IntervalTree

abjad> a = BoundedInterval(-1, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 16)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreetools.shift_aggregate_offset_by_rational(tree, Fraction(1, 3))
IntervalTree([
    BoundedInterval(Offset(-2, 3), Offset(10, 3), {}),
    BoundedInterval(Offset(19, 3), Offset(37, 3), {}),
    BoundedInterval(Offset(28, 3), Offset(49, 3), {})
])

```

Return interval tree.

intervaltreetools.shift_aggregate_offset_to_rational

`abjad.tools.intervaltreetools.shift_aggregate_offset_to_rational` (*intervals*, *rational*)

Shift the aggregate offset of *intervals* to *rational*

```

abjad> from abjad.tools import intervaltreetools
abjad> from abjad.tools.intervaltreetools import BoundedInterval
abjad> from abjad.tools.intervaltreetools import IntervalTree

abjad> a = BoundedInterval(-1, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 16)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreetools.shift_aggregate_offset_to_rational(tree, Fraction(10, 7))
IntervalTree([
    BoundedInterval(Offset(10, 7), Offset(38, 7), {}),
    BoundedInterval(Offset(59, 7), Offset(101, 7), {}),
    BoundedInterval(Offset(80, 7), Offset(129, 7), {})
])

```

Return interval tree.

intervaltreertools.split_intervals_at_rationals

`abjad.tools.intervaltreertools.split_intervals_at_rationals` (*intervals*, *rationals*)

Split *intervals* at each rational in *rationals*

```
abjad> from abjad.tools import intervaltreertools
abjad> from abjad.tools.intervaltreertools import BoundedInterval
abjad> from abjad.tools.intervaltreertools import IntervalTree

abjad> a = BoundedInterval(-1, 3)
abjad> b = BoundedInterval(6, 12)
abjad> c = BoundedInterval(9, 16)
abjad> tree = IntervalTree([a, b, c])
abjad> intervaltreertools.split_intervals_at_rationals(tree, [1, Fraction(19, 2)])
IntervalTree([
    BoundedInterval(Offset(-1, 1), Offset(1, 1), {}),
    BoundedInterval(Offset(1, 1), Offset(3, 1), {}),
    BoundedInterval(Offset(6, 1), Offset(19, 2), {}),
    BoundedInterval(Offset(9, 1), Offset(19, 2), {}),
    BoundedInterval(Offset(19, 2), Offset(12, 1), {}),
    BoundedInterval(Offset(19, 2), Offset(16, 1), {})
])
```

Return interval tree.

iotools

iotools.capitalize_string_start

`abjad.tools.iotools.capitalize_string_start` (*string*)

New in version 2.5. Capitalize *string*:

```
abjad> string = 'violin I'

abjad> iotools.capitalize_string_start(string)
'Violin I'
```

Function differs from built-in `string.capitalize()`.

This function affects only `string[0]` and leaves noninitial characters as-is.

Built-in `string.capitalize()` forces noninitial characters to lowercase.

```
abjad> string.capitalize() 'Violin i'
```

Return newly constructed string.

iotools.clear_terminal

`abjad.tools.iotools.clear_terminal()`

New in version 2.0. Run `clear` if OS is POSIX-compliant (UNIX / Linux / MacOS).

Run `cls` if OS is not POSIX-compliant (Windows):

```
abjad> iotools.clear_terminal()
```

Return none.

iotools.f

`abjad.tools.iotools.f(expr)`

Format *expr* and print to standard out:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
```

```
abjad> f(staff)
\new Staff {
  c'8
  d'8
  e'8
  f'8
}
```

Return none.

iotools.format_input_lines_as_doc_string

`abjad.tools.iotools.format_input_lines_as_doc_string(input_lines, tab_width=3)`

New in version 2.0. Format *input_lines* as doc string.

Format expressions intelligently.

Treat blank lines intelligently.

Capture hash-suffixed line output.

Use when writing docstrings.

Example skipped because docstring goes crazy on example input.

iotools.format_input_lines_as_regression_test

`abjad.tools.iotools.format_input_lines_as_regression_test(input_lines,
tab_width=3)`

New in version 2.0. Format *input_lines* as regression test:

```
abjad> input_lines = '''
... staff = Staff("c'8 d'8 e'8 f'8")
... spannertools.BeamSpanner(staff.leaves)
... f(staff)
...
... tuplettools.FixedDurationTuplet(Duration(2, 8), staff[:3])
... f(staff)
... '''
abjad> iotools.format_input_lines_as_regression_test(input_lines) # doctest: +SKIP

staff = Staff("c'8 d'8 e'8 f'8")
spannertools.BeamSpanner(staff.leaves)

r'''
\new Staff {
  c'8 [
  d'8
  e'8
  f'8 ]
}
```

```
'''
tupletools.FixedDurationTuplet(Duration(2, 8), staff[:3])

r'''
\new Staff {
  \times 2/3 {
    c'8 [
      d'8
      e'8
    ]
  }
  f'8 ]
}

assert componenttools.is_well_formed_component(staff)
assert staff.format == "\\new Staff {\\n\\t\\times 2/3 {\\n\\t\\tc'8 [\\n\\t\\td'8\\n\\t\\te'8\\n\\t}\\n\\t\\t
'''
```

Format expressions intelligently.

Treat blank lines intelligently.

Remove line-final hash characters.

Used when writing tests.

iotools.get_last_output_file_name

```
abjad.tools.iotools.get_last_output_file_name()
```

Get last output file name like 6222.ly.

Return string.

iotools.get_next_output_file_name

```
abjad.tools.iotools.get_next_output_file_name()
```

Get next output file name like 6223.1y.

Return string.

iotools.is_lowercase_string

```
abjad.tools.iotools.is_lowercamelcase_string(expr)
```

New in version 2.5. True when *expr* is a string and is lowercamelcase:

```
abjad> iotools.is_lowercamelcase_string('fooBar')
True
```

False otherwise:

```
abjad> iotools.is_lowercamelcase_string('FooBar')
False
```

Return boolean.

iotools.is_space_delimited_lowercase_string

`abjad.tools.iotools.is_space_delimited_lowercase_string(expr)`

New in version 2.5. True when *expr* is a string and is space-delimited lowercase:

```
abjad> iotools.is_space_delimited_lowercase_string('foo bar')
True
```

False otherwise:

```
abjad> iotools.is_space_delimited_lowercase_string('foo_bar')
False
```

Return boolean.

iotools.is_underscore_delimited_lowercase_package_name

`abjad.tools.iotools.is_underscore_delimited_lowercase_package_name(expr)`

New in version 2.5. True when *expr* is a string and is underscore-delimited lowercase package name:

```
abjad> iotools.is_underscore_delimited_lowercase_package_name('foo.bar.blah_package')
True
```

False otherwise:

```
abjad> iotools.is_underscore_delimited_lowercase_package_name('foo.bar.BlahPackage')
False
```

Return boolean.

iotools.is_underscore_delimited_lowercase_string

`abjad.tools.iotools.is_underscore_delimited_lowercase_string(expr)`

New in version 2.5. True when *expr* is a string and is underscore delimited lowercase:

```
abjad> iotools.is_underscore_delimited_lowercase_string('foo_bar')
True
```

False otherwise:

```
abjad> iotools.is_underscore_delimited_lowercase_string('foo bar')
False
```

Return boolean.

iotools.is_uppercamelcase_string

`abjad.tools.iotools.is_uppercamelcase_string(expr)`

New in version 2.5. True when *expr* is a string and is uppercamelcase:

```
abjad> iotools.is_uppercamelcase_string('FooBar')
True
```

False otherwise:

```
abjad> iotools.is_uppercamelcase_string('fooBar')
False
```

Return boolean.

iotools.log

`abjad.tools.iotools.log()`

Open the LilyPond log file in operating system-specific text editor:

```
abjad> iotools.log() # doctest: +SKIP
```

```
GNU LilyPond 2.12.2
Processing '0440.ly'
Parsing...
Interpreting music...
Preprocessing graphical objects...
Finding the ideal number of pages...
Fitting music on 1 page...
Drawing systems...
Layout output to '0440.ps'...
Converting to './0440.pdf'...
```

Exit text editor in the usual way.

Return none.

iotools.ly

`abjad.tools.iotools.ly(target=-1)`

Open the last LilyPond output file in text editor:

```
abjad> iotools.ly() # doctest: +SKIP
```

```
% Abjad revision 2162
% 2009-05-31 14:29

\version "2.12.2"
\include "english.ly"
\include "/Path/to/abjad/trunk/abjad/cfg/abjad.scm"

{
  c'4
}
```

Open the next-to-last LilyPond output file in text editor:

```
abjad> iotools.ly(-2) # doctest: +SKIP
```

Exit text editor in the usual way.

Return none.

iotools.parse_lilypond_input_string

`abjad.tools.iotools.parse_lilypond_input_string(note_entry_string)`

New in version 2.0. Parse LilyPond *note_entry_string*:

```
abjad> note_entry_string = "g'2 a'2 g'4. fs'8 e'4 d'4"
abjad> iotools.parse_lilypond_input_string(note_entry_string)
{g'2, a'2, g'4., fs'8, e'4, d'4}
```


Return container of note, rest and chord instances.

Handle simple beaming, slurs and articulations.

Do not parse tuplets, measures or other complex LilyPond input.

iotools.pdf

`abjad.tools.iotools.pdf(target=-1)`

Open the last PDF generated by Abjad with `iotools.pdf()`.

Open the next-to-last PDF generated by Abjad with `iotools.pdf(-2)`.

Return none.

Abjad writes PDFs to the `~/ .abjad/output` directory by default.

You may change this by setting the `abjad_output` variable in the `config.py` file.

iotools.play

`abjad.tools.iotools.play(expr)`

Play *expr*:

```
abjad> note = Note("c'4")
```

```
abjad> iotools.play(note) # doctest: +SKIP
```

This input creates and opens a one-note MIDI file.

Abjad outputs MIDI files of the format `filename.mid` under Windows.

Abjad outputs MIDI files of the format `filename.midi` under other operating systems.

iotools.profile_expr

`abjad.tools.iotools.profile_expr(expr, sort_by='cum', num_lines=12, strip_dirs=True)`

Profile *expr*:

```
abjad> iotools.profile_expr('Staff(notetools.make_repeated_notes(8))') # doctest: +SKIP
Tue Apr  5 20:32:40 2011      _tmp_abj_profile
```

2852 function calls (2829 primitive calls) in 0.006 CPU seconds

Ordered by: cumulative time

List reduced from 118 to 12 due to restriction <12>

ncalls	tottime	percall	cumtime	percall	filename:lineno(function)
1	0.000	0.000	0.006	0.006	<string>:1(<module>)
1	0.000	0.000	0.003	0.003	make_repeated_notes.py:5(make_repeated_notes)
1	0.001	0.001	0.003	0.003	make_notes.py:12(make_notes)
1	0.000	0.000	0.003	0.003	Staff.py:21(__init__)
1	0.000	0.000	0.003	0.003	_Context.py:11(__init__)
1	0.000	0.000	0.003	0.003	Container.py:23(__init__)
1	0.000	0.000	0.003	0.003	Container.py:271(_initialize_music)
2	0.000	0.000	0.002	0.001	all_are_thread_contiguous_components.py:9(all_are_
52	0.001	0.000	0.002	0.000	component_to_thread_signature.py:5(component_to_th
1	0.000	0.000	0.002	0.002	_construct_unprolated_notes.py:4(_construct_unprol

```

8      0.000      0.000      0.002      0.000 _construct_tied_note.py:5(_construct_tied_note)
8      0.000      0.000      0.002      0.000 _construct_tied_leaf.py:5(_construct_tied_leaf)

```

Function wraps the built-in Python `cProfile` module.

Set *expr* to any string of Abjad input.

Set *sort_by* to ‘*cum*’, ‘*time*’ or ‘*calls*’.

Set *num_lines* to any positive integer.

Set *strip_dirs* to `True` to strip directory names from output lines.

Note: This function fails on some Linux distros. Some Linux distributions do not include the Python `pstats` module.

Note: This function creates the file `_tmp_abj_profile` in the directory from which it is run.

Note: For information on reading the output of the different Python profilers, see [the Python docs](#).

Changed in version 2.0: renamed `check.profile()` to `iotools.profile_expr()`.

iotools.redo

`abjad.tools.iotools.redo(target=-1, lily_time=10)`

Rerender the last `.ly` file created in Abjad and then show the resulting PDF:

```
abjad> iotools.redo() # doctest: +SKIP
```

Rerender the next-to-last `.ly` file created in Abjad and then show the resulting PDF:

```
abjad> iotools.redo(-2) # doctest: +SKIP
```

Return `none`.

iotools.remove_abjad__pycache__directories

`abjad.tools.iotools.remove_abjad__pycache__directories()`

Remove `__pycache__` directories from Abjad source tree:

```
abjad> iotools.remove_abjad__pycache__directories() # doctest: +SKIP
```

Return `none`.

iotools.remove_abjad_pyc_files

`abjad.tools.iotools.remove_abjad_pyc_files()`

Remove `.pyc` files from Abjad source tree:

```
abjad> iotools.remove_abjad_pyc_files() # doctest: +SKIP
```

Return `none`.

iotools.save_last_ly_as

`abjad.tools.iotools.save_last_ly_as(file_name)`

New in version 2.0. Save last ly file as *file_name*:

```
abjad> iotools.save_last_ly_as('/project/output/example-1.ly') # doctest: +SKIP
```

Return none.

iotools.save_last_pdf_as

`abjad.tools.iotools.save_last_pdf_as(file_name)`

New in version 2.0. Save last PDF as *file_name*:

```
abjad> iotools.save_last_pdf_as('/project/output/example-1.pdf') # doctest: +SKIP
```

Return none.

iotools.show

`abjad.tools.iotools.show(expr, template=None, return_timing=False, suppress_pdf=False)`

Show *expr*:

```
abjad> note = Note("c'4")
abjad> show(note) # doctest: +SKIP
```

Show *expr* with *template*:

```
abjad> note = Note("c'4")
abjad> show(note, template = 'tangiers') # doctest: +SKIP
```

Show *expr* and return both Abjad and LilyPond processing time in seconds:

```
abjad> staff = Staff(Note("c'4") * 200)
abjad> show(note, return_timing = True) # doctest: +SKIP
(0, 3)
```

Return none or timing tuple.

Abjad writes LilyPond input files to the `~/ .abjad/output` directory by default.

You may change this by setting the `abjad_output` variable in the `config.py` file.

iotools.space_delimited_lowercase_to_uppercamelcase

`abjad.tools.iotools.space_delimited_lowercase_to_uppercamelcase(string)`

New in version 2.6. Change space-delimited lowercase *string* to uppercamelcase:

```
abjad> string = 'bass figure alignment positioning'
abjad> iotools.space_delimited_lowercase_to_uppercamelcase(string)
'BassFigureAlignmentPositioning'
```

Return string.

iotools.string_to_strict_directory_name

`abjad.tools.iotools.string_to_strict_directory_name(string)`

New in version 2.6. Change *string* to strict directory name:

```
abjad> iotools.string_to_strict_directory_name('Déja vu')
'deja_vu'
```

Strip accents from accented characters. Change all punctuation (including spaces) to underscore. Set to lower-case.

Return string.

iotools.strip_diacritics_from_binary_string

`abjad.tools.iotools.strip_diacritics_from_binary_string(binary_string)`

New in version 2.5. Strip diacritics from *binary_string*:

```
abjad> binary_string = 'Dvo\x5c5\x99\x3c3\xa1k'
```

```
abjad> print binary_string
Dvořák
```

```
abjad> iotools.strip_diacritics_from_binary_string(binary_string)
'Dvorak'
```

Return ASCII string.

iotools.underscore_delimited_lowercase_to_lowercamelcase

`abjad.tools.iotools.underscore_delimited_lowercase_to_lowercamelcase(string)`

New in version 2.0. Change underscore-delimited lowercase *string* to lowercamelcase:

```
abjad> string = 'bass_figure_alignment_positioning'
abjad> iotools.underscore_delimited_lowercase_to_lowercamelcase(string)
'bassFigureAlignmentPositioning'
```

Changed in version 2.0: renamed `stringtools.underscore_delimited_lowercase_to_lowercamelcase()` to `iotools.underscore_delimited_lowercase_to_lowercamelcase()`.

iotools.underscore_delimited_lowercase_to_uppercamelcase

`abjad.tools.iotools.underscore_delimited_lowercase_to_uppercamelcase(string)`

New in version 2.0. Change underscore-delimited lowercase *string* to uppercamelcase:

```
abjad> string = 'bass_figure_alignment_positioning'
abjad> iotools.underscore_delimited_lowercase_to_uppercamelcase(string)
'BassFigureAlignmentPositioning'
```

Changed in version 2.0: renamed `stringtools.underscore_delimited_lowercase_to_uppercamelcase()` to `iotools.underscore_delimited_lowercase_to_uppercamelcase()`.

iotools.uppercamelcase_to_space_delimited_lowercase

`abjad.tools.iotools.uppercamelcase_to_space_delimited_lowercase(string)`

New in version 2.6. Change uppercamelcase *string* to space-delimited lowercase:

```
abjad> string = 'KeySignatureMark'
```

```
abjad> iotools.uppercamelcase_to_space_delimited_lowercase(string)
'key signature mark'
```

Return string.

iotools.uppercamelcase_to_underscore_delimited_lowercase

`abjad.tools.iotools.uppercamelcase_to_underscore_delimited_lowercase(string)`

New in version 2.6. Change uppercamelcase *string* to underscore-delimited lowercase:

```
abjad> string = 'KeySignatureMark'
```

```
abjad> iotools.uppercamelcase_to_underscore_delimited_lowercase(string)
'key_signature_mark'
```

Return string.

iotools.write_expr_to_ly

`abjad.tools.iotools.write_expr_to_ly(expr, file_name, template=None, print_status=True, tagline=False)`

Write *expr* to *file_name*:

```
abjad> note = Note("c'4")
abjad> iotools.write_expr_to_ly(note, '/home/user/foo.ly') # doctest: +SKIP
```

Write *expr* to *file_name* with *template*:

```
abjad> note = Note("c'4")
abjad> iotools.write_expr_to_ly(note, '/home/user/foo.ly', 'paris') # doctest: +SKIP
```

Return none. Changed in version 2.0: renamed `io.write_ly()` to `io.write_expr_to_ly()`.

iotools.write_expr_to_ly_and_to_pdf_and_show

`abjad.tools.iotools.write_expr_to_ly_and_to_pdf_and_show(expr, name, template=None, write=True)`

Write *expr* to named `.ly` and to PDF and then open the resulting PDF:

```
abjad> iotools.write_expr_to_ly_and_to_pdf_and_show(Note("c'8"), 'file_name_stem') # doctest: +SKIP
```

Write *expr* to temporary `.ly` and to PDF and then open the resulting PDF:

```
abjad> iotools.write_expr_to_ly_and_to_pdf_and_show(Note("c'8"), 'file_name_stem', write = False)
```

Return none.

The purpose of this function is to save named `.ly` and PDF output. Changed in version 2.0: renamed `io.write_and_show()` to `io.write_expr_to_ly_and_to_pdf_and_show()`.

iotools.write_expr_to_pdf

`abjad.tools.iotools.write_expr_to_pdf(expr, file_name, template=None, print_status=True, tagline=False)`

Write *expr* to pdf *file_name*:

```
abjad> note = Note("c'4")
abjad> iotools.write_expr_to_pdf(note, 'one_note.pdf') # doctest: +SKIP
```

Write *expr* to pdf *file_name* with *template*:

```
abjad> note = Note("c'4")
abjad> iotools.write_expr_to_pdf(note, 'one_note.pdf', template='paris') # doctest: +SKIP
```

Return none.

layouttools

layouttools.SpacingIndication

class `abjad.tools.layouttools.SpacingIndication` (*tempo_indication*, *proportional_notation_duration*)
Bases: `abjad.core._StrictComparator`, `abjad.core._Immutable`, `abjad.core._StrictComparator`, `abjad.core._Immutable`, `abjad.core._Immutable`

Spacing indication token.

LilyPond `Score.proportionalNotationDuration` will equal `proportional_notation_duration` when `tempo` equals `tempo_indication`.

```
abjad> from abjad.tools import layouttools
```

```
abjad> tempo = contexttools.TempoMark(Duration(1, 8), 44)
abjad> spacing_indication = layouttools.SpacingIndication(tempo, Duration(1, 68))
abjad> spacing_indication
SpacingIndication(TempoMark(8, 44), 1/68)
```

Spacing indications are immutable.

normalized_spacing_duration

Read-only proportional notation duration at 60 MM.

proportional_notation_duration

LilyPond proportional notation duration context setting.

tempo_indication

Abjad tempo indication object.

layouttools.make_spacing_vector

`abjad.tools.layouttools.make_spacing_vector(basic_distance, minimum_distance, padding, stretchability)`

New in version 2.0. Make spacing vector:

```
abjad> from abjad.tools import layouttools
```

```
abjad> layouttools.make_spacing_vector(0, 0, 12, 0)
SchemeVector((basic_distance . 0), (minimum_distance . 0), (padding . 12), (stretchability . 0))
```

Use to set paper block spacing attributes:

```
abjad> staff = Staff("c'8 d'8 e'8 f'8")
abjad> lilypond_file = lilypondfiletools.make_basic_lilypond_file(staff)
abjad> lilypond_file.paper_block.system_system_spacing = layouttools.make_spacing_vector(0, 0, 1)

abjad> f(lilypond_file) # doctest: +SKIP
% Abjad revision 4229
% 2011-04-07 15:19

\version "2.13.44"
\include "english.ly"
\include "/abjad/trunk/abjad/cfg/abjad.scm"

\paper {
  system-system-spacing = #'((basic_distance . 0) (minimum_distance . 0) (padding . 12) (stretchable . 0))
}

\score {
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
}
```

Return scheme vector.

layouttools.set_line_breaks_cyclically_by_line_duration_ge

```
abjad.tools.layouttools.set_line_breaks_cyclically_by_line_duration_ge(expr,
                                                                    line_duration,
                                                                    klass=<class
                                                                    'ab-
                                                                    jad.tools.measuretools.Measure
                                                                    ad-
                                                                    just_eol=False,
                                                                    add_empty_bars=False)
```

Iterate *klass* instances in *expr* and accumulate prolated duration. Add line break after every total less than or equal to *line_duration*:

```
abjad> from abjad.tools import layouttools

abjad> t = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 4)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> f(t)
\new Staff {
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
    e'8
    f'8
  }
}
```

```

    }
    {
        \time 2/8
        g'8
        a'8
    }
    {
        \time 2/8
        b'8
        c''8
    }
}

abjad> layouttools.set_line_breaks_cyclically_by_line_duration_ge(t, Duration(4, 8))
abjad> f(t)
\new Staff {
    {
        \time 2/8
        c'8
        d'8
    }
    {
        \time 2/8
        e'8
        f'8
        \break
    }
    {
        \time 2/8
        g'8
        a'8
    }
    {
        \time 2/8
        b'8
        c''8
        \break
    }
}

```

Set `adjust_eol` to `True` to include a magic Scheme incantation to move end-of-line LilyPond TimeSignature and BarLine grobs to the right. Changed in version 2.0: renamed `layout.line_break_every_prolated()` to `layout.set_line_breaks_cyclically_by_line_duration_ge()`.

layouttools.set_line_breaks_cyclically_by_line_duration_in_seconds_ge

```

abjad.tools.layouttools.set_line_breaks_cyclically_by_line_duration_in_seconds_ge(expr,
    line_duration,
    klass=<class 'abjad.tools.layouttools.set_line_breaks_cyclically_by_line_duration_in_seconds_ge'>,
    adjust_eol=False,
    add_empty_line=False)

```

Iterate *klass* instances in *expr* and accumulate duration in seconds. Add line break after every total less than or equal to *line_duration*:


```

abjad> from abjad.tools import layouttools

abjad> t = Staff(Measure((2, 8), notetools.make_repeated_notes(2)) * 4)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(t)
abjad> tempo_mark = contexttools.TempoMark(Duration(1, 8), 44, target_context = Staff)(t)
abjad> f(t)
\new Staff {
  \tempo 8=44
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
    e'8
    f'8
  }
  {
    \time 2/8
    g'8
    a'8
  }
  {
    \time 2/8
    b'8
    c''8
  }
}

abjad> layouttools.set_line_breaks_cyclically_by_line_duration_in_seconds_ge(t, Duration(6))
abjad> f(t)
\new Staff {
  \tempo 8=44
  {
    \time 2/8
    c'8
    d'8
  }
  {
    \time 2/8
    e'8
    f'8
    \break
  }
  {
    \time 2/8
    g'8
    a'8
  }
  {
    \time 2/8
    b'8
    c''8
  }
}

```

Set `adjust_eol = True` to include a magic Scheme incantation to move

end-of-line LilyPond TimeSignature and BarLine grobs to the right. Changed in version 2.0: renamed `layout.line_break_every_seconds()` to `layout.set_line_breaks_cyclically_by_line_duration_in_seconds_ge()`.

mathtools

mathtools.are_relatively_prime

`abjad.tools.mathtools.are_relatively_prime(expr)`

New in version 2.5. True when *expr* is a sequence comprising zero or more numbers, all of which are relatively prime:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.are_relatively_prime([13, 14, 15])
True
```

Otherwise false:

```
abjad> mathtools.are_relatively_prime([13, 14, 15, 16])
False
```

Note that function returns true when *expr* is an empty sequence:

```
abjad> mathtools.are_relatively_prime([])
True
```

Function returns false when *expr* is nonsensical type:

```
abjad> mathtools.are_relatively_prime('foo')
False
```

Return boolean.

mathtools.arithmetic_mean

`abjad.tools.mathtools.arithmetic_mean(sequence)`

New in version 1.1. Arithmetic means of *sequence* as an exact integer:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.arithmetic_mean([1, 2, 2, 20, 30])
11
```

As a rational:

```
abjad> mathtools.arithmetic_mean([1, 2, 20])
Fraction(23, 3)
```

As a float:

```
abjad> mathtools.arithmetic_mean([2, 2, 20.0])
8.0
```

Return number. Changed in version 2.0: renamed `sequencetools.arithmetic_mean()` to `mathtools.arithmetic_mean()`.

mathtools.binomial_coefficient

abjad.tools.mathtools.**binomial_coefficient**(*n*, *k*)

New in version 2.0. Binomial coefficient of *n* choose *k*:

```

abjad> from abjad.tools import mathtools

abjad> for k in range(8):
...     print k, '\t', mathtools.binomial_coefficient(8, k)
...
0  1
1  8
2  28
3  56
4  70
5  56
6  28
7  8

```

Return positive integer.

mathtools.cumulative_products

abjad.tools.mathtools.**cumulative_products**(*sequence*)

Cumulative products of *sequence*:

```

abjad> from abjad.tools import mathtools

abjad> mathtools.cumulative_products([1, 2, 3, 4, 5, 6, 7, 8])
[1, 2, 6, 24, 120, 720, 5040, 40320]

abjad> mathtools.cumulative_products([1, -2, 3, -4, 5, -6, 7, -8])
[1, -2, -6, 24, 120, -720, -5040, 40320]

```

Raise type error when *sequence* is neither list nor tuple.

Raise value error on empty *sequence*.

Return list. Changed in version 2.0: renamed `sequencetools.cumulative_products()` to `mathtools.cumulative_products()`.

mathtools.cumulative_signed_weights

abjad.tools.mathtools.**cumulative_signed_weights**(*sequence*)

Cumulative signed weights of *sequence*:

```

abjad> from abjad.tools import mathtools

abjad> l = [1, -2, -3, 4, -5, -6, 7, -8, -9, 10]
abjad> mathtools.cumulative_signed_weights(l)
[1, -3, -6, 10, -15, -21, 28, -36, -45, 55]

```

Raise type error when *sequence* is not a list.

For cumulative (unsigned) weights use `mathtools.cumulative_sums([abs(x) for x in l])`.

Return list. Changed in version 2.0: renamed `sequencetools.cumulative_weights_signed()` to `mathtools.cumulative_signed_weights()`.

mathtools.cumulative_sums

`abjad.tools.mathtools.cumulative_sums(sequence)`

Cumulative sums of *sequence*:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.cumulative_sums([1, 2, 3, 4, 5, 6, 7, 8])
[1, 3, 6, 10, 15, 21, 28, 36]
```

Raise type error when *sequence* is neither list nor tuple.

Raise value error on empty *sequence*.

Return list. Changed in version 2.0: renamed `sequencetools.cumulative_sums()` to `mathtools.cumulative_sums()`.

mathtools.cumulative_sums_zero

`abjad.tools.mathtools.cumulative_sums_zero(sequence)`

Cumulative sums of *sequence* starting from 0:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.cumulative_sums_zero([1, 2, 3, 4, 5, 6, 7, 8])
[0, 1, 3, 6, 10, 15, 21, 28, 36]
```

Return `[0]` on empty *sequence*:

```
abjad> mathtools.cumulative_sums_zero([])
[0]
```

Return list. Changed in version 2.0: renamed `mathtools.cumulative_sums_zero()` to `mathtools.cumulative_sums_zero()`.

mathtools.cumulative_sums_zero_pairwise

`abjad.tools.mathtools.cumulative_sums_zero_pairwise(sequence)`

List pairwise cumulative sums of *sequence* from 0:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.cumulative_sums_zero_pairwise([1, 2, 3, 4, 5, 6])
[(0, 1), (1, 3), (3, 6), (6, 10), (10, 15), (15, 21)]
```

Return list of pairs. Changed in version 2.0: renamed `sequencetools.pairwise_cumulative_sums_zero()` to `mathtools.cumulative_sums_zero_pairwise()`.

mathtools.difference_series

`abjad.tools.mathtools.difference_series(sequence)`

Difference series of *sequence*:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.difference_series([1, 1, 2, 3, 5, 5, 6])
[0, 1, 1, 2, 0, 1]
```

Return list. Changed in version 2.0: renamed `sequencetools.difference_series()` to `mathtools.difference_series()`.

mathtools.divide_number_by_ratio

`abjad.tools.mathtools.divide_number_by_ratio(number, ratio)`

Divide integer by *ratio*:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.divide_number_by_ratio(1, [1, 1, 3])
[Fraction(1, 5), Fraction(1, 5), Fraction(3, 5)]
```

Divide fraction by *ratio*:

```
abjad> mathtools.divide_number_by_ratio(Fraction(1), [1, 1, 3])
[Fraction(1, 5), Fraction(1, 5), Fraction(3, 5)]
```

Divide float by *ratio*:

```
abjad> mathtools.divide_number_by_ratio(1.0, [1, 1, 3]) # doctest: +SKIP
[0.20000000000000001, 0.20000000000000001, 0.60000000000000009]
```

Raise type error on nonnumeric *number*.

Raise type error on noninteger in *ratio*.

Return list of fractions or list of floats. Changed in version 2.0: renamed `mathtools.divide_number_by_ratio()` to `mathtools.divide_number_by_ratio()`.

mathtools.divisors

`abjad.tools.mathtools.divisors(n)`

Positive divisors of integer *n* in increasing order:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.divisors(84)
[1, 2, 3, 4, 6, 7, 12, 14, 21, 28, 42, 84]
```

```
abjad> for x in range(10, 20):
...     print x, mathtools.divisors(x)
...
10 [1, 2, 5, 10]
11 [1, 11]
12 [1, 2, 3, 4, 6, 12]
13 [1, 13]
14 [1, 2, 7, 14]
15 [1, 3, 5, 15]
16 [1, 2, 4, 8, 16]
17 [1, 17]
18 [1, 2, 3, 6, 9, 18]
19 [1, 19]
```

Allow nonpositive *n*:

```
abjad> mathtools.divisors(-27)
[1, 3, 9, 27]
```

Raise type error on noninteger n .

Raise not implemented error on 0.

Return list of positive integers.

mathtools.factors

`abjad.tools.mathtools.factors(n)`
Integer factors of positive integer n in increasing order:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.factors(84)
[1, 2, 2, 3, 7]
```

```
abjad> for n in range(10, 20):
...     print n, mathtools.factors(n)
...
10 [1, 2, 5]
11 [1, 11]
12 [1, 2, 2, 3]
13 [1, 13]
14 [1, 2, 7]
15 [1, 3, 5]
16 [1, 2, 2, 2, 2]
17 [1, 17]
18 [1, 2, 3, 3]
19 [1, 19]
```

Raise type error on noninteger n .

Raise value error on nonpositive n .

Return list of one or more positive integers.

mathtools.get_shared_numeric_sign

`abjad.tools.mathtools.get_shared_numeric_sign($sequence$)`

Return 1 when all *sequence* elements are positive:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.get_shared_numeric_sign([1, 2, 3])
1
```

Return -1 when all *sequence* elements are negative:

```
abjad> mathtools.get_shared_numeric_sign([-1, -2, -3])
-1
```

Return 0 on empty *sequence*:

```
abjad> mathtools.get_shared_numeric_sign([])
0
```

Otherwise return none:

```
abjad> mathtools.get_shared_numeric_sign([1, 2, -3]) is None
True
```

Return 1, -1, 0 or none. Changed in version 2.0: renamed `sequencetools.sign()` to `mathtools.get_shared_numeric_sign()`.

mathtools.greatest_common_divisor

`abjad.tools.mathtools.greatest_common_divisor(*integers)`

New in version 2.0. Greatest common divisor of *integers*:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.greatest_common_divisor(84, -94, -144)
2
```

Allow nonpositive *integers*.

Raise type error on noninteger *integers*.

Raise not implemented error when 0 in *integers*.

Return positive integer.

mathtools.greatest_multiple_less_equal

`abjad.tools.mathtools.greatest_multiple_less_equal(m, n)`

Greatest integer multiple of *m* less than or equal to *n*:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.greatest_multiple_less_equal(10, 47)
40

abjad> for m in range(1, 10):
...     print m, mathtools.greatest_multiple_less_equal(m, 47)
...
1 47
2 46
3 45
4 44
5 45
6 42
7 42
8 40
9 45

abjad> for n in range(10, 100, 10):
...     print mathtools.greatest_multiple_less_equal(7, n), n
...
7 10
14 20
28 30
35 40
49 50
56 60
```

```
70 70
77 80
84 90
```

Raise type error on nonnumeric *m*.

Raise type error on nonnumeric *n*.

Return nonnegative integer.

mathtools.greatest_power_of_two_less_equal

`abjad.tools.mathtools.greatest_power_of_two_less_equal(n, i=0)`

Greatest integer power of two less than or equal to positive *n*:

```
abjad> from abjad.tools import mathtools
```

```
abjad> for n in range(10, 20):
...     print '\t%s\t%s' % (n, mathtools.greatest_power_of_two_less_equal(n))
...
    10 8
    11 8
    12 8
    13 8
    14 8
    15 8
    16 16
    17 16
    18 16
    19 16
```

Greatest-but-*i* integer power of 2 less than or equal to positive *n*:

```
abjad> for n in range(10, 20):
...     print '\t%s\t%s' % (n, mathtools.greatest_power_of_two_less_equal(n, i = 1))
...
    10 4
    11 4
    12 4
    13 4
    14 4
    15 4
    16 8
    17 8
    18 8
    19 8
```

Raise type error on nonnumeric *n*.

Raise value error on nonpositive *n*.

Return positive integer.

mathtools.integer_equivalent_number_to_integer

`abjad.tools.mathtools.integer_equivalent_number_to_integer(number)`

New in version 2.0. Integer-equivalent *number* to integer:


```
abjad> from abjad.tools import mathtools

abjad> mathtools.integer_equivalent_number_to_integer(17.0)
17
```

Return noninteger-equivalent number unchanged:

```
abjad> mathtools.integer_equivalent_number_to_integer(17.5)
17.5
```

Raise type error on nonnumber input.

Return number.

mathtools.integer_to_base_k_tuple

`abjad.tools.mathtools.integer_to_base_k_tuple(n, k)`
New in version 2.0. Nonnegative integer n to base- k tuple:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.integer_to_base_k_tuple(1066, 10)
(1, 0, 6, 6)
```

Return tuple of one or more positive integers.

mathtools.integer_to_binary_string

`abjad.tools.mathtools.integer_to_binary_string(n)`
Positive integer n to binary string:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.integer_to_binary_string(5)
'101'

abjad> for n in range(1, 17):
...     print '\t%s\t%s' % (n, mathtools.integer_to_binary_string(n))
...
1 1
2 10
3 11
4 100
5 101
6 110
7 111
8 1000
9 1001
10 1010
11 1011
12 1100
13 1101
14 1110
15 1111
16 10000
```

Return string. Changed in version 2.0: renamed `mathtools.binary_string()` to `mathtools.integer_to_binary_string()`.

mathtools.interpolate_cosine

`abjad.tools.mathtools.interpolate_cosine(y1, y2, mu)`

Cosine interpolate *y1* and *y2* with *mu* normalized [0, 1]:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.interpolate_cosine(0, 1, 0.5)
0.49999999999999994
```

Return float. Changed in version 2.0: renamed `interpolate.cosine()` to `mathtools.interpolate_cosine()`.

mathtools.interpolate_divide

`abjad.tools.mathtools.interpolate_divide(total, start_frac, stop_frac, exp='cosine')`

Divide *total* into segments of sizes computed from interpolating between *start_frac* and *stop_frac*:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.interpolate_divide(10, 1, 1, exp=1)
[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0]
abjad> sum(mathtools.interpolate_divide(10, 1, 1, exp=1))
10.0
```

```
abjad> mathtools.interpolate_divide(10, 5, 1) # doctest: +SKIP
[4.7986734489043181, 2.8792040693425909, 1.3263207210948171,
0.99580176065827419]
abjad> sum(mathtools.interpolate_divide(10, 5, 1))
10.0
```

Set `exp='cosine'` for cosine interpolation.

Set *exp* to a numeric value for exponential interpolation with *exp* as the exponent.

Scale resulting segments so that their sum equals exactly *total*.

Return a list of floats. Changed in version 2.0: renamed `interpolate.divide()` to `mathtools.interpolate_divide()`.

mathtools.interpolate_divide_multiple

`abjad.tools.mathtools.interpolate_divide_multiple(totals, key_values, exp='cosine')`

New in version 2.0. Interpolate *key_values* such that the sum of the resulting interpolated values equals the given *totals*:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.interpolate_divide_multiple([100, 50], [20, 10, 20]) # doctest: +SKIP
[19.4487, 18.5201, 16.2270, 13.7156, 11.7488, 10.4879,
9.8515, 9.5130, 10.4213, 13.0736, 16.9918]
```

The operation is the same as `mathtools.interpolate_divide()`. But this function takes multiple *totals* and *key_values* at once.

Precondition: `len(totals) == len(key_values) - 1`.

Set *totals* equal to a list or tuple of the total sum of interpolated values.

Set *key_values* equal a list or tuple of key values to interpolate.

Set *exp* to *consine* for consine interpolation.

Set *exp* to a number for exponential interpolation.

Returns a list of floats. Changed in version 2.0: renamed `interpolate.divide_multiple()` to `mathtools.interpolate_divide_multiple()`.

mathtools.interpolate_exponential

`abjad.tools.mathtools.interpolate_exponential(y1, y2, mu, exp=1)`

Exponential interpolate *y1* and *y2* with *mu* normalized [0, 1]:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.interpolate_exponential(0, 1, 0.5, 4)
0.0625
```

Set *exp* equal to the exponent of interpolation.

Return float. Changed in version 2.0: renamed `interpolate.exponential()` to `mathtools.interpolate_exponential()`.

mathtools.interpolate_linear

`abjad.tools.mathtools.interpolate_linear(y1, y2, mu)`

Linear interpolate *y1* and *y2* with *mu* normalized [0, 1]:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.interpolate_linear(0, 1, 0.5)
0.5
```

Return float. Changed in version 2.0: renamed `interpolate.linear()` to `mathtools.interpolate_linear()`.

mathtools.is_assignable_integer

`abjad.tools.mathtools.is_assignable_integer(expr)`

New in version 2.0. True when *expr* is equivalent to an integer and can be written without recourse to ties:

```
abjad> from abjad.tools import mathtools
```

```
abjad> for n in range(0, 16 + 1):
...     print '%s\t%s' % (n, mathtools.is_assignable_integer(n))
...
0 False
1 True
2 True
3 True
4 True
5 False
6 True
7 True
8 True
9 False
```

```

10 False
11 False
12 True
13 False
14 True
15 True
16 True

```

Otherwise false.

Return boolean. Changed in version 2.0: renamed `mathtools.is_assignable()` to `mathtools.is_assignable_integer()`.

mathtools.is_dotted_integer

`abjad.tools.mathtools.is_dotted_integer(expr)`

New in version 2.0. True when *expr* is equivalent to a positive integer and can be written with zero or more dots:

```

abjad> from abjad.tools import mathtools

abjad> for expr in range(16):
...     print '%s      %s' % (expr, mathtools.is_dotted_integer(expr))
...
0          False
1          False
2          False
3          True
4          False
5          False
6          True
7          True
8          False
9          False
10         False
11         False
12         True
13         False
14         True
15         True

```

Otherwise false.

Return boolean.

Integer *n* qualifies as dotted when `abs(n)` is of the form `2**j * (2**k - 1)` with integers `0 <= j, 2 < k`.

mathtools.is_integer_equivalent_expr

`abjad.tools.mathtools.is_integer_equivalent_expr(expr)`

New in version 2.5. True when *expr* is an integer-equivalent number:

```

abjad> from abjad.tools import mathtools

abjad> mathtools.is_integer_equivalent_expr(12.0)
True

```

True when *expr* evaluates to an integer:

```
abjad> mathtools.is_integer_equivalent_expr('12')
True
```

Otherwise false:

```
abjad> mathtools.is_integer_equivalent_expr('foo')
False
```

Return boolean.

mathtools.is_integer_equivalent_number

`abjad.tools.mathtools.is_integer_equivalent_number(expr)`

New in version 2.0. True when *expr* is a number and *expr* is equivalent to an integer:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.is_integer_equivalent_number(12.0)
True
```

Otherwise false:

```
abjad> mathtools.is_integer_equivalent_number(Duration(1, 2))
False
```

Return boolean.

mathtools.is_negative_integer

`abjad.tools.mathtools.is_negative_integer(expr)`

New in version 2.0. True when *expr* equals a negative integer:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.is_negative_integer(-1)
True
```

Otherwise false:

```
abjad> mathtools.is_negative_integer(0)
False
```

```
abjad> mathtools.is_negative_integer(99)
False
```

Return boolean.

mathtools.is_nonnegative_integer

`abjad.tools.mathtools.is_nonnegative_integer(expr)`

New in version 2.0. True when *expr* equals a nonnegative integer:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.is_nonnegative_integer(99)
True
```

```
abjad> mathtools.is_nonnegative_integer(0)
True
```

Otherwise false:

```
abjad> mathtools.is_nonnegative_integer(-1)
False
```

Return boolean.

mathtools.is_nonnegative_integer_equivalent_number

`abjad.tools.mathtools.is_nonnegative_integer_equivalent_number(expr)`
 New in version 2.0. True when *expr* is a nonnegative integer-equivalent number. Otherwise false:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.is_nonnegative_integer_equivalent_number(Duration(4, 2))
True
```

Return boolean.

mathtools.is_nonnegative_integer_power_of_two

`abjad.tools.mathtools.is_nonnegative_integer_power_of_two(expr)`
 True when *expr* is a nonnegative integer power of 2:

```
abjad> from abjad.tools import mathtools
```

```
abjad> for n in range(10):
...     print n, mathtools.is_nonnegative_integer_power_of_two(n)
...
0 True
1 True
2 True
3 False
4 True
5 False
6 False
7 False
8 True
9 False
```

Otherwise false.

Return boolean. Changed in version 2.0: renamed `mathtools.is_power_of_two()` to `mathtools.is_nonnegative_integer_power_of_two()`.

mathtools.is_positive_integer

`abjad.tools.mathtools.is_positive_integer(expr)`
 New in version 2.0. True when *expr* equals a positive integer:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.is_positive_integer(99)
True
```

Otherwise false:

```
abjad> mathtools.is_positive_integer(0)
False
```

```
abjad> mathtools.is_positive_integer(-1)
False
```

Return boolean.

mathtools.is_positive_integer_equivalent_number

`abjad.tools.mathtools.is_positive_integer_equivalent_number(expr)`

New in version 2.0. True when *expr* is a positive integer-equivalent number. Otherwise false:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.is_positive_integer_equivalent_number(Duration(4, 2))
True
```

Return boolean.

mathtools.is_positive_integer_power_of_two

`abjad.tools.mathtools.is_positive_integer_power_of_two(expr)`

True when *expr* is a positive integer power of 2:

```
abjad> from abjad.tools import mathtools
```

```
abjad> for n in range(10):
...     print n, mathtools.is_positive_integer_power_of_two(n)
...
0 False
1 True
2 True
3 False
4 True
5 False
6 False
7 False
8 True
9 False
```

Otherwise false.

Return boolean.

mathtools.least_common_multiple

`abjad.tools.mathtools.least_common_multiple(*integers)`

Least common multiple of positive *integers*:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.least_common_multiple(2, 4, 5, 10, 20)
20
```

Return positive integer.

mathtools.least_multiple_greater_equal

abjad.tools.mathtools.least_multiple_greater_equal (*m*, *n*)

Return the least integer multiple of *m* greater than or equal to *n*.

```
abjad> from abjad.tools import mathtools

abjad> mathtools.least_multiple_greater_equal(10, 47)
50

abjad> for m in range(1, 10):
...     print m, mathtools.least_multiple_greater_equal(m, 47)
...
1 47
2 48
3 48
4 48
5 50
6 48
7 49
8 48
9 54

abjad> for n in range(10, 100, 10):
...     print mathtools.least_multiple_greater_equal(7, n), n
...
14 10
21 20
35 30
42 40
56 50
63 60
70 70
84 80
91 90
```

Return integer.

mathtools.least_power_of_two_greater_equal

abjad.tools.mathtools.least_power_of_two_greater_equal (*n*, *i=0*)

Return least integer power of two greater than or equal to positive *n*:

```
abjad> from abjad.tools import mathtools

abjad> for n in range(10, 20):
...     print '\t%s\t%s' % (n, mathtools.least_power_of_two_greater_equal(n))
...
    10 16
```



```

11 16
12 16
13 16
14 16
15 16
16 16
17 32
18 32
19 32

```

When $i = 1$, return the first integer power of 2 greater than the least integer power of 2 greater than or equal to n .

```

abjad> for n in range(10, 20):
...     print '\t%s\t%s' % (n, mathtools.least_power_of_two_greater_equal(n, i = 1))
...
10 32
11 32
12 32
13 32
14 32
15 32
16 32
17 64
18 64
19 64

```

When $i = 2$, return the second integer power of 2 greater than the least integer power of 2 greater than or equal to n , and, in general, return the i th integer power of 2 greater than the least integer power of 2 greater than or equal to n .

Raise type error on nonnumeric n .

Raise value error on nonpositive n .

Return integer.

mathtools.next_integer_partition

`abjad.tools.mathtools.next_integer_partition(integer_partition)`

New in version 2.0. Next integer partition following *integer_partition* in descending lex order:

```

abjad> from abjad.tools import mathtools

abjad> mathtools.next_integer_partition((8, 3))
(8, 2, 1)

abjad> mathtools.next_integer_partition((8, 2, 1))
(8, 1, 1, 1)

abjad> mathtools.next_integer_partition((8, 1, 1, 1))
(7, 4)

```

Input *integer_partition* must be sequence of positive integers.

Return integer partition as tuple of positive integers.

mathtools.partition_integer_by_ratio

`abjad.tools.mathtools.partition_integer_by_ratio(n, ratio)`

Partition positive integer-equivalent n by $ratio$:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.partition_integer_by_ratio(10, [1, 2])
[3, 7]
```

Partition positive integer-equivalent n by $ratio$ with negative parts:

```
abjad> mathtools.partition_integer_by_ratio(10, [1, -2])
[3, -7]
```

Partition negative integer-equivalent n by $ratio$:

```
abjad> mathtools.partition_integer_by_ratio(-10, [1, 2])
[-3, -7]
```

Partition negative integer-equivalent n by $ratio$ with negative parts:

```
abjad> mathtools.partition_integer_by_ratio(-10, [1, -2])
[-3, 7]
```

Return result with weight equal to absolute value of n .

Raise type error on noninteger n .

Return list of integers.

mathtools.partition_integer_into_canonic_parts

`abjad.tools.mathtools.partition_integer_into_canonic_parts(n, direction='big-endian')`

Partition integer n into big-endian or small-endian parts.

Return all parts positive on positive n :

```
abjad> from abjad.tools import mathtools
```

```
abjad> for n in range(1, 11):
...     print n, mathtools.partition_integer_into_canonic_parts(n)
...
1 (1,)
2 (2,)
3 (3,)
4 (4,)
5 (4, 1)
6 (6,)
7 (7,)
8 (8,)
9 (8, 1)
10 (8, 2)
```

Return all parts negative on negative n :

```
abjad> for n in reversed(range(-20, -10)):
...     print n, mathtools.partition_integer_into_canonic_parts(n)
...
```

```
-11 (-8, -3)
-12 (-12,)
-13 (-12, -1)
-14 (-14,)
-15 (-15,)
-16 (-16,)
-17 (-16, -1)
-18 (-16, -2)
-19 (-16, -3)
-20 (-16, -4)
```

Return little-endian tuple When `direction = 'little-endian'`:

```
abjad> for n in range(11, 21):
...     print n, mathtools.partition_integer_into_canonic_parts(n, direction = 'little-endian')
...
11 (3, 8)
12 (12,)
13 (1, 12)
14 (14,)
15 (15,)
16 (16,)
17 (1, 16)
18 (2, 16)
19 (3, 16)
20 (4, 16)
```

Return big-endian tuple $t = (t_0, \dots, t_j)$ such that

- $\text{sum}(t) == n$
- t_i can be written without recourse to ties, and
- $t_{(i + 1)} < t_i$ for every t_i in t .

Raise type error on noninteger n .

Return tuple of one or more integers.

mathtools.partition_integer_into_halves

`abjad.tools.mathtools.partition_integer_into_halves` (n , *bigger*='left', *even*='allowed')

Write positive integer n as the pair $t = (\text{left}, \text{right})$ such that $n == \text{left} + \text{right}$.

When n is odd the greater part of t corresponds to the value of *bigger*:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.partition_integer_into_halves(7, bigger = 'left')
(4, 3)
abjad> mathtools.partition_integer_into_halves(7, bigger = 'right')
(3, 4)
```

Likewise when n is even and *even* = 'disallowed':

```
abjad> mathtools.partition_integer_into_halves(8, bigger = 'left', even = 'disallowed')
(5, 3)
abjad> mathtools.partition_integer_into_halves(8, bigger = 'right', even = 'disallowed')
(3, 5)
```

But when n is even and `even = 'allowed'` then `left == right` and *bigger* is ignored:

```
abjad> mathtools.partition_integer_into_halves(8)
(4, 4)
abjad> mathtools.partition_integer_into_halves(8, bigger = 'left')
(4, 4)
abjad> mathtools.partition_integer_into_halves(8, bigger = 'right')
(4, 4)
```

When n is 0 return (0, 0):

```
abjad> mathtools.partition_integer_into_halves(0)
(0, 0)
```

When n is 0 and `even = 'disallowed'` raise partition error.

Raise type error on noninteger n .

Raise value error on negative n .

Return pair of positive integers.

mathtools.partition_integer_into_thirds

`abjad.tools.mathtools.partition_integer_into_thirds`(n , *smallest='middle'*, *biggest='middle'*)

Partition positive integer n into left, middle, right parts.

When $n \% 3 == 0$, `left == middle == right`:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.partition_integer_into_thirds(9)
(3, 3, 3)
```

When $n \% 3 == 1$, set biggest part to *biggest*:

```
abjad> mathtools.partition_integer_into_thirds(10, biggest = 'left')
(4, 3, 3)
abjad> mathtools.partition_integer_into_thirds(10, biggest = 'middle')
(3, 4, 3)
abjad> mathtools.partition_integer_into_thirds(10, biggest = 'right')
(3, 3, 4)
```

When $n \% 3 == 2$, set smallest part to *smallest*:

```
abjad> mathtools.partition_integer_into_thirds(11, smallest = 'left')
(3, 4, 4)
abjad> mathtools.partition_integer_into_thirds(11, smallest = 'middle')
(4, 3, 4)
abjad> mathtools.partition_integer_into_thirds(11, smallest = 'right')
(4, 4, 3)
```

Raise type error on noninteger n .

Raise value error on nonpositive n .

Return triple of positive integers.

mathtools.partition_integer_into_units

abjad.tools.mathtools.**partition_integer_into_units**(*n*)

Partition positive integer into units:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.partition_integer_into_units(6)
[1, 1, 1, 1, 1, 1]
```

Partition negative integer into units:

```
abjad> mathtools.partition_integer_into_units(-5)
[-1, -1, -1, -1, -1]
```

Partition 0 into units:

```
abjad> mathtools.partition_integer_into_units(0)
[]
```

Return list of zero or more parts with absolute value equal to 1.

mathtools.remove_powers_of_two

abjad.tools.mathtools.**remove_powers_of_two**(*n*)

Remove powers of 2 from the factors of positive integer *n*:

```
abjad> from abjad.tools import mathtools
```

```
abjad> for n in range(10, 100, 10):
...     print '\t%s\t%s' % (n, mathtools.remove_powers_of_two(n))
...
    10 5
    20 5
    30 15
    40 5
    50 25
    60 15
    70 35
    80 5
    90 45
```

Raise type error on noninteger *n*.

Raise value error on nonpositive *n*.

Return positive integer.

mathtools.sign

abjad.tools.mathtools.**sign**(*n*)

Return -1 on negative *n*:

```
abjad> from abjad.tools import mathtools
```

```
abjad> mathtools.sign(-96.2)
-1
```

Return 0 when n is 0:

```
abjad> mathtools.sign(0)
0
```

Return 1 on positive n :

```
abjad> mathtools.sign(Duration(9, 8))
1
```

Return -1, 0 or 1.

mathtools.weight

`abjad.tools.mathtools.weight(sequence, start=0)`

Sum of the absolute value of the elements in *sequence*:

```
abjad> from abjad.tools import mathtools

abjad> mathtools.weight([-1, -2, 3, 4, 5])
15
```

Absolute value of *start*:

```
abjad> mathtools.weight([])
0
```

Return nonnegative integer. Changed in version 2.0: renamed `sequencetools.weight()` to `mathtools.weight()`.

mathtools.yield_all_compositions_of_integer

`abjad.tools.mathtools.yield_all_compositions_of_integer(n)`

New in version 2.0. Yield all compositions of positive integer n in descending lex order:

```
abjad> from abjad.tools import mathtools

abjad> for integer_composition in mathtools.yield_all_compositions_of_integer(5):
...     integer_composition
...
(5,)
(4, 1)
(3, 2)
(3, 1, 1)
(2, 3)
(2, 2, 1)
(2, 1, 2)
(2, 1, 1, 1)
(1, 4)
(1, 3, 1)
(1, 2, 2)
(1, 2, 1, 1)
(1, 1, 3)
(1, 1, 2, 1)
(1, 1, 1, 2)
(1, 1, 1, 1, 1)
```

Integer compositions are ordered integer partitions.

Return generator of positive integer tuples of length at least 1. Changed in version 2.0: renamed `mathtools.integer_compositions()` to `mathtools.yield_all_compositions_of_integer()`.

mathtools.yield_all_partitions_of_integer

`abjad.tools.mathtools.yield_all_partitions_of_integer(n)`

New in version 2.0. Yield all partitions of positive integer n in descending lex order:

```
abjad> from abjad.tools import mathtools
```

```
abjad> for partition in mathtools.yield_all_partitions_of_integer(7):
...     partition
...
(7,)
(6, 1)
(5, 2)
(5, 1, 1)
(4, 3)
(4, 2, 1)
(4, 1, 1, 1)
(3, 3, 1)
(3, 2, 2)
(3, 2, 1, 1)
(3, 1, 1, 1, 1)
(2, 2, 2, 1)
(2, 2, 1, 1, 1)
(2, 1, 1, 1, 1, 1)
(1, 1, 1, 1, 1, 1, 1)
```

Return generator of positive integer tuples of length at least 1. Changed in version 2.0: renamed `mathtools.integer_partitions()` to `mathtools.yield_all_partitions_of_integer()`.

`pitcharraytools`

pitcharraytools.PitchArray

class `abjad.tools.pitcharraytools.PitchArray(*args)`

Bases: `abjad.core._StrictComparator._StrictComparator._StrictComparator` New in version 2.0. Two-dimensional array of pitches.

append_column(*column*)

append_row(*row*)

apply_pitches_by_row(*pitch_lists*)

cell_tokens_by_row

cell_widths_by_row

cells

columns

copy_subarray(*upper_left_pair*, *lower_right_pair*)

```

depth
dimensions
has_spanning_cell_over_index(index)
has_voice_crossing
is_rectangular
pad_to_depth(depth)
pad_to_width(width)
pitches
pitches_by_row
pop_column(column_index)
pop_row(row_index=-1)
remove_row(row)
rows
size
voice_crossing_count
weight
width

```

pitcharraytools.PitchArrayCell

```

class abjad.tools.pitcharraytools.PitchArrayCell(cell_token=None)
    Bases: abjad.core._StrictComparator._StrictComparator._StrictComparator

```

One cell in a pitch array.

```

abjad> from abjad.tools import pitcharraytools

abjad> array = pitcharraytools.PitchArray([[1, 2, 1], [2, 1, 1]])
abjad> print array
[ ] [   ] [ ]
[   ] [ ] [ ]
abjad> cell = array[0][1]
abjad> cell
PitchArrayCell(x2)

abjad> cell.column_indices
(1, 2)

abjad> cell.indices
(0, (1, 2))

abjad> cell.is_first_in_row
False

abjad> cell.is_last_in_row
False

```



```
abjad> cell.next
PitchArrayCell(x1)

abjad> cell.parent_array
PitchArray(PitchArrayRow(x1, x2, x1), PitchArrayRow(x2, x1, x1))

abjad> cell.parent_column
PitchArrayColumn(x2, x2)

abjad> cell.parent_row
PitchArrayRow(x1, x2, x1)

abjad> cell.pitches
[]

abjad> cell.prev
PitchArrayCell(x1)

abjad> cell.row_index
0

abjad> cell.token
2

abjad> cell.width
2
```

Return pitch array cell.

column_indices

Read-only tuple of one or more nonnegative integer indices.

indices

is_first_in_row

is_last_in_row

matches_cell (*arg*)

next

parent_array

parent_column

parent_row

pitches

prev

row_index

token

weight

width

pitcharraytools.PitchArrayColumn

class abjad.tools.pitcharraytools.**PitchArrayColumn**(*cells*)
 Bases: abjad.core._StrictComparator._StrictComparator._StrictComparator New in version 2.0. Column in a pitch array:

```
abjad> from abjad.tools import pitcharraytools
```

```
abjad> array = pitcharraytools.PitchArray([
...     [1, (2, 1), (-1.5, 2)],
...     [(7, 2), (6, 1), 1]])
```

```
abjad> print array
[ ] [d'] [bqf ]
[g'     ] [fs'] [ ]
```

```
abjad> array.columns[0]
PitchArrayColumn(x1, g' x2)
```

```
abjad> print array.columns[0]
[ ]
[g'     ]
```

Return pitch array column.

append(*cell*)

cell_tokens

cell_widths

cells

column_index

depth

dimensions

extend(*cells*)

has_voice_crossing

is_defective

parent_array

pitches

remove_pitches()

start_cells

start_pitches

stop_cells

stop_pitches

weight

width

pitcharraytools.PitchArrayRow

class abjad.tools.pitcharraytools.**PitchArrayRow**(*cells*)
 Bases: abjad.core._StrictComparator._StrictComparator._StrictComparator New in version 2.0. One row in pitch array.

```
abjad> from abjad.tools import pitcharraytools

abjad> array = pitcharraytools.PitchArray([[1, 2, 1], [2, 1, 1]])
abjad> array[0].cells[0].pitches.append(0)
abjad> array[0].cells[1].pitches.append(2)
abjad> array[1].cells[2].pitches.append(4)
abjad> print array
[c'] [d'   ] [  ]
[      ] [  ] [e']

abjad> array[0]
PitchArrayRow(c', d' x2, x1)

abjad> array[0].cell_widths
(1, 2, 1)

abjad> array[0].dimensions
(1, 4)

abjad> array[0].pitches
(NamedChromaticPitch("c'"), NamedChromaticPitch("d'"))
```

Return pitch array row.

append(*cell_token*)
apply_pitches(*pitch_tokens*)
cell_tokens
cell_widths
cells
copy_subrow(*start=None, stop=None*)
depth
dimensions
empty_pitches()
extend(*cell_tokens*)
has_spanning_cell_over_index(*i*)
index(*cell*)
is_defective
is_in_range
merge(*cells*)
pad_to_width(*width*)
parent_array
pitch_range

pitches
pop (*cell_index*)
remove (*cell*)
row_index
weight
width
withdraw ()

pitcharraytools.all_are_pitch_arrays

`abjad.tools.pitcharraytools.all_are_pitch_arrays(expr)`

New in version 2.6. True when *expr* is a sequence of Abjad pitch arrays:

```

abjad> from abjad.tools import pitcharraytools

abjad> pitch_array = pitcharraytools.PitchArray([[1, 2, 1], [2, 1, 1]])

abjad> pitcharraytools.all_are_pitch_arrays([pitch_array])
True

```

True when *expr* is an empty sequence:

```

abjad> pitcharraytools.all_are_pitch_arrays([])
True

```

Otherwise false:

```

abjad> pitcharraytools.all_are_pitch_arrays('foo')
False

```

Return boolean.

pitcharraytools.concatenate_pitch_arrays

`abjad.tools.pitcharraytools.concatenate_pitch_arrays(pitch_arrays)`

New in version 2.0. Concatenate *pitch_arrays*:

```

abjad> from abjad.tools import pitcharraytools

abjad> array_1 = pitcharraytools.PitchArray([[1, 2, 1], [2, 1, 1]])
abjad> print array_1
[ ] [   ] [ ]
[   ] [ ] [ ]

abjad> array_2 = pitcharraytools.PitchArray([[3, 4], [4, 3]])
abjad> print array_2
[   ] [   ]
[   ] [   ]

abjad> array_3 = pitcharraytools.PitchArray([[1, 1], [1, 1]])
abjad> print array_3
[ ] [ ]
[ ] [ ]

```

```

abjad> merged_array = pitcharraytools.concatenate_pitch_arrays([array_1, array_2, array_3])
abjad> print merged_array
[ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

```

Return pitch array.

`pitcharraytools.list_nonspanning_subarrays_of_pitch_array`

`abjad.tools.pitcharraytools.list_nonspanning_subarrays_of_pitch_array` (*pitch_array*)

New in version 2.0. List nonspanning subarrays of *pitch_array*:

```

abjad> from abjad.tools import pitcharraytools

abjad> array = pitcharraytools.PitchArray([
...     [2, 2, 3, 1],
...     [1, 2, 1, 1, 2, 1],
...     [1, 1, 1, 1, 1, 1, 1, 1]])
abjad> print array
[ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

abjad> subarrays = pitcharraytools.list_nonspanning_subarrays_of_pitch_array(array)
abjad> len(subarrays)
3

abjad> print subarrays[0]
[ ] [ ] [ ]
[ ] [ ] [ ]
[ ] [ ] [ ]

abjad> print subarrays[1]
[ ] [ ]
[ ] [ ]
[ ] [ ]

abjad> print subarrays[2]
[ ]
[ ]
[ ]

```

Return list.

`pitcharraytools.make_empty_pitch_array_from_list_of_pitch_lists`

`abjad.tools.pitcharraytools.make_empty_pitch_array_from_list_of_pitch_lists` (*leaf_iterables*)

New in version 2.0. Make empty pitch array from *leaf_iterables*:

```

abjad> from abjad.tools import pitcharraytools

abjad> score = Score([])
abjad> score.append(Staff("c'8 d'8 e'8 f'8"))
abjad> score.append(Staff("c'4 d'4"))
abjad> score.append(Staff(tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8") * 2))
abjad> f(score)

```

```
\new Score <<
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
  \new Staff {
    c'4
    d'4
  }
  \new Staff {
    \times 2/3 {
      c'8
      d'8
      e'8
    }
    \times 2/3 {
      c'8
      d'8
      e'8
    }
  }
>>

abjad> array = pitcharraytools.make_empty_pitch_array_from_list_of_pitch_lists(score)
abjad> print array
[      ] [      ] [      ] [      ]
[      ] [      ] [      ] [      ]
[ ] [      ] [ ] [ ] [      ] [ ]
```

Return pitch array.

pitcharraytools.make_populated_pitch_array_from_list_of_pitch_lists

`abjad.tools.pitcharraytools.make_populated_pitch_array_from_list_of_pitch_lists` (*leaf_iterables*)
New in version 2.0. Make populated pitch array from *leaf_iterables*:

```
abjad> from abjad.tools import pitcharraytools

abjad> score = Score([])
abjad> score.append(Staff("c'8 d'8 e'8 f'8"))
abjad> score.append(Staff("c'4 d'4"))
abjad> score.append(Staff(tuplettools.FixedDurationTuplet(Duration(2, 8), "c'8 d'8 e'8") * 2))
abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8
    e'8
    f'8
  }
  \new Staff {
    c'4
    d'4
  }
  \new Staff {
```

```

        \times 2/3 {
            c'8
            d'8
            e'8
        }
        \times 2/3 {
            c'8
            d'8
            e'8
        }
    }
>>

abjad> array = pitcharraytools.make_populated_pitch_array_from_list_of_pitch_lists(score)
abjad> print array
[c'      ] [d'      ] [e'      ] [f'      ]
[c'      ] [d'      ] [e'      ] [f'      ]
[c'] [d'      ] [e'] [c'] [d'      ] [e']

```

Return pitch array.

sequencetools

sequencetools.CyclicList

class abjad.tools.sequencetools.**CyclicList**

Bases: list New in version 2.0. Abjad model of cyclic list:

```

abjad> from abjad.tools import sequencetools

abjad> cyclic_list = sequencetools.CyclicList('abcd')

abjad> cyclic_list
CyclicList([a, b, c, d])

abjad> for x in range(8):
...     print x, cyclic_list[x]
...
0 a
1 b
2 c
3 d
4 a
5 b
6 c
7 d

```

Cyclic lists overload the item-getting method of built-in lists.

Cyclic lists return a value for any integer index.

Cyclic lists otherwise behave exactly like built-in lists.

sequencetools.CyclicMatrix

class abjad.tools.sequencetools.**CyclicMatrix**(*args, **kwargs)

Bases: abjad.tools.sequencetools.Matrix.Matrix New in version 2.0. Abjad model of cyclic matrix.

Initialize from rows:

```
abjad> from abjad.tools import sequencetools

abjad> cyclic_matrix = sequencetools.CyclicMatrix([[0, 1, 2, 3], [10, 11, 12, 13], [20, 21, 22, 23]])

abjad> cyclic_matrix
CyclicMatrix(3x4)

abjad> cyclic_matrix[2]
CyclicTuple([20, 21, 22, 23])

abjad> cyclic_matrix[2][2]
22

abjad> cyclic_matrix[99]
CyclicTuple([0, 1, 2, 3])

abjad> cyclic_matrix[99][99]
3
```

Initialize from columns:

```
abjad> cyclic_matrix = sequencetools.CyclicMatrix(columns = [[0, 10, 20], [1, 11, 21], [2, 12, 22], [3, 13, 23]])

abjad> cyclic_matrix
CyclicMatrix(3x4)

abjad> cyclic_matrix[2]
CyclicTuple([20, 21, 22, 23])

abjad> cyclic_matrix[2][2]
22

abjad> cyclic_matrix[99]
CyclicTuple([0, 1, 2, 3])

abjad> cyclic_matrix[99][99]
3
```

CyclicMatrix implements only item retrieval in this revision.

Concatenation and division remain to be implemented.

Standard transforms of linear algebra remain to be implemented.

columns

Read-only columns:

```
abjad> cyclic_matrix = sequencetools.CyclicMatrix([[0, 1, 2, 3], [10, 11, 12, 13], [20, 21, 22, 23]])

abjad> cyclic_matrix.columns
CyclicTuple([[0, 10, 20], [1, 11, 21], [2, 12, 22], [3, 13, 23]])
```

Return cyclic tuple.

rows

Read-only rows:


```

abjad> cyclic_matrix = sequencetools.CyclicMatrix([[0, 1, 2, 3], [10, 11, 12, 13], [20, 21,
abjad> cyclic_matrix.rows
CyclicTuple([[0, 1, 2, 3], [10, 11, 12, 13], [20, 21, 22, 23]])

```

Return cyclic tuple.

sequencetools.CyclicTree

class `abjad.tools.sequencetools.CyclicTree(expr)`

Bases: `abjad.tools.sequencetools.Tree.Tree` New in version 2.5. Like `Tree` but with cyclic s Abjad data structure to work with a sequence whose elements have been grouped into arbitrarily many levels of **cyclic** containment.

Exactly like the `Tree` class but with the additional affordance that all integer indices of any size work at every level of structure; like `CyclicTuple`, `CyclicList` and `CyclicMatrix`, no index errors raises in working with objects of this class.

```

abjad> from abjad.tools import sequencetools

```

Here is a cyclic tree:

```

abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> cyclic_tree = sequencetools.CyclicTree(sequence)

abjad> cyclic_tree
CyclicTree([[0, 1], [2, 3], [4, 5], [6, 7]])

```

Here's an internal node:

```

abjad> cyclic_tree[2]
CyclicTree([4, 5])

```

Here's the same node indexed with a different way:

```

abjad> cyclic_tree[2]
CyclicTree([4, 5])

```

With a negative index:

```

abjad> cyclic_tree[-2]
CyclicTree([4, 5])

```

And another negative index:

```

abjad> cyclic_tree[-6]
CyclicTree([4, 5])

```

Here's a leaf node:

```

abjad> cyclic_tree[2][0]
CyclicTree(4)

```

And here's the same node indexed a different way:

```

abjad> cyclic_tree[2][20]
CyclicTree(4)

```

All other interface attributes function as in `Tree`.

sequencetools.CyclicTuple

class abjad.tools.sequencetools.**CyclicTuple**

Bases: tuple New in version 2.0. Abjad model of cyclic tuple:

```
abjad> from abjad.tools import sequencetools

abjad> cyclic_tuple = sequencetools.CyclicTuple('abcd')

abjad> cyclic_tuple
CyclicTuple([a, b, c, d])

abjad> for x in range(8):
...     print x, cyclic_tuple[x]
...
0 a
1 b
2 c
3 d
4 a
5 b
6 c
7 d
```

Cyclic tuples overload the item-getting method of built-in tuples.

Cyclic tuples return a value for any integer index.

Cyclic tuples otherwise behave exactly like built-in tuples.

sequencetools.Matrix

class abjad.tools.sequencetools.**Matrix**(*args, **kwargs)

Bases: object New in version 2.0. Abjad model of matrix.

Initialize from rows:

```
abjad> from abjad.tools import sequencetools

abjad> matrix = sequencetools.Matrix([[0, 1, 2, 3], [10, 11, 12, 13], [20, 21, 22, 23]])

abjad> matrix
Matrix(3x4)

abjad> matrix[:]
((0, 1, 2, 3), (10, 11, 12, 13), (20, 21, 22, 23))

abjad> matrix[2]
(20, 21, 22, 23)

abjad> matrix[2][0]
20
```

Initialize from columns:

```
abjad> matrix = sequencetools.Matrix(columns = [[0, 10, 20], [1, 11, 21], [2, 12, 22], [3, 13, 23]])
```

```

abjad> matrix
Matrix(3x4)

abjad> matrix[:]
((0, 1, 2, 3), (10, 11, 12, 13), (20, 21, 22, 23))

abjad> matrix[2]
(20, 21, 22, 23)

abjad> matrix[2][0]
20

```

Matrix implements only item retrieval in this revision.

Concatenation and division remain to be implemented.

Standard transforms of linear algebra remain to be implemented.

columns

Read-only columns:

```

abjad> matrix = sequencetools.Matrix([[0, 1, 2, 3], [10, 11, 12, 13], [20, 21, 22, 23]])

abjad> matrix.columns
((0, 10, 20), (1, 11, 21), (2, 12, 22), (3, 13, 23))

```

Return tuple.

rows

Read-only rows:

```

abjad> matrix = sequencetools.Matrix([[0, 1, 2, 3], [10, 11, 12, 13], [20, 21, 22, 23]])

abjad> matrix.rows
((0, 1, 2, 3), (10, 11, 12, 13), (20, 21, 22, 23))

```

Return tuple.

sequencetools.Tree

class abjad.tools.sequencetools.**Tree**(*expr*)

Bases: abjad.core._StrictComparator._StrictComparator._StrictComparator New in version 2.4. Abjad data structure to work with a sequence whose elements have been grouped into arbitrarily many levels of containment.

Example: a list of pitches that have been grouped into cells that have, in turn, been grouped into groups of cells that have, in turn, been grouped into groups of groups of cells.

```
abjad> from abjad.tools import sequencetools
```

Here is a tree:

```

abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree
Tree([[0, 1], [2, 3], [4, 5], [6, 7]])

```

```
abjad> tree.parent is None
True

abjad> tree.children
(Tree([0, 1]), Tree([2, 3]), Tree([4, 5]), Tree([6, 7]))

abjad> tree.depth
3
```

Here's an internal node:

```
abjad> tree[2]
Tree([4, 5])

abjad> tree[2].parent
Tree([0, 1], [2, 3], [4, 5], [6, 7])

abjad> tree[2].children
(Tree(4), Tree(5))

abjad> tree[2].depth
2

abjad> tree[2].level
1
```

Here's a leaf node:

```
abjad> tree[2][0]
Tree(4)

abjad> tree[2][0].parent
Tree([4, 5])

abjad> tree[2][0].children
()

abjad> tree[2][0].depth
1

abjad> tree[2][0].level
2

abjad> tree[2][0].position
(2, 0)

abjad> tree[2][0].payload
4
```

Only leaf nodes carry payload. Internal nodes carry no payload.

Negative levels are available to work with trees bottom-up instead of top-down.

Trees do not yet implement append or extend methods.

children

New in version 2.4. Children of node:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)
```

```
abjad> tree[1].children
(Tree(2), Tree(3))
```

Return tuple of zero or more nodes.

depth

New in version 2.4. Depth of subtree:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree[1].depth
2
```

Return nonnegative integer.

get_next_n_complete_nodes_at_level (*n*, *level*)

New in version 2.5. Get next *n* complete nodes at *level* from node.

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)
```

With nonnegative *level*:

Get next 4 nodes at level 2:

```
abjad> tree[0][0].get_next_n_complete_nodes_at_level(4, 2)
[Tree(1), Tree(2), Tree(3), Tree(4)]
```

Get next 3 nodes at level 1:

```
abjad> tree[0][0].get_next_n_complete_nodes_at_level(3, 1)
[Tree([1]), Tree([2, 3]), Tree([4, 5]), Tree([6, 7])]
```

With negative *level*:

Get next 4 nodes at level -1:

```
abjad> tree[0][0].get_next_n_complete_nodes_at_level(4, -1)
[Tree(1), Tree(2), Tree(3), Tree(4)]
```

Get next 3 nodes at level -2:

```
abjad> tree[0][0].get_next_n_complete_nodes_at_level(3, -2)
[Tree([1]), Tree([2, 3]), Tree([4, 5]), Tree([6, 7])]
```

Trim first node if necessary.

Return list of nodes.

get_next_n_nodes_at_level (*n*, *level*)

New in version 2.4. Get next *n* nodes at *level* from node.

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)
```

With nonnegative *level*:

Get next 4 nodes at level 2:

```
abjad> tree[0][0].get_next_n_nodes_at_level(4, 2)
[Tree(1), Tree(2), Tree(3), Tree(4)]
```

Get next 3 nodes at level 1:

```
abjad> tree[0][0].get_next_n_nodes_at_level(3, 1)
[Tree([1]), Tree([2, 3]), Tree([4, 5])]
```

Get next node at level 0:

```
abjad> tree[0][0].get_next_n_nodes_at_level(1, 0)
[Tree([1], [2, 3], [4, 5], [6, 7])]
```

With negative *level*:

Get next 4 nodes at level -1:

```
abjad> tree[0][0].get_next_n_nodes_at_level(4, -1)
[Tree(1), Tree(2), Tree(3), Tree(4)]
```

Get next 3 nodes at level -2:

```
abjad> tree[0][0].get_next_n_nodes_at_level(3, -2)
[Tree([1]), Tree([2, 3]), Tree([4, 5])]
```

Trim first node if necessary.

Return list of nodes.

get_node_at_position (*position*)

New in version 2.4. Get node at *position*:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree.get_node_at_position((2, 1))
Tree(5)
```

Return node.

get_position_of_descendant (*descendant*)

New in version 2.4. Get position of *descendant* relative to node rather than relative to root:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree[3].get_position_of_descendant(tree[3][0])
(0,)
```

Return tuple of zero or more nonnegative integers.

improper_parentage

New in version 2.4. Improper parentage of node:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree[1].improper_parentage
(Tree([2, 3]), Tree([0, 1], [2, 3], [4, 5], [6, 7]))
```

Return tuple of one or more nodes.

index_in_parent

New in version 2.4. Index of node in parent:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)
```

```
abjad> tree[1].index_in_parent
1
```

Return nonnegative integer.

is_at_level (*level*)

New in version 2.4. True when node is at *level* in tree:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)
```

```
abjad> tree[1][1].is_at_level(-1)
True
```

False otherwise:

```
abjad> tree[1][1].is_at_level(0)
False
```

Return boolean.

Predicate works for positive, negative and zero-valued *level*.

iterate_at_level (*level*)

New in version 2.4. Iterate depth at *level*:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)
```

```
abjad> for x in tree.iterate_at_level(0): x
...
Tree([[0, 1], [2, 3], [4, 5], [6, 7]])
```

```
abjad> for x in tree.iterate_at_level(1): x
...
Tree([0, 1])
Tree([2, 3])
Tree([4, 5])
Tree([6, 7])
```

```
abjad> for x in tree.iterate_at_level(2): x
...
Tree(0)
Tree(1)
Tree(2)
Tree(3)
Tree(4)
Tree(5)
Tree(6)
Tree(7)
```

```
abjad> for x in tree.iterate_at_level(-1): x
...
Tree(0)
Tree(1)
Tree(2)
Tree(3)
```

```

Tree(4)
Tree(5)
Tree(6)
Tree(7)

abjad> for x in tree.iterate_at_level(-2): x
...
Tree([0, 1])
Tree([2, 3])
Tree([4, 5])
Tree([6, 7])

abjad> for x in tree.iterate_at_level(-3): x
...
Tree([[0, 1], [2, 3], [4, 5], [6, 7]])

```

Return node generator.

iterate_depth_first()

New in version 2.4. Iterate tree depth-first:

```

abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> for node in tree.iterate_depth_first(): node
...
Tree([[0, 1], [2, 3], [4, 5], [6, 7]])
Tree([0, 1])
Tree(0)
Tree(1)
Tree([2, 3])
Tree(2)
Tree(3)
Tree([4, 5])
Tree(4)
Tree(5)
Tree([6, 7])
Tree(6)
Tree(7)

```

Return node generator.

iterate_payload()

New in version 2.4. Iterate tree payload:

```

abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> for element in tree.iterate_payload():
...     element
...
0
1
2
3
4
5
6
7

```


Return payload generator.

level

New in version 2.4. Level of node:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree[1].level
1
```

Return nonnegative integer.

negative_level

New in version 2.4. Negative level of node:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree[1].negative_level
-2
```

Return negative integer.

position

New in version 2.4. Position of node relative to root:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree[1].position
(1,)
```

Return tuple of zero or more nonnegative integers.

proper_parentage

New in version 2.4. Proper parentage of node:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree[1].proper_parentage
(Tree([[0, 1], [2, 3], [4, 5], [6, 7]]),)
```

Return tuple of zero or more nodes.

remove(*node*)

New in version 2.4. Remove *node* from tree:

```
abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree.remove(tree[1])

abjad> tree
Tree([[0, 1], [4, 5], [6, 7]])
```

Return none.

remove_to_root()

New in version 2.4. Remove node and all nodes left of node to root:

```

abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]

abjad> tree = sequencetools.Tree(sequence)
abjad> tree[0][0].remove_to_root()
abjad> tree
Tree([[1], [2, 3], [4, 5], [6, 7]])

abjad> tree = sequencetools.Tree(sequence)
abjad> tree[0][1].remove_to_root()
abjad> tree
Tree([[2, 3], [4, 5], [6, 7]])

abjad> tree = sequencetools.Tree(sequence)
abjad> tree[1].remove_to_root()
abjad> tree
Tree([[4, 5], [6, 7]])

```

Modify in-place to root.

Return none.

root

New in version 2.4. Root of tree:

```

abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree[1].proper_parentage
(Tree([[0, 1], [2, 3], [4, 5], [6, 7]]),)

```

Return node.

to_nested_lists()

New in version 2.5. Change tree to nested lists:

```

abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree
Tree([[0, 1], [2, 3], [4, 5], [6, 7]])

abjad> tree.to_nested_lists()
[[0, 1], [2, 3], [4, 5], [6, 7]]

```

Return list of lists.

width

New in version 2.4. Number of leaves in subtree:

```

abjad> sequence = [[0, 1], [2, 3], [4, 5], [6, 7]]
abjad> tree = sequencetools.Tree(sequence)

abjad> tree[1].width
2

```

Return nonnegative integer.

sequencetools.all_are_assignable_integers

`abjad.tools.sequencetools.all_are_assignable_integers(expr)`

New in version 2.0. True when *expr* is a sequence and all elements in *expr* are notehead-assignable integers:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_assignable_integers([1, 2, 3, 4, 6, 7, 8, 12, 14, 15, 16])
True
```

True when *expr* is an empty sequence:

```
abjad> sequencetools.all_are_assignable_integers([])
True
```

False otherwise:

```
abjad> sequencetools.all_are_assignable_integers('foo')
False
```

Return boolean.

sequencetools.all_are_equal

`abjad.tools.sequencetools.all_are_equal(expr)`

New in version 2.0. True when *expr* is a sequence and all elements in *expr* are equal:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_equal([99, 99, 99, 99, 99, 99])
True
```

True when *expr* is an empty sequence:

```
abjad> sequencetools.all_are_equal([])
True
```

False otherwise:

```
abjad> sequencetools.all_are_equal(17)
False
```

Return boolean.

sequencetools.all_are_integer_equivalent_numbers

`abjad.tools.sequencetools.all_are_integer_equivalent_numbers(expr)`

New in version 2.0. True when *expr* is a sequence and all elements in *expr* are integer-equivalent numbers:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_integer_equivalent_numbers([1, 2, 3.0, Fraction(4, 1)])
True
```

Otherwise false:

```
abjad> sequencetools.all_are_integer_equivalent_numbers([1, 2, 3.5, 4])
False
```

Return boolean.

sequencetools.all_are_nonnegative_integer_equivalent_numbers

`abjad.tools.sequencetools.all_are_nonnegative_integer_equivalent_numbers(expr)`

New in version 2.0. True *expr* is a sequence and when all elements in *expr* are nonnegative integer-equivalent numbers. Otherwise false:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_nonnegative_integer_equivalent_numbers([0, 0.0, Fraction(0), 2, 2.0])
True
```

Return boolean.

sequencetools.all_are_nonnegative_integer_powers_of_two

`abjad.tools.sequencetools.all_are_nonnegative_integer_powers_of_two(expr)`

New in version 2.0. True when *expr* is a sequence and all elements in *expr* are nonnegative integer powers of two:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_nonnegative_integer_powers_of_two([0, 1, 1, 1, 2, 4, 32, 32])
True
```

True when *expr* is an empty sequence:

```
abjad> sequencetools.all_are_nonnegative_integer_powers_of_two([])
True
```

False otherwise:

```
abjad> sequencetools.all_are_nonnegative_integer_powers_of_two(17)
False
```

Return boolean.

sequencetools.all_are_nonnegative_integers

`abjad.tools.sequencetools.all_are_nonnegative_integers(expr)`

New in version 2.0. True when *expr* is a sequence and all elements in *expr* are nonnegative integers:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_nonnegative_integers([0, 1, 2, 99])
True
```

Otherwise false:

```
abjad> sequencetools.all_are_nonnegative_integers([0, 1, 2, -99])
False
```

Return boolean.

sequencetools.all_are_numbers

`abjad.tools.sequencetools.all_are_numbers(expr)`

New in version 1.1. True when *expr* is a sequence and all elements in *expr* are numbers:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_numbers([1, 2, 3.0, Fraction(13, 8)])
True
```

True when *expr* is an empty sequence:

```
abjad> sequencetools.all_are_numbers([])
True
```

False otherwise:

```
abjad> sequencetools.all_are_numbers(17)
False
```

Return boolean. Changed in version 2.0: renamed `sequencetools.is_numeric()` to `sequencetools.all_are_numbers()`.

sequencetools.all_are_positive_integer_equivalent_numbers

`abjad.tools.sequencetools.all_are_positive_integer_equivalent_numbers(expr)`

New in version 2.0. True when *expr* is a sequence and all elements in *expr* are positive integer-equivalent numbers. Otherwise false:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_positive_integer_equivalent_numbers([Fraction(4, 2), 2.0, 2])
True
```

Return boolean.

sequencetools.all_are_positive_integers

`abjad.tools.sequencetools.all_are_positive_integers(expr)`

New in version 2.0. True when *expr* is a sequence and all elements in *expr* are positive integers:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_positive_integers([1, 2, 3, 99])
True
```

Otherwise false:

```
abjad> sequencetools.all_are_positive_integers(17)
False
```

Return boolean.

sequencetools.all_are_unequal

`abjad.tools.sequencetools.all_are_unequal(expr)`

New in version 1.1. True when *expr* is a sequence all elements in *expr* are unequal:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.all_are_unequal([1, 2, 3, 4, 9])
True
```

True when *expr* is an empty sequence:

```
abjad> sequencetools.all_are_unequal([])
True
```

False otherwise:

```
abjad> sequencetools.all_are_unequal(17)
False
```

Return boolean. Changed in version 2.0: renamed `sequencetools.is_unique()` to `sequencetools.all_are_unequal()`.

sequencetools.count_length_two_runs_in_sequence

`abjad.tools.sequencetools.count_length_two_runs_in_sequence(sequence)`

New in version 1.1. Count length-2 runs in *sequence*:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.count_length_two_runs_in_sequence([0, 0, 1, 1, 1, 2, 3, 4, 5])
3
```

Return nonnegative integer. Changed in version 2.0: renamed `sequencetools.count_repetitions()` to `sequencetools.count_length_two_runs_in_sequence()`.

sequencetools.divide_sequence_elements_by_greatest_common_divisor

`abjad.tools.sequencetools.divide_sequence_elements_by_greatest_common_divisor(sequence)`

New in version 2.0. Divide *sequence* elements by greatest common divisor:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.divide_sequence_elements_by_greatest_common_divisor([2, 2, -8, -16])
[1, 1, -4, -8]
```

Allow negative *sequence* elements.

Raise type error on noninteger *sequence* elements.

Raise not implemented error when 0 in *sequence*.

Return new *sequence* object.

sequencetools.flatten_sequence

`abjad.tools.sequencetools.flatten_sequence(sequence, classes=None, depth=-1)`

New in version 1.1. Flatten *sequence*:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.flatten_sequence([1, [2, 3, [4]], 5, [6, 7, [8]]])
[1, 2, 3, 4, 5, 6, 7, 8]
```

Flatten *sequence* to depth 1:

```
abjad> sequencetools.flatten_sequence([1, [2, 3, [4]], 5, [6, 7, [8]]], depth = 1)
[1, 2, 3, [4], 5, 6, 7, [8]]
```

Flatten *sequence* to depth 2:

```
abjad> sequencetools.flatten_sequence([1, [2, 3, [4]], 5, [6, 7, [8]]], depth = 2)
[1, 2, 3, 4, 5, 6, 7, 8]
```

Leave *sequence* unchanged.

Return newly constructed *sequence* object. Changed in version 2.0: renamed `listtools.flatten()` to `sequencetools.flatten_sequence()`.

sequencetools.flatten_sequence_at_indices

```
abjad.tools.sequencetools.flatten_sequence_at_indices(sequence, indices,
                                                         klases=None, depth=-1)
```

New in version 2.0. Flatten *sequence* at *indices*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.flatten_sequence_at_indices([0, 1, [2, 3, 4], [5, 6, 7]], [3])
[0, 1, [2, 3, 4], 5, 6, 7]
```

Flatten *sequence* at negative *indices*:

```
abjad> sequencetools.flatten_sequence_at_indices([0, 1, [2, 3, 4], [5, 6, 7]], [-1])
[0, 1, [2, 3, 4], 5, 6, 7]
```

Leave *sequence* unchanged.

Return newly constructed *sequence* object.

sequencetools.get_indices_of_sequence_elements_equal_to_true

```
abjad.tools.sequencetools.get_indices_of_sequence_elements_equal_to_true(sequence)
```

New in version 1.1. Get indices of *sequence* elements equal to true:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.get_indices_of_sequence_elements_equal_to_true([0, 0, 0, 1, 1, 1, 0, 0, 0,
(3, 4, 5, 9, 10, 11, 12)
```

Return newly constructed tuple of zero or more nonnegative integers. Changed in version 2.0: renamed `listtools.true_indices()` to `sequencetools.get_indices_of_sequence_elements_equal_to_true()`.

sequencetools.get_sequence_degree_of_rotational_symmetry

```
abjad.tools.sequencetools.get_sequence_degree_of_rotational_symmetry(sequence)
```

New in version 2.0. Change *sequence* to degree of rotational symmetry:

```
abjad> from abjad.tools import sequencetools
```

```

abjad> sequencetools.get_sequence_degree_of_rotational_symmetry([1, 2, 3, 4, 5, 6])
1

abjad> sequencetools.get_sequence_degree_of_rotational_symmetry([1, 2, 3, 1, 2, 3])
2

abjad> sequencetools.get_sequence_degree_of_rotational_symmetry([1, 2, 1, 2, 1, 2])
3

abjad> sequencetools.get_sequence_degree_of_rotational_symmetry([1, 1, 1, 1, 1, 1])
6

```

Return positive integer.

sequencetools.get_sequence_element_at_cyclic_index

`abjad.tools.sequencetools.get_sequence_element_at_cyclic_index(sequence, index)`

New in version 2.0. Get *sequence* element at nonnegative cyclic *index*:

```

abjad> from abjad.tools import sequencetools

abjad> for index in range(10):
...     print '%s\t%s' % (index, sequencetools.get_sequence_element_at_cyclic_index('string', in
...
0 s
1 t
2 r
3 i
4 n
5 g
6 s
7 t
8 r
9 i

```

Get *sequence* element at negative cyclic *index*:

```

abjad> for index in range(1, 11):
...     print '%s\t%s' % (-index, sequencetools.get_sequence_element_at_cyclic_index('string', -
...
-1 g
-2 n
-3 i
-4 r
-5 t
-6 s
-7 g
-8 n
-9 i
-10 r

```

Return reference to *sequence* element.

sequencetools.get_sequence_elements_at_indices

`abjad.tools.sequencetools.get_sequence_elements_at_indices(sequence, indices)`

New in version 2.0. Get *sequence* elements at *indices*:


```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.get_sequence_elements_at_indices('string of text', (2, 3, 10, 12))
('r', 'i', 't', 'x')
```

Return newly constructed tuple of references to *sequence* elements.

sequencetools.get_sequence_elements_frequency_distribution

`abjad.tools.sequencetools.get_sequence_elements_frequency_distribution(sequence)`

New in version 2.0. Get *sequence* elements frequency distribution:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.get_sequence_elements_frequency_distribution([1, 3, 3, 3, 2, 1, 1, 2, 3, 3,
[(1, 4), (2, 3), (3, 5)]
```

Return list of element / count pairs.

sequencetools.get_sequence_period_of_rotation

`abjad.tools.sequencetools.get_sequence_period_of_rotation(sequence, n)`

New in version 2.0. Change *sequence* to period of rotation:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.get_sequence_period_of_rotation([1, 2, 3, 1, 2, 3], 1)
3
```

```
abjad> sequencetools.get_sequence_period_of_rotation([1, 2, 3, 1, 2, 3], 2)
3
```

```
abjad> sequencetools.get_sequence_period_of_rotation([1, 2, 3, 1, 2, 3], 3)
1
```

Return positive integer.

sequencetools.increase_sequence_elements_at_indices_by_addenda

`abjad.tools.sequencetools.increase_sequence_elements_at_indices_by_addenda(sequence, addenda, indices)`

New in version 1.1. Increase *sequence* by *addenda* at *indices*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequence = [1, 1, 2, 3, 5, 5, 1, 2, 5, 5, 6]
```

```
abjad> sequencetools.increase_sequence_elements_at_indices_by_addenda(sequence, [0.5, 0.5], [0,
[1.5, 1.5, 2, 3, 5.5, 5.5, 1, 2, 5.5, 5.5, 6]
```

Return list. Changed in version 2.0: renamed `sequencetools.increase_at_indices()` to `sequencetools.increase_sequence_elements_at_indices_by_addenda()`.

sequencetools.increase_sequence_elements_cyclically_by_addenda

`abjad.tools.sequencetools.increase_sequence_elements_cyclically_by_addenda(sequence, addenda, shield=True, trim=True)`

New in version 1.1.. Increase *sequence* cyclically by *addenda*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.increase_sequence_elements_cyclically_by_addenda(range(10), [10, -10], shield=True, trim=True)
[10, -9, 12, -7, 14, -5, 16, -3, 18, -1]
```

Increase *sequence* cyclically by *addenda* and map nonpositive values to 1:

```
abjad> sequencetools.increase_sequence_elements_cyclically_by_addenda(range(10), [10, -10], shield=True, trim=True)
[10, 1, 12, 1, 14, 1, 16, 1, 18, 1]
```

Return list. Changed in version 2.0: renamed `sequencetools.increase_cyclic()` to `sequencetools.increase_sequence_elements_cyclically_by_addenda()`.

sequencetools.interlace_sequences

`abjad.tools.sequencetools.interlace_sequences(*sequences)`

New in version 1.1. Interlace *sequences*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> k = range(100, 103)
abjad> l = range(200, 201)
abjad> m = range(300, 303)
abjad> n = range(400, 408)
abjad> sequencetools.interlace_sequences(k, l, m, n)
[100, 200, 300, 400, 101, 301, 401, 102, 302, 402, 403, 404, 405, 406, 407]
```

Return list. Changed in version 2.0: renamed `sequencetools.interlace()` to `sequencetools.interlace_sequences()`.

sequencetools.is_monotonically_decreasing_sequence

`abjad.tools.sequencetools.is_monotonically_decreasing_sequence(expr)`

New in version 2.0. True when *expr* is a sequence and the elements in *expr* decrease monotonically:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> expr = [9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
abjad> sequencetools.is_monotonically_decreasing_sequence(expr)
True
```

```
abjad> expr = [3, 3, 3, 3, 3, 3, 3, 2, 1, 0]
abjad> sequencetools.is_monotonically_decreasing_sequence(expr)
True
```

```
abjad> expr = [3, 3, 3, 3, 3, 3, 3, 3, 3, 3]
abjad> sequencetools.is_monotonically_decreasing_sequence(expr)
True
```

False when *expr* is a sequence and the elements in *expr* do not decrease monotonically:

```
abjad> expr = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
abjad> sequencetools.is_monotonically_decreasing_sequence(expr)
False
```

```
abjad> expr = [0, 1, 2, 3, 3, 3, 3, 3, 3, 3]
abjad> sequencetools.is_monotonically_decreasing_sequence(expr)
False
```

True when *expr* is a sequence and *expr* is empty:

```
abjad> expr = []
abjad> sequencetools.is_monotonically_decreasing_sequence(expr)
True
```

False when *expr* is not a sequence:

```
abjad> sequencetools.is_monotonically_decreasing_sequence(17)
False
```

Return boolean.

sequencetools.is_monotonically_increasing_sequence

`abjad.tools.sequencetools.is_monotonically_increasing_sequence(expr)`

New in version 2.0. True when *expr* is a sequence and the elements in *expr* increase monotonically:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> expr = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
abjad> sequencetools.is_monotonically_increasing_sequence(expr)
True
```

```
abjad> expr = [0, 1, 2, 3, 3, 3, 3, 3, 3, 3]
abjad> sequencetools.is_monotonically_increasing_sequence(expr)
True
```

```
abjad> expr = [3, 3, 3, 3, 3, 3, 3, 3, 3, 3]
abjad> sequencetools.is_monotonically_increasing_sequence(expr)
True
```

False when *expr* is a sequence and the elements in *expr* do not increase monotonically:

```
abjad> expr = [9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
abjad> sequencetools.is_monotonically_increasing_sequence(expr)
False
```

```
abjad> expr = [3, 3, 3, 3, 3, 3, 3, 2, 1, 0]
abjad> sequencetools.is_monotonically_increasing_sequence(expr)
False
```

True when *expr* is a sequence and *expr* is empty:

```
abjad> expr = []
abjad> sequencetools.is_monotonically_increasing_sequence(expr)
True
```

False when *expr* is not a sequence:

```
abjad> sequencetools.is_monotonically_increasing_sequence(17)
False
```

Return boolean.

sequencetools.is_permutation

`abjad.tools.sequencetools.is_permutation(expr, length=None)`

New in version 2.0. True when *expr* is a permutation:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.is_permutation([4, 5, 0, 3, 2, 1])
True
```

Otherwise false:

```
abjad> sequencetools.is_permutation([1, 1, 5, 3, 2, 1])
False
```

True when *expr* is a permutation of first *length* nonnegative integers:

```
abjad> sequencetools.is_permutation([4, 5, 0, 3, 2, 1], length = 6)
True
```

Otherwise false:

```
abjad> sequencetools.is_permutation([4, 0, 3, 2, 1], length = 6)
False
```

Return boolean.

sequencetools.is_repetition_free_sequence

`abjad.tools.sequencetools.is_repetition_free_sequence(expr)`

New in version 2.0. True when *expr* is a sequence and *expr* is repetition free:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.is_repetition_free_sequence([0, 1, 2, 6, 7, 8])
True
```

False when *expr* is a sequence and *expr* is not repetition free:

```
abjad> sequencetools.is_repetition_free_sequence([0, 1, 2, 2, 7, 8])
False
```

True when *expr* is an empty sequence:

```
abjad> sequencetools.is_repetition_free_sequence([])
True
```

False *expr* is not a sequence:

```
abjad> sequencetools.is_repetition_free_sequence(17)
False
```

Return boolean.

sequencetools.is_restricted_growth_function

`abjad.tools.sequencetools.is_restricted_growth_function(expr)`

New in version 2.0. True when *expr* is a sequence and *expr* meets the criteria for a restricted growth function:

```

abjad> from abjad.tools import sequencetools

abjad> sequencetools.is_restricted_growth_function([1, 1, 1, 1])
True

abjad> sequencetools.is_restricted_growth_function([1, 1, 1, 2])
True

abjad> sequencetools.is_restricted_growth_function([1, 1, 2, 1])
True

abjad> sequencetools.is_restricted_growth_function([1, 1, 2, 2])
True

```

Otherwise false:

```

abjad> sequencetools.is_restricted_growth_function([1, 1, 1, 3])
False

abjad> sequencetools.is_restricted_growth_function(17)
False

```

A restricted growth function is a sequence *l* such that *l*[0] == 1 and such that *l*[*i*] <= max(*l*[:*i*]) + 1 for 1 <= *i* <= len(*l*).

Return boolean.

sequencetools.is_strictly_decreasing_sequence

`abjad.tools.sequencetools.is_strictly_decreasing_sequence(expr)`

New in version 2.0. True when *expr* is a sequence and the elements in *expr* decrease strictly:

```

abjad> from abjad.tools import sequencetools

abjad> expr = [9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
abjad> sequencetools.is_strictly_decreasing_sequence(expr)
True

```

False when *expr* is a sequence and the elements in *expr* do not decrease strictly:

```

abjad> expr = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
abjad> sequencetools.is_strictly_decreasing_sequence(expr)
False

abjad> expr = [0, 1, 2, 3, 3, 3, 3, 3, 3, 3]
abjad> sequencetools.is_strictly_decreasing_sequence(expr)
False

abjad> expr = [3, 3, 3, 3, 3, 3, 3, 3, 3, 3]
abjad> sequencetools.is_strictly_decreasing_sequence(expr)
False

abjad> expr = [3, 3, 3, 3, 3, 3, 3, 2, 1, 0]
abjad> sequencetools.is_strictly_decreasing_sequence(expr)
False

```

True when *expr* is an empty sequence:

```
abjad> sequencetools.is_strictly_decreasing_sequence([])
True
```

False *expr* is not a sequence:

```
abjad> sequencetools.is_strictly_decreasing_sequence(17)
False
```

Return boolean.

sequencetools.is_strictly_increasing_sequence

`abjad.tools.sequencetools.is_strictly_increasing_sequence(expr)`

New in version 2.0. True when *expr* is a sequence and the elements in *expr* increase strictly:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> expr = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
abjad> sequencetools.is_strictly_increasing_sequence(expr)
True
```

False when *expr* is a sequence and the elements in *expr* do not increase strictly:

```
abjad> expr = [9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
abjad> sequencetools.is_strictly_increasing_sequence(expr)
False
```

```
abjad> expr = [3, 3, 3, 3, 3, 3, 3, 2, 1, 0]
abjad> sequencetools.is_strictly_increasing_sequence(expr)
False
```

```
abjad> expr = [3, 3, 3, 3, 3, 3, 3, 3, 3, 3]
abjad> sequencetools.is_strictly_increasing_sequence(expr)
False
```

```
abjad> expr = [0, 1, 2, 3, 3, 3, 3, 3, 3, 3]
abjad> sequencetools.is_strictly_increasing_sequence(expr)
False
```

True when *expr* is an empty sequence:

```
abjad> sequencetools.is_strictly_increasing_sequence([])
True
```

False when *expr* is not a sequence:

```
abjad> sequencetools.is_strictly_increasing_sequence(17)
False
```

Return boolean.

sequencetools.iterate_sequence_cyclically

`abjad.tools.sequencetools.iterate_sequence_cyclically(sequence, step=1, start=0, length='inf')`

New in version 1.1. Iterate *sequence* cyclically according to *step*, *start* and *length*:

```

abjad> from abjad.tools import sequencetools

abjad> sequence = [1, 2, 3, 4, 5, 6, 7]

abjad> list(sequencetools.iterate_sequence_cyclically(sequence, length = 20))
[1, 2, 3, 4, 5, 6, 7, 1, 2, 3, 4, 5, 6, 7, 1, 2, 3, 4, 5, 6]

abjad> list(sequencetools.iterate_sequence_cyclically(sequence, 2, length = 20))
[1, 3, 5, 7, 2, 4, 6, 1, 3, 5, 7, 2, 4, 6, 1, 3, 5, 7, 2, 4]

abjad> list(sequencetools.iterate_sequence_cyclically(sequence, 2, 3, length = 20))
[4, 6, 1, 3, 5, 7, 2, 4, 6, 1, 3, 5, 7, 2, 4, 6, 1, 3, 5, 7]

abjad> list(sequencetools.iterate_sequence_cyclically(sequence, -2, 5, length = 20))
[6, 4, 2, 7, 5, 3, 1, 6, 4, 2, 7, 5, 3, 1, 6, 4, 2, 7, 5, 3]

```

Changed in version 2.0: allows generator input.

```

abjad> list(sequencetools.iterate_sequence_cyclically(xrange(1, 8), -2, 5, length = 20))
[6, 4, 2, 7, 5, 3, 1, 6, 4, 2, 7, 5, 3, 1, 6, 4, 2, 7, 5, 3]

```

Set *step* to jump size and direction across sequence.

Set *start* to the index of *sequence* where the function begins iterating.

Set *length* to number of elements to return. Set to 'inf' to return infinitely.

Return generator. Changed in version 2.0: renamed `sequencetools.phasor()` to `sequencetools.iterate_sequence_cyclically()`.

sequencetools.iterate_sequence_cyclically_from_start_to_stop

```

abjad.tools.sequencetools.iterate_sequence_cyclically_from_start_to_stop(sequence,
                                                                           start,
                                                                           stop)

```

New in version 1.1. Iterate *sequence* cyclically from *start* to *stop*:

```

abjad> from abjad.tools import sequencetools

abjad> list(sequencetools.iterate_sequence_cyclically_from_start_to_stop(range(20), 18, 10))
[18, 19, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

```

Return generator of references to *sequence* elements. Changed in version 2.0: renamed `sequencetools.get_cyclic()` to `sequencetools.iterate_sequence_cyclically_from_start_to_stop()`.

sequencetools.iterate_sequence_forward_and_backward_nonoverlapping

```

abjad.tools.sequencetools.iterate_sequence_forward_and_backward_nonoverlapping(sequence)

```

New in version 2.0. Iterate *sequence* first forward and then backward, with first and last elements repeated:

```

abjad> from abjad.tools import sequencetools

abjad> list(sequencetools.iterate_sequence_forward_and_backward_nonoverlapping([1, 2, 3, 4, 5]))
[1, 2, 3, 4, 5, 5, 4, 3, 2, 1]

```

Return generator.

sequencetools.iterate_sequence_forward_and_backward_overlapping

`abjad.tools.sequencetools.iterate_sequence_forward_and_backward_overlapping(sequence)`
New in version 2.0. Iterate *sequence* first forward and then backward, with first and last elements appearing only once:

```
abjad> from abjad.tools import sequencetools

abjad> list(sequencetools.iterate_sequence_forward_and_backward_overlapping([1, 2, 3, 4, 5]))
[1, 2, 3, 4, 5, 4, 3, 2]
```

Return generator.

sequencetools.iterate_sequence_nwise_cyclic

`abjad.tools.sequencetools.iterate_sequence_nwise_cyclic(sequence, n)`
New in version 2.0. Iterate elements in *sequence* cyclically *n* at a time:

```
abjad> from abjad.tools import sequencetools

abjad> g = sequencetools.iterate_sequence_nwise_cyclic(range(6), 3)
abjad> for n in range(10):
...     print g.next()
(0, 1, 2)
(1, 2, 3)
(2, 3, 4)
(3, 4, 5)
(4, 5, 0)
(5, 0, 1)
(0, 1, 2)
(1, 2, 3)
(2, 3, 4)
(3, 4, 5)
```

Return generator.

sequencetools.iterate_sequence_nwise_strict

`abjad.tools.sequencetools.iterate_sequence_nwise_strict(sequence, n)`
New in version 2.0. Iterate elements in *sequence* *n* at a time:

```
abjad> from abjad.tools import sequencetools

abjad> list(sequencetools.iterate_sequence_nwise_strict(range(10), 4))
[(0, 1, 2, 3), (1, 2, 3, 4), (2, 3, 4, 5), (3, 4, 5, 6), (4, 5, 6, 7), (5, 6, 7, 8), (6, 7, 8, 9)]
```

Return generator.

sequencetools.iterate_sequence_nwise_wrapped

`abjad.tools.sequencetools.iterate_sequence_nwise_wrapped(sequence, n)`
New in version 2.0. Iterate elements in *sequence* *n* at a time wrapped to beginning:

```
abjad> from abjad.tools import sequencetools
```



```
abjad> list(sequencetools.iterate_sequence_nwise_wrapped(range(6), 3))
[(0, 1, 2), (1, 2, 3), (2, 3, 4), (3, 4, 5), (4, 5, 0), (5, 0, 1)]
```

Return generator.

sequencetools.iterate_sequence_pairwise_cyclic

`abjad.tools.sequencetools.iterate_sequence_pairwise_cyclic(sequence)`

New in version 1.1. Iterate *sequence* pairwise cyclic:

```
abjad> from abjad.tools import sequencetools

abjad> generator = sequencetools.iterate_sequence_pairwise_cyclic(range(6))

abjad> generator.next()
(0, 1)
abjad> generator.next()
(1, 2)
abjad> generator.next()
(2, 3)
abjad> generator.next()
(3, 4)
abjad> generator.next()
(4, 5)
abjad> generator.next()
(5, 0)
abjad> generator.next()
(0, 1)
abjad> generator.next()
(1, 2)
```

Return pair generator.

sequencetools.iterate_sequence_pairwise_strict

`abjad.tools.sequencetools.iterate_sequence_pairwise_strict(sequence)`

New in version 1.1. Iterate *sequence* pairwise strict:

```
abjad> from abjad.tools import sequencetools

abjad> list(sequencetools.iterate_sequence_pairwise_strict(range(6)))
[(0, 1), (1, 2), (2, 3), (3, 4), (4, 5)]
```

Return pair generator.

sequencetools.iterate_sequence_pairwise_wrapped

`abjad.tools.sequencetools.iterate_sequence_pairwise_wrapped(sequence)`

New in version 1.1. Iterate *sequence* pairwise wrapped:

```
abjad> from abjad.tools import sequencetools

abjad> list(sequencetools.iterate_sequence_pairwise_wrapped(range(6)))
[(0, 1), (1, 2), (2, 3), (3, 4), (4, 5), (5, 0)]
```

Return pair generator.

sequencetools.join_subsequences

`abjad.tools.sequencetools.join_subsequences(sequence)`

New in version 2.4. Join subsequences in *sequence*:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.join_subsequences([(1, 2, 3), (), (4, 5), (), (6,)])
(1, 2, 3, 4, 5, 6)
```

Return newly constructed object of subsequence type.

sequencetools.join_subsequences_by_sign_of_subsequence_elements

`abjad.tools.sequencetools.join_subsequences_by_sign_of_subsequence_elements(sequence)`

New in version 1.1. Join subsequences in *sequence* by sign:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [[1, 2], [3, 4], [-5, -6, -7], [-8, -9, -10], [11, 12]]
abjad> sequencetools.join_subsequences_by_sign_of_subsequence_elements(sequence)
[[1, 2, 3, 4], [-5, -6, -7, -8, -9, -10], [11, 12]]

abjad> sequence = [[1, 2], [], [], [3, 4, 5], [6, 7]]
abjad> sequencetools.join_subsequences_by_sign_of_subsequence_elements(sequence)
[[1, 2], [], [3, 4, 5, 6, 7]]
```

Return newly constructed list. Changed in version 2.0: renamed `sequencetools.join_sublists_by_sign()` to `sequencetools.join_subsequences_by_sign_of_subsequence_elements()`.

sequencetools.map_sequence_elements_to_canonic_tuples

`abjad.tools.sequencetools.map_sequence_elements_to_canonic_tuples(sequence, direction='big-endian')`

New in version 1.1. Partition *sequence* elements into canonic big-endian parts:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.map_sequence_elements_to_canonic_tuples(range(10))
[(0,), (1,), (2,), (3,), (4,), (4, 1), (6,), (7,), (8,), (8, 1)]
```

Partition *sequence* elements into canonic little-endian parts:

```
abjad> sequencetools.map_sequence_elements_to_canonic_tuples(range(10), direction='little-endian')
[(0,), (1,), (2,), (3,), (4,), (1, 4), (6,), (7,), (8,), (1, 8)]
```

Raise type error when *sequence* is not a list.

Raise value error on noninteger elements in *sequence*.

Return list of tuples. Changed in version 2.0: renamed `sequencetools.partition_elements_into_canonic_parts()` to `sequencetools.map_sequence_elements_to_canonic_tuples()`.

sequencetools.map_sequence_elements_to_numbered_sublists

`abjad.tools.sequencetools.map_sequence_elements_to_numbered_sublists(sequence)`

New in version 1.1. Map *sequence* elements to numbered sublists:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.map_sequence_elements_to_numbered_sublists([1, 2, -3, -4, 5])
[[1], [2, 3], [-4, -5, -6], [-7, -8, -9, -10], [11, 12, 13, 14, 15]]

abjad> sequencetools.map_sequence_elements_to_numbered_sublists([1, 0, -3, -4, 5])
[[1], [], [-2, -3, -4], [-5, -6, -7, -8], [9, 10, 11, 12, 13]]
```

Note that numbering starts at 1.

Return newly constructed list of lists. Changed in version 2.0: renamed `sequencetools.lengths_to_counts()` to `sequencetools.map_sequence_elements_to_numbered_sublists()`.

sequencetools.negate_absolute_value_of_sequence_elements_at_indices

`abjad.tools.sequencetools.negate_absolute_value_of_sequence_elements_at_indices(sequence, indices)`

New in version 1.1. Negate the absolute value of *sequence* elements at *indices*:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [1, 2, 3, 4, 5, -6, -7, -8, -9, -10]

abjad> sequencetools.negate_sequence_elements_at_indices(sequence, [0, 1, 2])
[-1, -2, -3, 4, 5, -6, -7, -8, -9, -10]
```

Return newly constructed list. Changed in version 2.0: renamed `sequencetools.negate_elements_at_indices_absolutely()` to `sequencetools.negate_absolute_value_of_sequence_elements_at_indices()`.

sequencetools.negate_absolute_value_of_sequence_elements_cyclically

`abjad.tools.sequencetools.negate_absolute_value_of_sequence_elements_cyclically(sequence, indices, period)`

New in version 2.0. Negate the absolute value of *sequence* elements at *indices* cyclically according to *period*:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [1, 2, 3, 4, 5, -6, -7, -8, -9, -10]

abjad> sequencetools.negate_absolute_value_of_sequence_elements_cyclically(sequence, [0, 1, 2],
[-1, -2, -3, 4, 5, -6, -7, -8, -9, -10])
```

Return newly constructed list.

sequencetools.negate_sequence_elements_at_indices

`abjad.tools.sequencetools.negate_sequence_elements_at_indices` (*sequence*, *indices*)

New in version 1.1. Negate *sequence* elements at *indices*:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [1, 2, 3, 4, 5, -6, -7, -8, -9, -10]

abjad> sequencetools.negate_sequence_elements_at_indices(sequence, [0, 1, 2])
[-1, -2, -3, 4, 5, -6, -7, -8, -9, -10]
```

Return newly constructed list. Changed in version 2.0: renamed `sequencetools.negate_elements_at_indices()` to `sequencetools.negate_sequence_elements_at_`

sequencetools.negate_sequence_elements_cyclically

`abjad.tools.sequencetools.negate_sequence_elements_cyclically` (*sequence*, *indices*, *period*)

New in version 2.0. Negate *sequence* elements at *indices* cyclically according to *period*:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [1, 2, 3, 4, 5, -6, -7, -8, -9, -10]

abjad> sequencetools.negate_sequence_elements_cyclically(sequence, [0, 1, 2], 5)
[-1, -2, -3, 4, 5, 6, 7, 8, -9, -10]
```

Return newly constructed list.

sequencetools.overwrite_sequence_elements_at_indices

`abjad.tools.sequencetools.overwrite_sequence_elements_at_indices` (*sequence*, *pairs*)

New in version 1.1. Overwrite *sequence* elements at indices according to *pairs*:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.overwrite_sequence_elements_at_indices(range(10), [(0, 3), (5, 3)])
[0, 0, 0, 3, 4, 5, 5, 5, 8, 9]
```

Set *pairs* to a list of (anchor_index, length) pairs.

Return new list. Changed in version 2.0: renamed `sequencetools.overwrite_slices_at()` to `sequencetools.overwrite_sequence_elements_at_indices()`.

sequencetools.partition_sequence_by_ratio_of_lengths

`abjad.tools.sequencetools.partition_sequence_by_ratio_of_lengths` (*sequence*, *lengths*)

New in version 2.0. Partition *sequence* by ratio of *lengths*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.partition_sequence_by_ratio_of_lengths(tuple(range(10)), [1, 1, 2])
[(0, 1, 2), (3, 4), (5, 6, 7, 8, 9)]
```

Use rounding magic to avoid fractional part lengths.

Return list of *sequence* objects.

sequencetools.partition_sequence_by_ratio_of_weights

abjad.tools.sequencetools.**partition_sequence_by_ratio_of_weights**(*sequence*,
weights)

New in version 2.0. Partition *sequence* by ratio of *weights*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.partition_sequence_by_ratio_of_weights([1] * 10, [1, 1, 1])
[[1, 1, 1], [1, 1, 1, 1], [1, 1, 1]]
```

```
abjad> sequencetools.partition_sequence_by_ratio_of_weights([1] * 10, [1, 1, 1, 1])
[[1, 1, 1], [1, 1], [1, 1, 1], [1, 1]]
```

```
abjad> sequencetools.partition_sequence_by_ratio_of_weights([1] * 10, [2, 2, 3])
[[1, 1, 1], [1, 1, 1], [1, 1, 1, 1]]
```

```
abjad> sequencetools.partition_sequence_by_ratio_of_weights([1] * 10, [3, 2, 2])
[[1, 1, 1, 1], [1, 1, 1], [1, 1, 1]]
```

```
abjad> sequencetools.partition_sequence_by_ratio_of_weights([1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2])
[[1, 1, 1, 1, 1, 1, 2, 2], [2, 2, 2, 2]]
```

```
abjad> sequencetools.partition_sequence_by_ratio_of_weights([1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2])
[[1, 1, 1, 1, 1, 1], [2, 2, 2], [2, 2, 2]]
```

Weights of parts of returned list equal *weights_ratio* proportions with some rounding magic.

Return list of lists.

sequencetools.partition_sequence_by_restricted_growth_function

abjad.tools.sequencetools.**partition_sequence_by_restricted_growth_function**(*sequence*,
re-
stricted_growth_function)

New in version 2.0. Partition *sequence* by *restricted_growth_function*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> l = range(10)
abjad> rgf = [1, 1, 2, 2, 1, 2, 3, 3, 2, 4]
abjad> sequencetools.partition_sequence_by_restricted_growth_function(l, rgf)
[[0, 1, 4], [2, 3, 5, 8], [6, 7], [9]]
```

Raise value error when *sequence* length does not equal *restricted_growth_function* length.

Return list of lists.

sequencetools.partition_sequence_by_sign_of_elements

abjad.tools.sequencetools.partition_sequence_by_sign_of_elements(*sequence*,
sign=[-1, 0, 1])

New in version 1.1. Partition *sequence* elements by sign:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [0, 0, -1, -1, 2, 3, -5, 1, 2, 5, -5, -6]

abjad> list(sequencetools.partition_sequence_by_sign_of_elements(sequence))
[[0, 0], [-1, -1], [2, 3], [-5], [1, 2, 5], [-5, -6]]

abjad> list(sequencetools.partition_sequence_by_sign_of_elements(sequence, sign = [-1]))
[0, 0, [-1, -1], 2, 3, [-5], 1, 2, 5, [-5, -6]]

abjad> list(sequencetools.partition_sequence_by_sign_of_elements(sequence, sign = [0]))
[[0, 0], -1, -1, 2, 3, -5, 1, 2, 5, -5, -6]

abjad> list(sequencetools.partition_sequence_by_sign_of_elements(sequence, sign = [1]))
[0, 0, -1, -1, [2, 3], -5, [1, 2, 5], -5, -6]

abjad> list(sequencetools.partition_sequence_by_sign_of_elements(sequence, sign = [-1, 0]))
[[0, 0], [-1, -1], 2, 3, [-5], 1, 2, 5, [-5, -6]]

abjad> list(sequencetools.partition_sequence_by_sign_of_elements(sequence, sign = [-1, 1]))
[0, 0, [-1, -1], [2, 3], [-5], [1, 2, 5], [-5, -6]]

abjad> list(sequencetools.partition_sequence_by_sign_of_elements(sequence, sign = [0, 1]))
[[0, 0], -1, -1, [2, 3], -5, [1, 2, 5], -5, -6]

abjad> list(sequencetools.partition_sequence_by_sign_of_elements(sequence, sign = [-1, 0, 1]))
[[0, 0], [-1, -1], [2, 3], [-5], [1, 2, 5], [-5, -6]]
```

When -1 in sign, group negative elements.

When 0 in sign, group 0 elements.

When 1 in sign, group positive elements.

Return list of tuples of *sequence* element references. Changed in version 2.0: renamed `listtools.group_by_sign()` to `sequencetools.partition_sequence_by_sign_of_elements()`.

sequencetools.partition_sequence_by_value_of_elements

abjad.tools.sequencetools.partition_sequence_by_value_of_elements(*sequence*)

New in version 1.1. Group *sequence* elements by equality:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.partition_sequence_by_value_of_elements([0, 0, -1, -1, 2, 3, -5, 1, 1, 5, -5])
[(0, 0), (-1, -1), (2,), (3,), (-5,), (1, 1), (5,), (-5,)]
```

Return list of tuples of *sequence* element references. Changed in version 2.0: renamed `sequencetools.group_by_equality()` to `sequencetools.partition_sequence_by_value_of_elements()`.

sequencetools.partition_sequence_cyclically_by_counts_with_overhang

abjad.tools.sequencetools.**partition_sequence_cyclically_by_counts_with_overhang**(*sequence*,
counts)

New in version 1.1. Partition *sequence* cyclically by *counts* with overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.partition_sequence_cyclically_by_counts_with_overhang(range(16), [4, 6])
[[0, 1, 2, 3], [4, 5, 6, 7, 8, 9], [10, 11, 12, 13], [14, 15]]
```

Return list of *sequence* objects. Changed in version 2.0: renamed
listtools.partition_sequence_cyclically_by_counts_with_overhang() to
sequencetools.partition_sequence_cyclically_by_counts_with_overhang().

sequencetools.partition_sequence_cyclically_by_counts_without_overhang

abjad.tools.sequencetools.**partition_sequence_cyclically_by_counts_without_overhang**(*sequence*,
counts)

New in version 1.1. Partition *sequence* cyclically by *counts* without overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.partition_sequence_cyclically_by_counts_without_overhang(range(16), [4, 6])
[[0, 1, 2, 3], [4, 5, 6, 7, 8, 9], [10, 11, 12, 13]]
```

Return list of *sequence* objects. Changed in version 2.0: renamed
listtools.partition_sequence_cyclically_by_counts_without_overhang() to
sequencetools.partition_sequence_cyclically_by_counts_without_overhang().

sequencetools.partition_sequence_cyclically_by_weights_at_least_with_overhang

abjad.tools.sequencetools.**partition_sequence_cyclically_by_weights_at_least_with_overhang**(*sequence*,
weights)

New in version 1.1. Partition *sequence* elements cyclically by *weights* at least with overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5, 5]
abjad> sequencetools.partition_sequence_cyclically_by_weights_at_least_with_overhang(sequence, [3, 4, 5])
[[3, 3, 3, 3], [4], [4, 4, 4], [5], [5]]
```

Return list *sequence* element reference lists. Changed in version 2.0: renamed
sequencetools.group_sequence_elements_cyclically_by_weights_at_least_with_overhang()
to sequencetools.partition_sequence_cyclically_by_weights_at_least_with_overhang().

sequencetools.partition_sequence_cyclically_by_weights_at_least_without_overhang

abjad.tools.sequencetools.**partition_sequence_cyclically_by_weights_at_least_without_overhang**(*sequence*,
weights)

New in version 1.1. Partition *sequence* elements cyclically by *weights* at least without overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5, 5]
abjad> sequencetools.partition_sequence_cyclically_by_weights_at_least_without_overhang(sequence, [3, 3, 3, 3], [4], [4, 4, 4], [5])
```

Return list sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_cyclically_by_weights_at_least_without_overhang` to `sequencetools.partition_sequence_cyclically_by_weights_at_least_without_overhang`.

sequencetools.partition_sequence_cyclically_by_weights_at_most_with_overhang

`abjad.tools.sequencetools.partition_sequence_cyclically_by_weights_at_most_with_overhang` (sequence, weights)

New in version 1.1. Partition *sequence* elements cyclically by *weights* at most with overhang:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5, 5]
abjad> sequencetools.partition_sequence_cyclically_by_weights_at_most_with_overhang(sequence, [3, 3, 3], [3], [4, 4], [4], [4, 5], [5])
```

Return list sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_cyclically_by_weights_at_most_with_overhang` to `sequencetools.partition_sequence_cyclically_by_weights_at_most_with_overhang`.

sequencetools.partition_sequence_cyclically_by_weights_at_most_without_overhang

`abjad.tools.sequencetools.partition_sequence_cyclically_by_weights_at_most_without_overhang` (sequence, weights)

New in version 1.1. Partition *sequence* elements cyclically by *weights* at most without overhang:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5]
abjad> sequencetools.partition_sequence_cyclically_by_weights_at_most_without_overhang(sequence, [3, 3, 3], [3], [4, 4], [4])
```

Return list sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_cyclically_by_weights_at_most_without_overhang` to `sequencetools.partition_sequence_cyclically_by_weights_at_most_without_overhang`.

sequencetools.partition_sequence_cyclically_by_weights_exactly_with_overhang

`abjad.tools.sequencetools.partition_sequence_cyclically_by_weights_exactly_with_overhang` (sequence, weights)

New in version 1.1. Partition *sequence* elements cyclically by *weights* exactly with overhang:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5]
abjad> sequencetools.partition_sequence_cyclically_by_weights_exactly_with_overhang(sequence, [3, 3, 3, 3], [4, 4, 4], [4, 5])
```

Return list of sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_cyclically_by_weights_exactly_with_overhang` to `sequencetools.partition_sequence_cyclically_by_weights_exactly_with_overhang`.

sequencetools.partition_sequence_cyclically_by_weights_exactly_without_overhang

abjad.tools.sequencetools.partition_sequence_cyclically_by_weights_exactly_without_overhang

New in version 1.1. Partition *sequence* elements cyclically by *weights* exactly without overhang:

```
abjad> from abjad.tools import sequencetools

abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5]
abjad> sequencetools.partition_sequence_cyclically_by_weights_exactly_without_overhang(sequence,
[[3, 3, 3, 3], [4, 4, 4]]
```

Return list of sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_cyclically_by_weights_exactly_without_overhang()` to `sequencetools.partition_sequence_cyclically_by_weights_exactly_without_overhang()`.

sequencetools.partition_sequence_extended_to_counts_with_overhang

abjad.tools.sequencetools.partition_sequence_extended_to_counts_with_overhang(*sequence*,
counts)

New in version 2.0. Partition *sequence* extended to *counts* with overhang:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.partition_sequence_extended_to_counts_with_overhang([1, 2, 3, 4], [6, 6, 6])
[[1, 2, 3, 4, 1, 2], [3, 4, 1, 2, 3, 4], [1, 2, 3, 4, 1, 2], [3, 4]]
```

Return new object of *sequence* type.

sequencetools.partition_sequence_extended_to_counts_without_overhang

abjad.tools.sequencetools.partition_sequence_extended_to_counts_without_overhang(*sequence*,
counts)

New in version 2.0. Partition *sequence* extended to *counts* without overhang:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.partition_sequence_extended_to_counts_without_overhang([1, 2, 3, 4], [6, 6])
[[1, 2, 3, 4, 1, 2], [3, 4, 1, 2, 3, 4], [1, 2, 3, 4, 1, 2]]
```

Return new object of *sequence* type.

sequencetools.partition_sequence_once_by_counts_with_overhang

abjad.tools.sequencetools.partition_sequence_once_by_counts_with_overhang(*sequence*,
counts)

New in version 1.1. Partition *sequence* once by *counts* with overhang:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.partition_sequence_once_by_counts_with_overhang(range(16), [4, 6])
[[0, 1, 2, 3], [4, 5, 6, 7, 8, 9], [10, 11, 12, 13, 14, 15]]
```

Return list of *sequence* objects. Changed in version 2.0: renamed `listtools.partition_sequence_once_by_counts_with_overhang()` to `sequencetools.partition_sequence_once_by_counts_with_overhang()`.

sequencetools.partition_sequence_once_by_counts_without_overhang

`abjad.tools.sequencetools.partition_sequence_once_by_counts_without_overhang(sequence, counts)`

New in version 1.1. Partition *sequence* once by *counts* without overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.partition_sequence_once_by_counts_without_overhang(range(16), [4, 6])
[[0, 1, 2, 3], [4, 5, 6, 7, 8, 9]]
```

Return list of *sequence* objects. Changed in version 2.0: renamed `listtools.partition_sequence_once_by_counts_without_overhang()` to `sequencetools.partition_sequence_once_by_counts_without_overhang()`.

sequencetools.partition_sequence_once_by_weights_at_least_with_overhang

`abjad.tools.sequencetools.partition_sequence_once_by_weights_at_least_with_overhang(sequence, weights)`

New in version 1.1. Partition *sequence* elements once by *weights* at least with overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5, 5]
abjad> sequencetools.partition_sequence_once_by_weights_at_least_with_overhang(sequence, [10, 4])
[[3, 3, 3, 3], [4], [4, 4, 4, 5, 5]]
```

Return list sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_once_by_weights_at_least_with_overhang()` to `sequencetools.partition_sequence_once_by_weights_at_least_with_overhang()`.

sequencetools.partition_sequence_once_by_weights_at_least_without_overhang

`abjad.tools.sequencetools.partition_sequence_once_by_weights_at_least_without_overhang(sequence, weights)`

New in version 1.1. Partition *sequence* elements once by *weights* at least without overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5, 5]
abjad> sequencetools.partition_sequence_once_by_weights_at_least_without_overhang(sequence, [10, 4])
[[3, 3, 3, 3], [4]]
```

Return list sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_once_by_weights_at_least_without_overhang()` to `sequencetools.partition_sequence_once_by_weights_at_least_without_overhang()`.

sequencetools.partition_sequence_once_by_weights_at_most_with_overhang

`abjad.tools.sequencetools.partition_sequence_once_by_weights_at_most_with_overhang(sequence, weights)`

New in version 1.1. Partition *sequence* elements once by *weights* at most with overhang:

```
abjad> from abjad.tools import sequencetools
```

```

abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5, 5]
abjad> sequencetools.partition_sequence_once_by_weights_at_most_with_overhang(sequence, [10, 4])
[[3, 3, 3], [3], [4, 4, 4, 4, 5, 5]]

```

Return list sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_once_by_weights_at_most_with_overhang()` to `sequencetools.partition_sequence_once_by_weights_at_most_with_overhang()`.

`sequencetools.partition_sequence_once_by_weights_at_most_without_overhang`

`abjad.tools.sequencetools.partition_sequence_once_by_weights_at_most_without_overhang(sequence, weights)`

New in version 1.1. Partition *sequence* elements once by *weights* at most without overhang:

```

abjad> from abjad.tools import sequencetools

abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5, 5]
abjad> sequencetools.partition_sequence_once_by_weights_at_most_without_overhang(sequence, [10, 4])
[[3, 3, 3], [3]]

```

Return list sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_once_by_weights_at_most_without_overhang()` to `sequencetools.partition_sequence_once_by_weights_at_most_without_overhang()`.

`sequencetools.partition_sequence_once_by_weights_exactly_with_overhang`

`abjad.tools.sequencetools.partition_sequence_once_by_weights_exactly_with_overhang(sequence, weights)`

New in version 1.1. Partition *sequence* elements once by *weights* exactly with overhang:

```

abjad> from abjad.tools import sequencetools

abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5, 5]
abjad> sequencetools.partition_sequence_once_by_weights_exactly_with_overhang(sequence, [3, 9])
[[3], [3, 3, 3], [4, 4, 4, 4, 5, 5]]

```

Return list sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_once_by_weights_exactly_with_overhang()` to `sequencetools.partition_sequence_once_by_weights_exactly_with_overhang()`.

`sequencetools.partition_sequence_once_by_weights_exactly_without_overhang`

`abjad.tools.sequencetools.partition_sequence_once_by_weights_exactly_without_overhang(sequence, weights)`

New in version 1.1. Partition *sequence* elements once by *weights* exactly without overhang:

```

abjad> from abjad.tools import sequencetools

abjad> sequence = [3, 3, 3, 3, 4, 4, 4, 4, 5, 5]
abjad> sequencetools.partition_sequence_once_by_weights_exactly_without_overhang(sequence, [3, 9])
[[3], [3, 3, 3]]

```

Return list sequence element reference lists. Changed in version 2.0: renamed `sequencetools.group_sequence_elements_once_by_weights_exactly_without_overhang()` to `sequencetools.partition_sequence_once_by_weights_exactly_without_overhang()`.

sequencetools.permute_sequence

`abjad.tools.sequencetools.permute_sequence(sequence, permutation)`

New in version 2.0. Permute *sequence* by *permutation*:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.permute_sequence([10, 11, 12, 13, 14, 15], [5, 4, 0, 1, 2, 3])
[15, 14, 10, 11, 12, 13]
```

Return newly constructed *sequence* object.

sequencetools.remove_sequence_elements_at_indices

`abjad.tools.sequencetools.remove_sequence_elements_at_indices(sequence, indices)`

New in version 2.0. Remove *sequence* elements at *indices*:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.remove_sequence_elements_at_indices(range(20), [1, 16, 17, 18])
[0, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 19]
```

Ignore negative indices.

Return list.

sequencetools.remove_sequence_elements_at_indices_cyclically

`abjad.tools.sequencetools.remove_sequence_elements_at_indices_cyclically(sequence, indices, period, offset=0)`

New in version 2.0. Remove *sequence* elements at *indices* mod *period* plus *offset*:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.remove_sequence_elements_at_indices_cyclically(range(20), [0, 1], 5, 3)
[0, 1, 2, 5, 6, 7, 10, 11, 12, 15, 16, 17]
```

Ignore negative indices.

Return list.

sequencetools.remove_subsequence_of_weight_at_index

`abjad.tools.sequencetools.remove_subsequence_of_weight_at_index(sequence, weight, index)`

New in version 1.1. Remove subsequence of *weight* at *index*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.remove_subsequence_of_weight_at_index((1, 1, 2, 3, 5, 5, 1, 2, 5, 5, 6), 13)
(1, 1, 2, 3, 5, 5, 6)
```

Return newly constructed *sequence* object. Changed in version 2.0: renamed `listtools.remove_weighted_subrun_at()` to `sequencetools.remove_subsequence_of_weight_at_index()`.

sequencetools.repeat_runs_in_sequence_to_count

`abjad.tools.sequencetools.repeat_runs_in_sequence_to_count(sequence, indicators)`

New in version 1.1. Repeat subruns in *sequence* according to *indicators*. The *indicators* input parameter must be a list of zero or more (start, length, count) triples. For every (start, length, count) indicator in *indicators*, the function copies `sequence[start:start+length]` and inserts count new copies of `sequence[start:start+length]` immediately after `sequence[start:start+length]` in *sequence*.

Note: The function reads the value of count in every (start, length, count) triple not as the total number of occurrences of `sequence[start:start+length]` to appear in *sequence* after execution, but rather as the number of new occurrences of `sequence[start:start+length]` to appear in *sequence* after execution.

Note: The function wraps newly created subruns in tuples. That is, this function returns output with one more level of nesting than given in input.

To insert 10 count of `sequence[:2]` at `sequence[2:2]`:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.repeat_runs_in_sequence_to_count(range(20), [(0, 2, 10)])
[0, 1, (0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1),
 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
```

To insert 5 count of `sequence[10:12]` at `sequence[12:12]` and then insert 5 count of `sequence[:2]` at `sequence[2:2]`:

```
abjad> sequence = range(20)

abjad> sequencetools.repeat_runs_in_sequence_to_count(sequence, [(0, 2, 5), (10, 2, 5)])
[0, 1, (0, 1, 0, 1, 0, 1, 0, 1, 0, 1), 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, (10, 11, 10, 11, 10, 11, 10, 11),
 12, 13, 14, 15, 16, 17, 18, 19]
```

Note: This function wraps around the end of *sequence* whenever `len(sequence) < start + length`.

To insert 2 count of `[18, 19, 0, 1]` at `sequence[2:2]`:

```
abjad> sequencetools.repeat_runs_in_sequence_to_count(sequence, [(18, 4, 2)])
[0, 1, (18, 19, 0, 1, 18, 19, 0, 1), 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
```

To insert 2 count of `[18, 19, 0, 1, 2, 3, 4]` at `sequence[4:4]`:

```
abjad> sequencetools.repeat_runs_in_sequence_to_count(sequence, [(18, 8, 2)])
[0, 1, 2, 3, 4, 5, (18, 19, 0, 1, 2, 3, 4, 5, 18, 19, 0, 1, 2, 3, 4, 5), 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
```

Todo

Implement an optional *wrap* keyword to specify whether this function should wrap around the end of *sequence* whenever `len(sequence) < start + length` or not.

Todo

Reimplement this function to return a generator.

Generalizations of this function would include functions to repeat subruns in *sequence* to not only a certain count, as implemented here, but to a certain length, weight or sum. That is, `sequencetools.repeat_subruns_to_length()`, `sequencetools.repeat_subruns_to_weight()` and `sequencetools.repeat_subruns_to_sum()`. Changed in version 2.0: renamed `sequencetools.repeat_subruns_to_count()` to `sequencetools.repeat_runs_in_sequence_to_count()`.

sequencetools.repeat_sequence_elements_at_indices

`abjad.tools.sequencetools.repeat_sequence_elements_at_indices(sequence, indices, total)`

New in version 2.0. Repeat *sequence* elements at *indices* to *total* length:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.repeat_sequence_elements_at_indices(range(10), [6, 7, 8], 3)
[0, 1, 2, 3, 4, 5, [6, 6, 6], [7, 7, 7], [8, 8, 8], 9]
```

Return list.

sequencetools.repeat_sequence_elements_at_indices_cyclically

`abjad.tools.sequencetools.repeat_sequence_elements_at_indices_cyclically(sequence, cycle_token, total)`

New in version 2.0. Repeat *sequence* elements at indices specified by *cycle_token* to *total* length:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.repeat_sequence_elements_at_indices_cyclically(range(10), (5, [1, 2]), 3)
[0, [1, 1, 1], [2, 2, 2], 3, 4, 5, [6, 6, 6], [7, 7, 7], 8, 9]
```

The *cycle_token* may be a sieve:

```
abjad> from abjad.tools import sievetools

abjad> sieve = sievetools.cycle_tokens_to_sieve((5, [1, 2]))
abjad> sequencetools.repeat_sequence_elements_at_indices_cyclically(range(10), sieve, 3)
[0, [1, 1, 1], [2, 2, 2], 3, 4, 5, [6, 6, 6], [7, 7, 7], 8, 9]
```

Return list.

sequencetools.repeat_sequence_elements_n_times_each

`abjad.tools.sequencetools.repeat_sequence_elements_n_times_each(sequence, n)`

New in version 1.1. Repeat *sequence* elements *n* times each:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.repeat_sequence_elements_n_times_each((1, -1, 2, -3, 5, -5, 6), 2)
(1, 1, -1, -1, 2, 2, -3, -3, 5, 5, -5, -5, 6, 6)
```

Return newly constructed *sequence* object with copied *sequence* elements. Changed in version 2.0: renamed `listtools.repeat_elements_to_count()` to `sequencetools.repeat_sequence_elements_n_times_each()`.

sequencetools.repeat_sequence_n_times

```
abjad.tools.sequencetools.repeat_sequence_n_times(sequence, n)
```

New in version 2.0. Repeat *sequence* *n* times:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.repeat_sequence_n_times((1, 2, 3, 4, 5), 3)
(1, 2, 3, 4, 5, 1, 2, 3, 4, 5, 1, 2, 3, 4, 5)
```

Repeat *sequence* 0 times:

```
abjad> sequencetools.repeat_sequence_n_times((1, 2, 3, 4, 5), 0)
()
```

Return newly constructed *sequence* object of copied *sequence* elements.

sequencetools.repeat_sequence_to_length

```
abjad.tools.sequencetools.repeat_sequence_to_length(sequence, length, start=0)
```

New in version 1.1. Repeat *sequence* to nonnegative integer *length*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.repeat_sequence_to_length(range(5), 11)
[0, 1, 2, 3, 4, 0, 1, 2, 3, 4, 0]
```

Repeat *sequence* to nonnegative integer *length* from *start*:

```
abjad> sequencetools.repeat_sequence_to_length(range(5), 11, start = 2)
[2, 3, 4, 0, 1, 2, 3, 4, 0, 1, 2]
```

Return newly constructed *sequence* object. Changed in version 2.0: renamed `listtools.repeat_list_to_length()` to `sequencetools.repeat_sequence_to_length()`.

sequencetools.repeat_sequence_to_weight_at_least

```
abjad.tools.sequencetools.repeat_sequence_to_weight_at_least(sequence, weight)
```

New in version 1.1. Repeat *sequence* to *weight* at least:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.repeat_sequence_to_weight_at_least((5, -5, -5), 23)
(5, -5, -5, 5, -5)
```

Return newly constructed *sequence* object.

sequencetools.repeat_sequence_to_weight_at_most

`abjad.tools.sequencetools.repeat_sequence_to_weight_at_most(sequence, weight)`
 New in version 1.1. Repeat *sequence* to *weight* at most:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.repeat_sequence_to_weight_at_most((5, -5, -5), 23)
(5, -5, -5, 5)
```

Return newly constructed *sequence* object.

sequencetools.repeat_sequence_to_weight_exactly

`abjad.tools.sequencetools.repeat_sequence_to_weight_exactly(sequence, weight)`
 New in version 1.1. Repeat *sequence* to *weight* exactly:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.repeat_sequence_to_weight_exactly((5, -5, -5), 23)
(5, -5, -5, 5, -3)
```

Return newly constructed *sequence* object.

sequencetools.replace_sequence_elements_cyclically_with_new_material

`abjad.tools.sequencetools.replace_sequence_elements_cyclically_with_new_material(sequence, indices, new_material)`

New in version 1.1. Replace *sequence* elements cyclically at *indices* with *new_material*:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.replace_sequence_elements_cyclically_with_new_material(range(20), ([0], 2),
['A', 1, 'B', 3, 4, 5, 'A', 7, 'B', 9, 10, 11, 'A', 13, 'B', 15, 16, 17, 'A', 19])

abjad> sequencetools.replace_sequence_elements_cyclically_with_new_material(range(20), ([0], 2),
['*', 1, '*', 3, '*', 5, '*', 7, '*', 9, '*', 11, '*', 13, '*', 15, '*', 17, '*', 19])

abjad> sequencetools.replace_sequence_elements_cyclically_with_new_material(range(20), ([0], 2),
['A', 1, 'B', 3, 'C', 5, 'D', 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19])

abjad> sequencetools.replace_sequence_elements_cyclically_with_new_material(range(20), ([0, 1, 8], 2),
['A', 'B', 2, 3, 4, 5, 6, 7, 'C', 9, 10, 11, 12, 'D', 14, 15, 16, 17, 18, 19])
```

Raise type error when *sequence* not a list.

Return newly constructed list. Changed in version 2.0: renamed
`sequencetools.replace_elements_cyclic()` to `sequencetools.replace_sequence_elements_cyclically()`

sequencetools.retain_sequence_elements_at_indices

`abjad.tools.sequencetools.retain_sequence_elements_at_indices(sequence, indices)`

New in version 2.0. Retain *sequence* elements at *indices*:


```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.retain_sequence_elements_at_indices(range(20), [1, 16, 17, 18])
[1, 16, 17, 18]
```

Return sequence elements in the order they appear in *sequence*.

Ignore negative indices.

Return list.

sequencetools.retain_sequence_elements_at_indices_cyclically

```
abjad.tools.sequencetools.retain_sequence_elements_at_indices_cyclically(sequence,
                                                                           in-
                                                                           dices,
                                                                           pe-
                                                                           riod,
                                                                           off-
                                                                           set=0)
```

New in version 2.0. Retain *sequence* elements at *indices* mod *period* plus *offset*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.retain_sequence_elements_at_indices_cyclically(range(20), [0, 1], 5, 3)
[3, 4, 8, 9, 13, 14, 18, 19]
```

Ignore negative values in *indices*.

Return list.

sequencetools.reverse_sequence

```
abjad.tools.sequencetools.reverse_sequence(sequence)
```

New in version 2.0. Reverse *sequence*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.reverse_sequence((1, 2, 3, 4, 5))
(5, 4, 3, 2, 1)
```

Return new *sequence* object.

sequencetools.reverse_sequence_elements

```
abjad.tools.sequencetools.reverse_sequence_elements(sequence)
```

New in version 2.0. Reverse *sequence* elements:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.reverse_sequence_elements([1, (2, 3, 4), 5, (6, 7)])
[1, (4, 3, 2), 5, (7, 6)]
```

Return new *sequence* object.

sequencetools.rotate_sequence

`abjad.tools.sequencetools.rotate_sequence(sequence, n)`

New in version 1.1. Rotate *sequence* to the right:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.rotate_sequence(range(10), 4)
[6, 7, 8, 9, 0, 1, 2, 3, 4, 5]
```

Rotate *sequence* to the left:

```
abjad> sequencetools.rotate_sequence(range(10), -3)
[3, 4, 5, 6, 7, 8, 9, 0, 1, 2]
```

Rotate *sequence* neither to the right nor the left:

```
abjad> sequencetools.rotate_sequence(range(10), 0)
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Return newly created *sequence* object. Changed in version 2.0: renamed `sequencetools.rotate()` to `sequencetools.rotate_sequence()`.

sequencetools.splice_new_elements_between_sequence_elements

`abjad.tools.sequencetools.splice_new_elements_between_sequence_elements(sequence, new_elements, overhang=(0, 0))`

New in version 1.1. Splice copies of *new_elements* between each of the elements of *sequence*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequence = [0, 1, 2, 3, 4]
abjad> new_elements = ['A', 'B']
```

```
abjad> sequencetools.splice_new_elements_between_sequence_elements(sequence, new_elements)
[0, 'A', 'B', 1, 'A', 'B', 2, 'A', 'B', 3, 'A', 'B', 4]
```

Splice copies of *new_elements* between each of the elements of *sequence* and after the last element of *sequence*:

```
abjad> sequencetools.splice_new_elements_between_sequence_elements(sequence, new_elements, overhang=(0, 1))
[0, 'A', 'B', 1, 'A', 'B', 2, 'A', 'B', 3, 'A', 'B', 4, 'A', 'B']
```

Splice copies of *new_elements* before the first element of *sequence* and between each of the other elements of *sequence*:

```
abjad> sequencetools.splice_new_elements_between_sequence_elements(sequence, new_elements, overhang=(1, 0))
['A', 'B', 0, 'A', 'B', 1, 'A', 'B', 2, 'A', 'B', 3, 'A', 'B', 4]
```

Splice copies of *new_elements* before the first element of *sequence*, after the last element of *sequence* and between each of the other elements of *sequence*:

```
abjad> sequencetools.splice_new_elements_between_sequence_elements(sequence, new_elements, overhang=(1, 1))
['A', 'B', 0, 'A', 'B', 1, 'A', 'B', 2, 'A', 'B', 3, 'A', 'B', 4, 'A', 'B']
```

Return newly constructed list. Changed in version 2.0: renamed `sequencetools.insert_slice_cyclic()` to `sequencetools.splice_new_elements_between_sequence_elements()`.

sequencetools.split_sequence_cyclically_by_weights_with_overhang

`abjad.tools.sequencetools.split_sequence_cyclically_by_weights_with_overhang`(*sequence*,
weights)

New in version 2.0. Split *sequence* cyclically by *weights* with overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.split_sequence_cyclically_by_weights_with_overhang((10, -10, 10, -10), [3,
[(3,), (7, -8), (-2, 1), (3,), (6, -9), (-1,)]
```

Return list of *sequence* objects.

sequencetools.split_sequence_cyclically_by_weights_without_overhang

`abjad.tools.sequencetools.split_sequence_cyclically_by_weights_without_overhang`(*sequence*,
weights)

New in version 2.0. Split *sequence* cyclically by *weights* without overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.split_sequence_cyclically_by_weights_without_overhang((10, -10, 10, -10), [
[(3,), (7, -8), (-2, 1), (3,), (6, -9)]
```

Return list of *sequence* objects.

sequencetools.split_sequence_extended_to_weights_with_overhang

`abjad.tools.sequencetools.split_sequence_extended_to_weights_with_overhang`(*sequence*,
weights)

New in version 2.0. Split *sequence* extended to *weights* with overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.split_sequence_extended_to_weights_with_overhang([1, 2, 3, 4, 5], [7, 7, 7],
[[1, 2, 3, 1], [3, 4], [1, 1, 2, 3], [4, 5]]
```

Return new object of *sequence* type.

sequencetools.split_sequence_extended_to_weights_without_overhang

`abjad.tools.sequencetools.split_sequence_extended_to_weights_without_overhang`(*sequence*,
weights)

New in version 2.0. Split *sequence* extended to *weights* without overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.split_sequence_extended_to_weights_without_overhang([1, 2, 3, 4, 5], [7, 7],
[[1, 2, 3, 1], [3, 4], [1, 1, 2, 3]]
```

Return new object of *sequence* type.

sequencetools.split_sequence_once_by_weights_with_overhang

abjad.tools.sequencetools.**split_sequence_once_by_weights_with_overhang**(*sequence*,
weights)

New in version 2.0. Split *sequence* once by *weights* with overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.split_sequence_once_by_weights_with_overhang((10, -10, 10, -10), [3, 15, 3])
[(3,), (7, -8), (-2, 1), (9, -10)]
```

Return list of *sequence* objects.

sequencetools.split_sequence_once_by_weights_without_overhang

abjad.tools.sequencetools.**split_sequence_once_by_weights_without_overhang**(*sequence*,
weights)

New in version 2.0. Split *sequence* once by *weights* without overhang:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequencetools.split_sequence_once_by_weights_without_overhang((10, -10, 10, -10), [3, 15, 3])
[(3,), (7, -8), (-2, 1)]
```

Return list of *sequence* objects.

sequencetools.sum_consecutive_sequence_elements_by_sign

abjad.tools.sequencetools.**sum_consecutive_sequence_elements_by_sign**(*sequence*,
sign=[-1, 0, 1])

New in version 1.1. Sum consecutive *sequence* elements by *sign*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> sequence = [0, 0, -1, -1, 2, 3, -5, 1, 2, 5, -5, -6]
```

```
abjad> sequencetools.sum_consecutive_sequence_elements_by_sign(sequence)
[0, -2, 5, -5, 8, -11]
```

```
abjad> sequencetools.sum_consecutive_sequence_elements_by_sign(sequence, sign = [-1])
[0, 0, -2, 2, 3, -5, 1, 2, 5, -11]
```

```
abjad> sequencetools.sum_consecutive_sequence_elements_by_sign(sequence, sign = [0])
[0, -1, -1, 2, 3, -5, 1, 2, 5, -5, -6]
```

```
abjad> sequencetools.sum_consecutive_sequence_elements_by_sign(sequence, sign = [1])
[0, 0, -1, -1, 5, -5, 8, -5, -6]
```

```
abjad> sequencetools.sum_consecutive_sequence_elements_by_sign(sequence, sign = [-1, 0])
[0, -2, 2, 3, -5, 1, 2, 5, -11]
```

```
abjad> sequencetools.sum_consecutive_sequence_elements_by_sign(sequence, sign = [-1, 1])
[0, 0, -2, 5, -5, 8, -11]
```

```

abjad> sequencetools.sum_consecutive_sequence_elements_by_sign(sequence, sign = [0, 1])
[0, -1, -1, 5, -5, 8, -5, -6]

abjad> sequencetools.sum_consecutive_sequence_elements_by_sign(sequence, sign = [-1, 0, 1])
[0, -2, 5, -5, 8, -11]

```

When -1 in *sign*, sum consecutive negative elements.

When 0 in *sign*, sum consecutive 0 elements.

When 1 in *sign*, sum consecutive positive elements.

Return list. Changed in version 2.0: renamed `sequencetools.sum_by_sign()` to `sequencetools.sum_consecutive_sequence_elements_by_sign()`.

sequencetools.sum_sequence_elements_at_indices

```

abjad.tools.sequencetools.sum_sequence_elements_at_indices(sequence, pairs,
                                                            period=None, overhang=True)

```

New in version 1.1. Sum *sequence* elements at indices according to *pairs*:

```

abjad> from abjad.tools import sequencetools

abjad> sequencetools.sum_sequence_elements_at_indices(range(10), [(0, 3)])
[3, 3, 4, 5, 6, 7, 8, 9]

```

Sum *sequence* elements cyclically at indices according to *pairs* and *period*:

```

abjad> sequencetools.sum_sequence_elements_at_indices(range(10), [(0, 3)], period = 4)
[3, 3, 15, 7, 17]

```

Sum *sequence* elements cyclically at indices according to *pairs* and *period* and do not return incomplete final sum:

```

abjad> sequencetools.sum_sequence_elements_at_indices(range(10), [(0, 3)], period = 4, overhang
[3, 3, 15, 7]

```

Replace `sequence[i:i+count]` with `sum(sequence[i:i+count])` for each `(i, count)` in *pairs*.

Indices in *pairs* must be less than *period* when *period* is not none.

Return new list. Changed in version 2.0: renamed `sequencetools.sum_slices_at()` to `sequencetools.sum_sequence_elements_at_indices()`.

sequencetools.truncate_runs_in_sequence

```

abjad.tools.sequencetools.truncate_runs_in_sequence(sequence)

```

New in version 1.1. Truncate subruns of like elements in *sequence* to length 1:

```

abjad> from abjad.tools import sequencetools

abjad> sequencetools.truncate_runs_in_sequence([1, 1, 2, 3, 3, 3, 9, 4, 4, 4])
[1, 2, 3, 9, 4]

```

Return empty list when *sequence* is empty:

```

abjad> sequencetools.truncate_runs_in_sequence([])
[]

```

Raise type error when *sequence* is not a list.

Return new list. Changed in version 2.0: renamed `sequencetools.truncate_subruns()` to `sequencetools.truncate_runs_in_sequence()`.

sequencetools.truncate_sequence_to_sum

`abjad.tools.sequencetools.truncate_sequence_to_sum(sequence, sum)`

New in version 1.1. Truncate *sequence* to *sum*:

```
abjad> from abjad.tools import sequencetools

abjad> for n in range(10):
...     print n, sequencetools.truncate_sequence_to_sum([-1, 2, -3, 4, -5, 6, -7, 8, -9, 10], n)
...
0 []
1 [-1, 2]
2 [-1, 2, -3, 4]
3 [-1, 2, -3, 4, -5, 6]
4 [-1, 2, -3, 4, -5, 6, -7, 8]
5 [-1, 2, -3, 4, -5, 6, -7, 8, -9, 10]
6 [-1, 2, -3, 4, -5, 6, -7, 8, -9, 10]
7 [-1, 2, -3, 4, -5, 6, -7, 8, -9, 10]
8 [-1, 2, -3, 4, -5, 6, -7, 8, -9, 10]
9 [-1, 2, -3, 4, -5, 6, -7, 8, -9, 10]
```

Return empty list when *sum* is 0:

```
abjad> sequencetools.truncate_sequence_to_sum([1, 2, 3, 4, 5], 0)
[]
```

Raise type error when *sequence* is not a list.

Raise value error on negative *sum*.

Return new list. Changed in version 2.0: renamed `sequencetools.truncate_to_sum()` to `sequencetools.truncate_sequence_to_sum()`.

sequencetools.truncate_sequence_to_weight

`abjad.tools.sequencetools.truncate_sequence_to_weight(sequence, weight)`

New in version 1.1. Truncate *sequence* to *weight*:

```
abjad> from abjad.tools import sequencetools

abjad> l = [-1, 2, -3, 4, -5, 6, -7, 8, -9, 10]
abjad> for x in range(10):
...     print x, sequencetools.truncate_sequence_to_weight(l, x)
...
0 []
1 [-1]
2 [-1, 1]
3 [-1, 2]
4 [-1, 2, -1]
5 [-1, 2, -2]
6 [-1, 2, -3]
7 [-1, 2, -3, 1]
```

```
8 [-1, 2, -3, 2]
9 [-1, 2, -3, 3]
```

Return empty list when *weight* is 0:

```
abjad> sequencetools.truncate_sequence_to_weight([1, 2, 3, 4, 5], 0)
[]
```

Raise type error when *sequence* is not a list.

Raise value error on negative *weight*.

Return new list. Changed in version 2.0: renamed `sequencetools.truncate_to_weight()` to `sequencetools.truncate_sequence_to_weight()`.

sequencetools.yield_all_combinations_of_sequence_elements

```
abjad.tools.sequencetools.yield_all_combinations_of_sequence_elements(sequence,
                                                                    min_length=None,
                                                                    max_length=None)
```

New in version 2.0. Yield all combinations of *sequence* in binary string order:

```
abjad> from abjad.tools import sequencetools

abjad> list(sequencetools.yield_all_combinations_of_sequence_elements([1, 2, 3, 4]))
[[], [1], [2], [1, 2], [3], [1, 3], [2, 3], [1, 2, 3], [4], [1, 4],
 [2, 4], [1, 2, 4], [3, 4], [1, 3, 4], [2, 3, 4], [1, 2, 3, 4]]
```

Yield all combinations of *sequence* greater than or equal to *min_length* in binary string order:

```
abjad> list(sequencetools.yield_all_combinations_of_sequence_elements([1, 2, 3, 4], min_length =
[1, 2, 3], [1, 2, 4], [1, 3, 4], [2, 3, 4], [1, 2, 3, 4]]
```

Yield all combinations of *sequence* less than or equal to *max_length* in binary string order:

```
abjad> list(sequencetools.yield_all_combinations_of_sequence_elements([1, 2, 3, 4], max_length =
[[], [1], [2], [1, 2], [3], [1, 3], [2, 3], [4], [1, 4], [2, 4], [3, 4]]
```

Yield all combinations of *sequence* greater than or equal to *min_length* and less than or equal to *max_length* in lex order:

```
abjad> list(sequencetools.yield_all_combinations_of_sequence_elements([1, 2, 3, 4], min_length =
[1, 2], [1, 3], [2, 3], [1, 4], [2, 4], [3, 4]]
```

Return generator of newly created *sequence* objects. Changed in version 2.0: renamed `sequencetools.sublists()` to `sequencetools.yield_all_combinations_of_sequence_elements()`.

sequencetools.yield_all_k_ary_sequences_of_length

```
abjad.tools.sequencetools.yield_all_k_ary_sequences_of_length(k, length)
```

New in version 2.0. Generate all *k*-ary sequences of *length*:

```
abjad> from abjad.tools import sequencetools

abjad> for sequence in sequencetools.yield_all_k_ary_sequences_of_length(2, 3):
...     sequence
...
(0, 0, 0)
```

```
(0, 0, 1)
(0, 1, 0)
(0, 1, 1)
(1, 0, 0)
(1, 0, 1)
(1, 1, 0)
(1, 1, 1)
```

Return generator of tuples.

sequencetools.yield_all_pairs_between_sequences

`abjad.tools.sequencetools.yield_all_pairs_between_sequences(l, m)`

New in version 2.0. Yield all pairs between sequences *l* and *m*:

```
abjad> from abjad.tools import sequencetools

abjad> for pair in sequencetools.yield_all_pairs_between_sequences([1, 2, 3], [4, 5]):
...     pair
...
(1, 4)
(1, 5)
(2, 4)
(2, 5)
(3, 4)
(3, 5)
```

Return pair generator.

sequencetools.yield_all_partitions_of_sequence

`abjad.tools.sequencetools.yield_all_partitions_of_sequence(sequence)`

New in version 2.0. Yield all partitions of *sequence*:

```
abjad> from abjad.tools import sequencetools

abjad> for partition in sequencetools.yield_all_partitions_of_sequence([0, 1, 2, 3]):
...     partition
...
[[0, 1, 2, 3]]
[[0, 1, 2], [3]]
[[0, 1], [2, 3]]
[[0, 1], [2], [3]]
[[0], [1, 2, 3]]
[[0], [1, 2], [3]]
[[0], [1], [2, 3]]
[[0], [1], [2], [3]]
```

Return generator of newly created lists.

sequencetools.yield_all_permutations_of_sequence

`abjad.tools.sequencetools.yield_all_permutations_of_sequence(sequence)`

New in version 1.1. Yield all permutations of *sequence* in lex order:


```
abjad> from abjad.tools import sequencetools
```

```
abjad> list(sequencetools.yield_all_permutations_of_sequence((1, 2, 3)))
[(1, 2, 3), (1, 3, 2), (2, 1, 3), (2, 3, 1), (3, 1, 2), (3, 2, 1)]
```

Return generator of *sequence* objects. Changed in version 2.0: renamed `listtools.permutations()` to `sequencetools.yield_all_permutations_of_sequence()`.

sequencetools.yield_all_permutations_of_sequence_in_orbit

```
abjad.tools.sequencetools.yield_all_permutations_of_sequence_in_orbit(sequence,
                                                                    per-
                                                                    muta-
                                                                    tion)
```

New in version 2.0. Yield all permutations of *sequence* in orbit of *permutation* in lex order:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> list(sequencetools.yield_all_permutations_of_sequence_in_orbit((1, 2, 3, 4), [1, 2, 3, 0])
[(1, 2, 3, 4), (2, 3, 4, 1), (3, 4, 1, 2), (4, 1, 2, 3)]
```

Return generator of *sequence* objects.

sequencetools.yield_all_restricted_growth_functions_of_length

```
abjad.tools.sequencetools.yield_all_restricted_growth_functions_of_length(length)
```

New in version 2.0. Generate all restricted growth functions of *length* in lex order:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> for rgf in sequencetools.yield_all_restricted_growth_functions_of_length(4):
...     rgf
...
(1, 1, 1, 1)
(1, 1, 1, 2)
(1, 1, 2, 1)
(1, 1, 2, 2)
(1, 1, 2, 3)
(1, 2, 1, 1)
(1, 2, 1, 2)
(1, 2, 1, 3)
(1, 2, 2, 1)
(1, 2, 2, 2)
(1, 2, 2, 3)
(1, 2, 3, 1)
(1, 2, 3, 2)
(1, 2, 3, 3)
(1, 2, 3, 4)
```

Return generator of tuples.

sequencetools.yield_all_rotations_of_sequence

```
abjad.tools.sequencetools.yield_all_rotations_of_sequence(sequence, n=1)
```

New in version 2.0. Yield all *n*-rotations of *sequence* up to identity:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> list(sequencetools.yield_all_rotations_of_sequence([1, 2, 3, 4], -1))
[[1, 2, 3, 4], [2, 3, 4, 1], [3, 4, 1, 2], [4, 1, 2, 3]]
```

Return generator of *sequence* objects.

sequencetools.yield_all_set_partitions_of_sequence

`abjad.tools.sequencetools.yield_all_set_partitions_of_sequence(sequence)`

New in version 2.0. Yield all set partitions of *sequence* in restricted growth function order:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> for set_partition in sequencetools.yield_all_set_partitions_of_sequence([21, 22, 23, 24]):
...     set_partition
...
[[21, 22, 23, 24]]
[[21, 22, 23], [24]]
[[21, 22, 24], [23]]
[[21, 22], [23, 24]]
[[21, 22], [23], [24]]
[[21, 23, 24], [22]]
[[21, 23], [22, 24]]
[[21, 23], [22], [24]]
[[21, 24], [22, 23]]
[[21], [22, 23, 24]]
[[21], [22, 23], [24]]
[[21, 24], [22], [23]]
[[21], [22, 24], [23]]
[[21], [22], [23, 24]]
[[21], [22], [23], [24]]
```

Return generator of list of lists.

sequencetools.yield_all_subsequences_of_sequence

`abjad.tools.sequencetools.yield_all_subsequences_of_sequence(sequence, min_length=0, max_length=None)`

New in version 2.0. Yield all subsequences of *sequence* in lex order:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> list(sequencetools.yield_all_subsequences_of_sequence([0, 1, 2]))
[[], [0], [0, 1], [0, 1, 2], [1], [1, 2], [2]]
```

Yield all subsequences of *sequence* greater than or equal to *min_length* in lex order:

```
abjad> list(sequencetools.yield_all_subsequences_of_sequence([0, 1, 2, 3, 4], min_length = 3))
[[0, 1, 2], [0, 1, 2, 3], [0, 1, 2, 3, 4], [1, 2, 3], [1, 2, 3, 4], [2, 3, 4]]
```

Yield all subsequences of *sequence* less than or equal to *max_length* in lex order:

```
abjad> list(sequencetools.yield_all_subsequences_of_sequence([0, 1, 2, 3, 4], max_length = 3))
[[], [0], [0, 1], [0, 1, 2], [1], [1, 2], [1, 2, 3], [2], [2, 3], [2, 3, 4], [3], [3, 4], [4]]
```

Yield all subsequences of *sequence* greater than or equal to *min_length* and less than or equal to *max_length* in lex order:

```
abjad> list(sequencetools.yield_all_subsequences_of_sequence([0, 1, 2, 3, 4], min_length = 3, max_length = 4))
[[0, 1, 2], [1, 2, 3], [2, 3, 4]]
```

Return generator of newly created *sequence* slices.

sequencetools.yield_all_unordered_pairs_of_sequence

`abjad.tools.sequencetools.yield_all_unordered_pairs_of_sequence(sequence)`

New in version 2.0. Yield all unordered pairs of *sequence*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> list(sequencetools.yield_all_unordered_pairs_of_sequence([1, 2, 3, 4]))
[(1, 2), (1, 3), (1, 4), (2, 3), (2, 4), (3, 4)]
```

Yield all unordered pairs of length-1 *sequence*:

```
abjad> list(sequencetools.yield_all_unordered_pairs_of_sequence([1]))
[]
```

Yield all unordered pairs of empty *sequence*:

```
abjad> list(sequencetools.yield_all_unordered_pairs_of_sequence([]))
[]
```

Yield all unordered pairs of *sequence* with duplicate elements:

```
abjad> list(sequencetools.yield_all_unordered_pairs_of_sequence([1, 1, 1]))
[(1, 1), (1, 1), (1, 1)]
```

Pairs are tuples instead of sets to accommodate duplicate *sequence* elements.

Return generator.

sequencetools.yield_outer_product_of_sequences

`abjad.tools.sequencetools.yield_outer_product_of_sequences(sequences)`

New in version 1.1. Yield outer product of *sequences*:

```
abjad> from abjad.tools import sequencetools
```

```
abjad> list(sequencetools.yield_outer_product_of_sequences([[1, 2, 3], ['a', 'b']]))
[[1, 'a'], [1, 'b'], [2, 'a'], [2, 'b'], [3, 'a'], [3, 'b']]
```

```
abjad> list(sequencetools.yield_outer_product_of_sequences([[1, 2, 3], ['a', 'b'], ['X', 'Y']]))
[[1, 'a', 'X'], [1, 'a', 'Y'], [1, 'b', 'X'], [1, 'b', 'Y'],
 [2, 'a', 'X'], [2, 'a', 'Y'], [2, 'b', 'X'], [2, 'b', 'Y'],
 [3, 'a', 'X'], [3, 'a', 'Y'], [3, 'b', 'X'], [3, 'b', 'Y']]
```

```
abjad> list(sequencetools.yield_outer_product_of_sequences([[1, 2, 3], [4, 5], [6, 7, 8]]))
[[1, 4, 6], [1, 4, 7], [1, 4, 8], [1, 5, 6], [1, 5, 7], [1, 5, 8],
 [2, 4, 6], [2, 4, 7], [2, 4, 8], [2, 5, 6], [2, 5, 7], [2, 5, 8],
 [3, 4, 6], [3, 4, 7], [3, 4, 8], [3, 5, 6], [3, 5, 7], [3, 5, 8]]
```

Return generator. Changed in version 2.0: renamed `sequencetools.outer_product()` to `sequencetools.yield_outer_product_of_sequences()`.

sequencetools.zip_sequences_cyclically

`abjad.tools.sequencetools.zip_sequences_cyclically(*sequences)`

New in version 1.1. Zip *sequences* cyclically:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.zip_sequences_cyclically([1, 2, 3], ['a', 'b'])
[(1, 'a'), (2, 'b'), (3, 'a')]
```

New in version 1.1: Arbitrary number of input sequences now allowed.

```
abjad> sequencetools.zip_sequences_cyclically([10, 11, 12], [20, 21], [30, 31, 32, 33])
[(10, 20, 30), (11, 21, 31), (12, 20, 32), (10, 21, 33)]
```

Cycle over the elements of the sequences of shorter length.

Return list of length equal to sequence of greatest length in *sequences*. Changed in version 2.0: renamed `sequencetools.zip_cyclic()` to `sequencetools.zip_sequences_cyclically()`.

sequencetools.zip_sequences_without_truncation

`abjad.tools.sequencetools.zip_sequences_without_truncation(*sequences)`

New in version 1.1. Zip *sequences* nontruncating:

```
abjad> from abjad.tools import sequencetools

abjad> sequencetools.zip_sequences_without_truncation([1, 2, 3, 4], [11, 12, 13], [21, 22, 23])
[(1, 11, 21), (2, 12, 22), (3, 13, 23), (4,)]
```

Lengths of the tuples returned may differ but will always be greater than or equal to 1.

Return list of tuples. Changed in version 2.0: renamed `sequencetools.zip_nontruncating()` to `sequencetools.zip_sequences_without_truncation()`.

sievetools

sievetools.ResidueClass

class `abjad.tools.sievetools.ResidueClass(*args)`

Bases: `abjad.tools.sievetools._BaseResidueClass._BaseResidueClass._BaseResidueClass`, `abjad.core._Immutable._Immutable._Immutable`

Residue class (or congruence class). Residue classes form the basis of Xenakis sieves. They can be used to construct any complex periodic integer (or boolean) sequence as a combination of simple periodic sequences.

Example from the opening of Xenakis's *Psappha* for solo percussion:

```
abjad> from abjad.tools.sievetools import ResidueClass as RC

abjad> s1 = (RC(8, 0) | RC(8, 1) | RC(8, 7)) & (RC(5, 1) | RC(5, 3))
abjad> s2 = (RC(8, 0) | RC(8, 1) | RC(8, 2)) & RC(5, 0)
abjad> s3 = RC(8, 3)
abjad> s4 = RC(8, 4)
abjad> s5 = (RC(8, 5) | RC(8, 6)) & (RC(5, 2) | RC(5, 3) | RC(5, 4))
abjad> s6 = (RC(8, 1) & RC(5, 2))
abjad> s7 = (RC(8, 6) & RC(5, 1))
```

```

abjad> y = s1 | s2 | s3 | s4 | s5 | s6 | s7
abjad> y
{{ResidueClass(8, 0) | ResidueClass(8, 1) | ResidueClass(8, 7)} & {ResidueClass(5, 1) | ResidueClass(5, 2) | ResidueClass(5, 3) | ResidueClass(5, 4) | ResidueClass(5, 5) | ResidueClass(5, 6)}}
abjad> y.get_congruent_bases(40)
[0, 1, 3, 4, 6, 8, 10, 11, 12, 13, 14, 16, 17, 19, 20, 22, 23, 25, 27, 28, 29, 31, 33, 35, 36, 37, 38, 40]
abjad> y.get_boolean_train(40)
[1, 1, 0, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0]

```

Return residue class.

get_boolean_train (*min_max)

Returns a boolean train with 0s mapped to the integers that are not congruent bases of the residue class and 1s mapped to those that are. The method takes one or two integer arguments. If only one is given, it is taken as the max range and the min is assumed to be 0.

Example:

```

abjad> from abjad.tools.sievetools import ResidueClass as RC

abjad> r = RC(3, 0)
abjad> r.get_boolean_train(6)
[1, 0, 0, 1, 0, 0]
abjad> r.get_congruent_bases(-6, 6)
[-6, -3, 0, 3, 6]

```

Return list.

get_congruent_bases (*min_max)

Returns all the congruent bases of this residue class within the given range. The method takes one or two integer arguments. If only one is given, it is taken as the max range and the min is assumed to be 0.

Example:

```

abjad> from abjad.tools.sievetools import ResidueClass as RC

abjad> r = RC(3, 0)
abjad> r.get_congruent_bases(6)
[0, 3, 6]
abjad> r.get_congruent_bases(-6, 6)
[-6, -3, 0, 3, 6]

```

Return list.

modulo

Period of residue class.

residue

Residue of residue class.

sievetools.ResidueClassExpression

class abjad.tools.sievetools.**ResidueClassExpression** (rcs, operator='or')

Bases: abjad.tools.sievetools._BaseResidueClass._BaseResidueClass._BaseResidueClass, abjad.core._Immutable._Immutable._Immutable

get_boolean_train (*min_max)

Returns a boolean train with 0s mapped to the integers that are not congruent bases of the RC expression

and 1s mapped to those that are. The method takes one or two integer arguments. If only one is given, it is taken as the max range and min is assumed to be 0.

Example:

```
abjad> from abjad.tools.sievetools import ResidueClass as RC

abjad> e = RC(3, 0) | RC(2, 0)
abjad> e.get_boolean_train(6)
[1, 0, 1, 1, 1, 0]
abjad> e.get_congruent_bases(-6, 6)
[-6, -4, -3, -2, 0, 2, 3, 4, 6]
```

Return list.

get_congruent_bases (*min_max)

Returns all the congruent bases of this RC expression within the given range. The method takes one or two integer arguments. If only one it given, it is taken as the max range and min is assumed to be 0.

Example:

```
abjad> from abjad.tools.sievetools import ResidueClass as RC

abjad> e = RC(3, 0) | RC(2, 0)
abjad> e.get_congruent_bases(6)
[0, 2, 3, 4, 6]
abjad> e.get_congruent_bases(-6, 6)
[-6, -4, -3, -2, 0, 2, 3, 4, 6]
```

Return list.

is_congruent_base (integer)

operator

Operator of residue class expression.

period

rcls

Residue classes of expression.

representative_boolean_train

representative_congruent_bases

sievetools.all_are_residue_class_expressions

abjad.tools.sievetools.all_are_residue_class_expressions (expr)

New in version 2.6. True when *expr* is a sequence of Abjad residue class expressions:

```
abjad> from abjad.tools import sievetools

abjad> sieve = sievetools.ResidueClass(3, 0) | sievetools.ResidueClass(2, 0)

abjad> sieve
{ResidueClass(2, 0) | ResidueClass(3, 0)}

abjad> sievetools.all_are_residue_class_expressions([sieve])
True
```

True when *expr* is an empty sequence:

```
abjad> sievetools.all_are_residue_class_expressions([])
True
```

Otherwise false:

```
abjad> sievetools.all_are_residue_class_expressions('foo')
False
```

Return boolean.

sievetools.cycle_tokens_to_sieve

`abjad.tools.sievetools.cycle_tokens_to_sieve(*cycle_tokens)`

New in version 2.0. Make Xenakis sieve from arbitrarily many *cycle_tokens*.

```
abjad> from abjad.tools import sievetools
```

```
abjad> cycle_token_1 = (6, [0, 4, 5])
abjad> cycle_token_2 = (10, [0, 1, 2], 6)
abjad> sievetools.cycle_tokens_to_sieve(cycle_token_1, cycle_token_2)
{ResidueClass(6, 0) | ResidueClass(6, 4) | ResidueClass(6, 5) | ResidueClass(10, 6) | ResidueClass(10, 1) | ResidueClass(10, 2)}
```

Cycle token comprises mandatory *modulo*, mandatory *residues* and optional *offset*.

tempotools

tempotools.integer_tempo_to_multiplier_tempo_pairs

`abjad.tools.tempotools.integer_tempo_to_multiplier_tempo_pairs(integer_tempo, maxi-
mum_numerator=None, maxi-
mum_denominator=None)`

New in version 2.0. Return all multiplier, tempo pairs possible from *integer_tempo*.

Tempi must be no less than $\text{integer_tempo} / 2$ and not greater than $2 * \text{integer_tempo}$:

```
abjad> from abjad.tools import tempotools
```

```
abjad> pairs = tempotools.integer_tempo_to_multiplier_tempo_pairs(58, 8, 8)
abjad> for pair in pairs:
...     pair
...
(Fraction(1, 2), Fraction(29, 1))
(Fraction(1, 1), Fraction(58, 1))
(Fraction(3, 2), Fraction(87, 1))
(Fraction(2, 1), Fraction(116, 1))
```

Return list.

tempotools.integer_tempo_to_multiplier_tempo_pairs_report

`abjad.tools.tempotools.integer_tempo_to_multiplier_tempo_pairs_report` (*integer_tempo*,
maxi-
mum_numerator=None,
maxi-
mum_denominator=None)

New in version 2.0. Print all multiplier, tempo pairs possible from *integer_tempo*.

Allow no tempi less than $\text{integer_tempo} / 2$ nor greater than $2 * \text{integer_tempo}$:

```
abjad> from abjad.tools import tempotools
```

```
abjad> tempotools.integer_tempo_to_multiplier_tempo_pairs_report(58, 8, 8)
2:1      29
1:1      58
2:3      87
1:2     116
```

With more lenient numerator and denominator.

```
abjad> tempotools.integer_tempo_to_multiplier_tempo_pairs_report(58, 30, 30)
2:1      29
29:15    30
29:16    32
29:17    34
29:18    36
29:19    38
29:20    40
29:21    42
29:22    44
29:23    46
29:24    48
29:25    50
29:26    52
29:27    54
29:28    56
1:1      58
29:30    60
2:3      87
1:2     116
```

Return none.

threadtools

threadtools.component_to_thread_signature

`abjad.tools.threadtools.component_to_thread_signature` (*component*)
 Return `_ContainmentSignature` giving the root and first voice, staff and score in parentage of *component*.

threadtools.iterate_thread_backward_from_component

`abjad.tools.threadtools.iterate_thread_backward_from_component` (*component*,
klass=None)
 New in version 2.0. Yield right-to-left components in the thread of *component* starting from *component*.
 When `klass = None` return all components in the thread of *component*.

When *klass* is set to some other Abjad class, yield only *klass* instances in the thread of *component*:

```
abjad> from abjad.tools import threadtools

abjad> container = Container(Voice(notetools.make_repeated_notes(2)) * 2)
abjad> container.is_parallel = True
abjad> container[0].name = 'voice 1'
abjad> container[1].name = 'voice 2'
abjad> staff = Staff(container * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> print staff.format
\new Staff {
  <<
    \context Voice = "voice 1" {
      c'8
      d'8
    }
    \context Voice = "voice 2" {
      e'8
      f'8
    }
  >>
  <<
    \context Voice = "voice 1" {
      g'8
      a'8
    }
    \context Voice = "voice 2" {
      b'8
      c''8
    }
  >>
}
```

Starting from the last leaf in score.

```
abjad> for x in threadtools.iterate_thread_backward_from_component(staff.leaves[-1], Note):
...     x
Note("c'8")
Note("b'8")
Note("f'8")
Note("e'8")
```

Yield all components in thread:

```
abjad> for x in threadtools.iterate_thread_backward_from_component(staff.leaves[-1]):
...     x
Note("c'8")
Voice-"voice 2"{2}
Note("b'8")
Voice-"voice 2"{2}
Note("f'8")
Note("e'8")
```

Note that this function is a special type of depth-first search.

Compare	with	<code>threadtools.iterate_thread_backward_in_expr()</code> .
Changed in version 2.0:	renamed	<code>iterate.thread_backward_from()</code> to
		<code>threadtools.iterate_thread_backward_from_component()</code> .
Changed in version 2.0:	renamed	<code>iterate.thread_backward_from_component()</code> to

```
threadtools.iterate_thread_backward_from_component().
```

threadtools.iterate_thread_backward_in_expr

abjad.tools.threadtools.**iterate_thread_backward_in_expr**(*expr*, *class*, *thread_signature*)

New in version 2.0. Yield right-to-left instances of *class* in *expr* with *thread_signature*:

```
abjad> from abjad.tools import threadtools

abjad> container = Container(Voice(notetools.make_repeated_notes(2)) * 2)
abjad> container.is_parallel = True
abjad> container[0].name = 'voice 1'
abjad> container[1].name = 'vocie 2'
abjad> staff = Staff(container * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> f(staff)
\new Staff {
  <<
    \context Voice = "voice 1" {
      c'8
      d'8
    }
    \context Voice = "vocie 2" {
      e'8
      f'8
    }
  >>
  <<
    \context Voice = "voice 1" {
      g'8
      a'8
    }
    \context Voice = "vocie 2" {
      b'8
      c''8
    }
  >>
}

abjad> signature = threadtools.component_to_thread_signature(staff[0])
abjad> for x in threadtools.iterate_thread_backward_in_expr(staff, Note, signature): # doctest:
...     x
Note("c''8")
Note("b'8")
Note("f'8")
Note("e'8")
```

The important thing to note is that the function yields only those leaves that sit in the same thread.

Compare with `componenttools.iterate_components_backward_in_expr()`.
 Changed in version 2.0: renamed `iterate.thread_backward_in()` to `threadtools.iterate_thread_backward_in_expr()`.

threadtools.iterate_thread_forward_from_component

`abjad.tools.threadtools.iterate_thread_forward_from_component` (*component*,
klass=None)

New in version 1.1. Yield left-to-right components in the thread of *component* starting from *component*.

When *klass* = *None* return all components in the thread of *component*.

When *klass* is set to some other Abjad class, yield only *klass* instances in the thread of *component*:

```
abjad> from abjad.tools import threadtools
```

```
abjad> container = Container(Voice(notetools.make_repeated_notes(2)) * 2)
abjad> container.is_parallel = True
abjad> container[0].name = 'voice 1'
abjad> container[1].name = 'voice 2'
abjad> staff = Staff(container * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> print staff.format
\new Staff {
  <<
    \context Voice = "voice 1" {
      c'8
      d'8
    }
    \context Voice = "voice 2" {
      e'8
      f'8
    }
  >>
  <<
    \context Voice = "voice 1" {
      g'8
      a'8
    }
    \context Voice = "voice 2" {
      b'8
      c''8
    }
  >>
}
```

Starting from the first leaf in score.

```
abjad> for x in threadtools.iterate_thread_forward_from_component(staff.leaves[0], Note):
...     x
...
Note("c'8")
Note("d'8")
Note("g'8")
Note("a'8")
```

Starting from the second leaf in score.

```
abjad> for x in threadtools.iterate_thread_forward_from_component(staff.leaves[1], Note):
...     x
...
Note("d'8")
Note("g'8")
Note("a'8")
```

Yield all components in thread.

```
abjad> for x in threadtools.iterate_thread_forward_from_component(staff.leaves[0]):
...     x
...
Note("c'8")
Voice-"voice 1"{2}
Note("d'8")
Voice-"voice 1"{2}
Note("g'8")
Note("a'8")
```

Note that this function is a special type of depth-first search.

Compare with `threadtools.iterate_thread_forward_in_expr()`.
Changed in version 2.0: renamed `iterate.thread_forward_from()` to
`threadtools.iterate_thread_forward_from_component()`. Changed in
version 2.0: renamed `iterate.thread_forward_from_component()` to
`threadtools.iterate_thread_forward_from_component()`.

`threadtools.iterate_thread_forward_in_expr`

`abjad.tools.threadtools.iterate_thread_forward_in_expr(expr, class, thread_signature)`

New in version 1.1. Yield left-to-right instances of *class* in *expr* with *thread_signature*:

```
abjad> from abjad.tools import threadtools

abjad> container = Container(Voice(notetools.make_repeated_notes(2)) * 2)
abjad> container.is_parallel = True
abjad> container[0].name = 'voice 1'
abjad> container[1].name = 'voice 2'
abjad> staff = Staff(container * 2)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(staff)
abjad> print staff.format
\new Staff {
  <<
    \context Voice = "voice 1" {
      c'8
      d'8
    }
    \context Voice = "voice 2" {
      e'8
      f'8
    }
  >>
  <<
    \context Voice = "voice 1" {
      g'8
      a'8
    }
    \context Voice = "voice 2" {
      b'8
      c''8
    }
  >>
}
```

```
abjad> signature = threadtools.component_to_thread_signature(staff.leaves[0])
abjad> for x in threadtools.iterate_thread_forward_in_expr(staff, Note, signature):
...     x
...
Note("c'8")
Note("d'8")
Note("g'8")
Note("a'8")
```

The important thing to note is that the function yields only those leaves that sit in the same thread.

Compare with `componenttools.iterate_components_forward_in_expr()`.
 Changed in version 2.0: renamed `iterate.thread_forward_in()`
 to `threadtools.iterate_thread_forward_in_expr()`. Changed in
 version 2.0: renamed `iterate.thread_forward_in_expr()` to
`threadtools.iterate_thread_forward_in_expr()`.

`timesignaturetools`

`timesignaturetools.duration_and_possible_denominators_to_time_signature`

`abjad.tools.timesignaturetools.duration_and_possible_denominators_to_time_signature` (*duration*, *de-*
nom-
i-
na-
tors=None, *fac-*
tor=None)

Make new meter equal to *duration*:

```
abjad> from abjad.tools import timesignaturetools
```

```
abjad> timesignaturetools.duration_and_possible_denominators_to_time_signature(Duration(3, 2))
TimeSignatureMark((3, 2))
```

Make new meter equal to *duration* with denominator equal to the first possible element in *denominators*:

```
abjad> timesignaturetools.duration_and_possible_denominators_to_time_signature(Duration(3, 2), d
TimeSignatureMark((9, 6))
```

Make new meter equal to *duration* with denominator divisible by *factor*:

```
abjad> timesignaturetools.duration_and_possible_denominators_to_time_signature(Duration(3, 2), f
TimeSignatureMark((15, 10))
```

Return new meter. Changed in version 2.0: renamed `timesignaturetools.make_best()` to
`timesignaturetools.duration_and_possible_denominators_to_time_signature()`.

`timesignaturetools.get_nonbinary_factor_from_time_signature_denominator`

`abjad.tools.timesignaturetools.get_nonbinary_factor_from_time_signature_denominator` (*meter*)
 Get nonbinary factor from nonbinary *meter* denominator:

```
abjad> from abjad.tools import timesignaturetools
```

```
abjad> timesignaturetools.get_nonbinary_factor_from_time_signature_denominator(contexttools.TimeSignatureMark((2, 3))
3
```

```
abjad> timesignaturetools.get_nonbinary_factor_from_time_signature_denominator(contexttools.TimeSignatureMark((2, 13))
13
```

```
abjad> timesignaturetools.get_nonbinary_factor_from_time_signature_denominator(contexttools.TimeSignatureMark((2, 7))
7
```

```
abjad> timesignaturetools.get_nonbinary_factor_from_time_signature_denominator(contexttools.TimeSignatureMark((2, 15))
15
```

Get 1 from binary *meter* denominator:

```
abjad> timesignaturetools.get_nonbinary_factor_from_time_signature_denominator(contexttools.TimeSignatureMark((2, 1))
1
```

Return nonnegative integer.

timesignaturetools.is_time_signature_with_equivalent_binary_representation

`abjad.tools.timesignaturetools.is_time_signature_with_equivalent_binary_representation(expr)`
 True when *expr* is a meter with binary-valued duration:

```
abjad> from abjad.tools import timesignaturetools
```

```
abjad> timesignaturetools.is_time_signature_with_equivalent_binary_representation(contexttools.TimeSignatureMark((2, 4))
True
```

Otherwise false:

```
abjad> timesignaturetools.is_time_signature_with_equivalent_binary_representation(contexttools.TimeSignatureMark((3, 4))
False
```

```
abjad> timesignaturetools.is_time_signature_with_equivalent_binary_representation('text')
False
```

Return boolean.

timesignaturetools.time_signature_to_binary_time_signature

`abjad.tools.timesignaturetools.time_signature_to_binary_time_signature(nonbinary_meter, contents_multiplier=Fraction(1, 1))`

Change nonbinary *meter* to binary meter:

```
abjad> from abjad.tools import timesignaturetools
```

```
abjad> timesignaturetools.time_signature_to_binary_time_signature(contexttools.TimeSignatureMark((2, 8))
TimeSignatureMark((2, 8))
```

Preserve binary *meter*:

```
abjad> timesignaturetools.time_signature_to_binary_time_signature(contexttools.TimeSignatureMark((2, 8))
TimeSignatureMark((2, 8))
```

Return newly constructed meter. Changed in version 2.0: renamed `timesignaturetools.make_binary()` to `timesignaturetools.time_signature_to_binary_time_signature`

`tonalitytools`

`tonalitytools.ChordClass`

class `abjad.tools.tonalitytools.ChordClass`

Bases: `abjad.tools.pitchtools.NamedChromaticPitchClassSet.NamedChromaticPitchClassSet`.
 New in version 2.0. Abjad model of tonal chords like G 7, G 6/5, G half-diminished 6/5, etc.

Note that notions like G 7 represent an entire *class of* chords because there are many different spacings and registrations of a G 7 chord.

bass
cardinality
extent
figured_bass
inversion
markup
quality_indicator
quality_pair
root
root_string
transpose (*mdi*)

`tonalitytools.ChordQualityIndicator`

class `abjad.tools.tonalitytools.ChordQualityIndicator`

Bases: `abjad.tools.pitchtools.HarmonicDiatonicIntervalSegment.HarmonicDiatonicIntervalSegment`.
 New in version 2.0. Chord quality indicator.

cardinality
extent
extent_name
inversion
position
quality_string
rotation

`tonalitytools.DoublingIndicator`

class `abjad.tools.tonalitytools.DoublingIndicator` (*doublings*)

Bases: `abjad.core._Immutable._Immutable._Immutable` New in version 2.0. Indicator of chord doubling.

Value object that can not be changed after instantiation.

doublings

tonalitytools.ExtentIndicator

class abjad.tools.tonalitytools.**ExtentIndicator** (*arg*)

Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Indicator of chord extent, such as triad, seventh chord, ninth chord, etc.

Value object that can not be changed after instantiation.

name

number

tonalitytools.InversionIndicator

class abjad.tools.tonalitytools.**InversionIndicator** (*arg=0*)

Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Indicator of the inversion of tertian chords: 5, 63, 64 and also 7, 65, 43, 42, etc. Also root position, first, second, third inversions, etc.

Value object that can not be changed once initialized.

extent_to_figured_bass_string (*extent*)

name

number

title

tonalitytools.Mode

class abjad.tools.tonalitytools.**Mode** (*arg*)

Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Diatonic mode. Can be extended for nondiatonic mode.

Modes with different ascending and descending forms not yet implemented.

melodic_diatonic_interval_segment

mode_name

tonalitytools.OmissionIndicator

class abjad.tools.tonalitytools.**OmissionIndicator**

Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Indicator of missing chord tones.

Value object that can not be changed after instantiation.

tonalitytools.QualityIndicator

class abjad.tools.tonalitytools.**QualityIndicator** (*quality_string*)

Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Indicator of chord quality, such as major, minor, dominant, diminished, etc.

Value object that can not be changed after instantiation.

is_uppercase

quality_string

tonalitytools.Scale

class abjad.tools.tonalitytools.**Scale**

Bases: abjad.tools.pitchtools.NamedChromaticPitchClassSegment.NamedChromaticPitchClassSegment New in version 2.0. Abjad model of diatonic scale.

diatonic_interval_class_segment

dominant

key_signature

leading_tone

mediant

named_chromatic_pitch_class_to_scale_degree (**args*)

scale_degree_to_named_chromatic_pitch_class (**args*)

subdominant

submediant

superdominant

tonic

tonalitytools.ScaleDegree

class abjad.tools.tonalitytools.**ScaleDegree** (**args*)

Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Abjad model of diatonic scale degrees 1, 2, 3, 4, 5, 6, 7 and also chromatic alterations including flat-2, flat-3, flat-6, etc.

accidental

Read-only accidental applied to scale degree.

apply_accidental (*accidental*)

Apply accidental to self and emit new instance.

name

Read-only name of scale degree.

number

Read-only number of diatonic scale degree from 1 to 7, inclusive.

roman_numeral_string

symbolic_string

title_string

tonalitytools.SuspensionIndicator

```
class abjad.tools.tonalitytools.SuspensionIndicator(*args)
    Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Indicator of 9-8,
    7-6, 4-3, 2-1 and other types of suspension typical of, for example, the Bach chorales.

    Value object that can not be changed after instantiation.

    chord_name
    figured_bass_pair
    figured_bass_string
    is_empty
    start
    stop
    title_string
```

tonalitytools.TonalFunction

```
class abjad.tools.tonalitytools.TonalFunction(*args)
    Bases: abjad.core._Immutable._Immutable._Immutable New in version 2.0. Abjad model of
    functions in tonal harmony: I, I6, I64, V, V7, V43, V42, bII, bII6, etc., also i, i6, i64, v, v7, etc.

    Value object that can not be cahnged after instantiation.

    bass_scale_degree
    extent
    figured_bass_string
    inversion
    markup
    quality
    root_scale_degree
    scale_degree
    suspension
    symbolic_string
```

tonalitytools.analyze_chord

```
abjad.tools.tonalitytools.analyze_chord(expr)
    New in version 2.0. Analyze expr and return chord class.

    abjad> from abjad.tools import tonalitytools

    abjad> chord = Chord([7, 10, 12, 16], (1, 4))
    abjad> tonalitytools.analyze_chord(chord)
    CDominantSeventhInSecondInversion

    Return none when no tonal chord is understood.
```

```
abjad> chord = Chord(['c', 'cs', 'd'], (1, 4))
abjad> tonalitytools.analyze_chord(chord) is None
True
```

Raise tonal harmony error when chord can not analyze.

tonalitytools.analyze_incomplete_chord

`abjad.tools.tonalitytools.analyze_incomplete_chord(expr)`

New in version 2.0. Analyze *expr* and return chord class based on incomplete pitches.

```
abjad> from abjad.tools import tonalitytools

abjad> tonalitytools.analyze_incomplete_chord(Chord([7, 11], (1, 4)))
GMajorTriadInRootPosition

abjad> tonalitytools.analyze_incomplete_chord(Chord(['fs', 'g', 'b'], (1, 4)))
GMajorSeventhInSecondInversion
```

Return chord class.

tonalitytools.analyze_incomplete_tonal_function

`abjad.tools.tonalitytools.analyze_incomplete_tonal_function(expr, key_signature)`

New in version 2.0. Analyze tonal function of *expr* according to *key_signature*:

```
abjad> from abjad.tools import tonalitytools

abjad> chord = Chord("<c' e'>4")
abjad> key_signature = contexttools.KeySignatureMark('g', 'major')
abjad> tonalitytools.analyze_incomplete_tonal_function(chord, key_signature)
IVMajorTriadInRootPosition
```

Return tonal function.

tonalitytools.analyze_tonal_function

`abjad.tools.tonalitytools.analyze_tonal_function(expr, key_signature)`

New in version 2.0. Analyze *expr* and return tonal function according to *key_signature*.

```
abjad> from abjad.tools import tonalitytools

abjad> chord = Chord(['ef', 'g', 'bf'], (1, 4))
abjad> key_signature = contexttools.KeySignatureMark('c', 'major')
abjad> tonalitytools.analyze_tonal_function(chord, key_signature)
FlatIIIMajorTriadInRootPosition
```

Return none when no tonal function is understood.

```
abjad> chord = Chord(['c', 'cs', 'd'], (1, 4))
abjad> key_signature = contexttools.KeySignatureMark('c', 'major')
abjad> tonalitytools.analyze_tonal_function(chord, key_signature) is None
True
```

Return tonal function or none.

tonalitytools.are_scalar_notes

`abjad.tools.tonalitytools.are_scalar_notes(*expr)`

New in version 2.0. True when notes in *expr* are scalar.

```
abjad> from abjad.tools import tonalitytools
```

```
abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> tonalitytools.are_scalar_notes(t[:])
True
```

Otherwise false.

```
abjad> tonalitytools.are_scalar_notes(Note("c'4"), Note("c'4"))
False
```

Changed in version 2.0: renamed `tonalitytools.are_scalar()` to `tonalitytools.are_scalar_notes()`.

tonalitytools.are_stepwise_ascending_notes

`abjad.tools.tonalitytools.are_stepwise_ascending_notes(*expr)`

New in version 2.0. True when notes in *expr* are stepwise ascending.

```
abjad> from abjad.tools import tonalitytools
```

```
abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> tonalitytools.are_stepwise_ascending_notes(t[:])
True
```

Otherwise false.

```
abjad> tonalitytools.are_stepwise_ascending_notes(Note("c'4"), Note("c'4"))
False
```

Changed in version 2.0: renamed `tonalitytools.are_stepwise_ascending()` to `tonalitytools.are_stepwise_ascending_notes()`.

tonalitytools.are_stepwise_descending_notes

`abjad.tools.tonalitytools.are_stepwise_descending_notes(*expr)`

New in version 2.0. True when notes in *expr* are stepwise descending:

```
abjad> from abjad.tools import tonalitytools
```

```
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]
abjad> t = Staff(list(reversed(notes)))
abjad> tonalitytools.are_stepwise_descending_notes(t[:])
True
```

Otherwise false:

```
abjad> tonalitytools.are_stepwise_descending_notes(Note("c'4"), Note("c'4"))
False
```

Changed in version 2.0: renamed `tonalitytools.are_stepwise_descending()` to `tonalitytools.are_stepwise_descending_notes()`.

tonalitytools.are_stepwise_notes

`abjad.tools.tonalitytools.are_stepwise_notes(*expr)`

New in version 2.0. True when notes in *expr* are stepwise.

```
abjad> from abjad.tools import tonalitytools
```

```
abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> tonalitytools.are_stepwise_notes(t[:])
True
```

Otherwise false.

```
abjad> tonalitytools.are_stepwise_notes(Note("c'4"), Note("c'4"))
False
```

Changed in version 2.0: renamed `tonalitytools.are_stepwise()` to `tonalitytools.are_stepwise_notes()`.

tonalitytools.chord_class_cardinality_to_extent

`abjad.tools.tonalitytools.chord_class_cardinality_to_extent(cardinality)`

..versionadded:: 2.0

Change integer chord class *cardinality* to integer chord class extent:

```
abjad> from abjad.tools import tonalitytools
```

```
abjad> tonalitytools.chord_class_cardinality_to_extent(4)
7
```

The function above indicates that a tertian chord with 4 unique pitches qualifies as a seventh chord.

tonalitytools.chord_class_extent_to_cardinality

`abjad.tools.tonalitytools.chord_class_extent_to_cardinality(extent)`

..versionadded:: 2.0

Change integer chord class *extent* to integer chord class cardinality:

```
abjad> from abjad.tools import tonalitytools
```

```
abjad> tonalitytools.chord_class_extent_to_cardinality(7)
4
```

The call above shows that a seventh chord comprises 4 unique pitch-classes.

tonalitytools.chord_class_extent_to_extent_name

`abjad.tools.tonalitytools.chord_class_extent_to_extent_name(extent)`

New in version 2.0. Change integer chord class *extent* to extent name.

```
abjad> from abjad.tools import tonalitytools
```

```
abjad> tonalitytools.chord_class_extent_to_extent_name(7)
'seventh'
```

The call above shows that a tertian chord subtending 7 staff spaces qualifies as a seventh chord.

tonalitytools.diatonic_interval_class_segment_to_chord_quality_string

`abjad.tools.tonalitytools.diatonic_interval_class_segment_to_chord_quality_string(dic_seg)`
 New in version 2.0. Change diatonic interval-class segment *dic_seg* to chord quality string:

```
abjad> from abjad.tools import tonalitytools

abjad> dic_seg = pitchtools.InversionEquivalentDiatonicIntervalClassSegment([
...     pitchtools.InversionEquivalentDiatonicIntervalClass('major', 3),
...     pitchtools.InversionEquivalentDiatonicIntervalClass('minor', 3),])
abjad> tonalitytools.diatonic_interval_class_segment_to_chord_quality_string(dic_seg)
'major'
```

Todo

Implement `diatonic_interval_class_set_to_chord_quality_string()`.

tonalitytools.is_neighbor_note

`abjad.tools.tonalitytools.is_neighbor_note(note)`

New in version 2.0. True when *note* is preceeded by a stepwise interval in one direction and followed by a stepwise interval in the other direction. Otherwise false.

```
abjad> from abjad.tools import tonalitytools

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> for note in t:
...     print '%s\t%s' % (note, tonalitytools.is_neighbor_note(note))
...
c'8      False
d'8      False
e'8      False
f'8      False
```

Return boolean.

tonalitytools.is_passing_tone

`abjad.tools.tonalitytools.is_passing_tone(note)`

New in version 2.0. True when *note* is both preceeded and followed by scalewise sibling notes. Otherwise false.

```
abjad> from abjad.tools import tonalitytools

abjad> t = Staff("c'8 d'8 e'8 f'8")
abjad> for note in t:
...     print '%s\t%s' % (note, tonalitytools.is_passing_tone(note))
...
c'8      False
d'8      True
e'8      True
f'8      False
```

Return boolean.

tonalitytools.is_unlikely_melodic_diatonic_interval_in_chorale

`abjad.tools.tonalitytools.is_unlikely_melodic_diatonic_interval_in_chorale(mdi)`
 New in version 2.0. True when *mdi* is unlikely melodic diatonic interval in JSB chorale.

```
abjad> from abjad.tools import tonalitytools
```

```
abjad> mdi = pitchtools.MelodicDiatonicInterval('major', 7)
abjad> tonalitytools.is_unlikely_melodic_diatonic_interval_in_chorale(mdi)
True
```

Otherwise False.

```
abjad> mdi = pitchtools.MelodicDiatonicInterval('major', 2)
abjad> tonalitytools.is_unlikely_melodic_diatonic_interval_in_chorale(mdi)
False
```

Return boolean.

tonalitytools.make_all_notes_in_ascending_and_descending_diatonic_scale

`abjad.tools.tonalitytools.make_all_notes_in_ascending_and_descending_diatonic_scale(key_signature)`
 New in version 2.0. Construct one up-down period of scale according to *key_signature*:

```
abjad> from abjad.tools import tonalitytools
```

```
abjad> score = tonalitytools.make_all_notes_in_ascending_and_descending_diatonic_scale(contexttt)
abjad> f(score)
\new Score \with {
    tempoWholesPerMinute = #(ly:make-moment 30 1)
} <<
    \new Staff {
        \key e \major
        e'8
        fs'8
        gs'8
        a'8
        b'8
        cs''8
        ds''8
        e''8
        ds''8
        cs''8
        b'8
        a'8
        gs'8
        fs'8
        e'4
    }
>>
```

Changed in version 2.0: renamed `construct.scale_period()` to `tonalitytools.make_all_notes_in_ascending_and_descending_diatonic_scale()`. Changed in version 2.0: renamed `leaftools.make_all_notes_in_ascending_and_descending_diatonic_scale()` to `tonalitytools.make_all_notes_in_ascending_and_descending_diatonic_scale()`.

tonalitytools.make_first_n_notes_in_ascending_diatonic_scale

```
abjad.tools.tonalitytools.make_first_n_notes_in_ascending_diatonic_scale(count,
                                                                           writ-
                                                                           ten_duration=Duration(1.
                                                                           8),
                                                                           key_signature=None)
```

Construct *count* notes with *written_duration* according to *key_signature*:

```
abjad> from abjad.tools import tonalitytools

abjad> tonalitytools.make_first_n_notes_in_ascending_diatonic_scale(4)
[Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]
```

Allow nonassignable *written_duration*:

```
abjad> staff = Staff(tonalitytools.make_first_n_notes_in_ascending_diatonic_scale(2, (5, 16)))
abjad> f(staff)
\new Staff {
    c'4 ~
    c'16
    d'4 ~
    d'16
}
```

New in version 2.0: Optional *key_signature* keyword parameter. Changed in version 2.0: re-named `leaftools.make_first_n_notes_in_ascending_diatonic_scale()` to `tonalitytools.make_first_n_notes_in_ascending_diatonic_scale()`.

verticalitytools

verticalitytools.VerticalMoment

```
class abjad.tools.verticalitytools.VerticalMoment(prolated_offset, governors, components)
```

Bases: `abjad.core._Immutable._Immutable._Immutable`

Everything happening at a single moment in musical time:

```
abjad> from abjad.tools import verticalitytools

abjad> score = Score([scoretools.PianoStaff([Staff("c'4 e'4 d'4 f'4"), Staff('g2 f2')])])
abjad> contexttools.ClefMark('bass')(score[0][1])
ClefMark('bass')(Staff{2})

f(score)
\new Score <<
  \new PianoStaff <<
    \new Staff {
      c'4
      e'4
      d'4
      f'4
    }
    \new Staff {
      \clef "bass"
      g2
      f2
    }
  >>
>>
```



```

    }
    >>
>>

abjad> for vertical_moment in verticalitytools.iterate_vertical_moments_forward_in_expr(score):
...     vertical_moment
...
VerticalMoment(0, <<2>>)
VerticalMoment(1/4, <<2>>)
VerticalMoment(1/2, <<2>>)
VerticalMoment(3/4, <<2>>)

```

Create vertical moments with the getters and iterators implemented in the `verticalitytools` module.

Vertical moments are immutable.

attack_count

Positive integer number of pitch carriers starting at vertical moment.

components

Read-only tuple of zero or more components happening at vertical moment.

It is always the case that `self.components = self.overlap_components + self.start_components`.

governors

Read-only tuple of one or more containers in which vertical moment is evaluated.

leaves

Read-only tuple of zero or more leaves at vertical moment.

measures

Read-only tuple of zero or more measures at vertical moment.

next_vertical_moment

Read-only reference to next vertical moment forward in time.

notes

Read-only tuple of zero or more notes at vertical moment.

overlap_components

Read-only tuple of components in vertical moment starting before vertical moment, ordered by score index.

overlap_leaves

Read-only tuple of leaves in vertical moment starting before vertical moment, ordered by score index.

overlap_measures

Read-only tuple of measures in vertical moment starting before vertical moment, ordered by score index.

overlap_notes

Read-only tuple of notes in vertical moment starting before vertical moment, ordered by score index.

prev_vertical_moment

Read-only reference to prev vertical moment backward in time.

prolated_offset

Read-only rational-valued score offset at which vertical moment is evaluated.

start_components

Read-only tuple of components in vertical moment starting with at vertical moment, ordered by score index.

start_leaves

Read-only tuple of leaves in vertical moment starting with vertical moment, ordered by score index.

start_notes

Read-only tuple of notes in vertical moment starting with vertical moment, ordered by score index.

verticalitytools.get_vertical_moment_at_prolated_offset_in_expr

abjad.tools.verticalitytools.**get_vertical_moment_at_prolated_offset_in_expr**(*governor*,
*pro-
lated_offset*)

New in version 2.0. Get vertical moment at *prolated_offset* in *governor*:

```
abjad> from abjad.tools import verticalitytools

abjad> score = Score([])
abjad> score.append(Staff([tuplettools.FixedDurationTuplet(Duration(4, 8), notetools.make_repeat
abjad> piano_staff = scoretools.PianoStaff([])
abjad> piano_staff.append(Staff(notetools.make_repeated_notes(2, Duration(1, 4))))
abjad> piano_staff.append(Staff(notetools.make_repeated_notes(4)))
abjad> contexttools.ClefMark('bass')(piano_staff[1])
ClefMark('bass')(Staff{4})
abjad> score.append(piano_staff)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(list
abjad> f(score)
\new Score <<
  \new Staff {
    \fraction \times 4/3 {
      d''8
      c''8
      b'8
    }
  }
  \new PianoStaff <<
    \new Staff {
      a'4
      g'4
    }
    \new Staff {
      \clef "bass"
      f'8
      e'8
      d'8
      c'8
    }
  }
>>
>>
abjad> vertical_moment = verticalitytools.get_vertical_moment_at_prolated_offset_in_expr(piano_s
abjad> vertical_moment.leaves
(Note("a'4"), Note("e'8"))
```

Todo

optimize without full-component traversal.

Changed in version 2.0: renamed `iterate.get_vertical_moment_at_prolated_offset_in()` to `verticalitytools.get_vertical_moment_at_prolated_offset_in_expr()`.

verticalitytools.get_vertical_moment_starting_with_component

abjad.tools.verticalitytools.get_vertical_moment_starting_with_component(*expr*,
gov-
er-
nor=None)

New in version 2.0. When *governor* is none, get vertical moment at *expr*._offset.start in score root of *expr*:

```
abjad> from abjad.tools import verticalitytools

abjad> score = Score([])
abjad> score.append(Staff([tuplettools.FixedDurationTuplet(Duration(4, 8), notetools.make_repeat
abjad> piano_staff = scoretools.PianoStaff([])
abjad> piano_staff.append(Staff(notetools.make_repeated_notes(2, Duration(1, 4))))
abjad> piano_staff.append(Staff(notetools.make_repeated_notes(4)))
abjad> contexttools.ClefMark('bass')(piano_staff[1])
ClefMark('bass')(Staff{4})
abjad> score.append(piano_staff)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(list
abjad> f(score)
\new Score <<
  \new Staff {
    \fraction \times 4/3 {
      d''8
      c''8
      b'8
    }
  }
  \new PianoStaff <<
    \new Staff {
      a'4
      g'4
    }
    \new Staff {
      \clef "bass"
      f'8
      e'8
      d'8
      c'8
    }
  }
>>
>>
abjad> verticalitytools.get_vertical_moment_starting_with_component(piano_staff[1][1])
VerticalMoment(1/8, <<3>>)
```

When *governor* is not none, get vertical moment at *expr*._offset.start in *governor*.

```
abjad> verticalitytools.get_vertical_moment_starting_with_component(piano_staff[1][1], piano_sta
VerticalMoment(1/8, <<2>>)
```

Todo

optimize without full-component traversal.

Changed in version 2.0: renamed `iterate.get_vertical_moment_starting_with()` to `verticalitytools.get_vertical_moment_starting_with_component()`. Changed in

version 2.0: renamed `iterate.get_vertical_moment_starting_with_component()` to `verticalitytools.get_vertical_moment_starting_with_component()`.

`verticalitytools.iterate_vertical_moments_backward_in_expr`

`abjad.tools.verticalitytools.iterate_vertical_moments_backward_in_expr(governor)`

New in version 2.0. Yield vertical moments forward in *governor*:

```
abjad> from abjad.tools import verticalitytools

abjad> score = Score([])
abjad> score.append(Staff([tuplettools.FixedDurationTuplet(Duration(4, 8), notetools.make_repeat
abjad> piano_staff = scoretools.PianoStaff([])
abjad> piano_staff.append(Staff(notetools.make_repeated_notes(2, Duration(1, 4))))
abjad> piano_staff.append(Staff(notetools.make_repeated_notes(4)))
abjad> contexttools.ClefMark('bass')(piano_staff[1])
ClefMark('bass')(Staff{4})
abjad> score.append(piano_staff)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(lis
abjad> f(score)
\new Score <<
  \new Staff {
    \fraction \times 4/3 {
      d''8
      c''8
      b'8
    }
  }
  \new PianoStaff <<
    \new Staff {
      a'4
      g'4
    }
    \new Staff {
      \clef "bass"
      f'8
      e'8
      d'8
      c'8
    }
  }
>>
>>
abjad> for vertical_moment in verticalitytools.iterate_vertical_moments_backward_in_expr(score):
...     vertical_moment.leaves
...
(Note("b'8"), Note("g'4"), Note("c'8"))
(Note("b'8"), Note("g'4"), Note("d'8"))
(Note("c''8"), Note("g'4"), Note("d'8"))
(Note("c''8"), Note("a'4"), Note("e'8"))
(Note("d''8"), Note("a'4"), Note("e'8"))
(Note("d''8"), Note("a'4"), Note("f'8"))
abjad> for vertical_moment in verticalitytools.iterate_vertical_moments_backward_in_expr(piano_s
...     vertical_moment.leaves
...
(Note("g'4"), Note("c'8"))
(Note("g'4"), Note("d'8"))
(Note("a'4"), Note("e'8"))
(Note("a'4"), Note("f'8"))
```

Todo

optimize without multiple full-component traversal.

Changed in version 2.0: renamed `iterate.vertical_moments_backward_in()` to `verticalitytools.iterate_vertical_moments_backward_in_expr()`. Changed in version 2.0: renamed `iterate.vertical_moments_backward_in_expr()` to `verticalitytools.iterate_vertical_moments_backward_in_expr()`.

verticalitytools.iterate_vertical_moments_forward_in_expr

`abjad.tools.verticalitytools.iterate_vertical_moments_forward_in_expr(governor)`

New in version 2.0. Yield vertical moments forward in *governor*:

```
abjad> from abjad.tools import verticalitytools

abjad> score = Score([])
abjad> score.append(Staff([tuplettools.FixedDurationTuplet(Duration(4, 8), notetools.make_repeat
abjad> piano_staff = scoretools.PianoStaff([])
abjad> piano_staff.append(Staff(notetools.make_repeated_notes(2, Duration(1, 4))))
abjad> piano_staff.append(Staff(notetools.make_repeated_notes(4)))
abjad> contexttools.ClefMark('bass')(piano_staff[1])
ClefMark('bass')(Staff{4})
abjad> score.append(piano_staff)
abjad> pitchtools.set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr(list
abjad> f(score)
\new Score <<
  \new Staff {
    \fraction \times 4/3 {
      d''8
      c''8
      b'8
    }
  }
  \new PianoStaff <<
    \new Staff {
      a'4
      g'4
    }
    \new Staff {
      \clef "bass"
      f'8
      e'8
      d'8
      c'8
    }
  >>
>>
abjad> for vertical_moment in verticalitytools.iterate_vertical_moments_forward_in_expr(score):
...     vertical_moment.leaves
...
(Note("d''8"), Note("a'4"), Note("f'8"))
(Note("d''8"), Note("a'4"), Note("e'8"))
(Note("c''8"), Note("a'4"), Note("e'8"))
```

```
(Note("c'8"), Note("g'4"), Note("d'8"))
(Note("b'8"), Note("g'4"), Note("d'8"))
(Note("b'8"), Note("g'4"), Note("c'8"))
abjad> for vertical_moment in verticalitytools.iterate_vertical_moments_forward_in_expr(piano_st
...     vertical_moment.leaves
...
(Note("a'4"), Note("f'8"))
(Note("a'4"), Note("e'8"))
(Note("g'4"), Note("d'8"))
(Note("g'4"), Note("c'8"))
```

Todo

optimize without multiple full-component traversal.

Changed in version 2.0: renamed `iterate.vertical_moments_forward_in()` to `verticalitytools.iterate_vertical_moments_forward_in_expr()`. Changed in version 2.0: renamed `iterate.vertical_moments_forward_in_expr()` to `verticalitytools.iterate_vertical_moments_forward_in_expr()`.

`verticalitytools.label_vertical_moments_in_expr_with_chromatic_interval_classes`

`abjad.tools.verticalitytools.label_vertical_moments_in_expr_with_chromatic_interval_classes`

New in version 2.0. Label harmonic chromatic interval-classes of every vertical moment in *expr*:

```
abjad> from abjad.tools import verticalitytools

abjad> score = Score(Staff([]) * 3)
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]
abjad> score[0].extend(notes)
abjad> contexttools.ClefMark('alto')(score[1])
ClefMark('alto')(Staff{})
abjad> score[1].extend([Note(-5, (1, 4)), Note(-7, (1, 4))])
abjad> contexttools.ClefMark('bass')(score[2])
ClefMark('bass')(Staff{})
abjad> score[2].append(Note(-24, (1, 2)))
abjad> verticalitytools.label_vertical_moments_in_expr_with_chromatic_interval_classes(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8 _ \markup { \small { \column { 2 7 } } }
    e'8
    f'8 _ \markup { \small { \column { 5 5 } } }
  }
  \new Staff {
    \clef "alto"
    g4
    f4 _ \markup { \small { \column { 4 5 } } }
  }
  \new Staff {
    \clef "bass"
    c,2 _ \markup { \small { \column { 12 7 } } }
  }
>>
```

Changed in version 2.0: renamed `label.vertical_moment_chromatic_interval_classes()` to `verticalitytools.label_vertical_moments_in_expr_with_chromatic_interval_classes()`.

verticalitytools.label_vertical_moments_in_expr_with_chromatic_intervals

`abjad.tools.verticalitytools.label_vertical_moments_in_expr_with_chromatic_intervals`(*expr*, *markup*)

New in version 2.0. Label harmonic chromatic intervals of every vertical moment in *expr*:

```
abjad> from abjad.tools import verticalitytools

abjad> score = Score(Staff([]) * 3)
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]
abjad> score[0].extend(notes)
abjad> contexttools.ClefMark('alto')(score[1])
ClefMark('alto')(Staff{})
abjad> score[1].extend([Note(-5, (1, 4)), Note(-7, (1, 4))])
abjad> contexttools.ClefMark('bass')(score[2])
ClefMark('bass')(Staff{})
abjad> score[2].append(Note(-24, (1, 2)))
abjad> verticalitytools.label_vertical_moments_in_expr_with_chromatic_intervals(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8 _ \markup { \small { \column { 26 19 } } }
    e'8
    f'8 _ \markup { \small { \column { 29 17 } } }
  }
  \new Staff {
    \clef "alto"
    g4
    f4 _ \markup { \small { \column { 28 17 } } }
  }
  \new Staff {
    \clef "bass"
    c,2 _ \markup { \small { \column { 24 19 } } }
  }
>>
```

Changed in version 2.0: renamed `label.vertical_moment_chromatic_intervals()` to `verticalitytools.label_vertical_moments_in_expr_with_chromatic_intervals()`.

verticalitytools.label_vertical_moments_in_expr_with_counterpoint_intervals

`abjad.tools.verticalitytools.label_vertical_moments_in_expr_with_counterpoint_intervals`(*expr*, *markup*)

New in version 2.0. Label counterpoint interval of every vertical moment in *expr*:

```
abjad> from abjad.tools import verticalitytools

abjad> score = Score(Staff([]) * 3)
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]
abjad> score[0].extend(notes)
abjad> contexttools.ClefMark('alto')(score[1])
ClefMark('alto')(Staff{})
abjad> score[1].extend([Note(-5, (1, 4)), Note(-7, (1, 4))])
```

```

abjad> contexttools.ClefMark('bass')(score[2])
ClefMark('bass')(Staff{})
abjad> score[2].append(Note(-24, (1, 2)))
abjad> verticalitytools.label_vertical_moments_in_expr_with_counterpoint_intervals(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8 _ \markup { \small { \column { 2 5 } } }
    e'8
    f'8 _ \markup { \small { \column { 4 4 } } }
  }
  \new Staff {
    \clef "alto"
    g4
    f4 _ \markup { \small { \column { 3 4 } } }
  }
  \new Staff {
    \clef "bass"
    c,2 _ \markup { \small { \column { 8 5 } } }
  }
>>

```

Changed in version 2.0: renamed `label.vertical_moment_counterpoint_intervals()` to `verticalitytools.label_vertical_moments_in_expr_with_counterpoint_intervals()`.

verticalitytools.label_vertical_moments_in_expr_with_diatonic_intervals

`abjad.tools.verticalitytools.label_vertical_moments_in_expr_with_diatonic_intervals` (*expr*, *markup_c*)

New in version 2.0. Label diatonic intervals of every vertical moment in *expr*:

```

abjad> from abjad.tools import verticalitytools

abjad> score = Score(Staff([]) * 3)
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]
abjad> score[0].extend(notes)
abjad> contexttools.ClefMark('alto')(score[1])
ClefMark('alto')(Staff{})
abjad> score[1].extend([Note(-5, (1, 4)), Note(-7, (1, 4))])
abjad> contexttools.ClefMark('bass')(score[2])
ClefMark('bass')(Staff{})
abjad> score[2].append(Note(-24, (1, 2)))
abjad> verticalitytools.label_vertical_moments_in_expr_with_diatonic_intervals(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8 _ \markup { \small { \column { 16 12 } } }
    e'8
    f'8 _ \markup { \small { \column { 18 11 } } }
  }
  \new Staff {
    \clef "alto"
    g4
    f4 _ \markup { \small { \column { 17 11 } } }
  }

```



```
\new Staff {
  \clef "bass"
  c,2 _ \markup { \small { \column { 15 12 } } }
}
>>
```

Changed in version 2.0: renamed `label.vertical_moment_diatonic_intervals()` to `verticalitytools.label_vertical_moments_in_expr_with_diatonic_intervals()`.

verticalitytools.label_vertical_moments_in_expr_with_interval_class_vectors

`abjad.tools.verticalitytools.label_vertical_moments_in_expr_with_interval_class_vectors` (*expr*, *man*)

New in version 2.0. Label interval-class vector of every vertical moment in *expr*:

```
abjad> from abjad.tools import verticalitytools

abjad> score = Score(Staff([]) * 3)
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]
abjad> score[0].extend(notes)
abjad> contexttools.ClefMark('alto')(score[1])
ClefMark('alto')(Staff{})
abjad> score[1].extend([Note(-5, (1, 4)), Note(-7, (1, 4))])
abjad> contexttools.ClefMark('bass')(score[2])
ClefMark('bass')(Staff{})
abjad> score[2].append(Note(-24, (1, 2)))
abjad> verticalitytools.label_vertical_moments_in_expr_with_interval_class_vectors(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8 _ \markup { \tiny { 0010020 } }
    e'8
    f'8 _ \markup { \tiny { 1000020 } }
  }
  \new Staff {
    \clef "alto"
    g4
    f4 _ \markup { \tiny { 0100110 } }
  }
  \new Staff {
    \clef "bass"
    c,2 _ \markup { \tiny { 1000020 } }
  }
>>
```

Changed in version 2.0: renamed `label.vertical_moment_interval_class_vectors()` to `verticalitytools.label_vertical_moments_in_expr_with_interval_class_vectors()`.

verticalitytools.label_vertical_moments_in_expr_with_numbered_chromatic_pitch_classes

`abjad.tools.verticalitytools.label_vertical_moments_in_expr_with_numbered_chromatic_pitch_classes`

New in version 2.0. Label pitch-classes of every vertical moment in *expr*:

```

abjad> from abjad.tools import verticalitytools

abjad> score = Score(Staff([]) * 3)
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]
abjad> score[0].extend(notes)
abjad> contexttools.ClefMark('alto')(score[1])
ClefMark('alto')(Staff{})
abjad> score[1].extend([Note(-5, (1, 4)), Note(-7, (1, 4))])
abjad> contexttools.ClefMark('bass')(score[2])
ClefMark('bass')(Staff{})
abjad> score[2].append(Note(-24, (1, 2)))
abjad> verticalitytools.label_vertical_moments_in_expr_with_numbered_chromatic_pitch_classes(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8 _ \markup { \small { \column { 7 2 0 } } }
    e'8
    f'8 _ \markup { \small { \column { 5 0 } } }
  }
  \new Staff {
    \clef "alto"
    g4
    f4 _ \markup { \small { \column { 5 4 0 } } }
  }
  \new Staff {
    \clef "bass"
    c,2 _ \markup { \small { \column { 7 0 } } }
  }
>>

```

Changed in version 2.0: renamed `label.vertical_moment_pitch_classes()` to `verticalitytools.label_vertical_moments_in_expr_with_numbered_chromatic_pitch_classes()`

verticalitytools.label_vertical_moments_in_expr_with_pitch_numbers

`abjad.tools.verticalitytools.label_vertical_moments_in_expr_with_pitch_numbers` (*expr*, *markup_direction*)

New in version 2.0. Label pitch numbers of every vertical moment in *expr*:

```

abjad> from abjad.tools import verticalitytools

abjad> score = Score(Staff([]) * 3)
abjad> notes = [Note("c'8"), Note("d'8"), Note("e'8"), Note("f'8")]
abjad> score[0].extend(notes)
abjad> contexttools.ClefMark('alto')(score[1])
ClefMark('alto')(Staff{})
abjad> score[1].extend([Note(-5, (1, 4)), Note(-7, (1, 4))])
abjad> contexttools.ClefMark('bass')(score[2])
ClefMark('bass')(Staff{})
abjad> score[2].append(Note(-24, (1, 2)))
abjad> verticalitytools.label_vertical_moments_in_expr_with_pitch_numbers(score)
abjad> f(score)
\new Score <<
  \new Staff {
    c'8
    d'8 _ \markup { \small { \column { 2 -5 -24 } } }
  }
  \new Staff {
    \clef "alto"
    g4
    f4 _ \markup { \small { \column { 5 4 0 } } }
  }
  \new Staff {
    \clef "bass"
    c,2 _ \markup { \small { \column { 7 0 } } }
  }
>>

```

```

        e'8
        f'8 _ \markup { \small { \column { 5 -7 -24 } } }
    }
    \new Staff {
        \clef "alto"
        g4
        f4 _ \markup { \small { \column { 4 -7 -24 } } }
    }
    \new Staff {
        \clef "bass"
        c,2 _ \markup { \small { \column { 0 -5 -24 } } }
    }
>>

```

Changed in version 2.0: renamed `label.vertical_moment_pitch_numbers()` to `verticalitytools.label_vertical_moments_in_expr_with_pitch_numbers()`.

51.1.3 Unstable Abjad composition packages (load manually)

`lilypondparsertools`

`lilypondparsertools.LilyPondParser`

class `abjad.tools.lilypondparsertools.LilyPondParser`

Bases: `object`

`quantizationtools`

`quantizationtools.QEvent`

class `abjad.tools.quantizationtools.QEvent`

Bases: `abjad.core._Immutable._Immutable._Immutable`

A utility class for quantization comprising an offset time in milliseconds, and some pitch information: a `Number` representing a single pitch, `None` representing silence, or an `Iterable` comprised of `Numbers` representing a chord.

QEvents are immutable.

offset

The offset in milliseconds of the event.

value

The pitch information of the event.

`quantizationtools.QGrid`

class `abjad.tools.quantizationtools.QGrid`

Bases: `abjad.core._Immutable._Immutable._Immutable`

Abjad model of a `QGrid`, a nesting division structure which assists certain quantization algorithms.

QGrids are defined by a list, which must be prime in length, whose members are either `Numbers` or tuples of `Numbers` (useful for representing timepoint or pitch information), a `QEvent` or tuple of `QEvent` objects, or `None` (representing silence), or other lists which must recursively obey the same rules.

QGrids also have a *next* attribute, representing the downbeat of not “this” *QGrid*, but the next *QGrid* in a list of grids. This is useful as timepoints must often be quantized not to any internal division of a the “current” beat, but to the next beat.

```
abjad> from abjad.tools.quantizationtools import QGrid
abjad> q = QGrid([0, 0, [0, 0]], 0)
```

The values in the grid can be access via subscript, as though the grid were a flat list.

```
abjad> q[0] = 1
abjad> q[2] = 3
abjad> q[4] = 5
abjad> q
QGrid([1, 0, [3, 0]], 5)
```

QGrids are quasi-immutable.

definition

The nested list which defines the *QGrid*’s structure.

```
abjad> from abjad.tools.quantizationtools import QGrid
abjad> q = QGrid([0, 0, [0, 0]], 0)
abjad> q.definition
[0, 0, [0, 0]]
```

Read-only.

find_divisible_indices (points)

Given a list of numbers $0 \leq n \leq 1$, return a list of indices in self which countain those points, as though they were segments.

```
abjad> from abjad.tools.quantizationtools import QGrid
abjad> q = QGrid([0, [0, 0]], 0)
abjad> q.offsets
(Offset(0, 1), Offset(1, 2), Offset(3, 4), Offset(1, 1))
abjad> points = [0.1, 0.9]
abjad> q.find_divisible_indices(points)
[0, 2]
```

Returns a list.

find_parentage_of_index (index)

Return a tuple of the lengths of each container containing *index*, from the topmost to the bottommost.

```
abjad> from abjad.tools.quantizationtools import QGrid
abjad> q = QGrid([0, [0, [0, 0], 0], 0, 0, 0], 0)
abjad> q.find_parentage_of_index(0)
(5,)
abjad> q.find_parentage_of_index(1)
(5, 3)
abjad> q.find_parentage_of_index(2)
(5, 3, 2)
abjad> q.find_parentage_of_index(7)
(5,)
```

Returns a tuple.

format_for_beatspan (beatspan=Fraction(1, 4))

Return an Abjad container, whose structure mirrors the division structure of the *QGrid*. The values of the items in the *QGrid* have no effect on the output.

```

abjad> from abjad.tools.quantizationtools import QGrid
abjad> q = QGrid([0, [0, 0], 0], 0)
abjad> q.format_for_beatspan()
Tuplet(2/3, [c'8, c'16, c'16, c'8])

```

Returns a `Tuplet` or `Container`, depending on structure.

next

The contents of the final offset in the *QGrid*.

```

abjad> from abjad.tools.quantizationtools import QGrid
abjad> q = QGrid([0, 0, [0, 0]], 0)
abjad> q[-1] = 9
abjad> q
QGrid([0, 0, [0, 0]], 9)
abjad> q.next
9

```

Read-only.

offsets

An ordered tuple of those `Offset` objects generated by the division structure of a *QGrid*.

```

abjad> from abjad.tools.quantizationtools import QGrid
abjad> q = QGrid([0, [0, 0], 0], 0)
abjad> q.offsets
(Offset(0, 1), Offset(1, 3), Offset(1, 2), Offset(2, 3), Offset(1, 1))

```

Read-only.

subdivide_indices (pairs)

Given a list of 2-tuples, where for each tuple *t*, *t*[0] is a valid index into self, and *t*[1] is a prime integer greater than 1, return a new *QGrid* with those indices subdivided.

```

abjad> from abjad.tools.quantizationtools import QGrid
abjad> q = QGrid([0, 0], 0)
abjad> q.subdivide_indices([(0, 2), (1, 3)])
QGrid([[0, 0], [0, 0, 0]], 0)

```

Returns a new *QGrid*.

quantizationtools.QGridQuantizer

```

class abjad.tools.quantizationtools.QGridQuantizer (search_tree=None,          beat-
                                                    span=Fraction(1,          4),
                                                    tempo=TempoMark(4, 60), thresh-
                                                    old=None)

```

Bases: `abjad.tools.quantizationtools._Quantizer._Quantizer._Quantizer`

An Abjad implementation of Paul Nauert's Q-grid quantization algorithm.

Input is converted into timepoints, which are grouped according to which beat - or *beatspan* - they fall in, given a target tempo. Each beatspan is then divided into grids called Q-grids, which are based upon a nesting division structure (similar to nested tuples). The Q-grids generated for each beatspan are then tested against the timepoints falling within that beatspan, and the grid with least deviation is chosen to represent the rhythmic skeleton for that beat.

```

abjad> from abjad.tools.quantizationtools import QGridQuantizer
abjad> q = QGridQuantizer()

```

QGridQuantizer is immutable, but cheap to instantiate. Various attributes can be defined on instantiation. Please consult the documentation for each attribute respectively, for proper usage.

```
abjad> from abjad.tools.quantizationtools import QGridSearchTree
abjad> target_tempo = contexttools.TempoMark((1, 8), 73)
abjad> beatspan = Fraction(1, 4)
abjad> search_tree = QGridSearchTree({2: {2: None, 3: None}, 5: None})
abjad> threshold = 250
abjad> q = QGridQuantizer(tempo = target_tempo, beatspan = beatspan, search_tree = search_tree,
```

QGridQuantizer can quantize lists of leaves. If the source leaves have no effective tempo, one must be provided with the *tempo* keyword.

```
abjad> q = QGridQuantizer()
abjad> source = Staff("c'4 d'4 e'4. r'8 <c' e' g'>2. <d' g' b'>4")
abjad> source_tempo = contexttools.TempoMark((1, 4), 54)
abjad> result = q(source[:], tempo = source_tempo)

abjad> q = QGridQuantizer()
abjad> source = Staff("c'4 d'4 e'4. r'8 <c' e' g'>2. <d' g' b'>4")
abjad> t = contexttools.TempoMark((1, 8), 34, target_context = Staff)(source)
abjad> t = contexttools.TempoMark((1, 4), 135, target_context = Staff)(source[3])
abjad> result = q(source[:])
```

QGridQuantizer can quantize lists of millisecond durations. Negative values can be used to indicate silences.

```
abjad> q = QGridQuantizer()
abjad> milliseconds = [100, 120, -133, 500, -1003, 125]
abjad> result = q(milliseconds)
```

QGridQuantizer can also quantize lists of rationals, if a tempo is provided. As with quantizing millisecond durations, negative values can be used to indicate silences.

```
abjad> q = QGridQuantizer()
abjad> rationals = [1, Fraction(1, 2), Fraction(-1, 4), 3, Fraction(-1, 3), 2]
abjad> tempo = contexttools.TempoMark((1, 4), 45)
abjad> result = q(rationals, tempo = tempo)
```

Lastly, *QGridQuantizer* can quantize lists of pairs, where the first value in each pair is a millisecond duration, and the second value is an int or float - indicating a single pitch -, None - indicating silence, or a list of ints or floats - indicating a chord. This is probably most useful for assisting in the importation of audio analyses from other tools.

```
abjad> q = QGridQuantizer()
abjad> pairs = [(130, 0), (250, 2), (500, None), (1303, [0, 1, 4])]
abjad> result = q(pairs)
```

Todo

Write a documentation chapter on quantization.

Todo

Implement multiprocessing-based QGrid comparison

beatspan

The basic division of the beat for quantization.

Read-only, defaults to *Duration(1, 4)*.

beatspan_ms

The duration of *beatspan* in milliseconds, as determined by *tempo*.

Read-only, defaults to *Duration(1000)*.

search_tree

Reference to a `QGridSearchTree` object, which defines the permissible divisions for each `QGrid` comprising a quantization attempt.

Read-only, defaults to *QGridSearchTree()*.

Please consult the documentation for `QGrid` and `QGridSearchTree` for more information.

tempo

Reference to a `TempoMark`, defining the target tempo for all quantization results.

Read-only, defaults to *TempoMark((1, 4), 60)*.

tempo_lookup

Reference to a `QGridTempoLookup` object, a utility class for mapping rational divisions of a beat into milliseconds.

Read-only.

threshold

Millisecond duration, which if specified at instantiation will be used to call the quantizer's `QGridSearchTree`'s `prune()` method, in order to generate a pruned search tree for the quantizer, instead of either the user-provided or default search trees.

Read-only, defaults to `None`. See the documentation for `QGridSearchTree` for more information on pruning.

quantizationtools.QGridSearchTree

class `abjad.tools.quantizationtools.QGridSearchTree`

Bases: `abjad.core._Immutable._Immutable._Immutable`, `abjad.core._ImmutableDictionary._ImmutableDictionary`

A utility class for defining the permissible divisions of a collection of `QGrid` objects.

The search tree is defined by a nested dictionary structure, whose keys must be prime integers, and whose values must be `None` (indicating no further possible divisions) or another dictionary following the same rules.

```
abjad> from abjad.tools.quantizationtools import QGridSearchTree
```

For example, In the following tree, the beat may be divided into 2 or into 5. If divided into 2, it may be divided again into 2 or into 3.

```
abjad> search_tree = QGridSearchTree({2: {2: None, 3: None}, 5: None})
```

Return a new *QGridSearchTree*.

find_subtree_divisibility (*parentage*)

Given a parentage signature, defining some subtree of a *QGridSearchTree*, return a tuple of permitted divisions of that subtree.

```
abjad> from abjad.tools.quantizationtools import QGridSearchTree
abjad> qst = QGridSearchTree({2: {2: None, 3: {7: None, 11: None}}, 5: None})
abjad> qst.find_subtree_divisibility((2,))
(2, 3)
abjad> qst.find_subtree_divisibility((2, 2))
```

```
()
abjad> qst.find_subtree_divisibility((2, 3))
(7, 11)
abjad> qst.find_subtree_divisibility((2, 3, 7))
()
```

Returns a tuple.

offsets

An ordered tuple of all `Offset` objects which those `QGrid` objects governed by a specific `QGridSearchTree` can contain.

```
abjad> from abjad.tools.quantizationtools import QGridSearchTree
abjad> qst = QGridSearchTree({2: {3: None}})
abjad> qst.offsets
(Offset(0, 1), Offset(1, 6), Offset(1, 3), Offset(1, 2), Offset(2, 3), Offset(5, 6), Offset(
```

Returns a tuple.

prune (*beatspan, tempo, threshold*)

Prune those subtrees of a `QGridSearchTree` whose divisions in milliseconds, given *beatspan* and *tempo*, would be less than *threshold*.

This allows a composer to specify the maximum speed any quantization operation will permit.

```
abjad> from abjad.tools.quantizationtools import QGridSearchTree
abjad> qst = QGridSearchTree({2: {2: {2: {2: None}}}})
abjad> beatspan = Fraction(1, 4)
abjad> tempo = contexttools.TempoMark((1, 4), 60)
abjad> qst.prune(beatspan, tempo, 100)
{2: {2: {2: None}}}
abjad> qst.prune(beatspan, tempo, 200)
{2: {2: None}}
abjad> qst.prune(beatspan, tempo, 400)
{2: None}
```

Returns a new `QGridSearchTree`.

quantizationtools.QGridTempoLookup

class `abjad.tools.quantizationtools.QGridTempoLookup` (*offsets, beatspan, tempo*)

Bases: `abjad.core._Immutable._Immutable._Immutable, abjad.core._ImmutableDictionary._Immutable`

A utility class for matching fractional offsets within a beat to their tempo-scaled (real-time) millisecond values.

`QGridTempoLookup` objects are immutable.

beatspan

The duration which the `Offset` objects comprising the keys of the `QGridTempoLookup` are offsets into.

tempo

The `TempoMark` used to generate the lookup.

quantizationtools.is_valid_beatspan

`abjad.tools.quantizationtools.is_valid_beatspan` (*beatspan*)

True if *beatspan* is a valid beatspan.

1. A beatspan must be an int or `Fraction`.

2. It must be a binary rational.
3. If it is greater than zero, it must be a power of two.
4. If it is less than zero, it must be Fraction, whose numerator is 1 and whose denominator is a power of two.

quantizationtools.millisecond_pitch_pairs_to_q_events

`abjad.tools.quantizationtools.millisecond_pitch_pairs_to_q_events` (*pairs*)

Convert a list of pairs of millisecond durations and pitches to a list of `QEvent` instances.

Pitch values must be one of the following:

1. A single chromatic pitch number, indicating a note,
2. None, indicating a silence, or
3. An iterable of chromatic pitch numbers, indicating a chord.

```
abjad> from abjad.tools.quantizationtools import millisecond_pitch_pairs_to_q_events
abjad> durations = [1001, 503, 230, 1340]
abjad> pitches = [None, 0, (1, 2, 3), 4.5]
abjad> pairs = zip(durations, pitches)
abjad> millisecond_pitch_pairs_to_q_events(pairs)
[QEvent(Offset(0, 1), None), QEvent(Offset(1001, 1), 0), QEvent(Offset(1504, 1), (1, 2, 3)), QEvent(Offset(1834, 1), 4.5)]
```

Return a list of `QEvent` instances.

quantizationtools.milliseconds_to_q_events

`abjad.tools.quantizationtools.milliseconds_to_q_events` (*milliseconds*)

Convert a list of millisecond durations to a list of `QEvent` objects.

Negative duration values can be used to indicate silence. Any resulting pitched `QEvent` objects will default to using middle-C.

```
abjad> from abjad.tools.quantizationtools import milliseconds_to_q_events
abjad> durations = [100, -250, 500]
abjad> milliseconds_to_q_events(durations)
[QEvent(Offset(0, 1), 0), QEvent(Offset(100, 1), None), QEvent(Offset(350, 1), 0), QEvent(Offset(500, 1), 0)]
```

Return a list of `QEvent` objects.

quantizationtools.tempo_scaled_leaves_to_q_events

`abjad.tools.quantizationtools.tempo_scaled_leaves_to_q_events` (*leaves*, *tempo=None*)

Convert *leaves* to a list of `QEvent` objects. If the leaves have no effective tempo, *tempo* must be a `TempoMark`.

```
abjad> from abjad.tools.quantizationtools import tempo_scaled_leaves_to_q_events
abjad> source = Staff("c'4 r'4. e'8 <g' b' d'' fs''>2")
abjad> source_tempo = contexttools.TempoMark((1, 4), 55)
abjad> tempo_scaled_leaves_to_q_events(source[:], tempo = source_tempo)
[QEvent(Offset(0, 1), 0), QEvent(Offset(12000, 11), None), QEvent(Offset(30000, 11), 4), QEvent(Offset(36000, 11), 4)]
```

Return a list of `QEvent` objects.

quantizationtools.tempo_scaled_rational_to_milliseconds

`abjad.tools.quantizationtools.tempo_scaled_rational_to_milliseconds` (*rational*,
tempo)

Return the millisecond value of *rational* at *tempo*.

```
abjad> from abjad.tools.quantizationtools import tempo_scaled_rational_to_milliseconds
abjad> tempo = contexttools.TempoMark((1, 4), 60)
abjad> tempo_scaled_rational_to_milliseconds(Fraction(1, 4), tempo)
Duration(1000, 1)
```

Return a `Duration`.

quantizationtools.tempo_scaled_rationals_to_q_events

`abjad.tools.quantizationtools.tempo_scaled_rationals_to_q_events` (*durations*,
tempo)

Convert a list of rational durations to a list of `QEvent` objects.

Negative duration values can be used to indicate silence. Any resulting pitched `QEvent` objects will default to using middle-C.

```
abjad> from abjad.tools.quantizationtools import tempo_scaled_rationals_to_q_events
abjad> durations = [Duration(-1, 2), Duration(1, 4), Duration(1, 6)]
abjad> tempo = contexttools.TempoMark((1, 4), 55)
abjad> tempo_scaled_rationals_to_q_events(durations, tempo)
[QEvent(Offset(0, 1), None), QEvent(Offset(24000, 11), 0), QEvent(Offset(36000, 11), 0), QEvent(Offset(48000, 11), 0)]
```

Return a list of `QEvent` objects.

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INDEX

A

- AbjadRevisionToken (class in abjad.tools.lilypondfiletools), 403
- accidental (abjad.tools.tonalitytools.ScaleDegree attribute), 783
- Accidental (class in abjad.tools.pitchtools), 483
- accidental_spelling (abjad.tools.pitchtools.NamedChromaticPitch attribute), 494
- Accordion (class in abjad.tools.instrumenttools), 345
- add_artificial_harmonic_to_note() (in module abjad.tools.notetools), 473
- add_double_bar_to_end_of_score() (in module abjad.tools.scoretools), 559
- add_markup_to_end_of_score() (in module abjad.tools.scoretools), 560
- add_or_remove_tie_chain_notes_to_achieve_scaled_written_duration() (in module abjad.tools.tietools), 611
- add_or_remove_tie_chain_notes_to_achieve_written_duration() (in module abjad.tools.tietools), 612
- all_are_assignable_integers() (in module abjad.tools.sequencetools), 729
- all_are_chords() (in module abjad.tools.chordtools), 213
- all_are_chromatic_pitch_class_name_octave_number_pairs() (in module abjad.tools.pitchtools), 510
- all_are_components() (in module abjad.tools.componenttools), 219
- all_are_components_in_same_parent() (in module abjad.tools.componenttools), 220
- all_are_components_in_same_score() (in module abjad.tools.componenttools), 220
- all_are_components_in_same_thread() (in module abjad.tools.componenttools), 220
- all_are_components_scalable_by_multiplier() (in module abjad.tools.componenttools), 221
- all_are_containers() (in module abjad.tools.containertools), 278
- all_are_contiguous_components() (in module abjad.tools.componenttools), 221
- all_are_contiguous_components_in_same_parent() (in module abjad.tools.componenttools), 221
- all_are_contiguous_components_in_same_score() (in module abjad.tools.componenttools), 222
- all_are_contiguous_components_in_same_thread() (in module abjad.tools.componenttools), 222
- all_are_duration_tokens() (in module abjad.tools.durationtools), 644
- all_are_durations() (in module abjad.tools.durationtools), 644
- all_are_equal() (in module abjad.tools.sequencetools), 729
- all_are_grace_containers() (in module abjad.tools.gracetools), 343
- all_are_integer_equivalent_numbers() (in module abjad.tools.sequencetools), 729
- all_are_intervals_or_trees_or_empty() (in module abjad.tools.intervaltreetools), 663
- all_are_leaves() (in module abjad.tools.leaftools), 370
- all_are_markup() (in module abjad.tools.markuptools), 434
- all_are_measures() (in module abjad.tools.measuretools), 441
- all_are_named_chromatic_pitch_tokens() (in module abjad.tools.pitchtools), 511
- all_are_nonnegative_integer_equivalent_numbers() (in module abjad.tools.sequencetools), 730
- all_are_nonnegative_integer_powers_of_two() (in module abjad.tools.sequencetools), 730
- all_are_nonnegative_integers() (in module abjad.tools.sequencetools), 730
- all_are_notes() (in module abjad.tools.notetools), 474
- all_are_numbers() (in module abjad.tools.sequencetools), 730
- all_are_orphan_components() (in module abjad.tools.componenttools), 222
- all_are_pitch_arrays() (in module abjad.tools.pitcharraytools), 714
- all_are_positive_integer_equivalent_numbers() (in module abjad.tools.sequencetools), 731
- all_are_positive_integers() (in module abjad.tools.sequencetools), 731
- all_are_residue_class_expressions() (in module abjad.tools.sievetools), 772

- `all_are_rests()` (in module `abjad.tools.resttools`), 547
- `all_are_scores()` (in module `abjad.tools.scoretools`), 560
- `all_are_skips()` (in module `abjad.tools.skiptools`), 566
- `all_are_spanners()` (in module `abjad.tools.spannertools`), 593
- `all_are_staves()` (in module `abjad.tools.stafftools`), 609
- `all_are_thread_contiguous_components()` (in module `abjad.tools.componenttools`), 222
- `all_are_tuplets()` (in module `abjad.tools.tuplettools`), 626
- `all_are_unequal()` (in module `abjad.tools.sequencetools`), 731
- `all_are_voices()` (in module `abjad.tools.voicetools`), 637
- `all_intervals_are_contiguous()` (in module `abjad.tools.intervalreetools`), 663
- `all_intervals_are_nonoverlapping()` (in module `abjad.tools.intervalreetools`), 663
- `alpha()` (`abjad.tools.pitchtools.NumberedChromaticPitchClassSegment` method), 504
- `alphabetic_accidental_abbreviation` (`abjad.tools.pitchtools.Accidental` attribute), 483
- `alphabetic_accidental_abbreviation_to_symbolic_accidental_abbreviation()` (in module `abjad.tools.pitchtools`), 511
- `AltoFlute` (class in `abjad.tools.instrumenttools`), 346
- `AltoSaxophone` (class in `abjad.tools.instrumenttools`), 346
- `AltoTrombone` (class in `abjad.tools.instrumenttools`), 347
- `analyze_chord()` (in module `abjad.tools.tonalitytools`), 784
- `analyze_incomplete_chord()` (in module `abjad.tools.tonalitytools`), 785
- `analyze_incomplete_tonal_function()` (in module `abjad.tools.tonalitytools`), 785
- `analyze_tonal_function()` (in module `abjad.tools.tonalitytools`), 785
- `Annotation` (class in `abjad.tools.marktools`), 410
- `AnonymousMeasure` (class in `abjad.tools.measuretools`), 438
- `append()` (`abjad.tools.chordtools.Chord` method), 211
- `append()` (`abjad.tools.containertools.Container` method), 274
- `append()` (`abjad.tools.pitcharraytools.PitchArrayColumn` method), 712
- `append()` (`abjad.tools.pitcharraytools.PitchArrayRow` method), 713
- `append()` (`abjad.tools.spannertools.Spanner` method), 586
- `append_column()` (`abjad.tools.pitcharraytools.PitchArray` method), 709
- `append_left()` (`abjad.tools.spannertools.Spanner` method), 586
- `append_row()` (`abjad.tools.pitcharraytools.PitchArray` method), 709
- `append_spacer_skip_to_underfull_measure()` (in module `abjad.tools.measuretools`), 441
- `append_spacer_skips_to_underfull_measures_in_expr()` (in module `abjad.tools.measuretools`), 442
- `apply_accidental()` (`abjad.tools.pitchtools.NamedChromaticPitchClass` method), 497
- `apply_accidental()` (`abjad.tools.pitchtools.NumberedChromaticPitch` method), 503
- `apply_accidental()` (`abjad.tools.pitchtools.NumberedChromaticPitchClass` method), 504
- `apply_accidental()` (`abjad.tools.tonalitytools.ScaleDegree` method), 783
- `apply_accidental_to_named_chromatic_pitch()` (in module `abjad.tools.pitchtools`), 511
- `apply_beam_spanner_to_measure()` (in module `abjad.tools.measuretools`), 443
- `apply_beam_spanners_to_measures_in_expr()` (in module `abjad.tools.measuretools`), 443
- `apply_complex_beam_spanner_to_measure()` (in module `abjad.tools.measuretools`), 444
- `apply_complex_beam_spanners_to_measures_in_expr()` (in module `abjad.tools.measuretools`), 445
- `apply_durated_complex_beam_spanner_to_measures()` (in module `abjad.tools.measuretools`), 446
- `apply_full_measure_tuplets_to_contents_of_measures_in_expr()` (in module `abjad.tools.measuretools`), 446
- `apply_octavation_spanner_to_pitched_components()` (in module `abjad.tools.pitchtools`), 512
- `apply_pitches()` (`abjad.tools.pitcharraytools.PitchArrayRow` method), 713
- `apply_pitches_by_row()` (`abjad.tools.pitcharraytools.PitchArray` method), 709
- `apply_tie_spanner_to_leaf_pair()` (in module `abjad.tools.tietools`), 612
- `are_components_in_same_tie_spanner()` (in module `abjad.tools.tietools`), 612
- `are_relatively_prime()` (in module `abjad.tools.mathtools`), 688
- `are_scalar_notes()` (in module `abjad.tools.tonalitytools`), 786
- `are_stepwise_ascending_notes()` (in module `abjad.tools.tonalitytools`), 786
- `are_stepwise_descending_notes()` (in module `abjad.tools.tonalitytools`), 786
- `are_stepwise_notes()` (in module `abjad.tools.tonalitytools`), 787
- `arg` (`abjad.tools.schemetools.SchemeBoolean` attribute), 551
- `args` (`abjad.tools.markuptools.MarkupCommand` attribute), 434
- `arithmetic_mean()` (in module `abjad.tools.mathtools`), 688

arpeggiate_chord() (in module abjad.tools.chordtools), 214

Articulation (class in abjad.tools.marktools), 411

assignable_rational_to_dot_count() (in module abjad.tools.durationtools), 644

assignable_rational_to_lilypond_duration_string() (in module abjad.tools.durationtools), 645

attach() (abjad.tools.contexttools.ContextMark method), 309

attach() (abjad.tools.marktools.Mark method), 415

attach_annotations_to_components_in_expr() (in module abjad.tools.marktools), 417

attach_articulations_to_notes_and_chords_in_expr() (in module abjad.tools.marktools), 417

attach_lilypond_command_marks_to_components_in_expr() (in module abjad.tools.marktools), 417

attach_lilypond_comments_to_components_in_expr() (in module abjad.tools.marktools), 418

attach_stem_tremolos_to_notes_and_chords_in_expr() (in module abjad.tools.marktools), 418

attack_count (abjad.tools.verticalitytools.VerticalMoment attribute), 791

B

bar_line_string (abjad.tools.marktools.BarLine attribute), 412

BaritoneSaxophone (class in abjad.tools.instrumenttools), 348

BarLine (class in abjad.tools.marktools), 412

bass (abjad.tools.tonalitytools.ChordClass attribute), 781

bass_scale_degree (abjad.tools.tonalitytools.TonalFunction attribute), 784

BassClarinet (class in abjad.tools.instrumenttools), 348

BassFlute (class in abjad.tools.instrumenttools), 348

Bassoon (class in abjad.tools.instrumenttools), 350

BassSaxophone (class in abjad.tools.instrumenttools), 349

BassTrombone (class in abjad.tools.instrumenttools), 349

beam_bottommost_tuplets_in_expr() (in module abjad.tools.tuplettools), 626

BeamSpanner (class in abjad.tools.spannertools), 569

beatspan (abjad.tools.quantizationtools.QGridQuantizer attribute), 804

beatspan (abjad.tools.quantizationtools.QGridTempoLookup attribute), 806

beatspan_ms (abjad.tools.quantizationtools.QGridQuantizer attribute), 805

BFlatClarinet (class in abjad.tools.instrumenttools), 347

binomial_coefficient() (in module abjad.tools.mathtools), 689

BookBlock (class in abjad.tools.lilypondfiletools), 403

BookpartBlock (class in abjad.tools.lilypondfiletools), 404

BoundedInterval (class in abjad.tools.intervaltreetools), 661

bounds (abjad.tools.intervaltreetools.IntervalTree attribute), 662

BracketSpanner (class in abjad.tools.spannertools), 570

C

calculate_density_of_attacks_in_interval() (in module abjad.tools.intervaltreetools), 663

calculate_density_of_releases_in_interval() (in module abjad.tools.intervaltreetools), 664

calculate_depth_centroid_of_intervals() (in module abjad.tools.intervaltreetools), 664

calculate_depth_centroid_of_intervals_in_interval() (in module abjad.tools.intervaltreetools), 664

calculate_depth_density_of_intervals() (in module abjad.tools.intervaltreetools), 664

calculate_depth_density_of_intervals_in_interval() (in module abjad.tools.intervaltreetools), 665

calculate_harmonic_chromatic_interval_class_from_pitch_carrier_to_pitch_carrier() (in module abjad.tools.pitchtools), 512

calculate_harmonic_chromatic_interval_from_pitch_carrier_to_pitch_carrier() (in module abjad.tools.pitchtools), 512

calculate_harmonic_counterpoint_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch() (in module abjad.tools.pitchtools), 512

calculate_harmonic_counterpoint_interval_from_named_chromatic_pitch_to_named_chromatic_pitch() (in module abjad.tools.pitchtools), 513

calculate_harmonic_diatonic_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch() (in module abjad.tools.pitchtools), 513

calculate_harmonic_diatonic_interval_from_named_chromatic_pitch_to_named_chromatic_pitch() (in module abjad.tools.pitchtools), 513

calculate_mean_attack_of_intervals() (in module abjad.tools.intervaltreetools), 665

calculate_mean_release_of_intervals() (in module abjad.tools.intervaltreetools), 665

calculate_melodic_chromatic_interval_class_from_pitch_carrier_to_pitch_carrier() (in module abjad.tools.pitchtools), 513

calculate_melodic_chromatic_interval_from_pitch_carrier_to_pitch_carrier() (in module abjad.tools.pitchtools), 514

calculate_melodic_counterpoint_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch() (in module abjad.tools.pitchtools), 514

calculate_melodic_counterpoint_interval_from_named_chromatic_pitch_to_named_chromatic_pitch() (in module abjad.tools.pitchtools), 514

calculate_melodic_diatonic_interval_class_from_named_chromatic_pitch_to_named_chromatic_pitch() (in module abjad.tools.pitchtools), 514

calculate_melodic_diatonic_interval_from_named_chromatic_pitch_to_named_chromatic_pitch() (in module abjad.tools.pitchtools), 514

calculate_min_mean_and_max_depth_of_intervals() (in module abjad.tools.intervaltreetools), 665

calculate_min_mean_and_max_magnitude_of_intervals() (in module abjad.tools.intervaltreetools), 665

calculate_sustain_centroid_of_intervals() (in module abjad.tools.intervaltreetools), 665

[capitalize_string_start\(\)](#) (in module `abjad.tools.iotools`), [674](#)
[cardinality](#) (`abjad.tools.tonalitytools.ChordClass` attribute), [781](#)
[cardinality](#) (`abjad.tools.tonalitytools.ChordQualityIndicator` attribute), [781](#)
[cell_tokens](#) (`abjad.tools.pitcharraytools.PitchArrayColumn` attribute), [712](#)
[cell_tokens](#) (`abjad.tools.pitcharraytools.PitchArrayRow` attribute), [713](#)
[cell_tokens_by_row](#) (`abjad.tools.pitcharraytools.PitchArray` attribute), [709](#)
[cell_widths](#) (`abjad.tools.pitcharraytools.PitchArrayColumn` attribute), [712](#)
[cell_widths](#) (`abjad.tools.pitcharraytools.PitchArrayRow` attribute), [713](#)
[cell_widths_by_row](#) (`abjad.tools.pitcharraytools.PitchArray` attribute), [709](#)
[Cello](#) (class in `abjad.tools.instrumenttools`), [350](#)
[cells](#) (`abjad.tools.pitcharraytools.PitchArray` attribute), [709](#)
[cells](#) (`abjad.tools.pitcharraytools.PitchArrayColumn` attribute), [712](#)
[cells](#) (`abjad.tools.pitcharraytools.PitchArrayRow` attribute), [713](#)
[centroid](#) (`abjad.tools.intervaltreetools.BoundedInterval` attribute), [661](#)
[change_augmented_tuplets_in_expr_to_diminished\(\)](#) (in module `abjad.tools.tuplettools`), [627](#)
[change_defective_chord_to_note_or_rest\(\)](#) (in module `abjad.tools.chordtools`), [214](#)
[change_diminished_tuplets_in_expr_to_augmented\(\)](#) (in module `abjad.tools.tuplettools`), [628](#)
[change_written_leaf_duration_and_preserve_preprolated_leaf_duration\(\)](#) (in module `abjad.tools.leaftools`), [370](#)
[children](#) (`abjad.tools.sequencetools.Tree` attribute), [722](#)
[Chord](#) (class in `abjad.tools.chordtools`), [211](#)
[chord_class_cardinality_to_extent\(\)](#) (in module `abjad.tools.tonalitytools`), [787](#)
[chord_class_extent_to_cardinality\(\)](#) (in module `abjad.tools.tonalitytools`), [787](#)
[chord_class_extent_to_extent_name\(\)](#) (in module `abjad.tools.tonalitytools`), [787](#)
[chord_name](#) (`abjad.tools.tonalitytools.SuspensionIndicator` attribute), [784](#)
[ChordClass](#) (class in `abjad.tools.tonalitytools`), [781](#)
[ChordQualityIndicator](#) (class in `abjad.tools.tonalitytools`), [781](#)
[chromatic_interval_number](#) (`abjad.tools.pitchtools.MelodicChromaticInterval` attribute), [490](#)
[chromatic_pitch_class_name](#) (`abjad.tools.pitchtools.NamedChromaticPitch` attribute), [494](#)
[chromatic_pitch_class_name](#) (`abjad.tools.pitchtools.NamedDiatonicPitch` attribute), [500](#)
[chromatic_pitch_class_name_to_chromatic_pitch_class_number\(\)](#) (in module `abjad.tools.pitchtools`), [515](#)
[chromatic_pitch_class_name_to_diatonic_pitch_class_name\(\)](#) (in module `abjad.tools.pitchtools`), [515](#)
[chromatic_pitch_class_name_to_diatonic_pitch_class_name_alphabetic_accent\(\)](#) (in module `abjad.tools.pitchtools`), [515](#)
[chromatic_pitch_class_number](#) (`abjad.tools.pitchtools.NamedChromaticPitch` attribute), [494](#)
[chromatic_pitch_class_number](#) (`abjad.tools.pitchtools.NamedDiatonicPitch` attribute), [500](#)
[chromatic_pitch_class_number_to_chromatic_pitch_class_name\(\)](#) (in module `abjad.tools.pitchtools`), [515](#)
[chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_flats\(\)](#) (in module `abjad.tools.pitchtools`), [516](#)
[chromatic_pitch_class_number_to_chromatic_pitch_class_name_with_sharps\(\)](#) (in module `abjad.tools.pitchtools`), [516](#)
[chromatic_pitch_class_number_to_diatonic_pitch_class_number\(\)](#) (in module `abjad.tools.pitchtools`), [517](#)
[chromatic_pitch_class_numbers](#) (`abjad.tools.pitchtools.NumberedChromaticPitchClassVector` attribute), [507](#)
[chromatic_pitch_name](#) (`abjad.tools.pitchtools.NamedChromaticPitch` attribute), [494](#)
[chromatic_pitch_name](#) (`abjad.tools.pitchtools.NamedDiatonicPitch` attribute), [500](#)
[chromatic_pitch_name_to_chromatic_pitch_class_name\(\)](#) (in module `abjad.tools.pitchtools`), [517](#)
[chromatic_pitch_name_to_chromatic_pitch_class_number\(\)](#) (in module `abjad.tools.pitchtools`), [517](#)
[chromatic_pitch_name_to_chromatic_pitch_number\(\)](#) (in module `abjad.tools.pitchtools`), [517](#)
[chromatic_pitch_name_to_diatonic_pitch_class_name\(\)](#) (in module `abjad.tools.pitchtools`), [517](#)
[chromatic_pitch_name_to_diatonic_pitch_class_number\(\)](#) (in module `abjad.tools.pitchtools`), [517](#)
[chromatic_pitch_name_to_diatonic_pitch_name\(\)](#) (in module `abjad.tools.pitchtools`), [518](#)
[chromatic_pitch_name_to_diatonic_pitch_number\(\)](#) (in module `abjad.tools.pitchtools`), [518](#)
[chromatic_pitch_name_to_octave_number\(\)](#) (in module `abjad.tools.pitchtools`), [518](#)
[chromatic_pitch_names_string_to_named_chromatic_pitch_list\(\)](#) (in module `abjad.tools.pitchtools`), [518](#)

- chromatic_pitch_number (abjad.tools.pitchtools.NamedChromaticPitch attribute), 494
- chromatic_pitch_number (abjad.tools.pitchtools.NamedDiatonicPitch attribute), 501
- chromatic_pitch_number (abjad.tools.pitchtools.NumberedChromaticPitch attribute), 503
- chromatic_pitch_number (abjad.tools.pitchtools.NumberedDiatonicPitch attribute), 508
- chromatic_pitch_number_and_accidental_semitones_to_octave_number() (in module abjad.tools.pitchtools), 518
- chromatic_pitch_number_diatonic_pitch_class_name_to_alphabetic_index() (in module abjad.tools.pitchtools), 519
- chromatic_pitch_number_to_chromatic_pitch_class_number() (in module abjad.tools.pitchtools), 519
- chromatic_pitch_number_to_chromatic_pitch_name() (in module abjad.tools.pitchtools), 519
- chromatic_pitch_number_to_diatonic_pitch_class_name_alphabetic_index() (in module abjad.tools.pitchtools), 519
- chromatic_pitch_number_to_diatonic_pitch_class_number() (in module abjad.tools.pitchtools), 520
- chromatic_pitch_number_to_diatonic_pitch_number() (in module abjad.tools.pitchtools), 520
- chromatic_pitch_number_to_octave_number() (in module abjad.tools.pitchtools), 520
- chromatic_pitch_numbers (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 498
- chromatic_pitch_numbers (abjad.tools.pitchtools.NamedChromaticPitchSet attribute), 499
- chromatic_pitch_numbers (abjad.tools.pitchtools.NamedChromaticPitchVector attribute), 500
- ClarinetInA (class in abjad.tools.instrumenttools), 351
- clear() (abjad.tools.chordtools.Chord method), 211
- clear() (abjad.tools.spannertools.Spanner method), 586
- clear_terminal() (in module abjad.tools.iotools), 674
- clef_and_staff_position_number_to_named_chromatic_pitch() (in module abjad.tools.pitchtools), 520
- clef_name (abjad.tools.contexttools.ClefMark attribute), 308
- ClefMark (class in abjad.tools.contexttools), 307
- clip_interval_magnitudes_to_range() (in module abjad.tools.intervaltreetools), 665
- Cluster (class in abjad.tools.containertools), 274
- color_chord_note_heads_by_pitch_class_color_map() (in module abjad.tools.chordtools), 215
- color_contents_of_container() (in module abjad.tools.containertools), 278
- color_leaf() (in module abjad.tools.leaftools), 371
- color_leaves_in_expr() (in module abjad.tools.leaftools), 372
- color_measure() (in module abjad.tools.measuretools), 447
- color_name (abjad.tools.schemetools.SchemeColor attribute), 551
- color_nonbinary_measures_in_expr() (in module abjad.tools.measuretools), 448
- color_note_head_by_numbered_chromatic_pitch_class_color_map() (in module abjad.tools.notetools), 475
- colors (abjad.tools.pitchtools.NumberedChromaticPitchClassColorMap attribute), 504
- columns (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712
- columns (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
- columns (abjad.tools.pitcharraytools.PitchArray attribute), 709
- columns (abjad.tools.sequencetools.CyclicMatrix attribute), 718
- columns (abjad.tools.sequencetools.Matrix attribute), 720
- combine_markup_commands() (in module abjad.tools.markuptools), 435
- command (abjad.tools.markuptools.MarkupCommand attribute), 434
- command_name (abjad.tools.marktools.LilyPondCommandMark attribute), 413
- comment_measures_in_container_with_measure_numbers() (in module abjad.tools.measuretools), 449
- ComplexBeamSpanner (class in abjad.tools.spannertools), 570
- component_to_parentage_signature() (in module abjad.tools.componenttools), 223
- component_to_pitch_and_rhythm_skeleton() (in module abjad.tools.componenttools), 223
- component_to_score_depth() (in module abjad.tools.componenttools), 225
- component_to_score_index() (in module abjad.tools.componenttools), 225
- component_to_score_root() (in module abjad.tools.componenttools), 226
- component_to_thread_signature() (in module abjad.tools.threadtools), 774
- component_to_tuplet_depth() (in module abjad.tools.componenttools), 226
- components (abjad.tools.spannertools.Spanner attribute), 587
- components (abjad.tools.verticalitytools.VerticalMoment attribute), 791
- composite_dynamic_name_to_steady_state_dynamic_name() (abjad.tools.contexttools.DynamicMark static method), 310
- compute_depth_of_intervals() (in module abjad.tools.intervaltreetools), 665

- `compute_depth_of_intervals_in_interval()` (in module `abjad.tools.intervaltreetools`), 666
 - `compute_logical_and_of_intervals()` (in module `abjad.tools.intervaltreetools`), 666
 - `compute_logical_and_of_intervals_in_interval()` (in module `abjad.tools.intervaltreetools`), 666
 - `compute_logical_not_of_intervals()` (in module `abjad.tools.intervaltreetools`), 667
 - `compute_logical_not_of_intervals_in_interval()` (in module `abjad.tools.intervaltreetools`), 667
 - `compute_logical_or_of_intervals()` (in module `abjad.tools.intervaltreetools`), 667
 - `compute_logical_or_of_intervals_in_interval()` (in module `abjad.tools.intervaltreetools`), 667
 - `compute_logical_xor_of_intervals()` (in module `abjad.tools.intervaltreetools`), 667
 - `compute_logical_xor_of_intervals_in_interval()` (in module `abjad.tools.intervaltreetools`), 667
 - `concatenate_pitch_arrays()` (in module `abjad.tools.pitcharraytools`), 714
 - `concatenate_trees()` (in module `abjad.tools.intervaltreetools`), 667
 - `Container` (class in `abjad.tools.containertools`), 274
 - `contents_duration` (`abjad.tools.containertools.Container` attribute), 275
 - `contents_string` (`abjad.tools.marktools.LilyPondComment` attribute), 414
 - `contents_string` (`abjad.tools.markuptools.Markup` attribute), 433
 - `context_blocks` (`abjad.tools.lilypondfiletools.LayoutBlock` attribute), 405
 - `context_name` (`abjad.tools.lilypondfiletools.ContextBlock` attribute), 404
 - `ContextBlock` (class in `abjad.tools.lilypondfiletools`), 404
 - `ContextMark` (class in `abjad.tools.contexttools`), 308
 - `contexts` (`abjad.tools.lilypondfiletools.LayoutBlock` attribute), 406
 - `Contrabass` (class in `abjad.tools.instrumenttools`), 351
 - `ContrabassClarinet` (class in `abjad.tools.instrumenttools`), 352
 - `ContrabassFlute` (class in `abjad.tools.instrumenttools`), 352
 - `Contrabassoon` (class in `abjad.tools.instrumenttools`), 353
 - `ContrabassSaxophone` (class in `abjad.tools.instrumenttools`), 352
 - `copy_and_partition_governed_component_subtree_by_leaf_counts()` (in module `abjad.tools.componenttools`), 226
 - `copy_components_and_covered_spanners()` (in module `abjad.tools.componenttools`), 227
 - `copy_components_and_fracture_crossing_spanners()` (in module `abjad.tools.componenttools`), 228
 - `copy_components_and_immediate_parent_of_first_component()` (in module `abjad.tools.componenttools`), 230
 - `copy_components_and_remove_all_spanners()` (in module `abjad.tools.componenttools`), 231
 - `copy_governed_component_subtree_by_leaf_range()` (in module `abjad.tools.componenttools`), 232
 - `copy_governed_component_subtree_from_prolated_offset_to()` (in module `abjad.tools.componenttools`), 233
 - `copy_subarray()` (`abjad.tools.pitcharraytools.PitchArray` method), 709
 - `copy_subrow()` (`abjad.tools.pitcharraytools.PitchArrayRow` method), 713
 - `copy_written_duration_and_multiplier_from_leaf_to_leaf()` (in module `abjad.tools.leaftools`), 372
 - `count_length_two_runs_in_sequence()` (in module `abjad.tools.sequencetools`), 732
 - `CrescendoSpanner` (class in `abjad.tools.spannertools`), 572
 - `cumulative_products()` (in module `abjad.tools.mathtools`), 689
 - `cumulative_signed_weights()` (in module `abjad.tools.mathtools`), 689
 - `cumulative_sums()` (in module `abjad.tools.mathtools`), 690
 - `cumulative_sums_zero()` (in module `abjad.tools.mathtools`), 690
 - `cumulative_sums_zero_pairwise()` (in module `abjad.tools.mathtools`), 690
 - `cut_component_at_prolated_duration()` (in module `abjad.tools.componenttools`), 235
 - `cycle_tokens_to_sieve()` (in module `abjad.tools.sievetools`), 773
 - `CyclicList` (class in `abjad.tools.sequencetools`), 717
 - `CyclicMatrix` (class in `abjad.tools.sequencetools`), 717
 - `CyclicTree` (class in `abjad.tools.sequencetools`), 719
 - `CyclicTuple` (class in `abjad.tools.sequencetools`), 720
- ## D
- `DateTimeToken` (class in `abjad.tools.lilypondfiletools`), 404
 - `DecrescendoSpanner` (class in `abjad.tools.spannertools`), 573
 - `default_instrument_name` (`abjad.tools.contexttools.InstrumentMark` attribute), 311
 - `default_instrument_name_to_instrument_class()` (in module `abjad.tools.instrumenttools`), 364
 - `default_paper_size` (`abjad.tools.lilypondfiletools.LilyPondFile` attribute), 407
 - `default_short_instrument_name` (`abjad.tools.contexttools.InstrumentMark` attribute), 311
 - `definition` (`abjad.tools.quantizationtools.QGrid` attribute), 802

- `delete_contents_of_container()` (in module `abjad.tools.containertools`), 279
- `delete_contents_of_container_starting_at_or_after_prolated_offset()` (in module `abjad.tools.containertools`), 279
- `delete_contents_of_container_starting_before_or_at_prolated_offset()` (in module `abjad.tools.containertools`), 280
- `delete_contents_of_container_starting_strictly_after_prolated_offset()` (in module `abjad.tools.containertools`), 280
- `delete_contents_of_container_starting_strictly_before_prolated_offset()` (in module `abjad.tools.containertools`), 281
- `denominator` (`abjad.tools.contexttools.TimeSignatureMark` attribute), 316
- `denominator` (`abjad.tools.measuretools.DynamicMeasure` attribute), 439
- `depth` (`abjad.tools.pitcharraytools.PitchArray` attribute), 709
- `depth` (`abjad.tools.pitcharraytools.PitchArrayColumn` attribute), 712
- `depth` (`abjad.tools.pitcharraytools.PitchArrayRow` attribute), 713
- `depth` (`abjad.tools.sequencetools.Tree` attribute), 723
- `destroy_all_spanners_attached_to_component()` (in module `abjad.tools.spannertools`), 593
- `detach()` (`abjad.tools.contexttools.ContextMark` method), 309
- `detach()` (`abjad.tools.gracetools.Grace` method), 342
- `detach()` (`abjad.tools.marktools.Mark` method), 415
- `detach_annotations_attached_to_component()` (in module `abjad.tools.marktools`), 418
- `detach_articulations_attached_to_component()` (in module `abjad.tools.marktools`), 419
- `detach_clef_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 318
- `detach_context_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 318
- `detach_dynamic_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 319
- `detach_grace_containers_attached_to_leaf()` (in module `abjad.tools.gracetools`), 343
- `detach_instrument_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 320
- `detach_key_signature_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 320
- `detach_lilypond_command_marks_attached_to_component()` (in module `abjad.tools.marktools`), 420
- `detach_lilypond_comments_attached_to_component()` (in module `abjad.tools.marktools`), 420
- `detach_marks_attached_to_component()` (in module `abjad.tools.marktools`), 421
- `detach_noncontext_marks_attached_to_component()` (in module `abjad.tools.marktools`), 421
- `detach_staff_change_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 321
- `detach_stem_tremolos_attached_to_component()` (in module `abjad.tools.marktools`), 422
- `detach_tempo_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 321
- `detach_time_signature_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 322
- `deviation` (`abjad.tools.pitchtools.NamedChromaticPitch` attribute), 494
- `diatonic_interval_class_segment` (`abjad.tools.tonalitytools.Scale` attribute), 783
- `diatonic_interval_class_segment_to_chord_quality_string()` (in module `abjad.tools.tonalitytools`), 788
- `diatonic_interval_number_and_chromatic_interval_number_to_melodic_diatonic_interval_number()` (in module `abjad.tools.pitchtools`), 521
- `diatonic_pitch_class_name` (`abjad.tools.pitchtools.NamedChromaticPitch` attribute), 495
- `diatonic_pitch_class_name` (`abjad.tools.pitchtools.NamedDiatonicPitch` attribute), 501
- `diatonic_pitch_class_name_to_chromatic_pitch_class_number()` (in module `abjad.tools.pitchtools`), 521
- `diatonic_pitch_class_name_to_diatonic_pitch_class_number()` (in module `abjad.tools.pitchtools`), 521
- `diatonic_pitch_class_number` (`abjad.tools.pitchtools.NamedChromaticPitch` attribute), 495
- `diatonic_pitch_class_number` (`abjad.tools.pitchtools.NamedDiatonicPitch` attribute), 501
- `diatonic_pitch_class_number` (`abjad.tools.pitchtools.NumberedChromaticPitch` attribute), 503
- `diatonic_pitch_class_number_to_chromatic_pitch_class_number()` (in module `abjad.tools.pitchtools`), 521
- `diatonic_pitch_class_number_to_diatonic_pitch_class_name()` (in module `abjad.tools.pitchtools`), 521
- `diatonic_pitch_name` (`abjad.tools.pitchtools.NamedChromaticPitch` attribute), 495
- `diatonic_pitch_name` (`abjad.tools.pitchtools.NamedDiatonicPitch` attribute), 501
- `diatonic_pitch_name_to_chromatic_pitch_class_name()` (in module `abjad.tools.pitchtools`), 522
- `diatonic_pitch_name_to_chromatic_pitch_class_number()` (in module `abjad.tools.pitchtools`), 522
- `diatonic_pitch_name_to_chromatic_pitch_name()` (in module `abjad.tools.pitchtools`), 522
- `diatonic_pitch_name_to_chromatic_pitch_number()` (in module `abjad.tools.pitchtools`), 522
- `diatonic_pitch_name_to_diatonic_pitch_class_name()` (in module `abjad.tools.pitchtools`), 522

<code>diatonic_pitch_name_to_diatonic_pitch_class_number()</code> (in module <code>abjad.tools.pitchtools</code>), 523	<code>divide_leaves_in_expr_meiotically()</code> (in module <code>abjad.tools.leaftools</code>), 373
<code>diatonic_pitch_name_to_diatonic_pitch_number()</code> (in module <code>abjad.tools.pitchtools</code>), 523	<code>divide_number_by_ratio()</code> (in module <code>abjad.tools.mathtools</code>), 691
<code>diatonic_pitch_number</code> (<code>abjad.tools.pitchtools.NamedChromaticPitch</code> attribute), 495	<code>divide_sequence_elements_by_greatest_common_divisor()</code> (in module <code>abjad.tools.sequencetools</code>), 732
<code>diatonic_pitch_number</code> (<code>abjad.tools.pitchtools.NamedDiatonicPitch</code> attribute), 501	<code>divisors()</code> (in module <code>abjad.tools.mathtools</code>), 691
<code>diatonic_pitch_number</code> (<code>abjad.tools.pitchtools.NumberedChromaticPitch</code> attribute), 503	<code>dominant</code> (<code>abjad.tools.tonalitytools.Scale</code> attribute), 783
<code>diatonic_pitch_number</code> (<code>abjad.tools.pitchtools.NumberedDiatonicPitch</code> attribute), 508	<code>DoublingIndicator</code> (class in <code>abjad.tools.tonalitytools</code>), 781
<code>diatonic_pitch_number_to_chromatic_pitch_number()</code> (in module <code>abjad.tools.pitchtools</code>), 523	<code>doublings</code> (<code>abjad.tools.tonalitytools.DoublingIndicator</code> attribute), 782
<code>diatonic_pitch_number_to_diatonic_pitch_class_name()</code> (in module <code>abjad.tools.pitchtools</code>), 523	<code>duplicate_pitch_classes</code> (<code>abjad.tools.pitchtools.NamedChromaticPitchSet</code> attribute), 499
<code>diatonic_pitch_number_to_diatonic_pitch_class_number()</code> (in module <code>abjad.tools.pitchtools</code>), 523	<code>DuratedComplexBeamSpanner</code> (class in <code>abjad.tools.spannertools</code>), 574
<code>diatonic_pitch_number_to_diatonic_pitch_name()</code> (in module <code>abjad.tools.pitchtools</code>), 523	<code>duration</code> (<code>abjad.tools.contexttools.TempoMark</code> attribute), 315
<code>difference_series()</code> (in module <code>abjad.tools.mathtools</code>), 690	<code>duration</code> (<code>abjad.tools.contexttools.TimeSignatureMark</code> attribute), 317
<code>dimensions</code> (<code>abjad.tools.pitcharraytools.PitchArray</code> attribute), 710	<code>duration</code> (<code>abjad.tools.schemetools.SchemeMoment</code> attribute), 552
<code>dimensions</code> (<code>abjad.tools.pitcharraytools.PitchArrayColumn</code> attribute), 712	<code>Duration</code> (class in <code>abjad.tools.durationtools</code>), 643
<code>dimensions</code> (<code>abjad.tools.pitcharraytools.PitchArrayRow</code> attribute), 713	<code>duration_and_possible_denominators_to_time_signature()</code> (in module <code>abjad.tools.timesignaturetools</code>), 779
<code>direction_number</code> (<code>abjad.tools.pitchtools.MelodicChromaticInterval</code> attribute), 490	<code>duration_in_seconds</code> (<code>abjad.tools.containertools.Container</code> attribute), 275
<code>direction_number</code> (<code>abjad.tools.pitchtools.MelodicCounterpointInterval</code> attribute), 492	<code>duration_in_seconds</code> (<code>abjad.tools.spannertools.Spanner</code> attribute), 587
<code>direction_number</code> (<code>abjad.tools.pitchtools.MelodicDiatonicInterval</code> attribute), 492	<code>duration_pair_to_prolation_string()</code> (in module <code>abjad.tools.durationtools</code>), 645
<code>direction_number</code> (<code>abjad.tools.pitchtools.MelodicDiatonicIntervalClass</code> attribute), 493	<code>duration_token_to_big_endian_list_of_assignable_duration_pairs()</code> (in module <code>abjad.tools.durationtools</code>), 645
<code>direction_string</code> (<code>abjad.tools.marktools.Articulation</code> attribute), 411	<code>duration_token_to_duration_pair()</code> (in module <code>abjad.tools.durationtools</code>), 646
<code>direction_string</code> (<code>abjad.tools.pitchtools.MelodicDiatonicIntervalClass</code> attribute), 492	<code>duration_token_to_rational()</code> (in module <code>abjad.tools.durationtools</code>), 646
<code>direction_symbol</code> (<code>abjad.tools.pitchtools.MelodicDiatonicIntervalClass</code> attribute), 493	<code>duration_tokens_to_duration_pairs()</code> (in module <code>abjad.tools.durationtools</code>), 646
<code>direction_word</code> (<code>abjad.tools.pitchtools.MelodicDiatonicIntervalClass</code> attribute), 493	<code>duration_tokens_to_duration_pairs_with_least_common_denominator()</code> (in module <code>abjad.tools.durationtools</code>), 647
<code>divide_chord_by_chromatic_pitch_number()</code> (in module <code>abjad.tools.chordtools</code>), 216	<code>duration_tokens_to_least_common_denominator()</code> (in module <code>abjad.tools.durationtools</code>), 647
<code>divide_chord_by_diatonic_pitch_number()</code> (in module <code>abjad.tools.chordtools</code>), 216	<code>duration_tokens_to_rationals()</code> (in module <code>abjad.tools.durationtools</code>), 647
<code>divide_leaf_meiotically()</code> (in module <code>abjad.tools.leaftools</code>), 372	<code>DurationClass</code> (<code>abjad.tools.spannertools.DuratedComplexBeamSpanner</code> attribute), 575
	<code>dynamic_name</code> (<code>abjad.tools.contexttools.DynamicMark</code> attribute), 310
	<code>dynamic_name_to_dynamic_ordinal()</code> (<code>abjad.tools.contexttools.DynamicMark</code> static method), 310

- `dynamic_ordinal_to_dynamic_name()` (abjad.tools.contexttools.DynamicMark static method), 310
- `DynamicMark` (class in abjad.tools.contexttools), 309
- `DynamicMeasure` (class in abjad.tools.measuretools), 438
- `DynamicTextSpanner` (class in abjad.tools.spannertools), 576
- ## E
- `effective_context` (abjad.tools.contexttools.ContextMark attribute), 309
- `EFlatClarinet` (class in abjad.tools.instrumenttools), 353
- `eject_contents_of_container()` (in module abjad.tools.containertools), 281
- `empty_pitches()` (abjad.tools.pitcharraytools.PitchArrayRow method), 713
- `EnglishHorn` (class in abjad.tools.instrumenttools), 354
- `explode_intervals_compactly()` (in module abjad.tools.intervaltreetools), 667
- `explode_intervals_into_n_trees_heuristically()` (in module abjad.tools.intervaltreetools), 668
- `explode_intervals_uncompactly()` (in module abjad.tools.intervaltreetools), 668
- `expr_has_duplicate_named_chromatic_pitch()` (in module abjad.tools.pitchtools), 524
- `expr_has_duplicate_numbered_chromatic_pitch_class()` (in module abjad.tools.pitchtools), 524
- `expr_has_leaf_with_dotted_written_duration()` (in module abjad.tools.leaftools), 374
- `expr_to_melodic_chromatic_interval_segment()` (in module abjad.tools.pitchtools), 524
- `extend()` (abjad.tools.chordtools.Chord method), 212
- `extend()` (abjad.tools.containertools.Container method), 275
- `extend()` (abjad.tools.measuretools.DynamicMeasure method), 439
- `extend()` (abjad.tools.pitcharraytools.PitchArrayColumn method), 712
- `extend()` (abjad.tools.pitcharraytools.PitchArrayRow method), 713
- `extend()` (abjad.tools.spannertools.Spanner method), 587
- `extend_in_parent_of_component_and_do_not_grow_spanners()` (in module abjad.tools.componenttools), 235
- `extend_in_parent_of_component_and_grow_spanners()` (in module abjad.tools.componenttools), 236
- `extend_left()` (abjad.tools.spannertools.Spanner method), 587
- `extend_left_in_parent_of_component_and_do_not_grow_spanners()` (in module abjad.tools.componenttools), 237
- `extend_left_in_parent_of_component_and_grow_spanners()` (in module abjad.tools.componenttools), 237
- `extend_measures_in_expr_and_apply_full_measure_tuples_to_measure_components()` (in module abjad.tools.measuretools), 450
- `extent` (abjad.tools.tonalitytools.ChordClass attribute), 781
- `extent` (abjad.tools.tonalitytools.ChordQualityIndicator attribute), 781
- `extent` (abjad.tools.tonalitytools.TonalFunction attribute), 784
- `extent_name` (abjad.tools.tonalitytools.ChordQualityIndicator attribute), 781
- `extent_to_figured_bass_string()` (abjad.tools.tonalitytools.InversionIndicator method), 782
- `ExtentIndicator` (class in abjad.tools.tonalitytools), 782
- ## F
- `factors()` (in module abjad.tools.iotools), 675
- `factors()` (in module abjad.tools.mathtools), 692
- `figured_bass` (abjad.tools.tonalitytools.ChordClass attribute), 781
- `figured_bass_pair` (abjad.tools.tonalitytools.SuspensionIndicator attribute), 784
- `figured_bass_string` (abjad.tools.tonalitytools.SuspensionIndicator attribute), 784
- `figured_bass_string` (abjad.tools.tonalitytools.TonalFunction attribute), 784
- `file_initial_system_comments` (abjad.tools.lilypondfiletools.LilyPondFile attribute), 407
- `file_initial_system_includes` (abjad.tools.lilypondfiletools.LilyPondFile attribute), 407
- `file_initial_user_comments` (abjad.tools.lilypondfiletools.LilyPondFile attribute), 407
- `file_initial_user_includes` (abjad.tools.lilypondfiletools.LilyPondFile attribute), 407
- `fill_measures_in_expr_with_big_endian_notes()` (in module abjad.tools.measuretools), 450
- `fill_measures_in_expr_with_full_measure_spacer_skips()` (in module abjad.tools.measuretools), 451
- `fill_measures_in_expr_with_little_endian_notes()` (in module abjad.tools.measuretools), 451
- `fill_measures_in_expr_with_meter_denominator_notes()` (in module abjad.tools.measuretools), 451
- `fill_measures_in_expr_with_repeated_notes()` (in module abjad.tools.measuretools), 452
- `find_divisible_indices()` (abjad.tools.quantizationtools.QGrid method), 802
- `find_measure_of_spanner()` (in module abjad.tools.spannertools), 594

- `find_intervals_intersecting_or_tangent_to_interval()`
(`abjad.tools.intervaltreetools.IntervalTree`
method), 662
- `find_intervals_intersecting_or_tangent_to_offset()`
(`abjad.tools.intervaltreetools.IntervalTree`
method), 662
- `find_intervals_starting_after_offset()` (ab-
jad.tools.intervaltreetools.IntervalTree
method), 662
- `find_intervals_starting_and_stopping_within_interval()`
(`abjad.tools.intervaltreetools.IntervalTree`
method), 662
- `find_intervals_starting_at_offset()` (ab-
jad.tools.intervaltreetools.IntervalTree
method), 662
- `find_intervals_starting_before_offset()` (ab-
jad.tools.intervaltreetools.IntervalTree
method), 662
- `find_intervals_starting_or_stopping_at_offset()` (ab-
jad.tools.intervaltreetools.IntervalTree
method), 662
- `find_intervals_starting_within_interval()` (ab-
jad.tools.intervaltreetools.IntervalTree
method), 662
- `find_intervals_stopping_after_offset()` (ab-
jad.tools.intervaltreetools.IntervalTree
method), 663
- `find_intervals_stopping_at_offset()` (ab-
jad.tools.intervaltreetools.IntervalTree
method), 663
- `find_intervals_stopping_before_offset()` (ab-
jad.tools.intervaltreetools.IntervalTree
method), 663
- `find_intervals_stopping_within_interval()` (ab-
jad.tools.intervaltreetools.IntervalTree
method), 663
- `find_parentage_of_index()` (ab-
jad.tools.quantizationtools.QGrid method),
802
- `find_spanner_component_starting_at_exactly_score_offset()` (in module `abjad.tools.spannertools`), 594
- `find_subtree_divisibility()` (ab-
jad.tools.quantizationtools.QGridSearchTree
method), 805
- `fingered_pitch` (`abjad.tools.notetools.Note` attribute), 471
- `fingered_pitches` (`abjad.tools.chordtools.Chord` attribute),
212
- `fix_contents_of_tuplets_in_expr()` (in module `ab-
jad.tools.tuplettools`), 628
- `FixedDurationTuplet` (class in `abjad.tools.tuplettools`),
624
- `flatten_sequence()` (in module `abjad.tools.sequencetools`),
732
- `flatten_sequence_at_indices()` (in module `ab-
jad.tools.sequencetools`), 733
- `Flute` (class in `abjad.tools.instrumenttools`), 354
- `force_fraction` (`abjad.tools.tuplettools.Tuplet` attribute),
625
- `format` (`abjad.tools.contexttools.ClefMark` attribute), 308
- `format` (`abjad.tools.contexttools.DynamicMark` attribute),
310
- `format` (`abjad.tools.contexttools.InstrumentMark` at-
tribute), 311
- `format` (`abjad.tools.contexttools.KeySignatureMark` at-
tribute), 313
- `format` (`abjad.tools.contexttools.StaffChangeMark`
attribute), 314
- `format` (`abjad.tools.contexttools.TempoMark` attribute),
315
- `format` (`abjad.tools.contexttools.TimeSignatureMark` at-
tribute), 317
- `format` (`abjad.tools.lilypondfiletools.AbjadRevisionToken`
attribute), 403
- `format` (`abjad.tools.lilypondfiletools.DateTimeToken` at-
tribute), 405
- `format` (`abjad.tools.lilypondfiletools.LilyPondFile` at-
tribute), 407
- `format` (`abjad.tools.lilypondfiletools.LilyPondLanguageToken`
attribute), 407
- `format` (`abjad.tools.lilypondfiletools.LilyPondVersionToken`
attribute), 408
- `format` (`abjad.tools.marktools.Articulation` attribute), 412
- `format` (`abjad.tools.marktools.LilyPondCommandMark`
attribute), 413
- `format` (`abjad.tools.marktools.LilyPondComment` at-
tribute), 414
- `format` (`abjad.tools.marktools.StemTremolo` attribute),
416
- `format` (`abjad.tools.markuptools.Markup` attribute), 433
- `format` (`abjad.tools.markuptools.MarkupCommand` at-
tribute), 434
- `format` (`abjad.tools.notetools.NoteHead` attribute), 473
- `format` (`abjad.tools.pitchtools.Accidental` attribute), 483
- `format` (`abjad.tools.pitchtools.NamedChromaticPitch` at-
tribute), 495
- `format` (`abjad.tools.pitchtools.NamedDiatonicPitch` at-
tribute), 501
- `format` (`abjad.tools.schemetools.SchemeAssociativeList`
attribute), 551
- `format` (`abjad.tools.schemetools.SchemeBoolean` at-
tribute), 551
- `format` (`abjad.tools.schemetools.SchemeColor` attribute),
551
- `format` (`abjad.tools.schemetools.SchemeFunction` at-
tribute), 552
- `format` (`abjad.tools.schemetools.SchemeMoment` at-
tribute), 552

- p>format (abjad.tools.schemetools.SchemeNumber attribute), 553
- format (abjad.tools.schemetools.SchemePair attribute), 553
- format (abjad.tools.schemetools.SchemeString attribute), 553
- format (abjad.tools.schemetools.SchemeVariable attribute), 554
- format (abjad.tools.schemetools.SchemeVector attribute), 554
- format (abjad.tools.schemetools.SchemeVectorConstant attribute), 555
- format_for_beatspan() (abjad.tools.quantizationtools.QGrid method), 802
- format_input_lines_as_doc_string() (in module abjad.tools.iotools), 675
- format_input_lines_as_regression_test() (in module abjad.tools.iotools), 675
- format_slot (abjad.tools.marktools.LilyPondCommandMark attribute), 414
- format_slot (abjad.tools.marktools.LilyPondComment attribute), 415
- fracture() (abjad.tools.spannertools.Spanner method), 587
- fracture_all_spanners_attached_to_component() (in module abjad.tools.spannertools), 594
- fracture_spanners_that_cross_components() (in module abjad.tools.spannertools), 595
- FrenchHorn (class in abjad.tools.instrumenttools), 355
- fuse() (abjad.tools.spannertools.Spanner method), 588
- fuse_contiguous_measures_in_container_cyclically_by_counts() (in module abjad.tools.measuretools), 452
- fuse_leaves_big_endian() (in module abjad.tools.leaftools), 374
- fuse_leaves_in_container_once_by_counts_into_big_endian_notes() (in module abjad.tools.leaftools), 375
- fuse_leaves_in_container_once_by_counts_into_big_endian_rests() (in module abjad.tools.leaftools), 375
- fuse_leaves_in_container_once_by_counts_into_little_endian_notes() (in module abjad.tools.leaftools), 375
- fuse_leaves_in_container_once_by_counts_into_little_endian_rests() (in module abjad.tools.leaftools), 375
- fuse_leaves_in_tie_chain_by_immediate_parent_big_endian() (in module abjad.tools.leaftools), 375
- fuse_like_named_contiguous_containers_in_expr() (in module abjad.tools.containertools), 282
- fuse_measures() (in module abjad.tools.measuretools), 453
- fuse_overlapping_intervals() (in module abjad.tools.intervalreetools), 668
- fuse_tangent_or_overlapping_intervals() (in module abjad.tools.intervalreetools), 668
- fuse_tied_leaves_in_components_once_by_prolated_durations_without_overhang() (in module abjad.tools.leaftools), 376
- fuse_tuplets() (in module abjad.tools.tupletttools), 628
- ## G
- get() (abjad.tools.pitchtools.NumberedChromaticPitchClassColorMap method), 504
- get_abjad_revision_string() (in module abjad.tools.configurationtools), 641
- get_abjad_version_string() (in module abjad.tools.configurationtools), 641
- get_all_unique_bounds_in_intervals() (in module abjad.tools.intervalreetools), 669
- get_annotation_attached_to_component() (in module abjad.tools.marktools), 423
- get_annotations_attached_to_component() (in module abjad.tools.marktools), 423
- get_arithmetic_mean_of_chord() (in module abjad.tools.chordtools), 217
- get_articulation_attached_to_component() (in module abjad.tools.marktools), 423
- get_articulations_attached_to_component() (in module abjad.tools.marktools), 424
- get_beam_spanner_attached_to_component() (in module abjad.tools.spannertools), 596
- get_boolean_train() (abjad.tools.sievetools.ResidueClass method), 771
- get_boolean_train() (abjad.tools.sievetools.ResidueClassExpression method), 771
- get_clef_mark_attached_to_component() (in module abjad.tools.contexttools), 323
- get_clef_marks_attached_to_component() (in module abjad.tools.contexttools), 323
- get_component_start_offset() (in module abjad.tools.componenttools), 238
- get_component_start_offset_in_seconds() (in module abjad.tools.componenttools), 238
- get_component_stop_offset() (in module abjad.tools.componenttools), 238
- get_component_stop_offset_in_seconds() (in module abjad.tools.componenttools), 239
- get_composite_offset_difference_series_from_leaves_in_expr() (in module abjad.tools.leaftools), 376
- get_composite_offset_series_from_leaves_in_expr() (in module abjad.tools.leaftools), 377
- get_congruent_bases() (abjad.tools.sievetools.ResidueClass method), 771
- get_congruent_bases() (abjad.tools.sievetools.ResidueClassExpression method), 772
- get_context_mark_attached_to_component() (in module abjad.tools.contexttools), 323
- get_context_marks_attached_to_any_improper_parent_of_component() (in module abjad.tools.contexttools), 324

[get_context_marks_attached_to_component\(\)](#) (in module `abjad.tools.contexttools`), 324
[get_down_markup_attached_to_component\(\)](#) (in module `abjad.tools.markuptools`), 435
[get_dynamic_mark_attached_to_component\(\)](#) (in module `abjad.tools.contexttools`), 325
[get_dynamic_marks_attached_to_component\(\)](#) (in module `abjad.tools.contexttools`), 325
[get_effective_clef\(\)](#) (in module `abjad.tools.contexttools`), 326
[get_effective_context_mark\(\)](#) (in module `abjad.tools.contexttools`), 326
[get_effective_dynamic\(\)](#) (in module `abjad.tools.contexttools`), 327
[get_effective_instrument\(\)](#) (in module `abjad.tools.contexttools`), 327
[get_effective_key_signature\(\)](#) (in module `abjad.tools.contexttools`), 328
[get_effective_staff\(\)](#) (in module `abjad.tools.contexttools`), 328
[get_effective_tempo\(\)](#) (in module `abjad.tools.contexttools`), 329
[get_effective_time_signature\(\)](#) (in module `abjad.tools.contexttools`), 329
[get_element_starting_at_exactly_prolated_offset\(\)](#) (in module `abjad.tools.containertools`), 283
[get_first_component_in_expr_with_name\(\)](#) (in module `abjad.tools.componenttools`), 239
[get_first_component_with_name_in_improper_parentage_of_component\(\)](#) (in module `abjad.tools.componenttools`), 240
[get_first_component_with_name_in_proper_parentage_of_component\(\)](#) (in module `abjad.tools.componenttools`), 240
[get_first_container_in_improper_parentage_of_component\(\)](#) (in module `abjad.tools.containertools`), 283
[get_first_container_in_proper_parentage_of_component\(\)](#) (in module `abjad.tools.containertools`), 283
[get_first_element_starting_at_or_after_prolated_offset\(\)](#) (in module `abjad.tools.containertools`), 284
[get_first_element_starting_before_or_at_prolated_offset\(\)](#) (in module `abjad.tools.containertools`), 284
[get_first_element_starting_strictly_after_prolated_offset\(\)](#) (in module `abjad.tools.containertools`), 284
[get_first_element_starting_strictly_before_prolated_offset\(\)](#) (in module `abjad.tools.containertools`), 285
[get_first_instance_of_klass_in_improper_parentage_of_component\(\)](#) (in module `abjad.tools.componenttools`), 241
[get_first_instance_of_klass_in_proper_parentage_of_component\(\)](#) (in module `abjad.tools.componenttools`), 241
[get_first_measure_in_improper_parentage_of_component\(\)](#) (in module `abjad.tools.measuretools`), 454
[get_first_measure_in_proper_parentage_of_component\(\)](#) (in module `abjad.tools.measuretools`), 454
[get_first_score_in_improper_parentage_of_component\(\)](#) (in module `abjad.tools.scoretools`), 561
[get_first_score_in_proper_parentage_of_component\(\)](#) (in module `abjad.tools.scoretools`), 561
[get_first_staff_in_improper_parentage_of_component\(\)](#) (in module `abjad.tools.stafftools`), 609
[get_first_staff_in_proper_parentage_of_component\(\)](#) (in module `abjad.tools.stafftools`), 609
[get_first_tuplet_in_improper_parentage_of_component\(\)](#) (in module `abjad.tools.tuplettools`), 629
[get_first_tuplet_in_proper_parentage_of_component\(\)](#) (in module `abjad.tools.tuplettools`), 630
[get_first_voice_in_improper_parentage_of_component\(\)](#) (in module `abjad.tools.voicetools`), 638
[get_first_voice_in_proper_parentage_of_component\(\)](#) (in module `abjad.tools.voicetools`), 638
[get_grace_containers_attached_to_leaf\(\)](#) (in module `abjad.tools.gracetools`), 344
[get_improper_parentage_of_component\(\)](#) (in module `abjad.tools.componenttools`), 241
[get_indices_of_sequence_elements_equal_to_true\(\)](#) (in module `abjad.tools.sequencetools`), 733
[get_instrument_mark_attached_to_component\(\)](#) (in module `abjad.tools.contexttools`), 330
[get_instrument_marks_attached_to_component\(\)](#) (in module `abjad.tools.contexttools`), 330
[get_key_signature_mark_attached_to_component\(\)](#) (in module `abjad.tools.contexttools`), 331
[get_key_signature_marks_attached_to_component\(\)](#) (in module `abjad.tools.contexttools`), 331
[get_last_component_file_name\(\)](#) (in module `abjad.tools.iotools`), 676
[get_last_component_index_in_measure_number_in_expr\(\)](#) (in module `abjad.tools.leaftools`), 378
[get_leaf_in_expr_with_maximum_prolated_duration\(\)](#) (in module `abjad.tools.leaftools`), 378
[get_leaf_in_expr_with_minimum_prolated_duration\(\)](#) (in module `abjad.tools.leaftools`), 378
[get_leaves_in_tie_chain\(\)](#) (in module `abjad.tools.tietools`), 612
[get_likely_multiplier_of_components\(\)](#) (in module `abjad.tools.componenttools`), 241
[get_lilypond_command_mark_attached_to_component\(\)](#) (in module `abjad.tools.marktools`), 424
[get_lilypond_command_marks_attached_to_component\(\)](#) (in module `abjad.tools.marktools`), 425
[get_lilypond_comment_attached_to_component\(\)](#) (in module `abjad.tools.marktools`), 425
[get_lilypond_comments_attached_to_component\(\)](#) (in module `abjad.tools.marktools`), 426
[get_lilypond_version_string\(\)](#) (in module `abjad.tools.configurationtools`), 642
[get_mark_attached_to_component\(\)](#) (in module `abjad.tools.marktools`), 426
[get_marks_attached_to_component\(\)](#) (in module `abjad.tools.marktools`), 427

- `get_markup_attached_to_component()` (in module `abjad.tools.markuptools`), 436
- `get_named_chromatic_pitch_from_pitch_carrier()` (in module `abjad.tools.pitchtools`), 524
- `get_next_measure_from_component()` (in module `abjad.tools.measuretools`), 455
- `get_next_n_complete_nodes_at_level()` (`abjad.tools.sequencetools.Tree` method), 723
- `get_next_n_nodes_at_level()` (`abjad.tools.sequencetools.Tree` method), 723
- `get_next_output_file_name()` (in module `abjad.tools.iotools`), 676
- `get_node_at_position()` (`abjad.tools.sequencetools.Tree` method), 724
- `get_nonbinary_factor_from_time_signature_denominator()` (in module `abjad.tools.timesignaturetools`), 779
- `get_noncontext_mark_attached_to_component()` (in module `abjad.tools.marktools`), 427
- `get_noncontext_marks_attached_to_component()` (in module `abjad.tools.marktools`), 428
- `get_note_head_from_chord_by_pitch()` (in module `abjad.tools.chordtools`), 217
- `get_nth_component_in_expr()` (in module `abjad.tools.componenttools`), 242
- `get_nth_leaf_in_expr()` (in module `abjad.tools.leaftools`), 379
- `get_nth_leaf_in_spanner()` (in module `abjad.tools.spannertools`), 596
- `get_nth_leaf_in_thread_from_leaf()` (in module `abjad.tools.leaftools`), 380
- `get_nth_measure_in_expr()` (in module `abjad.tools.measuretools`), 456
- `get_nth_namesake_from_component()` (in module `abjad.tools.componenttools`), 243
- `get_numbered_chromatic_pitch_class_from_pitch_carrier()` (in module `abjad.tools.pitchtools`), 525
- `get_one_indexed_measure_number_in_expr()` (in module `abjad.tools.measuretools`), 456
- `get_overlap_with_interval()` (`abjad.tools.intervalreetools.BoundedInterval` method), 661
- `get_parent_and_start_stop_indices_of_components()` (in module `abjad.tools.componenttools`), 244
- `get_position_of_descendant()` (`abjad.tools.sequencetools.Tree` method), 724
- `get_preprolated_tie_chain_duration()` (in module `abjad.tools.tietools`), 613
- `get_prev_measure_from_component()` (in module `abjad.tools.measuretools`), 457
- `get_prolated_tie_chain_duration()` (in module `abjad.tools.tietools`), 613
- `get_proper_parentage_of_component()` (in module `abjad.tools.componenttools`), 244
- `get_python_version_string()` (in module `abjad.tools.configurationtools`), 642
- `get_sequence_degree_of_rotational_symmetry()` (in module `abjad.tools.sequencetools`), 733
- `get_sequence_element_at_cyclic_index()` (in module `abjad.tools.sequencetools`), 734
- `get_sequence_elements_at_indices()` (in module `abjad.tools.sequencetools`), 734
- `get_sequence_elements_frequency_distribution()` (in module `abjad.tools.sequencetools`), 735
- `get_sequence_period_of_rotation()` (in module `abjad.tools.sequencetools`), 735
- `get_shared_numeric_sign()` (in module `abjad.tools.mathtools`), 692
- `get_spanners_attached_to_any_improper_child_of_component()` (in module `abjad.tools.spannertools`), 597
- `get_spanners_attached_to_any_improper_parent_of_component()` (in module `abjad.tools.spannertools`), 597
- `get_spanners_attached_to_any_proper_child_of_component()` (in module `abjad.tools.spannertools`), 598
- `get_spanners_attached_to_any_proper_parent_of_component()` (in module `abjad.tools.spannertools`), 598
- `get_spanners_attached_to_component()` (in module `abjad.tools.spannertools`), 599
- `get_spanners_contained_by_components()` (in module `abjad.tools.spannertools`), 599
- `get_spanners_covered_by_components()` (in module `abjad.tools.spannertools`), 600
- `get_spanners_on_components_or_component_children()` (in module `abjad.tools.spannertools`), 600
- `get_spanners_that_cross_components()` (in module `abjad.tools.spannertools`), 600
- `get_spanners_that_dominates_component_pair()` (in module `abjad.tools.spannertools`), 600
- `get_spanners_that_dominates_components()` (in module `abjad.tools.spannertools`), 601
- `get_spanners_that_dominates_container_components_from_to()` (in module `abjad.tools.spannertools`), 601
- `get_staff_change_mark_attached_to_component()` (in module `abjad.tools.contexttools`), 332
- `get_staff_change_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 332
- `get_stem_tremolo_attached_to_component()` (in module `abjad.tools.marktools`), 428
- `get_stem_tremolos_attached_to_component()` (in module `abjad.tools.marktools`), 429
- `get_tempo_mark_attached_to_component()` (in module `abjad.tools.contexttools`), 333
- `get_tempo_marks_attached_to_component()` (in module `abjad.tools.contexttools`), 333
- `get_the_only_spanner_attached_to_any_improper_parent_of_component()` (in module `abjad.tools.spannertools`), 601
- `get_the_only_spanner_attached_to_component()` (in module `abjad.tools.spannertools`), 602

- [get_tie_chain\(\)](#) (in module `abjad.tools.tietools`), [613](#)
[get_tie_chain_duration_in_seconds\(\)](#) (in module `abjad.tools.tietools`), [613](#)
[get_tie_chains_in_expr\(\)](#) (in module `abjad.tools.tietools`), [613](#)
[get_time_signature_mark_attached_to_component\(\)](#) (in module `abjad.tools.contexttools`), [334](#)
[get_time_signature_marks_attached_to_component\(\)](#) (in module `abjad.tools.contexttools`), [334](#)
[get_up_markup_attached_to_component\(\)](#) (in module `abjad.tools.markuptools`), [436](#)
[get_value_of_annotation_attached_to_component\(\)](#) (in module `abjad.tools.marktools`), [429](#)
[get_vertical_moment_at_prolated_offset_in_expr\(\)](#) (in module `abjad.tools.verticalitytools`), [792](#)
[get_vertical_moment_starting_with_component\(\)](#) (in module `abjad.tools.verticalitytools`), [793](#)
[get_written_tie_chain_duration\(\)](#) (in module `abjad.tools.tietools`), [614](#)
[GlissandoSpanner](#) (class in `abjad.tools.spannertools`), [576](#)
[global_staff_size](#) (`abjad.tools.lilypondfiletools.LilyPondFile` attribute), [407](#)
[Glockenspiel](#) (class in `abjad.tools.instrumenttools`), [355](#)
[governors](#) (`abjad.tools.verticalitytools.VerticalMoment` attribute), [791](#)
[Grace](#) (class in `abjad.tools.gracetools`), [341](#)
[GrandStaff](#) (class in `abjad.tools.scoretools`), [555](#)
[greatest_common_divisor\(\)](#) (in module `abjad.tools.mathtools`), [693](#)
[greatest_multiple_less_equal\(\)](#) (in module `abjad.tools.mathtools`), [693](#)
[greatest_power_of_two_less_equal\(\)](#) (in module `abjad.tools.mathtools`), [694](#)
[group_duration_tokens_by_implied_prolation\(\)](#) (in module `abjad.tools.durationtools`), [647](#)
[group_leaves_in_tie_chain_by_immediate_parents\(\)](#) (in module `abjad.tools.tietools`), [614](#)
[group_overlapping_intervals_and_yield_groups\(\)](#) (in module `abjad.tools.intervaltreetools`), [669](#)
[group_tangent_or_overlapping_intervals_and_yield_groups\(\)](#) (in module `abjad.tools.intervaltreetools`), [669](#)
[Guitar](#) (class in `abjad.tools.instrumenttools`), [355](#)
- ## H
- [HairpinSpanner](#) (class in `abjad.tools.spannertools`), [577](#)
[harmonic_chromatic_interval](#) (`abjad.tools.pitchtools.MelodicChromaticInterval` attribute), [490](#)
[harmonic_chromatic_interval](#) (`abjad.tools.pitchtools.MelodicDiatonicInterval` attribute), [492](#)
[harmonic_chromatic_interval_class](#) (`abjad.tools.pitchtools.HarmonicChromaticInterval` attribute), [484](#)
[harmonic_chromatic_interval_class_segment](#) (`abjad.tools.pitchtools.NamedChromaticPitchSegment` attribute), [499](#)
[harmonic_chromatic_interval_numbers](#) (`abjad.tools.pitchtools.HarmonicChromaticIntervalSet` attribute), [485](#)
[harmonic_chromatic_interval_segment](#) (`abjad.tools.pitchtools.HarmonicDiatonicIntervalSegment` attribute), [487](#)
[harmonic_chromatic_interval_segment](#) (`abjad.tools.pitchtools.MelodicChromaticIntervalSegment` attribute), [491](#)
[harmonic_chromatic_interval_segment](#) (`abjad.tools.pitchtools.MelodicDiatonicIntervalSegment` attribute), [493](#)
[harmonic_chromatic_interval_segment](#) (`abjad.tools.pitchtools.NamedChromaticPitchSegment` attribute), [499](#)
[harmonic_chromatic_interval_set](#) (`abjad.tools.pitchtools.HarmonicDiatonicIntervalSet` attribute), [487](#)
[harmonic_chromatic_interval_set](#) (`abjad.tools.pitchtools.MelodicChromaticIntervalSet` attribute), [492](#)
[harmonic_chromatic_interval_set](#) (`abjad.tools.pitchtools.MelodicDiatonicIntervalSet` attribute), [493](#)
[harmonic_chromatic_intervals](#) (`abjad.tools.pitchtools.HarmonicChromaticIntervalSet` attribute), [485](#)
[harmonic_counterpoint_interval](#) (`abjad.tools.pitchtools.HarmonicDiatonicInterval` attribute), [486](#)
[harmonic_counterpoint_interval](#) (`abjad.tools.pitchtools.MelodicDiatonicInterval` attribute), [492](#)
[harmonic_counterpoint_interval_class](#) (`abjad.tools.pitchtools.HarmonicCounterpointInterval` attribute), [486](#)
[harmonic_diatonic_interval](#) (`abjad.tools.pitchtools.MelodicDiatonicInterval` attribute), [492](#)
[harmonic_diatonic_interval_class](#) (`abjad.tools.pitchtools.HarmonicDiatonicInterval` attribute), [486](#)
[harmonic_diatonic_interval_class_segment](#) (`abjad.tools.pitchtools.NamedChromaticPitchSegment` attribute), [499](#)
[harmonic_diatonic_interval_classes](#) (`abjad.tools.pitchtools.HarmonicDiatonicIntervalClassSet` attribute), [487](#)
[harmonic_diatonic_interval_numbers](#) (`abjad.tools.pitchtools.HarmonicDiatonicIntervalSet` attribute), [487](#)

harmonic_diatonic_interval_segment	(abjad.tools.pitchtools.MelodicDiatonicIntervalSegment attribute), 493	HiddenStaffSpanner (class in abjad.tools.spannertools), 579
harmonic_diatonic_interval_segment	(abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499	high (abjad.tools.intervaltreetools.BoundedInterval attribute), 661
harmonic_diatonic_interval_set	(abjad.tools.pitchtools.MelodicDiatonicIntervalSet attribute), 494	high (abjad.tools.intervaltreetools.IntervalTree attribute), 663
harmonic_diatonic_intervals	(abjad.tools.pitchtools.HarmonicDiatonicIntervalSet attribute), 487	high_max (abjad.tools.intervaltreetools.IntervalTree attribute), 663
HarmonicChromaticInterval	(class in abjad.tools.pitchtools), 484	high_min (abjad.tools.intervaltreetools.IntervalTree attribute), 663
HarmonicChromaticIntervalClass	(class in abjad.tools.pitchtools), 484	HorizontalBracketSpanner (class in abjad.tools.spannertools), 580
HarmonicChromaticIntervalClassVector	(class in abjad.tools.pitchtools), 485	
HarmonicChromaticIntervalSegment	(class in abjad.tools.pitchtools), 485	improper_parentage (abjad.tools.sequencetools.Tree attribute), 724
HarmonicChromaticIntervalSet	(class in abjad.tools.pitchtools), 485	include_rests (abjad.tools.spannertools.HairpinSpanner attribute), 578
HarmonicCounterpointInterval	(class in abjad.tools.pitchtools), 486	increase_sequence_elements_at_indices_by_addenda() (in module abjad.tools.sequencetools), 735
HarmonicCounterpointIntervalClass	(class in abjad.tools.pitchtools), 486	increase_sequence_elements_cyclically_by_addenda() (in module abjad.tools.sequencetools), 736
HarmonicDiatonicInterval	(class in abjad.tools.pitchtools), 486	index() (abjad.tools.containertools.Container method), 275
HarmonicDiatonicIntervalClass	(class in abjad.tools.pitchtools), 486	index() (abjad.tools.pitcharraytools.PitchArrayRow method), 713
HarmonicDiatonicIntervalClassSet	(class in abjad.tools.pitchtools), 487	index() (abjad.tools.spannertools.Spanner method), 588
HarmonicDiatonicIntervalSegment	(class in abjad.tools.pitchtools), 487	index_in_parent (abjad.tools.sequencetools.Tree attribute), 724
HarmonicDiatonicIntervalSet	(class in abjad.tools.pitchtools), 487	indices (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
Harp (class in abjad.tools.instrumenttools), 356		inflection_point_count (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499
Harpichord (class in abjad.tools.instrumenttools), 356		insert() (abjad.tools.containertools.Container method), 275
has_none_of() (abjad.tools.pitchtools.HarmonicChromaticIntervalClassVector method), 485		insert_and_transpose_nested_subruns_in_chromatic_pitch_class_number_1 (in module abjad.tools.pitchtools), 525
has_spanning_cell_over_index() (abjad.tools.pitcharraytools.PitchArray method), 710		insert_component_and_do_not_fracture_crossing_spanners() (in module abjad.tools.containertools), 285
has_spanning_cell_over_index() (abjad.tools.pitcharraytools.PitchArrayRow method), 713		insert_component_and_fracture_crossing_spanners() (in module abjad.tools.containertools), 286
has_voice_crossing (abjad.tools.pitcharraytools.PitchArray attribute), 710		instantiate_pitch_and_interval_test_collection() (in module abjad.tools.pitchtools), 526
has_voice_crossing (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712		instrument_count (abjad.tools.scoretools.InstrumentationSpecifier attribute), 556
HeaderBlock (class in abjad.tools.lilypondfiletools), 405		instrument_count (abjad.tools.scoretools.Performer attribute), 556
		instrument_name (abjad.tools.contexttools.InstrumentMark attribute), 311
		instrument_name_markup (abjad.tools.contexttools.InstrumentMark attribute), 311

InstrumentationSpecifier (class in abjad.tools.scoretools), 555

InstrumentMark (class in abjad.tools.contexttools), 311

instruments (abjad.tools.scoretools.InstrumentationSpecifier attribute), 556

instruments (abjad.tools.scoretools.Performer attribute), 557

integer_equivalent_number_to_integer() (in module abjad.tools.mathtools), 694

integer_tempo_to_multiplier_tempo_pairs() (in module abjad.tools.tempotools), 773

integer_tempo_to_multiplier_tempo_pairs_report() (in module abjad.tools.tempotools), 774

integer_to_base_k_tuple() (in module abjad.tools.mathtools), 695

integer_to_binary_string() (in module abjad.tools.mathtools), 695

interlace_sequences() (in module abjad.tools.sequencetools), 736

interpolate_cosine() (in module abjad.tools.mathtools), 696

interpolate_divide() (in module abjad.tools.mathtools), 696

interpolate_divide_multiple() (in module abjad.tools.mathtools), 696

interpolate_exponential() (in module abjad.tools.mathtools), 697

interpolate_linear() (in module abjad.tools.mathtools), 697

IntervalTree (class in abjad.tools.intervaltreetools), 662

inventory_aggregate_subsets() (in module abjad.tools.pitchtools), 527

inventory_inversion_equivalent_diatonic_interval_classes() (in module abjad.tools.pitchtools), 527

inversion (abjad.tools.tonalitytools.ChordClass attribute), 781

inversion (abjad.tools.tonalitytools.ChordQualityIndicator attribute), 781

inversion (abjad.tools.tonalitytools.TonalFunction attribute), 784

inversion_equivalent_chromatic_interval_class (abjad.tools.pitchtools.MelodicDiatonicInterval attribute), 493

inversion_equivalent_chromatic_interval_class_numbers (abjad.tools.pitchtools.InversionEquivalentChromaticIntervalClassSet attribute), 488

inversion_equivalent_chromatic_interval_class_segment (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499

inversion_equivalent_chromatic_interval_class_segment (abjad.tools.pitchtools.NumberedChromaticPitchClassSegment attribute), 505

inversion_equivalent_chromatic_interval_class_set (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499

inversion_equivalent_chromatic_interval_class_set (abjad.tools.pitchtools.NumberedChromaticPitchClassSet attribute), 506

inversion_equivalent_chromatic_interval_class_vector (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499

inversion_equivalent_chromatic_interval_class_vector (abjad.tools.pitchtools.NumberedChromaticPitchClassSet attribute), 506

inversion_equivalent_chromatic_interval_classes (abjad.tools.pitchtools.InversionEquivalentChromaticIntervalClassSet attribute), 488

inversion_equivalent_chromatic_interval_number (abjad.tools.pitchtools.InversionEquivalentChromaticIntervalClass attribute), 488

inversion_equivalent_diatonic_interval_class_segment (abjad.tools.pitchtools.NamedChromaticPitchClassSegment attribute), 497

inversion_equivalent_diatonic_interval_class_vector (abjad.tools.pitchtools.NamedChromaticPitchClassSet attribute), 498

InversionEquivalentChromaticIntervalClass (class in abjad.tools.pitchtools), 488

InversionEquivalentChromaticIntervalClassSegment (class in abjad.tools.pitchtools), 488

InversionEquivalentChromaticIntervalClassSet (class in abjad.tools.pitchtools), 488

InversionEquivalentChromaticIntervalClassVector (class in abjad.tools.pitchtools), 488

InversionEquivalentDiatonicIntervalClass (class in abjad.tools.pitchtools), 489

InversionEquivalentDiatonicIntervalClassSegment (class in abjad.tools.pitchtools), 489

InversionEquivalentDiatonicIntervalClassVector (class in abjad.tools.pitchtools), 489

InversionIndicator (class in abjad.tools.tonalitytools), 782

invert() (abjad.tools.pitchtools.HarmonicDiatonicIntervalClass method), 487

invert() (abjad.tools.pitchtools.NumberedChromaticPitchClass method), 504

invert() (abjad.tools.pitchtools.NumberedChromaticPitchClassSegment method), 505

invert() (abjad.tools.pitchtools.NumberedChromaticPitchClassSet method), 506

is_adjusted (abjad.tools.pitchtools.Accidental attribute), 483

is_alphabetic_accidental_abbreviation() (in module abjad.tools.pitchtools), 528

is_assignable_integer() (in module abjad.tools.mathtools), 697

is_assignable_rational() (in module abjad.tools.durationtools), 647

- `is_at_level()` (abjad.tools.sequencetools.Tree method), 725
- `is_augmentation` (abjad.tools.tuplettools.Tuplet attribute), 625
- `is_bar_line_crossing_leaf()` (in module abjad.tools.leaftools), 380
- `is_beamable_component()` (in module abjad.tools.componenttools), 244
- `is_binary` (abjad.tools.measuretools.Measure attribute), 440
- `is_binary` (abjad.tools.tuplettools.Tuplet attribute), 625
- `is_binary_rational()` (in module abjad.tools.durationtools), 648
- `is_braced` (abjad.tools.markuptools.MarkupCommand attribute), 434
- `is_chromatic_pitch_class_name()` (in module abjad.tools.pitchtools), 528
- `is_chromatic_pitch_class_name_octave_number_pair()` (in module abjad.tools.pitchtools), 528
- `is_chromatic_pitch_class_number()` (in module abjad.tools.pitchtools), 528
- `is_chromatic_pitch_name()` (in module abjad.tools.pitchtools), 529
- `is_chromatic_pitch_number()` (in module abjad.tools.pitchtools), 529
- `is_component_with_annotation_attached()` (in module abjad.tools.marktools), 430
- `is_component_with_articulation_attached()` (in module abjad.tools.marktools), 430
- `is_component_with_beam_spanner_attached()` (in module abjad.tools.spannertools), 602
- `is_component_with_clef_mark_attached()` (in module abjad.tools.contexttools), 335
- `is_component_with_context_mark_attached()` (in module abjad.tools.contexttools), 335
- `is_component_with_dynamic_mark_attached()` (in module abjad.tools.contexttools), 336
- `is_component_with_instrument_mark_attached()` (in module abjad.tools.contexttools), 336
- `is_component_with_key_signature_mark_attached()` (in module abjad.tools.contexttools), 337
- `is_component_with_lilypond_command_mark_attached()` (in module abjad.tools.marktools), 430
- `is_component_with_lilypond_comment_attached()` (in module abjad.tools.marktools), 431
- `is_component_with_mark_attached()` (in module abjad.tools.marktools), 431
- `is_component_with_noncontext_mark_attached()` (in module abjad.tools.marktools), 432
- `is_component_with_spanner_attached()` (in module abjad.tools.spannertools), 602
- `is_component_with_staff_change_mark_attached()` (in module abjad.tools.contexttools), 337
- `is_component_with_stem_tremolo_attached()` (in module abjad.tools.marktools), 432
- `is_component_with_tempo_mark_attached()` (in module abjad.tools.contexttools), 338
- `is_component_with_tie_spanner_attached()` (in module abjad.tools.tietools), 614
- `is_component_with_time_signature_mark_attached()` (in module abjad.tools.contexttools), 338
- `is_congruent_base()` (abjad.tools.sievetools.ResidueClassExpression method), 772
- `is_contained_by_interval()` (abjad.tools.intervaltreertools.BoundedInterval method), 661
- `is_container_of_interval()` (abjad.tools.intervaltreertools.BoundedInterval method), 662
- `is_defective` (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712
- `is_defective` (abjad.tools.pitcharraytools.PitchArrayRow attribute), 713
- `is_diatonic_pitch_class_name()` (in module abjad.tools.pitchtools), 529
- `is_diatonic_pitch_class_number()` (in module abjad.tools.pitchtools), 529
- `is_diatonic_pitch_name()` (in module abjad.tools.pitchtools), 529
- `is_diatonic_pitch_number()` (in module abjad.tools.pitchtools), 530
- `is_diatonic_quality_abbreviation()` (in module abjad.tools.pitchtools), 530
- `is_diminution` (abjad.tools.tuplettools.Tuplet attribute), 625
- `is_dotted_integer()` (in module abjad.tools.mathtools), 698
- `is_doubling` (abjad.tools.scoretools.Performer attribute), 557
- `is_duration_pair()` (in module abjad.tools.durationtools), 649
- `is_duration_token()` (in module abjad.tools.durationtools), 649
- `is_dynamic_name()` (abjad.tools.contexttools.DynamicMark static method), 310
- `is_empty` (abjad.tools.tonalitytools.SuspensionIndicator attribute), 784
- `is_equivalent_under_transposition()` (abjad.tools.pitchtools.NamedChromaticPitchClassSegment method), 497
- `is_first_in_row` (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
- `is_full` (abjad.tools.measuretools.Measure attribute), 440
- `is_hairpin_shape_string()` (abjad.tools.spannertools.HairpinSpanner static method), 497

- method), 578
- is_harmonic_diatonic_interval_abbreviation() (in module abjad.tools.pitchtools), 530
- is_in_range (abjad.tools.pitcharraytools.PitchArrayRow attribute), 713
- is_integer_equivalent_expr() (in module abjad.tools.mathtools), 698
- is_integer_equivalent_number() (in module abjad.tools.mathtools), 699
- is_invisible (abjad.tools.tuplettools.Tuplet attribute), 625
- is_last_in_row (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
- is_lilypond_duration_name() (in module abjad.tools.durationtools), 649
- is_lilypond_duration_string() (in module abjad.tools.durationtools), 649
- is_lilypond_rest_string() (in module abjad.tools.resttools), 547
- is_lowercamelcase_string() (in module abjad.tools.iotools), 676
- is_melodic_diatonic_interval_abbreviation() (in module abjad.tools.pitchtools), 530
- is_monotonically_decreasing_sequence() (in module abjad.tools.sequencetools), 736
- is_monotonically_increasing_sequence() (in module abjad.tools.sequencetools), 737
- is_named_chromatic_pitch_token() (in module abjad.tools.pitchtools), 531
- is_negative_integer() (in module abjad.tools.mathtools), 699
- is_neighbor_note() (in module abjad.tools.tonalitytools), 788
- is_nonbinary (abjad.tools.contexttools.TimeSignatureMark attribute), 317
- is_nonbinary (abjad.tools.measuretools.Measure attribute), 441
- is_nonbinary (abjad.tools.tuplettools.Tuplet attribute), 625
- is_nonnegative_integer() (in module abjad.tools.mathtools), 699
- is_nonnegative_integer_equivalent_number() (in module abjad.tools.mathtools), 700
- is_nonnegative_integer_power_of_two() (in module abjad.tools.mathtools), 700
- is_octave_tick_string() (in module abjad.tools.pitchtools), 531
- is_orphan_component() (in module abjad.tools.componenttools), 244
- is_overfull (abjad.tools.measuretools.Measure attribute), 441
- is_overlapped_by_interval() (abjad.tools.intervaltreetools.BoundedInterval method), 662
- is_parallel (abjad.tools.containertools.Container attribute), 276
- is_passing_tone() (in module abjad.tools.tonalitytools), 788
- is_permutation() (in module abjad.tools.sequencetools), 738
- is_pitch_carrier() (in module abjad.tools.pitchtools), 531
- is_pitch_class_octave_number_string() (in module abjad.tools.pitchtools), 531
- is_pitch_class_unique (abjad.tools.pitchtools.NamedChromaticPitchSet attribute), 499
- is_positive_integer() (in module abjad.tools.mathtools), 700
- is_positive_integer_equivalent_number() (in module abjad.tools.mathtools), 701
- is_positive_integer_power_of_two() (in module abjad.tools.mathtools), 701
- is_proper_tuplet_multiplier() (in module abjad.tools.tuplettools), 630
- is_rectangular (abjad.tools.pitcharraytools.PitchArray attribute), 710
- is_repetition_free_sequence() (in module abjad.tools.sequencetools), 738
- is_restricted_growth_function() (in module abjad.tools.sequencetools), 739
- is_space_delimited_lowercase_string() (in module abjad.tools.iotools), 677
- is_strictly_decreasing_sequence() (in module abjad.tools.sequencetools), 739
- is_strictly_increasing_sequence() (in module abjad.tools.sequencetools), 740
- is_symbolic_accidental_string() (in module abjad.tools.pitchtools), 531
- is_symbolic_pitch_range_string() (in module abjad.tools.pitchtools), 532
- is_tangent_to_interval() (abjad.tools.intervaltreetools.BoundedInterval method), 662
- is_tertian (abjad.tools.pitchtools.InversionEquivalentDiatonicIntervalClassSet attribute), 489
- is_tie_chain() (in module abjad.tools.tietools), 615
- is_tie_chain_with_all_leaves_in_same_parent() (in module abjad.tools.tietools), 615
- is_time_signature_with_equivalent_binary_representation() (in module abjad.tools.timesignaturetools), 780
- is_transposed_subset() (abjad.tools.pitchtools.NumberedChromaticPitchClassSet method), 506
- is_transposed_superset() (abjad.tools.pitchtools.NumberedChromaticPitchClassSet method), 507
- is_trivial (abjad.tools.tuplettools.Tuplet attribute), 625

[is_underfull](#) (abjad.tools.measuretools.Measure attribute), 441
[is_underscore_delimited_lowercase_package_name\(\)](#) (in module abjad.tools.iotools), 677
[is_underscore_delimited_lowercase_string\(\)](#) (in module abjad.tools.iotools), 677
[is_unlikely_melodic_diatonic_interval_in_chorale\(\)](#) (in module abjad.tools.tonalitytools), 789
[is_uppercamelcase_string\(\)](#) (in module abjad.tools.iotools), 677
[is_uppercase](#) (abjad.tools.tonalitytools.QualityIndicator attribute), 783
[is_valid_beatspan\(\)](#) (in module abjad.tools.quantizationtools), 806
[is_well_formed_component\(\)](#) (in module abjad.tools.componenttools), 245
[iterate_at_level\(\)](#) (abjad.tools.sequencetools.Tree method), 725
[iterate_chords_backward_in_expr\(\)](#) (in module abjad.tools.chordtools), 217
[iterate_chords_forward_in_expr\(\)](#) (in module abjad.tools.chordtools), 218
[iterate_components_and_grace_containers_forward_in_expr\(\)](#) (in module abjad.tools.gracetools), 345
[iterate_components_backward_in_expr\(\)](#) (in module abjad.tools.componenttools), 245
[iterate_components_backward_in_spanner\(\)](#) (in module abjad.tools.spannertools), 603
[iterate_components_depth_first\(\)](#) (in module abjad.tools.componenttools), 246
[iterate_components_forward_in_expr\(\)](#) (in module abjad.tools.componenttools), 247
[iterate_components_forward_in_spanner\(\)](#) (in module abjad.tools.spannertools), 603
[iterate_containers_backward_in_expr\(\)](#) (in module abjad.tools.containertools), 286
[iterate_containers_forward_in_expr\(\)](#) (in module abjad.tools.containertools), 287
[iterate_contexts_backward_in_expr\(\)](#) (in module abjad.tools.contexttools), 339
[iterate_contexts_forward_in_expr\(\)](#) (in module abjad.tools.contexttools), 339
[iterate_depth_first\(\)](#) (abjad.tools.sequencetools.Tree method), 726
[iterate_leaf_pairs_forward_in_expr\(\)](#) (in module abjad.tools.leaftools), 381
[iterate_leaves_backward_in_expr\(\)](#) (in module abjad.tools.leaftools), 382
[iterate_leaves_forward_in_expr\(\)](#) (in module abjad.tools.leaftools), 383
[iterate_measures_backward_in_expr\(\)](#) (in module abjad.tools.measuretools), 458
[iterate_measures_forward_in_expr\(\)](#) (in module abjad.tools.measuretools), 459
[iterate_named_chromatic_pitch_pairs_forward_in_expr\(\)](#) (in module abjad.tools.pitchtools), 532
[iterate_namesakes_backward_from_component\(\)](#) (in module abjad.tools.componenttools), 248
[iterate_namesakes_forward_from_component\(\)](#) (in module abjad.tools.componenttools), 249
[iterate_notes_and_chords_backward_in_expr\(\)](#) (in module abjad.tools.leaftools), 384
[iterate_notes_and_chords_forward_in_expr\(\)](#) (in module abjad.tools.leaftools), 384
[iterate_notes_and_chords_in_expr_outside_traditional_instrument_ranges\(\)](#) (in module abjad.tools.instrumenttools), 364
[iterate_notes_backward_in_expr\(\)](#) (in module abjad.tools.notetools), 475
[iterate_notes_forward_in_expr\(\)](#) (in module abjad.tools.notetools), 476
[iterate_payload\(\)](#) (abjad.tools.sequencetools.Tree method), 726
[iterate_rests_backward_in_expr\(\)](#) (in module abjad.tools.resttools), 548
[iterate_rests_forward_in_expr\(\)](#) (in module abjad.tools.resttools), 548
[iterate_scores_backward_in_expr\(\)](#) (in module abjad.tools.scoretools), 561
[iterate_scores_forward_in_expr\(\)](#) (in module abjad.tools.scoretools), 562
[iterate_semantic_voices_backward_in_expr\(\)](#) (in module abjad.tools.voicetools), 638
[iterate_semantic_voices_forward_in_expr\(\)](#) (in module abjad.tools.voicetools), 639
[iterate_sequence_cyclically\(\)](#) (in module abjad.tools.sequencetools), 740
[iterate_sequence_cyclically_from_start_to_stop\(\)](#) (in module abjad.tools.sequencetools), 741
[iterate_sequence_forward_and_backward_nonoverlapping\(\)](#) (in module abjad.tools.sequencetools), 741
[iterate_sequence_forward_and_backward_overlapping\(\)](#) (in module abjad.tools.sequencetools), 742
[iterate_sequence_nwise_cyclic\(\)](#) (in module abjad.tools.sequencetools), 742
[iterate_sequence_nwise_strict\(\)](#) (in module abjad.tools.sequencetools), 742
[iterate_sequence_nwise_wrapped\(\)](#) (in module abjad.tools.sequencetools), 742
[iterate_sequence_pairwise_cyclic\(\)](#) (in module abjad.tools.sequencetools), 743
[iterate_sequence_pairwise_strict\(\)](#) (in module abjad.tools.sequencetools), 743
[iterate_sequence_pairwise_wrapped\(\)](#) (in module abjad.tools.sequencetools), 743
[iterate_skips_backward_in_expr\(\)](#) (in module abjad.tools.skiptools), 567
[iterate_skips_forward_in_expr\(\)](#) (in module abjad.tools.skiptools), 567

iterate_staves_backward_in_expr() (in module abjad.tools.stafftools), 610

iterate_staves_forward_in_expr() (in module abjad.tools.stafftools), 610

iterate_thread_backward_from_component() (in module abjad.tools.threadtools), 774

iterate_thread_backward_in_expr() (in module abjad.tools.threadtools), 776

iterate_thread_forward_from_component() (in module abjad.tools.threadtools), 777

iterate_thread_forward_in_expr() (in module abjad.tools.threadtools), 778

iterate_tie_chains_backward_in_expr() (in module abjad.tools.tietools), 615

iterate_tie_chains_forward_in_expr() (in module abjad.tools.tietools), 616

iterate_timeline_backward_from_component() (in module abjad.tools.componenttools), 250

iterate_timeline_backward_in_expr() (in module abjad.tools.componenttools), 250

iterate_timeline_forward_from_component() (in module abjad.tools.componenttools), 251

iterate_timeline_forward_in_expr() (in module abjad.tools.componenttools), 252

iterate_topmost_tie_chains_and_components_forward_in_expr() (in module abjad.tools.tietools), 617

iterate_tuplets_backward_in_expr() (in module abjad.tools.tuplettools), 631

iterate_tuplets_forward_in_expr() (in module abjad.tools.tuplettools), 631

iterate_vertical_moments_backward_in_expr() (in module abjad.tools.verticalitytools), 794

iterate_vertical_moments_forward_in_expr() (in module abjad.tools.verticalitytools), 795

iterate_voices_backward_in_expr() (in module abjad.tools.voicetools), 640

iterate_voices_forward_in_expr() (in module abjad.tools.voicetools), 640

J

join_subsequences() (in module abjad.tools.sequencetools), 744

join_subsequences_by_sign_of_subsequence_elements() (in module abjad.tools.sequencetools), 744

K

key_signature (abjad.tools.tonalitytools.Scale attribute), 783

KeySignatureMark (class in abjad.tools.contexttools), 312

kind (abjad.tools.gracetools.Grace attribute), 342

kind (abjad.tools.spannertools.PianoPedalSpanner attribute), 585

known_untuned_percussion (abjad.tools.instrumenttools.UntunedPercussion attribute), 362

L

label_leaves_in_expr_with_inversion_equivalent_chromatic_interval_classes() (in module abjad.tools.leaftools), 385

label_leaves_in_expr_with_leaf_depth() (in module abjad.tools.leaftools), 385

label_leaves_in_expr_with_leaf_durations() (in module abjad.tools.leaftools), 386

label_leaves_in_expr_with_leaf_indices() (in module abjad.tools.leaftools), 386

label_leaves_in_expr_with_leaf_numbers() (in module abjad.tools.leaftools), 386

label_leaves_in_expr_with_melodic_chromatic_interval_classes() (in module abjad.tools.leaftools), 387

label_leaves_in_expr_with_melodic_chromatic_intervals() (in module abjad.tools.leaftools), 387

label_leaves_in_expr_with_melodic_counterpoint_interval_classes() (in module abjad.tools.leaftools), 388

label_leaves_in_expr_with_melodic_counterpoint_intervals() (in module abjad.tools.leaftools), 388

label_leaves_in_expr_with_melodic_diatonic_interval_classes() (in module abjad.tools.leaftools), 388

label_leaves_in_expr_with_melodic_diatonic_intervals() (in module abjad.tools.leaftools), 389

label_leaves_in_expr_with_pitch_class_numbers() (in module abjad.tools.leaftools), 389

label_leaves_in_expr_with_pitch_numbers() (in module abjad.tools.leaftools), 390

label_leaves_in_expr_with_prolated_leaf_duration() (in module abjad.tools.leaftools), 390

label_leaves_in_expr_with_tuplet_depth() (in module abjad.tools.leaftools), 391

label_leaves_in_expr_with_written_leaf_duration() (in module abjad.tools.leaftools), 391

label_notes_in_expr_with_note_indices() (in module abjad.tools.notetools), 477

label_tie_chains_in_expr_with_prolated_tie_chain_duration() (in module abjad.tools.tietools), 617

label_tie_chains_in_expr_with_tie_chain_durations() (in module abjad.tools.tietools), 618

label_tie_chains_in_expr_with_written_tie_chain_duration() (in module abjad.tools.tietools), 618

label_vertical_moments_in_expr_with_chromatic_interval_classes() (in module abjad.tools.verticalitytools), 796

label_vertical_moments_in_expr_with_chromatic_intervals() (in module abjad.tools.verticalitytools), 797

label_vertical_moments_in_expr_with_counterpoint_intervals() (in module abjad.tools.verticalitytools), 797

label_vertical_moments_in_expr_with_diatonic_intervals() (in module abjad.tools.verticalitytools), 798

- label_vertical_moments_in_expr_with_interval_class_vectors() (in module abjad.tools.verticalitytools), 799
- label_vertical_moments_in_expr_with_numbered_chromatic_intervals() (in module abjad.tools.verticalitytools), 799
- label_vertical_moments_in_expr_with_pitch_numbers() (in module abjad.tools.verticalitytools), 800
- LayoutBlock (class in abjad.tools.lilypondfiletools), 405
- leading_tone (abjad.tools.tonalitytools.Scale attribute), 783
- leaf_to_augmented_tuplet_with_n_notes_of_equal_written_duration() (in module abjad.tools.leaftools), 391
- leaf_to_augmented_tuplet_with_proportions() (in module abjad.tools.leaftools), 392
- leaf_to_diminished_tuplet_with_n_notes_of_equal_written_duration() (in module abjad.tools.leaftools), 392
- leaf_to_diminished_tuplet_with_proportions() (in module abjad.tools.leaftools), 393
- least_common_multiple() (in module abjad.tools.mathtools), 701
- least_multiple_greater_equal() (in module abjad.tools.mathtools), 702
- least_power_of_two_greater_equal() (in module abjad.tools.mathtools), 702
- leaves (abjad.tools.containertools.Container attribute), 276
- leaves (abjad.tools.spannertools.Spanner attribute), 589
- leaves (abjad.tools.verticalitytools.VerticalMoment attribute), 791
- level (abjad.tools.sequencetools.Tree attribute), 727
- likely_instruments_based_on_performer_name (abjad.tools.scoretools.Performer attribute), 557
- lilypond_duration_string_to_rational() (in module abjad.tools.durationtools), 650
- lilypond_duration_string_to_rational_list() (in module abjad.tools.durationtools), 650
- LilyPondCommandMark (class in abjad.tools.marktools), 413
- LilyPondComment (class in abjad.tools.marktools), 414
- LilyPondFile (class in abjad.tools.lilypondfiletools), 406
- LilyPondLanguageToken (class in abjad.tools.lilypondfiletools), 407
- LilyPondParser (class in abjad.tools.lilypondparsertools), 801
- LilyPondVersionToken (class in abjad.tools.lilypondfiletools), 408
- lines (abjad.tools.spannertools.StaffLinesSpanner attribute), 590
- list_abjad_environment_variables() (in module abjad.tools.configurationtools), 642
- list_abjad_templates() (in module abjad.tools.configurationtools), 642
- list_badly_formed_components_in_expr() (in module abjad.tools.componenttools), 253
- list_chromatic_pitch_numbers_in_expr() (in module abjad.tools.pitchtools), 533
- list_chromatic_intervals_in_expr() (in module abjad.tools.pitchtools), 533
- list_harmonic_diatonic_intervals_in_expr() (in module abjad.tools.pitchtools), 534
- list_improper_contents_of_component_that_cross_prolated_offset() (in module abjad.tools.componenttools), 253
- list_instrument_names() (in module abjad.tools.instrumenttools), 364
- list_instruments() (in module abjad.tools.instrumenttools), 365
- list_inversion_equivalent_chromatic_interval_classes_pairwise_between_pitches() (in module abjad.tools.pitchtools), 534
- list_leftmost_components_with_prolated_duration_at_most() (in module abjad.tools.componenttools), 254
- list_melodic_chromatic_interval_numbers_pairwise_between_pitch_carriers() (in module abjad.tools.pitchtools), 535
- list_named_chromatic_pitch_carriers_in_expr_sorted_by_numbered_chromatic_intervals() (in module abjad.tools.pitchtools), 536
- list_named_chromatic_pitches_in_expr() (in module abjad.tools.pitchtools), 536
- list_nonspanning_subarrays_of_pitch_array() (in module abjad.tools.pitcharraytools), 715
- list_numbered_chromatic_pitch_classes_in_expr() (in module abjad.tools.pitchtools), 536
- list_octave_transpositions_of_pitch_carrier_within_pitch_range() (in module abjad.tools.pitchtools), 537
- list_ordered_named_chromatic_pitch_pairs_from_expr_1_to_expr_2() (in module abjad.tools.pitchtools), 537
- list_package_dependency_versions() (in module abjad.tools.configurationtools), 642
- list_performer_names() (in module abjad.tools.scoretools), 562
- list_primary_instruments() (in module abjad.tools.instrumenttools), 366
- list_primary_performer_names() (in module abjad.tools.scoretools), 563
- list_prolated_durations_of_leaves_in_expr() (in module abjad.tools.leaftools), 393
- list_secondary_instruments() (in module abjad.tools.instrumenttools), 367
- list_time_signatures_of_measures_in_expr() (in module abjad.tools.measuretools), 459
- list_unordered_named_chromatic_pitch_pairs_in_expr() (in module abjad.tools.pitchtools), 537
- list_written_durations_of_leaves_in_expr() (in module abjad.tools.leaftools), 393
- local_maxima (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499
- local_minima (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499
- log() (in module abjad.tools.iotools), 678

lone (abjad.tools.spannertools.ComplexBeamSpanner attribute), 571

low (abjad.tools.intervaltreetools.BoundedInterval attribute), 662

low (abjad.tools.intervaltreetools.IntervalTree attribute), 663

low_max (abjad.tools.intervaltreetools.IntervalTree attribute), 663

low_min (abjad.tools.intervaltreetools.IntervalTree attribute), 663

ly() (in module abjad.tools.iotools), 678

M

magnitude (abjad.tools.intervaltreetools.BoundedInterval attribute), 662

magnitude (abjad.tools.intervaltreetools.IntervalTree attribute), 663

make_accelerating_notes_with_lilypond_multipliers() (in module abjad.tools.notetools), 478

make_all_notes_in_ascending_and_descending_diatonic_scale() (in module abjad.tools.tonalitytools), 789

make_augmented_tuplet_from_duration_and_proportions_and_favorite_rests() (in module abjad.tools.tuplettools), 632

make_augmented_tuplet_from_duration_and_proportions_and_favorite_rests() (in module abjad.tools.tuplettools), 632

make_basic_lilypond_file() (in module abjad.tools.lilypondfiletools), 409

make_big_centered_page_number_markup() (in module abjad.tools.markuptools), 436

make_covered_spanner_schema() (in module abjad.tools.spannertools), 604

make_diminished_tuplet_from_duration_and_proportions_and_favorite_rests() (in module abjad.tools.tuplettools), 633

make_diminished_tuplet_from_duration_and_proportions_and_favorite_rests() (in module abjad.tools.tuplettools), 634

make_dynamic_spanner_below_with_nib_at_right() (in module abjad.tools.spannertools), 604

make_empty_piano_score() (in module abjad.tools.scoretools), 563

make_empty_pitch_array_from_list_of_pitch_lists() (in module abjad.tools.pitcharraytools), 715

make_first_n_notes_in_ascending_diatonic_scale() (in module abjad.tools.tonalitytools), 790

make_invisible_staff() (in module abjad.tools.stafftools), 611

make_leaves() (in module abjad.tools.leaftools), 393

make_leaves_from_note_value_signal() (in module abjad.tools.leaftools), 394

make_measures_with_full_measure_spacer_skips() (in module abjad.tools.measuretools), 460

make_monophonic_percussion_score_from_nonoverlapping_intervals() (in module abjad.tools.intervaltreetools), 669

make_multi_measure_rests() (in module abjad.tools.resttools), 549

make_n_middle_c_centered_pitches() (in module abjad.tools.pitchtools), 537

make_notes() (in module abjad.tools.notetools), 478

make_notes_with_multiplied_durations() (in module abjad.tools.notetools), 479

make_percussion_note() (in module abjad.tools.notetools), 479

make_performer_name_instrument_dictionary() (abjad.tools.scoretools.Performer method), 557

make_piano_score_from_leaves() (in module abjad.tools.scoretools), 563

make_piano_sketch_score_from_leaves() (in module abjad.tools.scoretools), 564

make_pitch_array_score_from_pitch_arrays() (in module abjad.tools.scoretools), 565

make_polyphonic_percussion_score_from_nonoverlapping_trees() (in module abjad.tools.intervaltreetools), 669

make_populated_pitch_array_from_list_of_pitch_lists() (in module abjad.tools.pitcharraytools), 716

make_quarter_notes_with_lilypond_multipliers() (in module abjad.tools.notetools), 480

make_repeated_notes() (in module abjad.tools.notetools), 480

make_repeated_notes_from_time_signature() (in module abjad.tools.notetools), 481

make_repeated_notes_from_time_signatures() (in module abjad.tools.notetools), 481

make_repeated_notes_with_shorter_notes_at_end() (in module abjad.tools.notetools), 481

make_repeated_rests_from_time_signature() (in module abjad.tools.resttools), 549

make_repeated_rests_from_time_signatures() (in module abjad.tools.resttools), 549

make_repeated_skips_from_time_signature() (in module abjad.tools.skiptools), 568

make_repeated_skips_from_time_signatures() (in module abjad.tools.skiptools), 568

make_rests() (in module abjad.tools.resttools), 549

make_rhythmic_sketch_staff() (in module abjad.tools.stafftools), 611

make_skips_with_multiplied_durations() (in module abjad.tools.skiptools), 568

make_solid_text_spanner_above_with_nib_at_right() (in module abjad.tools.spannertools), 605

make_solid_text_spanner_below_with_nib_at_right() (in module abjad.tools.spannertools), 606

make_spacing_vector() (in module abjad.tools.layouttools), 684

make_spanner_schema() (in module abjad.tools.spannertools), 606

make_tuplet_from_proportions_and_pair() (in module abjad.tools.tuplettools), 634

map_sequence_elements_to_canonic_tuples() (in module abjad.tools.sequencetools), 744

- map_sequence_elements_to_numbered_sublists() (in module abjad.tools.sequencetools), 745
- Marimba (class in abjad.tools.instrumenttools), 357
- mark (abjad.tools.spannertools.DynamicTextSpanner attribute), 576
- Mark (class in abjad.tools.marktools), 415
- markup (abjad.tools.markuptools.MarkupCommand attribute), 434
- markup (abjad.tools.tonalitytools.ChordClass attribute), 781
- markup (abjad.tools.tonalitytools.TonalFunction attribute), 784
- Markup (class in abjad.tools.markuptools), 432
- MarkupCommand (class in abjad.tools.markuptools), 434
- mask_intervals_with_intervals() (in module abjad.tools.intervaltreetools), 669
- matches_cell() (abjad.tools.pitcharraytools.PitchArrayCell method), 711
- Matrix (class in abjad.tools.sequencetools), 720
- Measure (class in abjad.tools.measuretools), 440
- measure_number (abjad.tools.measuretools.Measure attribute), 441
- measure_to_one_line_input_string() (in module abjad.tools.measuretools), 461
- MeasuredComplexBeamSpanner (class in abjad.tools.spannertools), 580
- measures (abjad.tools.verticalitytools.VerticalMoment attribute), 791
- mediant (abjad.tools.tonalitytools.Scale attribute), 783
- melodic_chromatic_interval (abjad.tools.pitchtools.MelodicDiatonicInterval attribute), 493
- melodic_chromatic_interval_class (abjad.tools.pitchtools.MelodicChromaticInterval attribute), 490
- melodic_chromatic_interval_class_segment (abjad.tools.pitchtools.MelodicChromaticIntervalSegment attribute), 491
- melodic_chromatic_interval_class_segment (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499
- melodic_chromatic_interval_class_vector (abjad.tools.pitchtools.MelodicChromaticIntervalSegment attribute), 491
- melodic_chromatic_interval_numbers (abjad.tools.pitchtools.MelodicChromaticIntervalSegment attribute), 491
- melodic_chromatic_interval_numbers (abjad.tools.pitchtools.MelodicChromaticIntervalSet attribute), 492
- melodic_chromatic_interval_segment (abjad.tools.pitchtools.HarmonicDiatonicIntervalSegment attribute), 487
- melodic_chromatic_interval_segment (abjad.tools.pitchtools.MelodicDiatonicIntervalSegment attribute), 493
- melodic_chromatic_interval_segment (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499
- melodic_chromatic_interval_set (abjad.tools.pitchtools.MelodicDiatonicIntervalSet attribute), 494
- melodic_chromatic_intervals (abjad.tools.pitchtools.MelodicChromaticIntervalSet attribute), 492
- melodic_counterpoint_interval (abjad.tools.pitchtools.MelodicDiatonicInterval attribute), 493
- melodic_counterpoint_interval_class (abjad.tools.pitchtools.MelodicCounterpointInterval attribute), 492
- melodic_diatonic_interval_ascending (abjad.tools.pitchtools.HarmonicDiatonicInterval attribute), 486
- melodic_diatonic_interval_class (abjad.tools.pitchtools.MelodicDiatonicInterval attribute), 493
- melodic_diatonic_interval_class_segment (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499
- melodic_diatonic_interval_descending (abjad.tools.pitchtools.HarmonicDiatonicInterval attribute), 486
- melodic_diatonic_interval_numbers (abjad.tools.pitchtools.MelodicDiatonicIntervalSet attribute), 494
- melodic_diatonic_interval_segment (abjad.tools.pitchtools.HarmonicDiatonicIntervalSegment attribute), 487
- melodic_diatonic_interval_segment (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499
- melodic_diatonic_interval_segment (abjad.tools.tonalitytools.Mode attribute), 782
- melodic_diatonic_intervals (abjad.tools.pitchtools.MelodicDiatonicIntervalSet attribute), 494
- MelodicChromaticInterval (class in abjad.tools.pitchtools), 489
- MelodicChromaticIntervalClass (class in abjad.tools.pitchtools), 490
- MelodicChromaticIntervalClassSegment (class in abjad.tools.pitchtools), 490
- MelodicChromaticIntervalClassVector (class in abjad.tools.pitchtools), 491
- MelodicChromaticIntervalSegment (class in abjad.tools.pitchtools), 491

MelodicChromaticIntervalSet (class in abjad.tools.pitchtools), 491

MelodicCounterpointInterval (class in abjad.tools.pitchtools), 492

MelodicCounterpointIntervalClass (class in abjad.tools.pitchtools), 492

MelodicDiatonicInterval (class in abjad.tools.pitchtools), 492

MelodicDiatonicIntervalClass (class in abjad.tools.pitchtools), 493

MelodicDiatonicIntervalSegment (class in abjad.tools.pitchtools), 493

MelodicDiatonicIntervalSet (class in abjad.tools.pitchtools), 493

merge() (abjad.tools.pitcharraytools.PitchArrayRow method), 713

meters (abjad.tools.spannertools.MetricGridSpanner attribute), 582

MetricGridSpanner (class in abjad.tools.spannertools), 581

middle_c_position (abjad.tools.contexttools.ClefMark attribute), 308

MIDIBlock (class in abjad.tools.lilypondfiletools), 408

millisecond_pitch_pairs_to_q_events() (in module abjad.tools.quantizationtools), 807

milliseconds_to_q_events() (in module abjad.tools.quantizationtools), 807

minimal_page_breaking (abjad.tools.lilypondfiletools.PaperBlock attribute), 409

mode (abjad.tools.contexttools.KeySignatureMark attribute), 313

Mode (class in abjad.tools.tonalitytools), 782

mode_name (abjad.tools.tonalitytools.Mode attribute), 782

modulo (abjad.tools.sievetools.ResidueClass attribute), 771

most_likely_instrument_based_on_performer_name (abjad.tools.scoretools.Performer attribute), 557

move_component_subtree_to_right_in_immediate_parent_of_component() (in module abjad.tools.componenttools), 255

move_measure_prolation_to_full_measure_tuplet() (in module abjad.tools.measuretools), 461

move_parentage_and_spanners_from_components_to_components() (in module abjad.tools.componenttools), 256

move_parentage_children_and_spanners_from_components_to_empty_container() (in module abjad.tools.containertools), 288

move_prolation_of_full_measure_tuplet_to_meter_of_measure() (in module abjad.tools.measuretools), 461

move_prolation_of_tuplet_to_contents_of_tuplet_and_remove_tuplet() (in module abjad.tools.tuplettools), 635

move_spanners_from_component_to_children_of_component() (in module abjad.tools.spannertools), 607

MultiMeasureRest (class in abjad.tools.resttools), 547

MultipartBeamSpanner (class in abjad.tools.spannertools), 583

multiplied_duration (abjad.tools.tuplettools.FixedDurationTuplet attribute), 624

multiplied_duration (abjad.tools.tuplettools.Tuplet attribute), 626

multiplier (abjad.tools.contexttools.TimeSignatureMark attribute), 317

multiplier (abjad.tools.measuretools.Measure attribute), 441

multiplier (abjad.tools.tuplettools.FixedDurationTuplet attribute), 624

multiplier (abjad.tools.tuplettools.Tuplet attribute), 626

multiply() (abjad.tools.pitchtools.NumberedChromaticPitchClass method), 504

multiply() (abjad.tools.pitchtools.NumberedChromaticPitchClassSegment method), 505

multiply() (abjad.tools.pitchtools.NumberedChromaticPitchClassSet method), 507

multiply_contents_of_measures_in_expr() (in module abjad.tools.measuretools), 462

multiply_contents_of_measures_in_expr_and_scale_meter_denominators() (in module abjad.tools.measuretools), 463

multiply_duration_pair() (in module abjad.tools.durationtools), 650

multiply_duration_pair_and_reduce_factors() (in module abjad.tools.durationtools), 651

multiply_duration_pair_and_try_to_preserve_numerator() (in module abjad.tools.durationtools), 651

music (abjad.tools.containertools.Container attribute), 277

N

name (abjad.tools.contexttools.KeySignatureMark attribute), 313

name (abjad.tools.marktools.Annotation attribute), 410

name (abjad.tools.marktools.Articulation attribute), 412

name (abjad.tools.pitchtools.Accidental attribute), 483

name (abjad.tools.scoretools.Performer attribute), 558

name (abjad.tools.tonalitytools.ExtentIndicator attribute), 782

name (abjad.tools.tonalitytools.InversionIndicator attribute), 782

name (abjad.tools.tonalitytools.ScaleDegree attribute), 782

named_chromatic_pitch (abjad.tools.notetools.NoteHead attribute), 473

named_chromatic_pitch (abjad.tools.pitchtools.NamedDiatonicPitch attribute), 501

named_chromatic_pitch_and_clef_to_staff_position_number() (in module abjad.tools.pitchtools), 538

named_chromatic_pitch_class	(ab-	named_diatonic_pitch_class	(ab-
jad.tools.pitchtools.NamedChromaticPitch		jad.tools.pitchtools.NumberedDiatonicPitch	
attribute), 495		attribute), 508	
named_chromatic_pitch_class	(ab-	named_diatonic_pitch_class	(ab-
jad.tools.pitchtools.NamedDiatonicPitch		jad.tools.pitchtools.NumberedDiatonicPitchClass	
attribute), 501		attribute), 509	
named_chromatic_pitch_class_set	(ab-	NamedChromaticPitch (class in abjad.tools.pitchtools),	
jad.tools.pitchtools.NamedChromaticPitchClassSegment		494	
attribute), 497		NamedChromaticPitchClass (class in ab-	
named_chromatic_pitch_class_to_scale_degree()	(ab-	jad.tools.pitchtools), 497	
jad.tools.tonalitytools.Scale method), 783		NamedChromaticPitchClassSegment (class in ab-	
named_chromatic_pitch_class_vector	(ab-	jad.tools.pitchtools), 497	
jad.tools.pitchtools.NamedChromaticPitchSegment		NamedChromaticPitchClassSet (class in ab-	
attribute), 499		jad.tools.pitchtools), 498	
named_chromatic_pitch_classes	(ab-	NamedChromaticPitchSegment (class in ab-	
jad.tools.pitchtools.NamedChromaticPitchClassSegment		jad.tools.pitchtools), 498	
attribute), 498		NamedChromaticPitchSet (class in ab-	
named_chromatic_pitch_classes	(ab-	jad.tools.pitchtools), 499	
jad.tools.pitchtools.NamedChromaticPitchClassSet		NamedChromaticPitchVector (class in ab-	
attribute), 498		jad.tools.pitchtools), 500	
named_chromatic_pitch_set	(ab-	NamedDiatonicPitch (class in abjad.tools.pitchtools), 500	
jad.tools.pitchtools.NamedChromaticPitchSegment		NamedDiatonicPitchClass (class in ab-	
attribute), 499		jad.tools.pitchtools), 502	
named_chromatic_pitch_tokens_to_named_chromatic_pitch_tokens	(ab-	NaturalHarmonic (class in abjad.tools.notetools), 471	
(in module abjad.tools.pitchtools), 538		negate_absolute_value_of_sequence_elements_at_indices()	
named_chromatic_pitch_vector	(ab-	(in module abjad.tools.sequencetools), 745	
jad.tools.pitchtools.NamedChromaticPitchSegment		negate_absolute_value_of_sequence_elements_cyclically()	
attribute), 499		(in module abjad.tools.sequencetools), 745	
named_chromatic_pitches	(ab-	negate_sequence_elements_at_indices() (in module ab-	
jad.tools.pitchtools.NamedChromaticPitchSegment		jad.tools.sequencetools), 746	
attribute), 499		negate_sequence_elements_cyclically() (in module ab-	
named_chromatic_pitches	(ab-	jad.tools.sequencetools), 746	
jad.tools.pitchtools.NamedChromaticPitchSet		negative_level (abjad.tools.sequencetools.Tree attribute),	
attribute), 499		727	
named_chromatic_pitches	(ab-	next (abjad.tools.pitcharraytools.PitchArrayCell at-	
jad.tools.pitchtools.NamedChromaticPitchVector		tribute), 711	
attribute), 500		next (abjad.tools.quantizationtools.QGrid attribute), 803	
named_chromatic_pitches_to_harmonic_chromatic_interval	(ab-	next_integer_partition() (in module ab-	
(in module abjad.tools.pitchtools), 538		jad.tools.mathtools), 703	
named_chromatic_pitches_to_inversion_equivalent_chromatic_pitches	(ab-	next_integer_partition() (in module ab-	
(in module abjad.tools.pitchtools), 539		jad.tools.verticalitytools.VerticalMoment	
named_diatonic_pitch	(ab-	attribute), 791	
jad.tools.pitchtools.NamedChromaticPitch		normalized_spacing_duration (ab-	
attribute), 495		jad.tools.layouttools.SpacingIndication at-	
named_diatonic_pitch	(ab-	tribute), 684	
jad.tools.pitchtools.NumberedDiatonicPitch		Note (class in abjad.tools.notetools), 471	
attribute), 508		note_head (abjad.tools.notetools.Note attribute), 472	
named_diatonic_pitch_class	(ab-	note_heads (abjad.tools.chordtools.Chord attribute), 212	
jad.tools.pitchtools.NamedChromaticPitch		NoteHead (class in abjad.tools.notetools), 473	
attribute), 496		notes (abjad.tools.verticalitytools.VerticalMoment at-	
named_diatonic_pitch_class	(ab-	tribute), 791	
jad.tools.pitchtools.NamedDiatonicPitch		notes_and_chords_in_expr_are_on_expected_clefs() (in	
attribute), 502		module abjad.tools.instrumenttools), 367	

- notes_and_chords_in_expr_are_within_traditional_instrument_range() (in module abjad.tools.instrumenttools), 368
 - number (abjad.tools.schemetools.SchemeNumber attribute), 553
 - number (abjad.tools.tonalitytools.ExtentIndicator attribute), 782
 - number (abjad.tools.tonalitytools.InversionIndicator attribute), 782
 - number (abjad.tools.tonalitytools.ScaleDegree attribute), 783
 - number_is_between_prolated_start_and_stop_offsets_of_component() (in module abjad.tools.componenttools), 256
 - number_is_between_start_and_stop_offsets_of_component() (in module abjad.tools.componenttools), 256
 - numbered_chromatic_pitch (abjad.tools.pitchtools.NamedChromaticPitch attribute), 496
 - numbered_chromatic_pitch (abjad.tools.pitchtools.NamedDiatonicPitch attribute), 502
 - numbered_chromatic_pitch_class (abjad.tools.pitchtools.NamedChromaticPitch attribute), 496
 - numbered_chromatic_pitch_class (abjad.tools.pitchtools.NamedChromaticPitchClass attribute), 497
 - numbered_chromatic_pitch_class (abjad.tools.pitchtools.NamedDiatonicPitch attribute), 502
 - numbered_chromatic_pitch_class_segment (abjad.tools.pitchtools.NamedChromaticPitchClassSegment attribute), 498
 - numbered_chromatic_pitch_class_segment (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499
 - numbered_chromatic_pitch_class_set (abjad.tools.pitchtools.NamedChromaticPitchClassSegment attribute), 498
 - numbered_chromatic_pitch_class_set (abjad.tools.pitchtools.NamedChromaticPitchClassSet attribute), 498
 - numbered_chromatic_pitch_class_set (abjad.tools.pitchtools.NamedChromaticPitchSegment attribute), 499
 - numbered_chromatic_pitch_class_set (abjad.tools.pitchtools.NamedChromaticPitchSet attribute), 499
 - numbered_chromatic_pitch_class_set (abjad.tools.pitchtools.NumberedChromaticPitchClassSegment attribute), 505
 - numbered_chromatic_pitch_classes (abjad.tools.pitchtools.NamedChromaticPitchClassSegment attribute), 498
 - numbered_chromatic_pitch_classes (abjad.tools.pitchtools.NamedDiatonicPitch attribute), 502
 - numbered_chromatic_pitch_classes (abjad.tools.pitchtools.NumberedChromaticPitchClass attribute), 508
 - numbered_chromatic_pitch_classes (abjad.tools.pitchtools.NumberedChromaticPitchClassVector attribute), 508
 - numbered_diatonic_pitch (abjad.tools.pitchtools.NamedChromaticPitch attribute), 496
 - numbered_diatonic_pitch (abjad.tools.pitchtools.NamedDiatonicPitch attribute), 502
 - numbered_diatonic_pitch_class (abjad.tools.pitchtools.NamedChromaticPitch attribute), 496
 - numbered_diatonic_pitch_class (abjad.tools.pitchtools.NamedDiatonicPitch attribute), 502
 - numbered_diatonic_pitch_class (abjad.tools.pitchtools.NumberedDiatonicPitch attribute), 508
 - NumberedChromaticPitch (class in abjad.tools.pitchtools), 503
 - NumberedChromaticPitchClass (class in abjad.tools.pitchtools), 504
 - NumberedChromaticPitchClassColorMap (class in abjad.tools.pitchtools), 504
 - NumberedChromaticPitchClassSegment (class in abjad.tools.pitchtools), 504
 - NumberedChromaticPitchClassSet (class in abjad.tools.pitchtools), 506
 - NumberedChromaticPitchClassVector (class in abjad.tools.pitchtools), 507
 - NumberedDiatonicPitch (class in abjad.tools.pitchtools), 508
 - NumberedDiatonicPitchClass (class in abjad.tools.pitchtools), 509
 - numerator (abjad.tools.contexttools.TimeSignatureMark attribute), 317
 - numeric_seconds_to_clock_string() (in module abjad.tools.durationtools), 651
 - numeric_seconds_to_escaped_clock_string() (in module abjad.tools.durationtools), 651
- ## O
- OctaveSegment (class in abjad.tools.instrumenttools), 357
 - OctavationSpanner (class in abjad.tools.spannertools), 583

- p
-
- octave_number (abjad.tools.pitchtools.NamedChromaticPitch attribute), 496
-
- octave_number_to_octave_tick_string() (in module abjad.tools.pitchtools), 539
-
- octave_tick_string_to_octave_number() (in module abjad.tools.pitchtools), 539
-
- offset (abjad.tools.quantizationtools.QEvent attribute), 801
-
- offset (abjad.tools.spannertools.Spanner attribute), 589
-
- Offset (class in abjad.tools.durationtools), 643
-
- offsets (abjad.tools.quantizationtools.QGrid attribute), 803
-
- offsets (abjad.tools.quantizationtools.QGridSearchTree attribute), 806
-
- OmissionIndicator (class in abjad.tools.tonalitytools), 782
-
- one_line_named_chromatic_pitch_repr (abjad.tools.pitchtools.PitchRange attribute), 509
-
- one_line_numbered_chromatic_pitch_repr (abjad.tools.pitchtools.PitchRange attribute), 509
-
- operator (abjad.tools.sievetools.ResidueClassExpression attribute), 772
-
- order_by() (abjad.tools.pitchtools.NamedChromaticPitchClassSet method), 498
-
- ordered_chromatic_pitch_class_numbers_are_within_order() (in module abjad.tools.pitchtools), 540
-
- overlap_components (abjad.tools.verticalitytools.VerticalMoment attribute), 791
-
- overlap_leaves (abjad.tools.verticalitytools.VerticalMoment attribute), 791
-
- overlap_measures (abjad.tools.verticalitytools.VerticalMoment attribute), 791
-
- overlap_notes (abjad.tools.verticalitytools.VerticalMoment attribute), 791
-
- override (abjad.tools.lilypondfiletools.ContextBlock attribute), 404
-
- override (abjad.tools.spannertools.Spanner attribute), 589
-
- overwrite_sequence_elements_at_indices() (in module abjad.tools.sequencetools), 746
-
- pairs (abjad.tools.pitchtools.NumberedChromaticPitchClassColorMap attribute), 504
-
- PaperBlock (class in abjad.tools.lilypondfiletools), 409
-
- parent_array (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
-
- parent_array (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712
-
- parent_array (abjad.tools.pitcharraytools.PitchArrayRow attribute), 713
-
- parent_column (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
-
- parent_row (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
-
- parse_lilypond_input_string() (in module abjad.tools.iotools), 678
-
- partial (abjad.tools.contexttools.TimeSignatureMark attribute), 317
-
- partition_components_cyclically_by_durations_in_seconds_exactly_with_overlap() (in module abjad.tools.componenttools), 257
-
- partition_components_cyclically_by_durations_in_seconds_exactly_without_overlap() (in module abjad.tools.componenttools), 257
-
- partition_components_cyclically_by_durations_in_seconds_ge_with_overlap() (in module abjad.tools.componenttools), 257
-
- partition_components_cyclically_by_durations_in_seconds_ge_without_overlap() (in module abjad.tools.componenttools), 257
-
- partition_components_cyclically_by_durations_in_seconds_le_with_overlap() (in module abjad.tools.componenttools), 258
-
- partition_components_cyclically_by_durations_in_seconds_le_without_overlap() (in module abjad.tools.componenttools), 258
-
- partition_components_cyclically_by_prolated_durations_exactly_with_overlap() (in module abjad.tools.componenttools), 258
-
- partition_components_cyclically_by_prolated_durations_exactly_without_overlap() (in module abjad.tools.componenttools), 258
-
- partition_components_cyclically_by_prolated_durations_ge_with_overlap() (in module abjad.tools.componenttools), 258
-
- partition_components_cyclically_by_prolated_durations_ge_without_overlap() (in module abjad.tools.componenttools), 259
-
- partition_components_cyclically_by_prolated_durations_le_with_overlap() (in module abjad.tools.componenttools), 259
-
- partition_components_cyclically_by_prolated_durations_le_without_overlap() (in module abjad.tools.componenttools), 259
-
- partition_components_once_by_durations_in_seconds_exactly_with_overlap() (in module abjad.tools.componenttools), 260
-
- partition_components_once_by_durations_in_seconds_exactly_without_overlap() (in module abjad.tools.componenttools), 260
-
- partition_components_once_by_durations_in_seconds_ge_with_overlap() (in module abjad.tools.componenttools), 260
-
- partition_components_once_by_durations_in_seconds_ge_without_overlap() (in module abjad.tools.componenttools), 260
-
- partition_components_once_by_durations_in_seconds_le_with_overlap() (in module abjad.tools.componenttools), 260
-
- partition_components_once_by_durations_in_seconds_le_without_overlap() (in module abjad.tools.componenttools), 260

[partition_components_once_by_prolated_durations_exactly_with_overhang\(\)](#)
 (in module [abjad.tools.componenttools](#)), 261

[partition_components_once_by_prolated_durations_exactly_without_overhang\(\)](#)
 (in module [abjad.tools.componenttools](#)), 261

[partition_components_once_by_prolated_durations_ge_with_overhang\(\)](#)
 (in module [abjad.tools.componenttools](#)), 261

[partition_components_once_by_prolated_durations_ge_with_overhang_once_by_weights_at_least_with_overhang\(\)](#)
 (in module [abjad.tools.componenttools](#)), 261

[partition_components_once_by_prolated_durations_ge_with_overhang_once_by_weights_at_least_without_overhang\(\)](#)
 (in module [abjad.tools.componenttools](#)), 261

[partition_components_once_by_prolated_durations_ge_with_overhang_once_by_weights_at_most_with_overhang\(\)](#)
 (in module [abjad.tools.componenttools](#)), 261

[partition_components_once_by_prolated_durations_le_with_overhang\(\)](#)
 (in module [abjad.tools.componenttools](#)), 261

[partition_components_once_by_prolated_durations_le_with_overhang_once_by_weights_at_most_without_overhang\(\)](#)
 (in module [abjad.tools.componenttools](#)), 261

[partition_components_once_by_prolated_durations_le_with_overhang_once_by_weights_exactly_with_overhang\(\)](#)
 (in module [abjad.tools.componenttools](#)), 261

[partition_integer_by_ratio\(\)](#) (in module [abjad.tools.mathtools](#)), 704

[partition_integer_into_canonic_parts\(\)](#) (in module [abjad.tools.mathtools](#)), 704

[partition_integer_into_halves\(\)](#) (in module [abjad.tools.mathtools](#)), 705

[partition_integer_into thirds\(\)](#) (in module [abjad.tools.mathtools](#)), 706

[partition_integer_into_units\(\)](#) (in module [abjad.tools.mathtools](#)), 707

[partition_sequence_by_ratio_of_lengths\(\)](#) (in module [abjad.tools.sequencetools](#)), 746

[partition_sequence_by_ratio_of_weights\(\)](#) (in module [abjad.tools.sequencetools](#)), 747

[partition_sequence_by_restricted_growth_function\(\)](#) (in module [abjad.tools.sequencetools](#)), 747

[partition_sequence_by_sign_of_elements\(\)](#) (in module [abjad.tools.sequencetools](#)), 748

[partition_sequence_by_value_of_elements\(\)](#) (in module [abjad.tools.sequencetools](#)), 748

[partition_sequence_cyclically_by_counts_with_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 749

[partition_sequence_cyclically_by_counts_without_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 749

[partition_sequence_cyclically_by_weights_at_least_with_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 749

[partition_sequence_cyclically_by_weights_at_least_without_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 749

[partition_sequence_cyclically_by_weights_at_most_with_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 750

[partition_sequence_cyclically_by_weights_at_most_without_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 750

[partition_sequence_cyclically_by_weights_exactly_with_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 750

[partition_sequence_cyclically_by_weights_exactly_without_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 751

[partition_sequence_extended_to_counts_with_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 751

[partition_sequence_extended_to_counts_without_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 751

[partition_sequence_once_by_counts_with_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 751

[partition_sequence_once_by_counts_without_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 752

[partition_sequence_once_by_weights_at_least_with_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 752

[partition_sequence_once_by_weights_at_least_without_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 752

[partition_sequence_once_by_weights_at_most_with_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 752

[partition_sequence_once_by_weights_at_most_without_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 753

[partition_sequence_once_by_weights_exactly_with_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 753

[partition_sequence_once_by_weights_exactly_without_overhang\(\)](#)
 (in module [abjad.tools.sequencetools](#)), 753

[pdf\(\)](#) (in module [abjad.tools.iotools](#)), 679

[pentatonic_pitch_number_to_chromatic_pitch_number\(\)](#)
 (in module [abjad.tools.pitchtools](#)), 540

[Performer](#) (class in [abjad.tools.scoretools](#)), 556

[performer_count](#) ([abjad.tools.scoretools.InstrumentationSpecifier](#) attribute), 556

[performers](#) ([abjad.tools.scoretools.InstrumentationSpecifier](#) attribute), 556

[period](#) ([abjad.tools.sievetools.ResidueClassExpression](#) attribute), 772

[permute_named_chromatic_pitch_carrier_list_by_twelve_tone_row\(\)](#)
 (in module [abjad.tools.pitchtools](#)), 541

[permute_sequence\(\)](#) (in module [abjad.tools.sequencetools](#)), 754

[PhrasingSlurSpanner](#) (class in [abjad.tools.spannertools](#)), 584

[Piano](#) (class in [abjad.tools.instrumenttools](#)), 358

[PianoPedalSpanner](#) (class in [abjad.tools.spannertools](#)), 584

[PianoStaff](#) (class in [abjad.tools.scoretools](#)), 558

[Piccolo](#) (class in [abjad.tools.instrumenttools](#)), 358

[pitch](#) ([abjad.tools.spannertools.TrillSpanner](#) attribute), 592

[pitch_array_row_to_measure\(\)](#) (in module [abjad.tools.measuretools](#)), 467

[pitch_array_to_measures\(\)](#) (in module [abjad.tools.measuretools](#)), 467

[pitch_class_octave_label](#) ([abjad.tools.pitchtools.NamedChromaticPitch](#) attribute), 496

[pitch_class_octave_number_string_to_chromatic_pitch_name\(\)](#)
 (in module [abjad.tools.pitchtools](#)), 541

[pitch_classes](#) ([abjad.tools.pitchtools.NumberedChromaticPitchClassColor](#) attribute), 504

[pitch_range](#) ([abjad.tools.pitcharraytools.PitchArrayRow](#) attribute), 713

[PitchArray](#) (class in [abjad.tools.pitcharraytools](#)), 709

[PitchArrayCell](#) (class in [abjad.tools.pitcharraytools](#)), 710

[PitchArrayColumn](#) (class in [abjad.tools.pitcharraytools](#)), 712

- PitchArrayRow (class in abjad.tools.pitcharraytools), 713
- pitches (abjad.tools.pitcharraytools.PitchArray attribute), 710
- pitches (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
- pitches (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712
- pitches (abjad.tools.pitcharraytools.PitchArrayRow attribute), 713
- pitches_by_row (abjad.tools.pitcharraytools.PitchArray attribute), 710
- PitchRange (class in abjad.tools.pitchtools), 509
- play() (in module abjad.tools.iotools), 679
- pop() (abjad.tools.chordtools.Chord method), 212
- pop() (abjad.tools.containertools.Container method), 277
- pop() (abjad.tools.pitcharraytools.PitchArrayRow method), 714
- pop() (abjad.tools.spannertools.Spanner method), 589
- pop_column() (abjad.tools.pitcharraytools.PitchArray method), 710
- pop_left() (abjad.tools.spannertools.Spanner method), 589
- pop_row() (abjad.tools.pitcharraytools.PitchArray method), 710
- position (abjad.tools.sequencetools.Tree attribute), 727
- position (abjad.tools.tonalitytools.ChordQualityIndicator attribute), 781
- positive_integer_to_implied_prolation_multiplier() (in module abjad.tools.durationtools), 652
- preferred_denominator (abjad.tools.tuplettools.Tuplet attribute), 626
- preprolated_duration (abjad.tools.containertools.Container attribute), 277
- preprolated_duration (abjad.tools.measuretools.DynamicMeasure attribute), 439
- preprolated_duration (abjad.tools.measuretools.Measure attribute), 441
- preprolated_duration (abjad.tools.spannertools.Spanner attribute), 590
- preprolated_duration (abjad.tools.tuplettools.Tuplet attribute), 626
- prev (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
- prev_vertical_moment (abjad.tools.verticalitytools.VerticalMoment attribute), 791
- prime_form (abjad.tools.pitchtools.NumberedChromaticPitchClassSet attribute), 507
- profile_expr() (in module abjad.tools.iotools), 679
- prolated_duration (abjad.tools.spannertools.Spanner attribute), 590
- prolated_offset (abjad.tools.verticalitytools.VerticalMoment attribute), 791
- proper_parentage (abjad.tools.sequencetools.Tree attribute), 727
- proportional_notation_duration (abjad.tools.layouttools.SpacingIndication attribute), 684
- prune() (abjad.tools.quantizationtools.QGridSearchTree method), 806
- ## Q
- QEvent (class in abjad.tools.quantizationtools), 801
- QGrid (class in abjad.tools.quantizationtools), 801
- QGridQuantizer (class in abjad.tools.quantizationtools), 803
- QGridSearchTree (class in abjad.tools.quantizationtools), 805
- QGridTempoLookup (class in abjad.tools.quantizationtools), 806
- quality (abjad.tools.tonalitytools.TonalFunction attribute), 784
- quality_indicator (abjad.tools.tonalitytools.ChordClass attribute), 781
- quality_pair (abjad.tools.tonalitytools.ChordClass attribute), 781
- quality_string (abjad.tools.tonalitytools.ChordQualityIndicator attribute), 781
- quality_string (abjad.tools.tonalitytools.QualityIndicator attribute), 783
- QualityIndicator (class in abjad.tools.tonalitytools), 783
- quarters_per_minute (abjad.tools.contexttools.TempoMark attribute), 315
- ## R
- ratio (abjad.tools.tuplettools.Tuplet attribute), 626
- rational_to_duration_pair_with_multiple_of_specified_integer_denominator() (in module abjad.tools.durationtools), 652
- rational_to_duration_pair_with_specified_integer_denominator() (in module abjad.tools.durationtools), 653
- rational_to_equal_or_greater_assignable_rational() (in module abjad.tools.durationtools), 654
- rational_to_equal_or_greater_binary_rational() (in module abjad.tools.durationtools), 654
- rational_to_equal_or_lesser_assignable_rational() (in module abjad.tools.durationtools), 655
- rational_to_equal_or_lesser_binary_rational() (in module abjad.tools.durationtools), 656
- rational_to_flag_count() (in module abjad.tools.durationtools), 656
- rational_to_fraction_string() (in module abjad.tools.durationtools), 657
- rational_to_prolation_string() (in module abjad.tools.durationtools), 657

- ul style="list-style-type: none; padding-left: 0;">
- rational_to_proper_fraction() (in module abjad.tools.durationtools), 657
- rcs (abjad.tools.sievetools.ResidueClassExpression attribute), 772
- redo() (in module abjad.tools.iotools), 680
- register_chromatic_pitch_class_numbers_by_chromatic_pitch_number() (in module abjad.tools.pitchtools), 541
- remove() (abjad.tools.chordtools.Chord method), 212
- remove() (abjad.tools.containertools.Container method), 277
- remove() (abjad.tools.pitcharraytools.PitchArrayRow method), 714
- remove() (abjad.tools.sequencetools.Tree method), 727
- remove_abjad__pycache__directories() (in module abjad.tools.iotools), 680
- remove_abjad_pyc_files() (in module abjad.tools.iotools), 680
- remove_all_leaves_in_tie_chain_except_first() (in module abjad.tools.tietools), 619
- remove_component_subtree_from_score_and_spanners() (in module abjad.tools.componenttools), 261
- remove_empty_containers_in_expr() (in module abjad.tools.containertools), 288
- remove_initial_rests_from_sequence() (in module abjad.tools.leafertools), 395
- remove_leaf_and_shrink_durated_parent_containers() (in module abjad.tools.leafertools), 395
- remove_markup_attached_to_component() (in module abjad.tools.markuptools), 437
- remove_markup_from_leaves_in_expr() (in module abjad.tools.markuptools), 437
- remove_outer_rests_from_sequence() (in module abjad.tools.leafertools), 396
- remove_pitches() (abjad.tools.pitcharraytools.PitchArrayColumn method), 712
- remove_powers_of_two() (in module abjad.tools.mathtools), 707
- remove_row() (abjad.tools.pitcharraytools.PitchArray method), 710
- remove_sequence_elements_at_indices() (in module abjad.tools.sequencetools), 754
- remove_sequence_elements_at_indices_cyclically() (in module abjad.tools.sequencetools), 754
- remove_subsequence_of_weight_at_index() (in module abjad.tools.sequencetools), 754
- remove_terminal_rests_from_sequence() (in module abjad.tools.leafertools), 397
- remove_tie_spanners_from_components_in_expr() (in module abjad.tools.tietools), 619
- remove_to_root() (abjad.tools.sequencetools.Tree method), 727
- remove_trivial_tuplets_in_expr() (in module abjad.tools.tuplettools), 635
- repeat_contents_of_container() (in module abjad.tools.containertools), 289
- repeat_last_n_elements_of_container() (in module abjad.tools.containertools), 290
- repeat_leaf_and_extend_spanners() (in module abjad.tools.leafertools), 397
- repeat_leaves_in_expr_and_extend_spanners() (in module abjad.tools.leafertools), 398
- repeat_runs_in_sequence_to_count() (in module abjad.tools.sequencetools), 755
- repeat_sequence_elements_at_indices() (in module abjad.tools.sequencetools), 756
- repeat_sequence_elements_at_indices_cyclically() (in module abjad.tools.sequencetools), 756
- repeat_sequence_elements_n_times_each() (in module abjad.tools.sequencetools), 756
- repeat_sequence_n_times() (in module abjad.tools.sequencetools), 757
- repeat_sequence_to_length() (in module abjad.tools.sequencetools), 757
- repeat_sequence_to_weight_at_least() (in module abjad.tools.sequencetools), 757
- repeat_sequence_to_weight_at_most() (in module abjad.tools.sequencetools), 758
- repeat_sequence_to_weight_exactly() (in module abjad.tools.sequencetools), 758
- replace_components_with_children_of_components() (in module abjad.tools.componenttools), 263
- replace_contents_of_measures_in_expr() (in module abjad.tools.measuretools), 468
- replace_contents_of_target_container_with_contents_of_source_container() (in module abjad.tools.containertools), 290
- replace_larger_left_half_of_elements_in_container_with_big_endian_rests() (in module abjad.tools.containertools), 292
- replace_larger_left_half_of_elements_in_container_with_little_endian_rests() (in module abjad.tools.containertools), 292
- replace_larger_right_half_of_elements_in_container_with_big_endian_rests() (in module abjad.tools.containertools), 293
- replace_larger_right_half_of_elements_in_container_with_little_endian_rests() (in module abjad.tools.containertools), 294
- replace_leaves_in_expr_with_skips() (in module abjad.tools.skiptools), 568
- replace_n_edge_elements_in_container_with_big_endian_rests() (in module abjad.tools.containertools), 294
- replace_n_edge_elements_in_container_with_little_endian_rests() (in module abjad.tools.containertools), 295
- replace_n_edge_elements_in_container_with_rests() (in module abjad.tools.containertools), 295
- replace_sequence_elements_cyclically_with_new_material() (in module abjad.tools.sequencetools), 758
- replace_smaller_left_half_of_elements_in_container_with_big_endian_rests() (in module abjad.tools.containertools), 296
- replace_smaller_left_half_of_elements_in_container_with_little_endian_rests() (in module abjad.tools.containertools), 297

replace_smaller_right_half_of_elements_in_container_with_larger_elements() (in module abjad.tools.containertools), 298
 replace_smaller_right_half_of_elements_in_container_with_little_end() (in module abjad.tools.containertools), 298
 report() (abjad.tools.markuptools.MarkupCommand method), 434
 report_as_string_format_contributions_of_all_spanners_attached_to_container() (in module abjad.tools.spannertools), 607
 report_as_string_format_contributions_of_all_spanners_attached_to_inproper_percentage_of_component() (in module abjad.tools.spannertools), 607
 report_component_format_contributions_as_string() (in module abjad.tools.componenttools), 264
 report_container_modifications_as_string() (in module abjad.tools.containertools), 299
 report_meter_distribution_as_string() (in module abjad.tools.measuretools), 469
 representative_boolean_train (abjad.tools.sievetools.ResidueClassExpression attribute), 772
 representative_congruent_bases (abjad.tools.sievetools.ResidueClassExpression attribute), 772
 residue (abjad.tools.sievetools.ResidueClass attribute), 771
 ResidueClass (class in abjad.tools.sievetools), 770
 ResidueClassExpression (class in abjad.tools.sievetools), 771
 resolve_overlaps_between_nonoverlapping_trees() (in module abjad.tools.intervaltreetools), 670
 resolve_overlaps_between_nonoverlapping_trees_excluding() (in module abjad.tools.intervaltreetools), 670
 respell_named_chromatic_pitches_in_expr_with_flats() (in module abjad.tools.pitchtools), 541
 respell_named_chromatic_pitches_in_expr_with_sharps() (in module abjad.tools.pitchtools), 542
 Rest (class in abjad.tools.resttools), 547
 retain_sequence_elements_at_indices() (in module abjad.tools.sequencetools), 758
 retain_sequence_elements_at_indices_cyclically() (in module abjad.tools.sequencetools), 759
 retrograde() (abjad.tools.pitchtools.NamedChromaticPitchClassSegment method), 498
 retrograde() (abjad.tools.pitchtools.NumberedChromaticPitchClassSegment method), 505
 reverse_contents_of_container() (in module abjad.tools.containertools), 300
 reverse_sequence() (in module abjad.tools.sequencetools), 759
 reverse_sequence_elements() (in module abjad.tools.sequencetools), 759
 rewrite_rational_under_new_tempo() (in module abjad.tools.durationtools), 658
 RhythmicStaff (class in abjad.tools.stafftools), 608
 ScaleDegree (abjad.tools.tonalitytools.ScaleDegree attribute), 784
 root (abjad.tools.sequencetools.Tree attribute), 728
 root (abjad.tools.tonalitytools.ChordClass attribute), 781
 root_scale_degree (abjad.tools.tonalitytools.TonalFunction attribute), 784
 root_string (abjad.tools.tonalitytools.ChordClass attribute), 781
 rotate() (abjad.tools.pitchtools.NamedChromaticPitchClassSegment method), 498
 rotate() (abjad.tools.pitchtools.NumberedChromaticPitchClassSegment method), 505
 rotate_sequence() (in module abjad.tools.sequencetools), 760
 rotation (abjad.tools.tonalitytools.ChordQualityIndicator attribute), 781
 round_interval_bounds_to_nearest_multiple_of_rational() (in module abjad.tools.intervaltreetools), 671
 row_index (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
 row_index (abjad.tools.pitcharraytools.PitchArrayRow attribute), 714
 rows (abjad.tools.pitcharraytools.PitchArray attribute), 710
 rows (abjad.tools.sequencetools.CyclicMatrix attribute), 718
 rows (abjad.tools.sequencetools.Matrix attribute), 721
 S
 remainders_less_than_rational() (in module abjad.tools.iotools), 681
 save_last_ly_as() (in module abjad.tools.iotools), 681
 save_last_pdf_as() (in module abjad.tools.iotools), 681
 Scale (class in abjad.tools.tonalitytools), 783
 scale_aggregate_magnitude_by_rational() (in module abjad.tools.intervaltreetools), 671
 scale_aggregate_magnitude_to_rational() (in module abjad.tools.intervaltreetools), 671
 scale_by_rational() (abjad.tools.intervaltreetools.BoundedInterval method), 662
 scale_contents_of_container() (in module abjad.tools.containertools), 300
 scale_contents_of_measures_in_expr() (in module abjad.tools.measuretools), 469
 scale_contents_of_tuplets_in_expr_by_multiplier() (in module abjad.tools.tuplettools), 636
 scale_degree (abjad.tools.tonalitytools.TonalFunction attribute), 784
 scale_degree_to_named_chromatic_pitch_class() (abjad.tools.tonalitytools.Scale method), 783
 scale_interval_magnitudes_by_rational() (in module abjad.tools.intervaltreetools), 672
 scale_interval_magnitudes_to_rational() (in module abjad.tools.intervaltreetools), 672

- scale_interval_offsets_by_rational() (in module abjad.tools.intervaltreetools), 672
- scale_measure_by_multiplier_and_adjust_meter() (in module abjad.tools.measuretools), 469
- scale_measure_denominator_and_adjust_measure_contents() (in module abjad.tools.measuretools), 469
- scale_preprolated_leaf_duration() (in module abjad.tools.leafertools), 399
- scale_to_rational() (abjad.tools.intervaltreetools.BoundedInterval method), 662
- ScaleDegree (class in abjad.tools.tonalitytools), 783
- SchemeAssociativeList (class in abjad.tools.schemetools), 550
- SchemeBoolean (class in abjad.tools.schemetools), 551
- SchemeColor (class in abjad.tools.schemetools), 551
- SchemeFunction (class in abjad.tools.schemetools), 552
- SchemeMoment (class in abjad.tools.schemetools), 552
- SchemeNumber (class in abjad.tools.schemetools), 553
- SchemePair (class in abjad.tools.schemetools), 553
- SchemeString (class in abjad.tools.schemetools), 553
- SchemeVariable (class in abjad.tools.schemetools), 554
- SchemeVector (class in abjad.tools.schemetools), 554
- SchemeVectorConstant (class in abjad.tools.schemetools), 554
- Score (class in abjad.tools.scoretools), 558
- ScoreBlock (class in abjad.tools.lilypondfiletools), 409
- search_tree (abjad.tools.quantizationtools.QGridQuantizer attribute), 805
- semitones (abjad.tools.pitchtools.Accidental attribute), 484
- semitones (abjad.tools.pitchtools.HarmonicDiatonicInterval attribute), 486
- semitones (abjad.tools.pitchtools.MelodicDiatonicInterval attribute), 493
- set (abjad.tools.lilypondfiletools.ContextBlock attribute), 404
- set (abjad.tools.spannertools.Spanner attribute), 590
- set_accidental_style_on_sequential_contexts_in_expr() (in module abjad.tools.contexttools), 340
- set_ascending_named_chromatic_pitches_on_nontied_pitched_components_in_expr() (in module abjad.tools.pitchtools), 543
- set_ascending_named_diatonic_pitches_on_nontied_pitched_components_in_expr() (in module abjad.tools.pitchtools), 543
- set_container_multiplier() (in module abjad.tools.containertools), 301
- set_default_accidental_spelling() (in module abjad.tools.configurationtools), 643
- set_denominator_of_tuplets_in_expr_to_at_least() (in module abjad.tools.tuplettools), 636
- set_line_breaks_cyclically_by_line_duration_ge() (in module abjad.tools.layouttools), 685
- set_line_breaks_cyclically_by_line_duration_in_seconds_ge() (in module abjad.tools.layouttools), 686
- set_measure_denominator_and_adjust_numerator() (in module abjad.tools.measuretools), 470
- set_preprolated_leaf_duration() (in module abjad.tools.leafertools), 400
- set_vertical_positioning_pitch_on_rest() (in module abjad.tools.resttools), 550
- shape_string (abjad.tools.spannertools.HairpinSpanner attribute), 578
- shift_aggregate_offset_by_rational() (in module abjad.tools.intervaltreetools), 673
- shift_aggregate_offset_to_rational() (in module abjad.tools.intervaltreetools), 673
- shift_by_rational() (abjad.tools.intervaltreetools.BoundedInterval method), 662
- shift_to_rational() (abjad.tools.intervaltreetools.BoundedInterval method), 662
- short_instrument_name (abjad.tools.contexttools.InstrumentMark attribute), 312
- short_instrument_name_markup (abjad.tools.contexttools.InstrumentMark attribute), 312
- show() (in module abjad.tools.iotools), 681
- show_leaves() (in module abjad.tools.leafertools), 401
- sign() (in module abjad.tools.mathtools), 707
- signature (abjad.tools.intervaltreetools.BoundedInterval attribute), 662
- size (abjad.tools.pitcharraytools.PitchArray attribute), 710
- Skip (class in abjad.tools.skiptools), 566
- slope (abjad.tools.pitchtools.MelodicChromaticIntervalSegment attribute), 491
- SlurSpanner (class in abjad.tools.spannertools), 585
- SopraninoSaxophone (class in abjad.tools.instrumenttools), 359
- SopranoSaxophone (class in abjad.tools.instrumenttools), 359
- sounding_pitch (abjad.tools.notetools.Note attribute), 472
- sounding_pitches (abjad.tools.chordtools.Chord attribute), 472
- space_delimited_lowercase_to_uppercamelcase() (in module abjad.tools.iotools), 681
- SpacingIndication (class in abjad.tools.layouttools), 684
- span (abjad.tools.spannertools.DuratedComplexBeamSpanner attribute), 575
- span (abjad.tools.spannertools.MeasuredComplexBeamSpanner attribute), 581
- Spanner (class in abjad.tools.spannertools), 586
- splice_new_elements_between_sequence_elements() (in module abjad.tools.sequencetools), 760
- split_at_rational() (abjad.tools.intervaltreetools.BoundedInterval method), 662

`split_component_at_prolated_duration_and_do_not_fracture_crossing_spanners()` (in module `abjad.tools.componenttools`), 264
`StaffGroup` (class in `abjad.tools.contexttools`), 313
`split_component_at_prolated_duration_and_fracture_crossing_spanners()` (in module `abjad.tools.componenttools`), 265
`StaffSpanner` (class in `abjad.tools.spannertools`), 559
`split_components_cyclically_by_prolated_durations_and_do_not_fracture_crossing_spanners()` (in module `abjad.tools.componenttools`), 266
`OctavationSpanner` attribute), 583
`split_components_cyclically_by_prolated_durations_and_fracture_crossing_spanners()` (in module `abjad.tools.componenttools`), 267
`SuspensionIndicator` attribute), 784
`split_components_once_by_prolated_durations_and_do_not_fracture_crossing_spanners()` (in module `abjad.tools.componenttools`), 268
`PitchArrayColumn` attribute), 712
`split_components_once_by_prolated_durations_and_fracture_crossing_spanners()` (in module `abjad.tools.componenttools`), 269
`Mark` attribute), 416
`split_container_at_index_and_do_not_fracture_crossing_spanners()` (in module `abjad.tools.containertools`), 302
`VerticalMoment` attribute), 791
`split_container_at_index_and_fracture_crossing_spanners()` start_dynamic_string (abjad.tools.spannertools.HairpinSpanner attribute), 303
`split_container_cyclically_by_counts_and_do_not_fracture_crossing_spanners()` (in module `abjad.tools.containertools`), 304
`start_leaves` (abjad.tools.verticalitytools.VerticalMoment attribute), 791
`split_container_cyclically_by_counts_and_fracture_crossing_spanners()` (in module `abjad.tools.containertools`), 305
`start_notes` (abjad.tools.verticalitytools.VerticalMoment attribute), 792
`split_container_once_by_counts_and_do_not_fracture_crossing_spanners()` (in module `abjad.tools.containertools`), 306
`start_pitch` (abjad.tools.pitchtools.PitchRange attribute), 510
`split_container_once_by_counts_and_fracture_crossing_spanners()` (in module `abjad.tools.containertools`), 307
`start_pitch_is_included_in_range` (abjad.tools.pitchtools.PitchRange attribute), 510
`split_intervals_at_rationals()` (in module `abjad.tools.intervaltreetools`), 674
`start_pitches` (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712
`split_leaf_at_prolated_duration_and_rest_right_half()` (in module `abjad.tools.leaftools`), 402
`StemTremolo` (class in `abjad.tools.marktools`), 416
`split_on_bar()` (`abjad.tools.spannertools.MetricGridSpanner` method), 582
`stop` (abjad.tools.spannertools.OctavationSpanner attribute), 584
`split_sequence_cyclically_by_weights_with_overhang()` (in module `abjad.tools.sequencetools`), 761
`stop` (abjad.tools.tonalitytools.SuspensionIndicator attribute), 784
`split_sequence_cyclically_by_weights_without_overhang()` (in module `abjad.tools.sequencetools`), 761
`stop_cells` (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712
`split_sequence_extended_to_weights_with_overhang()` (in module `abjad.tools.sequencetools`), 761
`stop_dynamic_string` (abjad.tools.spannertools.HairpinSpanner attribute), 579
`split_sequence_extended_to_weights_without_overhang()` (in module `abjad.tools.sequencetools`), 761
`stop_pitch` (abjad.tools.pitchtools.PitchRange attribute), 510
`split_sequence_once_by_weights_with_overhang()` (in module `abjad.tools.sequencetools`), 762
`stop_pitch_is_included_in_range` (abjad.tools.pitchtools.PitchRange attribute), 510
`split_sequence_once_by_weights_without_overhang()` (in module `abjad.tools.sequencetools`), 762
`stop_pitches` (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712
`splitting_condition()` (abjad.tools.spannertools.MetricGridSpanner method), 582
`spread` (`abjad.tools.pitchtools.MelodicChromaticIntervalSegment` attribute), 491
`strong_to_strict_directory_name()` (in module `abjad.tools.iotools`), 682
`staff` (`abjad.tools.contexttools.StaffChangeMark` attribute), 314
`strip_diacritics_from_binary_string()` (in module `abjad.tools.iotools`), 682
`Staff` (class in `abjad.tools.stafftools`), 608
`style` (abjad.tools.spannertools.PianoPedalSpanner attribute), 585
`staff_spaces` (abjad.tools.pitchtools.HarmonicDiatonicInterval attribute), 486
`subdivide_indices()` (abjad.tools.quantizationtools.QGrid method), 803
`staff_spaces` (abjad.tools.pitchtools.MelodicDiatonicInterval attribute), 493

subdominant (abjad.tools.tonalitytools.Scale attribute), 783

submediant (abjad.tools.tonalitytools.Scale attribute), 783

suggest_clef_for_named_chromatic_pitches() (in module abjad.tools.pitchtools), 544

sum_consecutive_sequence_elements_by_sign() (in module abjad.tools.sequencetools), 762

sum_duration_of_components_in_seconds() (in module abjad.tools.componenttools), 270

sum_preprolated_duration_of_components() (in module abjad.tools.componenttools), 270

sum_prolated_duration_of_components() (in module abjad.tools.componenttools), 271

sum_sequence_elements_at_indices() (in module abjad.tools.sequencetools), 763

superdominant (abjad.tools.tonalitytools.Scale attribute), 783

suppress_meter (abjad.tools.measuretools.DynamicMeasure attribute), 439

suspension (abjad.tools.tonalitytools.TonalFunction attribute), 784

SuspensionIndicator (class in abjad.tools.tonalitytools), 784

symbolic_accidental_string (abjad.tools.pitchtools.Accidental attribute), 484

symbolic_accidental_string_to_alphabetic_accidental_abbreviation() (in module abjad.tools.pitchtools), 544

symbolic_string (abjad.tools.tonalitytools.ScaleDegree attribute), 783

symbolic_string (abjad.tools.tonalitytools.TonalFunction attribute), 784

T

tabulate_well_formedness_violations_in_expr() (in module abjad.tools.componenttools), 271

target_context (abjad.tools.contexttools.ContextMark attribute), 309

target_duration (abjad.tools.tuplettools.FixedDurationTuplet attribute), 624

tempo (abjad.tools.quantizationtools.QGridQuantizer attribute), 805

tempo (abjad.tools.quantizationtools.QGridTempoLookup attribute), 806

tempo_indication (abjad.tools.layouttools.SpacingIndication attribute), 684

tempo_lookup (abjad.tools.quantizationtools.QGridQuantizer attribute), 805

tempo_scaled_leaves_to_q_events() (in module abjad.tools.quantizationtools), 807

tempo_scaled_rational_to_milliseconds() (in module abjad.tools.quantizationtools), 808

tempo_scaled_rationals_to_q_events() (in module abjad.tools.quantizationtools), 808

TempoMark (class in abjad.tools.contexttools), 315

TenorSaxophone (class in abjad.tools.instrumenttools), 360

TenorTrombone (class in abjad.tools.instrumenttools), 360

TextScriptSpanner (class in abjad.tools.spannertools), 591

TextSpanner (class in abjad.tools.spannertools), 591

threshold (abjad.tools.quantizationtools.QGridQuantizer attribute), 805

tie_chain_to_augmented_tuplet_with_proportions_and_avoid_dots() (in module abjad.tools.tietools), 620

tie_chain_to_augmented_tuplet_with_proportions_and_encourage_dots() (in module abjad.tools.tietools), 621

tie_chain_to_diminished_tuplet_with_proportions_and_avoid_dots() (in module abjad.tools.tietools), 622

tie_chain_to_diminished_tuplet_with_proportions_and_encourage_dots() (in module abjad.tools.tietools), 623

TieSpanner (class in abjad.tools.tietools), 611

time_signature_to_binary_time_signature() (in module abjad.tools.timesignaturetools), 780

TimeSignatureMark (class in abjad.tools.contexttools), 316

title (abjad.tools.tonalitytools.InversionIndicator attribute), 782

title_string (abjad.tools.tonalitytools.ScaleDegree attribute), 783

title_string (abjad.tools.tonalitytools.SuspensionIndicator attribute), 784

to_nested_lists() (abjad.tools.sequencetools.Tree method), 728

token (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711

TonalFunction (class in abjad.tools.tonalitytools), 784

tonic (abjad.tools.contexttools.KeySignatureMark attribute), 313

tonic (abjad.tools.tonalitytools.Scale attribute), 783

transpose() (abjad.tools.pitchtools.NamedChromaticPitchClass method), 497

transpose() (abjad.tools.pitchtools.NamedChromaticPitchClassSegment method), 498

transpose() (abjad.tools.pitchtools.NamedChromaticPitchClassSet method), 498

transpose() (abjad.tools.pitchtools.NamedChromaticPitchSegment method), 499

transpose() (abjad.tools.pitchtools.NamedChromaticPitchSet method), 499

transpose() (abjad.tools.pitchtools.NumberedChromaticPitch method), 503

transpose() (abjad.tools.pitchtools.NumberedChromaticPitchClass method), 504

transpose() (abjad.tools.pitchtools.NumberedChromaticPitchClassSegment method), 505

- transpose() (abjad.tools.pitchtools.NumberedChromaticPitchClassSet method), 507
- transpose() (abjad.tools.tonalitytools.ChordClass method), 781
- transpose_chromatic_pitch_by_melodic_chromatic_interval_segment() (in module abjad.tools.pitchtools), 544
- transpose_chromatic_pitch_class_number_by_octaves_to_nearest_neighbor_of_chromatic_pitch_number() (in module abjad.tools.pitchtools), 544
- transpose_chromatic_pitch_number_by_octave_transposition_mapping() (in module abjad.tools.pitchtools), 545
- transpose_named_chromatic_pitch_by_melodic_chromatic_interval_and_respell() (in module abjad.tools.pitchtools), 546
- transpose_notes_and_chords_in_expr_from_fingered_pitch_to_sounding_pitch() (in module abjad.tools.instrumenttools), 369
- transpose_notes_and_chords_in_expr_from_sounding_pitch_to_fingered_pitch() (in module abjad.tools.instrumenttools), 369
- transpose_pitch_carrier_by_melodic_interval() (in module abjad.tools.pitchtools), 546
- transpose_pitch_expr_into_pitch_range() (in module abjad.tools.pitchtools), 546
- Tree (class in abjad.tools.sequencetools), 721
- tremolo_flags (abjad.tools.marktools.StemTremolo attribute), 416
- TrillSpanner (class in abjad.tools.spannertools), 592
- trim() (abjad.tools.tuplettools.FixedDurationTuplet method), 624
- Trumpet (class in abjad.tools.instrumenttools), 361
- truncate_runs_in_sequence() (in module abjad.tools.sequencetools), 763
- truncate_sequence_to_sum() (in module abjad.tools.sequencetools), 764
- truncate_sequence_to_weight() (in module abjad.tools.sequencetools), 764
- Tuba (class in abjad.tools.instrumenttools), 361
- Tuplet (class in abjad.tools.tuplettools), 625
- tweak (abjad.tools.notetools.NoteHead attribute), 473
- twelve_tone_complete (abjad.tools.pitchtools.NumberedChromaticPitchClassColorMap attribute), 504
- TwelveToneRow (class in abjad.tools.pitchtools), 510
- twenty_four_tone_complete (abjad.tools.pitchtools.NumberedChromaticPitchClassColorMap attribute), 504
- U**
- underscore_delimited_lowercase_to_lowercamelcase() (in module abjad.tools.iotools), 682
- underscore_delimited_lowercase_to_uppercamelcase() (in module abjad.tools.iotools), 682
- units_per_minute (abjad.tools.contexttools.TempoMark attribute), 316
- UntunedPercussion (class in abjad.tools.instrumenttools), 361
- uppercase_to_space_delimited_lowercase() (in module abjad.tools.iotools), 683
- uppercamelcase_to_underscore_delimited_lowercase() (in module abjad.tools.iotools), 683
- V**
- value (abjad.tools.quantizationtools.QEvent attribute), 411
- VerticalMoment (class in abjad.tools.verticalitytools), 411
- voice_crossing_count (abjad.tools.pitcharraytools.PitchArray attribute), 710
- voice_crossing_count (abjad.tools.voicetools.Voice attribute), 637
- Vibraphone (class in abjad.tools.instrumenttools), 362
- Violin (class in abjad.tools.instrumenttools), 363
- voice_crossing_count (abjad.tools.voicetools.Voice attribute), 637
- W**
- weight (abjad.tools.pitcharraytools.PitchArray attribute), 710
- weight (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
- weight (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712
- weight (abjad.tools.pitcharraytools.PitchArrayRow attribute), 714
- weight() (in module abjad.tools.mathtools), 708
- width (abjad.tools.pitcharraytools.PitchArray attribute), 710
- width (abjad.tools.pitcharraytools.PitchArrayCell attribute), 711
- width (abjad.tools.pitcharraytools.PitchArrayColumn attribute), 712
- width (abjad.tools.pitcharraytools.PitchArrayRow attribute), 714
- width (abjad.tools.sequencetools.Tree attribute), 728
- withdraw() (abjad.tools.pitcharraytools.PitchArrayRow method), 714
- withdraw_components_from_spanners_covered_by_components() (in module abjad.tools.spannertools), 608
- write_expr_to_ly() (in module abjad.tools.iotools), 683
- write_expr_to_ly_and_to_pdf_and_show() (in module abjad.tools.iotools), 683
- write_expr_to_pdf() (in module abjad.tools.iotools), 684
- written_duration (abjad.tools.spannertools.Spanner attribute), 590
- written_pitch (abjad.tools.notetools.Note attribute), 472
- written_pitch (abjad.tools.notetools.NoteHead attribute), 473
- written_pitch (abjad.tools.spannertools.TrillSpanner attribute), 592

written_pitches (abjad.tools.chordtools.Chord attribute), 213

X

Xylophone (class in abjad.tools.instrumenttools), 363

Y

yield_all_assignable_rationals_in_cantor_diagonalized_order() (in module abjad.tools.durationtools), 658

yield_all_combinations_of_sequence_elements() (in module abjad.tools.sequencetools), 765

yield_all_compositions_of_integer() (in module abjad.tools.mathtools), 708

yield_all_k_ary_sequences_of_length() (in module abjad.tools.sequencetools), 765

yield_all_pairs_between_sequences() (in module abjad.tools.sequencetools), 766

yield_all_partitions_of_integer() (in module abjad.tools.mathtools), 709

yield_all_partitions_of_sequence() (in module abjad.tools.sequencetools), 766

yield_all_permutations_of_sequence() (in module abjad.tools.sequencetools), 766

yield_all_permutations_of_sequence_in_orbit() (in module abjad.tools.sequencetools), 767

yield_all_positive_integer_pairs_in_cantor_diagonalized_order() (in module abjad.tools.durationtools), 659

yield_all_positive_rationals_in_cantor_diagonalized_order() (in module abjad.tools.durationtools), 659

yield_all_positive_rationals_in_cantor_diagonalized_order_uniquely() (in module abjad.tools.durationtools), 660

yield_all_prolation_rewrite_pairs_of_rational_in_cantor_diagonalized_order() (in module abjad.tools.durationtools), 660

yield_all_restricted_growth_functions_of_length() (in module abjad.tools.sequencetools), 767

yield_all_rotations_of_sequence() (in module abjad.tools.sequencetools), 767

yield_all_set_partitions_of_sequence() (in module abjad.tools.sequencetools), 768

yield_all_subchords_of_chord() (in module abjad.tools.chordtools), 218

yield_all_subsequences_of_sequence() (in module abjad.tools.sequencetools), 768

yield_all_unordered_pairs_of_sequence() (in module abjad.tools.sequencetools), 769

yield_components_grouped_by_preprolated_duration() (in module abjad.tools.componenttools), 272

yield_components_grouped_by_prolated_duration() (in module abjad.tools.componenttools), 272

yield_groups_of_chords_in_sequence() (in module abjad.tools.chordtools), 219

yield_groups_of_mixed_klasses_in_sequence() (in module abjad.tools.componenttools), 272

yield_groups_of_mixed_notes_and_chords_in_sequence() (in module abjad.tools.leaftools), 402

yield_groups_of_notes_in_sequence() (in module abjad.tools.notetools), 482

yield_groups_of_rests_in_sequence() (in module abjad.tools.resttools), 550

yield_groups_of_skips_in_sequence() (in module abjad.tools.skiptools), 569

yield_outer_product_of_sequences() (in module abjad.tools.sequencetools), 769

yield_topmost_components_grouped_by_type() (in module abjad.tools.componenttools), 273

yield_topmost_components_of_klass_grouped_by_type() (in module abjad.tools.componenttools), 273

Z

zip_sequences_cyclically() (in module abjad.tools.sequencetools), 770

zip_sequences_without_truncation() (in module abjad.tools.sequencetools), 770