LilyPond

The music typesetter

Extending

The LilyPond development team

This file explains how to extend the functionality of LilyPond version 2.14.2.

For more information about how this manual fits with the other documentation, or to read this manual in other formats, see Section "Manuals" in *General Information*.

If you are missing any manuals, the complete documentation can be found at `http://www.lilypond.org/`.

For LilyPond version 2.14.2

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1 Scheme tutorial

LilyPond uses the Scheme programming language, both as part of the input syntax, and as internal mechanism to glue modules of the program together. This section is a very brief overview of entering data in Scheme. If you want to know more about Scheme, see http://www.schemers.org.

LilyPond uses the GNU Guile implementation of Scheme, which is based on the Scheme "R5RS" standard. If you are learning Scheme to use with LilyPond, working with a different implementation (or referring to a different standard) is not recommended. Information on guile can be found at http://www.gnu.org/software/guile/. The "R5RS" Scheme standard is located at http://www.schemers.org/Documents/Standards/R5RS/.

1.1 Introduction to Scheme

We begin with an introduction to Scheme. For this brief introduction, we will use the GUILE interpreter to explore how the language works. Once we are familiar with Scheme, we will show how the language can be integrated in LilyPond files.

1.1.1 Scheme sandbox

The LilyPond installation includes the Guile implementation of Scheme. On most systems you can experiment in a Scheme sandbox by opening a terminal window and typing 'guile'. On some systems, notably Windows, you may need to set the environment variable `GUILE_LOAD_PATH` to the directory `../usr/shr/guile/1.8` in the LilyPond installation. For the full path to this directory see Section "Other sources of information" in *Learning Manual*. Alternatively, Windows users may simply choose 'Run' from the Start menu and enter 'guile'.

Once the guile sandbox is running, you will receive a guile prompt:

```
guile>
```

You can enter Scheme expressions at this prompt to experiment with Scheme.

1.1.2 Scheme variables

Scheme variables can have any valid scheme value, including a Scheme procedure.

Scheme variables are created with `define`:

```
guile> (define a 2)
guile>
```

Scheme variables can be evaluated at the guile prompt simply by typing the variable name:

```
guile> a
2
guile>
```

Scheme variables can be printed on the display by using the display function:

```
guile> (display a)
2guile>
```

Note that both the value `2` and the guile prompt `guile` showed up on the same line. This can be avoided by calling the newline procedure or displaying a newline character.

```
guile> (display a)(newline)
2
guile> (display a)(display "\n")
2
guile>
```

Once a variable has been created, its value can be changed with `set!`:

```
guile> (set! a 12345)
guile> a
12345
guile>
```

1.1.3 Scheme simple data types

The most basic concept in a language is data typing: numbers, character strings, lists, etc. Here is a list of simple Scheme data types that are often used with LilyPond.

Booleans
: Boolean values are True or False. The Scheme for True is `#t` and False is `#f`.

Numbers
: Numbers are entered in the standard fashion, `1` is the (integer) number one, while `-1.5` is a floating point number (a non-integer number).

Strings
: Strings are enclosed in double quotes:

```
"this is a string"
```

Strings may span several lines:

```
"this
is
a string"
```

and the newline characters at the end of each line will be included in the string.

Newline characters can also be added by including `\n` in the string.

```
"this\nis a\nmultiline string"
```

Quotation marks and backslashes are added to strings by preceding them with a backslash. The string `\a said "b"` is entered as

```
"\\a said \"b\""
```

There are additional Scheme data types that are not discussed here. For a complete listing see the Guile reference guide, http://www.gnu.org/software/guile/manual/html_node/Simple-Data-Types.h

1.1.4 Scheme compound data types

There are also compound data types in Scheme. The types commonly used in LilyPond programming include pairs, lists, alists, and hash tables.

Pairs

The foundational compound data type of Scheme is the `pair`. As might be expected from its name, a pair is two values glued together. The operator used to form a pair is called `cons`.

```
guile> (cons 4 5)
(4 . 5)
guile>
```

Note that the pair is displayed as two items surrounded by parentheses and separated by whitespace, a period (`.`), and more whitespace. The period is *not* a decimal point, but rather an indicator of the pair.

Pairs can also be entered as literal values by preceding them with a single quote character.

```
guile> '(4 . 5)
(4 . 5)
guile>
```

The two elements of a pair may be any valid Scheme value:

```
guile> (cons #t #f)
(#t . #f)
guile> '("blah-blah" . 3.1415926535)
```

```
("blah-blah" . 3.1415926535)
guile>
```

The first and second elements of the pair can be accessed by the Scheme procedures `car` and `cdr`, respectively.

```
guile> (define mypair (cons 123 "hello there")
... )
guile> (car mypair)
123
guile> (cdr mypair)
"hello there"
guile>
```

Note: `cdr` is pronounced "could-er", according Sussman and Abelson, see http://mitpress.mit.edu/sicp/full-text/book/book-Z-H-14.html#footnote_Temp_133

Lists

A very common Scheme data structure is the *list*. Formally, a list is defined as either the empty list (represented as `'()`, or a pair whose `cdr` is a list.

There are many ways of creating lists. Perhaps the most common is with the `list` procedure:

```
guile> (list 1 2 3 "abc" 17.5)
(1 2 3 "abc" 17.5)
```

As can be seen, a list is displayed in the form of individual elements separated by whitespace and enclosed in parentheses. Unlike a pair, there is no period between the elements.

A list can also be entered as a literal list by enclosing its elements in parentheses, and adding a quote:

```
guile> '(17 23 "foo" "bar" "bazzle")
(17 23 "foo" "bar" "bazzle")
```

Lists are a central part of Scheme. In, fact, Scheme is considered a dialect of lisp, where 'lisp' is an abbreviation for 'List Processing'. Scheme expressions are all lists.

Association lists (alists)

A special type of list is an *association list* or *alist*. An alist is used to store data for easy retrieval.

Alists are lists whose elements are pairs. The `car` of each element is called the *key*, and the `cdr` of each element is called the *value*. The Scheme procedure `assoc` is used to retrieve an entry from the alist, and `cdr` is used to retrieve the value:

```
guile> (define my-alist '((1  . "A") (2 . "B") (3 . "C")))
guile> my-alist
((1 . "A") (2 . "B") (3 . "C"))
guile> (assoc 2 my-alist)
(2 . "B")
guile> (cdr (assoc 2 my-alist))
"B"
guile>
```

Alists are widely used in LilyPond to store properties and other data.

Hash tables

A data structure that is used occasionally in LilyPond. A hash table is similar to an array, but the indexes to the array can be any type of Scheme value, not just integers.

Hash tables are more efficient than alists if there is a lot of data to store and the data changes very infrequently.

The syntax to create hash tables is a bit complex, but you can see examples of it in the LilyPond source.

```
guile> (define h (make-hash-table 10))
guile> h
#<hash-table 0/31>
guile> (hashq-set! h 'key1 "val1")
"val1"
guile> (hashq-set! h 'key2 "val2")
"val2"
guile> (hashq-set! h 3 "val3")
"val3"
```

Values are retrieved from hash tables with `hashq-ref`.

```
guile> (hashq-ref h 3)
"val3"
guile> (hashq-ref h 'key2)
"val2"
guile>
```

Keys and values are retrieved as a pair with `hashq-get-handle`. This is a preferred way, because it will return `#f` if a key is not found.

```
guile> (hashq-get-handle h 'key1)
(key1 . "val1")
guile> (hashq-get-handle h 'frob)
#f
guile>
```

1.1.5 Calculations in Scheme

Scheme can be used to do calculations. It uses *prefix* syntax. Adding 1 and 2 is written as `(+ 1 2)` rather than the traditional $1 + 2$.

```
guile> (+ 1 2)
3
```

Calculations may be nested; the result of a function may be used for another calculation.

```
guile> (+ 1 (* 3 4))
13
```

These calculations are examples of evaluations; an expression like `(* 3 4)` is replaced by its value `12`.

Scheme calculations are sensitive to the differences between integers and non-integers. Integer calculations are exact, while non-integers are calculated to the appropriate limits of precision:

```
guile> (/ 7 3)
7/3
guile> (/ 7.0 3.0)
2.33333333333333
```

When the scheme interpreter encounters an expression that is a list, the first element of the list is treated as a procedure to be evaluated with the arguments of the remainder of the list. Therefore, all operators in Scheme are prefix operators.

If the first element of a Scheme expression that is a list passed to the interpreter is *not* an operator or procedure, an error will occur:

```
guile> (1 2 3)

Backtrace:
```

```
In current input:
  52: 0* [1 2 3]

<unnamed port>:52:1: In expression (1 2 3):
<unnamed port>:52:1: Wrong type to apply: 1
ABORT: (misc-error)
guile>
```

Here you can see that the interpreter was trying to treat 1 as an operator or procedure, and it couldn't. Hence the error is "Wrong type to apply: 1".

Therefore, to create a list we need to use the list operator, or to quote the list so that the interpreter will not try to evaluate it.

```
guile> (list 1 2 3)
(1 2 3)
guile> '(1 2 3)
(1 2 3)
guile>
```

This is an error that can appear as you are working with Scheme in LilyPond.

1.1.6 Scheme procedures

Scheme procedures are executable scheme expressions that return a value resulting from their execution. They can also manipulate variables defined outside of the procedure.

Defining procedures

Procedures are defined in Scheme with define

```
(define (function-name arg1 arg2 ... argn)
 scheme-expression-that-gives-a-return-value)
```

For example, we could define a procedure to calculate the average:

```
guile> (define (average x y) (/ (+ x y) 2))
guile> average
#<procedure average (x y)>
```

Once a procedure is defined, it is called by putting the procedure name and the arguments in a list. For example, we can calculate the average of 3 and 12:

```
guile> (average 3 12)
15/2
```

Predicates

Scheme procedures that return boolean values are often called *predicates*. By convention (but not necessity), predicate names typically end in a question mark:

```
guile> (define (less-than-ten? x) (< x 10))
guile> (less-than-ten? 9)
#t
guile> (less-than-ten? 15)
#f
```

Return values

Scheme procedures always return a return value, which is the value of the last expression executed in the procedure. The return value can be any valid Scheme value, including a complex data structure or a procedure.

Sometimes the user would like to have multiple Scheme expressions in a procedure. There are two ways that multiple expressions can be combined. The first is the `begin` procedure, which allows multiple expressions to be evaluated, and returns the value of the last expression.

```
guile> (begin (+ 1 2) (- 5 8) (* 2 2))
4
```

The second way to combine multiple expressions is in a `let` block. In a let block, a series of bindings are created, and then a sequence of expressions that can include those bindings is evaluated. The return value of the let block is the return value of the last statement in the let block:

```
guile> (let ((x 2) (y 3) (z 4)) (display (+ x y)) (display (- z 4))
... (+ (* x y) (/ z x)))
508
```

1.1.7 Scheme conditionals

if

Scheme has an `if` procedure:

```
(if test-expression true-expression false-expression)
```

test-expression is an expression that returns a boolean value. If *test-expression* returns `#t`, the if procedure returns the value of *true-expression*, otherwise it returns the value of *false-expression*.

```
guile> (define a 3)
guile> (define b 5)
guile> (if (> a b) "a is greater than b" "a is not greater than b")
"a is not greater than b"
```

cond

Another conditional procedure in scheme is `cond`:

```
(cond (test-expression-1 result-expression-sequence-1)
      (test-expression-2 result-expression-sequence-2)
      ...
      (test-expression-n result-expression-sequence-n))
```

For example:

```
guile> (define a 6)
guile> (define b 8)
guile> (cond ((< a b) "a is less than b")
...          ((= a b) "a equals b")
...          ((> a b) "a is greater than b"))
"a is less than b"
```

1.2 Scheme in LilyPond

1.2.1 LilyPond Scheme syntax

The Guile interpreter is part of LilyPond, which means that Scheme can be included in LilyPond input files. The hash mark `#` is used to tell the LilyPond parser that the next value is a Scheme value.

Once the parser sees a hash mark, input is passed to the Guile interpreter to evaluate the Scheme expression. The interpreter continues to process input until the end of a Scheme expression is seen.

Scheme procedures can be defined in LilyPond input files:

```
#(define (average a b c) (/ (+ a b c) 3))
```

Note that LilyPond comments (`%` and `%{ %}`) cannot be used within Scheme code, even in a LilyPond input file, because the Guile interpreter, not the LilyPond parser, is interpreting the Scheme expression. Comments in Guile Scheme are entered as follows:

```
; this is a single-line comment

#!
  This a (non-nestable) Guile-style block comment
  But these are rarely used by Schemers and never in
  LilyPond source code
!#
```

For the rest of this section, we will assume that the data is entered in a music file, so we add `#`s at the beginning of each Scheme expression.

All of the top-level Scheme expressions in a LilyPond input file can be combined into a single Scheme expression by the use of the `begin` statement:

```
#(begin
  (define foo 0)
  (define bar 1))
```

1.2.2 LilyPond variables

LilyPond variables are stored internally in the form of Scheme variables. Thus,

```
twelve = 12
```

is equivalent to

```
#(define twelve 12)
```

This means that LilyPond variables are available for use in Scheme expressions. For example, we could use

```
twentyFour = #(* 2 twelve)
```

which would result in the number 24 being stored in the LilyPond (and Scheme) variable `twentyFour`.

1.2.3 Input variables and Scheme

The input format supports the notion of variables: in the following example, a music expression is assigned to a variable with the name `traLaLa`.

```
traLaLa = { c'4 d'4 }
```

There is also a form of scoping: in the following example, the `\layout` block also contains a `traLaLa` variable, which is independent of the outer `\traLaLa`.

```
traLaLa = { c'4 d'4 }
\layout { traLaLa = 1.0 }
```

In effect, each input file is a scope, and all `\header`, `\midi`, and `\layout` blocks are scopes nested inside that toplevel scope.

Both variables and scoping are implemented in the GUILE module system. An anonymous Scheme module is attached to each scope. An assignment of the form:

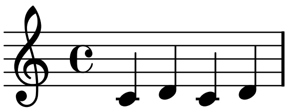
```
traLaLa = { c'4 d'4 }
```

is internally converted to a Scheme definition:

```
(define traLaLa Scheme value of '... ')
```

This means that LilyPond variables and Scheme variables may be freely mixed. In the following example, a music fragment is stored in the variable `traLaLa`, and duplicated using Scheme. The result is imported in a `\score` block by means of a second variable `twice`:

```
traLaLa = { c'4 d'4 }

%% dummy action to deal with parser lookahead
#(display "this needs to be here, sorry!")

#(define newLa (map ly:music-deep-copy
  (list traLaLa traLaLa)))
#(define twice
  (make-sequential-music newLa))

{ \twice }
```



In this example, the assignment happens after the parser has verified that nothing interesting happens after `traLaLa = { ... }`. Without the dummy statement in the above example, the `newLa` definition is executed before `traLaLa` is defined, leading to a syntax error.

The above example shows how to 'export' music expressions from the input to the Scheme interpreter. The opposite is also possible. By wrapping a Scheme value in the function `ly:export`, a Scheme value is interpreted as if it were entered in LilyPond syntax. Instead of defining `\twice`, the example above could also have been written as

```
...
{ #(ly:export (make-sequential-music (list newLa))) }
```

Scheme code is evaluated as soon as the parser encounters it. To define some Scheme code in a macro (to be called later), use Section 2.1.6 [Void functions], page 18, or

```
#(define (nopc)
  (ly:set-option 'point-and-click #f))

...
#(nopc)
{ c'4 }
```

Known issues and warnings

Mixing Scheme and LilyPond variables is not possible with the `--safe` option.

1.2.4 Object properties

Object properties are stored in LilyPond in the form of alist-chains, which are lists of alists. Properties are set by adding values at the beginning of the property list. Properties are read by retrieving values from the alists.

Setting a new value for a property requires assigning a value to the alist with both a key and a value. The LilyPond syntax for doing this is:

```
\override Stem #'thickness = #2.6
```

This instruction adjusts the appearance of stems. An alist entry `'(thickness . 2.6)` is added to the property list of the `Stem` object. `thickness` is measured relative to the thickness of staff lines, so these stem lines will be `2.6` times the width of staff lines. This makes stems almost twice as thick as their normal size. To distinguish between variables defined in input files (like `twentyFour` in the example above) and variables of internal objects, we will call the latter 'properties' and the former 'variables.' So, the stem object has a `thickness` property, while `twentyFour` is a variable.

1.2.5 LilyPond compound variables

Offsets

Two-dimensional offsets (X and Y coordinates) are stored as `pairs`. The `car` of the offset is the X coordinate, and the `cdr` is the Y coordinate.

```
\override TextScript #'extra-offset = #'(1 . 2)
```

This assigns the pair `(1 . 2)` to the `extra-offset` property of the TextScript object. These numbers are measured in staff-spaces, so this command moves the object 1 staff space to the right, and 2 spaces up.

Procedures for working with offsets are found in '`scm/lily-library.scm`'.

Extents

Pairs are also used to store intervals, which represent a range of numbers from the minimum (the `car`) to the maximum (the `cdr`). Intervals are used to store the X- and Y- extents of printable objects. For X extents, the `car` is the left hand X coordinate, and the `cdr` is the right hand X coordinate. For Y extents, the `car` is the bottom coordinate, and the `cdr` is the top coordinate.

Procedures for working with intervals are found in '`scm/lily-library.scm`'. These procedures should be used when possible to ensure consistency of code.

Property alists

A property alist is a LilyPond data structure that is an alist whose keys are properties and whose values are Scheme expressions that give the desired value for the property.

LilyPond properties are Scheme symbols, such as `'thickness`.

Alist chains

An alist chain is a list containing property alists.

The set of all properties that will apply to a grob is typically stored as an alist chain. In order to find the value for a particular property that a grob should have, each alist in the chain is searched in order, looking for an entry containing the property key. The first alist entry found is returned, and the value is the property value.

The Scheme procedure `chain-assoc-get` is normally used to get grob property values.

1.2.6 Internal music representation

Internally, music is represented as a Scheme list. The list contains various elements that affect the printed output. Parsing is the process of converting music from the LilyPond input representation to the internal Scheme representation.

When a music expression is parsed, it is converted into a set of Scheme music objects. The defining property of a music object is that it takes up time. The time it takes up is called its *duration*. Durations are expressed as a rational number that measures the length of the music object in whole notes.

A music object has three kinds of types:

- music name: Each music expression has a name. For example, a note leads to a Section "NoteEvent" in *Internals Reference*, and `\simultaneous` leads to a Section "SimultaneousMusic" in *Internals Reference*. A list of all expressions available is in the Internals Reference manual, under Section "Music expressions" in *Internals Reference*.
- 'type' or interface: Each music name has several 'types' or interfaces, for example, a note is an `event`, but it is also a `note-event`, a `rhythmic-event`, and a `melodic-event`. All classes of music are listed in the Internals Reference, under Section "Music classes" in *Internals Reference*.
- C++ object: Each music object is represented by an object of the C++ class `Music`.

The actual information of a music expression is stored in properties. For example, a Section "NoteEvent" in *Internals Reference* has `pitch` and `duration` properties that store the pitch and duration of that note. A list of all properties available can be found in the Internals Reference, under Section "Music properties" in *Internals Reference*.

A compound music expression is a music object that contains other music objects in its properties. A list of objects can be stored in the `elements` property of a music object, or a single 'child' music object in the `element` property. For example, Section "SequentialMusic" in *Internals Reference* has its children in `elements`, and Section "GraceMusic" in *Internals Reference* has its single argument in `element`. The body of a repeat is stored in the `element` property of Section "RepeatedMusic" in *Internals Reference*, and the alternatives in `elements`.

1.3 Building complicated functions

This section explains how to gather the information necessary to create complicated music functions.

1.3.1 Displaying music expressions

When writing a music function it is often instructive to inspect how a music expression is stored internally. This can be done with the music function `\displayMusic`

```
{
  \displayMusic { c'4\f }
}
```

will display

```
(make-music
  'SequentialMusic
  'elements
  (list (make-music
          'EventChord
          'elements
          (list (make-music
                  'NoteEvent
                  'duration
                  (ly:make-duration 2 0 1 1)
                  'pitch
                  (ly:make-pitch 0 0 0))
                (make-music
                  'AbsoluteDynamicEvent
                  'text
                  "f")))))
```

By default, LilyPond will print these messages to the console along with all the other messages. To split up these messages and save the results of `\display{STUFF}`, redirect the output to a file.

```
lilypond file.ly >display.txt
```

With a bit of reformatting, the above information is easier to read,

```
(make-music 'SequentialMusic
  'elements (list (make-music 'EventChord
                    'elements (list (make-music 'NoteEvent
                                      'duration (ly:make-duration 2 0 1 1)
                                      'pitch (ly:make-pitch 0 0 0))
                                    (make-music 'AbsoluteDynamicEvent
                                      'text "f")))))
```

A { ... } music sequence has the name SequentialMusic, and its inner expressions are stored as a list in its 'elements property. A note is represented as an EventChord expression, containing a NoteEvent object (storing the duration and pitch properties) and any extra information (in this case, an AbsoluteDynamicEvent with a "f" text property.

1.3.2 Music properties

TODO – make sure we delineate between *music* properties, *context* properties, and *layout* properties. These are potentially confusing.

The NoteEvent object is the first object of the 'elements property of someNote.

```
someNote = c'
\displayMusic \someNote
===>
(make-music
  'EventChord
  'elements
  (list (make-music
          'NoteEvent
          'duration
          (ly:make-duration 2 0 1 1)
          'pitch
          (ly:make-pitch 0 0 0))))
```

The display-scheme-music function is the function used by \displayMusic to display the Scheme representation of a music expression.

```
#(display-scheme-music (first (ly:music-property someNote 'elements)))
===>
(make-music
  'NoteEvent
  'duration
  (ly:make-duration 2 0 1 1)
  'pitch
  (ly:make-pitch 0 0 0))
```

Then the note pitch is accessed through the 'pitch property of the NoteEvent object,

```
#(display-scheme-music
   (ly:music-property (first (ly:music-property someNote 'elements))
                      'pitch))
===>
(ly:make-pitch 0 0 0)
```

The note pitch can be changed by setting this 'pitch property,

```
#(set! (ly:music-property (first (ly:music-property someNote 'elements))
                          'pitch)
```

```
       (ly:make-pitch 0 1 0)) ;; set the pitch to d'.
\displayLilyMusic \someNote
===>
d'
```

1.3.3 Doubling a note with slurs (example)

Suppose we want to create a function that translates input like `a` into `a( a)`. We begin by examining the internal representation of the desired result.

```
\displayMusic{ a'( a') }
===>
(make-music
  'SequentialMusic
  'elements
  (list (make-music
          'EventChord
          'elements
          (list (make-music
                  'NoteEvent
                  'duration
                  (ly:make-duration 2 0 1 1)
                  'pitch
                  (ly:make-pitch 0 5 0))
                (make-music
                  'SlurEvent
                  'span-direction
                  -1)))
        (make-music
          'EventChord
          'elements
          (list (make-music
                  'NoteEvent
                  'duration
                  (ly:make-duration 2 0 1 1)
                  'pitch
                  (ly:make-pitch 0 5 0))
                (make-music
                  'SlurEvent
                  'span-direction
                  1)))))
```

The bad news is that the `SlurEvent` expressions must be added 'inside' the note (or more precisely, inside the `EventChord` expression).

Now we examine the input,

```
(make-music
  'SequentialMusic
  'elements
  (list (make-music
          'EventChord
          'elements
          (list (make-music
                  'NoteEvent
                  'duration
```

```
                  (ly:make-duration 2 0 1 1)
                  'pitch
                  (ly:make-pitch 0 5 0))))))
```

So in our function, we need to clone this expression (so that we have two notes to build the sequence), add a `SlurEvent` to the `'elements` property of each one, and finally make a `SequentialMusic` with the two `EventChords`.

```
doubleSlur = #(define-music-function (parser location note) (ly:music?)
         "Return: { note ( note ) }.
         `note' is supposed to be an EventChord."
         (let ((note2 (ly:music-deep-copy note)))
           (set! (ly:music-property note 'elements)
                 (cons (make-music 'SlurEvent 'span-direction -1)
                       (ly:music-property note 'elements)))
           (set! (ly:music-property note2 'elements)
                 (cons (make-music 'SlurEvent 'span-direction 1)
                       (ly:music-property note2 'elements)))
           (make-music 'SequentialMusic 'elements (list note note2))))
```

1.3.4 Adding articulation to notes (example)

The easy way to add articulation to notes is to merge two music expressions into one context, as explained in Section "Creating contexts" in *Notation Reference*. However, suppose that we want to write a music function that does this.

A `$variable` inside the `#{...#}` notation is like a regular `\variable` in classical LilyPond notation. We know that

```
{ \music -. -> }
```

will not work in LilyPond. We could avoid this problem by attaching the articulation to a fake note,

```
{ << \music s1*0-.-> }
```

but for the sake of this example, we will learn how to do this in Scheme. We begin by examining our input and desired output,

```
%  input
\displayMusic c4
===>
(make-music
  'EventChord
  'elements
  (list (make-music
          'NoteEvent
          'duration
          (ly:make-duration 2 0 1 1)
          'pitch
          (ly:make-pitch -1 0 0))))
=====
%  desired output
\displayMusic c4->
===>
(make-music
  'EventChord
  'elements
  (list (make-music
```

```
          'NoteEvent
          'duration
          (ly:make-duration 2 0 1 1)
          'pitch
          (ly:make-pitch -1 0 0))
        (make-music
          'ArticulationEvent
          'articulation-type
          "marcato")))
```

We see that a note (c4) is represented as an EventChord expression, with a NoteEvent expression in its elements list. To add a marcato articulation, an ArticulationEvent expression must be added to the elements property of the EventChord expression.

To build this function, we begin with

```
(define (add-marcato event-chord)
  "Add a marcato ArticulationEvent to the elements of `event-chord',
  which is supposed to be an EventChord expression."
  (let ((result-event-chord (ly:music-deep-copy event-chord)))
    (set! (ly:music-property result-event-chord 'elements)
          (cons (make-music 'ArticulationEvent
                  'articulation-type "marcato")
                (ly:music-property result-event-chord 'elements)))
    result-event-chord))
```

The first line is the way to define a function in Scheme: the function name is add-marcato, and has one variable called event-chord. In Scheme, the type of variable is often clear from its name. (this is good practice in other programming languages, too!)

```
"Add a marcato..."
```

is a description of what the function does. This is not strictly necessary, but just like clear variable names, it is good practice.

```
(let ((result-event-chord (ly:music-deep-copy event-chord)))
```

let is used to declare local variables. Here we use one local variable, named result-event-chord, to which we give the value (ly:music-deep-copy event-chord). ly:music-deep-copy is a function specific to LilyPond, like all functions prefixed by ly:. It is use to make a copy of a music expression. Here we copy event-chord (the parameter of the function). Recall that our purpose is to add a marcato to an EventChord expression. It is better to not modify the EventChord which was given as an argument, because it may be used elsewhere.

Now we have a result-event-chord, which is a NoteEventChord expression and is a copy of event-chord. We add the marcato to its 'elements list property.

```
(set! place new-value)
```

Here, what we want to set (the 'place') is the 'elements property of result-event-chord expression.

```
(ly:music-property result-event-chord 'elements)
```

ly:music-property is the function used to access music properties (the 'elements, 'duration, 'pitch, etc, that we see in the \displayMusic output above). The new value is the former 'elements property, with an extra item: the ArticulationEvent expression, which we copy from the \displayMusic output,

```
(cons (make-music 'ArticulationEvent
        'articulation-type "marcato")
      (ly:music-property result-event-chord 'elements))
```

`cons` is used to add an element to a list without modifying the original list. This is what we want: the same list as before, plus the new `ArticulationEvent` expression. The order inside the `'elements` property is not important here.

Finally, once we have added the marcato articulation to its `elements` property, we can return `result-event-chord`, hence the last line of the function.

Now we transform the `add-marcato` function into a music function,

```
addMarcato = #(define-music-function (parser location event-chord)
                                     (ly:music?)
    "Add a marcato ArticulationEvent to the elements of `event-chord',
    which is supposed to be an EventChord expression."
    (let ((result-event-chord (ly:music-deep-copy event-chord)))
      (set! (ly:music-property result-event-chord 'elements)
            (cons (make-music 'ArticulationEvent
                    'articulation-type "marcato")
                  (ly:music-property result-event-chord 'elements)))
      result-event-chord))
```

We may verify that this music function works correctly,

```
\displayMusic \addMarcato c4
```

2 Interfaces for programmers

Advanced tweaks may be performed by using Scheme. If you are not familiar with Scheme, you may wish to read our Chapter 1 [Scheme tutorial], page 1.

2.1 Music functions

Music functions are scheme procedures that can create music expressions automatically, and can be used to greatly simplify the input file.

2.1.1 Music function syntax

The general form for music functions is:

```
function =
#(define-music-function
     (parser location arg1 arg2 ...)
     (type1? type2? ...)
   music)
```

where

argN — *n*th argument

typeN? — a scheme *type predicate* for which *argN* must return `#t`.

music — A music expression, optionally written in scheme, with any LilyPond code enclosed in hashed braces (`#{...#}`). Within LilyPond code blocks, use `$` to reference function arguments (eg., '`$arg1`') or to start an inline scheme expression containing function arguments (eg., '`$(cons arg1 arg2)`').

For a list of available type predicates, see Section "Predefined type predicates" in *Notation Reference*. User-defined type predicates are also allowed.

See also

Notation Reference: Section "Predefined type predicates" in *Notation Reference*.

Installed Files: '`lily/music-scheme.cc`', '`scm/c++.scm`', '`scm/lily.scm`'.

2.1.2 Simple substitution functions

Simple substitution functions are music functions whose output music expression is written in LilyPond format and contains function arguments in the output expression. They are described in Section "Substitution function examples" in *Notation Reference*.

2.1.3 Intermediate substitution functions

Intermediate substitution functions involve a mix of Scheme code and LilyPond code in the music expression to be returned.

Some `\override` commands require an argument consisting of a pair of numbers (called a *cons cell* in Scheme).

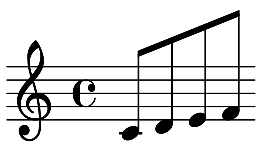
The pair can be directly passed into the music function, using a `pair?` variable:

```
manualBeam =
#(define-music-function
     (parser location beg-end)
```

```
      (pair?)
    #{
      \once \override Beam #'positions = $beg-end
    #})

\relative c' {
  \manualBeam #'(3 . 6) c8 d e f
}
```

Alternatively, the numbers making up the pair can be passed as separate arguments, and the Scheme code used to create the pair can be included in the music expression:

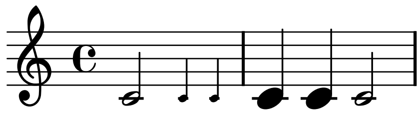
```
manualBeam =
#(define-music-function
      (parser location beg end)
      (number? number?)
    #{
      \once \override Beam #'positions = $(cons beg end)
    #})

\relative c' {
  \manualBeam #3 #6 c8 d e f
}
```



2.1.4 Mathematics in functions

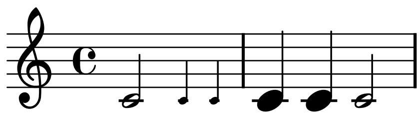
Music functions can involve Scheme programming in addition to simple substitution,

```
AltOn =
#(define-music-function
      (parser location mag)
      (number?)
    #{
      \override Stem #'length = $(* 7.0 mag)
      \override NoteHead #'font-size =
        $(inexact->exact (* (/ 6.0 (log 2.0)) (log mag)))
    #})

AltOff = {
  \revert Stem #'length
  \revert NoteHead #'font-size
}

\relative c' {
  c2 \AltOn #0.5 c4 c
  \AltOn #1.5 c c \AltOff c2
}
```



This example may be rewritten to pass in music expressions,

```
withAlt =
#(define-music-function
     (parser location mag music)
     (number? ly:music?)
   #{
     \override Stem #'length = $(* 7.0 mag)
     \override NoteHead #'font-size =
       $(inexact->exact (* (/ 6.0 (log 2.0)) (log mag)))
     $music
     \revert Stem #'length
     \revert NoteHead #'font-size
   #})

\relative c' {
  c2 \withAlt #0.5 { c4 c }
  \withAlt #1.5 { c c } c2
}
```



2.1.5 Functions without arguments

In most cases a function without arguments should be written with a variable,

```
dolce = \markup{ \italic \bold dolce }
```

However, in rare cases it may be useful to create a music function without arguments,

```
displayBarNum =
#(define-music-function
     (parser location)
     ()
   (if (eq? #t (ly:get-option 'display-bar-numbers))
       #{ \once \override Score.BarNumber #'break-visibility = ##f #}
       #{#}))
```

To actually display bar numbers where this function is called, invoke `lilypond` with

```
lilypond -d display-bar-numbers FILENAME.ly
```

2.1.6 Void functions

A music function must return a music expression, but sometimes we may want to have a function that does not involve music (such as turning off Point and Click). To do this, we return a `void` music expression.

That is why the form that is returned is the `(make-music ...)`. With the `'void` property set to `#t`, the parser is told to actually disregard this returned music expression. Thus the important part of the void music function is the processing done by the function, not the music expression that is returned.

```
noPointAndClick =
#(define-music-function
     (parser location)
```

```
     ()
   (ly:set-option 'point-and-click #f)
   (make-music 'SequentialMusic 'void #t))
...
\noPointAndClick   % disable point and click
```

2.2 Markup functions

Markups are implemented as special Scheme functions which produce a `Stencil` object given a number of arguments.

2.2.1 Markup construction in Scheme

The `markup` macro builds markup expressions in Scheme while providing a LilyPond-like syntax. For example,

```
(markup #:column (#:line (#:bold #:italic "hello" #:raise 0.4 "world")
                  #:larger #:line ("foo" "bar" "baz")))
```

is equivalent to:

```
\markup \column { \line { \bold \italic "hello" \raise #0.4 "world" }
                  \larger \line { foo bar baz } }
```

This example demonstrates the main translation rules between regular LilyPond markup syntax and Scheme markup syntax.

LilyPond	**Scheme**
`\markup markup1`	`(markup markup1)`
`\markup { markup1 markup2 ... }`	`(markup markup1 markup2 ... )`
`\markup-command`	`#:markup-command`
`\variable`	`variable`
`\center-column { ... }`	`#:center-column ( ... )`
`string`	`"string"`
`#scheme-arg`	`scheme-arg`

The whole Scheme language is accessible inside the `markup` macro. For example, You may use function calls inside `markup` in order to manipulate character strings. This is useful when defining new markup commands (see Section 2.2.3 [New markup command definition], page 20).

Known issues and warnings

The markup-list argument of commands such as `#:line`, `#:center`, and `#:column` cannot be a variable or the result of a function call.

```
(markup #:line (function-that-returns-markups))
```

is invalid. One should use the `make-line-markup`, `make-center-markup`, or `make-column-markup` functions instead,

```
(markup (make-line-markup (function-that-returns-markups)))
```

2.2.2 How markups work internally

In a markup like

```
\raise #0.5 "text example"
```

`\raise` is actually represented by the `raise-markup` function. The markup expression is stored as

```
(list raise-markup 0.5 (list simple-markup "text example"))
```

When the markup is converted to printable objects (Stencils), the `raise-markup` function is called as

```
(apply raise-markup
       \layout object
       list of property alists
       0.5
       the "text example" markup)
```

The `raise-markup` function first creates the stencil for the `text example` string, and then it raises that Stencil by 0.5 staff space. This is a rather simple example; more complex examples are in the rest of this section, and in '`scm/define-markup-commands.scm`'.

2.2.3 New markup command definition

This section discusses the definition of new markup commands.

Markup command definition syntax

New markup commands can be defined using the `define-markup-command` Scheme macro, at top-level.

```
(define-markup-command (command-name layout props arg1 arg2 ...)
    (arg1-type? arg2-type? ...)
    [ #:properties ((property1 default-value1)
                    ...) ]
  ..command body..)
```

The arguments are

`command-name`
: the markup command name

`layout`
: the 'layout' definition.

`props`
: a list of associative lists, containing all active properties.

`argi`
: *i*th command argument

`argi-type?`
: a type predicate for the i*th* argument

If the command uses properties from the `props` arguments, the `#:properties` keyword can be used to specify which properties are used along with their default values.

Arguments are distinguished according to their type:

- a markup, corresponding to type predicate `markup?`;
- a list of markups, corresponding to type predicate `markup-list?`;
- any other scheme object, corresponding to type predicates such as `list?`, `number?`, `boolean?`, etc.

There is no limitation on the order of arguments (after the standard `layout` and `props` arguments). However, markup functions taking a markup as their last argument are somewhat special as you can apply them to a markup list, and the result is a markup list where the markup function (with the specified leading arguments) has been applied to every element of the original markup list.

Since replicating the leading arguments for applying a markup function to a markup list is cheap mostly for Scheme arguments, you avoid performance pitfalls by just using Scheme arguments for the leading arguments of markup functions that take a markup as their last argument.

On properties

The `layout` and `props` arguments of markup commands bring a context for the markup interpretation: font size, line width, etc.

The `layout` argument allows access to properties defined in `paper` blocks, using the `ly:output-def-lookup` function. For instance, the line width (the same as the one used in scores) is read using:

```
(ly:output-def-lookup layout 'line-width)
```

The `props` argument makes some properties accessible to markup commands. For instance, when a book title markup is interpreted, all the variables defined in the `\header` block are automatically added to `props`, so that the book title markup can access the book title, composer, etc. It is also a way to configure the behaviour of a markup command: for example, when a command uses font size during processing, the font size is read from `props` rather than having a `font-size` argument. The caller of a markup command may change the value of the font size property in order to change the behaviour. Use the `#:properties` keyword of `define-markup-command` to specify which properties shall be read from the `props` arguments.

The example in next section illustrates how to access and override properties in a markup command.

A complete example

The following example defines a markup command to draw a double box around a piece of text.

Firstly, we need to build an approximative result using markups. Consulting the Section "Text markup commands" in *Notation Reference* shows us the `\box` command is useful:

```
\markup \box \box HELLO
```

Now, we consider that more padding between the text and the boxes is preferable. According to the `\box` documentation, this command uses a `box-padding` property, which defaults to 0.2. The documentation also mentions how to override it:

```
\markup \box \override #'(box-padding . 0.6) \box A
```

Then, the padding between the two boxes is considered too small, so we override it too:

```
\markup \override #'(box-padding . 0.4) \box \override #'(box-padding . 0.6) \box A
```

Repeating this lengthy markup would be painful. This is where a markup command is needed. Thus, we write a `double-box` markup command, taking one argument (the text). This draws the two boxes, with some padding.

```
#(define-markup-command (double-box layout props text) (markup?)
  "Draw a double box around text."
  (interpret-markup layout props
    (markup #:override '(box-padding . 0.4) #:box
            #:override '(box-padding . 0.6) #:box text)))
```

`text` is the name of the command argument, and `markup?` its type: it identifies it as a markup. The `interpret-markup` function is used in most of markup commands: it builds a stencil, using `layout`, `props`, and a markup. Here, this markup is built using the `markup` scheme macro, see Section 2.2.1 [Markup construction in Scheme], page 19. The transformation from `\markup` expression to scheme markup expression is straight-forward.

The new command can be used as follow:

```
\markup \double-box A
```

It would be nice to make the `double-box` command customizable: here, the `box-padding` values are hard coded, and cannot be changed by the user. Also, it would be better to distinguish the padding between the two boxes, from the padding between the inner box and the text. So we will introduce a new property, `inter-box-padding`, for the padding between the two boxes. The `box-padding` will be used for the inner padding. The new code is now as follows:

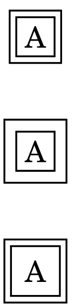
```
#(define-markup-command (double-box layout props text) (markup?)
  #:properties ((inter-box-padding 0.4)
                (box-padding 0.6))
  "Draw a double box around text."
  (interpret-markup layout props
    (markup #:override `(box-padding . ,inter-box-padding) #:box
            #:override `(box-padding . ,box-padding) #:box text)))
```

Here, the `#:properties` keyword is used so that the `inter-box-padding` and `box-padding` properties are read from the `props` argument, and default values are given to them if the properties are not defined.

Then, these values are used to override the `box-padding` properties used by the two `\box` commands. Note the backquote and the comma in the `\override` argument: they allow you to introduce a variable value into a literal expression.

Now, the command can be used in a markup, and the boxes padding be customized:

```
#(define-markup-command (double-box layout props text) (markup?)
  #:properties ((inter-box-padding 0.4)
                (box-padding 0.6))
  "Draw a double box around text."
  (interpret-markup layout props
    (markup #:override `(box-padding . ,inter-box-padding) #:box
            #:override `(box-padding . ,box-padding) #:box text)))

\markup \double-box A
\markup \override #'(inter-box-padding . 0.8) \double-box A
\markup \override #'(box-padding . 1.0) \double-box A
```



Adapting builtin commands

A good way to start writing a new markup command, is to take example on a builtin one. Most of the markup commands provided with LilyPond can be found in file '`scm/define-markup-commands.scm`'.

For instance, we would like to adapt the `\draw-line` command, to draw a double line instead. The `\draw-line` command is defined as follow (documentation stripped):

```
(define-markup-command (draw-line layout props dest)
  (number-pair?)
  #:category graphic
  #:properties ((thickness 1))
  "..documentation.."
  (let ((th (* (ly:output-def-lookup layout 'line-thickness)
               thickness))
        (x (car dest))
        (y (cdr dest)))
    (make-line-stencil th 0 0 x y)))
```

To define a new command based on an existing one, copy the definition, and change the command name. The `#:category` keyword can be safely removed, as it is only used for generating LilyPond documentation, and is of no use for user-defined markup commands.

```
(define-markup-command (draw-double-line layout props dest)
  (number-pair?)
  #:properties ((thickness 1))
  "..documentation.."
  (let ((th (* (ly:output-def-lookup layout 'line-thickness)
               thickness))
        (x (car dest))
        (y (cdr dest)))
    (make-line-stencil th 0 0 x y)))
```

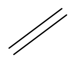
Then, a property for setting the gap between two lines is added, called `line-gap`, defaulting e.g. to 0.6:

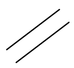
```
(define-markup-command (draw-double-line layout props dest)
  (number-pair?)
  #:properties ((thickness 1)
                (line-gap 0.6))
  "..documentation.."
  ...
```

Finally, the code for drawing two lines is added. Two calls to `make-line-stencil` are used to draw the lines, and the resulting stencils are combined using `ly:stencil-add`:

```
#(define-markup-command (my-draw-line layout props dest)
  (number-pair?)
  #:properties ((thickness 1)
                (line-gap 0.6))
  "..documentation.."
  (let* ((th (* (ly:output-def-lookup layout 'line-thickness)
                thickness))
         (dx (car dest))
         (dy (cdr dest))
         (w (/ line-gap 2.0))
         (x (cond ((= dx 0) w)
                  ((= dy 0) 0)
                  (else (/ w (sqrt (+ 1 (* (/ dx dy) (/ dx dy))))))))
         (y (* (if (< (* dx dy) 0) 1 -1)
               (cond ((= dy 0) w)
                     ((= dx 0) 0)
```

```
                     (else (/ w (sqrt (+ 1 (* (/ dy dx) (/ dy dx)))))))))
     (ly:stencil-add (make-line-stencil th x y (+ dx x) (+ dy y))
                     (make-line-stencil th (- x) (- y) (- dx x) (- dy y)))))

\markup \my-draw-line #'(4 . 3)
\markup \override #'(line-gap . 1.2) \my-draw-line #'(4 . 3)
```





2.2.4 New markup list command definition

Markup list commands are defined with the `define-markup-list-command` Scheme macro, which is similar to the `define-markup-command` macro described in Section 2.2.3 [New markup command definition], page 20, except that where the latter returns a single stencil, the former returns a list of stencils.

In the following example, a `\paragraph` markup list command is defined, which returns a list of justified lines, the first one being indented. The indent width is taken from the `props` argument.

```
#(define-markup-list-command (paragraph layout props args) (markup-list?)
   #:properties ((par-indent 2))
   (interpret-markup-list layout props
     (make-justified-lines-markup-list (cons (make-hspace-markup par-indent)
                                             args))))
```

Besides the usual `layout` and `props` arguments, the `paragraph` markup list command takes a markup list argument, named `args`. The predicate for markup lists is `markup-list?`.

First, the function gets the indent width, a property here named `par-indent`, from the property list `props`. If the property is not found, the default value is `2`. Then, a list of justified lines is made using the `make-justified-lines-markup-list` function, which is related to the `\justified-lines` built-in markup list command. A horizontal space is added at the beginning using the `make-hspace-markup` function. Finally, the markup list is interpreted using the `interpret-markup-list` function.

This new markup list command can be used as follows:

```
\markuplines {
  \paragraph {
    The art of music typography is called \italic {(plate) engraving.}
    The term derives from the traditional process of music printing.
    Just a few decades ago, sheet music was made by cutting and stamping
    the music into a zinc or pewter plate in mirror image.
  }
  \override-lines #'(par-indent . 4) \paragraph {
    The plate would be inked, the depressions caused by the cutting
    and stamping would hold ink.  An image was formed by pressing paper
    to the plate.  The stamping and cutting was completely done by
    hand.
  }
}
```

2.3 Contexts for programmers

2.3.1 Context evaluation

Contexts can be modified during interpretation with Scheme code. The syntax for this is

```
\applyContext function
```

function should be a Scheme function that takes a single argument: the context in which the `\applyContext` command is being called. The following code will print the current bar number on the standard output during the compile:

```
\applyContext
  #(lambda (x)
    (format #t "\nWe were called in barnumber ~a.\n"
     (ly:context-property x 'currentBarNumber)))
```

2.3.2 Running a function on all layout objects

The most versatile way of tuning an object is `\applyOutput` which works by inserting an event into the specified context (Section "ApplyOutputEvent" in *Internals Reference*). Its syntax is

```
\applyOutput context proc
```

where *proc* is a Scheme function, taking three arguments.

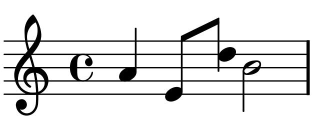
When interpreted, the function *proc* is called for every layout object found in the context *context* at the current time step, with the following arguments:

- the layout object itself,
- the context where the layout object was created, and
- the context where `\applyOutput` is processed.

In addition, the cause of the layout object, i.e., the music expression or object that was responsible for creating it, is in the object property `cause`. For example, for a note head, this is a Section "NoteHead" in *Internals Reference* event, and for a stem object, this is a Section "Stem" in *Internals Reference* object.

Here is a function to use for `\applyOutput`; it blanks note-heads on the center-line and next to it:

```
#(define (blanker grob grob-origin context)
   (if (and (memq 'note-head-interface (ly:grob-interfaces grob))
            (< (abs (ly:grob-property grob 'staff-position)) 2))
       (set! (ly:grob-property grob 'transparent) #t)))

\relative c' {
  a'4 e8 <<\applyOutput #'Voice #blanker a c d>> b2
}
```



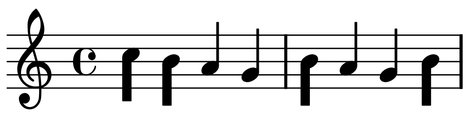
2.4 Callback functions

Properties (like `thickness`, `direction`, etc.) can be set at fixed values with `\override`, e.g.

```
\override Stem #'thickness = #2.0
```

Properties can also be set to a Scheme procedure,

```
\override Stem #'thickness = #(lambda (grob)
    (if (= UP (ly:grob-property grob 'direction))
        2.0
        7.0))
c b a g b a g b
```



In this case, the procedure is executed as soon as the value of the property is requested during the formatting process.

Most of the typesetting engine is driven by such callbacks. Properties that typically use callbacks include

`stencil` The printing routine, that constructs a drawing for the symbol

`X-offset` The routine that sets the horizontal position

`X-extent` The routine that computes the width of an object

The procedure always takes a single argument, being the grob.

If routines with multiple arguments must be called, the current grob can be inserted with a grob closure. Here is a setting from `AccidentalSuggestion`,

```
`(X-offset .
  ,(ly:make-simple-closure
    `(,+
        ,(ly:make-simple-closure
           (list ly:self-alignment-interface::centered-on-x-parent))
      ,(ly:make-simple-closure
           (list ly:self-alignment-interface::x-aligned-on-self)))))
```

In this example, both `ly:self-alignment-interface::x-aligned-on-self` and `ly:self-alignment-interface::centered-on-x-parent` are called with the grob as argument. The results are added with the `+` function. To ensure that this addition is properly executed, the whole thing is enclosed in `ly:make-simple-closure`.

In fact, using a single procedure as property value is equivalent to

```
(ly:make-simple-closure (ly:make-simple-closure (list proc)))
```

The inner `ly:make-simple-closure` supplies the grob as argument to *proc*, the outer ensures that result of the function is returned, rather than the `simple-closure` object.

From within a callback, the easiest method for evaluating a markup is to use grob-interpret-markup. For example:

```
my-callback = #(lambda (grob)
                 (grob-interpret-markup grob (markup "foo")))
```

2.5 Inline Scheme code

The main disadvantage of `\tweak` is its syntactical inflexibility. For example, the following produces a syntax error.

```
F = \tweak #'font-size #-3 -\flageolet

\relative c'' {
  c4^\F c4_\F
```

```
}
```

In other words, \tweak doesn't behave like an articulation regarding the syntax; in particular, it can't be attached with ^ and _.

Using Scheme, this problem can be avoided. The route to the result is given in Section 1.3.4 [Adding articulation to notes (example)], page 13, especially how to use \displayMusic as a helping guide.

```
F = #(let ((m (make-music 'ArticulationEvent
                          'articulation-type "flageolet")))
       (set! (ly:music-property m 'tweaks)
             (acons 'font-size -3
                    (ly:music-property m 'tweaks)))
       m)

\relative c'' {
  c4^\F c4_\F
}
```

Here, the tweaks properties of the flageolet object m (created with make-music) are extracted with ly:music-property, a new key-value pair to change the font size is prepended to the property list with the acons Scheme function, and the result is finally written back with set!. The last element of the let block is the return value, m itself.

2.6 Difficult tweaks

There are a few classes of difficult adjustments.

- One type of difficult adjustment involves the appearance of spanner objects, such as slurs and ties. Usually, only one spanner object is created at a time, and it can be adjusted with the normal mechanism. However, occasionally a spanner crosses a line break. When this happens, the object is cloned. A separate object is created for every system in which the spanner appears. The new objects are clones of the original object and inherit all properties, including \overrides.

  In other words, an \override always affects all pieces of a broken spanner. To change only one part of a spanner at a line break, it is necessary to hook into the formatting process. The after-line-breaking callback contains the Scheme procedure that is called after the line breaks have been determined and layout objects have been split over different systems.

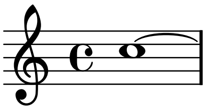
  In the following example, we define a procedure my-callback. This procedure

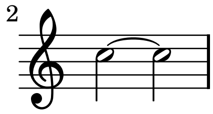
  - determines if the spanner has been split across line breaks
  - if yes, retrieves all the split objects
  - checks if this grob is the last of the split objects
  - if yes, it sets extra-offset.

  This procedure is installed into Section "Tie" in *Internals Reference*, so the last part of the broken tie is repositioned.

  ```
  #(define (my-callback grob)
     (let* (
            ;; have we been split?
            (orig (ly:grob-original grob))

            ;; if yes, get the split pieces (our siblings)
            (siblings (if (ly:grob? orig)
                          (ly:spanner-broken-into orig)
  ```

```
                        '()))))

     (if (and (>= (length siblings) 2)
              (eq? (car (last-pair siblings)) grob))
         (ly:grob-set-property! grob 'extra-offset '(-2 . 5)))))

\relative c'' {
  \override Tie #'after-line-breaking =
  #my-callback
  c1 ~ \break
  c2 ~ c
}
```





When applying this trick, the new `after-line-breaking` callback should also call the old one, if such a default exists. For example, if using this with `Hairpin`, `ly:spanner::kill-zero-spanned-time` should also be called.

- Some objects cannot be changed with `\override` for technical reasons. Examples of those are `NonMusicalPaperColumn` and `PaperColumn`. They can be changed with the `\overrideProperty` function, which works similar to `\once \override`, but uses a different syntax.

```
\overrideProperty
#"Score.NonMusicalPaperColumn"  % Grob name
#'line-break-system-details     % Property name
#'((next-padding . 20))         % Value
```

Note, however, that `\override`, applied to `NonMusicalPaperColumn` and `PaperColumn`, still works as expected within `\context` blocks.

3 LilyPond Scheme interfaces

This chapter covers the various tools provided by LilyPond to help Scheme programmers get information into and out of the music streams.

TODO – figure out what goes in here and how to organize it

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Version 1.3, 3 November 2008

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