

# Gura Library Reference

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June 30th, 2015

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# Chapter 1

## About This Reference

This reference explains about functions and classes that are shipped with Gura interpreter. Refer to Gura Language Manual if you want information about syntax and specifications of Gura language itself.

## Chapter 2

# Explanatory Note

Functions in this reference are described in a generic expression. For example, if there is a reference described like `func(num:number)` , it means that `func` function takes one argument named `num` with value type of `number` . You can call it like `func(3)` .

If an argument is optional, the argument name is followed by a symbol `?` . For example: `func(num?:number)` . You can call it as `func(2)` or can omit the argument like `func()` .

If the the argument name has `*` symbol followed, the argument takes zero or more values. For a function that has a generic expression `func(args*:number)` , it can be called like `func()` , `func(3)` , `func(3, 4)` , `func(3, 4, 2)` , and so on.

If the the argument name has `+` symbol followed, the argument takes one or more values. For a function that has a generic expression `func(args+:number)` , it can be called like `func(3)` , `func(3, 4)` , `func(3, 4, 2)` , and so on. In difference with `*` , it must take at least one value.

An argument may have a default value. The default value is described with `=>` operator like `func(num:number => 4)` . In such a case, if `num` is omitted, the default value `4` shall be used.

## Chapter 3

# Predefined Variables

Variable	Type	Explanation
<code>*</code>	iterator	An iterator instance equivalent with " <code>0..</code> ".
<code>-</code>	nil	Value of <code>nil</code> .
<code>@rem</code>	nil	Value of <code>nil</code> .
<code>__name__</code>	string	If the current script is a main one that the interpreter launches, this variable is set to ' <code>__main__</code> '. If it is imported by another as a module, this variable is set to that module name.
<code>false</code>	boolean	Value of false.
<code>nil</code>	nil	Value of <code>nil</code> .
<code>root</code>	environment	Top level scope.
<code>true</code>	boolean	Value of true.

## Chapter 4

# Built-in Function

### 4.1 Formatting and Printing of Text

#### format

`format(format:string, values*):map`

Converts `values` into string depending on formatter specifications in `format` and returns the result in string. For a detail information about formatter specications, refer to the document of `printf()` function.

#### print

`print(values*):map:void`

Prints out `values` to standard output.

#### printf

`printf(format:string, values*):map:void`

Prints out `values` to standard output according to formatter specifiers in `format` . The format specifier has a format of `%[flags][width][.precision]specifier` . The `specifier` takes one of the following characters:

- `d` , `i` .. decimal integer number with a sign mark
- `u` .. decimal integer number without a sign mark
- `b` .. binary integer number without a sign mark
- `o` .. octal integer number without a sign mark
- `x` .. hexadecimal integer number in lower character without a sign mark
- `X` .. hexadecimal integer number in upper character without a sign mark
- `e` .. floating number in exponential form
- `E` .. floating number in exponential form (in upper character)
- `f` .. floating number in decimal form
- `F` .. floating number in decimal form (in upper character)
- `g` .. better form between `e` and `f`
- `G` .. better form between `E` and `F`
- `s` .. string

- **c** .. character

The **flags** takes one of the following characters.

- **+** .. Appends a character **"+"** before a positive number.
- **-** .. Adjust a string to left.
- **[SPC]** .. Appends a space character before a positive number.
- **#** .. Appends a prefix before a numbers **"0b "** for a binary, **"0 "** for an octal and **"0x "** for a hexadecimal number.
- **0** .. Fills lacking columns with **"0 "** instead of space characters.

The **width** is a decimal number that specifies a minimum character. If the width of the corresponding field is less than this number, the lacking part will be filled with space characters or **"0 "**. If the width is equal to or more than this number, there's nothing to be processed. If an asterisk character **"\* "** is specified for **width** , the minimum character width will be retrieved from the argument list.

The **width** it a character width that appears on a console, and it takes into account each character width based on the specification of East Asian Width. This means that a kanji-character occupies two characters in width.

The **precision** is a decimal number and has different effects depending on **specifier** . For specifiers that formats integer numbers, it specifies a minimum character width and fills 0 for the lacking column. Format specifiers **"%03d "** and **"%.3d "** have the same effect. When it works in combination with **width** , **precision** fills 0 in the lacking space before **width** does padding. An example is shown below:

```
printf('%5.3d', 23) .. prints " 023"
```

For specifiers **e** , **f** and **g** , it specifies a digit number after a decimal point. Examples are shown below:

```
printf('%.3f', 1 / 3) .. prints "0.333"
printf('%.5f', 1 / 3) .. prints "0.33333"
```

For other specifiers, it has no effect.

println

`println(values*):map:void`

Prints out **values** and an end-of-line character to the standard output.

## 4.2 Repetition

cross

`cross ('expr+) {block}`

Executes the block until it evaluates all the combinations of results from **exprs** **"var in iterable ."** You can specify one or more such **exprs** as arguments and they are counted up from the one on the right side. Iterators and lists are the most popular iteratables, but even any objects that are cable of generating iterators can be specified as such.

It returns the last evaluated value in the block as its own result, but, if one of **:list** , **:xlist** , **:set** , **:xset** or **:iter** is specified, it returns a list or evaluated value or an iterator. The rule is as follows:

- **:list** .. returns a list of result values



- `:xlist` .. returns a list of result values eliminating `nil`
- `:set` .. returns a list of unique values of results
- `:xset` .. returns a list of unique values of results eliminating `nil`
- `:iter` .. returns an iterator that executes the block
- `:xiter` .. returns an iterator that executes the block, skipping `nil`

Block parameter format is `|idx:number, i0:number, i1:number, ...|` where `idx` indicates an index of the whole loop and each of `i0` , `i1` .. indicates an index of each corresponding iterable.

#### for

`for ('expr+) {block}`

Executes the block until any of the exprs of "`var in iterable` " reach at their ends. You can specify one or more such exprs as arguments. Iterators and lists are the most popular iterables, but even any objects that are cable of generating iterators can be specified as such. It returns the last evaluated value in the block as its own result, but, if one of `:list` , `:xlist` , `:set` , `:xset` or `:iter` is specified, it returns a list or evaluated value or an iterator. The rule is as follows:

- `:list` .. returns a list of result values
- `:xlist` .. returns a list of result values eliminating `nil`
- `:set` .. returns a list of unique values of results
- `:xset` .. returns a list of unique values of results eliminating `nil`
- `:iter` .. returns an iterator that executes the block
- `:xiter` .. returns an iterator that executes the block, skipping `nil`

Block parameter format is `|idx:number|` where `idx` indicates an index of the loop.

#### repeat

`repeat (n?:number) {block}`

Executes the block for `n` times. If `n` is omitted, it repeats the block execution forever. It returns the last evaluated value in the block as its own result, but, if one of `:list` , `:xlist` , `:set` , `:xset` or `:iter` is specified, it returns a list or evaluated value or an iterator. The rule is as follows:

- `:list` .. returns a list of result values
- `:xlist` .. returns a list of result values eliminating `nil`
- `:set` .. returns a list of unique values of results
- `:xset` .. returns a list of unique values of results eliminating `nil`
- `:iter` .. returns an iterator that executes the block
- `:xiter` .. returns an iterator that executes the block, skipping `nil`

Block parameter format is `|idx:number|` where `idx` indicates an index of the loop.

#### while

`while ('cond) {block}`

Executes the block while the evaluation result of `cond` is true. It returns the last evaluated value in the block as its own result, but, if one of `:list` , `:xlist` , `:set` , `:xset` or `:iter` is specified, it returns a list or evaluated value or an iterator. The rule is as follows:

- `:list` .. returns a list of result values
- `:xlist` .. returns a list of result values eliminating `nil`
- `:set` .. returns a list of unique values of results
- `:xset` .. returns a list of unique values of results eliminating `nil`
- `:iter` .. returns an iterator that executes the block
- `:xiter` .. returns an iterator that executes the block, skipping `nil`

Block parameter format is `|idx:number|` where `idx` indicates an index of the loop.

#### break

`break(value?):symbol_func:void`

Exits from an inside of a loop that is formed with repeating functions like `repeat()` , `while()` , `for()` and `cross()` , as well as other functions generating an iterator.

After this function is called, the current loop value would be set to `value` given in the function's argument. If the argument is omitted, that would be set to `nil` .

However, when the loop function is called with one of the attributes, `:list` , `:xlist` , `:set` , `:xset` , `:iter` and `:xiter` , the argument value of `break()` is NOT included as an element in the list or iterator.

#### continue

`continue(value?):symbol_func:void`

Cancels the current turn of a loop and continues on to the next. This function can be used in a loop that is formed with repeating functions like `repeat()` , `while()` , `for()` and `cross()` , as well as other functions generating an iterator.

After this function is called, the current loop value would be set to `value` given in the function's argument. If the argument is omitted, that would be set to `nil` .

If the loop function is specified with one of the attributes `:list` , `:xlist` , `:set` , `:xset` , `:iter` and `:xiter` , the argument value of `continue()` is included as an element in the list or iterator.

## 4.3 Value Generator

#### consts

`consts(value, num?:number) {block?}`

Creates an iterator that generates the same value specified by the argument `value` .

The argument `num` specifies the number of elements to be generated. If omitted, it would generate the value infinitely.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below is an example to create an iterator that returns constant values:

```
x = consts('hello', 10)
// x generates 'hello' for 10 times
```

### dim

```
dim(n+:number) {block?}
```

Returns a list that contains `n` values of `nil`. If you pass multiple numbers for `n`, it would create a nested list.

Below is an example to create a one-dimensional list:

```
x = dim(3)
// x is [nil, nil, nil]
```

Below is an example to create a two-dimensional list:

```
x = dim(3, 2)
// x is [[nil, nil], [nil, nil], [nil, nil]]
```

The optional `block` should return values for each element and takes block parameters: `|i0:number, i1:number, ...|` where the arguments `i0` and `i1` take indices of the loops.

Below is an example to create a one-dimensional list containing a string:

```
x = dim(3) {'Hi'}
// x is ['Hi', 'Hi', 'Hi']
```

Below is an example to create a two-dimensional list that consists of strings showing indices.

```
x = dim(3, 2) {|i, j| format('%d-%d', i, j)}
// x is [['0-0', '0-1'], ['1-0', '1-1'], ['2-0', '2-1']]
```

### interval

```
interval(begin:number, end:number, samples:number):map:[open,open_l,open_r] {block?}
```

Creates an iterator that generates a sequence of numbers by specifying the beginning and ending numbers, and the number of samples between them.

In default, it creates a sequence that contains the beginning and ending numbers. Following attributes would generate the following numbers:

- `:open` .. Numbers in range of `(begin, end)` that doesn't contain either `begin` or `end`.
- `:open_l` .. Numbers in range of `(begin, end]` that doesn't contain `begin`.
- `:open_r` .. Numbers in range of `[begin, end)` that doesn't contain `end`.

### range

```
range(num:number, num_end?:number, step?:number):map {block?}
```

Creates an iterator that generates a sequence of integer numbers.

This function can be called in three formats that generate following numbers:

- `range(num)` .. Numbers between 0 and (`num - 1`) .
- `range(num, num_end)` .. Numbers between `num` and (`num_end - 1`) .
- `range(num, num_end, step)` .. Numbers between `num` and (`num_end - 1`) incremented by `step` .

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below are examples:

```
x = range(10)
// x generates 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

x = range(3, 10)
// x generates 3, 4, 5, 6, 7, 8, 9

x = range(3, 10, 2)
// x generates 3, 5, 7, 9
```

## 4.4 Branch and Flow Control

### if

```
if ('cond'):leader {block}
```

Specify an "if" block within a statement of `if-elsif-else` .

If the evaluation result of `cond` is determined as true, the block would be executed, and its evaluation result would become the returned value of the function.

Otherwise, if the function is followed by a trailer `elsif` or `else` , that would be evaluated. If no trailer exists, the function returns `nil` value.

### elsif

```
elsif ('cond'):leader:trailer {block}
```

Specify an "elsif" block within a statement of `if-elsif-else` .

If the evaluation result of `cond` is determined as true, the block would be executed, and its evaluation result would become the returned value of the function.

Otherwise, if the function is followed by a trailer `elsif` or `else` , that would be evaluated. If no trailer exists, the function returns `nil` value.

### else

```
else():trailer {block}
```

Specify an "else" block within a statement of `if-elsif-else` or `try-catch-else-finally` .

end

`end(dummy*):end_marker:symbol_func:trailer:void`

Specify an end of a sequence.

This function is supposed to be used as a block terminator in an embedded script of a template.

switch

`switch() {block}`

Form a switch block that contains `case()` and `default()` function calls. It calls these functions sequentially and exits the execution when one of the conditions is evaluated as true.

case

`case('cond) {block}`

Specify an case block within a switch block. After evaluating an expr object `cond`, the block shall be executed if it has a value of true.

default

`default() {block}`

Specify a default block within a switch block. If all the preceding condition of case block are not evaluated as true, this block shall be executed.

return

`return(value?):symbol_func:void`

Skips the remaining procedure of the current function and returns to the context that calls it. If it takes an argument, the value is treated as a result of the function. Otherwise, the returned value would be `nil` .

## 4.5 Exception Handling

try

`try():leader {block}`

Specify a try block of a statement of `try-catch-else-finally`. It catches signals that occur in the block and executes a corresponding `catch()` or `else()` function that follow after it.

catch

`catch(errors*:error):leader:trailer {block}`

Specify an catch block of a statement of `try-catch-else-finally`. It can take multiple numbers of arguments of error objects to handle. If there's no error objects specified, it handles all the errors that are not handled in the preceding `catch()` function calls. Block parameter format: `|error:error|error` is an error object that contains information of the handled error.

finally

`finally():finalizer:trailer {block}`

raise

`raise(error:error, msg:string => 'error', value?)`

Raises an error signal with a specified error object, a message string and an additional value.

## 4.6 Data Converter

### chr

`chr(code:number):map`

Converts a UTF-32 code into a string.

### hex

`hex(num:number, digits?:number):map:[upper]`

Converts a number into a hexadecimal string. Argument `digits` specifies a minimum columns of the converted result and fills 0 in the lacking space.

In default, it uses lower-case characters in its conversion, while it uses upper-case ones when `:upper` attribute is specified.

### int

`int(value):map`

Converts a value into an integer number like below:

- For a number value, it would be converted into an integer number.
- For a complex value, its absolute number would be converted into an integer number.
- For a string value, it would be parsed as an integer number. An error occurs if it has an invalid format.
- For other values, an error occurs.

### ord

`ord(str:string):map`

Converts the first character of a string into a number of UTF-32 code. If the string contains more than one characters, it simply neglects trailing ones.

### tonumber

`tonumber(value):map:[nil,raise,strict,zero]`

Converts a string value into a number by a lexical parsing. If the value is not a string, it first tries to convert the value into a string.

If the string starts with a sequence of characters that can be parsed as a number literal, it's not a failure even when it contains other characters following them. Specifying an attribute `:strict` doesn't allow such a case and fails the process.

If it fails the conversion, it would return `nil` value. Attributes described below are prepared to customize the behaviour in the case of a failure.

- `:raise` .. raises an error
- `:zero` .. returns zero value
- `:nil` .. returns `nil` value (default)

### tostring

`tostring(value):map`

Converts a value into a string.

tosymbol

`tosymbol(str:string):map`

Converts a string into a symbol.

## 4.7 Class Operations

class

`class(superclass?:class) {block?}`

Creates a class that includes methods and properties described in the content of the `block`. The detail information on how to describe the block content for this function is written in "Gura Language Manual".

Below is an example to create a class named `Person` :

```
Person = class {
  __init__(name:string, age:number) = {
    this.name = name
    this.age = age
  }
  Print() = {
    printf('name:%s age:%d\n', this.name, this.age)
  }
}

person = Person('Smith', 26)
person.Print()
```

If the argument `superclass`, which is expected to be a constructor function of a super class, is specified, the created class would inherit methods and properties from the specified class.

classref

`classref(type+:expr):map {block?}`

Looks up a class by an expression of a type name.

struct

`struct('args+):nonamed:[loose] {block?}`

Returns a function object of a constructor for a structure that contains properties specified by `args`. It can optionally take `block` which declares methods and properties just like `class` function.

An element in `args` is an expression that has the same format with one in the argument list of a function's declaration. Each variable name becomes a member name in the created instance. Below is an example to create a struct named `Person` :

```
Person = struct(name:string, age:number)
person = Person('Smith', 26)
printf('name:%s age:%d\n', person.name, person.age)
```

If `:loose` attribute is specified, the generated constructor would take all the arguments as optional. Omitted variables are set to `nil`

super

`super(obj):map {block?}`

Returns a reference to `obj` that searches methods in a scope of the super class of its own. Example:

```

A = class {
  func() = {}
}

B = class(A) {
  func() = {}
}

b = B()
b.func()      // B#func() is called.
super(b).func() // A#func() is called.

```

## 4.8 Scope Operations

### local

```
local('syms+)
```

Declares symbols that is supposed to access variables in a local scope.

### locals

```
locals(module?:module) {block?}
```

Returns an environment object that belongs to a specified module. If module is omitted, it returns an environment object of the current scope.

### outers

```
outers() {block?}
```

Returns an environment object that accesses to an outer scope.

### public

```
public():void {block}
```

Declares symbols as public ones that are accessible from outer scopes.  
If you want to make `foo` and `bar` accessible, call this function like below:

```
public { foo, bar }
```

### scope

```
scope(target?) {block}
```

Evaluates block with a local scope.

## 4.9 Module Operations

### import

```
import('module, 'alias?):[binary,mixin.type,overwrite] {block?}
```

Imports a module and creates a variable that represents the imported module. It also returns a value that is a reference to the module.

It searches module files in directories specified by a variable `sys.path`.  
There are three format to call this function like follow:



- `import(foo)` .. imports `foo` module and creates a module object named `foo`
- `import(foo, bar)` .. imports `foo` module and creates a module object named `bar`
- `import(foo) {symbol1, symbol2, symbol3}` .. imports `foo` and mixes up the module's properties `symbol1` , `symbol2` and `symbol3` in the current scope.

In the third format, you can specify an asterisk character to mixes up all the symbols defined in the module like below:

```
import(foo) {*}
```

If a specified symbol conflicts with what already exists in the current scope, it will cause an error. Specifying the attribute `:overwrite` will avoid such an error and allow overwriting of symbols.

If the argument `module` is prefixed by a minus operator like `-foo` , it will not create a variable that represents the imported module.

If the argument `module` is prefixed by an and operator like `&foo` , the trailing expression will be evaluated and its result, which must be a string, is treated as a module name to be imported. Below is a sample to import `foo` module through a variable that contains that name:

```
var = 'foo'
import(&var)
```

#### module

```
module() {block}
```

Creates a module that contains functions and variables defined in the block and returns it as a module object. This can be used to realize a namespace.

## 4.10 Value Type Information

#### isbinary

```
isbinary(value)
```

Returns `true` if the type of the specified `value` is binary, and `false` otherwise.

#### isboolean

```
isboolean(value)
```

Returns `true` if the type of the specified `value` is boolean, and `false` otherwise.

#### isclass

```
isclass(value)
```

Returns `true` if the type of the specified `value` is class, and `false` otherwise.

#### iscomplex

```
iscomplex(value)
```

Returns `true` if the type of the specified `value` is complex, and `false` otherwise.

#### isdatetime

```
isdatetime(value)
```

Returns `true` if the type of the specified `value` is datetime, and `false` otherwise.

#### isdict

`isdict(value)`

Returns **true** if the type of the specified **value** is dict, and **false** otherwise.

#### isenvironment

`isenvironment(value)`

Returns **true** if the type of the specified **value** is environment, and **false** otherwise.

#### iserror

`iserror(value)`

Returns **true** if the type of the specified **value** is error, and **false** otherwise.

#### isexpr

`isexpr(value)`

Returns **true** if the type of the specified **value** is expr, and **false** otherwise.

#### isfunction

`isfunction(value)`

Returns **true** if the type of the specified **value** is function, and **false** otherwise.

#### isiterator

`isiterator(value)`

Returns **true** if the type of the specified **value** is iterator, and **false** otherwise.

#### islist

`islist(value)`

Returns **true** if the type of the specified **value** is list, and **false** otherwise.

#### ismatrix

`ismatrix(value)`

Returns **true** if the type of the specified **value** is matrix, and **false** otherwise.

#### ismodule

`ismodule(value)`

Returns **true** if the type of the specified **value** is module, and **false** otherwise.

#### isnil

`isnil(value)`

Returns **true** if the type of the specified **value** is nil, and **false** otherwise.

#### isnumber

`isnumber(value)`

Returns **true** if the type of the specified **value** is number, and **false** otherwise.

#### isrational

`isrational(value)`

Returns `true` if the type of the specified `value` is rational, and `false` otherwise.

issemaphore

`issemaphore(value)`

Returns `true` if the type of the specified `value` is semaphore, and `false` otherwise.

isstring

`isstring(value)`

Returns `true` if the type of the specified `value` is string, and `false` otherwise.

issymbol

`issymbol(value)`

Returns `true` if the type of the specified `value` is symbol, and `false` otherwise.

istimedelta

`istimedelta(value)`

Returns `true` if the type of the specified `value` is timedelta, and `false` otherwise.

isuri

`isuri(value)`

Returns `true` if the type of the specified `value` is uri, and `false` otherwise.

isdefined

`isdefined('identifier')`

Returns `true` if `identifier` is defined, and `false` otherwise.

isinstance

`isinstance(value, type+:expr):map`

Returns `true` if `value` is an instance of `type` or its descendant, and `false` otherwise.

istype

`istype(value, type+:expr):map`

Returns `true` if `value` is of the type of `type`, and `false` otherwise.

typename

`typename('value')`

Returns a type name of the value.

undef

`undef('identifier'): [raise]`

Undefines `identifier` in the current scope.

## 4.11 Data Processing

choose

`choose(index:number, values+):map`

Picks up a value placed at `index` in the argument list `values` .  
Sample:

```
choose(0, 'apple', 'orange', 'banana') // returns 'apple'
choose(2, 'apple', 'orange', 'banana') // returns 'banana'
```

### cond

`cond(flag:boolean, value1:nomap, value2?:nomap):map`

Returns `value1` if `flag` is determined as true, and `value2` otherwise. If the argument `value2` is omitted, it will return `nil` when `flag` is determined as false.

This function behaves in a similar way with `if` function when it's called like below:

```
if (flag) { value1 } else { value2 }
```

Notice that they have the following differences:

- Function `cond()` always evaluates arguments `value1` and `value2` no matter what `flag` value is, while function `if()` doesn't evaluate `value1` expression when `flag` is determined as false .
- Function `cond()` works with implicit mapping, which means that the argument `flag` may be a list or an iterator that are to be processed with the implicit mapping.

The arguments `value1` and `value2` are not processed by the implicit mapping, so you can specify a list or an iterator for them as selected items.

### conds

`conds(flag:boolean, value1, value2?):map`

Returns `value1` if `flag` is determined as true, and `value2` otherwise. If argument `value2` is omitted, it will return `nil` when `flag` is determined as false.

This function behaves in a similar way with `if` function when it's called like below:

```
if (flag) { value1 } else { value2 }
```

Notice that they have the following differences:

- Function `conds()` always evaluates arguments `value1` and `value2` no matter what `flag` value is, while function `if()` doesn't evaluate `value1` expression when `flag` is determined as false.
- Function `conds()` works with implicit mapping, which means that the arguments `flag`, `value1` and `value2` may be lists or iterators that are to be processed with the implicit mapping.

If you want to specify a list or an iterator for `value1` and `value2` as selected values, use `cond()` function instead.

### max

`max(values+):map`

Returns the maximum value among the given arguments.

### min

`min(values+):map`

Returns the minimum value among the given arguments.

## 4.12 Random

Random numbers are generated using SIMD-oriented Fast Mersenne Twister (SFMT) library.

### rand

`rand(range?:number) {block?}`

Returns a random number between 0 and `(range - 1)` . If argument `range` is not specified, it generates random numbers in a range of `[0, 1)`.

### rands

`rands(range?:number, num?:number) {block?}`

Creates an iterator that returns random numbers between 0 and `(range - 1)` .

If argument `range` is not specified, it generates random numbers in a range of `[0, 1)`.

In default, the created iterator infinitely generates random numbers. The argument `num` specifies how many elements should be generated.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below is an example to create a create that generates random numbers:

```
x = rands(100)
// x is an infinite iterator to generates random numbers between 0 and 99
```

### randseed

`randseed(seed:number):void`

Initializes random seed with a specified number.

## 4.13 Property Listing

### dir

`dir(obj?):[noesc]`

Returns a symbol list of variables and functions that are assigned in the environment of `obj` . In default, when the `obj` is an instance of a class, it also searches symbols assigned in the class that it belongs to and its parent classes. Specifying attribute `:noesc` avoids that behavior.

### dirtytype

`dirtytype(obj?):[noesc]`

Returns a symbol list of value types that are assigned in the environment of `obj` .  
In default, when the `obj` is an instance of a class, it also searches symbols assigned in the class that it belongs to and its parent classes. Specifying attribute `:noesc` inhibits avoids behavior.



# Chapter 5

## Built-in Operator

Operation	Explanation
+number	
+complex	
+rational	
+matrix	
+timedelta	
+array@char	
+array@uchar	
+array@short	
+array@ushort	
+array@long	
+array@ulong	
+array@int	
+array@uint	
+array@float	
+array@double	
-number	
-complex	
-rational	
-matrix	
-timedelta	
-array@char	
-array@uchar	
-array@short	
-array@ushort	
-prarray@long	
-array@ulong	
-array@int	
-array@uint	
-array@float	
-array@double	
number	
!any	
number..	
any?	
any*	
number + number	
number + complex	
number + rational	
complex + number	
complex + complex	
rational + number	
rational + rational	
matrix + matrix	
datetime + timedelta	
timedelta + datetime	
string + string	
list + list	



## Chapter 6

# Built-in Class

### 6.1 argument Class

The `argument` class provides measures to access argument information that is passed to a function. One of its purposes is to check if an attribute is specified in the function call. It also provides a method to control a leader-trailer sequence, a mechanism that flow controls such as `if-elsif-else` and `try-catch` utilize.

There's no constructor to realize an instance of `argument` class. Its instance is implicitly created when a function is called, and you can refer to it by a variable named `__arg__`.

Below is an example to use `argument` class:

```
func(v0, v1, v2):[attr1,attr2] = {
    printf('arg#%d %s\n', 0.., __arg__.values)
    printf('attr1:%s attr2:%s\n', __arg__.isset('attr1'), __arg__.isset('attr2'))
}
```

#### 6.1.1 Property

An `argument` instance has the following properties:

Property	Type	R/W	Explanation
<code>argument#function</code>	function	R	The <code>function</code> instance that has created the argument.
<code>argument#values</code>	list	R	A list of argument values.

#### 6.1.2 Method

`argument#finalize_trailer`

`argument#finalize_trailer():void`

Signals finalizing status to trailers after the current function.

`argument#isset`

`argument#isset(symbol:symbol)`

Returns `true` if the function is called with an attribute that matches the specified symbol.

`argument#quit_trailer`

`argument#quit_trailer():void`

Cancels evaluation of following trailers.  
Example:

```
f(flag:boolean) = {  
    !flag && __arg__.quit_trailer()  
}  
  
f(true) println('printed')  
f(false) println('not printed')
```

## 6.2 array Class

An instance of the `array` class stores multiple numeric values in a seamless binary sequence, which can be passed without any conversion to functions in C libraries that expect arrays of `char`, `short`, `int` and so on.

There are several `array` classes depending on the element type they handle. They're listed in the table below:

Class Name	Element Type
<code>array@char</code>	<code>char</code>
<code>array@uchar</code>	<code>unsigned char</code>
<code>array@short</code>	<code>short</code>
<code>array@ushort</code>	<code>unsigned short</code>
<code>array@long</code>	<code>long</code>
<code>array@ulong</code>	<code>unsigned long</code>
<code>array@int</code>	<code>int</code>
<code>array@uint</code>	<code>unsigned int</code>
<code>array@float</code>	<code>float</code>
<code>array@double</code>	<code>double</code>

### 6.2.1 Constructor

`array@T`

`array@T(arg, init?:number) {block?}`

### 6.2.2 Method

`array@T#dump`

`array@T#dump(stream?:stream):void: [upper]`

Prints out a binary dump of the array's content.

`array@T#each`

`array@T#each() {block?}`

Creates an iterator that iterates each element in the array.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.

- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned. The block parameter is `|elem:number, idx:number|` where `elem` is the element value.

#### array@T#fill

```
array@T#fill(value:number):map:void
```

Fills array with a specified value.

#### array@T#head

```
array@T#head(n:number):map {block?}
```

Creates an array that has extracted specified number of elements from the beginning of the source.

If `block` is specified, it would be evaluated with a block parameter `|array:array@T|`, where `array` is the created instance. In this case, the block's result would become the function's returned value.

#### array@T#offset

```
array@T#offset(n:number):map {block?}
```

Creates an array that has extracted elements of the source after skipping the first `n` elements. If `block` is specified, it would be evaluated with a block parameter `|array:array@T|`, where `array` is the created instance. In this case, the block's result would become the function's returned value.

#### array@T#paste

```
array@T#paste(offset:number, src:array@T):map
```

Pastes elements of `src` into the target `array` instance.

The argument `offset` specifies the position where elements are pasted in

#### array@T#tail

```
array@T#tail(n:number):map {block?}
```

Creates an array that has extracted specified number of elements from the bottom of the source. If `block` is specified, it would be evaluated with a block parameter `|array:array@T|`, where `array` is the created instance. In this case, the block's result would become the function's returned value.

## 6.3 audio Class

The `audio` class provides measures to work on audio data.

### 6.3.1 Method

#### audio#each

```
audio#each(channel:number, offset?:number):map {block?}
```

audio#get

audio#get(channel:number, offset:number):map

audio#put

audio#put(channel:number, offset:number, data:number):map:reduce

audio#sinewave

audio#sinewave(channel:number, freq:number, len:number, amplitude?:number):map:reduce

audio#store

audio#store(channel:number, offset:number, data:iterator):reduce

## 6.4 binary Class

The `binary` class provides measures to work on binary data that is a byte sequence without any format.

You can create a `binary` instance by calling `binary()` function.

You can also create the instance by specifying `b` prefix before a string literal. For example, the code below creates a `binary` instance that contains a sequence `0x41`, `0x42`, `0xfe`, `0x03`, `0x43`, `0x44` .

```
b'AB\xfe\x03CD'
```

### 6.4.1 Property

A `binary` instance has the following properties:

Property	Type	R/W	Explanation
<code>binary#writable</code>	boolean	R	Indicates if the content of the binary object is writable.

### 6.4.2 Constructor

binary

binary(buff\*) {block?}

### 6.4.3 Method

binary#add

binary#add(buff+:binary):map:reduce

binary.alloc

binary.alloc(bytes:number, data?:number):static:map {block?}

binary.decode

binary.decode(codec:codec)

### binary#dump

`binary#dump(stream?:stream:w):void:[upper]`

### binary#each

`binary#each() {block?}`

Returns an iterator picking up each byte in the buffer

### binary#encodeuri

`binary#encodeuri()`

Returns a string in which non-URIC characters are percent-encoded.

### binary#hex

`binary#hex():[carray,cstr,upper]`

### binary#len

`binary#len()`

Returns the length of the buffer in binary.

### binary.pack

`binary.pack(format:string, value*):static:map {block?}`

Creates a `binary` instance that has packed `values` in the argument list according to specifiers in the `format` .

A specifier has a format of "`nX` " where `X` is a format character that represents a packing format and `n` is a number of packing size. The number can be omitted, and it would be treated as 1 in that case.

Following format characters would take a `number` value from the argument list and pack them into a binary sequence.

- `b` .. A one-byte signed number.
- `B` .. A one-byte unsigned number.
- `h` .. A two-byte signed number.
- `H` .. A two-byte unsigned number.
- `i` .. A four-byte signed number.
- `I` .. A four-byte unsigned number.
- `l` .. A four-byte signed number.
- `L` .. A four-byte unsigned number.
- `q` .. A eight-byte signed number.
- `Q` .. A eight-byte unsigned number.
- `f` .. A float-typed number occupying four bytes.
- `d` .. A double-typed number occupying eight bytes.

As for them, the packing size `n` means the number of values to be packed. Below is an example to pack four `number` values as two-byte unsigned numbers into a binary:

Following format characters would take a `string` value from the argument list and pack them into a binary sequence.

- **s** .. Packs a sequence of UTF-8 codes in the string. The packing size **n** means the size of the room in bytes where the character codes are to be packed. Only the sequence within the allocated room would be packed. If the string length is smaller than the room, the lacking part would be filled with zero.
- **c** .. Picks the first byte of the string and packs it as a one-byte unsigned number. The packing size **n** means the number of values to be packed.

Following format character would take no value from the argument list.

- **x** .. Fills the binary with zero. The packing size **n** means the size of the room in bytes to be filled with zero.

The default byte-order for numbers of two-byte, four-byte and eight-byte depends on the system the interpreter is currently running. You can change it by the following specifiers:

- **@** .. System-dependent order.
- **=** .. System-dependent order.
- **<** .. Little endian
- **>** .. Big endian
- **!** .. Big endian

You can specify an asterisk character "\*" for the number of packing size that picks that number from the argument list.

You can specify encoding name embraced with "{" and "}" in the format to change coding character set while packing a string with format character "s" from UTF-8.

#### binary#pointer

`binary#pointer(offset?:number) {block?}`

Returns a `pointer` instance that has an initial offset specified by the argument `offset` . If the argument is omitted, it would return a `pointer` instance that points to the top of the binary.

#### binary#reader

`binary#reader() {block?}`

#### binary#store

`binary#store(offset:number, buff+:binary):map:reduce`

#### binary#unpack

`binary#unpack(format:string, values*:number):[nil]`

#### binary#unpacks

`binary#unpacks(format:string, values*:number) {block?}`

#### binary#writer

`binary#writer() {block?}`

## 6.5 boolean Class

The `boolean` class represents a boolean data type that is used in logical operations such as NOT, AND and OR.

There are only two values of pure `boolean` type: `true` and `false`. But other types of values can also be specified in logical operations according to the following general rule:

- Values `false` and `nil` are evaluated as false value.
- Other values are evaluated as true.

Notice that the number 0 is treated as true in logical operations.

## 6.6 codec Class

The `codec` class provides measures to convert character codes.

### 6.6.1 Predefined Variable

Variable	Type	Explanation
<code>codec.bom@utf8</code>	binary	BOM sequence of UTF-8: <code>'\xef\xbb\xbf'</code>
<code>codec.bom@utf16le</code>	binary	BOM sequence of UTF-16 little endian: <code>'\xff\xfe'</code>
<code>codec.bom@utf16be</code>	binary	BOM sequence of UTF-16 big endian: <code>'\xfe\xff'</code>
<code>codec.bom@utf32le</code>	binary	BOM sequence of UTF-32 little endian: <code>'\xff\xfe\x00\x00'</code>
<code>codec.bom@utf32be</code>	binary	BOM sequence of UTF-32 big endian: <code>'\x00\x00\xfe\xff'</code>

### 6.6.2 Constructor

`codec`

`codec(encoding:string) {block?}`

Creates a `codec` instance of the specified encoding name. You can call `codecs.dir()` to get a list of available encoding names.

If `block` is specified, it would be evaluated with a block parameter `|codec:codec|`, where `codec` is the created instance. In this case, the block's result would become the function's returned value.

### 6.6.3 Method

`codec#addcr`

`codec#addcr(flag?:boolean):reduce`

The `codec`'s encoder has a feature to add a CR code (0x0d) before a LF code (0x0a) so that the lines are joined with CR-LF codes in the encoded result. This method enables or disables the feature.

- To enable it, call the method with the argument `flag` set to `true` or without any argument.
- To disable it, call the method with the argument `flag` set to `false`.

#### codec#decode

`codec#decode(buff:binary):map`

Decodes a binary `buff` and returns the decoded result as `string` .

#### codec#delcr

`codec#delcr(flag?:boolean):reduce`

The codec's decoder has a feature to delete a CR code (0x0d) before a LF code (0x0a) so that the lines are joined with LF code in the decoded result. This method enables or disables the feature.

- To enable it, call the method with the argument `flag` set to `true` or without any argument.
- To disable it, call the method with the argument `flag` set to `false` .

#### codec#encode

`codec#encode(str:string):map`

Encodes a string `str` and returns the encoded result as `binary` .

## 6.7 color Class

An instance of the `color` class represents a color data that consists of red, green, blue and alpha elements.

You can create a `color` instance by calling `color()` function.

There are class variables as shown below:

### 6.7.1 Predefined Variable

Variable	Type	Explanation
<code>color.names</code>	<code>string[]</code>	A list of color names that can be passed to <code>color()</code> function.
<code>color.zero</code>	<code>color</code>	color instance created by <code>color(0, 0, 0, 0)</code>

There are also predefined variables that are defined with `color` instances of 16 basic colors: `color.black` , `color.maroon` , `color.green` , `color.olive` , `color.navy` , `color.purple` , `color.teal` , `color.gray` , `color.silver` , `color.red` , `color.lime` , `color.yellow` , `color.blue` , `color.fuchsia` , `color.aqua` and `color.white` .

### 6.7.2 Property

A `color` instance has the following properties:

Property	Type	R/W	Explanation
<code>color#r</code>	<code>number</code>	R/W	Value of the red element.
<code>color#g</code>	<code>number</code>	R/W	Value of the green element.
<code>color#b</code>	<code>number</code>	R/W	Value of the blue element.
<code>color#a</code>	<code>number</code>	R/W	Value of the alpha element.



### 6.7.3 Cast Operation

A function that expects a `color` instance in its argument can also take a value of `symbol` , `string` and `list` as below:

- `symbol` .. Recognized as a color name to look up the color table.
- `string` .. Recognized as a color name to look up the color table.
- `list` .. Expected to contain elements in a format `[red, green, blue]` or `[red, green, blue, alpha]` .

With the above casting feature, you can call a function `f(c:color)` that takes a `color` instance in its argument as below:

- `f(color('purple'))` .. The most explicit way.
- `f('purple')` .. Implicit casting: from `symbol` to `color` .
- `f('purple')` .. Implicit casting: from `string` to `color` .
- `f([128, 0, 128])` .. Implicit casting: from `list` to `color` .

### 6.7.4 Constructor

color

`color(args+):map {block?}`

Creates a `color` instance.

If `block` is specified, it would be evaluated with a block parameter `|c:color|` , where `c` is the created instance. In this case, the block's result would become the function's returned value.

There are two forms to call this function as below:

- `color(name:string, a?:number)` .. Creates an instance from color name and an optional alpha element. Predefined variable `color.names` is a list that contains available color names. A string in a format of `'#rrggbb'` that is used in HTML documents is also acceptable as a color name.
- `color(r:number, g?:number, b?:number, a?:number)` .. Creates an instance from RGB elements and an optional alpha element.

### 6.7.5 Method

color#getgray

`color#getgray()`

Calculates a gray scale from RGB elements in the `color` instance.

This is computed by a formula: `gray = 0.299 * red + 0.587 * blue + 0.114 * blue` .

color#html

`color#html()`

Returns a color string in a format of `'#rrggbb'` that is used in HTML documents.

color#tolist

`color#tolist():[alpha]`

Returns a list of RGB elements in a form `[r, g, b]` .

Specifying `:alpha` attribute would add the alpha element to the list.

## 6.8 complex Class

The `complex` class provides measures to calculate complex numbers. You can create a `complex` instance by following ways:

- Use `complex()` function. eg) `complex(2, 3)`
- Use `complex.polar()` function. eg) `complex.polar(5, math.pi / 6)`
- Append `j` suffix after a number literal. eg) `2 + 3j`

### 6.8.1 Constructor

#### complex

```
complex(real:number, imag?:number):map {block?}
```

Creates a `complex` instance with a real part `real` and an imaginary part `imag`. If the argument `imag` is omitted, the imaginary part would be set to zero. If `block` is specified, it would be evaluated with a block parameter `|n:complex|`, where `n` is the created instance. In this case, the block's result would become the function's returned value.

### 6.8.2 Method

#### complex.polar

```
complex.polar(abs:number, arg:number):static:map:[deg] {block?}
```

Creates a `complex` instance with an absolute number `abs` and an angle `arg` in polar coords. The argument `arg` is specified in a unit of radian. You can give it a degree value by calling the function with `:deg` attribute.

If `block` is specified, it would be evaluated with a block parameter `|n:complex|`, where `n` is the created instance. In this case, the block's result would become the function's returned value.

#### complex.roundoff

```
complex.roundoff(threshold:number => 1e-10) {block?}
```

Returns a complex number with real and imaginary parts being rounded off. The argument `threshold` specifies the threshold value for the round-off. If `block` is specified, it would be evaluated with a block parameter `|n:complex|`, where `n` is the created instance. In this case, the block's result would become the function's returned value.

## 6.9 datetime Class

The `datetime` class provides measures to handle date and time information. You can create a `datetime` instance by calling following functions:

- `datetime()` .. Creates an instance from specified date and time.
- `datetime.now()` .. Creates an instance with its date and time fields set as the current one.
- `datetime.today()` .. Creates an instance with its date field set as the current one. Its time fields, `hour`, `min`, `sec` and `usec`, are set to zero.

You can calculate a `datetime` with a `timedelta` to put its date and time values forward and backward.

### 6.9.1 Predefined Variable

Variable	Type	Explanation
<code>datetime.Sunday</code>	<code>number</code>	Assigned with number 0 that represents Sunday.
<code>datetime.Monday</code>	<code>number</code>	Assigned with number 1 that represents Monday.
<code>datetime.Tuesday</code>	<code>number</code>	Assigned with number 2 that represents Tuesday.
<code>datetime.Wednesday</code>	<code>number</code>	Assigned with number 3 that represents Wednesday.
<code>datetime.Thursday</code>	<code>number</code>	Assigned with number 4 that represents Thursday.
<code>datetime.Friday</code>	<code>number</code>	Assigned with number 5 that represents Friday.
<code>datetime.Saturday</code>	<code>number</code>	Assigned with number 6 that represents Saturday.

### 6.9.2 Property

A `datetime` instance has the following properties:

Property	Type	R/W	Explanation
<code>year</code>	<code>number</code>	R/W	Christian year.
<code>month</code>	<code>number</code>	R/W	Month starting from 1. Numbers from 1 to 12 correspond to January to December.
<code>day</code>	<code>number</code>	R/W	Day in a month starting from 1.
<code>hour</code>	<code>number</code>	R/W	Hour in a day between 0 and 23.
<code>min</code>	<code>number</code>	R/W	Minute in an hour between 0 and 59.
<code>sec</code>	<code>number</code>	R/W	Second in a minute between 0 and 59.
<code>usec</code>	<code>number</code>	R/W	Millisecond in a second between 0 and 999.
<code>wday</code>	<code>number</code>	R	Week number starting from 0. Number from 0 to 6 corresponds to Sunday to Saturday.
<code>week</code>	<code>number</code>	R	Week symbol that takes one of the followings: <code>'sunday</code> , <code>'monday</code> , <code>'tuesday</code> , <code>'wednesday</code> , <code>'thursday</code> , <code>'friday</code> , <code>'saturday</code>
<code>yday</code>	<code>number</code>	R	Day in a year starting from 1.
<code>unixtime</code>	<code>number</code>	R	Seconds passed from 00:00:00 on January 1st in 1970 in UTC.

### 6.9.3 Constructor

`datetime`

```
datetime(year:number, month:number, day:number, hour:number => 0, min:number => 0, sec:number  
=> 0, usec:number => 0, minsoff?:number):map {block?}
```

Creates an instance of `datetime` class based on the specified arguments.

Explanations of the arguments are shown below:

- `year` .. Christian year.
- `month` .. Month starting from 1. Numbers from 1 to 12 correspond to January to December.
- `day` .. Day in a month starting from 1.
- `hour` .. Hour in a day between 0 and 23.
- `min` .. Minute in an hour between 0 and 59.
- `sec` .. Second in a minute between 0 and 59.
- `usec` .. Millisecond in a second between 0 and 999.

- `minsoff` .. Timezone offset in minutes.

In default, the instance has a timezone offset based on the current system settings.

If `block` is specified, it would be evaluated with a block parameter `|dt:datetime|`, where `dt` is the created instance. In this case, the block's result would become the function's returned value.

## 6.9.4 Method

### datetime#clrtzoff

`datetime#clrtzoff():reduce`

Eliminates timezone offset information from the instance.

### datetime#format

`datetime#format(format => 'w3c')`

Returns a string of the datetime properties based on the specified format. For the argument `format`, you can specify either a string of user-specific format or a symbol of predefined style. A string of user-specific format contains following specifiers:

- `%d` .. day of month
- `%H` .. hour in 24-hour format
- `%I` .. hour in 12-hour format
- `%m` .. month
- `%M` .. minute
- `%S` .. second
- `%w` .. week number starting from 0 for Sunday.
- `%y` .. lower two digits of year
- `%Y` .. four digits of year

Below are the symbols of predefined styles:

- `'w3c` .. W3C style. eg) `'2015-01-01T12:34:56+09:00'`
- `'http` .. a style used in HTTP protocol. eg) `'Thu, 01 Jan 2015 12:34:56 +0900'`
- `'asctime` .. a style used by the C function `asctime()`. eg) `'Thu Jan 1 12:34:56 +0900 2015'`

### datetime.isleap

`datetime.isleap(year:number):static:map`

Returns `true` if the specified year is a leap one.

### datetime.monthdays

`datetime.monthdays(year:number, month:number):static:map {block?}`

Returns a number of days that exists in the specified month.

If `block` is specified, it would be evaluated with a block parameter `|n:number|`, where `n` is the created instance. In this case, the block's result would become the function's returned value.

### datetime.now

`datetime.now():static:[utc] {block?}`

Creates a `datetime` instance of the current time.

In default, the timezone offset is set to one in the system setting. Specifying `:utc` attribute would set the offset to 0.

If `block` is specified, it would be evaluated with a block parameter `|dt:datetime|`, where `dt` is the created instance. In this case, the block's result would become the function's returned value.

### datetime.parse

`datetime.parse(str:string):static:map {block?}`

Parses a string that describes date and time information and returns the `datetime` instance.

It is capable of parsing the following style:

- RFC1123 style. eg) 'Sat, 06 Nov 2010 08:49:37 GMT'
- RFC1036 style. eg) 'Saturday, 06-Nov-10 08:49:37 GMT'
- C's `asctime()` style. eg) 'Sat Nov 6 08:49:37 2010', 'Sat Nov 6 08:49:37 +0000 2010'
- W3C style. eg) '2010-11-06T08:49:37Z'

If `block` is specified, it would be evaluated with a block parameter `|dt:datetime|`, where `dt` is the created instance. In this case, the block's result would become the function's returned value.

### datetime#settzoff

`datetime#settzoff(mins:number):reduce`

Sets timezone offset in minutes.

### datetime.time

`datetime.time(hour:number => 0, minute:number => 0, sec:number => 0, usec:number => 0):static:map {block?}`

Creates a `datetime` instance from time information. The date information is set as 1st of January in the Christian year of 0.

If `block` is specified, it would be evaluated with a block parameter `|dt:datetime|`, where `dt` is the created instance. In this case, the block's result would become the function's returned value.

### datetime.today

`datetime.today():static:[utc] {block?}`

Creates a `datetime` instance of today. All the time information are cleared to 0.

In default, the timezone offset is set to one in the system setting. Specifying `:utc` attribute would set the offset to 0.

If `block` is specified, it would be evaluated with a block parameter `|dt:datetime|`, where `dt` is the created instance. In this case, the block's result would become the function's returned value.

### datetime#utc

`datetime#utc()`

Calculates UTC time of the target `datetime` instance. An error occurs if the instance has no timezone offset

`datetime.weekday`

`datetime.weekday(year:number, month:number, day:number):static:map`

Returns a week number for the specified date, which starts from 0 for Sunday.

## 6.10 declaration Class

The `declaration` class provides information about argument's declaration defined in a function. You can get an iterator of `declaration` instances with the following measures that the `function` class provides:

- A property value: `function#decls`
- An instance method: `function.getdecls()`

Below is an example to print argument names declared in a function.

```
f(a, b, c, d) = {}  
println(f.decls:*name)
```

### 6.10.1 Property

A `declaration` instance has the following properties:

Property	Type	R/W	Explanation
<code>declaration#symbol</code>	<code>symbol</code>	R	The name of the declaration in symbol.
<code>declaration#name</code>	<code>string</code>	R	The name of the declaration in string.
<code>declaration#default</code>	<code>expr</code>	R	The expression that provides a default value.

### 6.10.2 Method

`declaration#istype`

`declaration#istype(type+:expr):map`

Return `true` if the declaration is defined as a type that is specified in the arguments. The argument `type` has following formats:

- a single symbol.
- a sequence of symbols joined by a dot.

In the second format, a symbol on the left side indicates a container such as a module and a class.

Below is an example to check if the declaration is defined as `number` type.

```
decl.istype('number')
```

Below is an example to check if the declaration is defined as `re.match` type, which is a type named `match` defined in `re` module.

```
decl.istype('re.match')
```

You can also specify a type by describing factors in separate arguments like below:

```
decl.istype('re', 'match')
```

## 6.11 dict Class

The `dict` class provides measures to handle dictionary data.

You can create a `dict` instance by calling `dict()` function.

You can also use a function named `%` to create an instance that is an alias of `dict()` function.

### 6.11.1 Constructor

dict

`dict([elems?]):[icase] {block?}`

Creates a `dict` instance.

It takes a list of key-value pairs in an argument as shown below:

```
d = dict(['apple', 100], ['grape', 200], ['banana', 80])
```

Or, you can use a block to describe them like below:

```
d = dict {
  ['apple', 100], ['grape', 200], ['banana', 80]
}
```

You can specify values of `number`, `string` or `symbol` as dictionary keys.

You can also use the operator `=>` to create a key-value pair like below:

```
d = dict(['apple' => 100, 'grape' => 200, 'banana' => 80])
```

Below is an example using a block:

```
d = dict {
  'apple' => 100, 'grape' => 200, 'banana' => 80
}
```

The symbol `%` is an alias of the function `dict()`.

```
d = %{
  'apple' => 100, 'grape' => 200, 'banana' => 80
}
```

In default, if keys contain alphabet characters, different cases are distinguished. Appending the attribute `:icase` would ignore cases in them.

### 6.11.2 Method

dict#append

`dict#append([elems?]):reduce:[overwrite,strict,timid] {block?}`

Adds multiple key-value pairs. It takes a list of key-value pairs in an argument or in a block that has the same format with one for the function `dict()`.

If the specified key already exists in the dictionary, it would be overwritten. This behavior can be customized with the following attributes:

- `:overwrite` .. overwrite the existing one (default)

- `:strict` .. raises an error
- `:timid` .. keep the existing one

#### dict#clear

`dict#clear()`

Clears all the key-value pairs in the dictionary.

#### dict#erase

`dict#erase(key):map`

Erases a key-value pair that matches the provided `key` .  
The `key` is either `number` , `string` or `symbol` .

#### dict#get

`dict#get(key, default?):map:[raise]`

Seeks a value that is associated with the specified `key` .  
The method would return `nil` as its default value when the specified key doesn't exist in the dictionary. It would use different value if the argument `default` is specified.  
Since the `default` value is also processed with implicit mapping, you have to apply `object#nomap()` method to it if you want to specify a list or an iterator as a default value.  
When the attribute `:raise` is specified, an error occurs in the case of the key's absence.  
Another measure to get a value associated with a key is to use an index operator. The following two codes have the same effect.

- `v = d['foo']`
- `v = d.get('foo'):raise`

#### dict#haskey

`dict#haskey(key):map`

Returns `true` if the specified `key` exists in the dictionary.

#### dict#items

`dict#items() {block?}`

Returns an iterator of key-value pairs in the dictionary.  
In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.



### dict#keys

`dict#keys() {block?}`

Returns an iterator of keys in the dictionary.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

### dict#len

`dict#len()`

Returns the number of key-value pairs in the dictionary.

### dict#put

`dict#put(key, value):map:reduce:[overwrite,strict,timid]`

Adds a new key-value pair.

If the specified key already exists in the dictionary, it would be overwritten. This behavior can be customized with the following attributes:

- `:overwrite` .. overwrite the existing one (default)
- `:strict` .. raises an error
- `:timid` .. keep the existing one

Another measure to add a key-value pair is to use an index operator. The following two codes have the same effect.

- `d['foo'] = 3`
- `d.put('foo', 3)`

### dict#values

`dict#values() {block?}`

Returns an iterator of values in the dictionary.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.

- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

## 6.12 directory Class

The `directory` class handles information necessary to seek directory structure in a path. Its instance usually works with functions in `path` module: `path.dir()` and `path.walk()` . Though the instance can be created by `directory()` function, you don't have to use it in many cases because a casting from `string` to `directory` instance works implicitly in a function call.

### 6.12.1 Constructor

directory

```
directory(pathname:string):map {block?}
```

Creates a `directory` instance from the specified path name.

## 6.13 environment Class

The `environment` class provides measures to operate variables in an environment, which is a fundamental mechanism to store variables.

### 6.13.1 Method

environment#getprop!

```
environment#getprop!(symbol:symbol):map
```

environment#lookup

```
environment#lookup(symbol:symbol, escalate:boolean => true):map
```

Looks up a specified symbol in the environment and returns the associated value. In default, if the symbol is not defined in the environment, it will be searched in environments outside of the current one. Set `escalate` flag to false in order to disable such an escalation behaviour. Returns false when the symbol could not be found.

environment#setprop!

```
environment#setprop!(symbol:symbol, value):map
```

## 6.14 error Class

The `error` class provides measures to access error information.

There is no measures to create an `error` instance. They're instantiated and passed to a block of `catch()` function when an error occurs within a `try` block in a `try-catch` sequence. In the following code, `e` is an instance that contains information about an error that has occurred in the `try` block.

```

try {
    // any jobs
} catch { |e:error|
    // ...
}

```

### 6.14.1 Predefined Variable

Variable	Explanation
error.ArgumentError	
error.ArithmeticError	
error.AttributeError	
error.CodecError	
error.CommandError	
error.DeclarationError	
error.FormatError	
error.IOError	
error.ImportError	
error.IndexError	
error.IteratorError	
error.KeyError	
error.MemberAccessError	
error.MemoryError	
error.NameError	
error.NotImplementedError	
error.OutOfRange	
error.ResourceError	
error.RuntimeError	
error.SyntaxError	
error.SystemError	
error.TypeError	
error.ValueError	
error.ZeroDivisionError	

### 6.14.2 Property

An `error` instance has the following properties:

Property	Type	R/W	Explanation
error#source	string	R	The name of the file that causes this error.
error#lineno	number	R	The number of line where the expression that causes this error starts.
error#lineno	number	R	The number of line where the expression that causes this error ends.
error#postext	string	R	A text that consists of a source name and a line number.
error#text	string	R	An error message. If an attribute ‘:lineno’ is specified, it would contain a line number.
error#trace	expr[]	R	Stack trace.

## 6.15 expr Class

### 6.15.1 Property

An `expr` instance has the following properties:

Property	Type	R/W	Explanation
<code>expr#attrfront</code>	<code>symbol[]</code>	R	Exists in "identifier" and "caller".
<code>expr#attrs</code>	<code>symbol[]</code>	R	Exists in "identifier" and "caller".
<code>expr#attrsopt</code>	<code>symbol[]</code>	R	Exists in "identifier" and "caller".
<code>expr#block</code>	<code>expr</code>	R	Exists in "caller".
<code>expr#blockparam</code>	<code>iterator</code>	R	Exists in "block".
<code>expr#body</code>	<code>string</code>	R	Exists in "suffixed".
<code>expr#car</code>	<code>expr</code>	R	Exists in "compound".
<code>expr#cdr</code>	<code>iterator</code>	R	Exists in "compound".
<code>expr#child</code>	<code>expr</code>	R	Exists in "unary".
<code>expr#children</code>	<code>iterator</code>	R	Exists in "collector".
<code>expr#left</code>	<code>expr</code>	R	Exists in "binary".
<code>expr#lineno</code>	<code>number</code>	R	
<code>expr#linenobtm</code>	<code>number</code>	R	
<code>expr#operator</code>	<code>operator</code>	R	Exists in "unaryop", "binaryop" and "assign".
<code>expr#postext</code>	<code>string</code>	R	
<code>expr#right</code>	<code>expr</code>	R	Exists in "binary".
<code>expr#source</code>	<code>string</code>	R	
<code>expr#suffix</code>	<code>symbol</code>	R	Exists in "suffixed".
<code>expr#symbol</code>	<code>symbol</code>	R	Exists in "identifier".
<code>expr#trailer</code>	<code>expr</code>	R	Exists in "caller".
<code>expr#typename</code>	<code>string</code>	R	
<code>expr#typesym</code>	<code>symbol</code>	R	
<code>expr#value</code>	<code>any</code>	R	Exists in "value".

### 6.15.2 Constructor

`expr`

```
expr(src:stream:r):map {block?}
```

Parses a Gura script from the stream `src` and creates an `expr` instance.

If `block` is specified, it would be evaluated with a block parameter `|expr:expr|`, where `expr` is the created instance. In this case, the block's result would become the function's returned value.

### 6.15.3 Method

`expr#eval`

```
expr#eval(env?:environment)
```

Evaluates the `expr` instance.

If the argument `env` is specified, that environment is used for evaluation. If omitted, the current scope is used.

`expr.parse`

```
expr.parse(script:string):static:map {block?}
```

Parses a Gura script in the string `script` and creates an `expr` instance.

If `block` is specified, it will be evaluated with block parameter in a format of `|expr:expr|` where `expr` is the created instance.

### expr#textize

`expr#textize(style?:symbol, indent?:string)`

Composes a script text from a content of `expr` .

Argument `style` specifies the text style output, which takes the following symbols:

- `'crammed` .. Puts all the text in one line and removes volatile spaces.
- `'oneline` .. Puts all the text in one line.
- `'brief` .. Omits content of blocks and long strings with `".. "`.
- `'fancy` .. Prints in the most readable style. This is the default.

The argument `indent` specifies a string used for indentation. Its default is a sequence of four spaces.

### expr#tofunction

`expr#tofunction('args*)`

Converts the `expr` into a function.

If the `expr` is a block that has a block parameter, that would be used as an argument list of the created function. Otherwise, the argument `args` declares the argument list.

It would be an error if `args` is specified and a block parameter exists as well.

### expr#unquote

`expr#unquote()`

Returns `expr` instance that has removed quote operator from the original `expr` .

### expr#write

`expr#write(dst:stream:w, style?:symbol, indent?:string)`

Outputs a script that describes the expression to the specified `stream` .

Argument `style` specifies the text style output, which takes the following symbols:

- `'crammed` .. Puts all the text in one line and removes volatile spaces.
- `'oneline` .. Puts all the text in one line.
- `'brief` .. Omits content of blocks and long strings with `".. "`.
- `'fancy` .. Prints in the most readable style. This is the default.

The argument `indent` specifies a string used for indentation. Its default is a sequence of four spaces.

### expr#isunary

`expr#isunary()`

Returns `true` if `expr` is an expression of unary.

### expr#isunaryop

`expr#isunaryop()`

Returns `true` if `expr` is an expression of unaryop.

### expr#isquote

`expr#isquote()`

Returns `true` if `expr` is an expression of quote.

expr#isbinary

expr#isbinary()

Returns **true** if expr is an expression of binary.

expr#isbinaryop

expr#isbinaryop()

Returns **true** if expr is an expression of binaryop.

expr#isassign

expr#isassign()

Returns **true** if expr is an expression of assign.

expr#ismember

expr#ismember()

Returns **true** if expr is an expression of member.

expr#iscollector

expr#iscollector()

Returns **true** if expr is an expression of collector.

expr#isroot

expr#isroot()

Returns **true** if expr is an expression of root.

expr#isblock

expr#isblock()

Returns **true** if expr is an expression of block.

expr#islister

expr#islister()

Returns **true** if expr is an expression of lister.

expr#isiterer

expr#isiterer()

Returns **true** if expr is an expression of iterer.

expr#iscompound

expr#iscompound()

Returns **true** if expr is an expression of compound.

expr#isindexer

expr#isindexer()

Returns **true** if expr is an expression of indexer.

expr#iscaller

expr#iscaller()

Returns `true` if `expr` is an expression of caller.

`expr#isvalue`  
`expr#isvalue()`

Returns `true` if `expr` is an expression of value.

`expr#isidentifier`  
`expr#isidentifier()`

Returns `true` if `expr` is an expression of identifier.

`expr#issuffixed`  
`expr#issuffixed()`

Returns `true` if `expr` is an expression of suffixed.

## 6.16 formatter Class

The `formatter` class provides information about a format specifier.  
The function `printf()` has the following declaration:

```
printf(format:string, values*)
```

The argument `format` is a string containing format specifiers like `%d` and `%s` that correspond to instances specified by the arguments `values`. When a qualifier is found during the evaluation of the function, a format handler associated with an corresponding instance is called. Format handlers are instance methods named like `__format_X__()` where `X` is the symbol of the specifier. For example, the instance method `__format_d__()` is responsible to work on a specifier `%d`.

The `formatter` instance is created for each specifier and passed to a method like `__format_X__(fmt:formatter)`. Below is a table showing specifiers and corresponding method names:

Specifier	Method Name
<code>%d</code>	<code>__format_d__</code>
<code>%u</code>	<code>__format_u__</code>
<code>%b</code>	<code>__format_b__</code>
<code>%o</code>	<code>__format_o__</code>
<code>%x</code>	<code>__format_x__</code>
<code>%e</code>	<code>__format_e__</code>
<code>%f</code>	<code>__format_f__</code>
<code>%g</code>	<code>__format_g__</code>
<code>%s</code>	<code>__format_s__</code>
<code>%c</code>	<code>__format_c__</code>

### 6.16.1 Method

`formatter#getminwidth`  
`formatter#getminwidth()`

Returns an expected minimum width for the field.  
For example, with `'%3d'`, this method would return `3`.

`formatter#getpadding`  
`formatter#getpadding()`

Returns a string containing a padding character, a space or '0' .  
In default, a space is used for padding. For example, with '%3d' , this method would return ' , .

When a character '0' appears after '%', that becomes the padding character. For example, with '%03d' , this method would return '0' .

formatter#getplusmode  
`formatter#getplusmode()`

Returns a symbol that indicates an expected action when a positive number appears.

- 'none' .. No character ahead of the number.
- 'space' .. A space should be inserted.
- 'plus' .. A plus character should be inserted.

formatter#getprecision  
`formatter#getprecision()`

Returns an expected precision for the field.  
For example, with '%.3d' , this method would return 3 .

formatter#isleftalign  
`formatter#isleftalign()`

Returns `true` if the field is expected to be aligned on left.  
For example, with '%-3d' , this method would return `true` .

formatter#issharp  
`formatter#issharp()`

Returns `true` if the specifier sequence includes '#' flag, which means some literal prefixes such as 0x are expected to be appended at the top.  
For example, with '%#x' , this method would return `true` .

formatter#isuppercase  
`formatter#isuppercase()`

Returns `true` if alphabet characters are expected to be shown in upper case.  
Upper case characters are requested when a specifier such as '%X' , '%E' and '%G' is specified.

## 6.17 function Class

The `function` class provides measure to inspect information about the instance.  
All the functions are instances of `function` class, so an implementation of a function means a realization of a `function` instance. You can also create the instance using `function()` constructor. The following two codes have the same result:

```
f(a:number, b:number, c:number) = {  
  (a + b + c) / 3  
}  
  
f = function(a:number, b:number, c:number) {  
  (a + b + c) / 3  
}
```



Using `function()` , you can use variables prefixed by a dollar character so that they are automatically added to the argument list. In such a case, the variables are added to the argument list in the same order as they appear in the function body. The code below creates a function with a declaration `f($a, $b, $c)` .

```
f = function {
    ($a + $b + $c) / 3
}
```

You can use `&` as an alias of `function()` as shown below:

```
f = &{
    ($a + $b + $c) / 3
}
```

### 6.17.1 Property

A `function` instance has the following properties:

Property	Type	R/W	Explanation
<code>function#declaration</code>	iterator	R	iterator of <code>declaration</code> instances that provide information about argument declaration the function defines.
<code>function#expression</code>	expr	R/W	an expression of the function.
<code>function#format</code>	string	R	a string showing a declared format of the function.
<code>function#fullstring</code>	string	R	a full name of the function that is prefixed by a name of the module or the class it belongs to.
<code>function#name</code>	string	R	a name of the function in <code>string</code> .
<code>function#symbol</code>	symbol	R/W	a name of the function in <code>symbol</code> .

### 6.17.2 Operator

You can print a function's help from the interactive prompt using the unary operator `~` . Below is an example to print the help of `printf()` function:

```
>>> ~printf
```

### 6.17.3 Constructor

#### function

```
function('args*) {block}
```

Creates a `function` instance with an argument list of `args` and a procedure body provided by `block` .

Following two codes have the same effect with each other.

- `f = function(a, b, c) { /* any job */ }`
- `f(a, b, c) = { /* any job */ }`

## 6.17.4 Method

### function.addhelp

`function.addhelp(func:function, lang:symbol, format:string, help:string):static:map:void`

Adds help information to a `function` instance taking the following arguments:

- `func` .. The `function` instance to which the help is added.
- `lang` .. A symbol of the natural language in which the help text is written. For example, `'en'` for English and `'ja'` for Japanese.
- `format` .. A name of the syntax format in which the help text is described such as `'markdown'` .
- `help` .. The help text.

You can add multiple help information with different `lang` .

Below is an example to add help information to a function using the method `function#addhelp()` :

```
f(a:number, b:number, c:number) = {
  (a + b + c) / 3
}

function.addhelp(f, 'en', 'markdown', R'''
Computes a mean value of the provided three numbers.
''')
```

That has the same result with the code below:

```
f(a:number, b:number, c:number) = {
  (a + b + c) / 3
} % {'en', 'markdown', R'''
Computes a mean value of the provided three numbers.
'''}.
```

### function.getdecls

`function.getdecls(func:function):static:map`

Creates an iterator of `declaration` instances that provide information about argument declaration that the function instance `func` defines.

This class method returns the same information as the property `function#decls` .

### function.getexpr

`function.getexpr(func:function):static:map`

Returns an expression of the function instance `func` .

It would return `nil` if the function is implemented with binary programs, not scripts.

This class method returns the same information as the property `function#expr` .

### function.getformat

`function.getformat(func:function):static:map`

Returns a string showing a declared format of the function instance `func` .

This class method returns the same information as the property `function#format` .

### function.getfullname

`function.getfullname(func:function):static:map`

Returns a full name of the function instance `func` , which is prefixed by a name of the module or the class the instance belongs to.

This class method returns the same information as the property `function#fullname` .

#### function.gethelp

`function.gethelp(func:function, lang?:symbol):static:map`

Returns a `help` instance associated with the specified function instance `func` . If the function instance has no help registred, this function would return `nil` .

The argument `lang` is a symbol that indicates a natural language in which the help is written. If this argument is omitted or the specified language doesn't exist, help information that has been registered at first would be returned as a default.

#### function.getname

`function.getname(func:function):static:map`

Returns a name of the function instance `func` in `string` type.

This class method returns the same information as the property `function#name` .

#### function.getsymbol

`function.getsymbol(func:function):static:map`

Returns a name of the function instance `func` in `symbol` type.

This class method returns the same information as the property `function#symbol` .

#### function#mathdiff

`function#mathdiff(var?:symbol):reduce`

Returns a `function` instance that computes derivation of the target function, which is expected to contain only mathematical procedures. An error occurs if the target function has any elements that have nothing to do with mathematics.

In default, it differentiates the target function with respect to its first argument. Below is an example:

```
>>> f(x) = math.sin(x)
>>> g = f.mathdiff()    // g is a function to compute math.cos(x)
```

Specify a symbol to argument `var` when you want to differentiate with respect to another variable.

You can check the result of derivation by seeing property `function#expr` like below:

```
>>> g.expr
'math.cos(x)
```

## 6.18 help Class

The `help` class provides measures to access help information associated with a `function` instance.

You can get a `help` instance by calling the class method `function.gethelp()` .

### 6.18.1 Property

A `help` instance has the following properties:

Property	Type	R/W	Explanation
<code>help#format</code>	string	R	A name of the syntax format in which the help text is described such as 'markdown' .
<code>help#lang</code>	symbol	R	A symbol of the natural language in which the help text is written. For example, 'en' for English and 'ja' for Japanese.
<code>help#text</code>	string	R	The help text.

## 6.19 image Class

The `image` class provides following measures to handle graphic image data:

- Reads image data from a file.
- Writes image data to a file.
- Apply some modifications on image data including rotation, resize and color conversion.

Acceptable image data formats can be extended by importing modules. Below is a table to show image formats and name of modules that handle them. The string listed in "imagetype" column shows a name that is used by functions `image()` , `image#read()` and `image#write()` to explicitly specify the image data format in a process of reading and writing files.

Image Format	Module Name	imagetype
BMP	bmp	'bmp'
GIF	gif	'gif'
JPEG	jpeg	'jpeg'
Microsoft Icon	msico	'msico'
PNG	png	'png'
PPM	ppm	'ppm'
TIFF	tiff	'tiff'

### 6.19.1 Property

An `image` instance has the following properties:

Property	Type	R/W	Explanation
<code>image#format</code>	symbol	R	Takes one of the following symbols indicating what elements are stored in the memory: 'rgb' .. red, green and blue 'rgba' .. red, green, blue and alpha
<code>image#width</code>	number	R	Image width.
<code>image#height</code>	number	R	Image height.
<code>image#palette</code>	palette	R/W	A <code>palette</code> instance associated with this image. If there's no palette associated, this property returns <code>nil</code> .

### 6.19.2 Constructor

image

```
image(args+):map {block?}
```

Returns an image instance with specified characteristics. There are three forms to call the function as below:

- `image(format:symbol)` .. Creates an image instance of the specified format without buffer allocated.
- `image(format:symbol, width:number, height:number, color?:color)` .. Allocates an image buffer with the specified size and fills it with the color.
- `image(stream:stream, format?:symbol, imagetype?:string)` .. Reads image data from the stream and allocates necessary buffer in which the read data is stored.

The argument `format` specifies what elements are stored in the memory and takes one of the following symbols:

- `'rgb` .. red, green and blue
- `'rgba` .. red, green, blue and alpha

In the third form, the format of the image data is determined by the byte sequence of the stream data and its file name.

You can also explicitly specify the image data format by the argument `imagetype` .

### 6.19.3 Method

#### image#allocbuff

`image#allocbuff(width:number, height:number, color?:color):reduce`

Allocates a specified size of buffer in the `image` instance that is supposed to has no buffer allocated.

The allocated buffer will be filled with `color` . If omitted, it will be filled with zero value.

An error occurs in following cases:

- It fails to allocate necessary buffer.
- The `image` instance already has allocated buffer.

#### image#blur

`image#blur(radius:number, sigma?:number) {block?}`

Returns a new image that blurs the original image with the given parameters.

If `block` is specified, it would be evaluated with a block parameter `|img:image|` , where `img` is the created instance. In this case, the block's result would become the function's returned value.

#### image#clear

`image#clear():reduce`

Fills the buffer in the `image` instance with zero value.

This has the same effect with calling `image#fill()` with `color.zero` .

This method returns the reference to the target instance itself.

#### image#crop

`image#crop(x:number, y:number, width?:number, height?:number):map {block?}`

Returns a new image instance of the extracted area of the source image.

The extracted area is specified by the following arguments:

- `x` .. The left position.
- `y` .. The top position.

- **width** .. The width. If it's omitted or specified with **nil** , the whole area on the right of **x** will be extracted.
- **height** .. The height. If it's omitted or specified with **nil** , the whole area on the bottom of **y** will be extracted.

If **block** is specified, it would be evaluated with a block parameter `|img:image|` , where **img** is the created instance. In this case, the block's result would become the function's returned value.

#### image#delpalette

```
image#delpalette():reduce
```

Deletes a **palette** instance the image owns if it does.

This method returns the reference to the target instance itself.

#### image#extract

```
image#extract(x:number, y:number, width:number, height:number, element:symbol, dst):reduce
```

Extracts the element values within the specified area of the image, and store them into a list or matrix. The argument **x** and **y** specifies the left-top position, and **width** , and **height** does the size of the area.

The argument **element** takes the following symbol that specifies which element should be extracted:

- **'r** .. red
- **'g** .. green
- **'b** .. blue
- **'a** .. alpha

The argument **dst** specifies the variable into which the extracted data is stored, which must be a list or matrix that has enough space to store the data.

This method returns the reference to the target instance itself.

#### image#fill

```
image#fill(color:color):reduce
```

Fills the whole image with the specified color.

This method returns the reference to the target instance itself.

#### image#fillrect

```
image#fillrect(x:number, y:number, width:number, height:number, color:color):map:reduce
```

Fills the specified area with the specified color. The argument **x** and **y** specifies the left-top position, and **width** , and **height** does the size of the area.

This method returns the reference to the target instance itself.

#### image#flip

```
image#flip(orient:symbol):map {block?}
```

Returns a new **image** instance that flips the source image horizontally or vertically. You can specify the following symbol to the **orient** argument.

- **'horz** .. flips horizontally.
- **'vert** .. flips vertically.
- **'both** .. flips both horizontally and vertically. This has the same effect with rotating the image 180 degrees.

If `block` is specified, it would be evaluated with a block parameter `|img:image|`, where `img` is the created instance. In this case, the block's result would become the function's returned value.

#### image#getpixel

```
image#getpixel(x:number, y:number):map {block?}
```

Returns a color of a pixel data at the specified position.

If `block` is specified, it would be evaluated with a block parameter `|c:color|`, where `c` is the created instance. In this case, the block's result would become the function's returned value.

#### image#grayscale

```
image#grayscale() {block?}
```

Returns a new image instance that converts the source image into gray scale.

If `block` is specified, it would be evaluated with a block parameter `|img:image|`, where `img` is the created instance. In this case, the block's result would become the function's returned value.

#### image#mapcolorlevel

```
image#mapcolorlevel(map@r[:number], map@g[:?number], map@b[:?number]) {block?}
```

Returns a new image that converts color levels according to the given table.

Each of the arguments `map@r`, `map@g` and `map@b` is a list containing 256 numbers between 0 and 255 and corresponds to elements red, green and blue respectively. An element value in the source image becomes an index of the list and the indexed value will be stored as a converted element value.

If you want to apply a mapping table to all the elements, call the method with a single argument like `image#mapcolorlevel(map)`.

If `block` is specified, it would be evaluated with a block parameter `|img:image|`, where `img` is the created instance. In this case, the block's result would become the function's returned value.

#### image#paste

```
image#paste(x:number, y:number, src:image, width?:number, height?:number, xoffset:number => 0, yoffset:number => 0, a:number => 255):map:reduce
```

Pastes the source image `src` onto the target image instance at the specified position.

The argument `width`, `height`, `xoffset` and `yoffset` specify the source image's area to be pasted. If they're omitted, the whole image will be pasted.

The argument `a` specifies the alpha value that is put on the target image.

This method returns the reference to the target instance itself.

#### image#putpixel

```
image#putpixel(x:number, y:number, color:color):map:reduce
```

Puts a color on the specified position.

This method returns the reference to the target instance itself.

#### image#size

```
image#size()
```

Returns the image size as a list `[width, height]`.

#### image#store

```
image#store(x:number, y:number, width:number, height:number, element:symbol, src):reduce
```

### image#read

`image#read(stream:stream:r, imagetype?:string):map:reduce`

Reads image data from a stream.

The format of the image data is determined by the byte sequence of the stream data and its file name.

You can also explicitly specify the image data format by the argument `imagetype` .

This method returns the reference to the target instance itself.

### image#reducecolor

`image#reducecolor(palette?:palette) {block?}`

Creates an image that reduces colors in the original image with a set of colors in the given palette. The specified palette would be associated with the created image.

If no argument is specified, the associated palette would be used. In this case, an error occurs if there's no palette associated.

If `block` is specified, it would be evaluated with a block parameter `|img:image|` , where `img` is the created instance. In this case, the block's result would become the function's returned value.

### image#replacecolor

`image#replacecolor(colorOrg:color, color:color, tolerance?:number):reduce`

Replaces pixels that have a color matching `colorOrg` with the `color` .

The argument `tolerance` specifies an acceptable distance for the matching. If omitted, only an exact match is acceptable.

This method returns the reference to the target instance itself.

### image#resize

`image#resize(width?:number, height?:number):map:[box,ratio] {block?}`

Creates an image that resizes the original image to the sprcified `width` and `height` .

- When both `width` and `height` are specified, the image would be resized to the size.
- When `width` is specified and `height` is omitted or `nil` , the resized height would be calculated from the width so that they keep the same ratio as the original.
- When `width` is `nil` and `height` is specified, the resized width would be calculated from the height so that they keep the same ratio as the original.

The following attributes are acceptable:

- `box` .. When only `width` is specified, the same value is set to `height` .
- `ratio` .. Treats values of `width` and `height` as magnifying ration instead of pixel size.

If `block` is specified, it would be evaluated with a block parameter `|img:image|` , where `img` is the created instance. In this case, the block's result would become the function's returned value.

### image#rotate

`image#rotate(rotate:number, background?:color):map {block?}`

Creates an image that rotates the original image by the specified angle.

The argument `angle` specifies the rotation angle in degree unit, and positive numbers for counterclockwise direction and negative for clockwise direction.

The created instance has a size that exactly fits the rotated image. The argument `background` specifies the color of pixels to fill the empty area that appears after rotation. If omitted, the color that has all elements set to zero is used for filling.



If `block` is specified, it would be evaluated with a block parameter `|img:image|`, where `img` is the created instance. In this case, the block's result would become the function's returned value.

#### image#scan

`image#scan(x?:number, y?:number, width?:number, height?:number, scandir?:symbol) {block?}`

Returns an iterator that scans pixels in the image.

The arguments `x`, `y`, `width` and `height` specify the image area to scan. The argument `scandir` specifies the scan direction and takes one of the following symbol:

Symbol	Start Pos	Direction
'left_top_horz	left-top	horizontal
'left_top_vert	left-top	vertical
'left_bottom_horz	left-bottom	horizontal
'left_bottom_vert	left-bottom	vertical
'right_top_horz	right-top	horizontal
'right_top_vert	right-top	vertical
'right_bottom_horz	right-bottom	horizontal
'right_bottom_vert	right-bottom	vertical

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### image#setalpha

`image#setalpha(a:number, color?:color, tolerance?:number):reduce`

#### image#thumbnail

`image#thumbnail(width?:number, height?:number):map:[box] {block?}`

#### image#write

`image#write(stream:stream:w, imagetype?:string):map:reduce`

Writes image data to a stream.

The format of the image data is determined by the stream's file name.

You can also explicitly specify the image data format by the argument `imagetype`.

This method returns the reference to the target instance itself.

## 6.20 list/iterator Class

The `list` class provides measures to handle a list structure, which stores values on memory that can be accessed by indexer.

The `iterator` class provides measures to operate an iterator, which iterates values that come from containers and streams.

### 6.20.1 List-specific Features

#### Creating List

There are several ways to create a list.

```
[3, 1, 4, 1, 5, 9]
@{3, 1, 4, 1, 5, 9}
```

#### Index Access

You can read and write element values in a list with an indexer by giving it an index number starting from zero. Below is an example:

```
x = ['A', 'B', 'C', 'D', 'E', 'F']

println(x[2]) // prints 'C'
x[4] = 'e'    // replaces 'E' with 'e'
```

#### Function to Create list Instance

##### list

`list(value+)`

Creates a new list from given values in its argument list. If the value is a list or an iterator, its elements are added to the created list.

##### xlist

`xlist(value+)`

Creates a new list from given values except for `nil` in its argument list. If the value is a list or an iterator, its elements are added to the created list.

##### set

`set(iter+:iterator):[and,or,xor]`

Creates a new list that contains unique values from given iterators in its argument list. In default, all the elements in each iterators are added to the created list. Specifying the following attributes would apply a filtering condition.

- `:and` .. Elements that exist in all the iterators are added.
- `:or` .. All the elements are added. This is the default behavior.
- `:xor` .. Elements that exist in only one iterator are added.

##### xset

`xset(iter+:iterator):[and,or,xor]`

Creates a new list that contains unique values except for `nil` from given iterators in its argument list.

In default, all the elements in each iterators are added to the created list. Specifying the following attributes would apply a filtering condition.

- `:and` .. Elements that exist in all the iterators are added.
- `:or` .. All the elements are added. This is the default behavior.
- `:xor` .. Elements that exist in only one iterator are added.

### Method Specific to list Class

#### list#add

`list#add(elem+):reduce`

Add specified items to the list.

#### list#append

`list#append(elem+):reduce`

Adds specified items to the list. If the item is a list or an iterator, each element in such an item is added to the list.

#### list#clear

`list#clear():reduce`

Clear the content of the list.

#### list#combination

`list#combination(n:number) {block?}`

Creates an iterator that generates lists that contain elements picked up from the original list in a combination manner.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### list#erase

`list#erase(idx*:number):reduce`

Erases elements at the specified indices.

#### list#first

`list#first()`

Returns a first value in the list. An error occurs when the list is empty.

### list#flat

`list#flat():[bfs,dfs] {block?}`

Creates an iterator that searches items recursively if they are lists or iterators. Specifying an attribute could customize searching order as below:

- `:dfs` .. Searches in depth-first order. This is the default behavior.
- `:bfs` .. Searches in breadth-first order.

Unlike `iterator#walk()` , `iterator#flat()` creates an iterator without an infinite flag. This means that the created iterator can be converted to a list. You have to confirm that the source iterable doesn't contain any infinite iterators.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below is an example:

```
x = [['A', 'B', 'C'], ['D', 'E', ['F', 'G', 'H'], 'I', 'J'], 'K', 'L']

y = x.flat():dfs
// y generates 'A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I', 'J', 'K', 'L'

y = x.flat():bfs
// y generates 'K', 'L', 'A', 'B', 'C', 'D', 'E', 'I', 'J', 'F', 'G', 'H'
```

### list#get

`list#get(index:number):flat:map`

Returns a value stored at the specified index in the list. An error occurs when the index is out of range.

### list#insert

`list#insert(idx:number, elem+):reduce`

Insert specified items to the list from the selected index.

### list#isempty

`list#isempty()`

Return true if the list is empty.

### list#last

`list#last()`

Returns a last value in the list. An error occurs when the list is empty.

#### list#permutation

`list#permutation(n?:number) {block?}`

Creates an iterator that generates lists that contain elements picked up from the original list in a permutation manner.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### list#put

`list#put(index:number, value:nomap):map:reduce`

Stores a value at the specified index in the list. An error occurs when the index is out of range.

#### list#shift

`list#shift():[raise]`

Shifts the elements of the list. If the content of the list is `[1, 2, 3, 4]`, it becomes `[2, 3, 4]` after calling this method. In default, no error occurs even when the list is empty. To raise an error for executing this method on an empty list, specify `:raise` attribute.

#### list#shuffle

`list#shuffle():reduce`

Shuffle the order of the list content based on random numbers.

#### list.zip

`list.zip(values+):static {block?}`

Creates an iterator generating lists that bind given argument values. When the value is a list or an iterator, each item in it would be zipped.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.

- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

## 6.20.2 Iterator-specific Features

### Function to Create iterator Instance

#### iterator

```
iterator(value+) {block?}
```

Creates an iterator that combines iterators given in the argument.

If an argument is not an iterator, that would be added as an element.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

### Method Specific to iterator Class

#### iterator#delay

```
iterator#delay(delay:number) {block?}
```

Creates an iterator that returns each element with an interval time specified by the argument `delay` in seconds.

#### iterator#isinfinite

```
iterator#isinfinite()
```

Returns `true` if the iterator is infinite one.

The trait of iterator's infinity is used to avoid an endless process by evaluating an infinite iterator. An attempt to evaluate an infinite iterator such as creation of a list from it would occur an error.

#### iterator#next

```
iterator#next()
```

Returns a next element of the iterator. This operation updates the iterator's internal status.

#### iterator#repeater

```
iterator#repeater()
```

Makes the iterator behave as a "repeater". This would allow the iterator be evaluated when it appears as an element of another "repeater" iterator.  
Below is an example:

```
x = repeat(3):iter {
  ['apple', 'orange', 'grape'].each()
}
println(x)
// Just prints iterator instance three times
// since x can't evaluate the internal iterator.

x = repeat(3):iter {
  ['apple', 'orange', 'grape'].each().repeater()
}
println(x)
// Prints 'apple', 'orange' and 'grape' three times
// after evaluating the internal iterator.
```

### 6.20.3 Method Common to Both list and iterator Classes

#### iterable#after

`iterable#after(criteria) {block?}`

Creates an iterator that picks up elements that appear at positions after the criteria is evaluated to be `true`.

You can specify a function, a list or an iterator as the criteria.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### iterable#align

`iterable#align(n:number, value?) {block?}`

Creates an iterator that returns the specified number of elements in the source iterator. If the number is larger than the length of the source iterator, the lacking part is filled with `value`. If the argument `value` is omitted, `nil` is used for the filling.

Below is an example to specify a number less than the source length:

```
x = ['A', 'B', 'C', 'D', 'E', 'F'].align(3)
// x generates 'A', 'B', 'C'.
```

Below is an example to specify a number that exceeds the source length:

```
x = ['A', 'B', 'C', 'D', 'E', 'F'].align(8)
// x generates 'A', 'B', 'C', 'D', 'E', 'F', nil, nil.
```

#### iterable#and

`iterable#and()`

Calculates a logical AND result of all the values in the iterable.

#### iterable#average

`iterable#average()`

Calculates an average of elements in the iterable.

It can work on an iterable with elements of type that supports addition and division operators.

Below is a list of acceptable value types:

- `number`
- `complex`
- `matrix`
- `rational`
- `gmp.mpz`
- `gmp.mpq`
- `gmp.mpf`

#### iterable#before

`iterable#before(criteria) {block?}`

Creates an iterator that extracts elements in the iterable before criteria is evaluated as true. You can specify a function object, a list or an iterator as the criteria.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### iterable#contains

`iterable#contains(value)`

Returns `true` if the specified value appears in the iterable.



### iterable#count

`iterable#count(criteria?)`

Returns a number of elements that matches the given criteria which is a single-argument function or a value.

When a function is applied, it counts the number of true after evaluating element value with the function. If a value is applied, it counts the number of elements that are equal to the value.

### iterable#cycle

`iterable#cycle(n?:number) {block?}`

Creates an iterator that iterates elements in the source iterator cyclically.

The argument `n` specifies the number of elements the created iterator returns. If omitted, it would iterates elements infinitely.

Below is an example:

```
x = ['A', 'B', 'C', 'D', 'E'].cycle()
// x generates 'A', 'B', 'C', 'D', 'E', 'A', 'B', 'C', 'D', 'E', 'A', 'B', ..
```

### iterable#each

`iterable#each() {block?}`

Creates an iterator that iterates each element in the list.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

### iterable#filter

`iterable#filter(criteria?) {block?}`

Creates an iterable that filters values in the source iterable by a criteria.

A criteria can be an iterable or a function instance.

- When the criteria is an iterable, the created iterator would scan the source and the criteria iterable simultaneously and would return a value of the source when the corresponding criteria value is evaluated as `true` .
- When the criteria is a function instance, the created iterator would give it a value of the source as an argument and would return the value when the function has returned `true` .

Below is an example to use an iterable as its criteria:

```
x = [3, 1, 4, 1, 5, 9]
y = filter(x > 3)
// (x > 3) makes a list [false, false, true, false, true, true]
// y generates 4, 5, 9
```

Below is an example to use a function as its criteria:

```
x = [3, 1, 4, 1, 5, 9]
y = filter(&{$x > 3})
// y generates 4, 5, 9
```

iterable#find

`iterable#find(criteria?):[index]`

iterable#flat

`iterable#flat():[bfs,dfs] {block?}`

Creates an iterator that searches items recursively if they are lists or iterators. Specifying an attribute could customize searching order as below:

- `:dfs` .. Searches in depth-first order. This is the default behavior.
- `:bfs` .. Searches in breadth-first order.

Unlike `iterator#walk()`, `iterator#flat()` creates an iterator without an infinite flag. This means that the created iterator can be converted to a list. You have to confirm that the source iterable doesn't contain any infinite iterators.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below is an example:

```
x = [['A', 'B', 'C'], ['D', 'E', ['F', 'G', 'H'], 'I', 'J'], 'K', 'L']

y = x.flat():dfs
// y generates 'A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I', 'J', 'K', 'L'

y = x.flat():bfs
// y generates 'K', 'L', 'A', 'B', 'C', 'D', 'E', 'I', 'J', 'F', 'G', 'H'
```

### iterable#fold

`iterable#fold(n:number, nstep?:number):map:[iteritem,neat] {block?}`

Creates an iterator that packs `n` elements of the source iterator into a list and returns it as its element.

The argument `nstep` specifies the shift amount to the next packing. If omitted, the next packing is shifted by `n` elements.

Specifying the attribute `:iteritem` returns an iterator as its element instead of a list

If the last packing doesn't satisfy `n` elements, its list would be shorter than `n`. When specifying the attribute `:neat`, such an immature list would be eliminated.

Following is an example to fold elements by 3:

```
x = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H'].fold(3)
// x generates ['A', 'B', 'C'], ['D', 'E', 'F'], ['G', 'H'].
```

Following is an example to fold elements by 3 with a step of 2:

```
x = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H'].fold(3, 2)
// x generates ['A', 'B', 'C'], ['C', 'D', 'E'], ['E', 'F', 'G'], ['G', 'H'].
```

### iterable#format

`iterable#format(format:string):map {block?}`

Creates an iterator that converts element values in the source iterable into strings depending on formatter specifier in `format`.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

### iterable#head

`iterable#head(n:number):map {block?}`

Creates an iterator that takes the first `n` elements from the source iterable.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.

- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### iterable#join

`iterable#join(sep?:string):map`

Joins all the elements in the iterable as strings while inserting the specified separator `sep` and returns the result.

If an element is not a `string` value, it would be converted to a `string` before being joined.

#### iterable#joinb

`iterable#joinb()`

Joins all the `binary` values in the iterable and returns the result.

#### iterable#len

`iterable#len()`

Returns the length of the iterable.

#### iterable#map

`iterable#map(func:function) {block?}`

Creates an iterator that generates element values after applying the specified function on them. The function must take one argument.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### iterable#max

`iterable#max():[index,indices,last_index]`

Returns the maximum value in the iterable.

It would return a position index where the maximum value is found when one of the following attribute is specified:

- `:index` .. an index of the maximum value.
- `:indices` .. a list of indices where the maximum value is found.

- `:last_index` .. the last index of the maximum value when the value exists at multiple positions.

#### iterable#min

`iterable#min(): [index, indices, last_index]`

Returns the minimum value in the iterable.

It would return a position index where the minimum value is found when one of the following attribute is specified:

- `:index` .. an index of the minimum value.
- `:indices` .. a list of indices where the minimum value is found.
- `:last_index` .. the last index of the minimum value when the value exists at multiple positions.

#### iterable#nilto

`iterable#nilto(replace) {block?}`

Creates an iterator that converts `nil` in the source iterable to the specified value.

#### iterable#offset

`iterable#offset(n:number) {block?}`

Creates an iterator that returns skips the first `n` elements in the source iterable.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below is an example:

```
x = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H'].offset(3)
// x generates 'D', 'E', 'F', 'G', 'H'
```

#### iterable#or

`iterable#or()`

Calculates a logical OR result of all the values in the iterable.

#### iterable#pack

`iterable#pack(format:string) {block?}`

Creates a **binary** instance that has packed elements in the iterable according to specifiers in the **format** .

A specifier has a format of "**nX** " where **X** is a format character that represents a packing format and **n** is a number of packing size. The number can be omitted, and it would be treated as 1 in that case.

Following format characters would take a **number** value from the argument list and pack them into a binary sequence.

- **b** .. A one-byte signed number.
- **B** .. A one-byte unsigned number.
- **h** .. A two-byte signed number.
- **H** .. A two-byte unsigned number.
- **i** .. A four-byte signed number.
- **I** .. A four-byte unsigned number.
- **l** .. A four-byte signed number.
- **L** .. A four-byte unsigned number.
- **q** .. A eight-byte signed number.
- **Q** .. A eight-byte unsigned number.
- **f** .. A float-typed number occupying four bytes.
- **d** .. A double-typed number occupying eight bytes.

As for them, the packing size **n** means the number of values to be packed.

Following format characters would take a **string** value from the argument list and pack them into a binary sequence.

- **s** .. Packs a sequence of UTF-8 codes in the string. The packing size **n** means the size of the room in bytes where the character codes are to be packed. Only the sequence within the allocated room would be packed. If the string length is smaller than the room, the lacking part would be filled with zero.
- **c** .. Picks the first byte of the string and packs it as a one-byte unsigned number. The packing size **n** means the number of values to be packed.

Following format character would take no value from the argument list.

- **x** .. Fills the binary with zero. The packing size **n** means the size of the room in bytes to be filled with zero.

The default byte-order for numbers of two-byte, four-byte and eight-byte depends on the system the interpreter is currently running. You can change it by the following specifiers:

- **@** .. System-dependent order.
- **=** .. System-dependent order.
- **<** .. Little endian
- **>** .. Big endian
- **!** .. Big endian

You can specify an asterisk character "\*" for the number of packing size that picks that number from the argument list.

You can specify encoding name embraced with "{ " and "}" in the format to change coding character set while packing a string with format character "s" from UTF-8.

#### iterable#pingpong

```
iterable#pingpong(n?:number):[sticky,sticky@top,sticky@btm] {block?}
```

Creates an iterator that iterates elements in the source iterator from top to bottom, and then from bottom to top repeatedly.

The argument **n** specifies the number of elements the created iterator returns. If omitted, it would iterates elements infinitely.

Below is an example:

```
x = ['A', 'B', 'C', 'D', 'E'].pingpong()
// x generates 'A', 'B', 'C', 'D', 'E', 'D', 'C', 'B', 'A', 'B', ..
```

The following attributes specify whether the elements on top and bottom are duplicated:

- **:sticky** .. Duplicate the top and bottom elements.
- **:sticky@top** .. Duplicate the top element.
- **:sticky@btm** .. Duplicate the bottom element.

Below is an example:

```
x = ['A', 'B', 'C', 'D', 'E'].pingpong():sticky
// x generates 'A', 'B', 'C', 'D', 'E', 'E', 'D', 'C', 'B', 'A', 'A', 'B', ..
```

#### iterable#print

```
iterable#print(stream?:stream:w):void
```

Prints elements to the specified **stream** .

If omitted, they are printed to the standard output.

#### iterable#printf

```
iterable#printf(format:string, stream?:stream:w):void
```

Prints items in the iterable by using the format.

#### iterable#println

```
iterable#println(stream?:stream:w):void
```

#### iterable#rank

```
iterable#rank(directive?) {block?}
```

Creates an iterable of rank numbers for elements after sorting them.

In default, they are sorted in an ascending order. This means that, if two elements **x** and **y** has the relationship of **x < y** , **x** would be placed before **y** . You can change the order by specifying the argument **directive** with the following symbols:

- **'ascend** .. Sorts in an ascending order. This is the default.
- **'descend** .. Sorts in a descending order.

You can also put a function to the argument **directive** that takes two arguments **x** and **y** and is expected to return numbers below:

- `x == y` .. Zero.
- `x < y` .. A number less than zero.
- `x > y` .. A number greater than zero.

When an attribute `:stable` is specified, the original order shall be kept for elements that are determined as the same.

#### iterable#reduce

`iterable#reduce(accum) {block}`

Evaluates a block with a parameter format `|value, accum|` and leaves the result as the next `accum` value.

It returns the final `accum` value as its result.

Below is an example to calculate summation of the elements:

```
x = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
n = x.reduce(0) {|value, accum| value + accum}
// n is 55
```

#### iterable#replace

`iterable#replace(value, replace) {block?}`

Creates an iterator that replaces the `value` in the original iterable with the value of `replace`. In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### iterable#reverse

`iterable#reverse() {block?}`

Creates an iterator that iterates elements in the source iterable from tail to top.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.



- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### iterable#roundoff

```
iterable#roundoff(threshold:number => 1e-10) {block?}
```

Creates an iterator that replaces a number with zero if it is less than the specified `threshold` . In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### iterable#runlength

```
iterable#runlength() {block?}
```

Creates an iterator that counts the number of consecutive same value and generates elements in a form of `[cnt, value]` where `cnt` indicates how many `value` appears in a row. In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below is an example:

```
x = ['A', 'A', 'B', 'C', 'C', 'C', 'D', 'D'].runlength()
// x generates [2, 'A'], [1, 'B'], [3, 'C'], [2, 'D']
```

### iterable#since

`iterable#since(criteria) {block?}`

Creates an iterator that picks up each element in the iterable since criteria is evaluated as true. You can specify a function object, a list or an iterator as the criteria.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

### iterable#skip

`iterable#skip(n:number) {block?}`

Creates an iterator that skips `n` elements before picking up next element.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below is an example:

```
x = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H'].skip(2)
// x generates 'A', 'D', 'G'
```

### iterable#skipnil

`iterable#skipnil() {block?}`

Creates an iterator that skips `nil` in the source iterable.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.

- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below is an example:

```
x = ['A', nil, 'C', nil, nil, 'F', nil, 'H'].skipnil()
// x generates 'A', 'C', 'F', 'H'
```

### iterable#sort

```
iterable#sort(directive?, keys[]?):[stable] {block?}
```

Creates an iterator of elements after sorting them.

In default, they are sorted in an ascending order. This means that, if two elements `x` and `y` has the relationship of `x < y`, `x` would be placed before `y`. You can change the order by specifying the argument `directive` with the following symbols:

- `'ascend` .. Sorts in an ascending order. This is the default.
- `'descend` .. Sorts in a descending order.

You can also put a function to the argument `directive` that takes two arguments `x` and `y` and is expected to return numbers below:

- `x == y` .. Zero.
- `x < y` .. A number less than zero.
- `x > y` .. A number greater than zero.

When an attribute `:stable` is specified, the original order shall be kept for elements that are determined as the same. If the argument `keys` is specified, it would be used as a key instead of element values.

### iterable#stddev

```
iterable#stddev()
```

Calculates a standard deviation of elements in the iterable.

### iterable#sum

```
iterable#sum()
```

Calculates a summation of elements in the iterable.

It can work on an iterable with elements of a value type that supports addition operator. Below is a list of acceptable value types:

- `number`
- `complex`
- `string`

- `matrix`
- `rational`
- `timedelta`
- `gmp.mpz`
- `gmp.mpq`
- `gmp.mpf`

#### iterable#tail

`iterable#tail(n:number) {block?}`

Creates an iterator that takes the last `n` elements from the source iterable. In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### iterable#until

`iterable#until(criteria) {block?}`

Creates an iterator that picks up each element in the list until `criteria` is evaluated as true. You can specify a function object, a list or an iterator as the `criteria`. In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### iterable#variance

`iterable#variance()`

Calculates a variance of elements in the iterable.

#### iterable#walk

`iterable#walk(): [bfs,dfs] {block?}`

Creates an iterator that searches items recursively if they are lists or iterators.

Specifying an attribute could customize searching order as below:

- `:dfs` .. Searches in depth-first order. This is the default behavior.
- `:bfs` .. Searches in breadth-first order.

Unlike `iterator#flat()` , `iterator#walk()` creates an iterator with an infinite flag. This means that the created iterator is intended only for iteration and can not be converted to a list. In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

Below is an example:

```
x = [['A', 'B', 'C'], ['D', 'E', ['F', 'G', 'H'], 'I', 'J'], 'K', 'L']

y = x.walk():dfs
// y generates 'A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I', 'J', 'K', 'L'

y = x.walk():bfs
// y generates 'K', 'L', 'A', 'B', 'C', 'D', 'E', 'I', 'J', 'F', 'G', 'H'
```

#### iterable#while

`iterable#while (criteria) {block?}`

Creates an iterator that picks up each element in the list while criteria is evaluated as true. You can specify a function object, a list or an iterator as the criteria.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

## 6.21 matrix Class

The `matrix` class provides measures to calculate matrices.

### Creating Matrix

Below shows a way to create a matrix instance:

```
@@{{1, 2, 3}, {4, 5, 6}, {7, 8, 9}}
```

#### 6.21.1 Constructor

##### matrix

```
matrix(nrows:number, ncols:number, value?) {block?}
```

Creates a `matrix` instance that has specified rows and columns.

The content of the content will be initialized with `value` . If omitted, it will be initialized with zero value.

If `block` is specified, it would be evaluated with a block parameter `|mat:matrix|` , where `mat` is the created instance. In this case, the block's result would become the function's returned value.

#### 6.21.2 Method

##### matrix#col

```
matrix#col(col:number):map
```

Returns a list of values copied from a specified column of the matrix. Modification on the returned sub matrix will affect on the original one.

##### matrix#colsize

```
matrix#colsize()
```

Returns the matrix column size.

##### matrix#each

```
matrix#each():[transpose]
```

Returns an iterator that picks up each cell by scanning the matrix. In default, that scan is done in a horizontal direction. When an attribute `:transpose` is specified, it's done in a vertical direction.

##### matrix#eachcol

```
matrix#eachcol()
```

Returns an iterator that generates lists of values copied from each column of the matrix.

##### matrix#eachrow

```
matrix#eachrow()
```

Returns an iterator that generates lists of values copied from each row of the matrix.

##### matrix.identity

```
matrix.identity(n:number):static:map {block?}
```

matrix#invert

`matrix#invert()`

Returns an inverted matrix.

matrix#issquare

`matrix#issquare()`

Returns true if the matrix is a square one.

matrix.rotation

`matrix.rotation(angle:number, tx?:number, ty?:number):static:map:[deg] {block?}`

Creates a matrix that rotates a two-dimensional coordinate by the specified angle in radian unit.

In addition to rotation, you can add translation factors by the arguments `tx` and `ty` that specify translation amount of x and y respectively.

You can specify the angle in degree unit by appending `:deg` attribute.

Below is an example to create a matrix that rotates 30 degrees.

```
mat = matrix.rotation(30):deg
```

If `block` is specified, it would be evaluated with a block parameter `|mat:matrix|`, where `mat` is the created instance. In this case, the block's result would become the function's returned value.

matrix.rotation@x

`matrix.rotation@x(angle:number, tx?:number, ty?:number, tz?:number):static:map:[deg] {block?}`

Creates a matrix that rotates a three-dimensional coordinate around x-axis by the specified angle in radian unit.

In addition to rotation, you can add translation factors by the arguments `tx`, `ty` and `tz` that specify translation amount of x, y and z respectively.

You can specify the angle in degree unit by appending `:deg` attribute.

Below is an example to create a matrix that rotates 30 degrees around x-axis.

```
mat = matrix.rotation@x(30):deg
```

If `block` is specified, it would be evaluated with a block parameter `|mat:matrix|`, where `mat` is the created instance. In this case, the block's result would become the function's returned value.

matrix.rotation@y

`matrix.rotation@y(angle:number, tx?:number, ty?:number, tz?:number):static:map:[deg] {block?}`

Creates a matrix that rotates a three-dimensional coordinate around y-axis by the specified angle in radian unit.

In addition to rotation, you can add translation factors by the arguments `tx`, `ty` and `tz` that specify translation amount of x, y and z respectively.

You can specify the angle in degree unit by appending `:deg` attribute.

Below is an example to create a matrix that rotates 30 degrees around y-axis.

```
mat = matrix.rotation@y(30):deg
```

If `block` is specified, it would be evaluated with a block parameter `|mat:matrix|`, where `mat` is the created instance. In this case, the block's result would become the function's returned value.

### matrix.rotation@z

```
matrix.rotation@z(angle:number, tx?:number, ty?:number, tz?:number):static:map:[deg] {block?}
```

Creates a matrix that rotates a three-dimensional coordinate around z-axis by the specified angle in radian unit.

In addition to rotation, you can add translation factors by the arguments `tx` , `ty` and `tz` that specify translation amount of x, y and z respectively.

You can specify the angle in degree unit by appending `:deg` attribute.

Below is an example to create a matrix that rotates 30 degrees around z-axis.

```
mat = matrix.rotation@z(30):deg
```

If `block` is specified, it would be evaluated with a block parameter `|mat:matrix|` , where `mat` is the created instance. In this case, the block's result would become the function's returned value.

### matrix#roundoff

```
matrix#roundoff(threshold:number => 1e-10) {block?}
```

Returns a matrix with element values being rounded off.

The argument `threshold` specifies the threshold value for the round-off.

If `block` is specified, it would be evaluated with a block parameter `|mat:matrix|` , where `mat` is the created instance. In this case, the block's result would become the function's returned value.

### matrix#row

```
matrix#row(row:number):map
```

Returns a list of values copied from a specified row of the matrix. Modification on the returned sub matrix will affect on the original one.

### matrix#rowsize

```
matrix#rowsize()
```

Returns the matrix row size.

### matrix#set

```
matrix#set(value)
```

Sets all the cells of the matrix with a specified value.

### matrix#setcol

```
matrix#setcol(col:number, value)
```

Sets cells in a selected column of the matrix with a specified value.

### matrix#setrow

```
matrix#setrow(row:number, value)
```

Sets cells in a selected row of the matrix with a specified value.

### matrix#submat

```
matrix#submat(row:number, col:number, nrow:number, ncol:number):map
```

Returns a sub matrix that refers to cells in a specified area of the matrix. Modification on the returned sub matrix will affect on the original one.



matrix#tolist

`matrix#tolist():[transpose]`

Converts the matrix into a list containing sub-lists that represents its rows.

If `:transpose` attribute is specified, each sub-list contains values of corresponding column.

If `:flat` attribute is specified, it generates one-dimensional list.

Below is an example:

```
@@{{1, 2, 3}, {4, 5, 6}, {7, 8, 9}}.tolist()
[[1, 2, 3], [4, 5, 6], [7, 8, 9]]
```

Below is an example with `:transpose` attribute:

```
@@{{1, 2, 3}, {4, 5, 6}, {7, 8, 9}}.tolist():transpose
[[1, 4, 7], [2, 5, 8], [3, 6, 9]]
```

matrix#transpose

`matrix#transpose()`

Returns a transposed matrix.

## 6.22 nil Class

## 6.23 number Class

The `number` class provides measures to calculate numbers.

### 6.23.1 Method

number.roundoff

`number.roundoff(threshold:number => 1e-10)`

## 6.24 operator Class

The `operator` class provides measures to assign operators with a user-defined procedure.

### 6.24.1 Property

An `operator` instance has the following properties:

Property	Type	R/W	Explanation
<code>operator#symbol</code>	<code>symbol</code>	R	Operator symbol.

### 6.24.2 Constructor

operator

`operator(symbol:symbol):map {block?}`

Creates an `operator` instance that is associated with the specified symbol.

If `block` is specified, it would be evaluated with a block parameter `|op:operator|`, where `op` is the created instance. In this case, the block's result would become the function's returned value.

Below is an example to create an `operator` instance that is associated with the plus symbol.

```
op = operator('+')
```

### 6.24.3 Method

`operator#assign`

`operator#assign(type_l:expr, type_r?:expr):map:void {block}`

Associates the `operator` instance with a procedure described in `block` that takes values as a block parameter and returns its operation result.

Some `operator` instances have two forms of expression: unary and binary. This method assigns the procedure to one of them according to how it takes its arguments as below:

- `operator#assign(type:expr)` .. Assigns procedure to the unary form.
- `operator#assign(type_l:expr, type_r:expr)` .. Assigns procedure to the binary form.

They take different format of block parameters as below:

- `|value|` .. For unary form.
- `|value_l, value_r|` .. For binary form.

Below is an example to assign a procedure to a unary form of operator `-`.

```
operator('-').assign('string') = {|value|  
  // any job  
}
```

Below is an example to assign a procedure to a binary form of operator `-`.

```
operator('-').assign('string', 'number') = {|value_l, value_r|  
  // any job  
}
```

`operator#entries`

`operator#entries(type?:symbol)`

Returns a list that contains type expressions that the operator can accept as its arguments.

The argument `type` takes a symbol `'binary` or `'unary`.

- If it's omitted or specified with `'binary`, the method would return a list of pairs of type expressions for its left element and right one.
- If it's specified with `'unary`, the method would return a list of type expressions for its single element.

## 6.25 palette Class

The `palette` instance has a set of `color` instance.

### 6.25.1 Constructor

#### palette

`palette(type) {block?}`

Creates a `palette` instance.

If `block` is specified, it would be evaluated with a block parameter `|plt:palette|`, where `plt` is the created instance. In this case, the block's result would become the function's returned value.

This function can be called in the following two forms:

- `palette(n:number)` .. Creates an instance with the specified number of entries. All the entries are initialized with a color of black.
- `palette(type:symbol)` .. Creates an instance initialized with a pre-defined set of entries associated with the specified symbol.

In the second form, it can take one of the following symbols:

- `'basic` .. A palette with 16 basic colors that are: `color.black`, `color.maroon`, `color.green`, `color.olive`, `color.navy`, `color.purple`, `color.teal`, `color.gray`, `color.silver`, `color.red`, `color.lime`, `color.yellow`, `color.blue`, `color.fuchsia`, `color.aqua` and `color.white`.
- `'win256` .. A palette with 256 colors defined by Windows.
- `'websafe` .. A palette with 216 colors that assure to be displayed correctly in any Web environments. It actually has 256 entries though the last 40 entries are initialized with black.

### 6.25.2 Method

#### palette#each

`palette#each() {block?}`

Creates an iterator that iterates each element in the palette.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### palette#nearest

`palette#nearest(color:color):map:[index]`

Returns a `color` instance in the palette that is the nearest with the specified color.

If the attribute `:index` is specified, it would return an index of the nearest entry instead of its `color` instance.

palette#shrink

```
palette#shrink():reduce:[align]
```

Shrinks the size of the palette to a number powered by two that is enough to contain unique entries. The order of existing entries will be kept intact.

palette#updateby

```
palette#updateby(image_or_palette):reduce:[align,shrink]
```

Updates palette entries according to color data in an image or a palette. The order of existing entries will be kept intact. If attribute `shrink` is specified, the whole size will be shrunk to a number powered by two that is enough to contain unique entries.

## 6.26 pointer Class

The `pointer` class provides measures to read and write content in a `binary` instance.

### 6.26.1 Property

A `pointer` instance has the following properties:

Property	Type	R/W	Explanation
<code>binary</code>	<code>binary</code>	R	A <code>binary</code> instance associated with the pointer.
<code>offset</code>	<code>number</code>	R	The current offset.

### 6.26.2 Constructor

pointer

```
pointer(buff:binary, offset?:number) {block?}
```

Creates a `pointer` instance that points to the specified `binary` instance.

### 6.26.3 Method

pointer#forward

```
pointer#forward(distance:number):reduce
```

pointer#pack

```
pointer#pack(format:string, value+):reduce:[stay]
```

pointer#reset

```
pointer#reset()
```

pointer#unpack

```
pointer#unpack(format:string, values*:number):[nil,stay]
```

pointer#unpacks

```
pointer#unpacks(format:string, values*:number)
```

## 6.27 rational Class

The `rational` class provides measures to handle rational numbers. You can create a `rational` instance with following ways:

- Use `rational()` function.
- Append `r` suffix after a number literal.

Below are examples to realize a common fraction two-thirds:

```
rational(2, 3)
2r / 3
2 / 3r
```

### 6.27.1 Constructor

rational

```
rational(number:number, denom?:number):map {block?}
```

Creates a rational value from given numerator `number` and denominator `denom` .

If the argument `denom` is omitted, one is set as its denominator.

If `block` is specified, it would be evaluated with a block parameter `|r:rational|` , where `r` is the created instance. In this case, the block's result would become the function's returned value.

### 6.27.2 Method

rational.reduce

```
rational.reduce()
```

Reduces the rational number by dividing its numerator and denominator by their GCD.

## 6.28 semaphore Class

### 6.28.1 Constructor

semaphore

```
semaphore()
```

### 6.28.2 Method

semaphore#release

```
semaphore#release()
```

Releases the ownership of the semaphore that is grabbed by `semaphore#wait()`.

semaphore#session

```
semaphore#session() {block}
```

Forms a critical session by grabbing the semaphore's ownership, executing the block and releasing that ownership. It internally processes the same job as `semaphore#wait()` and `semaphore#release()` before and after the block execution

semaphore#wait  
`semaphore#wait()`

Watis for the semaphore being released by other threads, and ghen grabs that ownership.

## 6.29 stream Class

The `stream` class provides methods to read and write data through a stream, an abstract structure to handle a byte sequence. It also provides information of the stream such as the pathname and the creation date and time.

### 6.29.1 Property

A `stream` instance has the following properties:

Property	Type	R/W	Explanation
<code>stream#stat</code>	<code>object</code>	R	Status of the stream.
<code>stream#name</code>	<code>string</code>	R	Name of the stream.
<code>stream#identifier</code>	<code>string</code>	R	Identifier of the stream.
<code>stream#readable</code>	<code>boolean</code>	R	Indicates whether the stream is readable.
<code>stream#writable</code>	<code>boolean</code>	R	Indicates whether the stream is writable.
<code>stream#codec</code>	<code>codec</code>	R	'codec' instance associated with the stream.

### 6.29.2 Operator

You can use the operator "`<<`" to output a content of a value to a `stream` . It comes like "`stream << obj`" where `obj` is converted to a string before output to the stream.

```
sys.stdout << 'Hello World.'
```

Since the operator returns the `stream` instance specified on the left as its result, you can chain multiple operations as below:

```
sys.stdout << 'First' << 'Second'
```

### 6.29.3 Cast Operation

A function that expects a `stream` instance in its argument can also take a value of `string` and `binary` as below:

- `string` .. Recognized as a path name from which `stream` instance is created.
- `binary` .. Creates a `stream` instance that contains the specified binary data.

Using the above casting feature, you can call a function `f(stream:stream)` that takes a `stream` instance in its argument as below:

- `f(stream('foo.txt'))` .. The most explicit way.
- `f('foo.txt')` .. Implicit casting: from `string` to `stream` .
- `f(b'\x00\x12\x34\x56')` .. Implicit casting: from `binary` to `stream` .

## 6.29.4 Constructor

### stream

`stream(pathname:string, mode?:string, codec?:codec):map {block?}`

Creates a `stream` instance from the specified `pathname` .

The argument `mode` takes one of the strings that specifies what access should be allowed with the stream. If omitted, the stream would be opened with read mode.

- `'r'` .. read
- `'w'` .. write
- `'a'` .. append

The argument `codec` specifies a name of the character codec that converts between the stream's character code and UTF-8, which is a code used in the interpreter's internal process.

If `block` is specified, it would be evaluated with a block parameter `|s:stream|` , where `s` is the created instance. In this case, the block's result would become the function's returned value.

You can also call `open()` function that is just an alias of `stream()` to create a `stream` instance.

## 6.29.5 Utility Function

### readlines

`readlines(stream?:stream:r):[chop] {block?}`

Creates an iterator that reads text from the specified stream line by line.

If attribute `:chop` is specified, it eliminates an end-of-line character that appears at the end of each line.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

## 6.29.6 Method

### stream#addcr

`stream#addcr(flag?:boolean):reduce`

The codec's encoder in the stream has a feature to add a CR code (0x0d) before a LF code (0x0a) so that the lines are joined with CR-LF codes in the encoded result. This method enables or disables the feature.

- To enable it, call the method with the argument `flag` set to `true` or without any argument.
- To disable it, call the method with the argument `flag` set to `false` .

#### stream#close

`stream#close():void`

Closes the stream.

#### stream#compare

`stream#compare(stream:stream:r):map`

Returns `true` if there's no difference between the binary sequences of the target stream instance and that of `stream` in the argument.

#### stream.copy

`stream.copy(src:stream:r, dst:stream:w, bytesunit:number => 65536):static:map:void:[finalize] {block?}`

Copies the content in `src` to the stream `dst` .  
The copying is done by the following process:

1. Reads data from stream `src` into a buffer with the size specified by `bytesunit` .
2. If `block` is specified, it would be evaluated with a block parameter `|buff:binary|` where `buff` contains the read data. When the block's result is a `binary` instance, the content would be written to the stream `dst` . Otherwise, the read data would be written to stream `dst` .
3. If `block` is not specified, !!the read data would be written to stream `dst` .
4. Continues from step 1 to 3 until data from `src` runs out.

If the attribute `:finalize` is specified, some finalizing process will be applied at the end such as copying time stamp and attributes.

This has the same feature as `stream#copyfrom()` and `stream#copyto()` .

#### stream#copyfrom

`stream#copyfrom(src:stream:r, bytesunit:number => 65536):map:reduce:[finalize] {block?}`

Copies the content in `src` to the target stream instance.  
The copying is done by the following process:

1. Reads data from stream `src` into a buffer with the size specified by `bytesunit` .
2. If `block` is specified, it would be evaluated with a block parameter `|buff:binary|` where `buff` contains the read data. When the block's result is a `binary` instance, the content would be written to the stream `dst` . Otherwise, the read data would be written to stream `dst` .
3. If `block` is not specified, !!the read data would be written to stream `dst` .
4. Continues from step 1 to 3 until data from `src` runs out.

If the attribute `:finalize` is specified, some finalizing process will be applied at the end such as copying time stamp and attributes.

This has the same feature as `stream.copy()` and `stream#copyto()` .

#### stream#copyto

`stream#copyto(stream:stream:w, bytesunit:number => 65536):map:reduce:[finalize] {block?}`



Copies the content in the target stream instance to stream `dst` .  
The copying is done by the following process:

1. Reads data from stream `src` into a buffer with the size specified by `bytesunit` .
2. If `block` is specified, it would be evaluated with a block parameter `|buff:binary|` where `buff` contains the read data. When the block's result is a `binary` instance, the content would be written to the stream `dst` . Otherwise, the read data would be written to stream `dst` .
3. If `block` is not specified, !!the read data would be written to stream `dst` .
4. Continues from step 1 to 3 until data from `src` runs out.

If the attribute `:finalize` is specified, some finalizing process will be applied at the end such as copying time stamp and attributes.

This has the same feature as `stream.copy()` and `stream#copyfrom()` .

#### stream#delcr

`stream#delcr(flag?:boolean):reduce`

The codec's decoder in the stream has a feature to delete a CR code (0x0d) before a LF code (0x0a) so that the lines are joined with LF code in the decoded result. This method enables or disables the feature.

- To enable it, call the method with the argument `flag` set to `true` or without any argument.
- To disable it, call the method with the argument `flag` set to `false` .

#### stream#deserialize

`stream#deserialize()`

#### stream#flush

`stream#flush():void`

Flushes cached data to the stream.

#### stream#peek

`stream#peek(len?:number)`

Reads specified length of data from the stream and returns a `binary` instance that contains it. This doesn't move the stream's current file position.

#### stream#print

`stream#print(values*):map:void`

Prints out `values` to the `stream` instance.

#### stream#printf

`stream#printf(format:string, values*):map:void`

Prints out `values` to the `stream` instance according to formatter specifiers in `format` .  
Refer to the help of `printf()` function to see information about formatter specifiers.

#### stream#println

`stream#println(values*):map:void`

Prints out `values` and an end-of-line character to the `stream` instance.

#### stream#read

`stream#read(len?:number)`

Reads specified length of data from the stream and returns a **binary** instance that contains it. If the argument `len` is omitted, all the data available from the stream would be read.

#### stream#readchar

`stream#readchar()`

Reads one character from the stream and returns a **string** instance that contains it.

#### stream#readline

`stream#readline():[chop]`

Reads one line from the stream and returns a **string** instance that contains it. If the attribute `:chop` is specified, it would remove the last new line character from the result.

#### stream#readlines

`stream#readlines(nlines?:number):[chop] {block?}`

Creates an iterator that reads text from the specified stream line by line. The argument `nlines` specifies how many lines should be read from the stream. If omitted, it would read all the lines. If attribute `:chop` is specified, it eliminates an end-of-line character that appears at the end of each line. In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### stream#readtext

`stream#readtext()`

Reads the whole data in the stream as a text sequence and returns a **string** instance that contains it.

#### stream#seek

`stream#seek(offset:number, origin?:symbol):reduce`

#### stream#serialize

`stream#serialize(value):void`

#### stream#setcodec

`stream#setcodec(codec:codec:nil):reduce`

stream#tell  
`stream#tell()`

Returns the current file position at which read/write operation works.

stream#write  
`stream#write(buff:binary, len?:number):reduce`

Writes binary data contained in `buff` to the stream. The argument `len` limits the number of data that is to be written to the stream.

## 6.30 string Class

The `string` class provides measures to operate on strings. You can create a `string` instance by embracing a sequence of characters with a pair of single- or double-quotes.

```
'Hello World'

"Hello World"
```

If you need to declare a string that contains multiple lines, embrace it with a pair of sequences of three single- or double-quotes.

```
'''first line
second line
third line
'''
```

### 6.30.1 Suffix Management

When an string literal is suffixed by a character `$`, a handler registered by `string.translate()` function that is supposed to translate the string into other natural languages would be evaluated.

### 6.30.2 Method

string#align  
`string#align(width:number, padding:string => ' '):map:[center,left,right]`

Align the string to the left, right or center within the specified `width` and returns the result. The following attributes specify the alignment position:

- `:center` .. Aligns to the center. This is the default.
- `:left` .. Aligns to the left
- `:right` .. Aligns to the right

If the string width is narrower than the specified `width`, nothing would be done. It uses a string specified by the argument `padding` to fill lacking spaces. If omitted, a white space is used for padding.

This method takes into account the character width based on the specification of East Asian Width. A kanji-character occupies two characters in width.

string.binary  
`string.binary()`

Converts the string into `binary` instance.

string#capitalize

`string#capitalize()`

Returns a string that capitalizes the first character.

string#chop

`string#chop(suffix*:string):[eol,icase]`

Returns a string that removes a last character.

If an attribute `:eol` is specified, only the end-of-line character shall be removed. In this case, if the end-of-line has a sequence of CR-LF, CR code shall be removed as well.

string#decodeuri

`string#decodeuri()`

Returns a string in which percent-encoded characters are decoded.

string#each

`string#each():map:[utf32,utf8] {block?}`

Creates an iterator generating strings of each character in the original one.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

string#eachline

`string#eachline(nlines?:number):[chop] {block?}`

Creates an iterator generating strings of each line in the original one.

In default, end-of-line characters are involved in the result. You can eliminates them by specifying `:chop` attribute.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.

- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### string#embed

`string#embed(dst?:stream:w):[lasteol,noindent]`

Evaluates a string that contains embedded scripts and renders the result to the specified stream. If the stream is omitted, the function returns the rendered result as a string.

Calling this method is equivalent to calling a method `string#template()` to create a `template` instance on which a method `template#render()` is applied afterward.

#### string.encode

`string.encode(codec:codec)`

Encodes the string with the given `codec` and return the result as a `binary` .

#### string#encodeuri

`string#encodeuri()`

Returns a string in which non-URIC characters are percent-encoded.

#### string#endswith

`string#endswith(suffix:string, endpos?:number):map:[icase,rest]`

Returns `true` if the string ends with suffix.

If attribute `:rest` is specified, it returns the rest part if the string ends with suffix, or `nil` otherwise. You can specify a bottom position for the matching by an argument `endpos` .

With an attribute `:icase` , character cases are ignored while matching.

#### string#escapehtml

`string#escapehtml():[quote]`

Returns a string that converts characters into escape sequences.

#### string#find

`string#find(sub:string, pos:number => 0):map:[icase,rev]`

Finds a sub string from the string and returns its position.

Number of position starts from zero. You can specify a position to start finding by an argument `pos`. It returns `nil` if finding fails.

With an attribute `:icase` , case of characters are ignored while finding.

When an attribute `:rev` , finding starts from tail of the string

#### string#fold

`string#fold(len:number, step?:number):[neat] {block?}`

Creates an iterator that folds the source string by the specified length.

The argument `step` specifies the length of advancement for the next folding point. If omitted, it would be the same amount as `len` .

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.

- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### string#foldw

`string#foldw(width:number):[padding] {block?}`

Creates an iterator that folds the source string by the specified width. This method takes into account the character width based on the specification of East Asian Width.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### string#format

`string#format(values*):map`

Taking the string instance as a printf-styled formatter string, it converts `values` into a string depending on formatter specifiers in it.

#### string#isempty

`string#isempty()`

Returns `true` if the string is empty.

#### string#left

`string#left(len?:number):map`

Extracts the specified length of string from left of the source string. If the argument is omitted, it would return whole the source string.

#### string#len

`string#len()`

Returns the length of the string in characters.

### string#lower

`string#lower()`

Converts upper-case to lower-case characters.

### string#mid

`string#mid(pos:number => 0, len?:number):map`

Extracts the specified length of string from the position `pos` and returns the result.

If an argument `len` is omitted, it returns a string from `pos` to the end. The number of an argument `pos` starts from zero.

Below are examples:

```
'Hello world'.mid(3, 2) // 'lo'
'Hello world'.mid(5)    // 'world'
```

### string.print

`string.print(stream?:stream:w):void`

Prints out the string to the specified `stream`.

If the argument is omitted, it would print to the standard output.

### string.println

`string.println(stream?:stream:w):void`

Prints out the string and a line-break to the specified `stream`.

If the argument is omitted, it would print to the standard output.

### string#reader

`string#reader() {block?}`

Returns a `stream` instance that reads the string content as a binary sequence.

If `block` is specified, it would be evaluated with a block parameter `|s:stream|`, where `s` is the created instance. In this case, the block's result would become the function's returned value.

### string#replace

`string#replace(match:string, sub:string, count?:number):map:[icase] {block?}`

Replaces sub strings that matches the string `match` with a string specified by `sub` and returns the result.

The argument `count` limits the maximum number of substitution. If omitted, there's no limit of the work.

With an attribute `:icase`, character cases are ignored while matching strings.

If `block` is specified, it would be evaluated with a block parameter `|result:string, replaced:boolean|`, where `result` is the result string and `replaced` indicates if there is any change between the result and its original string. In this case, the block's result would become the function's returned value.

### string#replaces

`string#replaces(map[]:string, count?:number):map:[icase] {block?}`

Replaces string parts according to a list of pairs of a matching and a substituting string and returns the result.

The argument `map` contains the replacing list in a format of `[match1, sub1, match2, sub2, ...]`.

The argument `count` limits the maximum number of substitution. If omitted, there's no limit of the work.

With an attribute `:icase` , character cases are ignored while matching strings.

If `block` is specified, it would be evaluated with a block parameter `|result:string, replaced:boolean|` , where `result` is the result string and `replaced` indicates if there is any change between the result and its original string. In this case, the block's result would become the function's returned value.

#### string#right

`string#right(len?:number):map`

Extracts the specified length of string from right of the source string.

If the argument is omitted, it would return whole the source string.

#### string#split

`string#split(sep?:string, count?:number):[icase] {block?}`

Creates an iterator generating sub strings extracted from the original one separated by a specified string `sep` . With an attribute `:icase` , character cases are ignored while finding the separator.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### string#startswith

`string#startswith(prefix:string, pos:number => 0):map:[icase,rest]`

Returns `true` if the string starts with `prefix` .

If attribute `:rest` is specified, it returns the rest part if the string starts with prefix, or `nil` otherwise. You can specify a top position for the matching by an argument `pos` .

With an attribute `:icase` , character cases are ignored while matching.

#### string#strip

`string#strip():[both,left,right]`

Returns a string that removes space characters on the left, the right or the both sides of the original string.

The following attributes would specify which side of spaces should be removed:

- `:both` .. Removes spaces on both sides. This is the default.
- `:left` .. Removes spaces on the left side.
- `:right` .. Removes spaces on the right side.



#### string#template

`string#template():[lasteol,noindent] {block?}`

Parses the content of the string as a text containing embedded scripts and returns a `template` instance.

#### string#tosymbol

`string#tosymbol()`

Converts the string into a symbol.

#### string.translator

`string.translator():static:void {block}`

Register a procedure evaluated when a string literal appears with a suffix symbol "\$ ", which is meant to translate the string into another language.

The procedure is described in `block` takes a block parameter `|str:string|` where `str` is the original string, and is expected to return a string translated from the original.

#### string#unescapehtml

`string#unescapehtml()`

Converts escape sequences into readable characters.

#### string#upper

`string#upper()`

Converts lower-case to upper-case characters.

#### string#width

`string#width()`

Returns the width of the string.

This method takes into account the character width based on the specification of East Asian Width. For example, a kanji-character of Japanese occupies two characters in width.

#### string#zentohan

`string#zentohan()`

Converts zenkaku to hankaku characters.

## 6.31 suffixmgr Class

The `suffixmgr` class provides measures to access suffix managers that are responsible to handle suffix symbols appended to number or string literals.

Below is an example to register a suffix `X` that converts a string into upper case after being appended to a string literal:

```
suffixmgr('string').assign('X') {|body| body.upper() }
```

You can use that suffix like below:

```
'hello world'X
```

### 6.31.1 Constructor

#### suffixmgr

`suffixmgr(type:symbol) {block?}`

Creates a reference to one of two suffix managers, number and string.

- The number suffix manager works with number literals.
- The string suffix manager works with string literals.

Specify the argument `type` with a symbol `'number'` for a number suffix manager and `'string'` for a string suffix manager.

### 6.31.2 Method

#### suffixmgr#assign

`suffixmgr#assign(suffix:symbol):void:[overwrite] {block}`

Assigns a procedure to a specified symbol in the suffix manager. The procedure is provided by the `block` that takes a block parameter `|value|` where `value` comes from the preceded literal.

An error occurs if the same suffix symbol has already been assigned. Specifying `:overwrite` attribute will forcibly overwrite an existing assignment.

## 6.32 symbol Class

### 6.32.1 Method

#### symbol#eval

`symbol#eval(env?:environment)`

Evaluate a symbol object.

## 6.33 template Class

### 6.33.1 Cast Operation

A function that expects a `template` instance in its argument can also take a value of `stream` as below:

- `stream ..` Creates a `template` instance by parsing the content of the stream.

As a `stream` is capable of being casted from `string` and `binary`, such values can also be passed to the argument that expects `template`.

Using the above casting feature, you can call a function `f(tmpl:template)` that takes a `template` instance in its argument as below:

- `f(template(stream('foo.txt')))` .. The most explicit way.
- `f(stream('foo.txt'))` .. Implicit casting: from `stream` to `template`.
- `f(template('foo.txt'))` .. Implicit casting: from `string` to `stream`.
- `f('foo.txt')` .. Implicit casting: from `string` to `stream`, then from `stream` to `template`.

### 6.33.2 Constructor

#### template

`template(src?:stream:r):map:[lasteol,noindent] {block?}`

Creates a `template` instance.

If the stream `src` is specified, the instance would be initialized with the parsed result of the script-embedded text from the stream.

Following attributes would customize the parser's behavior:

- `:lasteol`
- `:noindent`

### 6.33.3 Method

#### template#parse

`template#parse(str:string):void:[lasteol,noindent]`

Creates a `template` instance by parsing a script-embedded text in a string.

Following attributes would customize the parser's behavior:

- `:lasteol`
- `:noindent`

#### template#read

`template#read(src:stream:r):void:[lasteol,noindent]`

Creates a `template` instance by parsing a script-embedded text from a stream.

Following attributes would customize the parser's behavior:

- `:lasteol`
- `:noindent`

#### template#render

`template#render(dst?:stream:w)`

Renders stored content to the specified stream.

If the stream is omitted, the function returns the rendered result as a string.

### 6.33.4 Method Called by Template Directive

#### template#block

`template#block(symbol:symbol):void`

Creates a template block which content is supposed to be replaced by a derived template.

This method is called by template directive `${=block()}` during both the initialization and presentation phase of a template process.

- **Initialization:** Creates a template block from the specified block that is then registered in the current template with the specified symbol.
- **Presentation:** Evaluates a template block registered with the specified symbol.

Consider an example. Assume that a block associated with symbol 'foo' is declared in a template file named `base.tmpl` as below:

[`base.tmpl`]

```
Block begins here.
${=block('foo')}
Content of base.
${end}
Block ends here.
```

This template renders the following result:

```
Block begins here.
Content of derived.
Block ends here.
```

Below is another template named `derived.tmpl` that devies from `base.tmpl` and overrides the block 'foo'.

[`derived.tmpl`]

```
${=extends('base.tmpl')}

${=block('foo')}
Content of derived.
${end}
```

This template renders the following result:

```
Block begins here.
Content of derived.
Block ends here.
```

### template#call

`template#call(symbol:symbol, args*)`

Calls a template macro that has been created by directive `${=define}`. This method is called by template directive `${=call()}` during the presentation phase of a template process.

Below is an exemple to call a template macro:

```
${=call('show_person', 'Harry', 24)}
```

This method would return `nil` if a line-break character is rendered at last and would return a null string otherwise.

### template#define

`template#define(symbol:symbol, 'args*'):void`

Creates a template macro from the specified block, which is supposed to be called by `${=call}` directive, and associates it with the specified symbol.

This method is called by template directive `${=define()}` during the initialization phase of a template process.

Below is an example to create a template macro:

```
#{=define('show_person, name:string, age:number)}  
#{name} is #{age} years old.  
#{end}
```

### template#embed

```
template#embed(template:template)
```

Renders the specified template at the current position.

This method is called by template directive `#{=embed()}` during the presentation phase of a template process.

Below is an example to embed a template file named `foo.tmp1` .

```
#{=embed('foo.tmp1')}
```

As the template rendered by this method runs in a different context from the current one, macros and blocks that it defines are not reflected to the current context.

This method would return `nil` if a line-break character is rendered at last and would return a null string otherwise.

### template#extends

```
template#extends(template:template):void
```

Declares the current template as a derived one from the specified template.

This method is called by template directive `#{=extends()}` during the initialization phase of a template process.

The directive must appear in a template only once. An error occurs if the current template has already derived from another template.

Below is an example to declare the current template as one derived from `base.tmp1` .

```
#{=extends('base.tmp1')}
```

### template#super

```
template#super(symbol:symbol):void
```

Evaluates a template block registered with the specified symbol in a template from which the current template has derived.

This method is called by template directive `#{=super()}` during the presentation phase of a template process. The directive is intended to be used within a directive `#{=block()}` .

Consider an example. Assume that a block associated with symbol `'foo'` is declared in a template named `base.tmp1` as below:

```
[base.tmp1]
```

```
Block begins here.  
#{=block('foo')}  
Content of base.  
#{end}  
Block ends here.
```

This template renders the following result:

```
Block begins here.  
Content of derived.  
Block ends here.
```

Below is another template named `derived.tmpl` that devies from `base.tmpl` and overrides the block 'foo' .  
`[derived.tmpl]`

```
#{=extends('base.tmpl')}

#{=block('foo')}
#{=super('foo')}
Content of derived.
#{end}
```

This template renders the following result:

```
Block begins here.
Content of base.
Content of derived.
Block ends here.
```

## 6.34 timedelta Class

The `timedelta` instance provides a time delta information that works with `datetime` instance. You can shift time information of `datetime` by applying addition or subtraction of `timedelta` to it.

### 6.34.1 Property

A `timedelta` instance has the following properties:

Property	Type	R/W	Explanation
<code>timedelta#days</code>	number	R/W	Offset of days.
<code>timedelta#secs</code>	number	R/W	Offset of seconds.
<code>timedelta#usec</code>	number	R/W	Offset of micro seconds.

### 6.34.2 Constructor

`timedelta`

```
timedelta(days:number => 0, secs:number => 0, usecs:number => 0):map {block?}
```

Returns a `timedelta` instance with specified values. The instance actually holds properties of days, secs and usecs.

## 6.35 uri Class

### 6.35.1 Property

A `uri` instance has the following properties:

Property	Type	R/W	Explanation
<code>uri#scheme</code>	string	R/W	
<code>uri#user</code>	string	R/W	
<code>uri#password</code>	string	R/W	
<code>uri#host</code>	string	R/W	
<code>uri#port</code>	string	R/W	
<code>uri#urlpath</code>	string	R/W	
<code>uri#misc</code>	string	R/W	

### 6.35.2 Constructor

uri

`uri(str?:string):map {block?}`

Creates `uri` instance.

If the argument `str` is specified, it would be parsed as a URI which is stored in the instance.

If omitted, the instance would be initialized as an empty one.

### 6.35.3 Method

uri#getfragment

`uri#getfragment()`

Returns the fragment part contained in the URI path of the `uri` instance.

uri#getpath

`uri#getpath()`

Returns the path part contained in the URI path of the `uri` instance.

uri#getquery

`uri#getquery()`

Returns the query part contained in the URI path of the `uri` instance.

uri.parsequery

`uri.parsequery(query:string):static:map`

Parses a query string and returns a dictionary that contains key-value pairs of the query.

## Chapter 7

# argopt Module

The `argopt` module provides measure to parse option strings in an argument list given through the command line.

Below is an example:

```
import(argopt)

argopt.Parser { |p|
  p.addParam('text', 't')
  p.addFlag('test')
  p.addFlag('bold', 'b')
  try {
    [cfg, argv] = p.parse(sys.argv)
  } catch { |e|
    println(e.text)
    sys.exit(1)
  }
}
```

## 7.1 argopt.Parser Class

### 7.1.1 Constructor

argopt.Parser.Parser

`argopt.Parser.Parser()` {block?}

### 7.1.2 Method

argopt.Parser#parse

`argopt.Parser#parse(argv[]:string)`

Parses an argument list which is usually the value of `sys.argv` given by `sys` module. It returns the result in a format `[cfg, argv]` where `cfg` is a `dict` instance containing parameter values and `argv` a list of arguments that have not been parsed as options.

argopt.Parser#addParam

`argopt.Parser#addParam(longName:string, shortName?:string, help?:string, helpValue?:string, defValue?:string)`



argopt.Parser#addFlag

argopt.Parser#addFlag(longName:string, shortName?:string, help?:string)

argopt.Parser#formatHelp

argopt.Parser#formatHelp(longNameFlag:boolean => true, shortNameFlag:boolean => true):[linefeed]

## Chapter 8

# base64 Module

The `base64` module provides measures to read/write text stream that is formatted in base64 format.

### 8.1 Module Function

#### base64.decode

```
base64.decode(stream:stream:r) {block?}
```

Reads text stream that is formatted in base64 and returns the decoded result in binary. If `block` is specified, it would be evaluated with a block parameter `|data:binary|`, where `data` is the created instance. In this case, the block's result would become the function's returned value.

#### base64.encode

```
base64.encode(stream:stream:r, linelen:number:nil => 76) {block?}
```

Encodes content of the stream into base64 format and returns the result in binary. If `block` is specified, it would be evaluated with a block parameter `|data:binary|`, where `data` is the created instance. In this case, the block's result would become the function's returned value.

#### base64.reader

```
base64.reader(stream:stream:r) {block?}
```

Creates a stream instance that reads data formatted in base64 from `stream`. If `block` is specified, it would be evaluated with a block parameter `|s:stream|`, where `s` is the created instance. In this case, the block's result would become the function's returned value.

#### base64.writer

```
base64.writer(stream:stream:w, linelen:number:nil => 76) {block?}
```

Creates a stream instance that encodes data to base64 format and writes it to the `stream`. The number of characters per line is specified by an argument `linelen`. If omitted, that is 76. If `block` is specified, it would be evaluated with a block parameter `|s:stream|`, where `s` is the created instance. In this case, the block's result would become the function's returned value.

### 8.2 Extension to stream Class

This module extends the `stream` class with methods described here.

stream#reader@base64

`stream#reader@base64()` {block?}

Creates a stream instance that reads data formatted in base64 from the target stream instance. If `block` is specified, it would be evaluated with a block parameter `|s:stream|`, where `s` is the created instance. In this case, the block's result would become the function's returned value.

stream#writer@base64

`stream#writer@base64(linelen:number:nil => 76)` {block?}

Creates a stream instance that encodes data to base64 format and writes it to the target stream instance.

The number of characters per line is specified by an argument `linelen`. If omitted, that is 76. If `block` is specified, it would be evaluated with a block parameter `|s:stream|`, where `s` is the created instance. In this case, the block's result would become the function's returned value.

## Chapter 9

# bmp Module

The `bmp` module provides measures to read/write image data in Microsoft BMP format. To utilize it, import the `bmp` module using `import` function. Below is an example to read a BMP file:

```
import(bmp)
img = image('foo.bmp')
```

### 9.1 Extension to Function's Capability

This module extends the capability of function `image()` and instance method `image#write()` so that they can read/write BMP files.

When function `image()` is provided with a stream that satisfies the following conditions, it would recognize the stream as a BMP file.

- The identifier of the stream ends with a suffix `".bmp"`.
- The stream data begins with a byte sequence `"BM"`.

When instance method `image#write()` is provided with a stream that satisfies the following condition, it would write image data in BMP format.

- The identifier of the stream ends with a suffix `".bmp"`.

### 9.2 Extension to image Class

This module extends the `image` class with methods described here.

`image#read@bmp`

`image#read@bmp(stream:stream:r):reduce`

Reads an BMP image from a stream.

This method returns the reference to the target instance itself.

`image#write@bmp`

`image#write@bmp(stream:stream:w):reduce`

Writes a BMP image to a stream.

This method returns the reference to the target instance itself.

## Chapter 10

# bzip2 Module

The `bzip2` module provides measures to read/write BZIP2 files. To utilize it, import the `bzip2` module using `import` function.

Below is an example to read data from a BZIP2 file and write its uncompressed data to another file.

```
import(bzip2)
bzip2.reader('foo.dat.bz2').copyto('foo.dat')
```

Below is an example to read data from a file and write its compressed data to a BZIP2 file.

```
import(bzip2)
bzip2.writer('foo.dat.bz2').copyfrom('foo.dat')
```

## 10.1 Module Function

### bzip2.reader

`bzip2.reader(stream:stream:r) {block?}`

Creates a stream instance that decompresses bzip2 data from the specified `stream` that has readable attribute.

If `block` is specified, it would be evaluated with a block parameter `|st:stream|`, where `st` is the created instance. In this case, the block's result would become the function's returned value.

### bzip2.writer

`bzip2.writer(stream:stream:w, blockSize100k?:number) {block?}`

Creates a stream instance that compresses data into bzip2 format and writes it to the specified `stream` that has writable attribute.

The argument `blockSize100k` takes a number between 1 and 9 that specifies the block size to be used for compression. The actual block size is 100000 times of this value. Nine gives the best compression but takes most memory.

If `block` is specified, it would be evaluated with a block parameter `|st:stream|`, where `st` is the created instance. In this case, the block's result would become the function's returned value.

## 10.2 Extension to stream Class

This module extends the `stream` class with methods described here.

stream#reader@bzip2

`stream#reader@bzip2() {block?}`

Creates a stream instance that decompresses bzip2 data from the specified `stream` that has readable attribute.

If `block` is specified, it would be evaluated with a block parameter `|st:stream|`, where `st` is the created instance. In this case, the block's result would become the function's returned value.

stream#writer@bzip2

`stream#writer@bzip2(blockSize100k?:number) {block?}`

Creates a stream instance that compresses data into bzip2 format and writes it to the specified `stream` that has writable attribute.

The argument `blockSize100k` takes a number between 1 and 9 that specifies the block size to be used for compression. The actual block size is 100000 times of this value. Nine gives the best compression but takes most memory.

If `block` is specified, it would be evaluated with a block parameter `|st:stream|`, where `st` is the created instance. In this case, the block's result would become the function's returned value.

## 10.3 Thanks

This module uses libbzip2 which is distributed in the following site:

<http://www.bzip.org/>

# Chapter 11

## cairo Module

The `cairo` module provides methods to draw 2-D graphics using Cairo library. Official site of Cairo is <http://cairographics.org/>.

### 11.1 Drawing

#### 11.1.1 `cairo_t` - The cairo drawing context

`cairo.context#status`

`cairo.context#status()`

Checks whether an error has previously occurred for this context.

`cairo.context#save`

`cairo.context#save():reduce {block?}`

Makes a copy of the current state of `cr` and saves it on an internal stack of saved states for `cr`. When `cairo.context#restore()` is called, `cr` will be restored to the saved state. Multiple calls to `cairo.context#save()` and `cairo.context#restore()` can be nested; each call to `cairo.context#restore()` restores the state from the matching paired `cairo.context#save()`.

It isn't necessary to clear all saved states before a `cairo_t` is freed. If the reference count of a `cairo_t` drops to zero in response to a call to `cairo.context#destroy()`, any saved states will be freed along with the `cairo_t`.

`cairo.context#restore`

`cairo.context#restore():reduce`

Restores `cr` to the state saved by a preceding call to `cairo.context#save()` and removes that state from the stack of saved states.

`cairo.context#get_target`

`cairo.context#get_target()`

Gets the target surface for the cairo context as passed to `cairo.context` constructor.

`cairo.context#push_group`

`cairo.context#push_group():reduce`

Temporarily redirects drawing to an intermediate surface known as a group. The redirection lasts until the group is completed by a call to `cairo.context#pop_group()` or `cairo.context#pop_group_to_source()`. These calls provide the result of any drawing to the group as a pattern, (either as an explicit object, or set as the source pattern).

This group functionality can be convenient for performing intermediate compositing. One common use of a group is to render objects as opaque within the group, (so that they occlude each other), and then blend the result with translucence onto the destination.

Groups can be nested arbitrarily deep by making balanced calls to `cairo.context#push_group()` / `cairo.context#pop_group()` . Each call pushes/pops the new target group onto/from a stack.

The `cairo.context#push_group()` function calls `cairo_save()` so that any changes to the graphics state will not be visible outside the group, (the `pop_group` functions call `cairo_restore()`). By default the intermediate group will have a content type of `cairo.CONTENT_COLOR_ALPHA` . Other content types can be chosen for the group by using `cairo.context#push_group_with_content()` instead.

As an example, here is how one might fill and stroke a path with translucence, but without any portion of the fill being visible under the stroke:

#### `cairo.context#push_group_with_content`

```
cairo.context#push_group_with_content(content:number):reduce
```

Temporarily redirects drawing to an intermediate surface known as a group. The redirection lasts until the group is completed by a call to `cairo.context#pop_group()` or `cairo.context#pop_group_to_source()` . These calls provide the result of any drawing to the group as a pattern, (either as an explicit object, or set as the source pattern).

The group will have a content type of content. The ability to control this content type is the only distinction between this function and `cairo.context#push_group()` which you should see for a more detailed description of group rendering.

#### `cairo.context#pop_group`

```
cairo.context#pop_group()
```

Terminates the redirection begun by a call to `cairo.context#push_group()` or `cairo.context#push_group_with_content()` and returns a new pattern containing the results of all drawing operations performed to the group.

The `cairo.context#pop_group()` function calls `cairo_restore()`, (balancing a call to `cairo_save()` by the `push_group` function), so that any changes to the graphics state will not be visible outside the group.

#### `cairo.context#pop_group_to_source`

```
cairo.context#pop_group_to_source():reduce
```

Terminates the redirection begun by a call to `cairo.context#push_group()` or `cairo.context#push_group_with_content()` and installs the resulting pattern as the source pattern in the given cairo context.

The `cairo.context#pop_group()` function calls `cairo_restore()`, (balancing a call to `cairo_save()` by the `push_group` function), so that any changes to the graphics state will not be visible outside the group.

#### `cairo.context#get_group_target`

```
cairo.context#get_group_target()
```

Gets the current destination surface for the context. This is either the original target surface as passed to `cairo.context` constructor or the target surface for the current group as started by the most recent call to `cairo.context#push_group()` or `cairo.context#push_group_with_content()` .

#### `cairo.context#set_source_rgb`

```
cairo.context#set_source_rgb(red:number, green:number, blue:number):reduce
```

Sets the source pattern within cr to an opaque color. This opaque color will then be used for any subsequent drawing operation until a new source pattern is set.



The color components are floating point numbers in the range 0 to 1. If the values passed in are outside that range, they will be clamped.

The default source pattern is opaque black, (that is, it is equivalent to `cr.set_source_rgb(0.0, 0.0, 0.0)`) .

#### cairo.context#set\_source\_rgba

`cairo.context#set_source_rgba(red:number, green:number, blue:number, alpha:number):reduce`

Sets the source pattern within `cr` to a translucent color. This color will then be used for any subsequent drawing operation until a new source pattern is set.

The color and alpha components are floating point numbers in the range 0 to 1. If the values passed in are outside that range, they will be clamped.

The default source pattern is opaque black, (that is, it is equivalent to `cr.set_source_rgba(0.0, 0.0, 0.0, 1.0)`) .

#### cairo.context#set\_source

`cairo.context#set_source(source:cairo.pattern):reduce`

Sets the source pattern within `cr` to `source`. This pattern will then be used for any subsequent drawing operation until a new source pattern is set.

Note: The pattern's transformation matrix will be locked to the user space in effect at the time of `cairo.context#set_source()` . This means that further modifications of the current transformation matrix will not affect the source pattern. See `cairo.pattern#set_matrix()` . The default source pattern is a solid pattern that is opaque black, (that is, it is equivalent to `cr.set_source_rgb(0.0, 0.0, 0.0)`) .

#### cairo.context#set\_source\_surface

`cairo.context#set_source_surface(surface:cairo.surface, x:number, y:number):reduce`

This is a convenience function for creating a pattern from `surface` and setting it as the source in `cr` with `cairo.context#set_source()` .

The `x` and `y` parameters give the user-space coordinate at which the surface origin should appear. (The surface origin is its upper-left corner before any transformation has been applied.)

The `x` and `y` parameters are negated and then set as translation values in the pattern matrix.

Other than the initial translation pattern matrix, as described above, all other pattern attributes, (such as its extend mode), are set to the default values as in `cairo.pattern.create_for_surface()` . The resulting pattern can be queried with `cairo.context#get_source()` so that these attributes can be modified if desired, (eg. to create a repeating pattern with `cairo.pattern#set_extend()` ).

#### cairo.context#get\_source

`cairo.context#get_source()`

Gets the current source pattern for `cr` .

#### cairo.context#set\_antialias

`cairo.context#set_antialias(antialias:number):reduce`

Set the antialiasing mode of the rasterizer used for drawing shapes. This value is a hint, and a particular backend may or may not support a particular value. At the current time, no backend supports `cairo.ANTIALIAS_SUBPIXEL` when drawing shapes.

Note that this option does not affect text rendering, instead see `cairo.font_options#set_antialias()` .

#### cairo.context#get\_antialias

`cairo.context#get_antialias()`

Gets the current shape antialiasing mode, as set by `cairo.context#set_antialias()` .

#### cairo.context#set\_dash

`cairo.context#set_dash(dashes[]:number, offset:number):reduce`

Sets the dash pattern to be used by `cairo.context#stroke()` . A dash pattern is specified by `dashes`, an array of positive values. Each value provides the length of alternate "on" and "off" portions of the stroke. The offset specifies an offset into the pattern at which the stroke begins. Each "on" segment will have caps applied as if the segment were a separate sub-path. In particular, it is valid to use an "on" length of 0.0 with `cairo.LINE_CAP_ROUND` or `cairo.LINE_CAP_SQUARE` in order to distributed dots or squares along a path.

Note: The length values are in user-space units as evaluated at the time of stroking. This is not necessarily the same as the user space at the time of `cairo.context#set_dash()` .

If length of dashes is 0 dashing is disabled.

If length of dashes is 1 a symmetric pattern is assumed with alternating on and off portions of the size specified by the single value in dashes.

If any value in dashes is negative, or if all values are 0, then cr will be put into an error state with a status of `cairo.STATUS_INVALID_DASH` .

#### cairo.context#get\_dash

`cairo.context#get_dash()`

Gets the current dash array.

#### cairo.context#set\_fill\_rule

`cairo.context#set_fill_rule(fill_rule:number):reduce`

Set the current fill rule within the cairo context. The fill rule is used to determine which regions are inside or outside a complex (potentially self-intersecting) path. The current fill rule affects both `cairo.context#fill()` and `cairo.context#clip()` . See `cairo_fill_rule_t` for details on the semantics of each available fill rule.

The default fill rule is `cairo.FILL_RULE_WINDING` .

#### cairo.context#get\_fill\_rule

`cairo.context#get_fill_rule()`

Gets the current fill rule, as set by `cairo.context#set_fill_rule()` .

#### cairo.context#set\_line\_cap

`cairo.context#set_line_cap(line_cap:number):reduce`

Sets the current line cap style within the cairo context. See `cairo_line_cap_t` for details about how the available line cap styles are drawn.

As with the other stroke parameters, the current line cap style is examined by `cairo.context#stroke()`, `cairo.context#stroke_extents()`, and `cairo.context#stroke_to_path()`, but does not have any effect during path construction.

The default line cap style is `cairo.LINE_CAP_BUTT`.

#### cairo.context#get\_line\_cap

`cairo.context#get_line_cap()`

Gets the current line cap style, as set by `cairo.context#set_line_cap()` .

#### cairo.context#set\_line\_join

`cairo.context#set_line_join(line_join:number):reduce`

Sets the current line join style within the cairo context. See `cairo_line_join_t` for details about how the available line join styles are drawn.

As with the other stroke parameters, the current line join style is examined by `cairo.context#stroke()`, `cairo.context#stroke_extents()` , and `cairo.context#stroke_to_path()` , but does not

have any effect during path construction.  
The default line join style is `cairo.LINE_JOIN_MITER` .

`cairo.context#get_line_join`

`cairo.context#get_line_join()`

Gets the current line join style, as set by `cairo.context#set_line_join()` .

`cairo.context#set_line_width`

`cairo.context#set_line_width(width:number):reduce`

Sets the current line width within the cairo context. The line width value specifies the diameter of a pen that is circular in user space, (though device-space pen may be an ellipse in general due to scaling/shear/rotation of the CTM).

Note: When the description above refers to user space and CTM it refers to the user space and CTM in effect at the time of the stroking operation, not the user space and CTM in effect at the time of the call to `cairo.context#set_line_width()`. The simplest usage makes both of these spaces identical. That is, if there is no change to the CTM between a call to `cairo.context#set_line_width()` and the stroking operation, then one can just pass user-space values to `cairo.context#set_line_width()` and ignore this note.

As with the other stroke parameters, the current line width is examined by `cairo.context#stroke()`, `cairo.context#stroke_extents()`, and `cairo.context#stroke_to_path()`, but does not have any effect during path construction.

The default line width value is 2.0.

`cairo.context#get_line_width`

`cairo.context#get_line_width()`

This function returns the current line width value exactly as set by `cairo.context#set_line_width()`.

Note that the value is unchanged even if the CTM has changed between the calls to `cairo.context#set_line_width()` and `cairo.context#get_line_width()`.

`cairo.context#set_miter_limit`

`cairo.context#set_miter_limit(limit:number):reduce`

Sets the current miter limit within the cairo context.

If the current line join style is set to `cairo.LINE_JOIN_MITER` (see `cairo_set_line_join()`), the miter limit is used to determine whether the lines should be joined with a bevel instead of a miter. Cairo divides the length of the miter by the line width. If the result is greater than the miter limit, the style is converted to a bevel.

As with the other stroke parameters, the current line miter limit is examined by `cairo.context#stroke()`, `cairo.context#stroke_extents()`, and `cairo.context#stroke_to_path()`, but does not have any effect during path construction.

The default miter limit value is 10.0, which will convert joins with interior angles less than 11 degrees to bevels instead of miters. For reference, a miter limit of 2.0 makes the miter cutoff at 60 degrees, and a miter limit of 1.414 makes the cutoff at 90 degrees.

A miter limit for a desired angle can be computed as:  $\text{miter limit} = 1/\sin(\text{angle}/2)$

`cairo.context#get_miter_limit`

`cairo.context#get_miter_limit()`

Gets the current miter limit, as set by `cairo.context#set_miter_limit()`.

`cairo.context#set_operator`

`cairo.context#set_operator(op:number):reduce`

Sets the compositing operator to be used for all drawing operations. See `cairo_operator_t` for details on the semantics of each available compositing operator.

The default operator is `cairo.OPERATOR_OVER`.

`cairo.context#get_operator`

`cairo.context#get_operator()`

Gets the current compositing operator for a cairo context.

`cairo.context#set_tolerance`

`cairo.context#set_tolerance(tolerance:number):reduce`

Sets the tolerance used when converting paths into trapezoids. Curved segments of the path will be subdivided until the maximum deviation between the original path and the polygonal approximation is less than tolerance. The default value is 0.1. A larger value will give better performance, a smaller value, better appearance. (Reducing the value from the default value of 0.1 is unlikely to improve appearance significantly.) The accuracy of paths within Cairo is limited by the precision of its internal arithmetic, and the prescribed tolerance is restricted to the smallest representable internal value.

`cairo.context#get_tolerance`

`cairo.context#get_tolerance()`

Gets the current tolerance value, as set by `cairo.context#set_tolerance()`.

`cairo.context#clip`

`cairo.context#clip():reduce`

Establishes a new clip region by intersecting the current clip region with the current path as it would be filled by `cairo.context#fill()` and according to the current fill rule (see `cairo.context#set_fill_rule()`). After `cairo.context#clip()`, the current path will be cleared from the cairo context.

The current clip region affects all drawing operations by effectively masking out any changes to the surface that are outside the current clip region.

Calling `cairo.context#clip()` can only make the clip region smaller, never larger. But the current clip is part of the graphics state, so a temporary restriction of the clip region can be achieved by calling `cairo.context#clip()` within a `cairo.context#save()/cairo.context#restore()` pair. The only other means of increasing the size of the clip region is `cairo.context#reset_clip()`.

`cairo.context#clip_preserve`

`cairo.context#clip_preserve():reduce`

Establishes a new clip region by intersecting the current clip region with the current path as it would be filled by `cairo.context#fill()` and according to the current fill rule (see `cairo.context#set_fill_rule()`). Unlike `cairo.context#clip()`, `cairo.context#clip_preserve()` preserves the path within the cairo context.

The current clip region affects all drawing operations by effectively masking out any changes to the surface that are outside the current clip region.

Calling `cairo.context#clip_preserve()` can only make the clip region smaller, never larger. But the current clip is part of the graphics state, so a temporary restriction of the clip region can be achieved by calling `cairo.context#clip_preserve()` within a `cairo.context#save()/cairo.context#restore()` pair. The only other means of increasing the size of the clip region is `cairo.context#reset_clip()`.

`cairo.context#clip_extents`

`cairo.context#clip_extents()`

Computes a bounding box in user coordinates covering the area inside the current clip.

`cairo.context#in_clip`

`cairo.context#in_clip(x:number, y:number)`

Tests whether the given point is inside the area that would be visible through the current clip, i.e. the area that would be filled by a `cairo.context#paint()` operation. See `cairo.context#clip()`, and `cairo.context#clip_preserve()`.

#### cairo.context#reset\_clip

`cairo.context#reset_clip():reduce`

Reset the current clip region to its original, unrestricted state. That is, set the clip region to an infinitely large shape containing the target surface. Equivalently, if infinity is too hard to grasp, one can imagine the clip region being reset to the exact bounds of the target surface. Note that code meant to be reusable should not call `cairo_reset_clip()` as it will cause results unexpected by higher-level code which calls `cairo.context#clip()`. Consider using `cairo.context#save()` and `cairo.context#restore()` around `cairo.context#clip()` as a more robust means of temporarily restricting the clip region.

#### cairo.context#copy\_clip\_rectangle\_list

`cairo.context#copy_clip_rectangle_list()`

Gets the current clip region as a list of rectangles in user coordinates. The status in the list may be `cairo.STATUS_CLIP_NOT_REPRESENTABLE` to indicate that the clip region cannot be represented as a list of user-space rectangles. The status may have other values to indicate other errors.

#### cairo.context#fill

`cairo.context#fill():reduce`

A drawing operator that fills the current path according to the current fill rule, (each sub-path is implicitly closed before being filled). After `cairo.context#fill()`, the current path will be cleared from the cairo context. See `cairo.context#set_fill_rule()` and `cairo.context#fill_preserve()`.

#### cairo.context#fill\_preserve

`cairo.context#fill_preserve():reduce`

A drawing operator that fills the current path according to the current fill rule, (each sub-path is implicitly closed before being filled). Unlike `cairo.context#fill()`, `cairo.context#fill_preserve()` preserves the path within the cairo context. See `cairo.context#set_fill_rule()` and `cairo.context#fill()`.

#### cairo.context#fill\_extents

`cairo.context#fill_extents():reduce`

Computes a bounding box in user coordinates covering the area that would be affected, (the "inked" area), by a `cairo.context#fill()` operation given the current path and fill parameters. If the current path is empty, returns an empty rectangle `((0,0), (0,0))`. Surface dimensions and clipping are not taken into account.

Contrast with `cairo.context#path_extents()`, which is similar, but returns non-zero extents for some paths with no inked area, (such as a simple line segment).

Note that `cairo.context#fill_extents()` must necessarily do more work to compute the precise inked areas in light of the fill rule, so `cairo.context#path_extents()` may be more desirable for sake of performance if the non-inked path extents are desired.

See `cairo.context#fill()`, `cairo.context#set_fill_rule()` and `cairo.context#fill_preserve()`.

#### cairo.context#in\_fill

`cairo.context#in_fill(x:number, y:number)`

Tests whether the given point is inside the area that would be affected by a `cairo.context#fill()` operation given the current path and filling parameters. Surface dimensions and clipping are not taken into account.

See `cairo.context#fill()`, `cairo.context#set_fill_rule()` and `cairo.context#fill_preserve()`.

#### `cairo.context#mask`

`cairo.context#mask(pattern:cairo.pattern):reduce`

A drawing operator that paints the current source using the alpha channel of pattern as a mask. (Opaque areas of pattern are painted with the source, transparent areas are not painted.)

#### `cairo.context#mask_surface`

`cairo.context#mask_surface(surface:cairo.surface, surface_x:number, surface_y:number):reduce`

A drawing operator that paints the current source using the alpha channel of surface as a mask. (Opaque areas of surface are painted with the source, transparent areas are not painted.)

#### `cairo.context#paint`

`cairo.context#paint():reduce`

A drawing operator that paints the current source everywhere within the current clip region.

#### `cairo.context#paint_with_alpha`

`cairo.context#paint_with_alpha(alpha:number):reduce`

A drawing operator that paints the current source everywhere within the current clip region using a mask of constant alpha value alpha. The effect is similar to `cairo.context#paint()`, but the drawing is faded out using the alpha value.

#### `cairo.context#stroke`

`cairo.context#stroke():reduce`

A drawing operator that strokes the current path according to the current line width, line join, line cap, and dash settings. After `cairo.context#stroke()`, the current path will be cleared from the cairo context. See `cairo.context#set_line_width()`, `cairo.context#set_line_join()`, `cairo.context#set_line_cap()`, `cairo.context#set_dash()`, and `cairo.context#stroke_preserve()`.

Note: Degenerate segments and sub-paths are treated specially and provide a useful result. These can result in two different situations:

1. Zero-length "on" segments set in `cairo.context#set_dash()`. If the cap style is `cairo.LINE_CAP_ROUND` or `cairo.LINE_CAP_SQUARE` then these segments will be drawn as circular dots or squares respectively. In the case of `cairo.LINE_CAP_SQUARE`, the orientation of the squares is determined by the direction of the underlying path.
2. A sub-path created by `cairo.context#move_to()` followed by either a `cairo.context#close_path()` or one or more calls to `cairo.context#line_to()` to the same coordinate as the `cairo.context#move_to()`. If the cap style is `cairo.LINE_CAP_ROUND` then these sub-paths will be drawn as circular dots. Note that in the case of `cairo.LINE_CAP_SQUARE` a degenerate sub-path will not be drawn at all, (since the correct orientation is indeterminate).

In no case will a cap style of `cairo.LINE_CAP_BUTT` cause anything to be drawn in the case of either degenerate segments or sub-paths.

#### `cairo.context#stroke_preserve`

`cairo.context#stroke_preserve():reduce`

A drawing operator that strokes the current path according to the current line width, line join, line cap, and dash settings. Unlike `cairo.context#stroke()`, `cairo.context#stroke_preserve()` preserves the path within the cairo context.

See `cairo.context#set_line_width()`, `cairo.context#set_line_join()`, `cairo.context#set_line_cap()`, `cairo.context#set_dash()`, and `cairo.context#stroke_preserve()`.

#### cairo.context#stroke\_extents

`cairo.context#stroke_extents()`

Computes a bounding box in user coordinates covering the area that would be affected, (the "inked" area), by a `cairo.context#stroke()` operation given the current path and stroke parameters. If the current path is empty, returns an empty rectangle `((0,0), (0,0))`. Surface dimensions and clipping are not taken into account.

Note that if the line width is set to exactly zero, then `cairo.context#stroke_extents()` will return an empty rectangle. Contrast with `cairo.context#path_extents()` which can be used to compute the non-empty bounds as the line width approaches zero.

Note that `cairo.context#stroke_extents()` must necessarily do more work to compute the precise inked areas in light of the stroke parameters, so `cairo.context#path_extents()` may be more desirable for sake of performance if non-inked path extents are desired.

See `cairo.context#stroke()`, `cairo.context#set_line_width()`, `cairo.context#set_line_join()`, `cairo.context#set_line_cap()`, `cairo.context#set_dash()`, and `cairo.context#stroke_preserve()`.

#### cairo.context#in\_stroke

`cairo.context#in_stroke(x:number, y:number)`

Tests whether the given point is inside the area that would be affected by a `cairo.context#stroke()` operation given the current path and stroking parameters. Surface dimensions and clipping are not taken into account. See `cairo.context#stroke()`, `cairo.context#set_line_width()`, `cairo.context#set_line_join()`, `cairo.context#set_line_cap()`, `cairo.context#set_dash()`, and `cairo.context#stroke_preserve()`.

#### cairo.context#copy\_page

`cairo.context#copy_page():reduce`

Emits the current page for backends that support multiple pages, but doesn't clear it, so, the contents of the current page will be retained for the next page too. Use `cairo.cairo#show_page()` if you want to get an empty page after the emission.

This is a convenience function that simply calls `cairo.context#surface_copy_page()` on `cr`'s target.

#### cairo.context#show\_page

`cairo.context#show_page():reduce`

Emits and clears the current page for backends that support multiple pages. Use `cairo.context#copy_page()` if you don't want to clear the page.

This is a convenience function that simply calls `cairo.context#surface_show_page()` on `cr`'s target.

### 11.1.2 Paths - Creating paths and manipulating path data

#### cairo.context#copy\_path

`cairo.context#copy_path()`

Creates a copy of the current path and returns it to the user as a `cairo.path`. See `cairo_path_data_t` for hints on how to iterate over the returned data structure.

The result will have no data (`data==nullptr` and `num_data==0`), if either of the following conditions hold:

1. If there is insufficient memory to copy the path. In this case `path->status` will be set to `cairo.STATUS_NO_MEMORY`.
2. If `cr` is already in an error state. In this case `path->status` will contain the same status that would be returned by `cairo.context#status()`.

### cairo.context#copy\_path\_flat

`cairo.context#copy_path_flat()`

Gets a flattened copy of the current path and returns it to the user as a `cairo.path`. See `cairo_path_data_t` for hints on how to iterate over the returned data structure.

This function is like `cairo.context#copy_path()` except that any curves in the path will be approximated with piecewise-linear approximations, (accurate to within the current tolerance value). That is, the result is guaranteed to not have any elements of type `cairo.PATH_CURVE_TO` which will instead be replaced by a series of `cairo.PATH_LINE_TO` elements.

The result will have no data (`data==nullptr` and `num_data==0`), if either of the following conditions hold:

1. If there is insufficient memory to copy the path. In this case `path->status` will be set to `cairo.STATUS_NO_MEMORY`.
2. If `cr` is already in an error state. In this case `path->status` will contain the same status that would be returned by `cairo.context#status()`.

### cairo.context#append\_path

`cairo.context#append_path(path:cairo.path):reduce`

Append the path onto the current path. The path may be either the return value from one of `cairo.context#copy_path()` or `cairo.context#copy_path_flat()` or it may be constructed manually. See `cairo_path_t` for details on how the path data structure should be initialized, and note that `path->status` must be initialized to `cairo.STATUS_SUCCESS`.

### cairo.context#has\_current\_point

`cairo.context#has_current_point()`

Returns whether a current point is defined on the current path. See `cairo.context#get_current_point()` for details on the current point.

### cairo.context#get\_current\_point

`cairo.context#get_current_point()`

Gets the current point of the current path, which is conceptually the final point reached by the path so far.

The current point is returned in the user-space coordinate system. If there is no defined current point or if `cr` is in an error status, `x` and `y` will both be set to 0.0. It is possible to check this in advance with `cairo.context#has_current_point()`.

Most path construction functions alter the current point. See the following for details on how they affect the current point: `cairo.context#new_path()`, `cairo.context#new_sub_path()`, `cairo.context#append_path()`, `cairo.context#close_path()`, `cairo.context#move_to()`, `cairo.context#line_to()`, `cairo.context#curve_to()`, `cairo.context#rel_move_to()`, `cairo.context#rel_line_to()`, `cairo.context#rel_curve_to()`, `cairo.context#arc()`, `cairo.context#arc_negative()`, `cairo.context#rectangle()`, `cairo.context#text_path()`, `cairo.context#glyph_path()`, `cairo.context#stroke_to_path()`.

Some functions use and alter the current point but do not otherwise change current path: `cairo.context#show_text()`.

Some functions unset the current path and as a result, current point: `cairo.context#fill()`, `cairo.context#stroke()`.

### cairo.context#new\_path

`cairo.context#new_path():reduce`

Clears the current path. After this call there will be no path and no current point.

### cairo.context#new\_sub\_path

`cairo.context#new_sub_path():reduce`



Begin a new sub-path. Note that the existing path is not affected. After this call there will be no current point.

In many cases, this call is not needed since new sub-paths are frequently started with `cairo.context#move_to()`.

A call to `cairo.context#new_sub_path()` is particularly useful when beginning a new sub-path with one of the `cairo.context#arc()` calls. This makes things easier as it is no longer necessary to manually compute the arc's initial coordinates for a call to `cairo.context#move_to()`.

#### `cairo.context#close_path`

`cairo.context#close_path():reduce`

Adds a line segment to the path from the current point to the beginning of the current sub-path, (the most recent point passed to `cairo.context#move_to()`), and closes this sub-path. After this call the current point will be at the joined endpoint of the sub-path.

The behavior of `cairo.context#close_path()` is distinct from simply calling `cairo.context#line_to()` with the equivalent coordinate in the case of stroking. When a closed sub-path is stroked, there are no caps on the ends of the sub-path. Instead, there is a line join connecting the final and initial segments of the sub-path.

If there is no current point before the call to `cairo.context#close_path()`, this function will have no effect.

Note: As of cairo version 1.2.4 any call to `cairo.context#close_path()` will place an explicit `MOVE_TO` element into the path immediately after the `CLOSE_PATH` element, (which can be seen in `cairo.context#copy_path()` for example). This can simplify path processing in some cases as it may not be necessary to save the "last move\_to point" during processing as the `MOVE_TO` immediately after the `CLOSE_PATH` will provide that point.

#### `cairo.context#arc`

`cairo.context#arc(xc:number, yc:number, radius:number, angle1?:number, angle2?:number):map:reduce:[deg]`

Adds a circular arc of the given radius to the current path. The arc is centered at (xc, yc), begins at angle1 and proceeds in the direction of increasing angles to end at angle2. If angle2 is less than angle1 it will be progressively increased by  $2 * \text{M\_PI}$  until it is greater than angle1.

If there is a current point, an initial line segment will be added to the path to connect the current point to the beginning of the arc. If this initial line is undesired, it can be avoided by calling `cairo.context#new_sub_path()` before calling `cairo.context#arc()`.

Angles are measured in radians. An angle of 0.0 is in the direction of the positive X axis (in user space). An angle of  $\text{math.pi}/2.0$  radians (90 degrees) is in the direction of the positive Y axis (in user space). Angles increase in the direction from the positive X axis toward the positive Y axis. So with the default transformation matrix, angles increase in a clockwise direction.

(To convert from degrees to radians, use  $\text{degrees} * (\text{math.pi} / 180.)$ .)

This function gives the arc in the direction of increasing angles; see `cairo.context#arc_negative()` to get the arc in the direction of decreasing angles.

The arc is circular in user space. To achieve an elliptical arc, you can scale the current transformation matrix by different amounts in the X and Y directions. For example, to draw an ellipse in the box given by x, y, width, height:

```
cr.save() cr.translate(x + width / 2., y + height / 2.) cr.scale(width / 2., height / 2.) cr.arc(0., 0., 1., 0., 2 * math.pi) cr.restore()
```

*Gura:* If attribute :deg is specified, angle1 and angle2 are represented in degrees instead of radians.

#### `cairo.context#arc_negative`

`cairo.context#arc_negative(xc:number, yc:number, radius:number, angle1?:number, angle2?:number):map:reduce:[deg]`

Adds a circular arc of the given radius to the current path. The arc is centered at (xc, yc), begins at angle1 and proceeds in the direction of decreasing angles to end at angle2. If angle2 is greater than angle1 it will be progressively decreased by  $2 * \text{math.pi}$  until it is less than angle1. See `cairo.context#arc()` for more details. This function differs only in the direction of the arc between the two angles.

*Gura:* If attribute :deg is specified, angle1 and angle2 are represented in degrees instead of radians.

#### cairo.context#curve\_to

```
cairo.context#curve_to(x1:number, y1:number, x2:number, y2:number, x3:number, y3:number):map:reduce
```

Adds a cubic Bezier spline to the path from the current point to position (x3, y3) in user-space coordinates, using (x1, y1) and (x2, y2) as the control points. After this call the current point will be (x3, y3).

If there is no current point before the call to `cairo.context#curve_to()` this function will behave as if preceded by a call to `cr.move_to(x1, y1)`.

#### cairo.context#line\_to

```
cairo.context#line_to(x:number, y:number):map:reduce
```

Adds a line to the path from the current point to position (x, y) in user-space coordinates. After this call the current point will be (x, y).

If there is no current point before the call to `cairo.context#line_to()` this function will behave as `cr.move_to(x, y)`.

#### cairo.context#move\_to

```
cairo.context#move_to(x:number, y:number):map:reduce
```

Begin a new sub-path. After this call the current point will be (x, y).

#### cairo.context#rectangle

```
cairo.context#rectangle(x:number, y:number, width:number, height:number):map:reduce
```

Adds a closed sub-path rectangle of the given size to the current path at position (x, y) in user-space coordinates.

This function is logically equivalent to:

```
cr.move_to(x, y) cr.rel_line_to(width, 0) cr.rel_line_to(0, height) cr.rel_line_to(-width, 0) cr.close_path()
```

#### cairo.context#text\_path

```
cairo.context#text_path(text:string):map:reduce
```

Adds closed paths for text to the current path. The generated path if filled, achieves an effect similar to that of `cairo.context#show_text()`.

Text conversion and positioning is done similar to `cairo.context#show_text()`.

Like `cairo.context#show_text()`, After this call the current point is moved to the origin of where the next glyph would be placed in this same progression. That is, the current point will be at the origin of the final glyph offset by its advance values. This allows for chaining multiple calls to `cairo.context#text_path()` without having to set current point in between.

Note: The `cairo.context#text_path()` function call is part of what the cairo designers call the "toy" text API. It is convenient for short demos and simple programs, but it is not expected to be adequate for serious text-using applications. See `cairo.context#glyph_path()` for the "real" text path API in cairo.

#### cairo.context#rel\_curve\_to

```
cairo.context#rel_curve_to(dx1:number, dy1:number, dx2:number, dy2:number, dx3:number, dy3:number):map:red
```

Relative-coordinate version of `cairo.context#curve_to()`. All offsets are relative to the current point. Adds a cubic Bezier spline to the path from the current point to a point offset from the current point by (dx3, dy3), using points offset by (dx1, dy1) and (dx2, dy2) as the control points. After this call the current point will be offset by (dx3, dy3).

Given a current point of (x, y), `cr.rel_curve_to(dx1, dy1, dx2, dy2, dx3, dy3)` is logically equivalent to `cr.curve_to(x+dx1, y+dy1, x+dx2, y+dy2, x+dx3, y+dy3)`.

It is an error to call this function with no current point. Doing so will cause cr to shutdown with a status of `cairo.STATUS_NO_CURRENT_POINT`.

#### cairo.context#rel\_line\_to

`cairo.context#rel_line.to(dx:number, dy:number):map:reduce`

Relative-coordinate version of `cairo.context#line_to()`. Adds a line to the path from the current point to a point that is offset from the current point by (dx, dy) in user space. After this call the current point will be offset by (dx, dy).

Given a current point of (x, y), `cr.rel_line.to(dx, dy)` is logically equivalent to `cr.line.to(x + dx, y + dy)`.

It is an error to call this function with no current point. Doing so will cause cr to shutdown with a status of `cairo.STATUS_NO_CURRENT_POINT`.

#### cairo.context#rel\_move\_to

`cairo.context#rel_move.to(dx:number, dy:number):map:reduce`

Begin a new sub-path. After this call the current point will offset by (dx, dy).

Given a current point of (x, y), `cr.rel_move.to(dx, dy)` is logically equivalent to `cr.move.to(x + dx, y + dy)`.

It is an error to call this function with no current point. Doing so will cause cr to shutdown with a status of `cairo.STATUS_NO_CURRENT_POINT`.

#### cairo.context#path\_extents

`cairo.context#path.extents()`

Computes a bounding box in user-space coordinates covering the points on the current path. If the current path is empty, returns an empty rectangle ((0,0), (0,0)). Stroke parameters, fill rule, surface dimensions and clipping are not taken into account.

Contrast with `cairo.context#fill_extents()` and `cairo.context#stroke_extents()` which return the extents of only the area that would be "inked" by the corresponding drawing operations.

The result of `cairo.context#path_extents()` is defined as equivalent to the limit of `cairo.context#stroke_extents()` with `cairo.LINE_CAP_ROUND` as the line width approaches 0.0, (but never reaching the empty-rectangle returned by `cairo.context#stroke_extents()` for a line width of 0.0).

Specifically, this means that zero-area sub-paths such as `cairo.context#move.to();cairo.context#line.to()` segments, (even degenerate cases where the coordinates to both calls are identical), will be considered as contributing to the extents. However, a lone `cairo.context#move.to()` will not contribute to the results of `cairo.context#path_extents()`.

### 11.1.3 cairo\_pattern\_t - Sources for drawing

#### cairo.pattern#add\_color\_stop\_rgb

`cairo.pattern#add_color_stop_rgb(offset:number, red:number, green:number, blue:number):reduce`

Adds an opaque color stop to a gradient pattern. The offset specifies the location along the gradient's control vector. For example, a linear gradient's control vector is from (x0,y0) to (x1,y1) while a radial gradient's control vector is from any point on the start circle to the corresponding point on the end circle.

The color is specified in the same way as in `cairo.context#set_source_rgb()`.

If two (or more) stops are specified with identical offset values, they will be sorted according to the order in which the stops are added, (stops added earlier will compare less than stops added later). This can be useful for reliably making sharp color transitions instead of the typical blend.

Note: If the pattern is not a gradient pattern, (eg. a linear or radial pattern), then the pattern will be put into an error status with a status of `cairo.STATUS_PATTERN_TYPE_MISMATCH`.

#### cairo.pattern#add\_color\_stop\_rgba

`cairo.pattern#add_color_stop_rgba(offset:number, red:number, green:number, blue:number, alpha:number):redu`

Adds a translucent color stop to a gradient pattern. The offset specifies the location along the gradient's control vector. For example, a linear gradient's control vector is from (x0,y0) to (x1,y1) while a radial gradient's control vector is from any point on the start circle to the corresponding point on the end circle.

The color is specified in the same way as in `cairo.context#set_source_rgba()`.

If two (or more) stops are specified with identical offset values, they will be sorted according to the order in which the stops are added, (stops added earlier will compare less than stops added later). This can be useful for reliably making sharp color transitions instead of the typical blend.

Note: If the pattern is not a gradient pattern, (eg. a linear or radial pattern), then the pattern will be put into an error status with a status of `cairo.STATUS_PATTERN_TYPE_MISMATCH`.

#### cairo.pattern#get\_color\_stop\_count

`cairo.pattern#get_color_stop_count()`

Gets the number of color stops specified in the given gradient pattern.

#### cairo.pattern#get\_color\_stop\_rgba

`cairo.pattern#get_color_stop_rgba(index:number)`

Gets the color and offset information at the given index for a gradient pattern. Values of index are 0 to 1 less than the number returned by `cairo.pattern#get_color_stop_count()`.

#### cairo.pattern.create\_rgb

`cairo.pattern.create_rgb(red:number, green:number, blue:number):static {block?}`

Creates a new `cairo.pattern` corresponding to an opaque color. The color components are floating point numbers in the range 0 to 1. If the values passed in are outside that range, they will be clamped.

#### cairo.pattern.create\_rgba

`cairo.pattern.create_rgba(red:number, green:number, blue:number, alpha:number):static {block?}`

Creates a new `cairo.pattern` corresponding to a translucent color. The color components are floating point numbers in the range 0 to 1. If the values passed in are outside that range, they will be clamped.

#### cairo.pattern#get\_rgba

`cairo.pattern#get_rgba()`

Gets the solid color for a solid color pattern.

#### cairo.pattern.create\_for\_surface

`cairo.pattern.create_for_surface(surface:cairo.surface):static {block?}`

Create a new `cairo.pattern` for the given surface.

#### cairo.pattern#get\_surface

`cairo.pattern#get_surface()`

Gets the surface of a surface pattern. The reference returned in surface is owned by the pattern; the caller should call `cairo_surface_reference()` if the surface is to be retained.

#### cairo.pattern.create\_linear

`cairo.pattern.create_linear(x0:number, y0:number, x1:number, y1:number):static {block?}`

Create a new linear gradient `cairo.pattern` along the line defined by `(x0, y0)` and `(x1, y1)`. Before using the gradient pattern, a number of color stops should be defined using `cairo.pattern#add_color_stop_rgb()` or `cairo.pattern#add_color_stop_rgba()`.

Note: The coordinates here are in pattern space. For a new pattern, pattern space is identical to user space, but the relationship between the spaces can be changed with `cairo.pattern#set_matrix()`.

`cairo.pattern#get_linear_points`

`cairo.pattern#get_linear_points()`

Gets the gradient endpoints for a linear gradient.

`cairo.pattern.create_radial`

`cairo.pattern.create_radial(cx0:number, cy0:number, radius0:number, cx1:number, cy1:number, radius1:number):static {block?}`

Creates a new radial gradient `cairo.pattern_t` between the two circles defined by `(cx0, cy0, radius0)` and `(cx1, cy1, radius1)`. Before using the gradient pattern, a number of color stops should be defined using `cairo.pattern#add_color_stop_rgb()` or `cairo.pattern#add_color_stop_rgba()`.

Note: The coordinates here are in pattern space. For a new pattern, pattern space is identical to user space, but the relationship between the spaces can be changed with `cairo.pattern#set_matrix()`.

`cairo.pattern#get_radial_circles`

`cairo.pattern#get_radial_circles()`

Gets the gradient endpoint circles for a radial gradient, each specified as a center coordinate and a radius.

`cairo.mesh_pattern.create`

`cairo.mesh_pattern.create():static {block?}`

`cairo.mesh_pattern#begin_patch`

`cairo.mesh_pattern#begin_patch():reduce`

`cairo.mesh_pattern#end_patch`

`cairo.mesh_pattern#end_patch():reduce`

`cairo.mesh_pattern#move_to`

`cairo.mesh_pattern#move_to(x:number, y:number):reduce`

`cairo.mesh_pattern#line_to`

`cairo.mesh_pattern#line_to(x:number, y:number):reduce`

`cairo.mesh_pattern#curve_to`

`cairo.mesh_pattern#curve_to(x1:number, y1:number, x2:number, y2:number, x3:number, y3:number):reduce`

`cairo.mesh_pattern#set_control_point`

`cairo.mesh_pattern#set_control_point(point_num:number, x:number, y:number):reduce`

`cairo.mesh_pattern#set_corner_color_rgb`

`cairo.mesh_pattern#set_corner_color_rgb(corner_num:number, red:number, green:number, blue:number):reduce`

#### cairo.mesh\_pattern#set\_corner\_color\_rgba

`cairo.mesh_pattern#set_corner_color_rgba(corner_num:number, red:number, green:number, blue:number, alpha:number):reduce`

#### cairo.pattern#status

`cairo.pattern#status()`

Checks whether an error has previously occurred for this pattern.

#### cairo.pattern#set\_extend

`cairo.pattern#set_extend(extend:number):reduce`

Sets the mode to be used for drawing outside the area of a pattern. See `cairo_extend.t` for details on the semantics of each extend strategy.

The default extend mode is `cairo.EXTEND_NONE` for surface patterns and `cairo.EXTEND_PAD` for gradient patterns.

#### cairo.pattern#get\_extend

`cairo.pattern#get_extend()`

Gets the current extend mode for a pattern. See `cairo_extend.t` for details on the semantics of each extend strategy.

#### cairo.pattern#set\_filter

`cairo.pattern#set_filter(filter:number):reduce`

Sets the filter to be used for resizing when using this pattern. See `cairo_filter.t` for details on each filter.

- Note that you might want to control filtering even when you do not have an explicit `cairo.pattern` object, (for example when using `cairo.context#set_source_surface()`). In these cases, it is convenient to use `cairo.context#get_source()` to get access to the pattern that cairo creates implicitly. For example:

```
cr.set_source_surface(image, x, y) cr.get_source().set_filter(cairo.FILTER_NEAREST)
```

#### cairo.pattern#get\_filter

`cairo.pattern#get_filter()`

Gets the current filter for a pattern. See `cairo_filter.t` for details on each filter.

#### cairo.pattern#set\_matrix

`cairo.pattern#set_matrix(matrix:matrix):reduce`

Sets the pattern's transformation matrix to `matrix`. This matrix is a transformation from user space to pattern space.

When a pattern is first created it always has the identity matrix for its transformation matrix, which means that pattern space is initially identical to user space.

Important: Please note that the direction of this transformation matrix is from user space to pattern space. This means that if you imagine the flow from a pattern to user space (and on to device space), then coordinates in that flow will be transformed by the inverse of the pattern matrix.

For example, if you want to make a pattern appear twice as large as it does by default the correct code to use is:

```
cairo_matrix_init_scale (&matrix, 0.5, 0.5); cairo_pattern_set_matrix (pattern, &matrix);
```

Meanwhile, using values of 2.0 rather than 0.5 in the code above would cause the pattern to appear at half of its default size.

Also, please note the discussion of the user-space locking semantics of `cairo.context#set_source()`.

cairo.pattern#get\_matrix

`cairo.pattern#get_matrix()`

Stores the pattern's transformation matrix into matrix.

cairo.pattern#get\_type

`cairo.pattern#get_type()`

This function returns the type a pattern. See `cairo_pattern_type_t` for available types.

## 11.1.4 Regions - Representing a pixel-aligned area

cairo.region.create

`cairo.region.create():static {block?}`

cairo.region.create\_rectangle

`cairo.region.create_rectangle(rectangle:cairo.rectangle_int):static {block?}`

cairo.region.create\_rectangles

`cairo.region.create_rectangles(rects[:cairo.rectangle_int]):static {block?}`

cairo.region#copy

`cairo.region#copy() {block?}`

cairo.region#status

`cairo.region#status()`

cairo.region#get\_extents

`cairo.region#get_extents()`

cairo.region#get\_rectangle

`cairo.region#get_rectangle(nth:number)`

cairo.region#is\_empty

`cairo.region#is_empty()`

cairo.region#contains\_point

`cairo.region#contains_point(x:number, y:number)`

cairo.region#contains\_rectangle

`cairo.region#contains_rectangle(rectangle:cairo.rectangle_int)`

cairo.region#equal

`cairo.region#equal(region:cairo.region)`

cairo.region#translate

`cairo.region#translate(dx:number, dy:number)`

cairo.region#intersect

`cairo.region#intersect(other:cairo.region)`

cairo.region#intersect\_rectangle

`cairo.region#intersect_rectangle(rectangle:cairo.rectangle_int)`

cairo.region#union

`cairo.region#union(other:cairo.region)`

cairo.region#union\_rectangle

`cairo.region#union_rectangle(rectangle:cairo.rectangle_int)`

cairo.region#xor

`cairo.region#xor(other:cairo.region)`

cairo.region#xor\_rectangle

`cairo.region#xor_rectangle(rectangle:cairo.rectangle_int)`

### 11.1.5 Transformations - Manipulating the current transformation matrix

cairo.context#translate

`cairo.context#translate(tx:number, ty:number):reduce`

Modifies the current transformation matrix (CTM) by translating the user-space origin by (tx, ty). This offset is interpreted as a user-space coordinate according to the CTM in place before the new call to `cairo.context#translate()`. In other words, the translation of the user-space origin takes place after any existing transformation.

cairo.context#scale

`cairo.context#scale(sx:number, sy:number):reduce`

Modifies the current transformation matrix (CTM) by scaling the X and Y user-space axes by sx and sy respectively. The scaling of the axes takes place after any existing transformation of user space.

cairo.context#rotate

`cairo.context#rotate(angle:number):reduce:[deg]`

Modifies the current transformation matrix (CTM) by rotating the user-space axes by angle radians. The rotation of the axes takes place after any existing transformation of user space. The rotation direction for positive angles is from the positive X axis toward the positive Y axis. *Gura:* If attribute :deg is specified, angle is represented in degrees instead of radians.

cairo.context#transform

`cairo.context#transform(matrix:matrix):reduce`



Modifies the current transformation matrix (CTM) by applying matrix as an additional transformation. The new transformation of user space takes place after any existing transformation.

cairo.context#set\_matrix

```
cairo.context#set_matrix(matrix:matrix):reduce
```

Modifies the current transformation matrix (CTM) by setting it equal to matrix.

cairo.context#get\_matrix

```
cairo.context#get_matrix()
```

Stores the current transformation matrix (CTM) into matrix.

cairo.context#identity\_matrix

```
cairo.context#identity_matrix():reduce
```

Resets the current transformation matrix (CTM) by setting it equal to the identity matrix. That is, the user-space and device-space axes will be aligned and one user-space unit will transform to one device-space unit.

cairo.context#user\_to\_device

```
cairo.context#user_to_device(x:number, y:number)
```

Transform a coordinate from user space to device space by multiplying the given point by the current transformation matrix (CTM).

cairo.context#user\_to\_device\_distance

```
cairo.context#user_to_device_distance(dx:number, dy:number)
```

Transform a distance vector from user space to device space. This function is similar to `cairo.context#user_to_device()` except that the translation components of the CTM will be ignored when transforming (dx,dy).

cairo.context#device\_to\_user

```
cairo.context#device_to_user(x:number, y:number)
```

Transform a coordinate from device space to user space by multiplying the given point by the inverse of the current transformation matrix (CTM).

cairo.context#device\_to\_user\_distance

```
cairo.context#device_to_user_distance(dx:number, dy:number)
```

Transform a distance vector from device space to user space. This function is similar to `cairo.context#device_to_user()` except that the translation components of the inverse CTM will be ignored when transforming (dx,dy).

### 11.1.6 text - Rendering text and glyphs

cairo.context#select\_font\_face

```
cairo.context#select_font_face(family:string, slant:number, weight:number):reduce
```

Note: The `cairo.context#select_font_face()` function call is part of what the cairo designers call the "toy" text API. It is convenient for short demos and simple programs, but it is not expected to be adequate for serious text-using applications.

Selects a family and style of font from a simplified description as a family name, slant and weight. Cairo provides no operation to list available family names on the system (this is a

"toy", remember), but the standard CSS2 generic family names, ("serif", "sans-serif", "cursive", "fantasy", "monospace"), are likely to work as expected.

If family starts with the string "cairo:", or if no native font backends are compiled in, cairo will use an internal font family. The internal font family recognizes many modifiers in the family string, most notably, it recognizes the string "monospace". That is, the family name "cairo:monospace" will use the monospace version of the internal font family.

For "real" font selection, see the font-backend-specific font\_face.create functions for the font backend you are using. (For example, if you are using the freetype-based cairo-ft font backend, see cairo\_ft.font\_face.create\_for\_ft\_face() or cairo\_ft.font\_face.create\_for\_pattern().) The resulting font face could then be used with cairo.scaled\_font.create() and cairo.context#set\_scaled\_font(). Similarly, when using the "real" font support, you can call directly into the underlying font system, (such as fontconfig or freetype), for operations such as listing available fonts, etc.

It is expected that most applications will need to use a more comprehensive font handling and text layout library, (for example, pango), in conjunction with cairo.

If text is drawn without a call to cairo.context#select\_font\_face(), (nor cairo.context#set\_font\_face() nor cairo.context#set\_scaled\_font()), the default family is platform-specific, but is essentially "sans-serif". Default slant is cairo.FONT\_SLANT\_NORMAL, and default weight is cairo.FONT\_WEIGHT\_NORMAL.

This function is equivalent to a call to cairo.toy\_font\_face.create() followed by cairo.context#set\_font\_face().

#### cairo.context#set\_font\_size

```
cairo.context#set_font_size(size:number):reduce
```

Sets the current font matrix to a scale by a factor of size, replacing any font matrix previously set with cairo.context#set\_font\_size() or cairo.context#set\_font\_matrix(). This results in a font size of size user space units. (More precisely, this matrix will result in the font's em-square being a size by size square in user space.)

If text is drawn without a call to cairo.context#set\_font\_size(), (nor cairo.context#set\_font\_matrix() nor cairo.context#set\_scaled\_font()), the default font size is 10.0.

#### cairo.context#set\_font\_matrix

```
cairo.context#set_font_matrix(matrix:matrix):reduce
```

Sets the current font matrix to matrix. The font matrix gives a transformation from the design space of the font (in this space, the em-square is 1 unit by 1 unit) to user space. Normally, a simple scale is used (see cairo.set\_font\_size()), but a more complex font matrix can be used to shear the font or stretch it unequally along the two axes.

#### cairo.context#get\_font\_matrix

```
cairo.context#get_font_matrix()
```

Stores the current font matrix into matrix. See cairo.context#set\_font\_matrix().

#### cairo.context#set\_font\_options

```
cairo.context#set_font_options(options:cairo.font_options):reduce
```

Sets a set of custom font rendering options for the cairo-t. Rendering options are derived by merging these options with the options derived from underlying surface; if the value in options has a default value (like cairo.ANTIALIAS\_DEFAULT), then the value from the surface is used.

#### cairo.context#get\_font\_options

```
cairo.context#get_font_options()
```

Retrieves font rendering options set via cairo.context#set\_font\_options. Note that the returned options do not include any options derived from the underlying surface; they are literally the options passed to cairo.context#set\_font\_options().

cairo.context#set\_font\_face

`cairo.context#set_font_face(font_face:cairo.font_face):reduce`

Replaces the current `cairo_font_face_t` object in the `cairo_t` with `font_face`. The replaced font face in the `cairo_t` will be destroyed if there are no other references to it.

cairo.context#get\_font\_face

`cairo.context#get_font_face()`

Gets the current font face for a `cairo_t`.

cairo.context#set\_scaled\_font

`cairo.context#set_scaled_font(scaled_font:cairo.scaled_font):reduce`

Replaces the current font face, font matrix, and font options in the `cairo_t` with those of the `cairo_scaled_font_t`. Except for some translation, the current CTM of the `cairo_t` should be the same as that of the `cairo_scaled_font_t`, which can be accessed using `cairo.context#scaled_font_get_ctm()`.

cairo.context#get\_scaled\_font

`cairo.context#get_scaled_font()`

Gets the current scaled font for a `cairo_t`.

cairo.context#show\_text

`cairo.context#show_text(text:string):reduce`

A drawing operator that generates the shape from a string of UTF-8 characters, rendered according to the current `font_face`, `font_size` (`font_matrix`), and `font_options`.

This function first computes a set of glyphs for the string of text. The first glyph is placed so that its origin is at the current point. The origin of each subsequent glyph is offset from that of the previous glyph by the advance values of the previous glyph.

After this call the current point is moved to the origin of where the next glyph would be placed in this same progression. That is, the current point will be at the origin of the final glyph offset by its advance values. This allows for easy display of a single logical string with multiple calls to `cairo.context#show_text()`.

Note: The `cairo.context#show_text()` function call is part of what the cairo designers call the "toy" text API. It is convenient for short demos and simple programs, but it is not expected to be adequate for serious text-using applications. See `cairo.context#show_glyphs()` for the "real" text display API in cairo.

cairo.context#show\_glyphs

`cairo.context#show_glyphs(glyphs:cairo.glyph):reduce`

A drawing operator that generates the shape from an array of glyphs, rendered according to the current font face, font size (`font_matrix`), and font options.

cairo.context#font\_extents

`cairo.context#font_extents()`

Gets the font extents for the currently selected font.

cairo.context#text\_extents

`cairo.context#text_extents(text:string)`

Gets the extents for a string of text. The extents describe a user-space rectangle that encloses the "inked" portion of the text, (as it would be drawn by `cairo.context#show_text()`). Additionally, the `x_advance` and `y_advance` values indicate the amount by which the current point would be advanced by `cairo.context#show_text()`.

Note that whitespace characters do not directly contribute to the size of the rectangle (extents.width and extents.height). They do contribute indirectly by changing the position of non-whitespace characters. In particular, trailing whitespace characters are likely to not affect the size of the rectangle, though they will affect the x\_advance and y\_advance values.

#### cairo.context#glyph\_extents

```
cairo.context#glyph_extents(glyphs:cairo.glyph)
```

Gets the extents for an array of glyphs. The extents describe a user-space rectangle that encloses the "inked" portion of the glyphs, (as they would be drawn by `cairo.context#show_glyphs()`). Additionally, the x\_advance and y\_advance values indicate the amount by which the current point would be advanced by `cairo.context#show_glyphs()`.

Note that whitespace glyphs do not contribute to the size of the rectangle (extents.width and extents.height).

#### cairo.toy\_font\_face.create

```
cairo.toy_font_face.create(family:string, slant:number, weight:number):static {block?}
```

Creates a font face from a triplet of family, slant, and weight. These font faces are used in implementation of the the `cairo_t` "toy" font API.

If family is the zero-length string "", the platform-specific default family is assumed. The default family then can be queried using `cairo.toy_font_face#get_family()`.

The `cairo.context#select_font_face()` function uses this to create font faces. See that function for limitations and other details of toy font faces.

#### cairo.toy\_font\_face#get\_family

```
cairo.toy_font_face#get_family()
```

Gets the family name of a toy font.

#### cairo.toy\_font\_face#get\_slant

```
cairo.toy_font_face#get_slant()
```

Gets the slant a toy font.

#### cairo.toy\_font\_face#get\_weight

```
cairo.toy_font_face#get_weight()
```

Gets the weight a toy font.

### 11.1.7 Raster Sources - Supplying arbitrary image data

## 11.2 Fonts

### 11.2.1 `cairo_font_face_t` - Base class for font faces

### 11.2.2 `cairo_scaled_font_t` - Font face at particular size and options

#### cairo.scaled\_font.create

```
cairo.scaled_font.create(font_face:cairo.font_face, font_matrix:matrix, ctm:matrix, options):static {block?}
```

- 11.2.3 `cairo_font_options_t` - How a font should be rendered
- 11.2.4 FreeType Fonts - Font support for FreeType
- 11.2.5 Win32 Fonts - Font support for Microsoft Windows
- 11.2.6 Quartz (CGFont) Fonts - Font support via CGFont on OS X
- 11.2.7 User Fonts - Font support with font data provided by the user

## 11.3 Surfaces

- 11.3.1 `cairo_device_t` - interface to underlying rendering system
- 11.3.2 `cairo_surface_t` - Base class for surfaces
- 11.3.3 Image Surfaces - Rendering to memory buffers
- 11.3.4 PDF Surfaces - Rendering PDF documents
- 11.3.5 PNG Support - Reading and writing PNG images
- 11.3.6 PostScript Surfaces - Rendering PostScript documents
- 11.3.7 Recording Surfaces - Records all drawing operations
- 11.3.8 Win32 Surfaces - Microsoft Windows surface support
- 11.3.9 SVG Surfaces - Rendering SVG documents
- 11.3.10 Quartz Surfaces - Rendering to Quartz surfaces
- 11.3.11 XCB Surfaces - X Window System rendering using the XCB library
- 11.3.12 XLib Surfaces - X Window System rendering using XLib
- 11.3.13 XLib-XRender Backend - X Window System rendering using XLib and the X Render extension
- 11.3.14 Script Surfaces - Rendering to replayable scripts

## 11.4 Utilities

- 11.4.1 `cairo_matrix_t` - Generic matrix operations

## 11.5 Thanks

This module uses Cairo library which is distributed in the following site:  
<http://cairographics.org/>

## Chapter 12

# calendar Module

The `calendar` module ...

### 12.1 Module Function

`calendar.calendar`

```
calendar.calendar(year:number, weekoffset:number => 0, ncols:number => 3)
```

Prints calendars of a specified year. Argument `weekoffset` specifies from which week the calendar starts, 0 from Sunday, 1 from Monday, and so on. Argument `ncols` specifies how many months are printed in one row.

## Chapter 13

# cbridge Module

The `cbridge` module ...

### 13.1 Module Function

# Chapter 14

## conio Module

The `conio` module provides following measures to work on a console screen:

- Moves the cursor where texts are printed.
- Changes text colors.
- Retrieves console size.
- Waits for keyboard input.

To utilize it, import the `conio` module using `import` function. Below is an example to print a frame around a console:

```
import(conio)

conio.clear()
[w, h] = conio.getwinsize()
conio.moveto(0, 0) {
    print('*' * w)
}
conio.moveto(0, 1 .. (h - 2)) {
    print('*', ' ' * (w - 2), '*')
}
conio.moveto(0, h - 1) {
    print('*' * w)
}
conio.waitkey():raise
```

### 14.1 Module Function

#### conio.clear

`conio.clear(region?:symbol):void`

Clears the screen.

In default, it clears whole the screen. Argument `region` that takes one of the symbols below would specify the region to be cleared.

- `'line'` .. clears characters in the line where the cursor exists.
- `'left'` .. clears characters on the left side of the cursor.
- `'right'` .. clears characters on the right side of the cursor.
- `'top'` .. clears characters on the above side of the cursor.



- 'bottom .. clears characters on the below side of the cursor.

#### conio.getwinsize

`conio.getwinsize()`

Returns the screen size as a list [width, height] .

#### conio.setcolor

`conio.setcolor(fg:symbol:nil, bg?:symbol):map:void {block?}`

Sets foreground and background color of text by specifying a color symbol. Available color symbols are listed below:

- 'black
- 'blue
- 'green
- 'aqua
- 'cyan
- 'red
- 'purple
- 'magenta
- 'yellow
- 'white
- 'gray
- 'bright\_blue
- 'bright\_green
- 'bright\_aqua
- 'bright\_cyan
- 'bright\_red
- 'bright\_purple
- 'bright\_magenta
- 'bright\_yellow
- 'bright\_white

If `fg` is set to `nil`, the foreground color remains unchanged. If `bg` is omitted or set to `nil`, the background color remains unchanged.

If `block` is specified, the color is changed before evaluating the block, and then gets back to what has been set when done.

#### conio.moveto

`conio.moveto(x:number, y:number):map:void {block?}`

Moves cursor to the specified position. The most top-left position on the screen is represented as 0, 0 .

If `block` is specified, the cursor is moved before evaluating the block, and then gets back to where it has been when done.

### conio.waitkey

`conio.waitkey():[raise]`

Waits for a keyboard input and returns a character code number associated with the key. If `:raise` attribute is specified, hitting `Ctrl-C` issues a terminating signal that causes the program done.

Character code numbers of some of the special keys are defined as below:

- `conio.K_BACKSPACE`
- `conio.K_TAB`
- `conio.K_RETURN`
- `conio.K_ESCAPE`
- `conio.K_SPACE`
- `conio.K_UP`
- `conio.K_DOWN`
- `conio.K_RIGHT`
- `conio.K_LEFT`
- `conio.K_INSERT`
- `conio.K_HOME`
- `conio.K_END`
- `conio.K_PAGEUP`
- `conio.K_PAGEDOWN`
- `conio.K_DELETE`

# Chapter 15

## csv Module

The `csv` module provides measures to read/write CSV files. To utilize it, import the `csv` module using `import` function.

Below is an example to read a CSV file that contains three fields per line:

```
import(csv)

Record = struct(name:string, age:number, email:string)
records = Record * csv.read('records.csv')
printf('name:%s, age:%d, email:%s!\n',
       records.*name, records.*age, records.*email)
```

### 15.1 Module Function

csv.parse

`csv.parse(str:string):map`

csv.read

`csv.read(stream:stream:r) {block?}`

### 15.2 csv.writer Class

#### 15.2.1 Constructor

csv.writer

`csv.writer(stream:stream:w, format?:string) {block?}`

#### 15.2.2 Method

csv.writer#write

`csv.writer#write(fields+):map:reduce`

### 15.3 Extension of stream Class

This module extends the `stream` class with methods described here.

stream#read@csv

stream#read@csv() {block?}

stream#writer@csv

stream#writer@csv(format?:string) {block?}

# Chapter 16

## curl Module

The `curl` module provides measures to access Internet resources using cURL library. To utilize it, import the `curl` module using `import` function.

### 16.1 Module Function

`curl.version`

`curl.version()` {block?}

Returns a string of the libcurl version.

`curl.easy_init`

`curl.easy_init()` {block?}

Initializes cURL and returns a `easy_handle` object.

### 16.2 `curl.easy_handle` Class

`curl.easy_handle#escape`

`curl.easy_handle#escape(string:string):void`

`curl.easy_handle#getinfo`

`curl.easy_handle#getinfo(info:number)`

`curl.easy_handle#perform`

`curl.easy_handle#perform(stream?:stream:w):void`

`curl.easy_handle#recv`

`curl.easy_handle#recv(buflen:number)`

`curl.easy_handle#reset`

`curl.easy_handle#reset():void`

`curl.easy_handle#send`

`curl.easy_handle#send(buffer:binary)`

curl.easy\_handle#setopt

`curl.easy_handle#setopt(option:number, arg):void`

curl.easy\_handle#unescape

`curl.easy_handle#unescape(string:string):void`

## 16.3 Thanks

This module uses libcurl which is distributed in the following site:

<http://curl.haxx.se/libcurl/>

# Chapter 17

## diff Module

The `diff` module provides measures to detect differences between texts. To utilize it, import the `diff` module using `import` function.

Below is an example to show differences between files `file1.txt` and `file2.txt` :

```
diff.compose(stream('file1.txt'), stream('file2.txt')).render(sys.stdout)
```

### 17.1 Module Function

diff.compose

`diff.compose(src1, src2):[icase, sync] {block?}`

Extracts differences between two sets of line sequence and returns `diff.diff@line` instance that contains the difference information.

You can specify a value of `string`, `stream`, `iterator` or `list` for the argument `src1` and `src2`. In the result, the content of `src1` is referred to as an "original" one and that of `src2` as a "new" one.

Below is an example to compare between two strings:

```
str1 = '...'
str2 = '...'
result = diff.compose(str1, str2)
```

Below is an example to compare between two files:

```
file1 = stream('file1.txt')
file2 = stream('file2.txt')
result = diff.compose(file1, file2)
```

Below is an example to compare between two iterators:

```
chars1 = '...'.each()
chars2 = '...'.each()
result = diff.compose(chars1, chars2)
```

Below is an example to compare between a file and a string:

```
file = stream('file.txt')
str = '...'
result = diff.compose(file, str)
```

If `block` is specified, it would be evaluated with a block parameter `|d:diff.diff@line|`, where `d` is the created instance. In this case, the block's result would become the function's returned value.

If attribute `:icase` is specified, it wouldn't distinguish upper and lower case of characters.

#### diff.compose@char

```
diff.compose@char(src1:string, src2:string):[icase] {block?}
```

Extracts differences between two strings and returns `diff.diff@line` instance that contains the difference information.

If `block` is specified, it would be evaluated with a block parameter `|d:diff.diff@char|`, where `d` is the created instance. In this case, the block's result would become the function's returned value.

If attribute `:icase` is specified, it wouldn't distinguish upper and lower case of characters.

## 17.2 diff.diff@line Class

The `diff.diff@line` instance is created by function `diff.compose()` and provides information about differences between two texts by lines.

### 17.2.1 Property

Property	Type	R/W	Explanation
<code>distance</code>	number	R	The distance between the texts. Zero means that they are identical each other.
<code>edits</code>	iterator	R	An iterator that returns <code>diff.edit@line</code> instances stored in the result.
<code>nlines@org</code>	number	R	Number of lines in the "original" text.
<code>nlines@new</code>	number	R	Number of lines in the "new" text.

### 17.2.2 Method

#### diff.diff@line#eachhunk

```
diff.diff@line#eachhunk(format?:symbol, lines?:number) {block?}
```

Creates an iterator that returns `diff.hunk@line` instance stored in the result.

The argument `format` takes one of the symbols that specifies the hunk format:

- `'normal` .. Normal format (not supported yet).
- `'context` .. Context format (not supported yet).
- `'unified` .. Unified format. This is the default.

The argument `lines` specifies a number of common lines appended before and after different lines

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.



- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### `diff.diff@line#render`

```
diff.diff@line#render(out?:stream:w, format?:symbol, lines?:number) {block?}
```

Renders diff result to the specified stream.

If the argument `out` is omitted, this method returns a string of the rendered text. Otherwise, it returns `nil`.

The argument `format` takes one of the symbols that specifies the rendering format:

- `'normal` .. Normal format (not supported yet).
- `'context` .. Context format (not supported yet).
- `'unified` .. Unified format. This is the default.

The argument `lines` specifies a number of common lines appended before and after different lines

## 17.3 diff.hunk@line Class

The `diff.hunk@line` instance provides information about a hunk.

### 17.3.1 Property

Property	Type	R/W	Explanation
<code>edits</code>	iterator	R	An iterator that returns <code>diff.edit@line</code> instances stored in the hunk.
<code>lineno@org</code>	number	R	Top line number of the "original" text covered by the hunk.
<code>lineno@new</code>	number	R	Top line number of the "new" text covered by the hunk.
<code>nlines@org</code>	number	R	Number of lines in the "original" text covered by the hunk.
<code>nlines@new</code>	number	R	Number of lines in the "new" text covered by the hunk.

### 17.3.2 Method

#### `diff.hunk@line#print`

```
diff.hunk@line#print(out?:stream):void {block?}
```

Prints the content of the `diff.hunk` instance to the specified stream.

## 17.4 diff.edit@line Class

The `diff.edit@line` provides information about an edit operation.

### 17.4.1 Property

Property	Type	R/W	Explanation
<code>diff.edit@line#symbol</code>	<code>symbol</code>	R	Edit operation: 'copy' .. Copy the line. 'add' .. Add the line. 'delete' .. Delete the line.
<code>mark</code>	<code>string</code>	R	A mark string that appears on the top of each line in Unified format.
<code>lineno@org</code>	<code>number</code>	R	Line number of the "original" text correspond to the edit.
<code>lineno@new</code>	<code>number</code>	R	Lop line number of the "new" text correspond to the edit.
<code>source</code>	<code>string</code>	R	A source text.
<code>unified</code>	<code>string</code>	R	A composed string in Unified format.

### 17.4.2 Method

`diff.edit@line#print`

```
diff.edit@line#print(out?:stream):void {block?}
```

Prints the content of the `diff.edit` instance to the specified stream.

## 17.5 diff.diff@char Class

The `diff.diff@char` instance is created by function `diff.compose@char()` and provides information about differences between two texts by characters.

### 17.5.1 Property

Property	Type	R/W	Explanation
<code>distance</code>	<code>number</code>	R	The distance between the texts. Zero means that they are identical each other.
<code>edits</code>	<code>iterator</code>	R	An iterator that returns <code>diff.edit@char</code> instances stored in the result.
<code>edits@org</code>	<code>iterator</code>	R	An iterator that returns <code>diff.edit@char</code> instances that are applied to the "original" string.
<code>edits@new</code>	<code>iterator</code>	R	An iterator that returns <code>diff.edit@char</code> instances that are applied to the "new" string.

## 17.6 diff.edit@char Class

The `diff.edit@char` provides information about an edit operation.

### 17.6.1 Property

Property	Type	R/W	Explanation
<code>diff.edit@char#symbol</code>	<code>symbol</code>	R	Edit operation: 'copy' .. Copy the line. 'add' .. Add the line. 'delete' .. Delete the line.
<code>diff.edit@char#mark</code>	<code>string</code>	R	A mark string that appears on the top of each line in Unified format.
<code>diff.edit@char#source</code>	<code>string</code>	R	A source text.

## 17.7 Thanks

This module uses dtl (Diff Template Library) which is distributed in the following site:  
<https://code.google.com/p/dtl-cpp/>

## Chapter 18

# example Module

The `example` module is just an example that is supposed to be referenced as a skeleton when you want to create a new module.

## Chapter 19

# freetype Module

The `freetype` module provides measures to access vectorized font data using freetype library. To utilize it, import the `freetype` module using `import` function.

### 19.1 Module Function

freetype.sysfontpath  
`freetype.sysfontpath(name:string):map`

### 19.2 freetype.BBox Class

### 19.3 freetype.BDF\_Property Class

### 19.4 freetype.Bitmap Class

#### 19.4.1 Method

freetype.Bitmap#Embolden  
`freetype.Bitmap#Embolden(strength:number):reduce`

### 19.5 freetype.CharMap Class

#### 19.5.1 Method

freetype.CharMap#Get\_Index  
`freetype.CharMap#Get_Index()`

## 19.6 freetype.FTC\_CMapCache Class

## 19.7 freetype.FTC\_ImageCache Class

## 19.8 freetype.FTC\_ImageType Class

## 19.9 freetype.FTC\_Manager Class

## 19.10 freetype.FTC\_Node Class

## 19.11 freetype.FTC\_SBit Class

## 19.12 freetype.FTC\_SBitCache Class

## 19.13 freetype.FTC\_Scaler Class

## 19.14 freetype.Face Class

### 19.14.1 Constructor

freetype.Face

freetype.Face(stream:stream, face\_index:number => 0):map {block?}

### 19.14.2 Method

freetype.Face#CheckTrueTypePatents

freetype.Face#CheckTrueTypePatents()

freetype.Face#Get\_Advance

freetype.Face#Get\_Advance(glyph\_index:number, load\_flags:number)

freetype.Face#Get\_Advances

freetype.Face#Get\_Advances(glyph\_index\_start:number, count:number, load\_flags:number)

freetype.Face#Get\_Glyph\_Name

freetype.Face#Get\_Glyph\_Name(glyph\_index:number)

freetype.Face#Get\_Postscript\_Name

freetype.Face#Get\_Postscript\_Name()

freetype.Face#Get\_Kerning

freetype.Face#Get\_Kerning(left\_glyph:number, right\_glyph:number, kern\_mode:number)

freetype.Face#Load\_Char

freetype.Face#Load\_Char(char\_code:number, load\_flags:number):reduce

freetype.Face#Load\_Glyph

freetype.Face#Load\_Glyph(glyph\_index:number, load\_flags:number):reduce

freetype.Face#Set\_Charmap

freetype.Face#Set\_Charmap(charmap:freetype.CharMap):reduce

freetype.Face#Set\_Pixel\_Sizes

freetype.Face#Set\_Pixel\_Sizes(pixel\_width:number, pixel\_height:number):reduce

## 19.15 freetype.Glyph Class

### 19.15.1 Method

freetype.Glyph#Copy

freetype.Glyph#Copy()

freetype.Glyph#Stroke

freetype.Glyph#Stroke(stroker:freetype.Stroker):reduce

freetype.Glyph#StrokeBorder

freetype.Glyph#StrokeBorder(stroker:freetype.Stroker, inside:boolean):reduce

## 19.16 freetype.GlyphSlot Class

### 19.16.1 Method

freetype.GlyphSlot#Get\_Glyph

freetype.GlyphSlot#Get\_Glyph()

freetype.GlyphSlot#Render

freetype.GlyphSlot#Render(render\_mode:number):reduce

## 19.17 freetype.Matrix Class

### 19.17.1 Constructor

freetype.Matrix

freetype.Matrix(matrix:matrix):map {block?}

### 19.17.2 Method

freetype.Matrix#Multiply

freetype.Matrix#Multiply(matrix:freetype.Matrix):reduce

freetype.Matrix#Invert

freetype.Matrix#Invert():reduce

## 19.18 freetype.Outline Class

### 19.18.1 Method

freetype.Outline#Translate

freetype.Outline#Translate(xOffset:freetype.Matrix, yOffset:freetype.Matrix):reduce

freetype.Outline#Transform

freetype.Outline#Transform(matrix:freetype.Matrix):reduce

freetype.Outline#Embolden

freetype.Outline#Embolden(strength:number):reduce

freetype.Outline#Reverse

freetype.Outline#Reverse():reduce

## 19.19 freetype.Raster Class

## 19.20 freetype.Span Class

## 19.21 freetype.Stroker Class

### 19.21.1 Constructor

freetype.Stroker

freetype.Stroker():map {block?}

### 19.21.2 Method

freetype.Stroker#BeginSubPath

freetype.Stroker#BeginSubPath(to:freetype.Vector, open:boolean):reduce

## 19.22 freetype.Vector Class

### 19.22.1 Constructor

freetype.Vector

freetype.Vector(x:number, y:number):map {block?}



### 19.22.2 Method

freetype.Vector#Length

freetype.Vector#Length()

freetype.Vector#Transform

freetype.Vector#Transform(matrix:freetype.Matrix):reduce

## 19.23 freetype.font Class

### 19.24 Constructor

freetype.font

freetype.font(face:freetype.Face):map {block?}

#### 19.24.1 Method

freetype.font#cleardeco

freetype.font#cleardeco():reduce

freetype.font#drawtext

freetype.font#drawtext(image:image, x:number, y:number, str:string):map:reduce {block?}

Draws a text on the image.

freetype.font#calcsz

freetype.font#calcsz(str:string):map

freetype.font#calcbbox

freetype.font#calcbbox(x:number, y:number, str:string):map

## 19.25 Extension to image Class

This module extends the `image` class with methods described here.

image#drawtext

image#drawtext(font:freetype.font, x:number, y:number, str:string):map:reduce {block?}

Draws a text on the image.

## 19.26 Thanks

This module uses FreeType library which is distributed in the following site:

<http://www.freetype.org/>

# Chapter 20

## fs Module

The `fs` module provides measures to access and modify information in file systems. This is a built-in module, so you can use it without being imported.

### 20.1 Module Function

#### fs.chdir

`fs.chdir(pathname:string) {block?}`

Changes the current working directory.

#### fs.chmod

`fs.chmod(mode, pathname:string):map:void:[follow_link]`

Changes the access mode of a file specified by `pathname` .

There are two formats to specify the mode: one is by a number, and another in a string.

When specified in a number, following bits are associated with access permissions:

- `b8 b7 b6` .. Read, write and executable permissions for owners
- `b5 b4 b3` .. Read, write and executable permissions for groups
- `b2 b1 b0` .. Read, write and executable permissions for others

When set to one, each permission is validated.

When specified in a string, it accepts a permission directive in a format of following regular expression

`[ugoa]+([-+=] [rwx]+)+`

It starts with characters that represent target which permissions are modified as described below:

- `u` .. owners
- `g` .. groups
- `o` .. others
- `a` .. all users

Then, follows an operation:

- `-` .. remove

- `+` .. append
- `=` .. set

At last, permission attributes are specified as below:

- `r` .. read permission
- `w` .. write permission
- `x` .. executable permission

If the modification target is a link file, each platform would have different result:

- Linux .. Modifies permissions of the link file itself. Specifying `:follow_link` attribute would modify permissions of the target file instead.
- MacOS .. Modifies permissions of the target file. Attribute `:follow_link` has no effect.
- Windows .. Modifies permissions of the link file. Attribute `:follow_link` has no effect.

#### fs.copy

```
fs.copy(src:string, dst:string):map:void:[overwrite]
```

Copies a file.

An argument `src` needs to specify a path name of a file that is to be copied while `dst` can specify a path name of either a file or a directory. If `dst` is a directory, the file would be copied into that. Otherwise, it would create a copy of `src` that has a name specified by `dst`.

If a destination file already exists, an error occurs. Specifying an attribute `:overwrite` would overwrite an existing one.

#### fs.copdir

```
fs.copdir(src:string, dst:string):map:void:[tree]
```

Copies a directory.

Arguments `src` and `dst` specify source directory and destination directory respectively. In default, sub directories are not copied. Specifying `:tree` attribute would copy all the sub directories in the source.

#### fs.getcwd

```
fs.getcwd()
```

Returns the current working directory.

#### fs.mkdir

```
fs.mkdir(pathname:string):map:void:[tree]
```

Creates a directory.

If `pathname` consists of multiple sub directories and some of them still doesn't exist, an error occurs. Specifying `:tree` attribute would create such directories.

#### fs.remove

```
fs.remove(pathname:string):map:void
```

Removes a file from the file system.

#### fs.rename

```
fs.rename(src:string, dst:string):map:void
```

Renames a file or directory.

fs.rmdir

`fs.rmdir(pathname:string):map:void:[tree]`

Removes a directory.

If the directory contains sub directories, an error occurs. Specifying `:tree` attribute would delete such a directory.

# Chapter 21

## gif Module

The `gif` module provides measures to read/write image data in GIF format. To utilize it, import the `gif` module using `import` function.

Below is an example to read a GIF file:

```
import(gif)
img = image('foo.gif')
```

Below is an example to create a GIF file that contains multiple images:

```
import(gif)
g = gif.content()
g.addimage(['cell1.png', 'cell2.png', 'cell3.png'], 10) g.write('anim.gif')
```

### 21.1 Exntension to Function's Capability

This module extends the capability of function `image()` and instance method `image#write()` so that they can read/write GIF files.

When function `image()` is provided with a stream that satisfies the following conditions, it would recognize the stream as a GIF file.

- The identifier of the stream ends with a suffix `".gif "`.
- The stream data begins with a byte sequence `"GIF87a "` or `"GIF89a "`.

When instance method `image#write()` is provided with a stream that satisfies the following condition, it would write image data in GIF format.

- The identifier of the stream ends with a suffix `".gif "`.

### 21.2 gif.content Class

#### gif.content

`gif.content(stream?:stream:r, format:symbol => 'rgba') {block?}`

Reads a GIF data from a stream and returns an object that contains GIF related information and images of a specified format. format is is `rgb`, `rgba` or `noimage`. If `noimage` is specified, only the information data is read

#### gif.content#addimage

`gif.content#addimage(image:image, delayTime:number => 10, leftPos:number => 0, topPos:number => 0, disposalMethod:symbol => 'none'):map:reduce`

Adds an image to GIF information.

You can add multiple images that can be played as a motion picture.

The argument `delayTime` specifies the delay time in 10 milli seconds between images.

The arguments `leftPos` and `topPos` specifies the rendered offset in the screen.

The argument `disposalMethod` takes one of following symbols that specifies how the image will be treated after being rendered.

- `'none ..`
- `'keep ..`
- `'background ..`
- `'previous ..`

This method returns the reference to the target instance itself.

`gif.content#write`

`gif.content#write(stream:stream:w):reduce`

Writes a GIF image to a stream.

This method returns the reference to the target instance itself.

## 21.3 Extension to image Class

This module extends the `stream` class with methods described here.

`image#read@gif`

`image#read@gif(stream:stream:r):reduce`

Reads a GIF image from a stream.

This method returns the reference to the target instance itself.

`image#write@gif`

`image#write@gif(stream:stream:w):reduce`

Writes a GIF image to a stream.

This method returns the reference to the target instance itself.

# Chapter 22

## glu Module

The `glu` module provides functions of GLU library.

### 22.1 Module Function

`glu.gluBeginCurve`

`glu.gluBeginCurve(nurb:glu.Nurbs):void {block?}`

`glu.gluBeginPolygon`

`glu.gluBeginPolygon(tess:glu.Tessellator):void {block?}`

`glu.gluBeginSurface`

`glu.gluBeginSurface(nurb:glu.Nurbs):void {block?}`

`glu.gluBeginTrim`

`glu.gluBeginTrim(nurb:glu.Nurbs):void {block?}`

`glu.gluBuild1DMipmaps`

`glu.gluBuild1DMipmaps(target:number, internalFormat:number, width:number, format:number, type:number, data)`

`glu.gluBuild1DMipmapsFromImage`

`glu.gluBuild1DMipmapsFromImage(target:number, internalFormat:number, image:image)`

`glu.gluBuild2DMipmaps`

`glu.gluBuild2DMipmaps(target:number, internalFormat:number, width:number, height:number, format:number, type:number, data)`

`glu.gluBuild2DMipmapsFromImage`

`glu.gluBuild2DMipmapsFromImage(target:number, internalFormat:number, image:image)`

`glu.gluCylinder`

`glu.gluCylinder(quad:glu.Quadric, base:number, top:number, height:number, slices:number, stacks:number):void`

#### glu.gluDeleteNurbsRenderer

glu.gluDeleteNurbsRenderer(nurb:glu.Nurbs):void

#### glu.gluDeleteQuadric

glu.gluDeleteQuadric(quad:glu.Quadric):void

#### glu.gluDeleteTess

glu.gluDeleteTess(tess:glu.Tessellator):void

#### glu.gluDisk

glu.gluDisk(quad:glu.Quadric, inner:number, outer:number, slices:number, loops:number):void

#### glu.gluEndCurve

glu.gluEndCurve(nurb:glu.Nurbs):void

#### glu.gluEndPolygon

glu.gluEndPolygon(tess:glu.Tessellator):void

#### glu.gluEndSurface

glu.gluEndSurface(nurb:glu.Nurbs):void

#### glu.gluEndTrim

glu.gluEndTrim(nurb:glu.Nurbs):void

#### glu.gluErrorString

glu.gluErrorString(error:number)

#### glu.gluGetNurbsProperty

glu.gluGetNurbsProperty(nurb:glu.Nurbs, property:number, data:array@float:nomap):void

#### glu.gluGetString

glu.gluGetString(name:number)

#### glu.gluGetTessProperty

glu.gluGetTessProperty(tess:glu.Tessellator, which:number, data:array@double:nomap):void

#### glu.gluLoadSamplingMatrices

glu.gluLoadSamplingMatrices(nurb:glu.Nurbs, model:array@float:nomap, perspective:array@float:nomap, view:array@int:nomap):void

#### glu.gluLookAt

glu.gluLookAt(eyeX:number, eyeY:number, eyeZ:number, centerX:number, centerY:number, centerZ:number, upX:number, upY:number, upZ:number):void



glu.gluNewNurbsRenderer

glu.gluNewNurbsRenderer()

glu.gluNewQuadric

glu.gluNewQuadric()

glu.gluNewTess

glu.gluNewTess()

glu.gluNextContour

glu.gluNextContour(tess:glu.Tessellator, type:number):void

glu.gluNurbsCallback

glu.gluNurbsCallback(nurbs:glu.Nurbs, which:number, func:function)

glu.gluNurbsCallbackData

glu.gluNurbsCallbackData(nurb:glu.Nurbs, userData):void

glu.gluNurbsCallbackDataEXT

glu.gluNurbsCallbackDataEXT(nurb:glu.Nurbs, userData):void

glu.gluNurbsCurve

glu.gluNurbsCurve(nurb:glu.Nurbs, knots:array@float:nomap, stride:number, control:array@float:nomap, order:number, type:number):void

glu.gluNurbsProperty

glu.gluNurbsProperty(nurb:glu.Nurbs, property:number, value:number):void

glu.gluNurbsSurface

glu.gluNurbsSurface(nurb:glu.Nurbs, sKnots:array@float:nomap, tKnots:array@float:nomap, sStride:number, tStride:number, control:array@float:nomap, sOrder:number, tOrder:number, type:number):void

glu.gluOrtho2D

glu.gluOrtho2D(left:number, right:number, bottom:number, top:number):void

glu.gluPartialDisk

glu.gluPartialDisk(quad:glu.Quadric, inner:number, outer:number, slices:number, loops:number, start:number, sweep:number):void

glu.gluPerspective

glu.gluPerspective(fovy:number, aspect:number, zNear:number, zFar:number):void

glu.gluPickMatrix

glu.gluPickMatrix(x:number, y:number, delX:number, delY:number, viewport:array@int:nomap):void

#### glu.gluProject

`glu.gluProject(objX:number, objY:number, objZ:number, model:array@double:nomap, proj:array@double:nomap, view:array@int:nomap, winX:array@double:nomap, winY:array@double:nomap, winZ:array@double:nomap)`

#### glu.gluPwlCurve

`glu.gluPwlCurve(nurb:glu.Nurbs, data:array@float:nomap, stride:number, type:number):void`

#### glu.gluQuadricCallback

`glu.gluQuadricCallback(quad:glu.Quadric, which:number, func:function:nil):void`

#### glu.gluQuadricDrawStyle

`glu.gluQuadricDrawStyle(quad:glu.Quadric, draw:number):void`

#### glu.gluQuadricNormals

`glu.gluQuadricNormals(quad:glu.Quadric, normal:number):void`

#### glu.gluQuadricOrientation

`glu.gluQuadricOrientation(quad:glu.Quadric, orientation:number):void`

#### glu.gluQuadricTexture

`glu.gluQuadricTexture(quad:glu.Quadric, texture:boolean):void`

#### glu.gluScaleImage

`glu.gluScaleImage(imageIn:image, wOut:number, hOut:number)`

#### glu.gluSphere

`glu.gluSphere(quad:glu.Quadric, radius:number, slices:number, stacks:number):void`

#### glu.gluTessBeginContour

`glu.gluTessBeginContour(tess:glu.Tessellator):void {block?}`

#### glu.gluTessBeginPolygon

`glu.gluTessBeginPolygon(tess:glu.Tessellator, polygon.data):void {block?}`

#### glu.gluTessCallback

`glu.gluTessCallback(tess:glu.Tessellator, which:number, func:function):void`

#### glu.gluTessEndContour

`glu.gluTessEndContour(tess:glu.Tessellator):void`

#### glu.gluTessEndPolygon

`glu.gluTessEndPolygon(tess:glu.Tessellator):void`

#### glu.gluTessNormal

`glu.gluTessNormal(tess:glu.Tessellator, valueX:number, valueY:number, valueZ:number):void`

#### glu.gluTessProperty

`glu.gluTessProperty(tess:glu.Tessellator, which:number, data:number):void`

#### glu.gluTessVertex

`glu.gluTessVertex(tess:glu.Tessellator, location:array@double:nomap, vertex_data):void`

#### glu.gluUnProject

`glu.gluUnProject(winX:number, winY:number, winZ:number, model:array@double:nomap, proj:array@double:nomap, view:array@int:nomap, objX:array@double:nomap, objY:array@double:nomap, objZ:array@double:nomap)`

# Chapter 23

## glut Module

The `glut` module provides functions of GLUT library.

### 23.1 Module Function

`glut.glutInit`

`glut.glutInit(argv[]:string) {block?}`

`glutInit` is used to initialize the GLUT library.

`glut.glutInitDisplayMode`

`glut.glutInitDisplayMode(mode:number):map:void`

`glutInitDisplayMode` sets the *initial display mode*.

`glut.glutInitDisplayString`

`glut.glutInitDisplayString(string:string):map:void`

`glut.glutInitWindowPosition`

`glut.glutInitWindowPosition(x:number, y:number):map:void`

`glutInitWindowPosition` sets the initial window position.

`glut.glutInitWindowSize`

`glut.glutInitWindowSize(width:number, height:number):map:void`

`glutInitWindowSize` sets the initial window size.

`glut.glutMainLoop`

`glut.glutMainLoop():void`

`glutMainLoop` enters the GLUT event processing loop.

`glut.glutCreateWindow`

`glut.glutCreateWindow(title:string):map {block?}`

`glutCreateWindow` creates a top-level window.

`glut.glutCreateSubWindow`

`glut.glutCreateSubWindow(win:number, x:number, y:number, width:number, height:number):map {block?}`

`glutCreateSubWindow` creates a subwindow.

`glut.glutDestroyWindow`

`glut.glutDestroyWindow(win:number):map:void`

`glutDestroyWindow` destroys the specified window.

`glut.glutPostRedisplay`

`glut.glutPostRedisplay():void`

`glutPostRedisplay` marks the *\*current window\** as needing to be redisplayed.

`glut.glutPostWindowRedisplay`

`glut.glutPostWindowRedisplay(win:number):map:void`

`glut.glutSwapBuffers`

`glut.glutSwapBuffers():void`

`glutSwapBuffers` swaps the buffers of the *current window* if double buffered.

`glut.glutGetWindow`

`glut.glutGetWindow() {block?}`

`glutGetWindow` returns the identifier of the *current window*.

`glut.glutSetWindow`

`glut.glutSetWindow(win:number):map:void`

`glutSetWindow` sets the *current window*.

`glut.glutSetWindowTitle`

`glut.glutSetWindowTitle(title:string):map:void`

`glutSetWindowTitle` changes the window title of the current top-level window.

`glut.glutSetIconTitle`

`glut.glutSetIconTitle(title:string):map:void`

`glutSetIconTitle` changes the icon title of the current top-level window.

`glut.glutPositionWindow`

`glut.glutPositionWindow(x:number, y:number):map:void`

`glutPositionWindow` requests a change to the position of the *current window*.

`glut.glutReshapeWindow`

`glut.glutReshapeWindow(width:number, height:number):map:void`

`glutReshapeWindow` requests a change to the size of the *current window*.

`glut.glutPopWindow`

`glut.glutPopWindow():void`

`glut.glutPushWindow`

`glut.glutPushWindow():void`

glut.glutIconifyWindow

glut.glutIconifyWindow():void

glut.glutShowWindow

glut.glutShowWindow():void

glut.glutHideWindow

glut.glutHideWindow():void

glut.glutFullScreen

glut.glutFullScreen():void

glut.glutSetCursor

glut.glutSetCursor(cursor:number):map:void

glut.glutWarpPointer

glut.glutWarpPointer(x:number, y:number):map:void

glut.glutEstablishOverlay

glut.glutEstablishOverlay():void

glut.glutRemoveOverlay

glut.glutRemoveOverlay():void

glut.glutUseLayer

glut.glutUseLayer(layer:number):map:void

glut.glutPostOverlayRedisplay

glut.glutPostOverlayRedisplay():void

glut.glutPostWindowOverlayRedisplay

glut.glutPostWindowOverlayRedisplay(win:number):map:void

glut.glutShowOverlay

glut.glutShowOverlay():void

glut.glutHideOverlay

glut.glutHideOverlay():void

glut.glutCreateMenu

glut.glutCreateMenu(func:function) {block?}

glut.glutDestroyMenu

glut.glutDestroyMenu(menu:number):map:void

#### glut.glutGetMenu

glut.glutGetMenu() {block?}

#### glut.glutSetMenu

glut.glutSetMenu(menu:number):map:void

#### glut.glutAddMenuEntry

glut.glutAddMenuEntry(label:string, value:number):map:void

#### glut.glutAddSubMenu

glut.glutAddSubMenu(label:string, submenu:number):map:void

#### glut.glutChangeToMenuEntry

glut.glutChangeToMenuEntry(item:number, label:string, value:number):map:void

#### glut.glutChangeToSubMenu

glut.glutChangeToSubMenu(item:number, label:string, submenu:number):map:void

#### glut.glutRemoveMenuItem

glut.glutRemoveMenuItem(item:number):map:void

#### glut.glutAttachMenu

glut.glutAttachMenu(button:number):map:void

#### glut.glutDetachMenu

glut.glutDetachMenu(button:number):map:void

#### glut.glutDisplayFunc

glut.glutDisplayFunc(func:function:nil):void

#### glut.glutReshapeFunc

glut.glutReshapeFunc(func:function:nil):void

#### glut.glutKeyboardFunc

glut.glutKeyboardFunc(func:function:nil):void

#### glut.glutMouseFunc

glut.glutMouseFunc(func:function:nil):void

#### glut.glutMotionFunc

glut.glutMotionFunc(func:function:nil):void

#### glut.glutPassiveMotionFunc

glut.glutPassiveMotionFunc(func:function:nil):void

#### glut.glutEntryFunc

glut.glutEntryFunc(func:function:nil):void

#### glut.glutVisibilityFunc

glut.glutVisibilityFunc(func:function:nil):void

#### glut.glutIdleFunc

glut.glutIdleFunc(func:function:nil):void

#### glut.glutTimerFunc

glut.glutTimerFunc(millis:number, func:function:nil, value:number):void

#### glut.glutMenuStateFunc

glut.glutMenuStateFunc(func:function:nil):void

#### glut.glutSpecialFunc

glut.glutSpecialFunc(func:function:nil):void

#### glut.glutSpaceballMotionFunc

glut.glutSpaceballMotionFunc(func:function:nil):void

#### glut.glutSpaceballRotateFunc

glut.glutSpaceballRotateFunc(func:function:nil):void

#### glut.glutSpaceballButtonFunc

glut.glutSpaceballButtonFunc(func:function:nil):void

#### glut.glutButtonBoxFunc

glut.glutButtonBoxFunc(func:function:nil):void

#### glut.glutDialsFunc

glut.glutDialsFunc(func:function:nil):void

#### glut.glutTabletMotionFunc

glut.glutTabletMotionFunc(func:function:nil):void

#### glut.glutTabletButtonFunc

glut.glutTabletButtonFunc(func:function:nil):void

#### glut.glutMenuStatusFunc

glut.glutMenuStatusFunc(func:function:nil):void

#### glut.glutOverlayDisplayFunc

glut.glutOverlayDisplayFunc(func:function:nil):void



#### glut.glutWindowStatusFunc

glut.glutWindowStatusFunc(func:function:nil):void

#### glut.glutKeyboardUpFunc

glut.glutKeyboardUpFunc(func:function:nil):void

#### glut.glutSpecialUpFunc

glut.glutSpecialUpFunc(func:function:nil):void

#### glut.glutJoystickFunc

glut.glutJoystickFunc(func:function:nil, pollInterval:number):void

#### glut.glutSetColor

glut.glutSetColor(ndx:number, red:number, green:number, blue:number):void

#### glut.glutGetColor

glut.glutGetColor(ndx:number, component:number):map {block?}

#### glut.glutCopyColormap

glut.glutCopyColormap(win:number):map:void

#### glut.glutGet

glut.glutGet(type:number):map {block?}

#### glut.glutDeviceGet

glut.glutDeviceGet(type:number):map {block?}

#### glut.glutExtensionSupported

glut.glutExtensionSupported(name:string):map {block?}

#### glut.glutGetModifiers

glut.glutGetModifiers() {block?}

#### glut.glutLayerGet

glut.glutLayerGet(type:number):map {block?}

#### glut.glutGetProcAddress

glut.glutGetProcAddress(procName:string):map:void {block?}

#### glut.glutBitmapCharacter

glut.glutBitmapCharacter(font:glut.Font, character:number):map:void

#### glut.glutBitmapWidth

glut.glutBitmapWidth(font:glut.Font, character:number):map {block?}

#### glut.glutStrokeCharacter

glut.glutStrokeCharacter(font:glut.Font, character:number):map:void

#### glut.glutStrokeWidth

glut.glutStrokeWidth(font:glut.Font, character:number):map {block?}

#### glut.glutBitmapLength

glut.glutBitmapLength(font:glut.Font, string:string):map {block?}

#### glut.glutStrokeLength

glut.glutStrokeLength(font:glut.Font, string:string):map {block?}

#### glut.glutWireSphere

glut.glutWireSphere(radius:number, slices:number, stacks:number):map:void

#### glut.glutSolidSphere

glut.glutSolidSphere(radius:number, slices:number, stacks:number):map:void

#### glut.glutWireCone

glut.glutWireCone(base:number, height:number, slices:number, stacks:number):map:void

#### glut.glutSolidCone

glut.glutSolidCone(base:number, height:number, slices:number, stacks:number):map:void

#### glut.glutWireCube

glut.glutWireCube(size:number):map:void

#### glut.glutSolidCube

glut.glutSolidCube(size:number):map:void

#### glut.glutWireTorus

glut.glutWireTorus(innerRadius:number, outerRadius:number, sides:number, rings:number):map:void

#### glut.glutSolidTorus

glut.glutSolidTorus(innerRadius:number, outerRadius:number, sides:number, rings:number):map:void

#### glut.glutWireDodecahedron

glut.glutWireDodecahedron():void

#### glut.glutSolidDodecahedron

glut.glutSolidDodecahedron():void

#### glut.glutWireTeapot

glut.glutWireTeapot(size:number):map:void

glut.glutSolidTeapot

glut.glutSolidTeapot(size:number):map:void

glut.glutWireOctahedron

glut.glutWireOctahedron():void

glut.glutSolidOctahedron

glut.glutSolidOctahedron():void

glut.glutWireTetrahedron

glut.glutWireTetrahedron():void

glut.glutSolidTetrahedron

glut.glutSolidTetrahedron():void

glut.glutWireIcosahedron

glut.glutWireIcosahedron():void

glut.glutSolidIcosahedron

glut.glutSolidIcosahedron():void

glut.glutVideoResizeGet

glut.glutVideoResizeGet(param:number):map {block?}

glut.glutSetupVideoResizing

glut.glutSetupVideoResizing():void

glut.glutStopVideoResizing

glut.glutStopVideoResizing():void

glut.glutVideoResize

glut.glutVideoResize(x:number, y:number, width:number, height:number):map:void

glut.glutVideoPan

glut.glutVideoPan(x:number, y:number, width:number, height:number):map:void

glut.glutReportErrors

glut.glutReportErrors():void

glut.glutIgnoreKeyRepeat

glut.glutIgnoreKeyRepeat(ignore:number):map:void

glut.glutSetKeyRepeat

glut.glutSetKeyRepeat(repeatMode:number):map:void

glut.glutForceJoystickFunc

`glut.glutForceJoystickFunc():void`

glut.glutGameModeString

`glut.glutGameModeString(string:string):map:void`

glut.glutEnterGameMode

`glut.glutEnterGameMode() {block?}`

glut.glutLeaveGameMode

`glut.glutLeaveGameMode():void`

glut.glutGameModeGet

`glut.glutGameModeGet(mode:number):map {block?}`

## 23.2 Thanks

This module uses freeglut which official site is:  
<http://freeglut.sourceforge.net/>

## Chapter 24

# gmp Module

The `gmp` module provides measures to calculate numbers with multiple precision using GMP library. To utilize it, import the `gmp` module using `import` function. It expands features of operators like addition and multiplier so that they can calculate such numbers.

### 24.1 Operator

Following tables show values types of operands and returned value for each operator:

<code>+x</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>
-----------------	----------------------	----------------------	----------------------

<code>-x</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>
-----------------	----------------------	----------------------	----------------------

<code>x</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>
----------------	----------------------	----------------------	----------------------

<code>x + y</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>number</code>	<code>rational</code>
<code>gmp.mpz</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>gmp.mpf</code>	<code>gmp.mpq</code>
<code>gmp.mpq</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>gmp.mpf</code>	<code>gmp.mpq</code>
<code>gmp.mpf</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>gmp.mpf</code>	<code>gmp.mpq</code>
<code>number</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>number</code>	<code>rational</code>
<code>rational</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>rational</code>	<code>rational</code>

<code>x - y</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>number</code>	<code>rational</code>
<code>gmp.mpz</code>					
<code>gmp.mpq</code>					
<code>gmp.mpf</code>					
<code>number</code>					
<code>rational</code>					

x * y	gmp.mpz	gmp.mpq	gmp.mpf	number	rational
gmp.mpz					
gmp.mpq					
gmp.mpf					
number					
rational					

x / y	gmp.mpz	gmp.mpq	gmp.mpf	number	rational
gmp.mpz					
gmp.mpq					
gmp.mpf					
number					
rational					

x % y	gmp.mpz	gmp.mpq	gmp.mpf	number	rational
gmp.mpz					
gmp.mpq					
gmp.mpf					
number					
rational					

x == y; x != y; x > y; x < y; x >= y; x <= y; x <=> y

comparator	gmp.mpz	gmp.mpq	gmp.mpf	number	rational
gmp.mpz					
gmp.mpq					
gmp.mpf					
number					
rational					

x & y	gmp.mpz	gmp.mpq	gmp.mpf	number	rational
gmp.mpz					
gmp.mpq					
gmp.mpf					
number					
rational					

x   y	gmp.mpz	gmp.mpq	gmp.mpf	number	rational
gmp.mpz					
gmp.mpq					
gmp.mpf					
number					
rational					

<code>x ^ y</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>number</code>	<code>rational</code>
<code>gmp.mpz</code>					
<code>gmp.mpq</code>					
<code>gmp.mpf</code>					
<code>number</code>					
<code>rational</code>					

<code>x y</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>number</code>	<code>rational</code>
<code>gmp.mpz</code>					
<code>gmp.mpq</code>					
<code>gmp.mpf</code>					
<code>number</code>					
<code>rational</code>					

<code>x y</code>	<code>gmp.mpz</code>	<code>gmp.mpq</code>	<code>gmp.mpf</code>	<code>number</code>	<code>rational</code>
<code>gmp.mpz</code>					
<code>gmp.mpq</code>					
<code>gmp.mpf</code>					
<code>number</code>					
<code>rational</code>					

`x..; x .. y`

## 24.2 Module Function

### gmp.gcd

`gmp.gcd(num1:gmp.mpz, num2:gmp.mpz):map`

Calculates the greatest common divisor, GCD, between `num1` and `num2` and returns the result as `gmp.mpz` .

### gmp.lcm

`gmp.lcm(num1:gmp.mpz, num2:gmp.mpz):map`

Calculates the least common multiple, LCM, between `num1` and `num2` and returns the result as `gmp.mpz` .

### gmp.sqrt

`gmp.sqrt(num):map`

Calculates the square root of `num` .

The type of the argument `num` must be `gmp.mpz` , `gmp.mpq` , `gmp.mpf` or `number` .

## 24.3 gmp.mpf Class

### 24.3.1 Constructor

#### gmp.mpf

`gmp.mpf(value?, prec?:number):map {block?}`

Creates a `gmp.mpf` instance.

If the argument `value` is specified, it would be casted to `gmp.mpf` . Acceptable types for `value` are: `number` , `string` , `gmp.mpf` , `gmp.mpz` and `gmp.mpq` . You can specify the precision of the number by the argument `prec` . If it's omitted, a default precision would be applied.

### 24.3.2 Method

`gmp.mpf.get_default_prec`

`gmp.mpf.get_default_prec():static`

Gets the default precision for `gmp.mpf` .

`gmp.mpf.set_default_prec`

`gmp.mpf.set_default_prec(prec:number):static:void`

Sets the default precision for `gmp.mpf` .

## 24.4 gmp.mpq Class

### 24.4.1 Constructor

`gmp.mpq`

`gmp.mpq(number?, denom?:number):map {block?}`

Creates a `gmp.mpq` instance.

You can call this function with one of the following form.

- `gmp.mpq(number:number)`
- `gmp.mpq(number:number, denom:number)`
- `gmp.mpq(str:string)`
- `gmp.mpq(num:gmp.mpq)`

### 24.4.2 Method

`gmp.mpq#cast@mpf`

`gmp.mpq#cast@mpf() {block?}`

Casts the value to `gmp.mpf` .

If `block` is specified, it would be evaluated with a block parameter `|num:gmp.mpf|` , where `num` is the created instance. In this case, the block's result would become the function's returned value.

## 24.5 gmp.mpz Class

### 24.5.1 Constructor

`gmp.mpz`

`gmp.mpz(value?):map {block?}`

Creates a `gmp.mpz` instance.

If the argument `value` is specified, it would be casted to `gmp.mpz` . Acceptable types for `value` are: `number` , `string` , `gmp.mpf` and `gmp.mpz` .



## 24.6 Extention to string Class

This module extends the `string` class with methods described here.

string#cast@mpf

`string#cast@mpf(prec?:number):map`

Casts the string to `gmp.mpf` .

You can specify the precision of the number by the argument `prec` . If it's omitted, a default precision would be applied.

If `block` is specified, it would be evaluated with a block parameter `|num:gmp.mpf|` , where `num` is the created instance. In this case, the block's result would become the function's returned value.

string#cast@mpq

`string#cast@mpq():map {block?}`

Casts the string to `gmp.mpq` .

If `block` is specified, it would be evaluated with a block parameter `|num:gmp.mpq|` , where `num` is the created instance. In this case, the block's result would become the function's returned value.

string#cast@mpz

`string#cast@mpz(base?:number):map`

Casts the string to `gmp.mpz` .

You can specify the basement of the number format by the argument `base` . If it's omitted, the basement would be decided by the prefix described in the string such as `"0 "` and `"0x "` .

If `block` is specified, it would be evaluated with a block parameter `|num:gmp.mpz|` , where `num` is the created instance. In this case, the block's result would become the function's returned value.

## 24.7 Thanks

This module uses GMP and its forked project MPIR which are distributed in the following sites:

- <https://gmplib.org>
- <http://www.mpir.org/>

## Chapter 25

# gurcbuild Module

The `gurcbuild` module ...

### 25.1 Module Function

## Chapter 26

# gzip Module

The `gzip` module provides measures to read/write GZIP files. To utilize it, import the `gzip` module using `import` function.

Below is an example to read data from a GZIP file and write its uncompressed data to another file.

```
import(gzip)
gzip.reader('foo.dat.gz').copyto('foo.dat')
```

Below is an example to read data from a file and write its compressed data to a GZIP file.

```
import(gzip)
gzip.writer('foo.dat.gz').copyfrom('foo.dat')
```

### 26.1 Module Function

#### gzip.reader

`gzip.reader(stream:stream:r) {block?}`

#### gzip.writer

`gzip.writer(stream:stream:w, level?:number) {block?}`

### 26.2 Extension to stream Class

This module extends the `stream` class with methods described here.

#### stream#reader@gzip

`stream#reader@gzip() {block?}`

#### stream#writer@gzip

`stream#writer@gzip(level?:number) {block?}`

### 26.3 Thanks

This module uses `zlib` which official site is:

<http://zlib.net/>

# Chapter 27

## hash Module

The `hash` module provides measures to calculate hash values of a data sequence in a stream. To utilize it, import the `hash` module using `import` function.

### 27.1 hash.accumulator Class

The `hash.accumulator` class provides measures to calculate hashed numbers including MD5, SHA-1 and CRC32.

As the class inherits from `stream`, you can call methods of `stream` class with `hash.accumulator` instances.

#### 27.1.1 Property

Property	Type	R/W	Explanation
<code>hash.accumulator.digest</code>	<code>#digest</code>	R	Returns the hashed result as <code>binary</code> .
<code>hash.accumulator.hexdigest</code>	<code>#hexdigest</code>	R	Returns the hashed result as <code>string</code> in hexadecimal format.
<code>hash.accumulator.number</code>	<code>#number</code>	R	Returns the hashed result as <code>number</code> . This field is valid only for CRC32 and returns 'nil' for other hashes.

#### 27.1.2 Constructor

##### hash.md5

```
hash.md5(stream?:stream:r) {block?}
```

Creates an `hash.accumulator` instance that calculates MD5 hashed value from the content of `stream`.

##### hash.sha1

```
hash.sha1(stream?:stream:r) {block?}
```

Creates an `hash.accumulator` instance that calculates SHA1 hashed value from the content of `stream`.

##### hash.crc32

```
hash.crc32(stream?:stream:r) {block?}
```

Creates an `hash.accumulator` instance that calculates CRC32 hashed value from the content of `stream`.

### 27.1.3 Method

hash.accumulator#init

hash.accumulator#init():reduce

Initializes the state of the accumulator.

hash.accumulator#update

hash.accumulator#update(stream:stream:r):reduce

Updates the accumulator with the content of **stream** .

## Chapter 28

# http Module

The `http` module provides measures to connect the Internet through HTTP protocol.

### 28.1 Module Function

## Chapter 29

# jpeg Module

The `jpeg` module provides measures to read/write image data in JPEG format. To utilize it, import the `jpeg` module using `import` function. Below is an example to read a JPEG file:

```
import(jpeg)
img = image('foo.jpeg')
```

### 29.1 Exntension to Function's Capability

This module extends the capability of function `image()` and instance method `image#write()` so that they can read/write JPEG files.

When function `image()` is provided with a stream that satisfies the following conditions, it would recognize the stream as a JPEG file.

- The identifier of the stream ends with a suffix `".jpeg "`, `".jpg "` or `".jpe "`.
- The stream data begins with a byte sequence `"\xff\xd8 "` that means SOI (start of Image) marker in JPEG specification.

When instance method `image#write()` is provided with a stream that satisfies the following condition, it would write image data in JPEG format.

- The identifier of the stream ends with a suffix `".jpeg "`, `".jpg "` or `".jpe "`.

### 29.2 jpeg.exif Class

The `jpeg.exif` class provides EXIF information in a JPEG stream.

A `jpeg.exif` instance contains `jpeg.ifd` instances as properties named `jpeg.exif#ifd0` and `jpeg.exif#ifd1` that include a list of `jpeg.tag` instances.

```
+-----+           +-----+           +-----+
| jpeg.exif |ifd0, ifd1 | jpeg.ifd |1..   | jpeg.tag |
|-----*-----+-----*-----+-----|
|           |           |           |
+-----+           +-----+           +-----+
```

#### 29.2.1 Property

A `jpeg.exif` instance has the following properties:

Property	Type	R/W	Explanation
jpeg.exif#endian	symbol	R	The endian type: 'big' for big-endian and 'little' for little-endian.
jpeg.exif#ifd0	jpeg.ifd	R	IFD0 instance.
jpeg.exif#ifd1	jpeg.ifd	R	IFD1 instance.
jpeg.exif#thumbnail	image	R	Thumbnail image as <code>image</code> value.
jpeg.exif#thumbnail@binary	binary	R	Thumbnail image as JPEG binary data.

## 29.2.2 Constructor

`jpeg.exif`

`jpeg.exif(stream?:stream:r):map:[raise] {block?}`

Reads EXIF data from `stream` and creates a `jpeg.exif` instance.

If no EXIF information exists in the stream, this function returns `nil`. If the attribute `:raise` is specified, an error occurs for that case.

If `block` is specified, it would be evaluated with a block parameter `|exif:jpeg.exif|`, where `exif` is the created instance. In this case, the block's result would become the function's returned value.

## 29.2.3 Method

`jpeg.exif#each`

`jpeg.exif#each() {block?}`

Creates an iterator that returns `jpeg.tag` values as elements that are stored in the property `jpeg.exif#ifd0`.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

## 29.3 jpeg.ifd Class

### 29.3.1 Property

A `jpeg.ifd` instance has the following properties:

Property	Type	R/W	Explanation
jpeg.ifd#name	string	R	
jpeg.ifd#symbol	symbol	R	



### 29.3.2 Method

jpeg.ifd#each

`jpeg.ifd#each() {block?}`

Creates an iterator that returns `jpeg.tag` values as elements that are stored in the target `jpeg.ifd` instance.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

## 29.4 jpeg.tag Class

### 29.4.1 Property

A `jpeg.tag` instance has the following properties:

Property	Type	R/W	Explanation
<code>jpeg.tag#id</code>	<code>number</code>	R	Tag ID.
<code>jpeg.tag#name</code>	<code>string</code>	R	Tag name.
<code>jpeg.tag#symbol</code>	<code>symbol</code>	R	Tag name as <code>symbol</code> .
<code>jpeg.tag#type</code>	<code>number</code>	R	Tag type.
<code>jpeg.tag#typename</code>	<code>string</code>	R	Tag type name.
<code>jpeg.tag#value</code>	<code>any</code>	R	Tag value. When the attribute <code>:cooked</code> is specified, numbers in some tags are translated to human-readable symbols.
<code>jpeg.tag#ifd</code>	<code>jpeg.ifd</code>	R	IFD instance. Valid only for tags <code>Exif</code> , <code>GPSInfo</code> and <code>Interoperability</code> .

## 29.5 Extension to image Class

This module extends the `image` class with methods described here.

image#read@jpeg

`image#read@jpeg(stream:stream:r):reduce`

Reads a JPEG image data from a stream.

image#write@jpeg

`image#write@jpeg(stream:stream:w, quality:number => 75):reduce`

Writes a JPEG image data to a stream.

## 29.6 Thanks

This module uses JPEG library which is distributed in the following site:  
<http://www.ijg.org/>

## Chapter 30

# markdown Module

The `markdown` module provides measures to parse a text formatted in markdown syntax. To utilize it, import the `markdown` module using `import` function. Below is an example to read a document written in Markdown format and then render its HTML text into a file.

```
import(markdown)
markdown.document('foo.md').render@html('foo.html')
```

`markdown` module consists of the following two module files:

- `markdown.gurd` .. a binary module file that provides parser procedures.
- `markdown.gura` .. a script module file that renders parsed result in desired formats.

### 30.1 Operator

`markdown.document << function`

### 30.2 Module Function

`markdown.setpresenter`

`markdown.setpresenter():void {block}`

Sets a presentation procedure that shows helps written in Markdown format. The procedure is written in the function's block that takes block parameters: `|title:string, doc:markdown.document|`.

### 30.3 `markdown.document` Class

The `markdown.document` class provides measures to parse a document written in Markdown format.

You can parse documents written in both string and stream using the following methods:

- `markdown.document#parse()` .. Parses document written in a string.
- `markdown.document#read()` .. Parses document from a stream.

You can get the parsed result by inspecting a property `markdown.document#root` and its children that are `markdown.item` instances.

### 30.3.1 Property

Property	Type	R/W	Explanation
<code>markdown.document#ref</code>	<code>Iterator</code>	R	An iterator that returns referee items as <code>markdown.item</code> .
<code>markdown.document#root</code>	<code>markdown.item</code>	R	The root item of the parsed Markdown document.

### 30.3.2 Constructor

#### markdown.document

```
markdown.document(stream?:stream:r) {block?}
```

Returns an instance of `markdown.document`. If `stream` is specified, the content of the instance shall be initialized with the result of parsing the stream.

### 30.3.3 Method

#### markdown.document#parse

```
markdown.document#parse(str:string):void
```

Parses a Markdown text in a string.

#### markdown.document#read

```
markdown.document#read(stream:stream:r):void
```

Parses a Markdown text from a stream.

#### markdown.render@console

```
markdown.render@console(colorFlag:boolean => true)
```

Renders the content of markdown document to the console.  
In default, it uses colors to highlight items. Specify the argument `colorFlag` with `false` to disable the coloring process.

#### markdown.render@html

```
markdown.render@html(out?:stream:w, easyFormatFlag:boolean => true, captionIndex:boolean  
=> false)
```

#### markdown.render@toc

```
markdown.render@toc() {block}
```

## 30.4 markdown.item Class

The `markdown.item` class provides information about items that composes a Markdown document.

Below is a table of item type:

Item Type	Explanation
root	container
h1	container
h2	container
h3	container
h4	container
h5	container
h6	container
p	container
blockquote	container
em	container
strong	container
codeblock	container
ol	container
ul	container
li	container
line	container
a	container
img	text
text	text
code	text
entity	text
tag	container/text
hr	no-content
br	no-content
referee	no-content

### 30.4.1 Property

Property	Type	R/W	Explanation
markdown.item#type	string	R	
markdown.item#text	string	R	
markdown.item#children	iterator	R	
markdown.item#url	string	R	
markdown.item#title	string	R	
markdown.item#attrs	string	R	
markdown.item#align	symbol	R	
			none , left , center , right

### 30.4.2 Method

markdown.item#print

markdown.item#print(indent?:number):void

Prints structured content of the item. Argument `indent` specifies an indentation level and is set to zero when omitted.

# Chapter 31

## math Module

The `math` module provides functions for mathematical calculation. This is a built-in module, so you can use it without being imported.

### 31.1 Module Function

`math.real`

`math.real(num) : map`

Returns a real part of a complex number.

`math.imag`

`math.imag(num) : map`

Returns an imaginary part of a complex number.

`math.arg`

`math.arg(num) : map : [deg]`

Returns an argument value of a complex number in radian.

`math.norm`

`math.norm(num) : map`

Returns a norm value of a complex number.

`math.conj`

`math.conj(num) : map`

Returns a conjugate of a complex number.

`math.acos`

`math.acos(num) : map : [deg]`

Returns an inverse cosine value.

`math.asin`

`math.asin(num) : map : [deg]`

Returns an inverse sine value.

`math.atan`

`math.atan(num) : map : [deg]`

Returns an inverse tangent value.

math.atan2

`math.atan2(num1, num2):map:[deg]`

Returns an inverse tangent value of a fraction of num1 and num2.

math.ceil

`math.ceil(num):map`

Returns a nearest integer number above or equal to the specified value.

math.cos

`math.cos(num):map:[deg]`

Returns a cosine value.

math.cosh

`math.cosh(num):map`

Returns a hyperbolic cosine value.

math.exp

`math.exp(num):map`

Returns an exponential value.

math.abs

`math.abs(num):map`

Returns an absolute value.

math.floor

`math.floor(num):map`

Returns a nearest integer number below or equal to the specified value.

math.log

`math.log(num):map`

Returns a natural logarithm value.

math.log10

`math.log10(num):map`

Returns a decadic logarithm value.

math.sin

`math.sin(num):map:[deg]`

Returns a sine value.

math.sinh

`math.sinh(num):map`

Returns a hyperbolic sine value.

#### math.sqrt

`math.sqrt(num):map`

Returns a square root value.

#### math.tan

`math.tan(num):map:[deg]`

Returns a tangent value.

#### math.tanh

`math.tanh(num):map`

Returns a hyperbolic tangent value.

#### math.hypot

`math.hypot(x, y):map`

Returns a hyperbolic tangent value.

#### math.least\_square

`math.least_square(x:iterator, y:iterator, dim:number => 1, var:symbol => 'x')`

Calculates a least square method using a sequence of pairs of `x` and `y`, and returns an expression of the fitted curve. You can specify the dimension by an argument `dim`. In default, a symbol of the expression's variable is `x` and it can be changed by specifying an argument `var`.

#### math.bezier

`math.bezier(nums[]+:number)`

Returns a list that consists of functions that generate coordinates of bezier curves with specified control points. One or more lists of control points can be specified. This means that if you give it two lists of numbers as arguments, it returns two functions of bezier curve.

#### math.diff

`math.diff(expr:expr, var:symbol):map {block?}`

Returns a mathematical differential expression of the given `expr` by a variable `var`.  
Example: `math.diff((math.sin(x 2)), x) **`

#### math.optimize

`math.optimize(expr:expr):map {block?}`

#### math.fft

`math.fft(seq[])`

#### math.dot\_product

`math.dot_product(a[], b[])`

#### math.cross\_product

`math.cross_product(a[], b[])`



math.covariance

`math.covariance(a:iterator, b:iterator)`

Returns a covariance between the sequences of values.

math.integral

`math.integral()`

math.gcd

`math.gcd(a:number, b+:number):map`

Returns a greatest common divisor among two or more numbers.

math.lcm

`math.lcm(a:number, b+:number):map`

Returns a least common multiple among two or more numbers.

## Chapter 32

# midi Module

The `midi` module provides measures to read/write MIDI files. To utilize it, import the `midi` module using `import` function.

### 32.1 Module Function

### 32.2 midi.event Class

### 32.3 midi.track Class

midi.track#seek

`midi.track#seek(offset:number, origin?:symbol):reduce`

Moves the insertion point in the track at which the next event is inserted. If `origin` is omitted or set to `'set'`, the insertion point will be set to absolute offset from the beginning. If `origin` is set to `'cur'`, the insertion point will be moved by offset from the current position.

midi.track#tell

`midi.track#tell()`

Returns the current insertion point in the track.

midi.track#erase

`midi.track#erase(n?:number):reduce`

Deletes an event at the current insertion point in the track. The argument `n` specifies the number of events to be deleted. If `n` is omitted, one event will be deleted.

midi.track#mml

`midi.track#mml(str:string, max_velocity?:number):map:reduce`

Parses MML in the string `str` and inserts resulted MIDI events at the current insertion point in the track.

The argument `max_velocity` specifies the maximum number of velocity in the MML. If omitted, it will be set to 127.

midi.track#note\_off

`midi.track#note_off(channel:number, note:number, velocity:number, deltaTime?:number):map:reduce`

midi.track#note\_on

`midi.track#note_on(channel:number, note:number, velocity:number, deltaTime?:number):map:reduce`

midi.track#poly\_pressure

midi.track#poly\_pressure(channel:number, note:number, value:number, deltaTime?:number):map:reduce

midi.track#control\_change

midi.track#control\_change(channel:number, controller, value:number, deltaTime?:number):map:reduce

midi.track#program\_change

midi.track#program\_change(channel:number, program, deltaTime?:number):map:reduce

midi.track#channel\_pressure

midi.track#channel\_pressure(channel:number, pressure:number, deltaTime?:number):map:reduce

midi.track#pitch\_bend

midi.track#pitch\_bend(channel:number, value:number, deltaTime?:number):map:reduce

midi.track#sequence\_number

midi.track#sequence\_number(number:number, deltaTime?:number):map:reduce

midi.track#text\_event

midi.track#text\_event(text:string, deltaTime?:number):map:reduce

midi.track#copyright\_notice

midi.track#copyright\_notice(text:string, deltaTime?:number):map:reduce

midi.track#sequence\_or\_track\_name

midi.track#sequence\_or\_track\_name(text:string, deltaTime?:number):map:reduce

midi.track#instrument\_name

midi.track#instrument\_name(text:string, deltaTime?:number):map:reduce

midi.track#lyric\_text

midi.track#lyric\_text(text:string, deltaTime?:number):map:reduce

midi.track#marker\_text

midi.track#marker\_text(text:string, deltaTime?:number):map:reduce

midi.track#cue\_point

midi.track#cue\_point(text:string, deltaTime?:number):map:reduce

midi.track#midi\_channel\_prefix\_assignment

midi.track#midi\_channel\_prefix\_assignment(channel:number, deltaTime?:number):map:reduce

midi.track#end\_of\_track

midi.track#end\_of\_track(deltaTime?:number):map:reduce

midi.track#tempo\_setting

midi.track#tempo\_setting(mpqn:number, deltaTime?:number):map:reduce

midi.track#smpte\_offset

midi.track#smpte\_offset(hour:number, minute:number, second:number, frame:number, subFrame:number, deltaTime?:number):map:reduce

midi.track#time\_signature

midi.track#time\_signature(numerator:number, denominator:number, metronome:number, cnt32nd:number, deltaTime?:number):map:reduce

midi.track#key\_signature

midi.track#key\_signature(key:number, scale:number, deltaTime?:number):map:reduce

midi.track#sequencer\_specific\_event

midi.track#sequencer\_specific\_event(binary:binary, deltaTime?:number):map:reduce

## 32.4 midi.sequence Class

midi.sequence

midi.sequence(stream?:stream) {block?}

It creates an instance that contains SMF information.

midi.sequence#read

midi.sequence#read(stream:stream:r):map:reduce

midi.sequence#write

midi.sequence#write(stream:stream:w):map:reduce

midi.sequence#play

midi.sequence#play(port:midi.port, speed?:number, repeat:number:nil => 1):[background,player]

midi.sequence#track

midi.sequence#track(index:number):map {block?}

midi.sequence#mml

midi.sequence#mml(str:string, max\_velocity?:number):reduce

midi.sequence#readmml

midi.sequence#readmml(stream:stream, max\_velocity?:number):reduce

## 32.5 midi.port Class

midi.port#send

midi.port#send(msg+:number):map:reduce

midi.port#play

midi.port#play(sequence:midi.sequence, speed?:number, repeat:number:nil => 1):map:[background,player]

midi.port#mml

midi.port#mml(str:string, max\_velocity?:number):[background,player]

midi.port#readmml

midi.port#readmml(stream:stream, max\_velocity?:number):[background,player]

midi.port#note\_off

midi.port#note\_off(channel:number, note:number, velocity:number):map:reduce

midi.port#note\_on

midi.port#note\_on(channel:number, note:number, velocity:number):map:reduce

midi.port#poly\_pressure

midi.port#poly\_pressure(channel:number, note:number, value:number):map:reduce

midi.port#control\_change

midi.port#control\_change(channel:number, controller:number, value:number):map:reduce

midi.port#program\_change

midi.port#program\_change(channel:number, program:number):map:reduce

midi.port#channel\_pressure

midi.port#channel\_pressure(channel:number, pressure:number):map:reduce

midi.port#pitch\_bend

midi.port#pitch\_bend(channel:number, value:number):map:reduce

## 32.6 midi.controller Class

## 32.7 midi.program Class

## 32.8 midi.soundfont Class

midi.soundfont

midi.soundfont(stream:stream) {block?}

It creates an instance to access data in SoundFont file.

midi.soundfont#synthesizer

midi.soundfont#synthesizer(preset:number, bank:number, key:number, velocity:number):map {block?}

midi.soundfont#print

midi.soundfont#print():void

## 32.9 midi.synthesizer Class

## Chapter 33

# modbuild Module

The `modbuild` module ...

### 33.1 Module Function

# Chapter 34

## msico Module

The `msico` module provides measures to read/write image data in Microsoft Icon file format. To utilize it, import the `msico` module using `import` function. Below is an example to read an ICO file:

```
import(msico)
img = image('foo.ico')
```

### 34.1 Exntension to Function's Capability

This module extends the capability of function `image()` and instance method `image#write()` so that they can read/write ICO files.

When function `image()` is provided with a stream that satisfies the following conditions, it would recognize the stream as a ICO file.

- The identifier of the stream ends with a suffix `".ico"`.

When instance method `image#write()` is provided with a stream that satisfies the following condition, it would write image data in ICO format.

- The identifier of the stream ends with a suffix `".ico"`.

### 34.2 msico.content Class

#### 34.2.1 Constructor

msico.content

`msico.content(stream?:stream:r, format:symbol => 'rgba') {block?}`

#### 34.2.2 Method

msico.content#write

`msico.content#write(stream:stream:w):reduce`

Writes an ICO image to a stream.

msico.content#addimage

`msico.content#addimage(image:image):map:reduce`



### 34.3 Extension to image Class

This module extends the `image` class with methods described here.

`image#read@msico`

`image#read@msico(stream:stream:r, idx:number => 0):reduce`

Reads an ICO image from a stream.

## Chapter 35

# opengl Module

The `opengl` module provides functions of OpenGL library.

### 35.1 Module Function

#### opengl.glAccum

`opengl.glAccum(op:number, value:number):map:void`

operate on the accumulation buffer

#### opengl.glAlphaFunc

`opengl.glAlphaFunc(func:number, ref:number):map:void`

specify the alpha test function

#### opengl.glAreTexturesResident

`opengl.glAreTexturesResident(textures:array@uint:nomap):map {block?}`

determine if textures are loaded in texture memory

#### opengl.glArrayElement

`opengl.glArrayElement(i:number):map:void`

render a vertex using the specified vertex array element

#### opengl.glBegin

`opengl.glBegin(mode:number):map:void {block?}`

delimit the vertices of a primitive or a group of like primitives

#### opengl.glBindTexture

`opengl.glBindTexture(target:number, texture:number):map:void`

#### opengl.glBitmap

`opengl.glBitmap(width:number, height:number, xorig:number, yorig:number, xmove:number, ymove:number, bitmap:array@uchar:nil:nomap):map:void`

#### opengl.glBlendFunc

`opengl.glBlendFunc(sfactor:number, dfactor:number):map:void`

#### opengl.glCallList

opengl.glCallList(list:number):map:void

#### opengl.glCallLists

opengl.glCallLists(type:number, lists[]:number):map:void

#### opengl.glClear

opengl.glClear(mask:number):map:void

#### opengl.glClearAccum

opengl.glClearAccum(red:number, green:number, blue:number, alpha:number):map:void

#### opengl.glClearColor

opengl.glClearColor(red:number, green:number, blue:number, alpha:number):map:void

#### opengl.glClearDepth

opengl.glClearDepth(depth:number):map:void

#### opengl.glClearIndex

opengl.glClearIndex(c:number):map:void

#### opengl.glClearStencil

opengl.glClearStencil(s:number):map:void

#### opengl.glClipPlane

opengl.glClipPlane(plane:number, equation:array@double:nomap):map:void {block?}

#### opengl.glColor3b

opengl.glColor3b(red:number, green:number, blue:number):map:void

#### opengl.glColor3bv

opengl.glColor3bv(v:array@char:nomap):map:void

#### opengl.glColor3d

opengl.glColor3d(red:number, green:number, blue:number):map:void

#### opengl.glColor3dv

opengl.glColor3dv(v:array@double:nomap):map:void

#### opengl.glColor3f

opengl.glColor3f(red:number, green:number, blue:number):map:void

#### opengl.glColor3fv

opengl.glColor3fv(v:array@float:nomap):map:void

opengl.glColor3i

opengl.glColor3i(red:number, green:number, blue:number):map:void

opengl.glColor3iv

opengl.glColor3iv(v:array@int:nomap):map:void

opengl.glColor3s

opengl.glColor3s(red:number, green:number, blue:number):map:void

opengl.glColor3sv

opengl.glColor3sv(v:array@short:nomap):map:void

opengl.glColor3ub

opengl.glColor3ub(red:number, green:number, blue:number):map:void

opengl.glColor3ubv

opengl.glColor3ubv(v:array@uchar:nomap):map:void

opengl.glColor3ui

opengl.glColor3ui(red:number, green:number, blue:number):map:void

opengl.glColor3uiv

opengl.glColor3uiv(v:array@uint:nomap):map:void

opengl.glColor3us

opengl.glColor3us(red:number, green:number, blue:number):map:void

opengl.glColor3usv

opengl.glColor3usv(v:array@ushort:nomap):map:void

opengl.glColor4b

opengl.glColor4b(red:number, green:number, blue:number, alpha:number):map:void

opengl.glColor4bv

opengl.glColor4bv(v:array@char:nomap):map:void

opengl.glColor4d

opengl.glColor4d(red:number, green:number, blue:number, alpha:number):map:void

opengl.glColor4dv

opengl.glColor4dv(v:array@double:nomap):map:void

opengl.glColor4f

opengl.glColor4f(red:number, green:number, blue:number, alpha:number):map:void

opengl.glColor4fv

opengl.glColor4fv(v:array@float:nomap):map:void

opengl.glColor4i

opengl.glColor4i(red:number, green:number, blue:number, alpha:number):map:void

opengl.glColor4iv

opengl.glColor4iv(v:array@int:nomap):map:void

opengl.glColor4s

opengl.glColor4s(red:number, green:number, blue:number, alpha:number):map:void

opengl.glColor4sv

opengl.glColor4sv(v:array@short:nomap):map:void

opengl.glColor4ub

opengl.glColor4ub(red:number, green:number, blue:number, alpha:number):map:void

opengl.glColor4ubv

opengl.glColor4ubv(v:array@uchar:nomap):map:void

opengl.glColor4ui

opengl.glColor4ui(red:number, green:number, blue:number, alpha:number):map:void

opengl.glColor4uiv

opengl.glColor4uiv(v:array@uint:nomap):map:void

opengl.glColor4us

opengl.glColor4us(red:number, green:number, blue:number, alpha:number):map:void

opengl.glColor4usv

opengl.glColor4usv(v:array@ushort:nomap):map:void

opengl.glColorMask

opengl.glColorMask(red:boolean, green:boolean, blue:boolean, alpha:boolean):map:void

opengl.glColorMaterial

opengl.glColorMaterial(face:number, mode:number):map:void

opengl.glCopyPixels

opengl.glCopyPixels(x:number, y:number, width:number, height:number, type:number):map:void

#### opengl.glCopyTexImage1D

opengl.glCopyTexImage1D(target:number, level:number, internalformat:number, x:number, y:number, width:number, border:number):map:void

#### opengl.glCopyTexImage2D

opengl.glCopyTexImage2D(target:number, level:number, internalformat:number, x:number, y:number, width:number, height:number, border:number):map:void

#### opengl.glCopyTexSubImage1D

opengl.glCopyTexSubImage1D(target:number, level:number, xoffset:number, x:number, y:number, width:number):map:void

#### opengl.glCopyTexSubImage2D

opengl.glCopyTexSubImage2D(target:number, level:number, xoffset:number, yoffset:number, x:number, y:number, width:number, height:number):map:void

#### opengl.glCullFace

opengl.glCullFace(mode:number):map:void

#### opengl.glDeleteLists

opengl.glDeleteLists(list:number, range:number):map:void

#### opengl.glDeleteTextures

opengl.glDeleteTextures(textures:array@uint:nomap):map:void

#### opengl.glDepthFunc

opengl.glDepthFunc(func:number):map:void

#### opengl.glDepthMask

opengl.glDepthMask(flag:boolean):map:void

#### opengl.glDepthRange

opengl.glDepthRange(zNear:number, zFar:number):map:void

#### opengl.glDisable

opengl.glDisable(cap:number):map:void

#### opengl.glDisableClientState

opengl.glDisableClientState(array:number):map:void

#### opengl.glDrawArrays

opengl.glDrawArrays(mode:number, first:number, count:number):map:void

#### opengl.glDrawBuffer

opengl.glDrawBuffer(mode:number):map:void

opengl.glDrawPixels

opengl.glDrawPixels(width:number, height:number, format:number, type:number, pixels):map:void

opengl.glDrawPixelsFromImage

opengl.glDrawPixelsFromImage(image:image):map:void

opengl.glEdgeFlag

opengl.glEdgeFlag(flag:boolean):map:void

opengl.glEdgeFlagv

opengl.glEdgeFlagv(flag[]:boolean):map:void

opengl.glEnable

opengl.glEnable(cap:number):map:void

opengl.glEnableClientState

opengl.glEnableClientState(array:number):map:void

opengl.glEnd

opengl.glEnd():void

opengl.glEndList

opengl.glEndList():void

opengl.glEvalCoord1d

opengl.glEvalCoord1d(u:number):map:void

opengl.glEvalCoord1dv

opengl.glEvalCoord1dv(u:array@double:nomap):map:void

opengl.glEvalCoord1f

opengl.glEvalCoord1f(u:number):map:void

opengl.glEvalCoord1fv

opengl.glEvalCoord1fv(u:array@float:nomap):map:void

opengl.glEvalCoord2d

opengl.glEvalCoord2d(u:number, v:number):map:void

opengl.glEvalCoord2dv

opengl.glEvalCoord2dv(u:array@double:nomap):map:void

opengl.glEvalCoord2f

opengl.glEvalCoord2f(u:number, v:number):map:void

#### opengl.glEvalCoord2fv

opengl.glEvalCoord2fv(u:array@float:nomap):map:void

#### opengl.glEvalMesh1

opengl.glEvalMesh1(mode:number, i1:number, i2:number):map:void

#### opengl.glEvalMesh2

opengl.glEvalMesh2(mode:number, i1:number, i2:number, j1:number, j2:number):map:void

#### opengl.glEvalPoint1

opengl.glEvalPoint1(i:number):map:void

#### opengl.glEvalPoint2

opengl.glEvalPoint2(i:number, j:number):map:void

#### opengl.glFeedbackBuffer

opengl.glFeedbackBuffer(type:number, buffer:array@float:nil:nomap):void

#### opengl.glFinish

opengl.glFinish():void

#### opengl.glFlush

opengl.glFlush():void

#### opengl.glFogf

opengl.glFogf(pname:number, param:number):map:void

#### opengl.glFogfv

opengl.glFogfv(pname:number, params:array@float:nomap):map:void

#### opengl.glFogi

opengl.glFogi(pname:number, param:number):map:void

#### opengl.glFogiv

opengl.glFogiv(pname:number, params:array@int:nomap):map:void

#### opengl.glFrontFace

opengl.glFrontFace(mode:number):map:void

#### opengl.glFrustum

opengl.glFrustum(left:number, right:number, bottom:number, top:number, zNear:number, zFar:number):map:void

#### opengl.glGenLists

opengl.glGenLists(range:number):map {block?}



#### opengl.glGenTextures

opengl.glGenTextures(n:number):map {block?}

#### opengl.glGetBooleanv

opengl.glGetBooleanv(pname:number):map {block?}

#### opengl.glGetClipPlane

opengl.glGetClipPlane(plane:number):map

#### opengl.glGetDoublev

opengl.glGetDoublev(pname:number):map {block?}

#### opengl.glGetError

opengl.glGetError() {block?}

#### opengl.glGetFloatv

opengl.glGetFloatv(pname:number):map {block?}

#### opengl.glGetIntegerv

opengl.glGetIntegerv(pname:number):map {block?}

#### opengl.glGetLightfv

opengl.glGetLightfv(light:number, pname:number):map {block?}

#### opengl.glGetLightiv

opengl.glGetLightiv(light:number, pname:number):map {block?}

#### opengl.glGetMapdv

opengl.glGetMapdv(target:number, query:number, v:array@double:nomap):map:void

#### opengl.glGetMapfv

opengl.glGetMapfv(target:number, query:number, v:array@float:nomap):map:void

#### opengl.glGetMapiv

opengl.glGetMapiv(target:number, query:number, v:array@int:nomap):map:void

#### opengl.glGetMaterialfv

opengl.glGetMaterialfv(face:number, pname:number):map {block?}

#### opengl.glGetMaterialiv

opengl.glGetMaterialiv(face:number, pname:number):map {block?}

#### opengl.glGetPixelMapfv

opengl.glGetPixelMapfv(map:number, values:array@float:nomap):map:void

opengl.glGetPixelMapuiv

opengl.glGetPixelMapuiv(map:number, values:array@uint:nomap):map:void

opengl.glGetPixelMapusv

opengl.glGetPixelMapusv(map:number, values:array@ushort:nomap):map:void

opengl.glGetPolygonStipple

opengl.glGetPolygonStipple(mask:array@uchar:nomap):map:void

opengl.glGetString

opengl.glGetString(name:number):map {block?}

opengl.glGetTexEnvfv

opengl.glGetTexEnvfv(target:number, pname:number):map {block?}

opengl.glGetTexEnviv

opengl.glGetTexEnviv(target:number, pname:number):map {block?}

opengl.glGetTexGendv

opengl.glGetTexGendv(coord:number, pname:number):map {block?}

opengl.glGetTexGenfv

opengl.glGetTexGenfv(coord:number, pname:number):map {block?}

opengl.glGetTexGeniv

opengl.glGetTexGeniv(coord:number, pname:number):map {block?}

opengl.glGetTexLevelParameterfv

opengl.glGetTexLevelParameterfv(target:number, level:number, pname:number):map {block?}

opengl.glGetTexLevelParameteriv

opengl.glGetTexLevelParameteriv(target:number, level:number, pname:number):map {block?}

opengl.glGetTexParameterfv

opengl.glGetTexParameterfv(target:number, pname:number):map {block?}

opengl.glGetTexParameteriv

opengl.glGetTexParameteriv(target:number, pname:number):map {block?}

opengl.glHint

opengl.glHint(target:number, mode:number):map:void

opengl.glIndexMask

opengl.glIndexMask(mask:number):map:void

#### opengl.glIndexd

opengl.glIndexd(c:number):map:void

#### opengl.glIndexdv

opengl.glIndexdv(c:array@double:nomap):map:void

#### opengl.glIndexf

opengl.glIndexf(c:number):map:void

#### opengl.glIndexfv

opengl.glIndexfv(c:array@float:nomap):map:void

#### opengl.glIndexi

opengl.glIndexi(c:number):map:void

#### opengl.glIndexiv

opengl.glIndexiv(c:array@int:nomap):map:void

#### opengl.glIndexs

opengl.glIndexs(c:number):map:void

#### opengl.glIndexsv

opengl.glIndexsv(c:array@short:nomap):map:void

#### opengl.glIndexub

opengl.glIndexub(c:number):map:void

#### opengl.glIndexubv

opengl.glIndexubv(c:array@uchar:nomap):map:void

#### opengl.glInitNames

opengl.glInitNames():void

#### opengl.glIsEnabled

opengl.glIsEnabled(cap:number):map {block?}

#### opengl.glIsList

opengl.glIsList(list:number):map {block?}

#### opengl.glIsTexture

opengl.glIsTexture(texture:number):map {block?}

#### opengl.glLightModelf

opengl.glLightModelf(pname:number, param:number):map:void

opengl.glLightModelfv

opengl.glLightModelfv(pname:number, params:array@float:nomap):map:void

opengl.glLightModeli

opengl.glLightModeli(pname:number, param:number):map:void

opengl.glLightModeliv

opengl.glLightModeliv(pname:number, params:array@int:nomap):map:void

opengl.glLightf

opengl.glLightf(light:number, pname:number, param:number):map:void

opengl.glLightfv

opengl.glLightfv(light:number, pname:number, params:array@float:nomap):map:void

opengl.glLighti

opengl.glLighti(light:number, pname:number, param:number):map:void

opengl.glLightiv

opengl.glLightiv(light:number, pname:number, params:array@int:nomap):map:void

opengl.glLineStipple

opengl.glLineStipple(factor:number, pattern:number):map:void

opengl.glLineWidth

opengl.glLineWidth(width:number):map:void

opengl.glListBase

opengl.glListBase(base:number):map:void

opengl.glLoadIdentity

opengl.glLoadIdentity():void

opengl.glLoadMatrixd

opengl.glLoadMatrixd(m):void

opengl.glLoadMatrixf

opengl.glLoadMatrixf(m):void

opengl.glLoadName

opengl.glLoadName(name:number):map:void

opengl.glLogicOp

opengl.glLogicOp(opcode:number):map:void

#### opengl.glMap1d

opengl.glMap1d(target:number, u1:number, u2:number, stride:number, order:number, points:array@double:nomap):map:void

#### opengl.glMap1f

opengl.glMap1f(target:number, u1:number, u2:number, stride:number, order:number, points:array@float:nomap):map:void

#### opengl.glMap2d

opengl.glMap2d(target:number, u1:number, u2:number, ustride:number, uorder:number, v1:number, v2:number, vstride:number, vorder:number, points:array@double:nomap):map:void

#### opengl.glMap2f

opengl.glMap2f(target:number, u1:number, u2:number, ustride:number, uorder:number, v1:number, v2:number, vstride:number, vorder:number, points:array@float:nomap):map:void

#### opengl.glMapGrid1d

opengl.glMapGrid1d(un:number, u1:number, u2:number):map:void

#### opengl.glMapGrid1f

opengl.glMapGrid1f(un:number, u1:number, u2:number):map:void

#### opengl.glMapGrid2d

opengl.glMapGrid2d(un:number, u1:number, u2:number, vn:number, v1:number, v2:number):map:void

#### opengl.glMapGrid2f

opengl.glMapGrid2f(un:number, u1:number, u2:number, vn:number, v1:number, v2:number):map:void

#### opengl.glMaterialf

opengl.glMaterialf(face:number, pname:number, param:number):map:void

#### opengl.glMaterialfv

opengl.glMaterialfv(face:number, pname:number, params:array@float:nomap):map:void

#### opengl.glMateriali

opengl.glMateriali(face:number, pname:number, param:number):map:void

#### opengl.glMaterialiv

opengl.glMaterialiv(face:number, pname:number, params:array@int:nomap):map:void

#### opengl.glMatrixMode

opengl.glMatrixMode(mode:number):map:void

#### opengl.glMultMatrixd

opengl.glMultMatrixd(m):void

opengl.glMultMatrixf

opengl.glMultMatrixf(m):void

opengl.glNewList

opengl.glNewList(list:number, mode:number):map:void {block?}

opengl.glNormal3b

opengl.glNormal3b(nx:number, ny:number, nz:number):map:void

opengl.glNormal3bv

opengl.glNormal3bv(v:array@char:nomap):map:void

opengl.glNormal3d

opengl.glNormal3d(nx:number, ny:number, nz:number):map:void

opengl.glNormal3dv

opengl.glNormal3dv(v:array@double:nomap):map:void

opengl.glNormal3f

opengl.glNormal3f(nx:number, ny:number, nz:number):map:void

opengl.glNormal3fv

opengl.glNormal3fv(v:array@float:nomap):map:void

opengl.glNormal3i

opengl.glNormal3i(nx:number, ny:number, nz:number):map:void

opengl.glNormal3iv

opengl.glNormal3iv(v:array@int:nomap):map:void

opengl.glNormal3s

opengl.glNormal3s(nx:number, ny:number, nz:number):map:void

opengl.glNormal3sv

opengl.glNormal3sv(v:array@short:nomap):map:void

opengl.glOrtho

opengl.glOrtho(left:number, right:number, bottom:number, top:number, zNear:number, zFar:number):map:void

opengl.glPassThrough

opengl.glPassThrough(token:number):map:void

opengl.glPixelMapfv

opengl.glPixelMapfv(map:number, mapsize:number, values:array@float:nomap):map:void

opengl.glPixelMapuiv

opengl.glPixelMapuiv(map:number, mapsize:number, values:array@uint:nomap):map:void

opengl.glPixelMapusv

opengl.glPixelMapusv(map:number, mapsize:number, values:array@ushort:nomap):map:void

opengl.glPixelStoref

opengl.glPixelStoref(pname:number, param:number):map:void

opengl.glPixelStorei

opengl.glPixelStorei(pname:number, param:number):map:void

opengl.glPixelTransferf

opengl.glPixelTransferf(pname:number, param:number):map:void

opengl.glPixelTransferi

opengl.glPixelTransferi(pname:number, param:number):map:void

opengl.glPixelZoom

opengl.glPixelZoom(xfactor:number, yfactor:number):map:void

opengl.glPointSize

opengl.glPointSize(size:number):map:void

opengl.glPolygonMode

opengl.glPolygonMode(face:number, mode:number):map:void

opengl.glPolygonOffset

opengl.glPolygonOffset(factor:number, units:number):map:void

opengl.glPolygonStipple

opengl.glPolygonStipple(mask:array@uchar:nomap):map:void

opengl.glPopAttrib

opengl.glPopAttrib():void

opengl.glPopClientAttrib

opengl.glPopClientAttrib():void

opengl.glPopMatrix

opengl.glPopMatrix():void

opengl.glPopName

opengl.glPopName():void

#### opengl.glPrioritizeTextures

opengl.glPrioritizeTextures(textures:array@uint:nomap, priorities:array@float:nomap):map:void

#### opengl.glPushAttrib

opengl.glPushAttrib(mask:number):map:void {block?}

#### opengl.glPushClientAttrib

opengl.glPushClientAttrib(mask:number):map:void {block?}

#### opengl.glPushMatrix

opengl.glPushMatrix():void {block?}

#### opengl.glPushName

opengl.glPushName(name:number):map:void {block?}

#### opengl.glRasterPos2d

opengl.glRasterPos2d(x:number, y:number):map:void

#### opengl.glRasterPos2dv

opengl.glRasterPos2dv(v:array@double:nomap):map:void

#### opengl.glRasterPos2f

opengl.glRasterPos2f(x:number, y:number):map:void

#### opengl.glRasterPos2fv

opengl.glRasterPos2fv(v:array@float:nomap):map:void

#### opengl.glRasterPos2i

opengl.glRasterPos2i(x:number, y:number):map:void

#### opengl.glRasterPos2iv

opengl.glRasterPos2iv(v:array@int:nomap):map:void

#### opengl.glRasterPos2s

opengl.glRasterPos2s(x:number, y:number):map:void

#### opengl.glRasterPos2sv

opengl.glRasterPos2sv(v:array@short:nomap):map:void

#### opengl.glRasterPos3d

opengl.glRasterPos3d(x:number, y:number, z:number):map:void

#### opengl.glRasterPos3dv

opengl.glRasterPos3dv(v:array@double:nomap):map:void



opengl.glRasterPos3f

opengl.glRasterPos3f(x:number, y:number, z:number):map:void

opengl.glRasterPos3fv

opengl.glRasterPos3fv(v:array@float:nomap):map:void

opengl.glRasterPos3i

opengl.glRasterPos3i(x:number, y:number, z:number):map:void

opengl.glRasterPos3iv

opengl.glRasterPos3iv(v:array@int:nomap):map:void

opengl.glRasterPos3s

opengl.glRasterPos3s(x:number, y:number, z:number):map:void

opengl.glRasterPos3sv

opengl.glRasterPos3sv(v:array@short:nomap):map:void

opengl.glRasterPos4d

opengl.glRasterPos4d(x:number, y:number, z:number, w:number):map:void

opengl.glRasterPos4dv

opengl.glRasterPos4dv(v:array@double:nomap):map:void

opengl.glRasterPos4f

opengl.glRasterPos4f(x:number, y:number, z:number, w:number):map:void

opengl.glRasterPos4fv

opengl.glRasterPos4fv(v:array@float:nomap):map:void

opengl.glRasterPos4i

opengl.glRasterPos4i(x:number, y:number, z:number, w:number):map:void

opengl.glRasterPos4iv

opengl.glRasterPos4iv(v:array@int:nomap):map:void

opengl.glRasterPos4s

opengl.glRasterPos4s(x:number, y:number, z:number, w:number):map:void

opengl.glRasterPos4sv

opengl.glRasterPos4sv(v:array@short:nomap):map:void

opengl.glReadBuffer

opengl.glReadBuffer(mode:number):map:void

#### opengl.glReadPixels

opengl.glReadPixels(x:number, y:number, width:number, height:number, format:symbol):map {block?}

#### opengl.glRectd

opengl.glRectd(x1:number, y1:number, x2:number, y2:number):map:void

#### opengl.glRectdv

opengl.glRectdv(v1:array@double:nomap, v2:array@double:nomap):map:void

#### opengl.glRectf

opengl.glRectf(x1:number, y1:number, x2:number, y2:number):map:void

#### opengl.glRectfv

opengl.glRectfv(v1:array@float:nomap, v2:array@float:nomap):map:void

#### opengl.glRecti

opengl.glRecti(x1:number, y1:number, x2:number, y2:number):map:void

#### opengl.glRectiv

opengl.glRectiv(v1:array@int:nomap, v2:array@int:nomap):map:void

#### opengl.glRects

opengl.glRects(x1:number, y1:number, x2:number, y2:number):map:void

#### opengl.glRectsv

opengl.glRectsv(v1:array@short:nomap, v2:array@short:nomap):map:void

#### opengl.glRenderMode

opengl.glRenderMode(mode:number):map {block?}

#### opengl.glRotated

opengl.glRotated(angle:number, x:number, y:number, z:number):map:void

#### opengl.glRotatef

opengl.glRotatef(angle:number, x:number, y:number, z:number):map:void

#### opengl.glScaled

opengl.glScaled(x:number, y:number, z:number):map:void

#### opengl.glScalef

opengl.glScalef(x:number, y:number, z:number):map:void

#### opengl.glScissor

opengl.glScissor(x:number, y:number, width:number, height:number):map:void

opengl.glSelectBuffer

opengl.glSelectBuffer(buffer:array@uint:nil:nomap):void

opengl.glShadeModel

opengl.glShadeModel(mode:number):map:void

opengl.glStencilFunc

opengl.glStencilFunc(func:number, ref:number, mask:number):map:void

opengl.glStencilMask

opengl.glStencilMask(mask:number):map:void

opengl.glStencilOp

opengl.glStencilOp(fail:number, zfail:number, zpass:number):map:void

opengl.glTexCoord1d

opengl.glTexCoord1d(s:number):map:void

opengl.glTexCoord1dv

opengl.glTexCoord1dv(v:array@double:nomap):map:void

opengl.glTexCoord1f

opengl.glTexCoord1f(s:number):map:void

opengl.glTexCoord1fv

opengl.glTexCoord1fv(v:array@float:nomap):map:void

opengl.glTexCoord1i

opengl.glTexCoord1i(s:number):map:void

opengl.glTexCoord1iv

opengl.glTexCoord1iv(v:array@int:nomap):map:void

opengl.glTexCoord1s

opengl.glTexCoord1s(s:number):map:void

opengl.glTexCoord1sv

opengl.glTexCoord1sv(v:array@short:nomap):map:void

opengl.glTexCoord2d

opengl.glTexCoord2d(s:number, t:number):map:void

opengl.glTexCoord2dv

opengl.glTexCoord2dv(v:array@double:nomap):map:void

opengl.glTexCoord2f

opengl.glTexCoord2f(s:number, t:number):map:void

opengl.glTexCoord2fv

opengl.glTexCoord2fv(v:array@float:nomap):map:void

opengl.glTexCoord2i

opengl.glTexCoord2i(s:number, t:number):map:void

opengl.glTexCoord2iv

opengl.glTexCoord2iv(v:array@int:nomap):map:void

opengl.glTexCoord2s

opengl.glTexCoord2s(s:number, t:number):map:void

opengl.glTexCoord2sv

opengl.glTexCoord2sv(v:array@short:nomap):map:void

opengl.glTexCoord3d

opengl.glTexCoord3d(s:number, t:number, r:number):map:void

opengl.glTexCoord3dv

opengl.glTexCoord3dv(v:array@double:nomap):map:void

opengl.glTexCoord3f

opengl.glTexCoord3f(s:number, t:number, r:number):map:void

opengl.glTexCoord3fv

opengl.glTexCoord3fv(v:array@float:nomap):map:void

opengl.glTexCoord3i

opengl.glTexCoord3i(s:number, t:number, r:number):map:void

opengl.glTexCoord3iv

opengl.glTexCoord3iv(v:array@int:nomap):map:void

opengl.glTexCoord3s

opengl.glTexCoord3s(s:number, t:number, r:number):map:void

opengl.glTexCoord3sv

opengl.glTexCoord3sv(v:array@short:nomap):map:void

opengl.glTexCoord4d

opengl.glTexCoord4d(s:number, t:number, r:number, q:number):map:void

opengl.glTexCoord4dv

opengl.glTexCoord4dv(v:array@double:nomap):map:void

opengl.glTexCoord4f

opengl.glTexCoord4f(s:number, t:number, r:number, q:number):map:void

opengl.glTexCoord4fv

opengl.glTexCoord4fv(v:array@float:nomap):map:void

opengl.glTexCoord4i

opengl.glTexCoord4i(s:number, t:number, r:number, q:number):map:void

opengl.glTexCoord4iv

opengl.glTexCoord4iv(v:array@int:nomap):map:void

opengl.glTexCoord4s

opengl.glTexCoord4s(s:number, t:number, r:number, q:number):map:void

opengl.glTexCoord4sv

opengl.glTexCoord4sv(v:array@short:nomap):map:void

opengl.glTexEnvf

opengl.glTexEnvf(target:number, pname:number, param:number):map:void

opengl.glTexEnvfv

opengl.glTexEnvfv(target:number, pname:number, params:array@float:nomap):map:void

opengl.glTexEnvi

opengl.glTexEnvi(target:number, pname:number, param:number):map:void

opengl.glTexEnviv

opengl.glTexEnviv(target:number, pname:number, params:array@int:nomap):map:void

opengl.glTexGend

opengl.glTexGend(coord:number, pname:number, param:number):map:void

opengl.glTexGendv

opengl.glTexGendv(coord:number, pname:number, params:array@double:nomap):map:void

opengl.glTexGenf

opengl.glTexGenf(coord:number, pname:number, param:number):map:void

opengl.glTexGenfv

opengl.glTexGenfv(coord:number, pname:number, params:array@float:nomap):map:void

#### opengl.glTexGeni

opengl.glTexGeni(coord:number, pname:number, param:number):map:void

#### opengl.glTexGeniv

opengl.glTexGeniv(coord:number, pname:number, params:array@int:nomap):map:void

#### opengl.glTexImage1D

opengl.glTexImage1D(target:number, level:number, internalformat:number, width:number, border:number, format:number, type:number, pixels):map:void

#### opengl.glTexImage1DFromImage

opengl.glTexImage1DFromImage(target:number, level:number, internalformat:number, border:number, image:image):map:void

#### opengl.glTexImage2D

opengl.glTexImage2D(target:number, level:number, internalformat:number, width:number, height:number, border:number, format:number, type:number, pixels):map:void

#### opengl.glTexImage2DFromImage

opengl.glTexImage2DFromImage(target:number, level:number, internalformat:number, border:number, image:image):map:void

#### opengl.glTexParameterf

opengl.glTexParameterf(target:number, pname:number, param:number):map:void

#### opengl.glTexParameterfv

opengl.glTexParameterfv(target:number, pname:number, params:array@float:nomap):map:void

#### opengl.glTexParameteri

opengl.glTexParameteri(target:number, pname:number, param:number):map:void

#### opengl.glTexParameteriv

opengl.glTexParameteriv(target:number, pname:number, params:array@int:nomap):map:void

#### opengl.glTexSubImage1D

opengl.glTexSubImage1D(target:number, level:number, xoffset:number, width:number, format:number, type:number, pixels):map:void

#### opengl.glTexSubImage1DFromImage

opengl.glTexSubImage1DFromImage(target:number, level:number, xoffset:number, image:image):map:void

#### opengl.glTexSubImage2D

opengl.glTexSubImage2D(target:number, level:number, xoffset:number, yoffset:number, width:number, height:number, format:number, type:number, pixels):map:void

#### opengl.glTexSubImage2DFromImage

opengl.glTexSubImage2DFromImage(target:number, level:number, xoffset:number, yoffset:number, image:image):map:void

#### opengl.glTranslated

opengl.glTranslated(x:number, y:number, z:number):map:void

#### opengl.glTranslatef

opengl.glTranslatef(x:number, y:number, z:number):map:void

#### opengl.glVertex2d

opengl.glVertex2d(x:number, y:number):map:void

#### opengl.glVertex2dv

opengl.glVertex2dv(v:array@double:nomap):map:void

#### opengl.glVertex2f

opengl.glVertex2f(x:number, y:number):map:void

#### opengl.glVertex2fv

opengl.glVertex2fv(v:array@float:nomap):map:void

#### opengl.glVertex2i

opengl.glVertex2i(x:number, y:number):map:void

#### opengl.glVertex2iv

opengl.glVertex2iv(v:array@int:nomap):map:void

#### opengl.glVertex2s

opengl.glVertex2s(x:number, y:number):map:void

#### opengl.glVertex2sv

opengl.glVertex2sv(v:array@short:nomap):map:void

#### opengl.glVertex3d

opengl.glVertex3d(x:number, y:number, z:number):map:void

#### opengl.glVertex3dv

opengl.glVertex3dv(v:array@double:nomap):map:void

#### opengl.glVertex3f

opengl.glVertex3f(x:number, y:number, z:number):map:void

opengl.glVertex3fv

opengl.glVertex3fv(v:array@float:nomap):map:void

opengl.glVertex3i

opengl.glVertex3i(x:number, y:number, z:number):map:void

opengl.glVertex3iv

opengl.glVertex3iv(v:array@int:nomap):map:void

opengl.glVertex3s

opengl.glVertex3s(x:number, y:number, z:number):map:void

opengl.glVertex3sv

opengl.glVertex3sv(v:array@short:nomap):map:void

opengl.glVertex4d

opengl.glVertex4d(x:number, y:number, z:number, w:number):map:void

opengl.glVertex4dv

opengl.glVertex4dv(v:array@double:nomap):map:void

opengl.glVertex4f

opengl.glVertex4f(x:number, y:number, z:number, w:number):map:void

opengl.glVertex4fv

opengl.glVertex4fv(v:array@float:nomap):map:void

opengl.glVertex4i

opengl.glVertex4i(x:number, y:number, z:number, w:number):map:void

opengl.glVertex4iv

opengl.glVertex4iv(v:array@int:nomap):map:void

opengl.glVertex4s

opengl.glVertex4s(x:number, y:number, z:number, w:number):map:void

opengl.glVertex4sv

opengl.glVertex4sv(v:array@short:nomap):map:void

opengl.glViewport

opengl.glViewport(x:number, y:number, width:number, height:number):map:void

opengl.glGetAttachedShaders

opengl.glGetAttachedShaders(program:number, maxCount:number, count[:number], shaders:array@uint:nomap):map



#### opengl.glGetShaderInfoLog

opengl.glGetShaderInfoLog(shader:number, bufSize:number, length[]:number, infoLog:array@char:nomap):map:void

#### opengl.glGetProgramInfoLog

opengl.glGetProgramInfoLog(program:number, bufSize:number, length[]:number, infoLog:array@char:nomap):map:void

#### opengl.glGetUniformLocation

opengl.glGetUniformLocation(program:number, name:array@char:nomap):map {block?}

#### opengl.glGetActiveUniform

opengl.glGetActiveUniform(program:number, index:number, bufSize:number, length[]:number, size:array@int:nomap, type[]:number, name:array@char:nomap):map:void

#### opengl.glGetUniformfv

opengl.glGetUniformfv(program:number, location:number, params:array@float:nomap):map:void

#### opengl.glGetUniformiv

opengl.glGetUniformiv(program:number, location:number, params:array@int:nomap):map:void

#### opengl.glGetShaderSource

opengl.glGetShaderSource(shader:number, bufSize:number, length[]:number, source:array@char:nomap):map:void

#### opengl.glBindAttribLocation

opengl.glBindAttribLocation(program:number, index:number, name:array@char:nomap):map:void

#### opengl.glGetActiveAttrib

opengl.glGetActiveAttrib(program:number, index:number, bufSize:number, length[]:number, size:array@int:nomap, type[]:number, name:array@char:nomap):map:void

#### opengl.glGetAttribLocation

opengl.glGetAttribLocation(program:number, name:array@char:nomap):map {block?}

#### opengl.glUniformMatrix2x3fv

opengl.glUniformMatrix2x3fv(location:number, count:number, transpose:boolean, value:array@float:nomap):map:void

#### opengl.glUniformMatrix3x2fv

opengl.glUniformMatrix3x2fv(location:number, count:number, transpose:boolean, value:array@float:nomap):map:void

#### opengl.glUniformMatrix2x4fv

opengl.glUniformMatrix2x4fv(location:number, count:number, transpose:boolean, value:array@float:nomap):map:void

#### opengl.glUniformMatrix4x2fv

opengl.glUniformMatrix4x2fv(location:number, count:number, transpose:boolean, value:array@float:nomap):map:void

opengl.glUniformMatrix3x4fv

opengl.glUniformMatrix3x4fv(location:number, count:number, transpose:boolean, value:array@float:nomap):map

opengl.glUniformMatrix4x3fv

opengl.glUniformMatrix4x3fv(location:number, count:number, transpose:boolean, value:array@float:nomap):map

# Chapter 36

## os Module

The `os` module provides functions that are specific to each OS environment. This is a built-in module, so you can use it without being imported.

### 36.1 Module Function

#### os.clock

```
os.clock() {block?}
```

Returns the time duration in second since the system has started.

If `block` is specified, it would calculate how much time has been spent during evaluating the block.

#### os.exec

```
os.exec(pathname:string, args*:string):map:[fork]
```

Executes the specified executable file.

#### os.fromnative

```
os.fromnative(buff:binary):map
```

Converts binary data that includes OS's native string into Gura's regulated string.

#### os.getenv

```
os.getenv(name:string, default?:string):map
```

Returns the value of an environment variable.

#### os.putenv

```
os.putenv(name:string, value:string):void
```

Set the value of an environment variable.

#### os.redirect

```
os.redirect(stdin:stream:nil:r, stdout:stream:nil:w, stderr?:stream:w) {block?}
```

Modifies variables `os.stdin`, `os.stdout` and `os.stderr` with values of arguments. When `block` is specified, the modification only has effect within the block.

#### os.sleep

```
os.sleep(secs:number)
```

Sleeps for a time specified in seconds.

#### os.symlink

`os.symlink(src:string, tgt:string):map:void`

Creates a symbol link.

#### os.tonative

`os.tonative(str:string):map`

Converts Gura's regulated string into binary data that includes OS's native string.

#### os.unsetenv

`os.unsetenv(name:string):void`

Unset an environment variable.

## Chapter 37

# path Module

The `path` module provides functions related to path operations. This is a built-in module, so you can use it without being imported.

Below is an example to list path names that exist in the current directory.

```
println(path.dir('.'))
```

Below is an example to list path names that exist in the current directory and its child directories.

```
println(path.walk('.'))
```

Below is an example to list path names that matches a wild card pattern `"*.txt"`.

```
println(path.glob('*.txt'))
```

### 37.1 Module Function

#### path.absname

```
path.absname(name:string):map:[uri]
```

Returns an absolute path name of the given name.

#### path.basename

```
path.basename(pathname:string):map
```

Removes a suffix part of a path name.

#### path.bottom

```
path.bottom(pathname:string):map
```

Returns the last part of a path name.

#### path.cutbottom

```
path.cutbottom(pathname:string):map
```

Returns a path name after eliminating its bottom part.

#### path.dir

```
path.dir(directory?:directory, pattern*:string):flat:map:[dir,file,stat] {block?}
```

Creates an iterator that lists item names in the specified directory. If `pathname` is omitted, the current directory shall be listed. In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### path.dirname

```
path.dirname(pathname:string):map
```

Splits a pathname by a directory separator and returns a directory name part.

#### path.exists

```
path.exists(pathname:string):map
```

Returns true if the specified file exists in a file system.

#### path.extname

```
path.extname(pathname:string):map
```

Extracts a suffix part of a path name.

#### path.filename

```
path.filename(pathname:string):map
```

Splits a pathname by a directory separator and returns a file name part.

#### path.glob

```
path.glob(pattern:string):flat:map:[dir,file,stat] {block?}
```

Creates an iterator for item names that match with a pattern supporting UNIX shell-style wild cards. In default, case of characters is distinguished. In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### path.join

```
path.join(paths+:string):map:[uri]
```

Returns a path name that joins given strings with directory separators.

#### path.match

```
path.match(pattern:string, name:string):map
```

Returns true if a name matches with a pattern that supports UNIX shell-style wild cards. In default, case of characters is distinguished.

#### path.regulate

```
path.regulate(name:string):map:[uri]
```

Returns a regulated path name of the given name.

#### path.split

```
path.split(pathname:string):map:[bottom]
```

Splits a pathname by a directory separator and returns a list containing a directory name as the first element and a base name as the second one. This has the same result as calling `path.dirname()` and `path.filename()`.

#### path.splitext

```
path.splitext(pathname:string):map
```

Splits a pathname by a dot character indicating a beginning of an extension and returns a list containing a path name without an extension and an extension part.

#### path.stat

```
path.stat(directory:directory):map
```

Returns a stat object associated with the specified item.

#### path.walk

```
path.walk(directory?:directory, maxdepth?:number, pattern*:string):flat:map:[dir,file,stat]
{block?}
```

Creates an iterator that recursively lists item names under the specified directory. If pathname is omitted, search starts at the current directory. In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.



# Chapter 38

## png Module

The `png` module provides measures to read/write image data in PNG format. To utilize it, import the `png` module using `import` function.

Below is an example to read a PNG file:

```
import(png)
img = image('foo.png')
```

### 38.1 Exntension to Function's Capability

This module extends the capability of function `image()` and instance method `image#write()` so that they can read/write PNG files.

When function `image()` is provided with a stream that satisfies the following conditions, it would recognize the stream as a PNG file.

- The identifier of the stream ends with a suffix `".png"`.
- The stream data begins with a byte sequence `"\x89\x50\x4e\x47\x0d\x0a\x1a\x0a"`.

When instance method `image#write()` is provided with a stream that satisfies the following condition, it would write image data in PNG format.

- The identifier of the stream ends with a suffix `".png"`.

### 38.2 Module Function

### 38.3 Extension to image Class

This module extends the `image` class with methods described here.

`image#read@png`

`image#read@png(stream:stream:r):reduce`

Reads a PNG image from a stream.

`image#write@png`

`image#write@png(stream:stream:w):reduce`

Writes a PNG image to a stream.

## 38.4 Thanks

This module uses libpng library which is distributed in the following site:  
<http://www.libpng.org/pub/png/libpng.html>

## Chapter 39

# ppm Module

The `ppm` module provides measures to read/write image data in PPM format. To utilize it, import the `ppm` module using `import` function.

Below is an example to read a PPM file:

```
import(ppm)
img = image('foo.ppm')
```

### 39.1 Exntension to Function's Capability

This module extends the capability of function `image()` and instance method `image#write()` so that they can read/write PPM files.

When function `image()` is provided with a stream that satisfies the following conditions, it would recognize the stream as a PPM file.

- The identifier of the stream ends with a suffix `".ppm "` or `".pbm "`.
- The stream data begins with a byte sequence `"P2 "`, `"P3 "` or `"P6 "`.

When instance method `image#write()` is provided with a stream that satisfies the following condition, it would write image data in PPM format.

- The identifier of the stream ends with a suffix `".ppm "` or `".pbm "`.

### 39.2 Extension to image Class

This module extends the `image` class with methods described here.

`image#read@ppm`

`image#read@ppm(stream:stream:r):reduce`

Reads a PPM/PGM image from a stream.

`image#write@ppm`

`image#write@ppm(stream:stream:w):reduce:[gray]`

Writes a PPM/PGM image to a stream.

# Chapter 40

## re Module

The `re` module provides measures to operate strings with a regular expression. To utilize it, import the `re` module using `import` function.

This module provides three different forms of function that has the same feature as below:

- Module function
- Method of `re.pattern` class
- Method of `string` class

For example, a feature to match a string with a regular expression can be described as below:  
Using a module function:

```
m = re.match('gur[ai]', str)
```

Using a method of `re.pattern` class:

```
m = re.pattern('gur[ai]').match(str)
```

Using a method of `string` class:

```
m = str.match('gur[ai]')
```

The table below shows the features related to regular-expression and functions that provides them.

Feature	Module Function	Method of <code>re.pattern</code>	Method of <code>string</code>
Match	<code>re.match()</code>	<code>re.pattern#match()</code>	<code>string#match()</code>
Subtraction	<code>re.sub()</code>	<code>re.pattern#sub()</code>	<code>string#sub()</code>
Split	<code>re.split()</code>	<code>re.pattern#split()</code>	<code>string#split()</code>
Scan	<code>re.scan()</code>	<code>re.pattern#scan()</code>	<code>string#scan()</code>

### 40.1 Regular Expression

You can describe a matching pattern using a syntax based on POSIX Extended Regular Expression.

The syntax uses a back slash character to avoid some characters such as "`(`" and "`)`" from being recognized as a meta character. Since a back slash is used as an escaping character in Gura string as well, you have to write two back slashes to represent a single back slash in a regular expression. For example, an expression "`sin\\(x\\)`" that matches a string "`sin(x)`" is described as below:

```
m = str.match('sin\\(x\\)')
```

Using a raw string appended with a prefix "r ", in which a back slash is parsed as a regular character, could avoid such complications.

```
m = str.match(r'sin\(x\)')
```

## 40.2 re.match Class

An instance of `re.match` class is used as a result value of `re.match()` , `re.pattern#match()` and `string#match()` to provide matching information.

### 40.2.1 Property

Property	Type	R/W	Explanation
<code>re.match#source</code>	string	R	String that has been matched.
<code>re.match#string</code>	string	R	String of the matched part.
<code>re.match#begin</code>	number	R	Beginning position of the matched part.
<code>re.match#end</code>	number	R	Ending position of the matched part.

### 40.2.2 Index Access

A `re.match` instance can be indexed with a `number` or `string` value. The value of `number` indicates the group index number that starts from zero. The group indexed by zero is special and represents the whole region of the match. The groups indexed by numbers greater than zero correspond to matching patterns of grouping. Below is an example:

```
str = '12:34:56'\n"
m = str.match(r'(\d\d):(\d\d):(\d\d)')\n"
m[0] // returns the whole region of matching: 12:34:56\n"
m[1] // returns the 1st group: 12\n"
m[2] // returns the 2nd group: 34\n"
m[3] // returns the 3rd group: 56\n"
```

The value of `string` is used to point out a named capturing group that is described as "(?<name>group)" in a regular expression. Below is an example:

```
str = '12:34:56'\n"
m = str.match(r'(?<hour>\d\d):(?<min>\d\d):(?<sec>\d\d)')\n"
m['hour'] // returns the group named 'hour': 12\n"
m['min'] // returns the group named 'min': 34\n"
m['sec'] // returns the group named 'sec': 56\n";
```

### 40.2.3 Method

`re.match#group`

`re.match#group(index):map`

Returns a `re.group` instance that is positioned by the specified index.

The argument `index` is a value of `number` or `string` .  
The value of `number` indicates the group index number that starts from zero. The group indexed by zero is special and represents the whole region of the match. The groups indexed by numbers greater than zero correspond to matching patterns of grouping. Below is an example:

```
str = '12:34:56'
m = str.match(r'(\d\d):(\d\d):(\d\d)')
m.group(0).string // returns the whole region of matching: 12:34:56
m.group(1).string // returns the 1st group: 12
m.group(2).string // returns the 2nd group: 34
m.group(3).string // returns the 3rd group: 56
```

The value of `string` is used to point out a named capturing group that is described in a regular expression as `"(?<name>group)"`.  
Below is an example:

```
str = '12:34:56'
m = str.match(r'(?<hour>\d\d):(?<min>\d\d):(?<sec>\d\d)')
m.group('hour').string // returns the group named 'hour': 12
m.group('min').string // returns the group named 'min': 34
m.group('sec').string // returns the group named 'sec': 56
```

## re.match#groups

re.match#groups() {block?}

Creates an iterator that returns `re.group` instances.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

## 40.3 re.group Class

The `re.group` instance provides information of capturing groups that are stored in `re.match` instance.

### 40.3.1 Property

Property	Type	R/W	Explanation
re.group#string	string	R	String of the group.
re.group#begin	number	R	Beginning position of the group.
re.group#end	number	R	Ending position of the group.

## 40.4 re.pattern Class

The `re.pattern` class is used to describe a pattern of regular expression.

### 40.4.1 Cast Operation

A function that expects a `re.pattern` instance in its argument can also take a value of `string` below:

- `string` .. Recognized as a regular expression from which `re.pattern` instance is created.

Using the above casting feature, you can call a function `f(pattern:re.pattern)` that expects a `re.pattern` instance in its argument as below:

- `f(re.pattern('gur[ai]'))` .. The most explicit way.
- `f('gur[ai]')` .. Implicit casting: from `string` to `re.pattern` .

### 40.4.2 Constructor

re.pattern

```
re.pattern(pattern:string):map:[icase,multiline] {block?}
```

Creates a `re.pattern` instance from the given pattern string.  
Following attributes would customize some traits of the pattern:

- `:icase` .. Ignores character cases.
- `:multiline` .. Matches `". "` with a line break.

If `block` is specified, it would be evaluated with a block parameter `|pat:re.pattern|` , where `pat` is the created instance. In this case, the block's result would become the function's returned value.

### 40.4.3 Method

re.pattern#match

```
re.pattern#match(str:string, pos:number => 0, endpos?:number):map {block?}
```

Applies a pattern matching to the given string and returns a `re.match` instance if the matching succeeds. If not, it would return `nil` .

The argument `pos` specifies the starting position for matching process. If omitted, it starts from the beginning of the string.

The argument `endpos` specifies the ending position for matching process. If omitted, it would be processed until the end of the string.

If `block` is specified, it would be evaluated with a block parameter `|m:re.match|` , where `m` is the created instance. In this case, the block's result would become the function's returned value.

re.pattern#sub

```
re.pattern#sub(replace, str:string, count?:number):map {block?}
```

Substitutes strings that matches `pattern` with the specified replacer.

The argument `replace` takes a `string` or `function` .

If a `string` is specified, it would be used as a substituting string, in which you can use macros `\0` , `\1` , `\2` .. to refer to matched groups.

If a `function` is specified, it would be called with an argument `m:re.match` and is expected to return a string for substitution.

The argument `count` specifies the maximum number of substitutions. If omitted, no limit would be applied.

If `block` is specified, it would be evaluated with a block parameter `|str:string|`, where `str` is the created instance. In this case, the block's result would become the function's returned value.

#### re.pattern#split

```
re.pattern#split(str:string, count?:number):map {block?}
```

Creates an iterator that splits the source string with the specified pattern.

The argument `count` specifies the maximum number for splitting. If omitted, no limit would be applied.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### re.pattern#scan

```
re.pattern#scan(str:string, pos:number => 0, endpos?:number):map {block?}
```

Creates an iterator that returns strings that match the specified pattern.

The argument `pos` specifies the starting position for matching process. If omitted, it starts from the beginning of the string.

The argument `endpos` specifies the ending position for matching process. If omitted, it would be processed until the end of the string.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.



## 40.5 Extension to string Class

This module extends the `string` class with methods described here.

### string#match

```
string#match(pattern:re.pattern, pos:number => 0, endpos?:number):map {block?}
```

Applies a pattern matching to the given string and returns a `re.match` instance if the matching successes. If not, it would return `nil`.

The argument `pos` specifies the starting position for matching process. If omitted, it starts from the beginning of the string.

The argument `endpos` specifies the ending position for matching process. If omitted, it would be processed until the end of the string.

If `block` is specified, it would be evaluated with a block parameter `|m:re.match|`, where `m` is the created instance. In this case, the block's result would become the function's returned value.

### string#sub

```
string#sub(pattern:re.pattern, replace, count?:number):map {block?}
```

Substitutes strings that matches `pattern` with the specified replacer.

The argument `replace` takes a `string` or `function`.

If a `string` is specified, it would be used as a substituting string, in which you can use macros `\0`, `\1`, `\2` .. to refer to matched groups.

If a `function` is specified, it would be called with an argument `m:re.match` and is expected to return a string for substitution.

The argument `count` specifies the maximum number of substitutions. If omitted, no limit would be applied.

If `block` is specified, it would be evaluated with a block parameter `|str:string|`, where `str` is the created instance. In this case, the block's result would become the function's returned value.

### string#splitreg

```
string#splitreg(pattern:re.pattern, count?:number):map {block?}
```

Creates an iterator that splits the source string with the specified pattern.

The argument `count` specifies the maximum number for splitting. If omitted, no limit would be applied.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

### string#scan

```
string#scan(pattern:re.pattern, pos:number => 0, endpos?:number):map {block?}
```

Creates an iterator that returns strings that match the specified pattern.  
The argument `pos` specifies the starting position for matching process. If omitted, it starts from the beginning of the string.  
The argument `endpos` specifies the ending position for matching process. If omitted, it would be processed until the end of the string.  
In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

## 40.6 Extension to iterable Classes

This module extends the iterable classes, `list` and `iterator`, with methods described here.

iterable#grep

```
iterable#grep(pattern:re.pattern):map {block?}
```

## 40.7 Module Function

re.match

```
re.match(pattern:re.pattern, str:string, pos:number => 0, endpos?:number):map {block?}
```

Applies a pattern matching to the given string and returns a `re.match` instance if the matching successes. If not, it would return `nil`.

The argument `pos` specifies the starting position for matching process. If omitted, it starts from the beginning of the string.

The argument `endpos` specifies the ending position for matching process. If omitted, it would be processed until the end of the string.

If `block` is specified, it would be evaluated with a block parameter `|m:re.match|`, where `m` is the created instance. In this case, the block's result would become the function's returned value.

re.sub

```
re.sub(pattern:re.pattern, replace, str:string, count?:number):map {block?}
```

Substitutes strings that matches `pattern` with the specified replacer.

The argument `replace` takes a `string` or `function`.

If a `string` is specified, it would be used as a substituting string, in which you can use macros `\0`, `\1`, `\2` .. to refer to matched groups.

If a `function` is specified, it would be called with an argument `m:re.match` and is expected to return a string for substitution.

The argument `count` specifies the maximum number of substitutions. If omitted, no limit would be applied.

If `block` is specified, it would be evaluated with a block parameter `|str:string|`, where `str` is the created instance. In this case, the block's result would become the function's returned value.

#### re.split

```
re.split(pattern:re.pattern, str:string, count?:number):map {block?}
```

Creates an iterator that splits the source string with the specified pattern.

The argument `count` specifies the maximum number for splitting. If omitted, no limit would be applied.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

#### re.scan

```
re.scan(pattern:re.pattern, str:string, pos:number => 0, endpos?:number):map {block?}
```

Creates an iterator that returns strings that match the specified pattern.

The argument `pos` specifies the starting position for matching process. If omitted, it starts from the beginning of the string.

The argument `endpos` specifies the ending position for matching process. If omitted, it would be processed until the end of the string.

In default, this returns an iterator as its result value. Specifying the following attributes would convert it into other formats:

- `:iter` .. An iterator. This is the default behavior.
- `:xiter` .. An iterator that eliminates `nil` from its elements.
- `:list` .. A list.
- `:xlist` .. A list that eliminates `nil` from its elements.
- `:set` .. A list that eliminates duplicated values from its elements.
- `:xset` .. A list that eliminates duplicated values and `nil` from its elements.

If a block is specified, it would be evaluated repeatedly with block parameters `|value, idx:number|` where `value` is the iterated value and `idx` the loop index starting from zero. In this case, the last evaluated value of the block would be the result value. If one of the attributes listed above is specified, an iterator or a list of the evaluated value would be returned.

## 40.8 Thanks

This module uses Oniguruma library which is distributed in the following site:  
<http://www.geocities.jp/kosako3/oniguruma/index.html>

## Chapter 41

# show Module

The `show` module ...

### 41.1 Module Function

# Chapter 42

## SDL2 Module

The `SDL2` module provides functions of the SDL2 library.

### 42.1 Module Function

#### SDL2.Init

`SDL2.Init(flags:number):void`

Use this function to initialize the SDL library. This must be called before using any other SDL function.

The Event Handling, File I/O, and Threading subsystems are initialized by default. You must specifically initialize other subsystems if you use them in your application.

`flags` may be any of the following OR'd together:

- `SDL2.INIT_TIMER` .. timer subsystem
- `SDL2.INIT_AUDIO` .. audio subsystem
- `SDL2.INIT_VIDEO` .. video subsystem
- `SDL2.INIT_JOYSTICK` .. joystick subsystem
- `SDL2.INIT_HAPTIC` .. haptic (force feedback) subsystem
- `SDL2.INIT_GAMECONTROLLER` .. controller subsystem
- `SDL2.INIT_EVENTS` .. events subsystem
- `SDL2.INIT_EVERYTHING` .. all of the above subsystems
- `SDL2.INIT_NOPARACHUTE` .. compatibility; this flag is ignored

If you want to initialize subsystems separately you would call `SDL_Init(0)` followed by `SDL_InitSubSystem()` with the desired subsystem flag.

#### SDL2.InitSubSystem

`SDL2.InitSubSystem(flags:number):void`

Use this function to initialize specific SDL subsystems.

After SDL has been initialized with `SDL_Init()` you may initialize uninitialized subsystems with `SDL_InitSubSystem()`.

These are the flags which may be passed to `SDL_InitSubSystem()` and may be OR'd together to initialize multiple subsystems simultaneously.

- `SDL2.INIT_TIMER` .. timer subsystem
- `SDL2.INIT_AUDIO` .. audio subsystem

- `SDL2.INIT_VIDEO` .. video subsystem
- `SDL2.INIT_JOYSTICK` .. joystick subsystem
- `SDL2.INIT_HAPTIC` .. haptic (force feedback) subsystem
- `SDL2.INIT_GAMECONTROLLER` .. controller subsystem
- `SDL2.INIT_EVENTS` .. events subsystem
- `SDL2.INIT_EVERYTHING` .. all of the above subsystems
- `SDL2.INIT_NOPARACHUTE` .. compatibility; this flag is ignored

If you want to initialize subsystems separately you would call `SDL_Init(0)` followed by `SDL_InitSubSystem()` with the desired subsystem flag.

### SDL2.Quit

`SDL2.Quit():void`

Use this function to clean up all initialized subsystems. You should call it upon all exit conditions.

You should call this function even if you have already shutdown each initialized subsystem with `SDL_QuitSubSystem()` .

If you start a subsystem using a call to that subsystem's init function (for example `SDL_VideoInit()` ) instead of `SDL_Init()` or `SDL_InitSubSystem()` , then you must use that subsystem's quit function (`SDL_VideoQuit()` ) to shut it down before calling `SDL_Quit()` .

You can use this function with `atexit()` to ensure that it is run when your application is shutdown, but it is not wise to do this from a library or other dynamically loaded code.

### SDL2.QuitSubSystem

`SDL2.QuitSubSystem(flags:number):void`

Use this function to shut down specific SDL subsystems.

These are the flags which may be passed to `SDL_QuitSubSystem()` and may be OR'd together to quit multiple subsystems simultaneously.

- `SDL2.INIT_TIMER` .. timer subsystem
- `SDL2.INIT_AUDIO` .. audio subsystem
- `SDL2.INIT_VIDEO` .. video subsystem
- `SDL2.INIT_JOYSTICK` .. joystick subsystem
- `SDL2.INIT_HAPTIC` .. haptic (force feedback) subsystem
- `SDL2.INIT_GAMECONTROLLER` .. controller subsystem
- `SDL2.INIT_EVENTS` .. events subsystem
- `SDL2.INIT_EVERYTHING` .. all of the above subsystems
- `SDL2.INIT_NOPARACHUTE` .. compatibility; this flag is ignored

If you want to initialize subsystems separately you would call `SDL_Init(0)` followed by `SDL_InitSubSystem()` with the desired subsystem flag.

### SDL2.SetMainReady

`SDL2.SetMainReady():void`

Use this function to circumvent failure of `SDL_Init()` when not using `SDL_main()` as an entry point.

This function is defined in `SDL_main.h`, along with the preprocessor rule to redefine `main()` as `SDL_main()`. Thus to ensure that your `main()` function will not be changed it is necessary to define `SDL_MAIN_HANDLED` before including `SDL.h`.

#### SDL2.WasInit

`SDL2.WasInit(flags:number) {block?}`

Use this function to return a mask of the specified subsystems which have previously been initialized.

These are the flags which may be passed to `SDL2.WasInit()` and may be OR'd together to query multiple subsystems simultaneously.

- `SDL2.INIT_TIMER` .. timer subsystem
- `SDL2.INIT_AUDIO` .. audio subsystem
- `SDL2.INIT_VIDEO` .. video subsystem
- `SDL2.INIT_JOYSTICK` .. joystick subsystem
- `SDL2.INIT_HAPTIC` .. haptic (force feedback) subsystem
- `SDL2.INIT_GAMECONTROLLER` .. controller subsystem
- `SDL2.INIT_EVENTS` .. events subsystem
- `SDL2.INIT_EVERYTHING` .. all of the above subsystems
- `SDL2.INIT_NOPARACHUTE` .. compatibility; this flag is ignored

If you want to initialize subsystems separately you would call `SDL_Init(0)` followed by `SDL_InitSubSystem()` with the desired subsystem flag.

#### SDL2.AddHintCallback

`SDL2.AddHintCallback():void`

#### SDL2.ClearHints

`SDL2.ClearHints():void`

#### SDL2.DelhintCallback

`SDL2.DelhintCallback():void`

#### SDL2.GetHint

`SDL2.GetHint():void`

#### SDL2.SetHint

`SDL2.SetHint():void`

#### SDL2.SetHintWithPriority

`SDL2.SetHintWithPriority():void`

#### SDL2.ClearError

`SDL2.ClearError():void`

Use this function to clear any previous error message.

### SDL2.GetError

`SDL2.GetError()` {block?}

Use this function to retrieve a message about the last error that occurred.

Returns a message with information about the specific error that occurred, or an empty string if there hasn't been an error since the last call to `SDL_ClearError()` . Without calling `SDL_ClearError()` , the message is only applicable when an SDL function has signaled an error. You must check the return values of SDL function calls to determine when to appropriately call `SDL_GetError()` .

This string is statically allocated and must not be freed by the application.

It is possible for multiple errors to occur before calling `SDL_GetError()` . Only the last error is returned.

### SDL2.SetError

`SDL2.SetError():void`

### SDL2.Log

`SDL2.Log():void`

### SDL2.LogCritical

`SDL2.LogCritical():void`

### SDL2.LogDebug

`SDL2.LogDebug():void`

### SDL2.LogError

`SDL2.LogError():void`

### SDL2.LogGetOutputFunction

`SDL2.LogGetOutputFunction():void`

### SDL2.LogGetPriority

`SDL2.LogGetPriority():void`

### SDL2.LogInfo

`SDL2.LogInfo():void`

### SDL2.LogMessage

`SDL2.LogMessage():void`

### SDL2.LogMessageV

`SDL2.LogMessageV():void`

### SDL2.LogResetPriorities

`SDL2.LogResetPriorities():void`



SDL2.LogSetAllPriority

SDL2.LogSetAllPriority():void

SDL2.LogSetOutputFunction

SDL2.LogSetOutputFunction():void

SDL2.LogSetPriority

SDL2.LogSetPriority():void

SDL2.LogVerbose

SDL2.LogVerbose():void

SDL2.LogWarn

SDL2.LogWarn():void

SDL2.GetAssertionHandler

SDL2.GetAssertionHandler():void

SDL2.GetAssertionReport

SDL2.GetAssertionReport():void

SDL2.GetDefaultAssertionHandler

SDL2.GetDefaultAssertionHandler():void

SDL2.ResetAssertionReport

SDL2.ResetAssertionReport():void

SDL2.SetAssertionHandler

SDL2.SetAssertionHandler():void

SDL2.TriggerBreakpoint

SDL2.TriggerBreakpoint():void

SDL2.assert

SDL2.assert():void

SDL2.assert\_paranoid

SDL2.assert\_paranoid():void

SDL2.assert\_release

SDL2.assert\_release():void

SDL2.GetRevision

SDL2.GetRevision() {block?}

#### SDL2.GetRevisionNumber

SDL2.GetRevisionNumber() {block?}

#### SDL2.GetVersion

SDL2.GetVersion() {block?}

#### SDL2.VERSION

SDL2.VERSION() {block?}

#### SDL2.VERSION\_ATLEAST

SDL2.VERSION\_ATLEAST(X:number, Y:number, Z:number) {block?}

#### SDL2.CreateWindow

SDL2.CreateWindow(title:string, x:number, y:number, w:number, h:number, flags:number) {block?}

#### SDL2.CreateWindowAndRenderer

SDL2.CreateWindowAndRenderer(width:number, height:number, window\_flags:number) {block?}

#### SDL2.CreateWindowFrom

SDL2.CreateWindowFrom():void

#### SDL2.DestroyWindow

SDL2.DestroyWindow(window:SDL2.Window):void

#### SDL2.DisableScreenSaver

SDL2.DisableScreenSaver():void

#### SDL2.EnableScreenSaver

SDL2.EnableScreenSaver():void

#### SDL2.GL\_CreateContext

SDL2.GL\_CreateContext(window:SDL2.Window) {block?}

#### SDL2.GL\_DeleteContext

SDL2.GL\_DeleteContext(context:SDL2.GLContext):void

#### SDL2.GL\_ExtensionSupported

SDL2.GL\_ExtensionSupported(extension:string) {block?}

#### SDL2.GL\_GetAttribute

SDL2.GL\_GetAttribute(attr:number) {block?}

#### SDL2.GL\_GetCurrentContext

SDL2.GL\_GetCurrentContext() {block?}

#### SDL2.GL\_GetCurrentWindow

SDL2.GL\_GetCurrentWindow() {block?}

#### SDL2.GL\_GetDrawableSize

SDL2.GL\_GetDrawableSize(window:SDL2.Window) {block?}

#### SDL2.GL\_GetProcAddress

SDL2.GL\_GetProcAddress():void

#### SDL2.GL\_GetSwapInterval

SDL2.GL\_GetSwapInterval() {block?}

#### SDL2.GL\_LoadLibrary

SDL2.GL\_LoadLibrary(path:string):void

#### SDL2.GL\_MakeCurrent

SDL2.GL\_MakeCurrent(window:SDL2.Window, context:SDL2.GLContext):void

#### SDL2.GL\_ResetAttributes

SDL2.GL\_ResetAttributes():void

#### SDL2.GL\_SetAttribute

SDL2.GL\_SetAttribute(attr:number, value:number):void

#### SDL2.GL\_SetSwapInterval

SDL2.GL\_SetSwapInterval(interval:number):void

#### SDL2.GL\_SwapWindow

SDL2.GL\_SwapWindow(window:SDL2.Window):void

#### SDL2.GL\_UnloadLibrary

SDL2.GL\_UnloadLibrary():void

#### SDL2.GetClosestDisplayMode

SDL2.GetClosestDisplayMode(displayIndex:number, mode:SDL2.DisplayMode) {block?}

#### SDL2.GetCurrentDisplayMode

SDL2.GetCurrentDisplayMode(displayIndex:number) {block?}

#### SDL2.GetCurrentVideoDriver

SDL2.GetCurrentVideoDriver() {block?}

#### SDL2.GetDesktopDisplayMode

SDL2.GetDesktopDisplayMode(displayIndex:number) {block?}

#### SDL2.GetDisplayBounds

SDL2.GetDisplayBounds(displayIndex:number) {block?}

#### SDL2.GetDisplayMode

SDL2.GetDisplayMode(displayIndex:number, modeIndex:number) {block?}

#### SDL2.GetDisplayName

SDL2.GetDisplayName(displayIndex:number) {block?}

#### SDL2.GetNumDisplayModes

SDL2.GetNumDisplayModes(displayIndex:number) {block?}

#### SDL2.GetNumVideoDisplays

SDL2.GetNumVideoDisplays() {block?}

#### SDL2.GetNumVideoDrivers

SDL2.GetNumVideoDrivers() {block?}

#### SDL2.GetVideoDriver

SDL2.GetVideoDriver(index:number) {block?}

#### SDL2.GetWindowBrightness

SDL2.GetWindowBrightness(window:SDL2.Window) {block?}

#### SDL2.GetWindowData

SDL2.GetWindowData(window:SDL2.Window, name:string):void

#### SDL2.GetWindowDisplayIndex

SDL2.GetWindowDisplayIndex(window:SDL2.Window) {block?}

#### SDL2.GetWindowDisplayMode

SDL2.GetWindowDisplayMode(window:SDL2.Window, mode:SDL2.DisplayMode):void

#### SDL2.GetWindowFlags

SDL2.GetWindowFlags(window:SDL2.Window) {block?}

#### SDL2.GetWindowFromID

SDL2.GetWindowFromID(id:number) {block?}

#### SDL2.GetWindowGammaRamp

SDL2.GetWindowGammaRamp(window:SDL2.Window) {block?}

#### SDL2.GetWindowGrab

SDL2.GetWindowGrab(window:SDL2.Window) {block?}

#### SDL2.GetWindowID

SDL2.GetWindowID(window:SDL2.Window) {block?}

#### SDL2.GetWindowMaximumSize

SDL2.GetWindowMaximumSize(window:SDL2.Window) {block?}

#### SDL2.GetWindowMinimumSize

SDL2.GetWindowMinimumSize(window:SDL2.Window) {block?}

#### SDL2.GetWindowPixelFormat

SDL2.GetWindowPixelFormat(window:SDL2.Window) {block?}

#### SDL2.GetWindowPosition

SDL2.GetWindowPosition(window:SDL2.Window) {block?}

#### SDL2.GetWindowSize

SDL2.GetWindowSize(window:SDL2.Window) {block?}

#### SDL2.GetWindowSurface

SDL2.GetWindowSurface(window:SDL2.Window) {block?}

#### SDL2.GetWindowTitle

SDL2.GetWindowTitle(window:SDL2.Window) {block?}

#### SDL2.GetWindowWMInfo

SDL2.GetWindowWMInfo(window:SDL2.Window):void

#### SDL2.HideWindow

SDL2.HideWindow(window:SDL2.Window):void

#### SDL2.IsScreenSaverEnabled

SDL2.IsScreenSaverEnabled() {block?}

#### SDL2.MaximizeWindow

SDL2.MaximizeWindow(window:SDL2.Window):void

#### SDL2.MinimizeWindow

SDL2.MinimizeWindow(window:SDL2.Window):void

#### SDL2.RaiseWindow

SDL2.RaiseWindow(window:SDL2.Window):void

#### SDL2.RestoreWindow

SDL2.RestoreWindow(window:SDL2.Window):void

#### SDL2.SetWindowBordered

SDL2.SetWindowBordered(window:SDL2.Window, bordered:boolean):void

#### SDL2.SetWindowBrightness

SDL2.SetWindowBrightness(window:SDL2.Window, brightness:number):void

#### SDL2.SetWindowData

SDL2.SetWindowData(window:SDL2.Window, name:string):void

#### SDL2.SetWindowDisplayMode

SDL2.SetWindowDisplayMode(window:SDL2.Window, mode:SDL2.DisplayMode):void

#### SDL2.SetWindowFullscreen

SDL2.SetWindowFullscreen(window:SDL2.Window, flags:number):void

#### SDL2.SetWindowGammaRamp

SDL2.SetWindowGammaRamp(window:SDL2.Window, red[:number], green[:number], blue[:number]):void

#### SDL2.SetWindowGrab

SDL2.SetWindowGrab(window:SDL2.Window, grabbed:boolean):void

#### SDL2.SetWindowHitTest

SDL2.SetWindowHitTest(window:SDL2.Window):void

#### SDL2.SetWindowIcon

SDL2.SetWindowIcon(window:SDL2.Window, icon:SDL2.Surface):void

#### SDL2.SetWindowMaximumSize

SDL2.SetWindowMaximumSize(window:SDL2.Window, max\_w:number, max\_h:number):void

#### SDL2.SetWindowMinimumSize

SDL2.SetWindowMinimumSize(window:SDL2.Window, min\_w:number, min\_h:number):void

#### SDL2.SetWindowPosition

SDL2.SetWindowPosition(window:SDL2.Window, x:number, y:number):void

#### SDL2.SetWindowSize

SDL2.SetWindowSize(window:SDL2.Window, w:number, h:number):void

#### SDL2.SetWindowTitle

SDL2.SetWindowTitle(window:SDL2.Window, title:string):void

#### SDL2.ShowMessageBox

SDL2.ShowMessageBox():void

#### SDL2.ShowSimpleMessageBox

SDL2.ShowSimpleMessageBox(flags:number, title:string, message:string, window:SDL2.Window):void

#### SDL2.ShowWindow

SDL2.ShowWindow(window:SDL2.Window):void

#### SDL2.UpdateWindowSurface

SDL2.UpdateWindowSurface(window:SDL2.Window):void

#### SDL2.UpdateWindowSurfaceRects

SDL2.UpdateWindowSurfaceRects(window:SDL2.Window, rects[]:SDL2.Rect):void

#### SDL2.VideoInit

SDL2.VideoInit(driver\_name:string):void

#### SDL2.VideoQuit

SDL2.VideoQuit():void

#### SDL2.CreateRenderer

SDL2.CreateRenderer(window:SDL2.Window, index:number, flags:number) {block?}

#### SDL2.CreateSoftwareRenderer

SDL2.CreateSoftwareRenderer(surface:SDL2.Surface) {block?}

#### SDL2.CreateTexture

SDL2.CreateTexture(renderer:SDL2.Renderer, format:number, access:number, w:number, h:number) {block?}

#### SDL2.CreateTextureFromSurface

SDL2.CreateTextureFromSurface(renderer:SDL2.Renderer, surface:SDL2.Surface) {block?}

#### SDL2.DestroyRenderer

SDL2.DestroyRenderer(renderer:SDL2.Renderer):void

#### SDL2.DestroyTexture

SDL2.DestroyTexture(texture:SDL2.Texture):void

#### SDL2.GL\_BindTexture

SDL2.GL\_BindTexture(texture:SDL2.Texture) {block?}

#### SDL2.GL\_UnbindTexture

SDL2.GL\_UnbindTexture(texture:SDL2.Texture):void

#### SDL2.GetNumRenderDrivers

SDL2.GetNumRenderDrivers() {block?}

#### SDL2.GetRenderDrawBlendMode

SDL2.GetRenderDrawBlendMode(renderer:SDL2.Renderer) {block?}

#### SDL2.GetRenderDrawColor

SDL2.GetRenderDrawColor(renderer:SDL2.Renderer) {block?}

#### SDL2.GetRenderDriverInfo

SDL2.GetRenderDriverInfo(index:number) {block?}

#### SDL2.GetRenderTarget

SDL2.GetRenderTarget(renderer:SDL2.Renderer) {block?}

#### SDL2.GetRenderer

SDL2.GetRenderer(window:SDL2.Window) {block?}

#### SDL2.GetRendererInfo

SDL2.GetRendererInfo(renderer:SDL2.Renderer) {block?}

#### SDL2.GetRenderOutputSize

SDL2.GetRenderOutputSize(renderer:SDL2.Renderer) {block?}

#### SDL2.GetTextureAlphaMod

SDL2.GetTextureAlphaMod(texture:SDL2.Texture) {block?}

#### SDL2.GetTextureBlendMode

SDL2.GetTextureBlendMode(texture:SDL2.Texture) {block?}

#### SDL2.GetTextureColorMod

SDL2.GetTextureColorMod(texture:SDL2.Texture) {block?}

#### SDL2.LockTexture

SDL2.LockTexture(texture:SDL2.Texture, rect:SDL2.Rect):void

#### SDL2.QueryTexture

SDL2.QueryTexture(texture:SDL2.Texture) {block?}

#### SDL2.RenderClear

SDL2.RenderClear(renderer:SDL2.Renderer):void

#### SDL2.RenderCopy

SDL2.RenderCopy(renderer:SDL2.Renderer, texture:SDL2.Texture, srcrect:SDL2.Rect:nil, dstrect:SDL2.Rect:nil)



#### SDL2.RenderCopyEx

```
SDL2.RenderCopyEx(renderer:SDL2.Renderer, texture:SDL2.Texture, srcrect:SDL2.Rect:nil, dstrect:SDL2.Rect:nil, angle:number, center:SDL2.Point:nil, flip:number):void
```

#### SDL2.RenderDrawLine

```
SDL2.RenderDrawLine(renderer:SDL2.Renderer, x1:number, y1:number, x2:number, y2:number):void
```

#### SDL2.RenderDrawLines

```
SDL2.RenderDrawLines(renderer:SDL2.Renderer, points[]:SDL2.Point):void
```

#### SDL2.RenderDrawPoint

```
SDL2.RenderDrawPoint(renderer:SDL2.Renderer, x:number, y:number):void
```

#### SDL2.RenderDrawPoints

```
SDL2.RenderDrawPoints(renderer:SDL2.Renderer, points[]:SDL2.Point):void
```

#### SDL2.RenderDrawRect

```
SDL2.RenderDrawRect(renderer:SDL2.Renderer, rect:SDL2.Rect:nil):void
```

#### SDL2.RenderDrawRects

```
SDL2.RenderDrawRects(renderer:SDL2.Renderer, rects[]:SDL2.Rect):void
```

#### SDL2.RenderFillRect

```
SDL2.RenderFillRect(renderer:SDL2.Renderer, rect:SDL2.Rect:nil):void
```

#### SDL2.RenderFillRects

```
SDL2.RenderFillRects(renderer:SDL2.Renderer, rects[]:SDL2.Rect):void
```

#### SDL2.RenderGetClipRect

```
SDL2.RenderGetClipRect(renderer:SDL2.Renderer) {block?}
```

#### SDL2.RenderGetLogicalSize

```
SDL2.RenderGetLogicalSize(renderer:SDL2.Renderer) {block?}
```

#### SDL2.RenderGetScale

```
SDL2.RenderGetScale(renderer:SDL2.Renderer) {block?}
```

#### SDL2.RenderGetViewport

```
SDL2.RenderGetViewport(renderer:SDL2.Renderer) {block?}
```

#### SDL2.RenderIsClipEnabled

```
SDL2.RenderIsClipEnabled(renderer:SDL2.Renderer)
```

#### SDL2.RenderPresent

SDL2.RenderPresent(renderer:SDL2.Renderer):void

#### SDL2.RenderReadPixels

SDL2.RenderReadPixels(renderer:SDL2.Renderer, rect:SDL2.Rect:nil, format:symbol) {block?}

#### SDL2.RenderSetClipRect

SDL2.RenderSetClipRect(renderer:SDL2.Renderer, rect:SDL2.Rect:nil):void

#### SDL2.RenderSetLogicalSize

SDL2.RenderSetLogicalSize(renderer:SDL2.Renderer, w:number, h:number):void

#### SDL2.RenderSetScale

SDL2.RenderSetScale(renderer:SDL2.Renderer, scaleX:number, scaleY:number):void

#### SDL2.RenderSetViewport

SDL2.RenderSetViewport(renderer:SDL2.Renderer, rect:SDL2.Rect:nil):void

#### SDL2.RenderTargetSupported

SDL2.RenderTargetSupported(renderer:SDL2.Renderer) {block?}

#### SDL2.SetRenderDrawBlendMode

SDL2.SetRenderDrawBlendMode(renderer:SDL2.Renderer, blendMode:number):void

#### SDL2.SetRenderDrawColor

SDL2.SetRenderDrawColor(renderer:SDL2.Renderer, r:number, g:number, b:number, a:number):void

#### SDL2.SetRenderTarget

SDL2.SetRenderTarget(renderer:SDL2.Renderer, texture:SDL2.Texture:nil):void

#### SDL2.SetTextureAlphaMod

SDL2.SetTextureAlphaMod(texture:SDL2.Texture, alpha:number):void

#### SDL2.SetTextureBlendMode

SDL2.SetTextureBlendMode(texture:SDL2.Texture, blendMode:number):void

#### SDL2.SetTextureColorMod

SDL2.SetTextureColorMod(texture:SDL2.Texture, r:number, g:number, b:number):void

#### SDL2.UnlockTexture

SDL2.UnlockTexture(texture:SDL2.Texture):void

#### SDL2.UpdateTexture

SDL2.UpdateTexture(texture:SDL2.Texture, rect:SDL2.Rect:nil, pitch:number):void

#### SDL2.UpdateYUVTexture

SDL2.UpdateYUVTexture():void

#### SDL2.AllocFormat

SDL2.AllocFormat(pixel\_format:number) {block?}

#### SDL2.AllocPalette

SDL2.AllocPalette(ncolors:number) {block?}

#### SDL2.CalculateGammaRamp

SDL2.CalculateGammaRamp(gamma:number) {block?}

#### SDL2.FreeFormat

SDL2.FreeFormat(format:SDL2.PixelFormat):void

#### SDL2.FreePalette

SDL2.FreePalette(palette:SDL2.Palette):void

#### SDL2.GetPixelFormatName

SDL2.GetPixelFormatName(format:number) {block?}

#### SDL2.GetRGB

SDL2.GetRGB(pixel:number, format:SDL2.PixelFormat) {block?}

#### SDL2.GetRGBA

SDL2.GetRGBA(pixel:number, format:SDL2.PixelFormat) {block?}

#### SDL2.MapRGB

SDL2.MapRGB(format:SDL2.PixelFormat, r:number, g:number, b:number) {block?}

#### SDL2.MapRGBA

SDL2.MapRGBA(format:SDL2.PixelFormat, r:number, g:number, b:number, a:number) {block?}

#### SDL2.MasksToPixelFormatEnum

SDL2.MasksToPixelFormatEnum(bpp:number, Rmask:number, Gmask:number, Bmask:number, Amask:number) {block?}

#### SDL2.PixelFormatEnumToMasks

SDL2.PixelFormatEnumToMasks(format:number) {block?}

#### SDL2.SetPaletteColors

SDL2.SetPaletteColors(palette:SDL2.Palette, colors[:SDL2.Color, firstcolor:number, ncolors:number):void

#### SDL2.SetPixelFormatPalette

SDL2.SetPixelFormatPalette(format:SDL2.PixelFormat, palette:SDL2.Palette):void

#### SDL2.EnclosePoints

SDL2.EnclosePoints(points[:SDL2.Point, clip:SDL2.Rect) {block?}

#### SDL2.HasIntersection

SDL2.HasIntersection(A:SDL2.Rect, B:SDL2.Rect) {block?}

#### SDL2.IntersectRect

SDL2.IntersectRect(A:SDL2.Rect, B:SDL2.Rect) {block?}

#### SDL2.IntersectRectAndLine

SDL2.IntersectRectAndLine(rect:SDL2.Rect, X1:number, Y1:number, X2:number, Y2:number):void

#### SDL2.PointInRect

SDL2.PointInRect(p:SDL2.Point, r:SDL2.Rect):void

#### SDL2.RectEmpty

SDL2.RectEmpty(r:SDL2.Rect) {block?}

#### SDL2.RectEquals

SDL2.RectEquals(a:SDL2.Rect, b:SDL2.Rect) {block?}

#### SDL2.UnionRect

SDL2.UnionRect(A:SDL2.Rect, B:SDL2.Rect) {block?}

#### SDL2.BlitScaled

SDL2.BlitScaled(src:SDL2.Surface, srcrect:SDL2.Rect:nil, dst:SDL2.Surface, dstrect:SDL2.Rect:nil):void

#### SDL2.BlitSurface

SDL2.BlitSurface(src:SDL2.Surface, srcrect:SDL2.Rect:nil, dst:SDL2.Surface, dstrect:SDL2.Rect:nil):void

#### SDL2.ConvertPixels

SDL2.ConvertPixels(width:number, height:number, src\_format:number, dst\_format:number):void

#### SDL2.ConvertSurface

SDL2.ConvertSurface(src:SDL2.Surface, fmt:SDL2.PixelFormat, flags:number) {block?}

#### SDL2.ConvertSurfaceFormat

SDL2.ConvertSurfaceFormat(src:SDL2.Surface, pixel\_format:number, flags:number) {block?}

#### SDL2.CreateRGBSurface

SDL2.CreateRGBSurface(flags:number, width:number, height:number, depth:number, Rmask:number, Gmask:number, Bmask:number, Amask:number) {block?}

#### SDL2.CreateRGBSurfaceFrom

SDL2.CreateRGBSurfaceFrom(pixels, width:number, height:number, depth:number, pitch:number, Rmask:number, Gmask:number, Bmask:number, Amask:number) {block?}

#### SDL2.CreateRGBSurfaceFromImage

SDL2.CreateRGBSurfaceFromImage(image:image) {block?}

#### SDL2.FillRect

SDL2.FillRect(dst:SDL2.Surface, rect:SDL2.Rect:nil, color:number):void

#### SDL2.FillRects

SDL2.FillRects(dst:SDL2.Surface, rects[]:SDL2.Rect, color:number):void

#### SDL2.FreeSurface

SDL2.FreeSurface(surface:SDL2.Surface):void

#### SDL2.GetClipRect

SDL2.GetClipRect(surface:SDL2.Surface) {block?}

#### SDL2.GetColorKey

SDL2.GetColorKey(surface:SDL2.Surface) {block?}

#### SDL2.GetSurfaceAlphaMod

SDL2.GetSurfaceAlphaMod(surface:SDL2.Surface) {block?}

#### SDL2.GetSurfaceBlendMode

SDL2.GetSurfaceBlendMode(surface:SDL2.Surface) {block?}

#### SDL2.GetSurfaceColorMod

SDL2.GetSurfaceColorMod(surface:SDL2.Surface) {block?}

#### SDL2.LoadBMP

SDL2.LoadBMP(src:stream) {block?}

#### SDL2.LoadBMP\_RW

SDL2.LoadBMP\_RW():void

#### SDL2.LockSurface

SDL2.LockSurface(surface:SDL2.Surface):void

#### SDL2.LowerBlit

SDL2.LowerBlit(src:SDL2.Surface, srcrect:SDL2.Rect:nil, dst:SDL2.Surface, dstrect:SDL2.Rect:nil):void

#### SDL2.LowerBlitScaled

SDL2.LowerBlitScaled(src:SDL2.Surface, srcrect:SDL2.Rect:nil, dst:SDL2.Surface, dstrect:SDL2.Rect:nil):void

#### SDL2.MUSTLOCK

SDL2.MUSTLOCK(surface:SDL2.Surface) {block?}

#### SDL2.SaveBMP

SDL2.SaveBMP(surface:SDL2.Surface, dst:stream) {block?}

#### SDL2.SaveBMP\_RW

SDL2.SaveBMP\_RW():void

#### SDL2.SetClipRect

SDL2.SetClipRect(surface:SDL2.Surface, rect:SDL2.Rect) {block?}

#### SDL2.SetColorKey

SDL2.SetColorKey(surface:SDL2.Surface, flag:number, key:number):void

#### SDL2.SetSurfaceAlphaMod

SDL2.SetSurfaceAlphaMod(surface:SDL2.Surface, alpha:number):void

#### SDL2.SetSurfaceBlendMode

SDL2.SetSurfaceBlendMode(surface:SDL2.Surface, blendMode:number):void

#### SDL2.SetSurfaceColorMod

SDL2.SetSurfaceColorMod(surface:SDL2.Surface, r:number, g:number, b:number):void

#### SDL2.SetSurfacePalette

SDL2.SetSurfacePalette(surface:SDL2.Surface, palette:SDL2.Palette):void

#### SDL2.SetSurfaceRLE

SDL2.SetSurfaceRLE(surface:SDL2.Surface, flag:number):void

#### SDL2.UnlockSurface

SDL2.UnlockSurface(surface:SDL2.Surface):void

#### SDL2.GetClipboardText

SDL2.GetClipboardText() {block?}

#### SDL2.HasClipboardText

SDL2.HasClipboardText() {block?}

#### SDL2.SetClipboardText

SDL2.SetClipboardText(text:string):void

#### SDL2.AddEventWatch

SDL2.AddEventWatch():void

#### SDL2.DelEventWatch

SDL2.DelEventWatch():void

#### SDL2.EventState

SDL2.EventState(type:number, state:number) {block?}

#### SDL2.FilterEvents

SDL2.FilterEvents():void

#### SDL2.FlushEvent

SDL2.FlushEvent(type:number):void

#### SDL2.FlushEvents

SDL2.FlushEvents(minType:number, maxType:number):void

#### SDL2.GetEventFilter

SDL2.GetEventFilter():void

#### SDL2.GetNumTouchDevices

SDL2.GetNumTouchDevices() {block?}

#### SDL2.GetNumTouchFingers

SDL2.GetNumTouchFingers(touchId:number) {block?}

#### SDL2.GetTouchDevice

SDL2.GetTouchDevice(index:number) {block?}

#### SDL2.GetTouchFinger

SDL2.GetTouchFinger(touchId:number, index:number) {block?}

#### SDL2.HasEvent

SDL2.HasEvent(type:number) {block?}

#### SDL2.HasEvents

SDL2.HasEvents(minType:number, maxType:number) {block?}

#### SDL2.LoadDollarTemplates

SDL2.LoadDollarTemplates(touchId:number, src:stream) {block?}

#### SDL2.AddEvents

SDL2.AddEvents(events[]:SDL2.Event) {block?}

#### SDL2.PeekEvents

SDL2.PeekEvents(numevents:number, minType:number, maxType:number) {block?}

#### SDL2.GetEvents

SDL2.GetEvents(numevents:number, minType:number, maxType:number) {block?}

#### SDL2.PollEvent

SDL2.PollEvent() {block?}

#### SDL2.PumpEvents

SDL2.PumpEvents():void

#### SDL2.PushEvent

SDL2.PushEvent(event:SDL2.Event) {block?}

#### SDL2.QuitRequested

SDL2.QuitRequested() {block?}

#### SDL2.RecordGesture

SDL2.RecordGesture(touchId:number) {block?}

#### SDL2.RegisterEvents

SDL2.RegisterEvents(numevents:number) {block?}

#### SDL2.SaveAllDollarTemplates

SDL2.SaveAllDollarTemplates(dst:stream) {block?}

#### SDL2.SaveDollarTemplate

SDL2.SaveDollarTemplate(gestureId:number, dst:stream):void

#### SDL2.SetEventFilter

SDL2.SetEventFilter():void

#### SDL2.WaitEvent

SDL2.WaitEvent() {block?}

#### SDL2.WaitEventTimeout

SDL2.WaitEventTimeout(timeout:number) {block?}

#### SDL2.CheckKeyboardState

SDL2.CheckKeyboardState(scancode:number) {block?}



#### SDL2.GetKeyFromName

SDL2.GetKeyFromName(name:string) {block?}

#### SDL2.GetKeyFromScancode

SDL2.GetKeyFromScancode(scancode:number) {block?}

#### SDL2.GetKeyName

SDL2.GetKeyName(key:number) {block?}

#### SDL2.GetKeyboardFocus

SDL2.GetKeyboardFocus() {block?}

#### SDL2.GetKeyboardState

SDL2.GetKeyboardState() {block?}

#### SDL2.GetModState

SDL2.GetModState() {block?}

#### SDL2.GetScancodeFromKey

SDL2.GetScancodeFromKey(key:number) {block?}

#### SDL2.GetScancodeFromName

SDL2.GetScancodeFromName(name:string) {block?}

#### SDL2.GetScancodeName

SDL2.GetScancodeName(scancode:number) {block?}

#### SDL2.HasScreenKeyboardSupport

SDL2.HasScreenKeyboardSupport() {block?}

#### SDL2.IsScreenKeyboardShown

SDL2.IsScreenKeyboardShown(window:SDL2.Window) {block?}

#### SDL2.IsTextInputActive

SDL2.IsTextInputActive() {block?}

#### SDL2.SetModState

SDL2.SetModState(modstate:number):void

#### SDL2.SetTextInputRect

SDL2.SetTextInputRect(rect:SDL2.Rect):void

#### SDL2.StartTextInput

SDL2.StartTextInput():void

#### SDL2.StopTextInput

SDL2.StopTextInput():void

#### SDL2.CaptureMouse

SDL2.CaptureMouse(enabled:boolean):void

#### SDL2.CreateColorCursor

SDL2.CreateColorCursor(surface:SDL2.Surface, hot\_x:number, hot\_y:number) {block?}

#### SDL2.CreateCursor

SDL2.CreateCursor(data:array@uchar:nomap, mask:array@uchar:nomap, w:number, h:number, hot\_x:number, hot\_y:number) {block?}

#### SDL2.CreateSystemCursor

SDL2.CreateSystemCursor(id:number) {block?}

#### SDL2.FreeCursor

SDL2.FreeCursor(cursor:SDL2.Cursor):void

#### SDL2.GetCursor

SDL2.GetCursor() {block?}

#### SDL2.GetDefaultCursor

SDL2.GetDefaultCursor() {block?}

#### SDL2.GetGlobalMouseState

SDL2.GetGlobalMouseState():void

#### SDL2.GetMouseFocus

SDL2.GetMouseFocus() {block?}

#### SDL2.GetMouseState

SDL2.GetMouseState() {block?}

#### SDL2.GetRelativeMouseMode

SDL2.GetRelativeMouseMode() {block?}

#### SDL2.GetRelativeMouseState

SDL2.GetRelativeMouseState() {block?}

#### SDL2.SetCursor

SDL2.SetCursor(cursor:SDL2.Cursor):void

#### SDL2.SetRelativeMouseMode

SDL2.SetRelativeMouseMode(enabled:boolean):void

#### SDL2.ShowCursor

SDL2.ShowCursor(toggle:number):void

#### SDL2.WarpMouseGlobal

SDL2.WarpMouseGlobal(x:number, y:number):void

#### SDL2.WarpMouseInWindow

SDL2.WarpMouseInWindow(window:SDL2.Window, x:number, y:number):void

#### SDL2.JoystickClose

SDL2.JoystickClose(joystick:SDL2.Joystick):void

#### SDL2.JoystickEventState

SDL2.JoystickEventState(state:number) {block?}

#### SDL2.JoystickGetAttached

SDL2.JoystickGetAttached(joystick:SDL2.Joystick) {block?}

#### SDL2.JoystickGetAxis

SDL2.JoystickGetAxis(joystick:SDL2.Joystick, axis:number) {block?}

#### SDL2.JoystickGetBall

SDL2.JoystickGetBall(joystick:SDL2.Joystick, ball:number) {block?}

#### SDL2.JoystickGetButton

SDL2.JoystickGetButton(joystick:SDL2.Joystick, button:number) {block?}

#### SDL2.JoystickGetDeviceGUID

SDL2.JoystickGetDeviceGUID(device\_index:number) {block?}

#### SDL2.JoystickGetGUID

SDL2.JoystickGetGUID(joystick:SDL2.Joystick) {block?}

#### SDL2.JoystickGetGUIDFromString

SDL2.JoystickGetGUIDFromString(pchGUID:string) {block?}

#### SDL2.JoystickGetGUIDString

SDL2.JoystickGetGUIDString(guid:SDL2.JoystickGUID) {block?}

#### SDL2.JoystickGetHat

SDL2.JoystickGetHat(joystick:SDL2.Joystick, hat:number) {block?}

#### SDL2.JoystickInstanceID

SDL2.JoystickInstanceID(joystick:SDL2.Joystick) {block?}

#### SDL2.JoystickName

SDL2.JoystickName(joystick:SDL2.Joystick) {block?}

#### SDL2.JoystickNameForIndex

SDL2.JoystickNameForIndex(device\_index:number) {block?}

#### SDL2.JoystickNumAxes

SDL2.JoystickNumAxes(joystick:SDL2.Joystick) {block?}

#### SDL2.JoystickNumBalls

SDL2.JoystickNumBalls(joystick:SDL2.Joystick) {block?}

#### SDL2.JoystickNumButtons

SDL2.JoystickNumButtons(joystick:SDL2.Joystick) {block?}

#### SDL2.JoystickNumHats

SDL2.JoystickNumHats(joystick:SDL2.Joystick) {block?}

#### SDL2.JoystickOpen

SDL2.JoystickOpen(device\_index:number) {block?}

#### SDL2.JoystickUpdate

SDL2.JoystickUpdate():void

#### SDL2.NumJoysticks

SDL2.NumJoysticks() {block?}

#### SDL2.GameControllerAddMapping

SDL2.GameControllerAddMapping(mapping\_string:string) {block?}

#### SDL2.GameControllerAddMappingsFromFile

SDL2.GameControllerAddMappingsFromFile(file:stream) {block?}

#### SDL2.GameControllerAddMappingsFromRW

SDL2.GameControllerAddMappingsFromRW():void

#### SDL2.GameControllerClose

SDL2.GameControllerClose(gamecontroller:SDL2.GameController):void

#### SDL2.GameControllerEventState

SDL2.GameControllerEventState(state:number) {block?}

#### SDL2.GameControllerGetAttached

SDL2.GameControllerGetAttached(gamecontroller:SDL2.GameController) {block?}

#### SDL2.GameControllerGetAxis

SDL2.GameControllerGetAxis(gamecontroller:SDL2.GameController, axis:number) {block?}

#### SDL2.GameControllerGetAxisFromString

SDL2.GameControllerGetAxisFromString(pchString:string) {block?}

#### SDL2.GameControllerGetBindForAxis

SDL2.GameControllerGetBindForAxis(gamecontroller:SDL2.GameController, axis:number) {block?}

#### SDL2.GameControllerGetBindForButton

SDL2.GameControllerGetBindForButton(gamecontroller:SDL2.GameController, button:number) {block?}

#### SDL2.GameControllerGetButton

SDL2.GameControllerGetButton(gamecontroller:SDL2.GameController, button:number) {block?}

#### SDL2.GameControllerGetButtonFromString

SDL2.GameControllerGetButtonFromString(pchString:string) {block?}

#### SDL2.GameControllerGetJoystick

SDL2.GameControllerGetJoystick(gamecontroller:SDL2.GameController) {block?}

#### SDL2.GameControllerGetStringForAxis

SDL2.GameControllerGetStringForAxis(axis:number) {block?}

#### SDL2.GameControllerGetStringForButton

SDL2.GameControllerGetStringForButton(button:number) {block?}

#### SDL2.GameControllerMapping

SDL2.GameControllerMapping(gamecontroller:SDL2.GameController) {block?}

#### SDL2.GameControllerMappingForGUID

SDL2.GameControllerMappingForGUID(guid:SDL2.JoystickGUID) {block?}

#### SDL2.GameControllerName

SDL2.GameControllerName(gamecontroller:SDL2.GameController) {block?}

#### SDL2.GameControllerNameForIndex

SDL2.GameControllerNameForIndex(joystick\_index:number) {block?}

#### SDL2.GameControllerOpen

SDL2.GameControllerOpen(joystick\_index:number) {block?}

#### SDL2.GameControllerUpdate

SDL2.GameControllerUpdate():void

#### SDL2.IsGameController

SDL2.IsGameController(joystick\_index:number) {block?}

#### SDL2.HapticClose

SDL2.HapticClose(haptic:SDL2.Haptic):void

#### SDL2.HapticDestroyEffect

SDL2.HapticDestroyEffect(haptic:SDL2.Haptic, effect:number):void

#### SDL2.HapticEffectSupported

SDL2.HapticEffectSupported(haptic:SDL2.Haptic, effect:SDL2.HapticEffect) {block?}

#### SDL2.HapticGetEffectStatus

SDL2.HapticGetEffectStatus(haptic:SDL2.Haptic, effect:number) {block?}

#### SDL2.HapticIndex

SDL2.HapticIndex(haptic:SDL2.Haptic) {block?}

#### SDL2.HapticName

SDL2.HapticName(device\_index:number) {block?}

#### SDL2.HapticNewEffect

SDL2.HapticNewEffect(haptic:SDL2.Haptic, effect:SDL2.HapticEffect) {block?}

#### SDL2.HapticNumAxes

SDL2.HapticNumAxes(haptic:SDL2.Haptic) {block?}

#### SDL2.HapticNumEffects

SDL2.HapticNumEffects(haptic:SDL2.Haptic) {block?}

#### SDL2.HapticNumEffectsPlaying

SDL2.HapticNumEffectsPlaying(haptic:SDL2.Haptic) {block?}

#### SDL2.HapticOpen

SDL2.HapticOpen(device\_index:number) {block?}

#### SDL2.HapticOpenFromJoystick

SDL2.HapticOpenFromJoystick(joystick:SDL2.Joystick) {block?}

#### SDL2.HapticOpenFromMouse

SDL2.HapticOpenFromMouse() {block?}

#### SDL2.HapticOpened

SDL2.HapticOpened(device\_index:number) {block?}

#### SDL2.HapticPause

SDL2.HapticPause(haptic:SDL2.Haptic):void

#### SDL2.HapticQuery

SDL2.HapticQuery(haptic:SDL2.Haptic) {block?}

#### SDL2.HapticRumbleInit

SDL2.HapticRumbleInit(haptic:SDL2.Haptic):void

#### SDL2.HapticRumblePlay

SDL2.HapticRumblePlay(haptic:SDL2.Haptic, strength:number, length:number):void

#### SDL2.HapticRumbleStop

SDL2.HapticRumbleStop(haptic:SDL2.Haptic):void

#### SDL2.HapticRumbleSupported

SDL2.HapticRumbleSupported(haptic:SDL2.Haptic) {block?}

#### SDL2.HapticRunEffect

SDL2.HapticRunEffect(haptic:SDL2.Haptic, effect:number, iterations:number):void

#### SDL2.HapticSetAutocenter

SDL2.HapticSetAutocenter(haptic:SDL2.Haptic, autocenter:number):void

#### SDL2.HapticSetGain

SDL2.HapticSetGain(haptic:SDL2.Haptic, gain:number):void

#### SDL2.HapticStopAll

SDL2.HapticStopAll(haptic:SDL2.Haptic):void

#### SDL2.HapticStopEffect

SDL2.HapticStopEffect(haptic:SDL2.Haptic, effect:number):void

#### SDL2.HapticUnpause

SDL2.HapticUnpause(haptic:SDL2.Haptic):void

#### SDL2.HapticUpdateEffect

SDL2.HapticUpdateEffect(haptic:SDL2.Haptic, effect:number, data:SDL2.HapticEffect):void

#### SDL2.JoystickIsHaptic

SDL2.JoystickIsHaptic(joystick:SDL2.Joystick) {block?}

#### SDL2.MouseIsHaptic

SDL2.MouseIsHaptic() {block?}

#### SDL2.NumHaptics

SDL2.NumHaptics() {block?}

#### SDL2.AudioInit

SDL2.AudioInit(driver\_name:string):void

#### SDL2.AudioQuit

SDL2.AudioQuit():void

#### SDL2.BuildAudioCVT

SDL2.BuildAudioCVT(cvt:SDL2.AudioCVT, src\_format:number, src\_channels:number, src\_rate:number, dst\_format:number, dst\_channels:number, dst\_rate:number) {block?}

#### SDL2.ClearQueuedAudio

SDL2.ClearQueuedAudio(dev:number):void

#### SDL2.CloseAudio

SDL2.CloseAudio():void

#### SDL2.CloseAudioDevice

SDL2.CloseAudioDevice(dev:number):void

#### SDL2.ConvertAudio

SDL2.ConvertAudio(cvt:SDL2.AudioCVT):void

#### SDL2.FreeWAV

SDL2.FreeWAV(wav:SDL2.Wav):void

#### SDL2.GetAudioDeviceName

SDL2.GetAudioDeviceName(index:number, iscapture:number) {block?}

#### SDL2.GetAudioDeviceStatus

SDL2.GetAudioDeviceStatus(dev:number) {block?}

#### SDL2.GetAudioDriver

SDL2.GetAudioDriver(index:number) {block?}

#### SDL2.GetAudioStatus

SDL2.GetAudioStatus() {block?}



#### SDL2.GetCurrentAudioDriver

SDL2.GetCurrentAudioDriver() {block?}

#### SDL2.GetNumAudioDevices

SDL2.GetNumAudioDevices(iscapture:number) {block?}

#### SDL2.GetNumAudioDrivers

SDL2.GetNumAudioDrivers() {block?}

#### SDL2.GetQueuedAudioSize

SDL2.GetQueuedAudioSize(dev:number):void

#### SDL2.LoadWAV

SDL2.LoadWAV(file:string) {block?}

#### SDL2.LoadWAV\_RW

SDL2.LoadWAV\_RW():void

#### SDL2.LockAudio

SDL2.LockAudio():void

#### SDL2.LockAudioDevice

SDL2.LockAudioDevice(dev:number):void

#### SDL2.MixAudio

SDL2.MixAudio(volume:number):void

#### SDL2.MixAudioFormat

SDL2.MixAudioFormat(format:number, volume:number):void

#### SDL2.OpenAudio

SDL2.OpenAudio(desired:SDL2.AudioSpec) {block?}

#### SDL2.OpenAudioDevice

SDL2.OpenAudioDevice(device:string, iscapture:number, desired:SDL2.AudioSpec, allowed\_changes:number):void

#### SDL2.PauseAudio

SDL2.PauseAudio(pause\_on:number):void

#### SDL2.PauseAudioDevice

SDL2.PauseAudioDevice(dev:number, pause\_on:number):void

#### SDL2.QueueAudio

SDL2.QueueAudio(dev:number):void

#### SDL2.UnlockAudio

SDL2.UnlockAudio():void

#### SDL2.UnlockAudioDevice

SDL2.UnlockAudioDevice(dev:number):void

#### SDL2.AUDIO\_BITSIZ

SDL2.AUDIO\_BITSIZ(x:number) {block?}

#### SDL2.AUDIO\_ISFLOAT

SDL2.AUDIO\_ISFLOAT(x:number) {block?}

#### SDL2.AUDIO\_ISBIGENDIAN

SDL2.AUDIO\_ISBIGENDIAN(x:number) {block?}

#### SDL2.AUDIO\_ISSIGNED

SDL2.AUDIO\_ISSIGNED(x:number) {block?}

#### SDL2.AUDIO\_ISINT

SDL2.AUDIO\_ISINT(x:number) {block?}

#### SDL2.AUDIO\_ISLITTLEENDIAN

SDL2.AUDIO\_ISLITTLEENDIAN(x:number) {block?}

#### SDL2.AUDIO\_ISUNSIGNED

SDL2.AUDIO\_ISUNSIGNED(x:number) {block?}

#### SDL2.CreateThread

SDL2.CreateThread():void

#### SDL2.DetachThread

SDL2.DetachThread():void

#### SDL2.GetThreadID

SDL2.GetThreadID():void

#### SDL2.GetThreadName

SDL2.GetThreadName():void

#### SDL2.GetThreadPriority

SDL2.GetThreadPriority():void

#### SDL2.TLSCreate

SDL2.TLSCreate():void

#### SDL2.TLSGet

SDL2.TLSGet():void

#### SDL2.TLSSet

SDL2.TLSSet():void

#### SDL2.ThreadID

SDL2.ThreadID():void

#### SDL2.WaitThread

SDL2.WaitThread():void

#### SDL2.CondBroadcast

SDL2.CondBroadcast():void

#### SDL2.CondSignal

SDL2.CondSignal():void

#### SDL2.CondWait

SDL2.CondWait():void

#### SDL2.CondWaitTimeout

SDL2.CondWaitTimeout():void

#### SDL2.CreateCond

SDL2.CreateCond():void

#### SDL2.CreateMutex

SDL2.CreateMutex():void

#### SDL2.CreateSemaphore

SDL2.CreateSemaphore():void

#### SDL2.DestroyCond

SDL2.DestroyCond():void

#### SDL2.DestroyMutex

SDL2.DestroyMutex():void

#### SDL2.DestroySemaphore

SDL2.DestroySemaphore():void

#### SDL2.LockMutex

SDL2.LockMutex():void

#### SDL2.SemPost

SDL2.SemPost():void

#### SDL2.SemTryWait

SDL2.SemTryWait():void

#### SDL2.SemValue

SDL2.SemValue():void

#### SDL2.SemWait

SDL2.SemWait():void

#### SDL2.SemWaitTimeout

SDL2.SemWaitTimeout():void

#### SDL2.TryLockMutex

SDL2.TryLockMutex():void

#### SDL2.UnlockMutex

SDL2.UnlockMutex():void

#### SDL2.AtomicAdd

SDL2.AtomicAdd():void

#### SDL2.AtomicCAS

SDL2.AtomicCAS():void

#### SDL2.AtomicCASPtr

SDL2.AtomicCASPtr():void

#### SDL2.AtomicDecRef

SDL2.AtomicDecRef():void

#### SDL2.AtomicGet

SDL2.AtomicGet():void

#### SDL2.AtomicGetPtr

SDL2.AtomicGetPtr():void

#### SDL2.AtomicIncRef

SDL2.AtomicIncRef():void

#### SDL2.AtomicLock

SDL2.AtomicLock():void

#### SDL2.AtomicSet

SDL2.AtomicSet():void

#### SDL2.AtomicSetPtr

SDL2.AtomicSetPtr():void

#### SDL2.AtomicTryLock

SDL2.AtomicTryLock():void

#### SDL2.AtomicUnlock

SDL2.AtomicUnlock():void

#### SDL2.CompilerBarrier

SDL2.CompilerBarrier():void

#### SDL2.AddTimer

SDL2.AddTimer(interval:number):void

#### SDL2.Delay

SDL2.Delay(ms:number):void

#### SDL2.GetPerformanceCounter

SDL2.GetPerformanceCounter() {block?}

#### SDL2.GetPerformanceFrequency

SDL2.GetPerformanceFrequency() {block?}

#### SDL2.GetTicks

SDL2.GetTicks() {block?}

#### SDL2.RemoveTimer

SDL2.RemoveTimer(id:number) {block?}

#### SDL2.TICKS\_PASSED

SDL2.TICKS\_PASSED(A:number, B:number) {block?}

#### SDL2.GetBasePath

SDL2.GetBasePath():void

#### SDL2.GetPrefPath

SDL2.GetPrefPath(org:string, app:string):void

#### SDL2.AllocRW

SDL2.AllocRW():void

SDL2.FreeRW

SDL2.FreeRW():void

SDL2.RWFromConstMem

SDL2.RWFromConstMem():void

SDL2.RWFromFP

SDL2.RWFromFP():void

SDL2.RWFromFile

SDL2.RWFromFile():void

SDL2.RWFromMem

SDL2.RWFromMem():void

SDL2.RWclose

SDL2.RWclose():void

SDL2.RWread

SDL2.RWread():void

SDL2.RWseek

SDL2.RWseek():void

SDL2.RWtell

SDL2.RWtell():void

SDL2.RWwrite

SDL2.RWwrite():void

SDL2.ReadBE16

SDL2.ReadBE16():void

SDL2.ReadBE32

SDL2.ReadBE32():void

SDL2.ReadBE64

SDL2.ReadBE64():void

SDL2.ReadLE16

SDL2.ReadLE16():void

SDL2.ReadLE32

SDL2.ReadLE32():void

#### SDL2.ReadLE64

SDL2.ReadLE64():void

#### SDL2.WriteBE16

SDL2.WriteBE16():void

#### SDL2.WriteBE32

SDL2.WriteBE32():void

#### SDL2.WriteBE64

SDL2.WriteBE64():void

#### SDL2.WriteLE16

SDL2.WriteLE16():void

#### SDL2.WriteLE32

SDL2.WriteLE32():void

#### SDL2.WriteLE64

SDL2.WriteLE64():void

#### SDL2.GetPlatform

SDL2.GetPlatform() {block?}

#### SDL2.GetCPUCacheLineSize

SDL2.GetCPUCacheLineSize() {block?}

#### SDL2.GetCPUCount

SDL2.GetCPUCount() {block?}

#### SDL2.GetSystemRAM

SDL2.GetSystemRAM() {block?}

#### SDL2.Has3DNow

SDL2.Has3DNow() {block?}

#### SDL2.HasAVX

SDL2.HasAVX() {block?}

#### SDL2.HasAVX2

SDL2.HasAVX2():void

#### SDL2.HasAltivec

SDL2.HasAltivec() {block?}

#### SDL2.HasMMX

SDL2.HasMMX() {block?}

#### SDL2.HasRDTSC

SDL2.HasRDTSC() {block?}

#### SDL2.HasSSE

SDL2.HasSSE() {block?}

#### SDL2.HasSSE2

SDL2.HasSSE2() {block?}

#### SDL2.HasSSE3

SDL2.HasSSE3() {block?}

#### SDL2.HasSSE41

SDL2.HasSSE41() {block?}

#### SDL2.HasSSE42

SDL2.HasSSE42() {block?}

#### SDL2.Swap16

SDL2.Swap16():void

#### SDL2.Swap32

SDL2.Swap32():void

#### SDL2.Swap64

SDL2.Swap64():void

#### SDL2.SwapBE16

SDL2.SwapBE16():void

#### SDL2.SwapBE32

SDL2.SwapBE32():void

#### SDL2.SwapBE64

SDL2.SwapBE64():void

#### SDL2.SwapFloat

SDL2.SwapFloat():void

#### SDL2.SwapFloatBE

SDL2.SwapFloatBE():void



#### SDL2.SwapFloatLE

SDL2.SwapFloatLE():void

#### SDL2.SwapLE16

SDL2.SwapLE16():void

#### SDL2.SwapLE32

SDL2.SwapLE32():void

#### SDL2.SwapLE64

SDL2.SwapLE64():void

#### SDL2.MostSignificantBitIndex32

SDL2.MostSignificantBitIndex32(x:number):void

#### SDL2.GetPowerInfo

SDL2.GetPowerInfo() {block?}

#### SDL2.AndroidGetActivity

SDL2.AndroidGetActivity():void

#### SDL2.AndroidGetExternalStoragePath

SDL2.AndroidGetExternalStoragePath():void

#### SDL2.AndroidGetExternalStorageState

SDL2.AndroidGetExternalStorageState():void

#### SDL2.AndroidGetInternalStoragePath

SDL2.AndroidGetInternalStoragePath():void

#### SDL2.AndroidGetJNIEnv

SDL2.AndroidGetJNIEnv():void

#### SDL2.acos

SDL2.acos(x:number) {block?}

- 42.2    `sdl2.Window` Class
- 42.3    `sdl2.Renderer` Class
- 42.4    `sdl2.Texture` Class
- 42.5    `sdl2.Event` Class
- 42.6    `sdl2.Point` Class
- 42.7    `sdl2.Rect` Class
- 42.8    `sdl2.Color` Class
- 42.9    `sdl2.Palette` Class
- 42.10   `sdl2.PixelFormat` Class
- 42.11   `sdl2.Keysym` Class
- 42.12   `sdl2.Cursor` Class
- 42.13   `sdl2.Joystick` Class
- 42.14   `sdl2.JoystickGUID` Class
- 42.15   `sdl2.GameController` Class
- 42.16   `sdl2.GameControllerButtonBind` Class
- 42.17   `sdl2.AudioCVT` Class
- 42.18   `sdl2.AudioSpec` Class
- 42.19   `sdl2.Wav` Class
- 42.20   `sdl2.RendererInfo` Class
- 42.21   `sdl2.DisplayMode` Class
- 42.22   `sdl2.GLContext` Class
- 42.23   `sdl2.HapticEffect` Class
- 42.24   `sdl2.Surface` Class
- 42.25   `sdl2.Finger` Class
- 42.26   Thanks

This module uses SDL2 library which is distributed in the following site:

<http://www.libsdl.org/>

## Chapter 43

# sqlite3 Module

The `sqlite3` module provides measures to access SQLite3 database. To utilize it, import the `sqlite3` module using `import` function.

### 43.1 Module Function

### 43.2 `sqlite3.db` Class

#### `sqlite3.db`

`sqlite3.db(filename:string) {block?}`

Opens an `sqlite3` database file. If `block` is not specified, it returns a connection handle with an `sqlite3` server. If `block` is specified, it executes the program in the block with a connection handle as a block parameter, and returns the result afterwards. The connection handle will automatically closed when the block finishes.

Block parameter format: `|db:sqlite3|`

#### `sqlite3.db#close`

`sqlite3.db#close()`

Shuts down the connection with an `sqlite3` server.

#### `sqlite3.db#exec`

`sqlite3.db#exec(sql:string):map`

Executes an SQL statement and returns the result as a list.

#### `sqlite3.db#getcolnames`

`sqlite3.db#getcolnames(sql:string):map {block?}`

#### `sqlite3.db#query`

`sqlite3.db#query(sql:string):map {block?}`

Executes an SQL statement and returns the result as an iterator. You should use `sqlite3.db#query()` instead of `sqlite3.db#exec()` when it's likely that you get a large size of data as the result.

#### `sqlite3.db#transaction`

`sqlite3.db#transaction() {block}`

Executes the block within a transaction. The process is like following:

1. Executes a `sqlite3` command 'BEGIN TRANSACTION'

2. Executes code in the block
3. Executes a sqlite3 command 'END TRANSACTION'

### **43.3 Thanks**

This module uses SQLite3 library which is distributed in the following site:  
<http://www.sqlite.org/index.html>

# Chapter 44

## sys Module

The `sys` module provides system-related information. This is a built-in module, so you can use it without being imported.

### 44.1 Module Variable

- `sys.argv`
- `sys.path`
- `sys.maindir`
- `sys.version`
- `sys.banner`
- `sys.timestamp`
- `sys.build`
- `sys.platform`
- `sys.ps1`
- `sys.ps2`
- `sys.langcode`
- `sys.executable`
- `sys.incdir`
- `sys.libdir`
- `sys.datadir`
- `sys.moddir`
- `sys.localdir`
- `sys.appdir`
- `sys.cfgdir`
- `sys.workdir`

## 44.2 Module Function

sys.echo

`sys.echo(flag:boolean)`

Enables or disables echo-back functionality according to flag.

sys.exit

`sys.exit(status?:number)`

Terminates the program with a specified status number.

sys.required\_version

`sys.required_version(major:number, minor:number, patch:number)`

Raises an error if the running interpreter doesn't satisfy the required version.

# Chapter 45

## tar Module

The `tar` module provides measures to read/write TAR files. To utilize it, import the `tar` module using `import` function.

### 45.1 tar.reader Class

#### 45.1.1 Function To Create Instance

tar.reader

```
tar.reader(stream:stream:r, compression?:symbol) {block?}
```

Reads a tar file from `stream` and returns a `tar.reader` instance that is to be used to read contents from the archive.

The argument `compression` specifies the compression format of the tar file and takes one of the following symbols:

- 'auto' .. determines the format from a suffix name of the stream.
- 'gzip' .. gzip format
- 'bzip2' .. bzip2 format

#### 45.1.2 Method

tar.reader#entries

```
tar.reader#entries() {block?}
```

Creates an iterator that returns stream instances for each entry in the tar file.

### 45.2 tar.writer Class

#### 45.2.1 Function To Create Instance

tar.writer

```
tar.writer(stream:stream:w, compression?:symbol) {block?}
```

Creates a tar file on `stream` and returns a `tar.writer` instance that is to be used to write contents to the archive.

The argument `compression` specifies the compression format of the tar file and takes one of the following symbols:

- 'auto' .. determines the format from a suffix name of the stream.



- ‘gzip’ .. gzip format
- ‘bzip2’ .. bzip2 format

### 45.2.2 Method

tar.writer#add

`tar.writer#add(stream:stream:r, filename?:string):map:reduce`

Adds an entry to the tar archive with a content from `stream` and a name of `filename` .  
If the argument `filename` is omitted, an identifier associated with the `stream` would be used as the entry name.

tar.writer#close

`tar.writer#close():reduce`

Flushes all the unfinished writing processes and invalidates the `tar.writer` instance.

## 45.3 Thanks

This module uses zlib and bzip2 library which are distributed in the following sites:

- <http://zlib.net/>
- <http://www.bzip.org/>

## Chapter 46

# tiff Module

The `tiff` module provides measures to read/write image data in TIFF format. To utilize it, import the `tiff` module using `import` function. Below is an example to read a TIFF file:

```
import(tiff)
img = image('foo.tiff')
```

### 46.1 Exntension to Function's Capability

This module extends the capability of function `image()` and instance method `image#write()` so that they can read/write TIFF files.

When function `image()` is provided with a stream that satisfies the following conditions, it would recognize the stream as a TIFF file.

- The identifier of the stream ends with a suffix `".tif "` or `".tiff "`.

When instance method `image#write()` is provided with a stream that satisfies the following condition, it would write image data in TIFF format.

- The identifier of the stream ends with a suffix `".tif "` or `".tiff "`.

### 46.2 Extension to image Class

This module extends the `image` class with methods described here.

```
image#read@tiff
image#read@tiff(stream:stream:r):reduce
```

Reads a TIFF image from a stream.

### 46.3 Thanks

This module uses libtiff which is distributed in the following site:  
<http://www.libtiff.org/>

## Chapter 47

# tokenizer Module

The `tokenizer` module ...

### 47.1 Module Function

## Chapter 48

# units Module

The `units` module ...

### 48.1 Module Function

## Chapter 49

# uuid Module

The `uuid` module provides functions to generate UUIDs. To utilize it, import the `uuid` module using `import` function.

### 49.1 Module Function

`uuid.generate`

`uuid.generate(): [upper]`

Generates a Universal Unique Identifier (UUID). In default, results are output in lower-case characters. Specifying `:upper` would generates it in upper-case characters.

# Chapter 50

## wav Module

### 50.1 Module Function

### 50.2 Extension to audio Class

This module extends the `audio` class with methods described here.

`audio#read@wav`

`audio#read@wav(stream:stream:r):reduce`

Reads WAV audio from a stream.

`audio#write@wav`

`audio#write@wav(stream:stream:w):reduce`

Writes WAV audio to a stream.

# Chapter 51

## wx Module

The `wx` module provides functions and methods of wxWidgets library.

### 51.1 Module Function

### 51.2 Thanks

This module uses wxWidgets library which is distributed in the following site:  
<http://www.wxwidgets.org/>

## Chapter 52

# xml Module

### 52.1 Module Function

xml.comment

`xml.comment(comment:string)`

### 52.2 xml.attribute Class

### 52.3 xml.document Class

#### 52.3.1 Constructor

xml.document

`xml.document(stream?:stream:r) {block?}`

#### 52.3.2 Method

xml.document#parse

`xml.document#parse(str:string):void`

xml.document#read

`xml.document#read(stream:stream:r):void`

xml.document#textize

`xml.document#textize(fancy?:boolean, tabs?:number)`

xml.document#write

`xml.document#write(stream:stream:w, fancy?:boolean, tabs?:number):void`



## 52.4 xml.element Class

### 52.4.1 Constructor

xml.element

```
xml.element(_tagname_:string, attrs%):map {block?}
```

### 52.4.2 Method

xml.element#addchild

```
xml.element#addchild(value):map:void
```

xml.element#gettext

```
xml.element#getText()
```

xml.element#textize

```
xml.element#textize(fancy?:boolean, indentLevel?:number, tabs?:number)
```

xml.element#write

```
xml.element#write(stream:stream:w, fancy?:boolean, indentLevel?:number, tabs?:number):void
```

## 52.5 xml.parser Class

### 52.5.1 Constructor

xml.parser

```
xml.parser() {block?}
```

### 52.5.2 Method

xml.parser#parse

```
xml.parser#parse(stream:stream:r):void
```

## 52.6 Thanks

This module uses expat library which is distributed in the following site:  
<http://expat.sourceforge.net/>

## Chapter 53

# xpm Module

The `xpm` module provides measures to write image data in XPM format and to parse a list of strings that is described in the format. To utilize it, import the `xpm` module using `import` function.

Below is an example to parse a list of strings described in XPM format.

```
import(xpm)
foo_xpm = @{"13 13 2 2 0 0",
" c #000000",
"# c #ffffff",
"          #          ",
"          #          ",
"  # # # # # # # # # # ",
"          #          ",
"          #   #       ",
"        # # # # # #   ",
"      #  #  #  #  #   ",
"    #    #    #    #   ",
"  #      #      #      ",
" #        #        #      ",
" #        #        #      ",
" #        #        #      ",
" #        #        #      ",
"  # # #          #      ",
"                # #      ",
"}
img = image('rgba').xpdata(foo_xpm)
```

### 53.1 Extension to image Class

This module extends the `image` class with methods described here.

`image#write@xpm`

`image#write@xpm(stream:stream:w):reduce`

Writes a xpm image to a stream.

`image#xpdata`

`image#xpdata(xpm[:string]):reduce`

Read xpm data from a string list.

## Chapter 54

# yaml Module

The `yaml` module provides measures to read/write YAML files.

### 54.1 Module Function

`yaml.compose`

`yaml.compose(obj)`

`yaml.parse`

`yaml.parse(str:string)`

`yaml.read`

`yaml.read(stream:stream:r)`

`yaml.write`

`yaml.write(stream:stream:w, obj):reduce`

### 54.2 Thanks

This module uses yaml library which is distributed in the following site:  
<http://pyyaml.org/wiki/LibYAML>

# Chapter 55

## zip Module

The `zip` module provides measures to read/write ZIP files. Below is an example to reads entries from an archive file:

```
import(zip)
zip.reader('foo.zip') {|r|
  println(r.entries():*stat:*filename)
}
```

Below is an exapmple to create a ZIP archive file:

```
import(zip)
zip.writer('foo.zip') {|w|
  w.add('file1.txt')
  w.add('file2.txt')
  w.add('file3.txt')
  w.close()
}
```

### 55.1 zip.reader Class

#### 55.1.1 Constructor

zip.reader

`zip.reader(stream:stream:r) {block?}`

Creates `zip.reader` instance from the stream.

#### 55.1.2 Method

zip.reader#entry

`zip.reader#entry(name:string) {block?}`

Seeks entry in the zip file that matches the specified name and returns the stream instance.

zip.reader#entries

`zip.reader#entries() {block?}`

Creates an iterator that returns stream instances for each entry in the ZIP file.

## 55.2 zip.writer Class

### 55.2.1 Constructor

zip.writer

`zip.writer(stream:stream:w, compression?:symbol) {block?}`

Creates `zip.writer` instance from the stream.

Argument `compression` specifies the compression method and takes one of the following symbol.

- 'store
- 'deflate
- 'bzip2

### 55.2.2 Method

zip.writer#add

`zip.writer#add(stream:stream:r, filename?:string, compression?:symbol):map:reduce`

Reads data from `stream` and adds it to the zip file. Entry name is decided by the file name associated with the stream unless it's specified by argument `filename`.

Argument `compression` specifies the compression method and takes one of the following symbol.

- 'store
- 'deflate
- 'bzip2

zip.writer#close

`zip.writer#close():void`

Closes the zip file after flushing cached data.

## 55.3 Thanks

This module uses zlib and bzip2 library which are distributed in the following sites:

- <http://zlib.net/>
- <http://www.bzip.org/>