

# Theme-D Standard Library Reference

Tommi Höynälänmaa

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# Chapter 1

## Introduction

Here is an overview for the modules in the Theme-D standard library:

- Module `core` includes basic functionality of the Theme-D environment and it should generally be always included by the user source code.
- Module `platform-specific-impl` is a platform-dependent module. It implements procedure `raise` and forms `guard-general`, `guard-general-nonpure`, and `guard-general-without-result`.
- Module `core-forms` defines some basic control structures as macros.
- Module `core-forms2` defines some basic control structures that depend on the platform-specific features.
- Module `list-utilities` implements basic list operations.
- Module `string-utilities` implements basic string operations.
- Module `basic-math` defines basic arithmetical operations for integer and real numbers.
- Module `bitwise-arithmetic` implements basic bit operations.
- Module `promise` implements promises (delayed evaluation).
- Module `stream` implements streams.
- Module `iterator` implements purely functional iterators.
- Module `nonpure-iterator` implements nonpure iterators analogous to the pure ones.
- Module `object-string-conversion` implements readable string forms of the Theme-D objects.
- Module `bytevector` implements utilities for bytevectors.
- Module `files` defines primitive classes for input and output ports and operations to open and close them.
- Module `text-file-io` defines basic operations for text file IO.

- Module `binary-file-io` defines basic operations for binary file IO.
- Module `console-io` implements console input and output.
- Module `system` implements some OS level functionality.
- Module `rational` implements rational numbers.
- Module `complex` implements complex numbers.
- Module `real-math` implements operations between real and rational values and real scientific functions.
- Module `math` implements the numerical tower and generic scientific functions. It is a frontend to other mathematical modules.
- Module `extra-math` implements wrapper procedures for many standard C mathematical functions. Some methods using the wrappers are implemented, too.
- Module `posix-math` implements wrapper procedures for some POSIX C mathematical functions not present in the C standard. Some methods using the wrappers are implemented, too.
- Module `matrix` implements matrices.
- Module `bvm-matrix-base` implements matrices using the bytevector IEEE 754 interface.
- Module `bvm-diag-matrix` implements diagonal matrices using the bytevector IEEE 754 interface.
- Module `bvm-matrices` exports both `bvm-matrix-base` and `bvm-diag-matrix`.
- Module `dynamic-list` implements dynamically type checked lists.
- Module `mutable-pair` implements mutable pairs.
- Module `singleton` implements singletons.
- Module `hash-table0` implements hash tables using the guile hash tables.
- Modules `hash-table` and `hash-table-opt` implement hash tables from scratch. Module `hash-table-opt` is slightly more optimized.
- Module `command-line-parser` implements a parser for command line arguments.
- Module `statprof` provides an interface to the guile `statprof` profiler.
- Module `plugins` implements dynamically loaded plugins.
- Module `raw-vector` implements support for Scheme vectors.

Modules `hash-table0`, `extra-math`, and `posix-math` work only for the target platform Guile.

When we document procedures and methods we use the notation

```
proc-name: (arg-type-1 ... arg-type-n) → result-type
```

to indicate that method `method-name` takes arguments of types `arg-type-i` and returns a value of type `result-type`.

When we document methods we use the notation

```
method-name: (arg-type-1 ... arg-type-n) → result-type = procedure
```

that the method is additionally equal to the procedure `procedure`.

The notation

```
method-name: (arg-type-1 ... arg-type-n) → result-type abstract
```

means that the method only raises an exception and its purpose is to help in the static dispatch of the result type. When we document virtual methods we use the notation

```
vgp: (arg-type-1 ... arg-type-n) → result-type (method)
```

to mean that the virtual generic procedure `vgp` includes a normal method `method` with the same signature. We write “pure” in a procedure definition to indicate that the procedure is pure and “static” to indicate that the method is dispatched statically.



## Chapter 2

# Exceptions

Error handling in Theme-D is based on exceptions that resemble Scheme R7RS [2] exceptions. The module `core` in the standard library defines custom primitive class `<condition>`, which represents Scheme exceptions in the runtime target environment. Note that the exceptions do not have to be objects of class `<condition>`. Exceptions are raised with procedure `raise` (or procedures using `raise`). Exception handlers are defined by the following forms:

- `guard`
- `guard-nonpure`,
- `guard-without-result`
- `guard-general`
- `guard-general-nonpure`
- `guard-general-without-result`

See section 7.1 and 5.2 for the guard expressions and 4.1.2 for raise expressions.

The Theme-D runtime environment and standard library create runtime environment (RTE) exceptions. An RTE exception is an object of class `<condition>` having *kind* and *info*. *Kind* is a symbol that defines the kind of the exception. *Info* is an association list containing properties (pairs) with a key (a symbol).

When the exception info is enabled the runtime environment adds some extra information into the exceptions it generates. When a Theme-D program is run the flag is initially `#f` and it is set to `#t` when the main procedure is called. The reason for this behaviour is that the Theme-D objects in the exception info could cause ugly output with the default Guile error handler. When the info is disabled then exceptions raised by the Theme-D runtime environment contain only the exception kind (a symbol). Note that this is not true for the exceptions raised by the Scheme code called by the runtime environment. The exception info can be enabled with procedure `enable-rte-exception-info` and disabled with procedure `disable-rte-exception-info` (section 4.1.2).

A Theme-D program can be terminated with procedures `exit` or `raw-exit` (section 4.1.2). In general, you should normally use Theme-D procedure `exit` unless you exit the program in a toplevel expression in a script.



## Chapter 3

# Numerical Tower

The Theme-D Standard Library implements a numerical tower similar to Scheme. Easiest way to import it is to import module (`standard-library math`). Numerical types `<integer>` and `<real>` are built in the Theme-D language and types `<rational>` and `<complex>` are implemented by the standard library.

We say that a rational number is in the *simplified form* if its denominator is positive and the greatest common divisor between the numerator and the denominator is 1. Additionally we require that if the numerator is 0 the denominator is 1.

Terms NaN, inf, and -inf mean the exceptional floating point values (not a number, positive infinity, and negative infinity) defined by the IEEE 754 standard. If your system does not support these the behaviour of the procedures in case they are specified to return an exceptional value is undefined.

Numbers belonging to classes `<integer>` and `<rational>` are called *exact* and numbers belonging to classes `<real>` and `<complex>` *inexact*. The terms *exact 0* and *exact 1* mean the integer and rational values 0 and 1.

When the results of the real math functions in module `real-math` are complex or not defined these procedures usually return an exceptional value. When the optimized real functions are used (this is on by default) the complex value is not actually computed but the exceptional values are returned directly.

When applied to integer or real numbers the equality predicate `equal?` follows the rules for Scheme predicate `eqv?` in the R7RS standard [2]. The equality predicate `=` follows the rules for Scheme predicate `=` in R7RS for integer and real numbers. Predicate `=` returns `#t` when its arguments are numerically equal.





## Chapter 4

# Module (standard-library core)

### 4.1 Control Structures

#### 4.1.1 Data Types

*Data type name:* <condition>

*Type:* <class>

*Description:* The data type for Scheme conditions

*Data type name:* <rte-exception-kind>

*Type:* <class>

*Description:* The kind of an exception.

*Definition:* <symbol>

*Data type name:* <rte-exception-info>

*Type:* :union

*Description:* Auxiliary information for an exception.

*Definition:* (:alist <symbol> <object>)

#### 4.1.2 Simple Procedures

call-with-current-continuation

call/cc

*Syntax:*

(call-with-current-continuation body )

*Type parameters:* %body-type, %jump-type

*Arguments:*

    Name: body  
    Type: (:procedure ((:procedure (%jump-type) <none> pure)) %body-type  
pure)  
    Description: The procedure to be called

*Result value:* Either the value of the body procedure or a value passed into the  
jump procedure

*Result type:* (:union %body-type %jump-type)

*Purity of the procedure:* pure

This procedure is a built-in parametrized procedure that works as the corresponding procedure in Scheme. The argument **body** is a procedure taking a single procedure argument. If the body procedure invokes this argument the continuation is transferred into the continuation of the **call-with-current-continuation** expression. Variable **call/cc** is defined as an alias to **call-with-current-continuation**.

**call-with-current-continuation-nonpure**

**call/cc-nonpure**

*Syntax:*

(call-with-current-continuation-nonpure body )

*Type parameters:* %body-type, %jump-type

*Arguments:*

    Name: body  
    Type: (:procedure ((:procedure (%jump-type) <none> pure)) %body-type  
nonpure)  
    Description: The procedure to be called

*Result value:* Either the value of the body procedure or a value passed into the  
jump procedure

*Result type:* (:union %body-type %jump-type)

*Purity of the procedure:* nonpure

This is a nonpure version of `call-with-current-continuation`, see the previous section. This procedure has an alias `call/cc-nonpure`.

`call-with-current-continuation-without-result`

`call/cc-without-result`

*Syntax:*

```
(call-with-current-continuation-without-result body )
```

*Arguments:*

Name: `body`

Type: `(:procedure ((:procedure () <none> pure)) <none> nonpure)`

Description: The procedure to be called

No result value.

*Purity of the procedure:* nonpure

This is a version of `call-with-current-continuation` having no result value. This procedure has an alias `call/cc-without-result`.

`exit`

*Syntax:*

```
(exit exit-code)
```

*Arguments:*

Name: `exit-code`

Type: `<integer>`

Description: The exit code passed to the operating system

No result value.

*Purity of the procedure:* nonpure

Procedure `exit` terminates a program. The exit code given as an argument

is passed to the operating system. This procedure actually rows an RTE exception with kind `exit` and property `i-exit-code` containing the exit code. The Theme-D main program exception handler terminates the program with the exit code when it receives this exception.

## `raw-exit`

*Syntax:*

```
(raw-exit exit-code)
```

*Arguments:*

Name: `exit-code`

Type: `<integer>`

Description: The exit code passed to the operating system

No result value.

*Purity of the procedure:* nonpure

This procedure calls the Guile procedure `exit` in order to terminate the program. In general, you should normally use Theme-D procedure `exit` unless you exit the program in a toplevel expression in a script.

## `enable-rte-exception-info`

*Syntax:*

```
(enable-rte-exception-info)
```

No arguments.

No result value.

*Purity of the procedure:* pure

This procedure sets the exception info flag on. See chapter 2.

## `disable-rte-exception-info`

*Syntax:*

```
(disable-rte-exception-info)
```

No arguments.

No result value.

*Purity of the procedure:* pure

This procedure sets the exception info flag off. See chapter 2.

## make-rte-exception

*Syntax:*

```
(make-rte-exception s-kind al-info)
```

*Arguments:*

Name: `s-kind`

Type: `<rte-exception-kind>`

Description: The kind of the exception

Name: `al-info`

Type: `<rte-exception-info>`

Description: Auxiliary information for the exception

*Result value:* An exception object

*Result type:* `<condition>`

*Purity of the procedure:* pure

## rte-exception?

*Syntax:*

```
(rte-exception? x)
```

*Arguments:*

Name: `x`

Type: `<object>`

Description: An object

*Result value:* `#t` iff the object is an RTE exception

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## get-rte-exception-kind0

*Syntax:*

```
(get-rte-exception-kind0 exc)
```

*Arguments:*

Name: `exc`

Type: `<condition>`

Description: A condition object

*Result value:* The kind of the RTE exception

*Result type:* `(:alt-maybe <rte-exception-kind>)`

*Purity of the procedure:* pure

This procedure returns `#f` if the argument is not a RTE exception.

## get-rte-exception-kind

*Syntax:*

```
(get-rte-exception-kind exc)
```

*Arguments:*

Name: `exc`

Type: `<condition>`

Description: An RTE exception

*Precondition:* The argument has to be a RTE exception.

*Result value:* The kind of the RTE exception

*Result type:* `<rte-exception-kind>`

*Purity of the procedure:* pure

## get-rte-exception-info0

*Syntax:*

```
(get-rte-exception-info0 exc)
```

*Arguments:*

Name: `exc`  
Type: `<condition>`  
Description: A condition object

*Result value:* The RTE exception auxiliary info

*Result type:* `(:alt-maybe <rte-exception-info>)`

*Purity of the procedure:* pure

This procedure returns `#f` if the argument is not a RTE exception.

## get-rte-exception-info

*Syntax:*

```
(get-rte-exception-info exc)
```

*Arguments:*

Name: `exc`  
Type: `<condition>`  
Description: An RTE exception

*Precondition:* The argument has to be a RTE exception.

*Result value:* The RTE exception info

*Result type:* `<rte-exception-info>`

*Purity of the procedure:* pure

## make-simple-exception

*Syntax:*

```
(make-simple-exception s-kind)
```

*Arguments:*

Name: `s-kind`  
Type: `<symbol>`  
Description: The kind of the exception

*Result value:* An RTE exception object

*Result type:* `<condition>`

*Purity of the procedure:* pure

The result is an RTE exception object whose kind is the value of the argument and info is `null`.

## raise-simple

*Syntax:*

```
(raise-simple s-kind)
```

*Arguments:*

Name: `s-kind`  
Type: `<symbol>`  
Description: The kind of the exception

No result value.

*Purity of the procedure:* pure

This procedure raises a simple exception and the procedure never returns. The exception is created with procedure `make-simple-exception`.

## make-numerical-overflow

*Syntax:*



```
(make-numerical-overflow s-procedure)
```

*Arguments:*

Name: **s-procedure**

Type: **<symbol>**

Description: The name of the procedure from which the exception is raised

*Result value:* An RTE exception object

*Result type:* **<condition>**

*Purity of the procedure:* pure

The result is an RTE exception object whose kind is **numerical-overflow** and the value corresponding to key **s-proc-name** is the value the argument **s-procedure**.

## **\_debug-print**

*Syntax:*

```
(_debug-print x-message)
```

*Arguments:*

Name: **x-message**

Type: **<object>**

Description: The object to be printed

No result value.

*Purity of the procedure:* nonpure

This procedure prints the argument with Scheme procedure **display** and flushes the ports. This procedure may be called body and program toplevel without prelinking any module bodies.

## **raise-numerical-overflow**

*Syntax:*

```
(raise-numerical-overflow s-procedure)
```

*Arguments:*

Name: **s-procedure**

Type: **<symbol>**

Description: The name of the procedure from which the exception is raised

No result value.

*Purity of the procedure:* pure

This procedure raises a numerical overflow exception and the procedure never returns.

## 4.2 Command Line

### 4.2.1 Simple Procedures

**command-line-arguments**

*Syntax:*

**(command-line-arguments)**

No arguments.

*Result value:* List of command line arguments

*Result type:* **(:uniform-list <string>)**

*Purity of the procedure:* pure

## 4.3 Equality Predicates

The main equality predicate in Theme-D is the generic procedure **equal?**.

### 4.3.1 Simple Procedures

**boolean=?**

*Syntax:*

(boolean=? object1 object2)

*Arguments:*

Name: object1  
Type: <boolean>  
Description: A boolean value to be compared

Name: object2  
Type: <boolean>  
Description: A boolean value to be compared

*Result value:* #t iff object1 is equal to object2

*Result type:* <boolean>

*Purity of the procedure:* pure

character=?

*Syntax:*

(character=? object1 object2)

*Arguments:*

Name: object1  
Type: <character>  
Description: A character to be compared

Name: object2  
Type: <character>  
Description: A character to be compared

*Result value:* #t iff object1 is equal to object2

*Result type:* <boolean>

*Purity of the procedure:* pure

eq?

*Syntax:*

```
(eq? object1 object2)
```

*Arguments:*

Name: `object1`  
Type: `<object>`  
Description: An object to be compared

Name: `object2`  
Type: `<object>`  
Description: An object to be compared

*Result value:* `#t` iff `object1` and `object2` are the same object

*Result type:* `<boolean>`

*Purity of the procedure:* pure

This procedure calls the Scheme procedure `eq?`. See references [3] and [2] for more information.

## `integer=?`

*Syntax:*

```
(integer=? object1 object2)
```

*Arguments:*

Name: `object1`  
Type: `<integer>`  
Description: An integer value to be compared

Name: `object2`  
Type: `<integer>`  
Description: An integer value to be compared

*Result value:* `#t` iff `object1` is equal to `object2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## `integer=`

*Syntax:*

```
(integer= object1 object2)
```

*Arguments:*

Name: `object1`  
 Type: `<integer>`  
 Description: An integer value to be compared

Name: `object2`  
 Type: `<integer>`  
 Description: An integer value to be compared

*Result value:* `#t` iff `object1` is numerically equal to `object2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## integer-real=

*Syntax:*

```
(integer-real= object1 object2)
```

*Arguments:*

Name: `object1`  
 Type: `<integer>`  
 Description: An integer value to be compared

Name: `object2`  
 Type: `<real>`  
 Description: A real value to be compared

*Result value:* `#t` iff `object1` is numerically equal to `object2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## keyword=?

*Syntax:*

```
(keyword=? object1 object2)
```

*Arguments:*

Name: `object1`  
 Type: `<keyword>`  
 Description: A keyword to be compared

Name: `object2`  
 Type: `<keyword>`  
 Description: A keyword to be compared

*Result value:* `#t` iff `object1` is equal to `object2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**real=?**

*Syntax:*

```
(real=? object1 object2)
```

*Arguments:*

Name: `object1`  
 Type: `<real>`  
 Description: A real value to be compared

Name: `object2`  
 Type: `<real>`  
 Description: A real value to be compared

*Result value:* `#t` iff `object1` is equal to `object2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**real=**

*Syntax:*

```
(real= object1 object2)
```

*Arguments:*

Name: `object1`  
 Type: `<real>`  
 Description: A real value to be compared

Name: `object2`  
 Type: `<real>`  
 Description: A real value to be compared

*Result value:* `#t` iff `object1` is numerically equal to `object2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## real-integer=

*Syntax:*

```
(real-integer= object1 object2)
```

*Arguments:*

Name: `object1`  
 Type: `<real>`  
 Description: A real value to be compared

Name: `object2`  
 Type: `<integer>`  
 Description: An integer value to be compared

*Result value:* `#t` iff `object1` is numerically equal to `object2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## string=?

*Syntax:*

```
(string=? object1 object2)
```

*Arguments:*

Name: `object1`  
Type: `<string>`  
Description: A string to be compared

Name: `object2`  
Type: `<string>`  
Description: A string to be compared

*Result value:* `#t` iff `object1` is equal to `object2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

This procedure compares the contents of the argument strings.

**symbol=?**

*Syntax:*

```
(symbol=? object1 object2)
```

*Arguments:*

Name: `object1`  
Type: `<symbol>`  
Description: A symbol to be compared

Name: `object2`  
Type: `<symbol>`  
Description: A symbol to be compared

*Result value:* `#t` iff `object1` is equal to `object2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure



### 4.3.2 Virtual Methods

```

equal?: (<object> <object>) → <boolean> pure    =    equal-values?
equal?: (<boolean> <boolean>) → <boolean> pure    =    boolean=?
equal?: (<integer> <integer>) → <boolean> pure    =    integer=?
equal?: (<real> <real>) → <boolean> pure    =    real=?
equal?: (<symbol> <symbol>) → <boolean> pure    =    symbol=?
equal?: (<string> <string>) → <boolean> pure    =    string=?
equal?: (<character> <character>) → <boolean> pure    =    character=?
equal?: (<keyword> <keyword>) → <boolean> pure    =    keyword=?
equal?: (<null> <null>) → <boolean> pure

```

```

equal?: (<boolean> <object>) → <boolean>    static pure
equal?: (<object> <boolean>) → <boolean>    static pure
equal?: (<integer> <object>) → <boolean>    static pure
equal?: (<object> <integer>) → <boolean>    static pure
equal?: (<real> <object>) → <boolean>    static pure
equal?: (<object> <real>) → <boolean>    static pure
equal?: (<symbol> <object>) → <boolean>    static pure
equal?: (<object> <symbol>) → <boolean>    static pure
equal?: (<string> <object>) → <boolean>    static pure
equal?: (<object> <string>) → <boolean>    static pure
equal?: (<character> <object>) → <boolean>    static pure
equal?: (<object> <character>) → <boolean>    static pure
equal?: (<keyword> <object>) → <boolean>    static pure
equal?: (<object> <keyword>) → <boolean>    static pure
equal?: (<null> <object>) → <boolean>    static pure
equal?: (<object> <null>) → <boolean>    static pure

```

```

=: (<integer> <integer>) → <boolean> pure    =    integer=
=: (<real> <real>) → <boolean> pure    =    real=
=: (<integer> <real>) → <boolean> pure    =    integer-real=
=: (<real> <integer>) → <boolean> pure    =    real-integer=

```

The static `equal?` methods ensure that equality checks involving primitive types are optimized to use Scheme procedures `eq?` and `eqv?`, except `<string>` for which Scheme procedure `equal?` is used.

## 4.4 Class Membership Predicates

### 4.4.1 Data Types

*Data type name:* <type-predicate>

*Type:* :procedure

*Description:* The data type for type membership predicates

### 4.4.2 Simple Procedures

#### boolean?

*Syntax:*

(boolean? object)

*Arguments:*

Name: object  
Type: <object>  
Description: An object to be tested

*Result value:* #t iff object is an instance of <boolean>

*Result type:* <boolean>

*Purity of the procedure:* pure

#### character?

*Syntax:*

(character? object)

*Arguments:*

Name: object  
Type: <object>  
Description: An object to be tested

*Result value:* #t iff object is an instance of <character>

*Result type:* <boolean>

*Purity of the procedure:* pure

#### integer?

*Syntax:*

`(integer? object)`

*Arguments:*

Name: `object`  
Type: `<object>`  
Description: An object to be tested

*Result value:* `#t` iff `object` is an instance of `<integer>`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**`null?`**

*Syntax:*

`(null? object)`

*Arguments:*

Name: `object`  
Type: `<object>`  
Description: An object to test

*Result value:* `#t` iff `object` is null

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**`not-null?`**

*Syntax:*

`(not-null? object)`

*Arguments:*

Name: `object`  
Type: `<object>`

Description: An object to test

*Result value:* `#t` iff `object` is not null

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## pair?

*Syntax:*

`(pair? object)`

*Arguments:*

Name: `object`

Type: `<object>`

Description: An object to be tested

*Result value:* `#t` iff `object` is an instance of `<pair>`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

This procedure returns `#t` for any pair.

## real?

*Syntax:*

`(real? object)`

*Arguments:*

Name: `object`

Type: `<object>`

Description: An object to be tested

*Result value:* `#t` iff `object` is an instance of `<real>`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**string?***Syntax:*`(string? object)`*Arguments:*

Name: `object`  
 Type: `<object>`  
 Description: An object to be tested

*Result value:* `#t` iff `object` is an instance of `<string>`*Result type:* `<boolean>`*Purity of the procedure:* pure**symbol?***Syntax:*`(symbol? object)`*Arguments:*

Name: `object`  
 Type: `<object>`  
 Description: An object to be tested

*Result value:* `#t` iff `object` is an instance of `<symbol>`*Result type:* `<boolean>`*Purity of the procedure:* pure**4.5 Lists, Tuples, and Pairs****4.5.1 Data Types***Data type name:* `:alist`*Type:* `<param-logical-type>`*Number of type parameters:* 2*Description:* An association list

*Data type name:* `:nonempty-alist`  
*Type:* `<param-logical-type>`  
*Number of type parameters:* 2  
*Description:* An association list containing at least one element  
*Data type name:* `:maybe`  
*Type:* `<param-logical-type>`  
*Number of type parameters:* 1  
*Description:* A value that is either `null` or an instance of the component type  
*Data type name:* `:alt-maybe`  
*Type:* `<param-logical-type>`  
*Number of type parameters:* 1  
*Description:* A value that is either `<boolean>` or an instance of the component type. Usually the value is not allowed to be `#t`.  
*Data type name:* `:nonempty-uniform-list`  
*Type:* `<param-logical-type>`  
*Number of type parameters:* 1  
*Description:* A uniform list with at least one element  
*Data type name:* `<list>`  
*Type:* `:union`  
*Description:* A list consisting of any objects  
*Data type name:* `<nonempty-list>`  
*Type:* `:pair`  
*Description:* A nonempty list consisting of any objects  
*Data type name:* `<pair>`  
*Type:* `:pair`  
*Description:* A pair consisting of any objects

### 4.5.2 Parametrized Procedures

**car**

*Syntax:*

`(car pair)`

*Type parameters:* `%type1`, `%type2`

*Arguments:*

Name: `pair`  
 Type: `(:pair %type1 %type2)`  
 Description: A pair

*Result value:* The first element of the pair

*Result type:* `%type1`

*Purity of the procedure:* pure

## cdr

*Syntax:*

```
(cdr pair)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: pair  
Type: (:pair %type1 %type2)  
Description: A pair

*Result value:* The second element of the pair

*Result type:* %type2

*Purity of the procedure:* pure

## gen-car

*Syntax:*

```
(gen-car pair)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: pair  
Type: (:union (:pair %type1 %type2) <null>)  
Description: A pair

*Result value:* The first element of the pair

*Result type:* %type1

*Purity of the procedure:* pure

If the argument is `null` an exception is raised.

## gen-cdr

*Syntax:*

```
(gen-cdr pair)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `pair`  
Type: `(:union (:pair %type1 %type2) <null>)`  
Description: A pair

*Result value:* The second element of the pair

*Result type:* %type2

*Purity of the procedure:* pure

If the argument is `null` an exception is raised.

## cons

*Syntax:*

```
(cons first second)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `first`  
Type: %type1  
Description: The first object of the new pair

Name: `second`  
Type: %type2  
Description: The second object of the new pair

*Result value:* A pair with values `first` and `second`

*Result type:* `(:pair %type1 %type2)`

*Purity of the procedure:* pure



**list***Syntax:*

```
(list item-1 ... item-n)
```

*Type parameters:* %arglist*Arguments:*

Name: item-k

Type:  $t_k$ 

Description: A list item

*Result value:* A list constructed from the arguments*Result type:* %arglist*Purity of the procedure:* pure

Metavariable  $t_k$  is the type of item-k for each  $k$ .. Type variable %arglist is equivalent to (:tuple  $t_1$  ...  $t_n$ ).

**member?***Syntax:*

```
(member? object lst)
```

*Type parameters:* %type*Arguments:*

Name: object

Type: %type

Description: the object to be searched

Name: lst

Type: (:uniform-list %type)

Description: the list to be searched

*Result value:* Result of the search*Result type:* <boolean>*Purity of the procedure:* pure

The list `lst` is searched for `object`. If `object` is found return `#t`. Otherwise return `#f`. The list items are compared with the equivalence predicate `equal?`.

## 4.6 Logical Operations

### 4.6.1 Simple Procedures

`not`

*Syntax:*

```
(not boolean-value)
```

*Arguments:*

Name: `boolean-value`  
 Type: `<boolean>`  
 Description: A boolean value

*Result value:* `#t` iff the value of `boolean-value` is `#f`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`not-false?`

*Syntax:*

```
(not-false? x)
```

*Arguments:*

Name: `x`  
 Type: `<boolean>`  
 Description: Any value

*Result value:* `#t` iff the value of `boolean-value` is not `#f`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**not-object***Syntax:*

```
(not-object obj)
```

*Arguments:*

Name: `obj`  
Type: `<object>`  
Description: Any object

*Result value:* `#t` iff `obj` is false, `#f` otherwise*Result type:* `<boolean>`*Purity of the procedure:* pure**xor***Syntax:*

```
(xor boolean-value1 boolean-value2)
```

*Arguments:*

Name: `boolean-value1`  
Type: `<boolean>`  
Description: A boolean value

Name: `boolean-value2`  
Type: `<boolean>`  
Description: A boolean value

*Result value:* `#t` iff exactly one of the values `boolean-value1` and `boolean-value2` is `#t`*Result type:* `<boolean>`*Purity of the procedure:* pure

## 4.7 Vectors

### 4.7.1 Parametrized Procedures

#### mutable-value-vector-length

*Syntax:*

```
(mutable-value-vector-length vec)
```

*Type parameters:* %type

*Arguments:*

Name: `vec`  
Type: `(:mutable-value-vector %type)`  
Description: A vector

*Result value:* Length of the vector `vec`

*Result type:* `<integer>`

*Purity of the procedure:* pure

#### mutable-value-vector-ref

*Syntax:*

```
(mutable-value-vector-ref vec index)
```

*Type parameters:* %type

*Arguments:*

Name: `vec`  
Type: `(:mutable-value-vector %type)`  
Description: A vector

Name: `index`  
Type: `<integer>`  
Description: Index to the vector

*Result value:* Element of vector `vec` at the position `index`

*Result type:* `%type`

*Purity of the procedure:* pure

## `mutable-value-vector-set!`

*Syntax:*

```
(mutable-value-vector-set!  vec index element)
```

*Type parameters:* `%type`

*Arguments:*

Name: `vec`  
Type: `(:mutable-value-vector %type)`  
Description: A vector

Name: `index`  
Type: `<integer>`  
Description: Index to the vector

Name: `element`  
Type: `%type`  
Description: The new value of the element

No result value.

*Purity of the procedure:* nonpure

## `mutable-vector-length`

*Syntax:*

```
(mutable-vector-length vec)
```

*Type parameters:* `%type`

*Arguments:*

Name: `vec`  
Type: `(:mutable-vector %type)`  
Description: A vector

*Result value:* Length of the vector `vec`  
*Result type:* `<integer>`

*Purity of the procedure:* pure

## `mutable-vector-ref`

*Syntax:*

```
(mutable-vector-ref vec index)
```

*Type parameters:* `%type`

*Arguments:*

Name: `vec`  
Type: `(:mutable-vector %type)`  
Description: A vector

Name: `index`  
Type: `<integer>`  
Description: Index to the vector

*Result value:* Element of vector `vec` at the position `index`  
*Result type:* `%type`

*Purity of the procedure:* pure

## `mutable-vector-set!`

*Syntax:*

```
(mutable-vector-set! vec index element)
```

*Type parameters:* `%type`

*Arguments:*

Name: `vec`  
Type: `(:mutable-vector %type)`  
Description: A vector

Name: `index`  
Type: `<integer>`  
Description: Index to the vector

Name: `element`  
Type: `%type`  
Description: The new value of the element

No result value.

*Purity of the procedure:* nonpure

## value-vector-length

*Syntax:*

```
(value-vector-length vec)
```

*Type parameters:* `%type`

*Arguments:*

Name: `vec`  
Type: `(:value-vector %type)`  
Description: A vector

*Result value:* Length of the vector `vec`

*Result type:* `<integer>`

*Purity of the procedure:* pure

## value-vector-ref

*Syntax:*

```
(value-vector-ref vec index)
```

*Type parameters:* %type

*Arguments:*

Name: `vec`  
Type: `(:value-vector %type)`  
Description: A vector

Name: `index`  
Type: `<integer>`  
Description: Index to the vector

*Result value:* Element of vector `vec` at the position `index`

*Result type:* %type

*Purity of the procedure:* pure

## vector-length

*Syntax:*

`(vector-length vec)`

*Type parameters:* %type

*Arguments:*

Name: `vec`  
Type: `(:vector %type)`  
Description: A vector

*Result value:* Length of the vector `vec`

*Result type:* `<integer>`

*Purity of the procedure:* pure

## vector-ref

*Syntax:*

`(vector-ref vec index)`



*Type parameters:* %type

*Arguments:*

Name: `vec`  
 Type: `(:vector %type)`  
 Description: A vector

Name: `index`  
 Type: `<integer>`  
 Description: Index to the vector

*Result value:* Element of vector `vec` at the position `index`

*Result type:* %type

*Purity of the procedure:* pure

## 4.8 Arithmetic Operations

### 4.8.1 Simple Procedures

#### `integer+`

*Syntax:*

`(integer+ int1 int2)`

*Arguments:*

Name: `int1`  
 Type: `<integer>`  
 Description: An integer value

Name: `int2`  
 Type: `<integer>`  
 Description: An integer value

*Result value:* The sum of the arguments

*Result type:* `<integer>`

*Purity of the procedure:* pure

## `integer-`

*Syntax:*

```
(integer- int1 int2)
```

*Arguments:*

Name: `int1`  
Type: `<integer>`  
Description: An integer value

Name: `int2`  
Type: `<integer>`  
Description: An integer value

*Result value:* The difference of the arguments

*Result type:* `<integer>`

*Purity of the procedure:* pure

## `integer*`

*Syntax:*

```
(integer* int1 int2)
```

*Arguments:*

Name: `int1`  
Type: `<integer>`  
Description: An integer value

Name: `int2`  
Type: `<integer>`  
Description: An integer value

*Result value:* The product of the arguments

*Result type:* `<integer>`

*Purity of the procedure:* pure

**integer<***Syntax:*

```
(integer< int1 int2)
```

*Arguments:*

Name: `int1`  
Type: `<integer>`  
Description: An integer value

Name: `int2`  
Type: `<integer>`  
Description: An integer value

*Result value:* `#t` iff `int1 < int2`*Result type:* `<boolean>`*Purity of the procedure:* pure**integer>***Syntax:*

```
(integer> int1 int2)
```

*Arguments:*

Name: `int1`  
Type: `<integer>`  
Description: An integer value

Name: `int2`  
Type: `<integer>`  
Description: An integer value

*Result value:* `#t` iff `int1 > int2`*Result type:* `<boolean>`*Purity of the procedure:* pure

**integer>=**

*Syntax:*

`(integer>= int1 int2)`

*Arguments:*

Name: `int1`  
Type: `<integer>`  
Description: An integer value

Name: `int2`  
Type: `<integer>`  
Description: An integer value

*Result value:* `#t` iff  $\text{int1} \geq \text{int2}$

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**integer<=**

*Syntax:*

`(integer<= int1 int2)`

*Arguments:*

Name: `int1`  
Type: `<integer>`  
Description: An integer value

Name: `int2`  
Type: `<integer>`  
Description: An integer value

*Result value:* `#t` iff  $\text{int1} \leq \text{int2}$

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**i-neg**

*Syntax:*

`(i-neg n)`

*Arguments:*

Name: `n`  
Type: `<integer>`  
Description: An integer number

*Result value:* The opposite number of the argument

*Result type:* `<integer>`

*Purity of the procedure:* pure

**integer-real+**

*Syntax:*

`(integer-real+ i r)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The sum of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

**integer-real-**

*Syntax:*

`(integer-real- i r)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The difference of the arguments

*Result type:* `<integer>`

*Purity of the procedure:* pure

`integer-real*`

*Syntax:*

`(integer-real* i r)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The product of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

`integer-real/`

*Syntax:*

`(integer-real/ i r)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The quotient of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

`integer-real<`

*Syntax:*

`(integer-real< i r)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* `#t` iff `i < r`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`integer-real<=`

*Syntax:*

`(integer-real<= i r)`

*Arguments:*

Name: `i`  
 Type: `<integer>`  
 Description: An integer value

Name: `r`  
 Type: `<real>`  
 Description: A real value

*Result value:* `#t` iff `i <= r`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`integer-real>`

*Syntax:*

`(integer-real> i r)`

*Arguments:*

Name: `i`  
 Type: `<integer>`  
 Description: An integer value

Name: `r`  
 Type: `<real>`  
 Description: A real value

*Result value:* `#t` iff `i > r`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`integer-real>=`

*Syntax:*



`(integer-real>= i r)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* `#t` iff `i >= r`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## **r-neg**

*Syntax:*

`(r-neg r)`

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real number

*Result value:* The opposite number of the argument

*Result type:* `<real>`

*Purity of the procedure:* pure

## **real+**

*Syntax:*

`(real+ real1 real2)`

*Arguments:*

Name: `real1`  
Type: `<real>`  
Description: A real value

Name: `real2`  
Type: `<real>`  
Description: A real value

*Result value:* The sum of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

**real-**

*Syntax:*

`(real- real1 real2)`

*Arguments:*

Name: `real1`  
Type: `<real>`  
Description: A real value

Name: `real2`  
Type: `<real>`  
Description: A real value

*Result value:* The difference of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

**real\***

*Syntax:*

`(real* real1 real2)`

*Arguments:*

Name: `real1`  
Type: `<real>`  
Description: A real value

Name: `real2`  
Type: `<real>`  
Description: A real value

*Result value:* The product of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

**real/**

*Syntax:*

`(real/ real1 real2)`

*Arguments:*

Name: `real1`  
Type: `<real>`  
Description: A real value

Name: `real2`  
Type: `<real>`  
Description: A real value

*Result value:* The quotient of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

**real<**

*Syntax:*

`(real< real1 real2)`

*Arguments:*

Name: `real1`  
Type: `<real>`  
Description: A real value

Name: `real2`  
Type: `<real>`  
Description: A real value

*Result value:* `#t` iff `real1 < real2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`real>`

*Syntax:*

`(real> real1 real2)`

*Arguments:*

Name: `real1`  
Type: `<real>`  
Description: A real value

Name: `real2`  
Type: `<real>`  
Description: A real value

*Result value:* `#t` iff `real1 > real2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`real<=`

*Syntax:*

`(real<= real1 real2)`

*Arguments:*

Name: `real1`  
Type: `<real>`  
Description: A real value

Name: `real2`  
Type: `<real>`  
Description: A real value

*Result value:* `#t` iff `real1 ≤ real2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**`real>=`**

*Syntax:*

`(real>= real1 real2)`

*Arguments:*

Name: `real1`  
Type: `<real>`  
Description: A real value

Name: `real2`  
Type: `<real>`  
Description: A real value

*Result value:* `#t` iff `real1 ≥ real2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**`real->integer`**

*Syntax:*

`(real->integer r)`

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: An integer value of type `<real>`

*Result value:* The real value converted to an integer value of type `<integer>`

*Result type:* `<integer>`

*Purity of the procedure:* pure

If `r` is not an integer value (xxx.0) an exception is raised.

## `real-integer+`

*Syntax:*

`(real-integer+ r i)`

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The sum of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

## `real-integer-`

*Syntax:*

`(real-integer- r i)`

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The difference of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

## `real-integer*`

*Syntax:*

```
(real-integer* r i)
```

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The product of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

## `real-integer/`

*Syntax:*

```
(real-integer/ r i)
```

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The quotient of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

**real-integer<**

*Syntax:*

`(real-integer< r i)`

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* `#t` iff `r < i`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**real-integer<=**

*Syntax:*

`(real-integer<= r i)`



*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* `#t` iff `r <= i`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`real-integer>`

*Syntax:*

`(real-integer> r i)`

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* `#t` iff `r > i`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`real-integer>=`

*Syntax:*

`(real-integer>= r i)`

*Arguments:*

Name: `r`  
 Type: `<real>`  
 Description: A real value

Name: `i`  
 Type: `<integer>`  
 Description: An integer value

*Result value:* `#t` iff `r >= i`  
*Result type:* `<boolean>`

*Purity of the procedure:* pure

## 4.8.2 Virtual Methods

```

+: (<integer> <integer>) → <integer> pure  =  integer+
+: (<integer> <real>) → <real> pure  =  integer-real+
+: (<real> <integer>) → <real> pure  =  real-integer+
+: (<real> <real>) → <real> pure  =  real+

-: (<integer> <integer>) → <integer> pure  =  integer-
-: (<integer> <real>) → <real> pure  =  integer-real-
-: (<real> <integer>) → <real> pure  =  real-integer-
-: (<real> <real>) → <real> pure  =  real-

*: (<integer> <integer>) → <integer> pure  =  integer*
*: (<integer> <real>) → <real> pure  =  integer-real*
*: (<real> <integer>) → <real> pure  =  real-integer*
*: (<real> <real>) → <real> pure  =  real*

/: (<integer> <real>) → <real> pure  =  integer-real/
/: (<real> <integer>) → <real> pure  =  real-integer/
/: (<real> <real>) → <real> pure  =  real/

```

Note that division `/` between two integers is not defined in the core module as its result is a rational number.

```

<: (<integer> <integer>) → <boolean> pure  =  integer<
<: (<integer> <real>) → <boolean> pure  =  integer-real<
<: (<real> <integer>) → <boolean> pure  =  real-integer<
<: (<real> <real>) → <boolean> pure  =  real<

<=: (<integer> <integer>) → <boolean> pure  =  integer<=
<=: (<integer> <real>) → <boolean> pure  =  integer-real<=
<=: (<real> <integer>) → <boolean> pure  =  real-integer<=
<=: (<real> <real>) → <boolean> pure  =  real<=

```

```

>: (<integer> <integer>) → <boolean> pure   =   integer>
>: (<integer> <real>) → <boolean> pure   =   integer-real>
>: (<real> <integer>) → <boolean> pure   =   real-integer>
>: (<real> <real>) → <boolean> pure   =   real>

>=: (<integer> <integer>) → <boolean> pure   =   integer>=
>=: (<integer> <real>) → <boolean> pure   =   integer-real>=
>=: (<real> <integer>) → <boolean> pure   =   real-integer>=
>=: (<real> <real>) → <boolean> pure   =   real>=

-: (<integer>) → <integer> pure   =   i-neg
-: (<real>) → <real> pure   =   r-neg

```

## 4.9 Other

### 4.9.1 Data Types

*Data type name:* `:unary-predicate`  
*Type:* parametrized procedure class  
*Description:* Unary predicate

*Data type name:* `:binary-predicate`  
*Type:* parametrized procedure class  
*Description:* Binary predicate

### 4.9.2 Simple Procedures

#### keyword->symbol

*Syntax:*

```
(keyword->symbol kw)
```

*Arguments:*

Name: `kw`  
Type: `<keyword>`  
Description: A keyword

*Result value:* The symbol corresponding to the keyword

*Result type:* `<symbol>`

*Purity of the procedure:* pure

Note that the returned symbol does not contain the prefix `#:`.

**symbol->keyword***Syntax:*

```
(symbol->keyword s)
```

*Arguments:*

Name: **s**  
Type: **<symbol>**  
Description: A symbol

*Result value:* The keyword corresponding to the symbol*Result type:* **<keyword>***Purity of the procedure:* pure

Note that the prefix **#:** is appended to the result.

**4.9.3 Parametrized Procedures****identity***Syntax:*

```
(identity x)
```

*Type parameters:* **%type***Arguments:*

Name: **x**  
Type: **%type**  
Description: an object

*Result value:* The argument object*Result type:* **%type***Purity of the procedure:* pure

## Chapter 5

# Module (standard-library platform-specific-impl)

### 5.1 Simple Procedures

**raise**

*Syntax:*

```
(raise exception-object)
```

*Arguments:*

Name: **exception-object**  
Type: <object>  
Description: The exception object to be raised

No result value.

*Purity of the procedure:* pure

Procedure **raise** raises an exception. Exceptions can be caught with **guard-general** and **guard** forms, see the language manual and section 7.1 in this guide. The semantics of **guard** and **raise** are similar to their semantics in Scheme.

**object-address**

*Syntax:*

(object-address object)

*Arguments:*

Name: object  
 Type: <object>  
 Description: An object

*Result value:* The memory address of the argument object

*Result type:* <integer>

*Purity of the procedure:* pure

## 5.2 Macros

### guard-general

*Syntax:*

(**guard-general** *variable-name exception-handler body* )

*variable-name* ::= identifier

Form **guard-general** evaluates the expression *body*. If an exception is raised the variable *variable-name* is bound to the exception object and expression *exception-handler* is evaluated and its value is the value of the **guard-general** expression. If no exception is raised during the evaluation of the body its value is returned as the value of the **guard-general** expression. Note that the exception handler may itself raise exceptions in which case the surrounding exception handler evaluates them. Both the exception handler and body must be pure expressions. Their types may not be <none>. The exception handler must never return.

### guard-general-nonpure

This form is like **guard-general** except that the body and exception handler may be nonpure.

### guard-general-without-result

This form is like **guard-general** except that the result type of the body and

exception handler may be `<none>` and the type of the form is `<none>`, too.





## Chapter 6

# Module (standard-library core-forms)

### 6.1 Macros

#### **with-syntax**

See [3].

#### **syntax-rules**

See [3].

#### **identifier-syntax**

See [3].

#### **quasiquote**

See [3].

#### **quasisyntax**

See [3].

## apply

*Syntax:*

```
(apply proc arglist )
(apply proc arg1 ... argn arglist )
proc ::=expression
arglist ::=expression
argk ::=expression
```

The semantics of this form is similar to procedure `apply` in Scheme [3]. In the first form, procedure *proc* is called with arguments from *arglist*. In the second form, procedure *proc* is called with argument list obtained by concatenating list (*arg<sub>1</sub> ... arg<sub>n</sub>*) and *arglist*, although the actual argument list computation is not done this way. Procedure *proc* has to be a pure procedure.

## apply-nonpure

*Syntax:*

```
(apply-nonpure proc arglist )
(apply-nonpure proc arg1 ... argn arglist )
proc ::=expression
arglist ::=expression
argk ::=expression
```

This form is similar to **apply** except the argument procedure does not have to be pure.

## cond

*Syntax:*

```
(cond [clause-list] [else-clause] )

clause-list ::=clause1, ..., clausen
clausek ::=(conditionk exprk,1, ..., exprk,m(k) )
else-clause ::=(else else-expr1, ..., else-exprp )
```

Each condition must have type `<boolean>`. The type of each *clause<sub>k</sub>* is the type of *expr<sub>k,m(k)</sub>* (the last expression in the clause). If *else-clause* is present its type is the type of *else-expr<sub>p</sub>* (the last expression in the else clause). If *else-expression* is defined the type of the **cond** expression is the union of the types of each clause and the type of the *else-clause*. Otherwise the type of the **cond** expression is `<none>`.

Each  $condition_k$  is evaluated in order until some of them returns **#t**. When some  $condition_k$  returns **#t** the expressions  $expr_{k,1}, \dots, expr_{k,m(k)}$  are evaluated in order. If the result type of the **cond** expression is not **<none>** the value of the last expression  $expr_{k,m(k)}$  is returned as the value of the **cond** expression. If none of the conditions return **#t** and *else-clause* is present the expressions  $else-expr_1, \dots, else-expr_p$  are evaluated in order. If the result type of the **cond** expression is not **<none>** the value of the last expression  $else-expr_p$  is returned as the value of the **cond** expression.

## and

*Syntax:*

(**and**  $arg_1 \dots arg_n$  )

The type of each  $arg_k$  has to be **<boolean>**. The arguments are evaluated in order until some of the arguments returns **#f**. If all of the arguments return **#t** the result of the **and** expression is **#t**. Otherwise the result value is **#f**. Note that all of the arguments are not necessarily evaluated at all.

## or

*Syntax:*

(**or**  $arg_1 \dots arg_n$  )

The type of each  $arg_k$  has to be **<boolean>**. The arguments are evaluated in order until some of the arguments returns **#t**. If all of the arguments return **#f** the result of the **or** expression is **#f**. Otherwise the result value is **#t**. Note that all of the arguments are not necessarily evaluated at all.

## cond-object

*Syntax:*

(**cond-object** [*clause-list*] [*else-clause*] )

*clause-list* ::=  $clause_1, \dots, clause_n$

$clause_k$  ::= ( $condition_k \ expr_{k,1}, \dots, expr_{k,m(k)}$  ) | ( $condition_k \Rightarrow handler_k$  )

*else-clause* ::= (**else**  $else-expr_1, \dots, else-expr_p$  )

This form works as **cond** except all nonfalse values are implemented as true in the conditions. When a clause is of type ( $condition_k \Rightarrow handler_k$  ) expression  $handler_k$  has to be a procedure accepting a single argument. When

this kind of clause is encountered the  $condition_k$  is evaluated and if its result is not false it is passed to the procedure  $handler_k$  whose result is returned.

## and-object

*Syntax:*

**(and-object** *expression* ... )

Start evaluating the argument expressions from the left. If any argument returns **#f** stop the evaluation and return **#f**. Otherwise return the value of the last expression.

## or-object

*Syntax:*

**(or-object** *expression* ... )

Start evaluating the argument expressions from the left. If any argument returns a nonfalse value stop the evaluation and return this value. Otherwise return **#f**.

## let\*

*Syntax:*

**(let\*** (*var-spec*<sub>1</sub> ... *var-spec*<sub>*n*</sub>) *let-body-expressions* )

*var-spec*<sub>*k*</sub> ::= (*var-name*<sub>*k*</sub> [*var-type*<sub>*k*</sub>] *value*<sub>*k*</sub> )

*var-name*<sub>*k*</sub> ::= identifier

*let-body-expressions* ::= expression ...

The **let\*** form is similar to **let** except that the expressions *value*<sub>*k*</sub> are evaluated in order and each expression may use the variables defined before it.

## let\*-mutable

*Syntax:*

**(let\*-mutable** (*var-spec*<sub>1</sub> ... *var-spec*<sub>*n*</sub>) *let-body-expressions* )

$var-spec_k ::= (var-name_k \ var-type_k \ value_k)$   
 $var-name_k ::= identifier$   
 $let-body-expressions ::= expression \ \dots$

The **let\*-mutable** form is similar to **let-mutable** except that the expressions  $value_k$  are evaluated in order and each expression may use the variables defined before it.

## let\*-volatile

*Syntax:*

**(let\*-volatile**  $(var-spec_1 \ \dots var-spec_n)$   $let-body-expressions$  **)**

$var-spec_k ::= (var-name_k \ var-type_k \ value_k)$   
 $var-name_k ::= identifier$   
 $let-body-expressions ::= expression \ \dots$

The **let\*-volatile** form is similar to **let-volatile** except that the expressions  $value_k$  are evaluated in order and each expression may use the variables defined before it.

## case

*Syntax:*

**(case**  $value$   $[clause-list]$   $[else-clause]$  **)**

$clause-list ::= clause_1, \dots, clause_n$   
 $clause_k ::= ((key_{k,1} \ \dots key_{k,p(k)}) \ expr_{k,1}, \dots, expr_{k,m(k)})$   
 $else-clause ::= (\text{else} \ else-expr_1, \dots, else-expr_q)$

The clauses are processed in order. If  $value$  is equal to some of the keys for clause  $k$  in the sense of the equality predicate **equal?** processing the clauses is stopped and expressions  $expr_{k,j}$  are evaluated in order and the value of the last of these expressions is returned as the value of the **case** expression. If none of the clauses match and the else clause is present the expressions  $else-expr_j$  are evaluated in order and the value of the last of these expressions is returned. If none of the clauses match and the else clause is not present the **case** expression returns nothing.

## do

*Syntax:*

```
(do (var-spec1 ... var-specn )
    (condition [result-expression] )
    body-expression1 ...body-expressionn )
```

$var-spec_k ::= (var-name_k \ var-type_k \ init-value_k \ update-expr_k \ )$   
 $var-name_k ::= identifier$

The type of *condition* has to be **<boolean>**. At the beginning of each iteration *condition* is evaluated. If it returns **#t** the iteration is stopped and the value of *result-expression* is returned as the result of the **do** expression. Otherwise the body expressions are evaluated in order, variables  $var-name_k$  are assigned new values obtained by evaluating each  $update-expr_k$  in order, and the next iteration is started from the beginning. If *result-type* is not specified the type of the **do** expression is **<none>**. Expression

```
(do ((var-name1 var-type1 init-value1 update-expr1 )...
    (var-namem var-typem init-valuem update-exprm ))
    (condition [result-expression] )
    body-expression1 ...body-expressionn )
```

is equivalent to

```
(let-mutable ((var-name1 var-type1 init-value1 )...
              (var-namem var-typem init-valuem ))
  (until (condition [result-expression] )
         body-expression1 ...
         body-expressionn
         (set! var-name1 update-expr1 )...
         (set! var-namem update-exprm )))
```

## receive

*Syntax:*

```
(receive (var1 ... varn ) source-expr body-expr )
```

Expression *source-expr* has to return a tuple value with  $n$  components. The expression *source-expr* is evaluated and variables  $var_k$  are bound to the components of the return value. Then expression *body-expr* is evaluated and its value is returned as the value of the **receive** expression.

## fluid-let

*Syntax:*

**(fluid-let** (*var-spec*<sub>1</sub> ... *var-spec*<sub>*m*</sub>) *body-expr*<sub>1</sub> ... *body-expr*<sub>*n*</sub>)

*var-spec*<sub>*k*</sub> ::= (*var-name*<sub>*k*</sub> *value*<sub>*k*</sub>)

*var-name*<sub>*k*</sub> ::= identifier

Variables *var-name*<sub>*k*</sub> have to be defined in the environment of the **fluid-let** expression. First the values of the component variables are saved. Then each variable *var-name*<sub>*k*</sub> is assigned the value of expression *value*<sub>*k*</sub>. Expressions *body-expr*<sub>*k*</sub> are evaluated and the values of the variables are restored from the saved values. The result of the last body expression is returned as the result of the **fluid-let** expression.

## unwind-protect-local

*Syntax:*

**(unwind-protect-local** *expr protect*)

First *expr* is evaluated, then *protect* is evaluated and the value of *expr* is returned as the value of the **unwind-protect-local** expression. Note that *protect* is not evaluated if *expr* is exited nonlocally.

**\$let\***  
**\$letrec**  
**\$letrec\***

*Syntax:*

( { **\$let\*** | **\$letrec** | **\$letrec\*** } (*var-spec*<sub>1</sub> ... *var-spec*<sub>*n*</sub>) *let-body-expressions* )

*var-spec*<sub>*k*</sub> ::= (*var-name*<sub>*k*</sub> *value*<sub>*k*</sub>)

*var-name*<sub>*k*</sub> ::= identifier

*let-body-expressions* ::= expression ...

These forms work like the corresponding Scheme forms without the leading '\$', see [2]. These forms may only be used in macro transformers.

## \$and

*Syntax:*

**(\$and** *expression ...*)

This form works like Theme-D **and-object** and Scheme form **and**. This form may only be used in macro transformers.

## \$or

*Syntax:*

**(\$or** *expression ...*)

This form works like Theme-D **or-object** and Scheme form **or**. This form may only be used in macro transformers.

## create

*Syntax:*

**(create** *class field-value<sub>1</sub> ...field-value<sub>n</sub>* )

Keyword **create** creates an instance of *class* calling the constructor of *class* and passing the arguments *field-value<sub>k</sub>*. Expression *class* has to be a static type expression and its value has to be a class.

## define-normal-goops-class

*Syntax:*

**(define-normal-goops-class** *name target-name superclass inheritable? immutable? equal-by-value?* )  
*name* ::=identifier  
*target-name* ::=identifier  
*inheritable?* ::=boolean  
*immutable?* ::=boolean  
*equal-by-value?* ::=boolean

This is a more compact syntax to define GOOPS classes.

## define-param-method



## define-param-virtual-method

## define-static-param-virtual-method

*Syntax:*

*(keyword method-name (type<sub>1</sub> ... type<sub>n</sub>) (argument-list result-type attribute-list) body-expr<sub>1</sub>, ..., body-expr<sub>n</sub>)*

*keyword* ::= **define-param-method** | **define-param-virtual-method** | **define-static-param-virtual-method**

*method-name* ::= identifier

*argument-list* ::= ([arg<sub>1</sub> ... arg<sub>n</sub>])

*arg<sub>k</sub>* ::= (arg-name<sub>k</sub> arg-type<sub>k</sub>)

*arg-name<sub>k</sub>* ::= identifier

*attribute-list* ::= (attribute ... ) | attribute

*attribute* ::= **pure** | **nonpure** | **force-pure**

| **always-returns** | **may-return** | **never-returns**

Keyword **define-param-method** defines a normal parametrized method. Keyword **define-param-virtual-method** defines a virtual dynamic parametrized method. Keyword **define-static-param-virtual-method** defines a virtual static parametrized method. Note that the argument list may be (). Expressions *arg-type<sub>k</sub>* and *result-type* have to be static type expressions. It is an error if the result type is not **<none>** and the type of the last body expression is not a subtype of *result-type*. If *result-type* is not **<none>** the result value of the procedure is the value of the last body expression.

## define-param-proc

*Syntax:*

*(define-param-proc procedure-name (type<sub>1</sub> ... type<sub>n</sub>) (argument-list result-type attribute-list) body-expr<sub>1</sub>, ..., body-expr<sub>n</sub>)*

*procedure-name* ::= identifier

*type<sub>k</sub>* ::= identifier

*argument-list* ::= ([arg<sub>1</sub> ... arg<sub>n</sub>])

*arg<sub>k</sub>* ::= (arg-name<sub>k</sub> arg-type<sub>k</sub>)

*arg-name<sub>k</sub>* ::= identifier

*attribute-list* ::= (attribute ... ) | attribute

*attribute* ::= **pure** | **nonpure** | **force-pure**

| **always-returns** | **may-return** | **never-returns**

Keyword **define-param-proc** defines constant *procedure-name* with a parametrized procedure value. Note that the argument list may be (). Expressions *arg-type<sub>k</sub>* and *result-type* have to be static type expressions. It is an error if the type of the last body expression is not a subtype of *result-type*. If *result-type* is not **<none>** the result value of the procedure is the value of the last body expression.

## define-simple-method

## define-simple-virtual-method

## define-static-simple-virtual-method

*Syntax:*

(*keyword method-name (argument-list result-type attribute-list ) body-expr<sub>1</sub>, ..., body-expr<sub>n</sub>* )

*keyword* ::= **define-simple-method** | **define-simple-virtual-method** | **define-static-simple-virtual-method**

*method-name* ::= identifier

*argument-list* ::= ([*arg<sub>1</sub> ... arg<sub>n</sub>*] )

*arg<sub>k</sub>* ::= (*arg-name<sub>k</sub> arg-type<sub>k</sub>*)

*arg-name<sub>k</sub>* ::= identifier

*attribute-list* ::= (*attribute ...* ) | *attribute*

*attribute* ::= **pure** | **nonpure** | **force-pure**

| **always-returns** | **may-return** | **never-returns**

Keyword **define-simple-method** defines a normal simple method. Keyword **define-simple-virtual-method** defines a virtual dynamic simple method. Keyword **define-static-simple-virtual-method** defines a virtual static simple method. Note that the argument list may be (). Expressions *arg-type<sub>k</sub>* and *result-type* have to be static type expressions. It is an error if the result type is not **<none>** and the type of the last body expression is not a subtype of *result-type*. If *result-type* is not **<none>** the result value of the procedure is the value of the last body expression.

## define-simple-proc

*Syntax:*

**(define-simple-proc** *procedure-name* (*argument-list* *result-type* *attribute-list*  
*)* *body-expr*<sub>1</sub>, ..., *body-expr*<sub>*n*</sub> *)*

*procedure-name* ::= identifier  
*argument-list* ::= ([*arg*<sub>1</sub> ... *arg*<sub>*n*</sub>] )  
*arg*<sub>*k*</sub> ::= (*arg-name*<sub>*k*</sub> *arg-type*<sub>*k*</sub>)  
*arg-name*<sub>*k*</sub> ::= identifier  
*attribute-list* ::= (*attribute* ... ) | *attribute*  
*attribute* ::= pure | nonpure | force-pure  
| always-returns | may-return | never-returns

Keyword **define-simple-proc** defines constant *procedure-name* with a simple procedure value. Note that the argument list may be (). Expressions *arg-type*<sub>*k*</sub> and *result-type* have to be static type expressions. It is an error if the result type is not <none> and the type of the last body expression is not a subtype of *result-type*. If *result-type* is not <none> the result value of the procedure is the value of the last body expression.

## define-main-proc

*Syntax:*

**(define-main-proc** (*argument-list* *result-type* *attribute-list* *)* *body-expr*<sub>1</sub>, ..., *body-expr*<sub>*n*</sub> *)*

*argument-list* ::= ([*arg*<sub>1</sub> ... *arg*<sub>*n*</sub>] )  
*arg*<sub>*k*</sub> ::= (*arg-name*<sub>*k*</sub> *arg-type*<sub>*k*</sub>)  
*arg-name*<sub>*k*</sub> ::= identifier  
*attribute-list* ::= (*attribute* ... ) | *attribute*  
*attribute* ::= pure | nonpure | force-pure  
| always-returns | may-return | never-returns

This form defines the main procedure of a program. See section “Programs and Modules” in the language manual.

## execute-with-current-continuation exec/cc

**(execute-with-current-continuation** | **exec/cc** *jump-proc* *jump-type* *body* *)*

*jump-proc* ::= identifier

This is a frontend for the procedure `call/cc`. The *body* is an expression that may invoke procedure *jump-proc*. This kind of invocation sets the current continuation to the continuation of the `exec/cc` expression. Type *jump-type* is the type of the object that *jump-proc* passes into the continuation. Keyword `exec/cc` is defined as an alias to `execute-with-current-continuation`. The body expression has to be pure and its type must not be `<none>`.

**execute-with-current-continuation-nonpure** `exec/cc-`

**nonpure**

These macros are like `exec/cc` except that the body expression may be nonpure.

**execute-with-current-continuation-without-result**

**exec/cc-without-result**

These macros are like `exec/cc-nonpure` except that the type of the body expression may be `<none>`.

## Chapter 7

# Module (standard-library core-forms2)

### 7.1 Macros

#### **guard**

*Syntax:*

```
(guard (exception-variable clause1 ... clausen [else-clause] )  
body-expr1 ... body-exprn )  
clausek ::= (conditionk exprk,1, ..., exprk,m(k) )  
else-clause ::= (else else-expr1, ..., else-exprp )
```

The syntax of *clause*<sub>*k*</sub> and *else-clause* is similar to the same syntax elements in **cond** form, see section 6.1. When a **guard** form is executed it starts evaluating the body expressions in order. If an exception is raised during the body expression evaluation do the following:

- Bind the variable *exception-variable* to the exception.
- Evaluate conditions in clauses *clause*<sub>*k*</sub> in order. When the first condition returns true evaluate the corresponding clause expressions and return the value of the last expression as the value of the **guard** expression.
- If none of the conditions returns true evaluate the *else-clause* and return its value as the value of the **guard** expression.
- If none of the conditions returns true and *else-clause* is not present reraise the exception to be handled by the surrounding exception handler.

The conditions, condition expressions, and the body expressions have to be pure and not **<none>**.

## **guard-nonpure**

This form is like **guard** except that the conditions, condition expressions, and the body expressions may be nonpure.

## **guard-without-result**

This form is like **guard-nonpure** except that the types of the condition expressions and body expressions may be **<none>**.

## Chapter 8

# Module (standard-library list-utilities)

### 8.1 Simple Methods

`length`

*Syntax:*

```
(length lst)
```

*Arguments:*

Name: `lst`

Type: `(:uniform-list <object>)`

Description: A list

*Result value:* Number of elements in the list

*Result type:* `<integer>`

*Purity of the procedure:* pure

### 8.2 Parametrized Methods

`but-last`

*Syntax:*

`(but-last lst)`

*Type parameters:* %element

*Arguments:*

Name: `lst`  
Type: `(:nonempty-uniform-list %element)`  
Description: A nonempty list

*Result value:* The list without the last element

*Result type:* `(:uniform-list %element)`

*Purity of the procedure:* pure

## `but-last0`

*Syntax:*

`(but-last0 lst)`

*Type parameters:* %element

*Arguments:*

Name: `lst`  
Type: `(:uniform-list %element)`  
Description: A list

*Result value:* The list without the last element

*Result type:* `(:uniform-list %element)`

*Purity of the procedure:* pure

If the argument list is empty raise an exception.

## `caar`

*Syntax:*

`(caar x)`



*Type parameters:* %type

*Arguments:*

Name: x  
 Type: (:pair (:pair %type <object>) <object>))  
 Description: An object

*Result value:* A value

*Result type:* %type

*Purity of the procedure:* pure

Expression (caar x) is equivalent to (car (car x)).

## cadr

*Syntax:*

(cadr x)

*Type parameters:* %type

*Arguments:*

Name: x  
 Type: (:pair <object> (:pair %type <object>))  
 Description: An object

*Result value:* A value

*Result type:* %type

*Purity of the procedure:* pure

Expression (cadr x) is equivalent to (car (cdr x)).

## cdar

*Syntax:*

(cdar x)

*Type parameters:* %type

*Arguments:*

Name: x  
Type: (:pair (:pair <object> %type) <object>)  
Description: An object

*Result value:* A value

*Result type:* %type

*Purity of the procedure:* pure

Expression (cdar x) is equivalent to (cdr (car x)).

## cddr

*Syntax:*

(cddr x)

*Type parameters:* %type

*Arguments:*

Name: x  
Type: (:pair <object> (:pair <object> %type))  
Description: An object

*Result value:* A value

*Result type:* %type

*Purity of the procedure:* pure

Expression (cddr x) is equivalent to (cdr (cdr x)).

## caddr

*Syntax:*

(caddr x)

*Type parameters:* %type

*Arguments:*

Name: `x`  
 Type: `(:pair <object> (:pair <object> (:pair %type <object>)))`  
 Description: An object

*Result value:* A value

*Result type:* `%type`

*Purity of the procedure:* pure

Expression `(caddr x)` is equivalent to `(car (cdr (cdr x)))`.

## `cdddr`

*Syntax:*

`(cdddr x)`

*Type parameters:* `%type`

*Arguments:*

Name: `x`  
 Type: `(:pair <object> (:pair <object> (:pair <object> %type)))`  
 Description: An object

*Result value:* A value

*Result type:* `%type`

*Purity of the procedure:* pure

Expression `(cdddr x)` is equivalent to `(cdr (cdr (cdr x)))`.

## `cadddr`

*Syntax:*

`(cadddr x)`

*Type parameters:* `%type`

*Arguments:*

Name: `x`  
 Type: `(:pair <object> (:pair <object> (:pair <object> (:pair %type <object>))))`  
 Description: An object

*Result value:* A value

*Result type:* `%type`

*Purity of the procedure:* pure

Expression `(caddr x)` is equivalent to `(car (cdr (cdr (cdr x))))`.

## delete

*Syntax:*

`(delete x l pred-eq)`

*Type parameters:* `%type`

*Arguments:*

Name: `x`  
 Type: `%type`  
 Description: An object

Name: `l`  
 Type: `(:uniform-list %type)`  
 Description: A list

Name: `pred-eq`  
 Type: `(:binary-predicate %type %type)`  
 Description: A binary predicate

*Result value:* A list constructed by deleting elements equal to `x` from `l`

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

The equality of objects is checked with procedure `pred-eq`.

## drop

*Syntax:*

```
(drop lst count)
```

*Type parameters:* %type

*Arguments:*

Name: `lst`  
Type: `(:uniform-list %type)`  
Description: A list

Name: `count`  
Type: `<integer>`  
Description: Number of elements to be dropped

*Result value:* A list constructed by dropping away the first `count` elements of list `lst`

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

If `count` is larger than the length of `lst` an exception is raised.

## drop-right

*Syntax:*

```
(drop-right lst count)
```

*Type parameters:* %type

*Arguments:*

Name: `lst`  
Type: `(:uniform-list %type)`  
Description: A list

Name: `count`  
Type: `<integer>`  
Description: Number of elements to be dropped

*Result value:* A list constructed by dropping away the last `count` elements of list `lst`

*Result type:* (:uniform-list %type)

*Purity of the procedure:* pure

If `count` is larger than the length of `lst` an exception is raised.

## head

*Syntax:*

(head 1)

*Type parameters:* %type

*Arguments:*

Name: 1  
Type: (:uniform-list %type)  
Description: A list

*Result value:* The head of the list

*Result type:* %type

*Purity of the procedure:* pure

This method returns the head of the list. If the list is empty an exception is raised.

## tail

*Syntax:*

(tail 1)

*Type parameters:* %type

*Arguments:*

Name: 1  
Type: (:uniform-list %type)  
Description: A list

*Result value:* The tail of the list

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

This method returns the tail of the list. If the list is empty an exception is raised.

## take

*Syntax:*

```
(take lst count)
```

*Type parameters:* `%type`

*Arguments:*

Name: `lst`

Type: `(:uniform-list %type)`

Description: A list

Name: `count`

Type: `<integer>`

Description: Number of elements to be taken

*Result value:* A list containing the first `count` elements of list `lst`

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

If `count` is larger than the length of `lst` an exception is raised.

## take-right

*Syntax:*

```
(take-right lst count)
```

*Type parameters:* `%type`

*Arguments:*

Name: `lst`  
Type: `(:uniform-list %type)`  
Description: A list

Name: `count`  
Type: `<integer>`  
Description: Number of elements to be taken

*Result value:* A list containing the last `count` elements of list `lst`  
*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

If `count` is larger than the length of `lst` an exception is raised.

## `last`

*Syntax:*

`(last lst)`

*Type parameters:* `%type`

*Arguments:*

Name: `lst`  
Type: `(:nonempty-uniform-list %type)`  
Description: A nonempty list

*Result value:* The last element of the list `lst`  
*Result type:* `%type`

*Purity of the procedure:* pure

## `last0`

*Syntax:*

`(last0 lst)`

*Type parameters:* `%type`



*Arguments:*

Name: `lst`  
 Type: `(:uniform-list %type)`  
 Description: A list

*Result value:* The last element of the list `lst`

*Result type:* `%type`

*Purity of the procedure:* pure

If the argument list is empty an exception is raised.

## for-each

*Syntax:*

```
(for-each proc lst-1 ... lst-n)
```

*Type parameters:* `%arglist`

*Arguments:*

Name: `proc`  
 Type: `(:procedure ((splice %arglist)) <none> nonpure)`  
 Description: A procedure to apply

Name: `lst-k`  
 Type: `(:uniform-list  $t_k$ )`  
 Description: A list to take arguments from

No result value.

*Purity of the procedure:* nonpure

The semantics resembles Scheme `for-each`. Procedure `proc` is applied to the  $j$ th elements of the `lst-k`'s for each  $j = 1, \dots, m$  (in this order) where  $m$  is the minimum of the lengths of `lst-k`'s. You may use a procedure with result type `<none>` as the first argument to `for-each`. The value of the type parameter `%arglist` is a tuple type consisting of types  $t_k$ ,  $k = 1, \dots, n$ . Procedure `proc` takes arguments with types  $t_k$ ,  $k = 1, \dots, n$ .

## for-each1

*Syntax:*

```
(for-each1 proc lst)
```

*Type parameters:* %arg-type

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%arg-type) <none> nonpure)`  
 Description: A procedure to apply

Name: `lst`  
 Type: `(:uniform-list %arg-type)`  
 Description: Values to which the procedure is applied

No result value.

*Purity of the procedure:* nonpure

The semantics resembles Scheme `for-each`. You may use a procedure with result type `<none>` as the first argument to `for-each`.

## for-each2

*Syntax:*

```
(for-each2 proc lst1 lst2)
```

*Type parameters:* %arg1, %arg2

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%arg1 %arg2) <none> nonpure)`  
 Description: A procedure to apply

Name: `lst1`  
 Type: `(:uniform-list %arg1)`  
 Description: Values to which the procedure is applied

Name: `lst2`  
 Type: `(:uniform-list %arg2)`  
 Description: Values to which the procedure is applied

No result value.

*Purity of the procedure:* nonpure

The semantics resembles Scheme `for-each`. You may use a procedure with result type `<none>` as the first argument to `for-each`.

## map

*Syntax:*

```
(map proc lst-1 ... lst-n)
```

*Type parameters:* %arglist, %result-type

*Arguments:*

Name: `proc`  
 Type: `(:procedure ((splice %arglist)) %result-type pure)`  
 Description: A procedure to apply

Name: `lst-k`  
 Type: `(:uniform-list  $t_k$ )`  
 Description: Lists to take arguments from

*Result value:* A list constructed by applying `proc` to the  $j$ th elements of the `lst-k`'s for each  $j = 1, \dots, m$  where  $m$  is the minimum of the list lengths

*Result type:* `(:uniform-list %result-type)`

*Purity of the procedure:* pure

The semantics resembles Scheme `map`. The procedure is applied to the arguments in the order of increasing  $j$ . The value of the type parameter `%arglist` is a tuple type consisting of types  $t_k$ ,  $k = 1, \dots, n$ . Note that you cannot use procedure with result type `<none>` as the first argument of `map`.

## map1

*Syntax:*

```
(map1 proc lst)
```

*Type parameters:* %arg-type, %result-type

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%arg-type) %result-type pure)`  
 Description: A procedure to apply

Name: `lst`  
 Type: `(:uniform-list %arg-type)`  
 Description: Values to which the procedure is applied

*Result value:* A list constructed by applying `proc` to the elements of list `lst`

*Result type:* `(:uniform-list %result-type)`

*Purity of the procedure:* `pure`

The semantics resembles `map` except this procedure takes exactly one argument list. The procedure is applied to the arguments in the order they are listed. Note that you cannot use procedure with result type `<none>` as the first argument of `map1`.

## map2

*Syntax:*

```
(map2 proc lst1 lst2)
```

*Type parameters:* `%arg1, %arg2, %result`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%arg1 %arg2) %result pure)`  
 Description: A procedure to apply

Name: `lst1`  
 Type: `(:uniform-list %arg1)`  
 Description: Values to which the procedure is applied

Name: `lst2`  
 Type: `(:uniform-list %arg2)`  
 Description: Values to which the procedure is applied

*Result value:* A list constructed by applying `proc` to the elements of lists `lst1` and `lst2`

*Result type:* `(:uniform-list %result)`

*Purity of the procedure:* pure

The semantics resembles `map` except this procedure takes exactly two argument lists. Note that you cannot use procedure with result type `<none>` as the first argument of `map2`.

## map-nonpure

*Syntax:*

```
(map-nonpure proc lst-1 ... lst-n)
```

*Type parameters:* %arglist, %result-type

*Arguments:*

Name: `proc`  
 Type: `(:procedure ((splice %arglist)) %result-type nonpure)`  
 Description: A procedure to apply

Name: `lst-k`  
 Type: `(:uniform-list  $t_k$ )`  
 Description: A list to take arguments from

*Result value:* A list constructed by applying `proc` to the  $j$ th elements of the `lst-k`'s for each  $j = 1, \dots, m$  where  $m$  is the minimum of the list lengths

*Result type:* `(:uniform-list %result-type)`

*Purity of the procedure:* nonpure

The semantics of `map-nonpure` resemble `map` except `proc` may be nonpure. The value of the type parameter `%arglist` is a tuple type consisting of types  $t_k$ ,  $k = 1, \dots, n$ . Note that you cannot use procedure with result type `<none>` as the first argument of `map-nonpure`.

## map-nonpure1

*Syntax:*

```
(map-nonpure1 proc lst)
```

*Type parameters:* %arg-type, %result-type

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%arg-type) %result-type nonpure)`  
 Description: A procedure to apply

Name: `lst`  
 Type: `(:uniform-list %arg-type)`  
 Description: Values to which the procedure is applied

*Result value:* A list constructed by applying `proc` to the elements of list `lst`

*Result type:* `(:uniform-list %result-type)`

*Purity of the procedure:* `nonpure`

The semantics resembles `map-nonpure` except this procedure takes exactly one argument list. Note that you cannot use procedure with result type `<none>` as the first argument of `map-nonpure1`.

## `map-nonpure2`

*Syntax:*

```
(map-nonpure2 proc lst1 lst2)
```

*Type parameters:* `%arg1`, `%arg2`, `%result`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%arg1 %arg2) %result nonpure)`  
 Description: A procedure to apply

Name: `lst1`  
 Type: `(:uniform-list %arg1)`  
 Description: Values to which the procedure is applied

Name: `lst2`  
 Type: `(:uniform-list %arg2)`  
 Description: Values to which the procedure is applied

*Result value:* A list constructed by applying `proc` to the elements of lists `lst1` and `lst2`

*Result type:* `(:uniform-list %result)`

*Purity of the procedure:* `nonpure`

The semantics resembles `map-nonpure` except this procedure takes exactly two argument lists. Note that you cannot use procedure with result type `<none>` as the first argument of `map2`.

## fold1

*Syntax:*

```
(fold1 proc x-init l)
```

*Type parameters:* `%component`, `%result`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%component %result) %result pure)`  
 Description: A procedure to apply

Name: `x-init`  
 Type: `%result`  
 Description: Initial value for folding

Name: `l`  
 Type: `(:uniform-list %component)`  
 Description: A list to fold

*Result value:* A list constructed by folding the argument list with the argument procedure

*Result type:* `%result`

*Purity of the procedure:* pure

Each `proc` call is `(proc elem previous)` where `elem` is from `l` and `previous` is the return value from the previous call to `proc`, or the given `x-init` for the first call. Procedure `fold1` works through the list elements from first to last.

## fold-right1

*Syntax:*

```
(fold-right1 proc x-init l)
```

*Type parameters:* `%component`, `%result`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%component %result) %result pure)`  
 Description: A procedure to apply

Name: `x-init`  
 Type: `%result`  
 Description: Initial value for folding

Name: `l`  
 Type: `(:uniform-list %component)`  
 Description: A list to fold

*Result value:* A list constructed by folding the argument list with the argument procedure

*Result type:* `%result`

*Purity of the procedure:* pure

This procedure is similar to `fold1` but the list elements are worked from last to first.

**for-all?***Syntax:*

```
(for-all?  proc lst-1 ... lst-n)
```

*Type parameters:* `%arglist`

*Arguments:*

Name: `proc`  
 Type: `(:procedure ((splice %arglist)) <boolean> pure)`  
 Description: A procedure to apply

Name: `lst-k`  
 Type: `(:uniform-list  $t_k$ )`  
 Description: Lists to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for each elementwise application to lists `lst-k`

*Result type:* `<boolean>`

*Purity of the procedure:* pure



Procedure `proc` is applied to the arguments in the order they are listed. Note that if any of the applications of `proc` returns `#f` the rest of the elements are not evaluated. If the lengths of the lists are different the number of evaluations is the length of the shortest list. If all the argument lists are `null` return `#t`. The value of the type parameter `%arglist` is a tuple type consisting of types  $t_k$ ,  $k = 1, \dots, n$ . Procedure `proc` takes arguments with types  $t_k$ ,  $k = 1, \dots, n$ .

## for-all1?

*Syntax:*

```
(for-all1? proc lst)
```

*Type parameters:* `%argtype`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%argtype)) <boolean> pure`  
 Description: A procedure to apply

Name: `lst`  
 Type: `(:uniform-list %argtype)`  
 Description: A list to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for each application to the elements of list `lst`

*Result type:* `<boolean>`

*Purity of the procedure:* `pure`

Procedure `proc` is applied to the arguments in the order they are listed. Note that if any of the applications of `proc` returns `#f` the rest of the elements are not evaluated. If `lst` is `null` return `#t`.

## for-all2?

*Syntax:*

```
(for-all2? proc lst1 lst2)
```

*Type parameters:* `%arg1`, `%arg2`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%arg1 %arg2)) <boolean> pure`  
 Description: A procedure to apply

Name: `lst1`  
 Type: `(:uniform-list %arg1)`  
 Description: A list to take arguments from

Name: `lst2`  
 Type: `(:uniform-list %arg2)`  
 Description: A list to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for each application to the elements of lists `lst1` and `lst2`

*Result type:* `<boolean>`

*Purity of the procedure:* `pure`

Procedure `proc` is applied to the arguments in the order they are listed. Note that if any of the applications of `proc` returns `#f` the rest of the elements are not evaluated. If `lst1` or `lst2` is null return `#t`.

## for-all-nonpure?

*Syntax:*

```
(for-all-nonpure? proc lst-1 ... lst-n)
```

*Type parameters:* `%arglist`

*Arguments:*

Name: `proc`  
 Type: `(:procedure ((splice %arglist)) <boolean> nonpure)`  
 Description: A procedure to apply

Name: `lst-k`  
 Type: `(:uniform-list  $t_k$ )`  
 Description: Lists to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for each elementwise application to lists `lst-k`

*Result type:* `<boolean>`

*Purity of the procedure:* nonpure

This procedure is similar to `for-all?` except that `proc` may have side effects.

## `for-all-nonpure1?`

*Syntax:*

```
(for-all-nonpure1? proc lst)
```

*Type parameters:* %argtype

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%argtype)) <boolean> nonpure`  
 Description: A procedure to apply

Name: `lst`  
 Type: `(:uniform-list %argtype)`  
 Description: A list to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for each application to the elements of list `lst`

*Result type:* `<boolean>`

*Purity of the procedure:* nonpure

This procedure is similar to `for-all1?` except that `proc` may have side effects.

## `for-all-nonpure2?`

*Syntax:*

```
(for-all-nonpure2? proc lst1 lst2)
```

*Type parameters:* %arg1, %arg2

*Arguments:*

Name: `proc`

Type: (:procedure (%arg1 %arg2)) <boolean> nonpure)

Description: A procedure to apply

Name: `lst1`

Type: (:uniform-list %arg1)

Description: A list to take arguments from

Name: `lst2`

Type: (:uniform-list %arg2)

Description: A list to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for each application to the elements of lists `lst1` and `lst2`

*Result type:* <boolean>

*Purity of the procedure:* nonpure

This procedure is similar to `for-all2?` except that `proc` may have side effects.

## exists?

*Syntax:*

```
(exists? proc lst-1 ... lst-n)
```

*Type parameters:* %arglist

*Arguments:*

Name: `proc`

Type: (:procedure ((splice %arglist)) <boolean> pure)

Description: A procedure to apply

Name: `lst-k`

Type: (:uniform-list  $t_k$ )

Description: Lists to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for any elementwise application to lists `lst-k`

*Result type:* <boolean>

*Purity of the procedure:* pure

The value of the type parameter %arglist is a tuple type consisting of types  $t_k$ ,  $k = 1, \dots, n$ . Procedure `proc` takes arguments with types  $t_k$ ,  $k = 1, \dots, n$ .

Procedure `proc` is applied to the arguments in the order they are listed. Note that if any of the applications of `proc` returns `#t` the rest of the elements are not evaluated. If the lengths of the lists are different the number of evaluations is the length of the shortest list. If all the argument lists are `null` return `#f`.

## `exists1?`

*Syntax:*

```
(exists1?  proc lst)
```

*Type parameters:* `%argtype`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%argtype)) <boolean> pure`  
 Description: A procedure to apply

Name: `lst`  
 Type: `(:uniform-list %argtype)`  
 Description: A list to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for some application to the elements of list `lst`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

Procedure `proc` is applied to the arguments in the order they are listed. Note that if any of the applications of `proc` returns `#t` the rest of the elements are not evaluated. If `lst` is `null` return `#f`.

## `exists2?`

*Syntax:*

```
(exists2?  proc lst1 lst2)
```

*Type parameters:* `%arg1, %arg2`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%arg1 %arg2)) <boolean> pure`  
 Description: A procedure to apply

Name: `lst1`  
 Type: `(:uniform-list %arg1)`  
 Description: A list to take arguments from

Name: `lst2`  
 Type: `(:uniform-list %arg2)`  
 Description: A list to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for some application to the elements of lists `lst1` and `lst2`

*Result type:* `<boolean>`

*Purity of the procedure:* `pure`

Procedure `proc` is applied to the arguments in the order they are listed. Note that if any of the applications of `proc` returns `#t` the rest of the elements are not evaluated. If `lst1` or `lst2` is `null` return `#f`.

## exists-nonpure?

*Syntax:*

```
(exists-nonpure?  proc lst-1 ... lst-n)
```

*Type parameters:* `%arglist`

*Arguments:*

Name: `proc`  
 Type: `(:procedure ((splice %arglist)) <boolean> nonpure)`  
 Description: A procedure to apply

Name: `lst-k`  
 Type: `(:uniform-list  $t_k$ )`  
 Description: Lists to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for any elementwise application to lists `lst-k`

*Result type:* `<boolean>`

*Purity of the procedure:* `nonpure`

This procedure is similar to `exists?` except that `proc` may have side effects.

### `exists-nonpure1?`

*Syntax:*

```
(exists-nonpure1? proc lst)
```

*Type parameters:* `%argtype`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%argtype)) <boolean> nonpure`  
 Description: A procedure to apply

Name: `lst`  
 Type: `(:uniform-list %argtype)`  
 Description: A list to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for some application to the elements of list `lst`

*Result type:* `<boolean>`

*Purity of the procedure:* `nonpure`

This procedure is similar to `exists1?` except that `proc` may have side effects.

### `exists-nonpure2?`

*Syntax:*

```
(exists-nonpure2? proc lst1 lst2)
```

*Type parameters:* `%arg1, %arg2`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%arg1 %arg2)) <boolean> nonpure`  
 Description: A procedure to apply

Name: `lst1`  
 Type: `(:uniform-list %arg1)`  
 Description: A list to take arguments from

Name: `lst2`  
 Type: `(:uniform-list %arg2)`  
 Description: A list to take arguments from

*Result value:* `#t` iff `proc` returns `#t` for some application to the elements of lists `lst1` and `lst2`

*Result type:* `<boolean>`

*Purity of the procedure:* nonpure

This procedure is similar to `exists2?` except that `proc` may have side effects.

## map-car

*Syntax:*

```
(map-car lst)
```

*Type parameters:* `%arglist`

*Arguments:*

Name: `lst`  
 Type: `(:tuple (:nonempty-uniform-list  $t_1$ ) ... (:nonempty-uniform-list  $t_n$ ))`  
 Description: Lists to take arguments from

*Result value:* A list constructed by taking the first element of each component list of `lst`

*Result type:* `%arglist`

*Purity of the procedure:* pure

The value of the type parameter `%arglist` is a tuple type consisting of types  $t_k$ ,  $k = 1, \dots, n$ .

## map-cdr

*Syntax:*



```
(map-cdr lst)
```

*Type parameters:* %arglist

*Arguments:*

Name: `lst`  
 Type: `(:tuple (:nonempty-uniform-list  $t_1$ ) ... (:nonempty-uniform-list  $t_n$ ))`  
 Description: Lists to take arguments from

*Result value:* A list constructed by taking the tail of each component list of `lst`

*Result type:* `(type-loop %type %arglist (:uniform-list %type))`

*Purity of the procedure:* pure

The value of the type parameter %arglist is a tuple type consisting of types  $t_k$ ,  $k = 1, \dots, n$ .

## assoc-general

*Syntax:*

```
(assoc-general key association-list default my-eq?)
```

*Type parameters:* %type1, %type2, %default

*Arguments:*

Name: `key`  
 Type: %type1  
 Description: the key to be searched

Name: `association-list`  
 Type: `(:alist %type1 %type2)`  
 Description: the association list to be searched

Name: `default`  
 Type: %default  
 Description: the value returned if no association is found

Name: `my-eq?`  
 Type: `(:procedure (%type1 %type1) <boolean> pure)`  
 Description: the equivalence predicate to be used in the search

*Result value:* The result of the search

*Result type:* `(:union (:pair %type1 %type2) %default)`

*Purity of the procedure:* pure

The association list `association-list` is searched for `key`. If `key` is found return the first association having the key. Otherwise return `default`. The keys are compared with the equivalence predicate `my-eq?`.

## ASSOC

*Syntax:*

```
(assoc key association-list default)
```

*Type parameters:* `%type1`, `%type2`, `%default`

*Arguments:*

Name: `key`

Type: `%type1`

Description: the key to be searched

Name: `association-list`

Type: `(:alist %type1 %type2)`

Description: the association list to be searched

Name: `default`

Type: `%default`

Description: the value returned if no association is found

*Result value:* The result of the search

*Result type:* `(:union (:pair %type1 %type2) %default)`

*Purity of the procedure:* pure

The association list `association-list` is searched for `key`. If `key` is found return the first association having the key. Otherwise return `default`. The keys are compared with the equivalence predicate `equal?`.

## assoc-values

*Syntax:*

```
(assoc-values key association-list default)
```

*Type parameters:* %type1, %type2, %default

*Arguments:*

Name: **key**

Type: %type1

Description: the key to be searched

Name: **association-list**

Type: (:alist %type1 %type2)

Description: the association list to be searched

Name: **default**

Type: %default

Description: the value returned if no association is found

*Result value:* The result of the search

*Result type:* (:union (:pair %type1 %type2) %default)

*Purity of the procedure:* pure

The association list **association-list** is searched for **key**. If **key** is found return the first association having the key. Otherwise return **default**. The keys are compared with the equivalence predicate **equal-values?**.

## assoc-objects

*Syntax:*

```
(assoc-objects key association-list default)
```

*Type parameters:* %type1, %type2, %default

*Arguments:*

Name: **key**

Type: %type1

Description: the key to be searched

Name: **association-list**

Type: (:alist %type1 %type2)

Description: the association list to be searched

Name: **default**  
 Type: **%default**  
 Description: the value returned if no association is found

*Result value:* The result of the search

*Result type:* **(:union (:pair %type1 %type2) %default)**

*Purity of the procedure:* pure

The association list **association-list** is searched for **key**. If **key** is found return the first association having the key. Otherwise return **default**. The keys are compared with the equivalence predicate **equal-objects?**.

## **assoc-contents**

*Syntax:*

**(assoc-contents key association-list default)**

*Type parameters:* **%type1, %type2, %default**

*Arguments:*

Name: **key**  
 Type: **%type1**  
 Description: the key to be searched

Name: **association-list**  
 Type: **(:alist %type1 %type2)**  
 Description: the association list to be searched

Name: **default**  
 Type: **%default**  
 Description: the value returned if no association is found

*Result value:* The result of the search

*Result type:* **(:union (:pair %type1 %type2) %default)**

*Purity of the procedure:* pure

The association list **association-list** is searched for **key**. If **key** is found return the first association having the key. Otherwise return **default**. The keys are compared with the equivalence predicate **equal-contents?**.

## **general-alist-delete**

*Syntax:*

```
(general-alist-delete key alist my-eq?)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `key`  
Type: %type1  
Description: the key to be searched

Name: `alist`  
Type: `(:alist %type1 %type2)`  
Description: the association list to be searched

Name: `my-eq?`  
Type: `(:procedure (%type1 %type1) <boolean> pure)`  
Description: the equivalence predicate to be used in the search

*Result value:* The association list obtained by removing all bindings for key `key` from `alist`

*Result type:* `(:alist %type1 %type2)`

*Purity of the procedure:* pure

The keys are compared with the equivalence predicate `my-eq?`.

## **alist-delete**

*Syntax:*

```
(alist-delete key alist)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `key`  
Type: %type1  
Description: the key to be searched

Name: `alist`  
Type: `(:alist %type1 %type2)`  
Description: the association list to be searched

*Result value:* The association list obtained by removing all bindings for key `key` from `alist`

*Result type:* `(:alist %type1 %type2)`

*Purity of the procedure:* pure

The keys are compared with the equivalence predicate `equal?`.

## value-alist-delete

*Syntax:*

```
(value-alist-delete key alist)
```

*Type parameters:* `%type1`, `%type2`

*Arguments:*

Name: `key`  
Type: `%type1`  
Description: the key to be searched

Name: `alist`  
Type: `(:alist %type1 %type2)`  
Description: the association list to be searched

*Result value:* The association list obtained by removing all bindings for key `key` from `alist`

*Result type:* `(:alist %type1 %type2)`

*Purity of the procedure:* pure

The keys are compared with the equivalence predicate `equal-values?`.

## object-alist-delete

*Syntax:*

```
(object-alist-delete key alist)
```

*Type parameters:* `%type1`, `%type2`

*Arguments:*

Name: `key`  
 Type: `%type1`  
 Description: the key to be searched

Name: `alist`  
 Type: `(:alist %type1 %type2)`  
 Description: the association list to be searched

*Result value:* The association list obtained by removing all bindings for key `key` from `alist`

*Result type:* `(:alist %type1 %type2)`

*Purity of the procedure:* pure

The keys are compared with the equivalence predicate `equal-objects?`.

## `content-alist-delete`

*Syntax:*

`(content-alist-delete key alist)`

*Type parameters:* `%type1`, `%type2`

*Arguments:*

Name: `key`  
 Type: `%type1`  
 Description: the key to be searched

Name: `alist`  
 Type: `(:alist %type1 %type2)`  
 Description: the association list to be searched

*Result value:* The association list obtained by removing all bindings for key `key` from `alist`

*Result type:* `(:alist %type1 %type2)`

*Purity of the procedure:* pure

The keys are compared with the equivalence predicate `equal-contents?`.

## `member-general?`

*Syntax:*

```
(member-general? object lst my-eq?)
```

*Type parameters:* %type

*Arguments:*

Name: `object`  
 Type: %type  
 Description: the object to be searched

Name: `lst`  
 Type: (:uniform-list %type)  
 Description: the list to be searched

Name: `my-eq?`  
 Type: (:procedure (%type %type) <boolean> pure)  
 Description: equivalence predicate to be used in the search

*Result value:* Result of the search

*Result type:* <boolean>

*Purity of the procedure:* pure

The list `lst` is searched for `object`. If `object` is found return `#t`. Otherwise return `#f`. The list items are compared with the equivalence predicate `my-eq?`.

## member-values?

*Syntax:*

```
(member-values? object lst)
```

*Type parameters:* %type

*Arguments:*

Name: `object`  
 Type: %type  
 Description: the object to be searched

Name: `lst`  
 Type: (:uniform-list %type)  
 Description: the list to be searched



*Result value:* Result of the search

*Result type:* <boolean>

*Purity of the procedure:* pure

The list `lst` is searched for `object`. If `object` is found return `#t`. Otherwise return `#f`. The list items are compared with the equivalence predicate `equal-values?`.

## member-objects?

*Syntax:*

```
(member-objects? object lst)
```

*Type parameters:* %type

*Arguments:*

Name: `object`  
 Type: %type  
 Description: the object to be searched

Name: `lst`  
 Type: (:uniform-list %type)  
 Description: the list to be searched

*Result value:* Result of the search

*Result type:* <boolean>

*Purity of the procedure:* pure

The list `lst` is searched for `object`. If `object` is found return `#t`. Otherwise return `#f`. The list items are compared with the equivalence predicate `equal-objects?`.

## member-contents?

*Syntax:*

```
(member-contents? object lst)
```

*Type parameters:* %type

*Arguments:*

Name: object  
 Type: %type  
 Description: the object to be searched

Name: lst  
 Type: (:uniform-list %type)  
 Description: the list to be searched

*Result value:* Result of the search

*Result type:* <boolean>

*Purity of the procedure:* pure

The list `lst` is searched for `object`. If `object` is found return `#t`. Otherwise return `#f`. The list items are compared with the equivalence predicate `equal-contents?`.

## append

*Syntax:*

```
(append list-1 ... list-n)
```

*Type parameters:* %types

*Arguments:*

Name: list-k  
 Type: (:uniform-list  $t_k$ )  
 Description: A list to be merged

*Result value:* A list constructed by appending the arguments

*Result type:* (:uniform-list (:union  $t_1$  ...  $t_n$ ))

*Purity of the procedure:* pure

## append-tuples

*Syntax:*

```
(append-tuples tuple-1 ... tuple-n)
```

*Type parameters:* %tuples

*Arguments:*

Name: tuple-k  
 Type: (:tuple  $t_{k,1} \dots t_{k,m(k)}$ )  
 Description: A tuple to be merged

*Result value:* A tuple constructed by appending the arguments

*Result type:* (:tuple  $t_{1,1} \dots t_{1,m(1)} \dots t_{n,1} \dots t_{n,m(n)}$ )

*Purity of the procedure:* pure

## append-uniform

*Syntax:*

```
(append-uniform list-1 ... list-n)
```

*Type parameters:* %type

*Arguments:*

Name: list-k  
 Type: (:uniform-list %type)  
 Description: A list to be merged

*Result value:* A list constructed by appending the arguments

*Result type:* (:uniform-list %type)

*Purity of the procedure:* pure

## append-uniform0

*Syntax:*

```
(append-uniform0 lists)
```

*Type parameters:* %type

*Arguments:*

Name: lists  
Type: (:uniform-list (:uniform-list %type))  
Description: Lists to be merged

*Result value:* A list constructed by appending the component lists of the argument

*Result type:* (:uniform-list %type)

*Purity of the procedure:* pure

## append-uniform2

*Syntax:*

```
(append-uniform2 lst1 lst2)
```

*Type parameters:* %type

*Arguments:*

Name: lst1  
Type: (:uniform-list %type)  
Description: A list to be merged

Name: lst2  
Type: (:uniform-list %type)  
Description: A list to be merged

*Result value:* A list constructed by appending the arguments

*Result type:* (:uniform-list %type)

*Purity of the procedure:* pure

## reverse

*Syntax:*

```
(reverse lst)
```

*Type parameters:* %type

*Arguments:*

Name: `lst`  
Type: `(:uniform-list %type)`  
Description: A list to be reversed

*Result value:* A list constructed by reversing the argument list

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

## uniform-list-ref

*Syntax:*

```
(uniform-list-ref lst index)
```

*Type parameters:* %type

*Arguments:*

Name: `lst`  
Type: `(:uniform-list %type)`  
Description: A uniform list

Name: `index`  
Type: `<integer>`  
Description: Index to the list

*Result value:* Element of `lst` at position `index`

*Result type:* %type

*Purity of the procedure:* pure

The indices start from zero.

## filter

*Syntax:*

```
(filter pred lst)
```

*Type parameters:* %type

*Arguments:*

Name: `pred`

Type: `(:procedure (%type) <boolean> pure)`

Description: the predicate used for picking the elements

Name: `lst`

Type: `(:uniform-list %type)`

Description: The list to be searched

*Result value:* The list computed by picking all the elements in `lst` for which `pred` returns `#t`

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

## distinct-elements?

*Syntax:*

```
(distinct-elements? lst my-eq?)
```

*Type parameters:* %type

*Arguments:*

Name: `lst`

Type: `(:uniform-list %type)`

Description: The list to be checked

Name: `my-eq?`

Type: `(:procedure (%type %type) <boolean> pure)`

Description: the equivalence predicate used for checking the elements

*Result value:* `#t` iff no two elements of `lst` are equal by `my-eq?`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## find

*Syntax:*

```
(find pred l x-default)
```

*Type parameters:* %type, %default

*Arguments:*

Name: `pred`  
Type: `(:procedure (%type) <boolean> pure)`  
Description: the predicate used for the search

Name: `l`  
Type: `(:uniform-list %type)`  
Description: The list to be searched

*Result value:* The first element satisfying the predicate in the list

*Result type:* `(:union %type %default)`

*Purity of the procedure:* pure

If no list element satisfies the predicate value `x-default` is returned.

## count

*Syntax:*

```
(count pred l)
```

*Type parameters:* %type

*Arguments:*

Name: `pred`  
Type: `(:procedure (%type) <boolean> pure)`  
Description: the predicate used for counting

Name: `l`  
Type: `(:uniform-list %type)`  
Description: The list to be searched

*Result value:* The number of the list elements satisfying the predicate

*Result type:* <integer>

*Purity of the procedure:* pure

## delete-duplicates

*Syntax:*

```
(delete-duplicates l pred-eq)
```

*Type parameters:* %type

*Arguments:*

Name: l

Type: (:uniform-list %type)

Description: The list to be processed

Name: pred-eq

Type: (:procedure (%type %type) <boolean> pure)

Description: An equality predicate

*Result value:* The argument list with duplicates removed

*Result type:* (:uniform-list %type)

*Purity of the procedure:* pure

Argument `pred-eq` is used to determine whether the list elements are equal.

## list-set-diff

*Syntax:*

```
(list-set-diff l1 l2 pred-eq)
```

*Type parameters:* %type

*Arguments:*

Name: l1

Type: (:uniform-list %type)

Description: A list



Name: `l2`  
 Type: `(:uniform-list %type)`  
 Description: A list

Name: `pred-eq`  
 Type: `(:procedure (%type %type) <boolean> pure)`  
 Description: An equality predicate

*Result value:* A list of elements of `l1` that do not belong to `l2`

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

Argument `pred-eq` is used to determine whether the list elements are equal.

## union-of-lists

*Syntax:*

```
(union-of-lists l1 l2 pred-eq)
```

*Type parameters:* `%type`

*Arguments:*

Name: `l1`  
 Type: `(:uniform-list %type)`  
 Description: A list

Name: `l2`  
 Type: `(:uniform-list %type)`  
 Description: A list

Name: `pred-eq`  
 Type: `(:binary-predicate %type %type)`  
 Description: An equality predicate

*Result value:* Union of lists `l1` and `l2`

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

The result of the method consists of the elements of both of the arguments with duplicates removed. Argument `pred-eq` is used to determine whether the list elements are equal.

## union-of-alists

*Syntax:*

```
(union-of-alists al1 al2 pred-eq)
```

*Type parameters:* %key, %value

*Arguments:*

Name: al1  
Type: (:alist %key %value)  
Description: An association list

Name: l2  
Type: (:alist %key %value)  
Description: An association list

Name: pred-eq  
Type: (:binary-predicate %key %key)  
Description: An equality predicate

*Result value:* Union of association lists al1 and al2

*Result type:* (:alist %key %value)

*Purity of the procedure:* pure

The result of the method consists of the elements of both of the arguments with duplicate keys removed. Argument `pred-eq` is used to determine whether the keys are equal.

## 8.3 Macros

### iterate-list

*Syntax:*

```
(iterate-list (var type list) body1 ...bodyn)
```

Variable *var* is bound to each element of *list* in order and the *body<sub>k</sub>* are evaluated. The value *list* has to be an instance of type (:uniform-list *type*) and the static type of *var* is *type*.

## iterate-list-pure

*Syntax:*

```
(iterate-list-pure (var type list ) body1 ...bodyn )
```

Same as `iterate-list` except that the form is a pure expression. The body expressions have to be pure.

## iterate-list-with-break

*Syntax:*

```
(iterate-list-with-break (var type list condition ) body1 ...bodyn )
```

Variable *var* is bound to each element of *list* in order and the *body<sub>k</sub>* are evaluated. Expression *condition* is evaluated before each iteration step and if it returns `#t` the iteration is stopped. The value *list* has to be an instance of type `(:uniform-list type)` and the static type of *var* is *type*.

## iterate-list-with-break-pure

*Syntax:*

```
(iterate-list-with-break-pure (var type list condition ) body1 ...bodyn )
```

Same as `iterate-list-with-break` except that the form is a pure expression. The body expressions have to be pure.

## iterate-2-lists

*Syntax:*

```
(iterate-2-lists ((var1 type1 list1 )(var2 type2 list2 )) body1 ...bodyn )
```

Variables *var1* and *var2* are bound to each element of *list1* and *list2* in order and the expressions *body<sub>k</sub>* are evaluated. The value *list1* has to be an instance of type `(:uniform-list type1)` and the static type of *var1* is *type1*. The value *list2* has to be an instance of type `(:uniform-list type2)` and the static type of *var2* is *type2*. If the lengths of *list1* and *list2* are different the shorter list determines the number of elements handled.

## iterate-2-lists-pure

*Syntax:*

```
(iterate-2-lists-pure ((var1 type1 list1 )(var2 type2 list2 ))
  body1 ...bodyn )
```

This macro is similar to **iterate-2-lists** except that the expression is pure and all the body expressions have to be pure.

## iterate-2-lists-with-break

*Syntax:*

```
(iterate-2-lists-with-break ((var1 type1 list1 )(var2 type2 list2 ))
  condition body1 ...bodyn )
```

This macro is similar to **iterate-2-lists** except that *condition* is checked at each iteration step and the iteration is stopped if *condition* is **#t**.

## iterate-2-lists-with-break-pure

*Syntax:*

```
(iterate-2-lists-with-break-pure ((var1 type1 list1 )(var2 type2 list2 ))
  condition body1 ...bodyn )
```

This macro is similar to **iterate-2-lists-with-break** except that the expression is pure and all the body expressions have to be pure.

## Chapter 9

# Module (standard-library string-utilities)

### 9.1 Data Types

*Data type name:* <string-match-result>

*Type:* :union

*Description:* Return value of procedure `string-match`

### 9.2 Simple Methods

#### replace-char

*Syntax:*

```
(replace-char str ch-src ch-dest)
```

*Arguments:*

Name: `str`

Type: <string>

Description: A string

Name: `ch-src`

Type: <character>

Description: The character to be replaced

Name: `ch-dest`

Type: <character>

Description: The destination character

*Result value:* A string obtained by replacing character `ch-src` with `ch-dest` in string `str`

*Result type:* `<string>`

*Purity of the procedure:* pure

## replace-char-with-string

*Syntax:*

```
(replace-char-with-string str ch-src str-dest)
```

*Arguments:*

Name: `str`

Type: `<string>`

Description: A string

Name: `ch-src`

Type: `<character>`

Description: The character to be replaced

Name: `str-dest`

Type: `<string>`

Description: The destination string

*Result value:* A string obtained by replacing character `ch-src` with `str-dest` in string `str`

*Result type:* `<string>`

*Purity of the procedure:* pure

## join-strings-with-sep

*Syntax:*

```
(join-strings-with-sep lst str-separator)
```

*Arguments:*

Name: `lst`  
Type: `(:uniform-list <string>)`  
Description: A list of strings to join

Name: `str-separator`  
Type: `<string>`  
Description: The separator

*Result value:* A string obtained to join the strings in `lst` in order  
*Result type:* `<string>`

*Purity of the procedure:* pure

## search-substring

*Syntax:*

```
(search-substring str str-match)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string

Name: `str-match`  
Type: `<string>`  
Description: The string to be searched

*Purity of the procedure:* pure

*Result value:* Index of the first occurrence of string `str-match` in string `str` (-1 if the string is not found)

*Result type:* `<integer>`

## search-substring-from-end

*Syntax:*

```
(search-substring-from-end str str-match)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string

Name: `str-match`  
 Type: `<string>`  
 Description: The string to be searched

*Purity of the procedure:* pure

*Result value:* Search for string `str-match` in string `str` starting from the end of `str` and return the index of the first match (-1 if the search does not succeed)

*Result type:* `<integer>`

## split-string

*Syntax:*

```
(split-string str ch)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string to be split

Name: `ch`  
 Type: `<character>`  
 Description: The separator character

*Result value:* A list constructed by splitting the string `str`

*Result type:* `(:uniform-list <string>)`

*Purity of the procedure:* pure

The character `ch` is used as a separator in splitting.

## string

*Syntax:*



```
(string char-1 ... char-n)
```

*Arguments:*

Name: `char-k`  
Type: `<character>`  
Description: A character

*Result value:* A string consisting of characters `char-1 ... char-n`

*Result type:* `<string>`

*Purity of the procedure:* pure

## string-append

*Syntax:*

```
(string-append str-1 ... str-n)
```

*Arguments:*

Name: `str-k`  
Type: `<string>`  
Description: A string

*Purity of the procedure:* pure

*Result value:* A string obtained by concatenating strings `str-1 ... str-n`

*Result type:* `<string>`

## string-char-index

*Syntax:*

```
(string-char-index str ch)
```

*Arguments:*

Name: `str`  
Type: `<string>`

Description: A string

Name: `ch`

Type: `<character>`

Description: A character to be searched

*Purity of the procedure:* pure

*Result value:* Index of the first occurrence of character `ch` in string `str` (-1 if the character is not found)

*Result type:* `<integer>`

## string-char-index-right

*Syntax:*

```
(string-char-index-right str ch)
```

*Arguments:*

Name: `str`

Type: `<string>`

Description: A string

Name: `ch`

Type: `<character>`

Description: A character to be searched

*Purity of the procedure:* pure

*Result value:* Index of the last occurrence of character `ch` in string `str` (-1 if the character is not found)

*Result type:* `<integer>`

## string-contains-char?

*Syntax:*

```
(string-contains-char? str ch)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string

Name: `ch`  
Type: `<character>`  
Description: A character

*Purity of the procedure:* pure

*Result value:* `#t` iff string `str` contains character `ch`

*Result type:* `<boolean>`

## string-drop

*Syntax:*

```
(string-drop str count)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string

Name: `count`  
Type: `<integer>`  
Description: Number of characters to be dropped

*Result value:* A string constructed of by dropping away the first `count` characters of `str`

*Result type:* `<string>`

*Purity of the procedure:* pure

If `count` is larger than the length of `str` an exception is raised.

## string-drop-right

*Syntax:*

```
(string-drop-right str count)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string

Name: `count`  
 Type: `<integer>`  
 Description: Number of characters to be dropped

*Result value:* A string constructed of by dropping away the last `count` characters of `str`

*Result type:* `<string>`

*Purity of the procedure:* pure

If `count` is larger than the length of `str` an exception is raised.

## string-empty?

*Syntax:*

```
(string-empty? str)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string

*Result value:* `#t` iff the string is empty

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## string-exact-match?

*Syntax:*

```
(string-exact-match? str-pattern str-source)
```

*Arguments:*

Name: `str-pattern`  
Type: `<string>`  
Description: A pattern

Name: `str-source`  
Type: `<string>`  
Description: The source string for matching

*Result value:* `#t` iff the pattern matches the whole source string

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## string-last-char

*Syntax:*

```
(string-last-char str)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string

*Result value:* The last character of the string `str`

*Result type:* `<character>`

*Purity of the procedure:* pure

If `str` is empty raise an exception.

## string-length

*Syntax:*

```
(string-length str)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string

*Result value:* The length of the string `str`  
*Result type:* `<integer>`

*Purity of the procedure:* pure

## string-match

*Syntax:*

```
(string-match str-pattern str-source)
```

*Arguments:*

Name: `str-pattern`  
 Type: `<string>`  
 Description: A pattern

Name: `str-source`  
 Type: `<string>`  
 Description: The source string for matching

*Result value:* The results of the matching  
*Result type:* `<string-match-results>`

*Purity of the procedure:* pure

If the matching fails return `null`. Otherwise the result is a tuple consisting of three elements: the first element is the substring to which the pattern matched, the second item is the index to the source string where the matching started, and the third item the index where the matching stopped.

## string-ref

*Syntax:*

```
(string-ref str index)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string

Name: `index`  
Type: `<integer>`  
Description: An index to the string

*Result value:* The character at the `index`th position of string `str`

*Result type:* `<character>`

*Purity of the procedure:* pure

## string-take

*Syntax:*

```
(string-take str count)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string

Name: `count`  
Type: `<integer>`  
Description: Number of characters to be taken

*Result value:* A string consisting of the first `count` characters of `str`

*Result type:* `<string>`

*Purity of the procedure:* pure

If `count` is larger than the length of `str` an exception is raised.

## string-take-right

*Syntax:*

```
(string-take-right str count)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string

Name: `count`  
 Type: `<integer>`  
 Description: Number of characters to be taken

*Result value:* A string consisting of the last `count` characters of `str`  
*Result type:* `<string>`

*Purity of the procedure:* pure

If `count` is larger than the length of `str` an exception is raised.

## substring

*Syntax:*

```
(substring str i-start i-end)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string

Name: `i-start`  
 Type: `<integer>`  
 Description: Index from which to start the extraction

Name: `i-end`  
 Type: `<integer>`  
 Description: Index to which to stop the extraction

*Result value:* A substring of `str`  
*Result type:* `<string>`

*Purity of the procedure:* pure

Note that the character at the position `i-end` is not included in the substring.



## Chapter 10

# Module (standard-library basic-math)

### 10.1 Simple Methods

#### ceiling

*Syntax:*

```
(ceiling r)
```

*Arguments:*

Name: r

Type: <real>

Description: A real number

*Result value:* Rounded value

*Result type:* <integer>

*Purity of the procedure:* pure

This procedure rounds a real number towards infinity.

#### even?

*Syntax:*

```
(even? i)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer number

*Result value:* Return `#t` iff the argument is even

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**factorial***Syntax:*

`(factorial i)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: A nonnegative integer number

*Result value:* The factorial of the argument

*Result type:* `<integer>`

*Purity of the procedure:* pure

**finite?***Syntax:*

`(finite? r)`

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real number

*Result value:* Returns `#t` iff `r` is a finite value

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## **floor**

*Syntax:*

```
(floor r)
```

*Arguments:*

Name: `r`

Type: `<real>`

Description: A real number

*Result value:* Rounded value

*Result type:* `<integer>`

*Purity of the procedure:* pure

This procedure rounds a real number towards minus infinity.

## **gcd**

*Syntax:*

```
(gcd i1 i2)
```

*Arguments:*

Name: `i1`

Type: `<integer>`

Description: An integer number

Name: `i2`

Type: `<integer>`

Description: An integer number

*Result value:* The greatest common divisor of the arguments

*Result type:* `<integer>`

*Purity of the procedure:* pure

## i-log10-exact

*Syntax:*

```
(i-log10-exact i)
```

*Arguments:*

Name: i  
Type: `<integer>`  
Description: A positive integer number

*Result value:* The base 10 logarithm of the argument or `null` if the logarithm is not an integer

*Result type:* `(:maybe <integer>)`

*Purity of the procedure:* pure

## i-log2-exact

*Syntax:*

```
(i-log2-exact i)
```

*Arguments:*

Name: i  
Type: `<integer>`  
Description: A positive integer number

*Result value:* The base 2 logarithm of the argument or `null` if the logarithm is not an integer

*Result type:* `(:maybe <integer>)`

*Purity of the procedure:* pure

**infinite?***Syntax:*

```
(infinite? r)
```

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* Returns **#t** iff **r** is an infinite value*Result type:* **<boolean>***Purity of the procedure:* pure**integer->real***Syntax:*

```
(integer->real int)
```

*Arguments:*

Name: **int**  
Type: **<integer>**  
Description: An integer value

*Result value:* The integer value converted to a real value*Result type:* **<real>***Purity of the procedure:* pure**i-abs***Syntax:*

```
(i-abs n)
```

*Arguments:*

Name: `n`  
Type: `<integer>`  
Description: An integer number

*Result value:* Absolute value of the argument

*Result type:* `<integer>`

*Purity of the procedure:* pure

## `i-nonneg-expt`

*Syntax:*

`(i-nonneg-expt i-base i-expt)`

*Arguments:*

Name: `i-base`  
Type: `<integer>`  
Description: An integer number

Name: `i-expt`  
Type: `<integer>`  
Description: A nonnegative integer number

*Result value:* `i-base` raised to the power `i-expt`

*Result type:* `<integer>`

*Purity of the procedure:* pure

## `i-sign`

*Syntax:*

`(i-sign i)`

*Arguments:*

Name: `i`

Type: `<integer>`

Description: An integer number

*Result value:* Return 0 if `i` = 0, 1 if `i` > 0, and -1 if `i` < 0

*Result type:* `<integer>`

*Purity of the procedure:* pure

## `i-square`

*Syntax:*

`(i-square n)`

*Arguments:*

Name: `n`

Type: `<integer>`

Description: An integer number

*Result value:* Square of the argument

*Result type:* `<integer>`

*Purity of the procedure:* pure

## `inf`

*Syntax:*

`(inf)`

No arguments.

*Result value:* The exceptional floating point value `inf` (positive infinity)

*Result type:* `<real>`

*Purity of the procedure:* pure

## `integer-float?`

*Syntax:*

`(integer-float? r)`

*Arguments:*

Name: `r`

Type: `<real>`

Description: A real number

*Result value:* `#t` iff `r` is an integer value

*Result type:* `<integer>`

*Purity of the procedure:* pure

## **nan**

*Syntax:*

`(nan)`

No arguments.

*Result value:* The exceptional floating point value NaN (not a number)

*Result type:* `<real>`

*Purity of the procedure:* pure

## **nan?**

*Syntax:*

`(nan? r)`

*Arguments:*

Name: `r`

Type: `<real>`

Description: A real number



*Result value:* Returns **#t** iff **r** is a NaN value

*Result type:* **<boolean>**

*Purity of the procedure:* pure

## neg-inf

*Syntax:*

**(neg-inf)**

No arguments.

*Result value:* The exceptional floating point value -inf (negative infinity)

*Result type:* **<real>**

*Purity of the procedure:* pure

## odd?

*Syntax:*

**(odd? i)**

*Arguments:*

Name: **i**

Type: **<integer>**

Description: An integer number

*Result value:* Return **#t** iff the argument is odd

*Result type:* **<boolean>**

*Purity of the procedure:* pure

## quotient

*Syntax:*

```
(quotient int1 int2)
```

*Arguments:*

Name: `int1`  
Type: `<integer>`  
Description: An integer value

Name: `int2`  
Type: `<integer>`  
Description: An integer value

*Result value:* The quotient of the arguments

*Result type:* `<integer>`

*Purity of the procedure:* pure

If the second argument is 0 raise exception `numerical-overflow`. Note that this procedure always returns an integer.

## **r-abs**

*Syntax:*

```
(r-abs r)
```

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real number

*Result value:* Absolute value of the argument

*Result type:* `<real>`

*Purity of the procedure:* pure

## **r-ceiling**

*Syntax:*

```
(r-ceiling r)
```

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* Rounded value

*Result type:* **<real>**

*Purity of the procedure:* pure

This procedure rounds a real number towards infinity and returns a real number.

## **r-floor**

*Syntax:*

```
(r-floor r)
```

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* Rounded value

*Result type:* **<real>**

*Purity of the procedure:* pure

This procedure rounds a real number towards minus infinity and returns a real number.

## **r-int-expt**

*Syntax:*

```
(r-int-expt r-base i-expt)
```

*Arguments:*

Name: **r-base**  
Type: **<real>**  
Description: A real number

Name: **i-expt**  
Type: **<integer>**  
Description: An integer number

*Result value:* **r-base** raised to the power **i-expt**  
*Result type:* **<real>**

*Purity of the procedure:* pure

## **r-nonneg-int-expt**

*Syntax:*

**(r-nonneg-int-expt r-base i-expt)**

*Arguments:*

Name: **r-base**  
Type: **<real>**  
Description: A real number

Name: **i-expt**  
Type: **<integer>**  
Description: A nonnegative integer number

*Result value:* **r-base** raised to the power **i-expt**  
*Result type:* **<real>**

*Purity of the procedure:* pure

## **r-round**

*Syntax:*

**(r-round r)**

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* Rounded value

*Result type:* **<real>**

*Purity of the procedure:* pure

This procedure rounds a real number and return a real number.

## **r-sign**

*Syntax:*

**(r-sign r)**

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* Return 0 if **r** = 0.0, 1 if **r** > 0.0, and -1 if **r** < 0.0

*Result type:* **<integer>**

*Purity of the procedure:* pure

Return 0 for the exceptional value NaN.

## **r-square**

*Syntax:*

**(r-square r)**

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* Square of the argument

*Result type:* <real>

*Purity of the procedure:* pure

## **r-truncate**

*Syntax:*

```
(r-truncate r)
```

*Arguments:*

Name: **r**

Type: <real>

Description: A real number

*Result value:* Rounded value

*Result type:* <real>

*Purity of the procedure:* pure

This procedure rounds a real number towards zero and returns a real number.

## **remainder**

*Syntax:*

```
(remainder dividend divisor)
```

*Arguments:*

Name: **dividend**

Type: <integer>

Description: The dividend

Name: **divisor**

Type: <integer>

Description: The divisor

*Result value:* The remainder obtained by dividing the dividend with the divisor

*Result type:* <integer>

*Purity of the procedure:* pure

The semantics of `remainder` is the same as the semantics of procedure `remainder` in Scheme (R6RS).

## **round**

*Syntax:*

```
(round r)
```

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real number

*Result value:* Rounded value

*Result type:* `<integer>`

*Purity of the procedure:* pure

This procedure rounds a real number and returns an integer.

## **truncate**

*Syntax:*

```
(truncate r)
```

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real number

*Result value:* Rounded value

*Result type:* `<integer>`

*Purity of the procedure:* pure

This procedure rounds a real number towards zero.

## 10.2 Parametrized Methods

### **min**

*Syntax:*

```
(min nr1 nr2)
```

*Type parameters:* %number

*Arguments:*

Name: **nr1**  
Type: %number  
Description: A number

Name: **nr2**  
Type: %number  
Description: A number

*Result value:* The minimum of the arguments

*Result type:* %number

*Purity of the procedure:* pure

The type %number has to define a boolean-valued two-argument predicate `<=`.

### **max**

*Syntax:*

```
(max nr1 nr2)
```

*Type parameters:* %number

*Arguments:*

Name: **nr1**  
Type: %number  
Description: A number



Name: `nr2`  
 Type: `%number`  
 Description: A number

*Result value:* The maximum of the arguments

*Result type:* `%number`

*Purity of the procedure:* pure

The type `%number` has to define a boolean-valued two-argument predicate `>=`.

## 10.3 Virtual Methods

```
abs: (<integer>) → <integer> pure  =  i-abs
abs: (<real>) → <real> pure      =  r-abs
square: (<integer>) → <integer> pure  =  i-square
square: (<real>) → <real> pure      =  r-square
sign: (<integer>) → <integer> pure  =  i-sign
sign: (<real>) → <integer> pure    =  r-sign
```



## Chapter 11

# Module (standard-library bitwise-arithmetic)

### 11.1 Simple Methods

#### bitwise-not

*Syntax:*

```
(bitwise-not i)
```

*Arguments:*

Name: `i`

Type: `<integer>`

Description: An integer number

*Result value:* The ones-complement of the argument

*Result type:* `<integer>`

*Purity of the procedure:* pure

#### bitwise-and

*Syntax:*

```
(bitwise-and i1 i2)
```

*Arguments:*

Name: `i1`  
 Type: `<integer>`  
 Description: An integer number

Name: `i2`  
 Type: `<integer>`  
 Description: An integer number

*Result value:* The bitwise AND between the arguments

*Result type:* `<integer>`

*Purity of the procedure:* pure

## bitwise-ior

*Syntax:*

```
(bitwise-ior i1 i2)
```

*Arguments:*

Name: `i1`  
 Type: `<integer>`  
 Description: An integer number

Name: `i2`  
 Type: `<integer>`  
 Description: An integer number

*Result value:* The bitwise OR between the arguments

*Result type:* `<integer>`

*Purity of the procedure:* pure

## bitwise-xor

*Syntax:*

```
(bitwise-xor i1 i2)
```

*Arguments:*

Name: `i1`  
Type: `<integer>`  
Description: An integer number

Name: `i2`  
Type: `<integer>`  
Description: An integer number

*Result value:* The bitwise XOR between the arguments

*Result type:* `<integer>`

*Purity of the procedure:* pure

**bitwise-arithmetic-shift***Syntax:*

`(bitwise-arithmetic-shift i i-shift)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer number

Name: `i-shift`  
Type: `<integer>`  
Description: The number of bits to be shifted (maybe negative)

*Result value:* Value of `i` with bits shifted by `i-shift` positions

*Result type:* `<integer>`

*Purity of the procedure:* pure

Positive values of `i-shift` mean shifting bits left and negative values shifting right. Name `ash` is an alias for `bitwise-arithmetic-shift`.

**bitwise-arithmetic-shift-right***Syntax:*

```
(bitwise-arithmetic-shift-right i i-shift)
```

*Arguments:*

Name: `i`  
 Type: `<integer>`  
 Description: An integer number

Name: `i-shift`  
 Type: `<integer>`  
 Description: The number of bits to be shifted (maybe negative)

*Result value:* Value of `i` with bits shifted right by `i-shift` positions

*Result type:* `<integer>`

*Purity of the procedure:* pure

Negative values of `i-shift` shift bit to the left.

## bitwise-arithmetic-shift-left

*Syntax:*

```
(bitwise-arithmetic-shift-left i i-shift)
```

*Arguments:*

Name: `i`  
 Type: `<integer>`  
 Description: An integer number

Name: `i-shift`  
 Type: `<integer>`  
 Description: The number of bits to be shifted (maybe negative)

*Result value:* Value of `i` with bits shifted left by `i-shift` positions

*Result type:* `<integer>`

*Purity of the procedure:* pure

Negative values of `i-shift` shift bit to the right.

## Chapter 12

# Module (standard-library promise)

This module implements delayed evaluation with the promise objects. The promises resemble Scheme promises, see [2].

### 12.1 Data Types

*Data type name:* `:promise`

*Type:* `:procedure`

*Number of type parameters:* 1

*Description:* A promise object

*Data type name:* `:nonpure-promise`

*Type:* `:procedure`

*Number of type parameters:* 1

*Description:* A promise object that can have side effects

### 12.2 Macros

#### **delay**

*Syntax:*

**(delay *expression* )**

This macro creates a promise that delays the evaluation of the given expression. This is a frontend to the procedure `make-promise`. The argument expression has to be pure.

#### **delay-nonpure**

*Syntax:*

```
(delay-nonpure expression )
```

This macro creates a promise that delays the evaluation of the given expression. This is a frontend to the procedure `make-promise`. The argument expression may be nonpure.

## 12.3 Parametrized Methods

### `force`

*Syntax:*

```
(force promise)
```

*Type parameters:* `%type`

*Arguments:*

```
Name: promise
Type: (:promise %type)
Description: A promise
```

*Result value:* The value of the promise

*Result type:* `%type`

*Purity of the procedure:* pure

This procedure evaluates the promise if it has not already been done and returns the value.

### `force-nonpure`

*Syntax:*

```
(force-nonpure promise)
```

*Type parameters:* `%type`

*Arguments:*



Name: **promise**  
Type: **(:nonpure-promise %type)**  
Description: A nonpure promise

*Result value:* The value of the promise

*Result type:* **%type**

*Purity of the procedure:* nonpure

This procedure evaluates the promise if it has not already been done and returns the value.

## **make-nonpure-promise**

*Syntax:*

**(make-nonpure-promise proc)**

*Type parameters:* **%type**

*Arguments:*

Name: **proc**  
Type: **(:procedure () %type nonpure)**  
Description: A procedure

*Result value:* A promise

*Result type:* **(:nonpure-promise %type)**

*Purity of the procedure:* pure

This procedure creates a promise that delays the evaluation of the given procedure.

## **make-promise**

*Syntax:*

**(make-promise proc)**

*Type parameters:* **%type**

*Arguments:*

Name: `proc`  
Type: `(:procedure () %type pure)`  
Description: A procedure

*Result value:* A promise

*Result type:* `(:promise %type)`

*Purity of the procedure:* pure

This procedure creates a promise that delays the evaluation of the given procedure. The procedure has to be pure.

## Chapter 13

# Module (standard-library stream)

Streams are kind of abstract sequences. A stream is defined by the following operations:

- *stream-value*: Return the current value of the stream.
- *stream-next*: Read one stream element forward and return the stream with the new element as its current value.
- *stream-empty?*: Return true iff the stream is empty.

See programs `test451.thp`, `test452.thp`, and `test453.thp` in directory `theme-d-code/tests` for examples.

### 13.1 Data Types

*Data type name:* `:stream`

*Type:* `:union`

*Number of type parameters:* 1

*Description:* A stream

*Data type name:* `:nonempty-stream`

*Type:* `:pair`

*Number of type parameters:* 1

*Description:* A nonempty stream

*Data type name:* `:nonpure-stream`

*Type:* `:union`

*Number of type parameters:* 1

*Description:* A nonpure stream

*Data type name:* `:nonempty-nonpure-stream`

*Type:* `:pair`

*Number of type parameters:* 1

*Description:* A nonempty nonpure stream

## 13.2 Simple Methods

### make-input-expr-stream

*Syntax:*

```
(make-input-expr-stream ip)
```

*Arguments:*

Name: `ip`  
Type: `<input-port>`  
Description: An input port

*Result value:* A nonpure stream that reads from the given input port

*Result type:* `(:nonpure-stream <object>)`

*Purity of the procedure:* pure

## 13.3 Parametrized Methods

### stream-value

*Syntax:*

```
(stream-value stm)
```

*Type parameters:* `%type`

*Arguments:*

Name: `stm`  
Type: `(:stream %type)`  
Description: A stream

*Result value:* The current value of the stream

*Result type:* `%type`

*Purity of the procedure:* pure

If the stream `stm` is empty this procedure raises an exception.

## `stream-next`

*Syntax:*

```
(stream-next stm)
```

*Type parameters:* `%type`

*Arguments:*

Name: `stm`  
Type: `(:stream %type)`  
Description: A stream

*Result value:* A stream located one step forward from the given stream

*Result type:* `(:stream %type)`

*Purity of the procedure:* pure

If the stream `stm` is empty this procedure raises an exception.

## `stream-empty?`

*Syntax:*

```
(stream-empty? stm)
```

*Type parameters:* `%type`

*Arguments:*

Name: `stm`  
Type: `(:stream %type)`  
Description: A stream

*Result value:* `#t` iff the stream is empty

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**stream->list***Syntax:*

```
(stream->list stm)
```

*Type parameters:* %type*Arguments:*

Name: **stm**  
Type: (:stream %type)  
Description: A stream

*Result value:* A list*Result type:* (:uniform-list %type)*Purity of the procedure:* pure

This procedure constructs a list by reading the stream until it is empty.

**list->stream***Syntax:*

```
(list->stream l)
```

*Type parameters:* %type*Arguments:*

Name: **stm**  
Type: (:uniform-list %type)  
Description: A list

*Result value:* A stream that processes the given list*Result type:* (:stream %type)*Purity of the procedure:* pure**nonpure-stream-value**

*Syntax:*

```
(nonpure-stream-value stm)
```

*Type parameters:* %type

*Arguments:*

Name: `stm`  
Type: `(:nonpure-stream %type)`  
Description: A nonpure stream

*Result value:* The current value of the stream

*Result type:* %type

*Purity of the procedure:* pure

If the stream `stm` is empty this procedure raises an exception.

## `nonpure-stream-next`

*Syntax:*

```
(nonpure-stream-next stm)
```

*Type parameters:* %type

*Arguments:*

Name: `stm`  
Type: `(:nonpure-stream %type)`  
Description: A nonpure stream

*Result value:* A nonpure stream located one step forward from the given nonpure-stream

*Result type:* `(:nonpure-stream %type)`

*Purity of the procedure:* nonpure

If the stream `stm` is empty this procedure raises an exception.

## `nonpure-stream-empty?`

*Syntax:*

```
(nonpure-stream-empty? stm)
```

*Type parameters:* %type

*Arguments:*

Name: `stm`  
Type: `(:nonpure-stream %type)`  
Description: A nonpure stream

*Result value:* `#t` iff the stream is empty

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## `nonpure-stream->list`

*Syntax:*

```
(nonpure-stream->list stm)
```

*Type parameters:* %type

*Arguments:*

Name: `stm`  
Type: `(:nonpure-stream %type)`  
Description: A nonpure stream

*Result value:* A list

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* nonpure

This procedure constructs a list by reading the stream until it is empty.

## `stream-map`

*Syntax:*



```
(stream-map proc stm)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `proc`  
Type: `(:procedure (%type1) %type2 pure)`  
Description: The procedure to be applied

Name: `stm`  
Type: `(:stream %type1)`  
Description: The source stream

*Result value:* The target stream

*Result type:* `(:stream %type2)`

*Purity of the procedure:* pure

This procedure applies the argument procedure to the source stream elements with delayed evaluation. Another stream is returned.

## stream-map-nonpure

*Syntax:*

```
(stream-map-nonpure proc stm)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `proc`  
Type: `(:procedure (%type1) %type2 nonpure)`  
Description: The procedure to be applied

Name: `stm`  
Type: `(:stream %type1)`  
Description: The source stream

*Result value:* The target stream

*Result type:* `(:nonpure-stream %type2)`

*Purity of the procedure:* nonpure

This procedure applies the argument procedure to the source stream elements with delayed evaluation. Another stream is returned. The applied procedure may have side effects and the result is a nonpure stream.

## stream-for-each

*Syntax:*

```
(stream-for-each proc stm)
```

*Type parameters:* %type1

*Arguments:*

Name: `proc`  
Type: `(:procedure (%type1) <none> nonpure)`  
Description: The procedure to be applied

Name: `stm`  
Type: `(:stream %type1)`  
Description: A stream

No result value.

*Purity of the procedure:* nonpure

This procedure applies the argument procedure to the source stream elements. The evaluation is not delayed and no value is returned.

## nonpure-stream-map

*Syntax:*

```
(nonpure-stream-map proc stm)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `proc`  
Type: `(:procedure (%type1) %type2 nonpure)`  
Description: The procedure to be applied

Name: `stm`  
Type: `(:nonpure-stream %type1)`  
Description: The source stream

*Result value:* The target stream

*Result type:* `(:nonpure-stream %type2)`

*Purity of the procedure:* nonpure

This procedure applies the argument procedure to the source nonpure stream elements with delayed evaluation. Another stream is returned. The applied procedure may have side effects and the result is a nonpure stream.

## nonpure-stream-for-each

*Syntax:*

```
(nonpure-stream-for-each proc stm)
```

*Type parameters:* `%type1`

*Arguments:*

Name: `proc`  
Type: `(:procedure (%type1) <none> nonpure)`  
Description: The procedure to be applied

Name: `stm`  
Type: `(:nonpure-stream %type1)`  
Description: A nonpure stream

No result value.

*Purity of the procedure:* nonpure

This procedure applies the argument procedure to the source nonpure stream elements. The evaluation is not delayed and no value is returned.



## Chapter 14

# Module (standard-library iterator)

This module implements purely functional iterators, see [1].

### 14.1 Data Types

*Data type name:* `:iterator`

*Type:* `<param-logical-type>`

*Number of type parameters:* 1

*Definition:* `(:param-proc (%target) ((:consumer %source %target)) %target pure)`

*Description:* An iterator

*Data type name:* `:iterator-inst`

*Type:* `<param-logical-type>`

*Number of type parameters:* 2

*Definition:* `(:procedure ((:consumer %source %target)) %target pure)`

*Description:* An instance of an iterator for which the target type or the iteration is fixed

*Data type name:* `:consumer`

*Type:* `<param-logical-type>`

*Number of type parameters:* 2

*Definition:* `(:procedure ((:maybe %source) <boolean> (:maybe (:iterator-inst %source %target))) %target pure)`

*Description:* A procedure that “consumes” values yielded by an iterator

### 14.2 Parametrized Methods

`end-iter`

*Syntax:*

```
(end-iter consumer)
```

*Type parameters:* %source, %target

*Arguments:*

```
Name: consumer
Type: (:consumer %source %target)
Description: A consumer procedure
```

*Result value:* Target object

*Result type:* %target

*Purity of the procedure:* pure

This procedure is used when the iterator reaches its end.

## gen-list

*Syntax:*

```
(gen-list l consumer iterator-inst)
```

*Type parameters:* %source, %target

*Arguments:*

```
Name: l
Type: (:uniform-list %source)
Description: A list for which to create an iterator
```

```
Name: consumer
Type: (:consumer %source %target)
Description: A consumer procedure
```

```
Name: iterator-inst
Type: (:iterator-inst %source %target)
Description: An iterator instance
```

*Result value:* Target object

*Result type:* %target

*Purity of the procedure:* pure

This procedure is used internally to create a list iterator.

## get-list-iterator

*Syntax:*

```
(get-list-iterator l)
```

*Type parameters:* %source

*Arguments:*

Name: l  
Type: (:uniform-list %source)  
Description: A list for which to create an iterator

*Result value:* An iterator for the given list

*Result type:* (:iterator %source)

*Purity of the procedure:* pure

This procedure is used to create a list iterator.

## gen-mutable-vector

*Syntax:*

```
(gen-mutable-vector v consumer iterator-inst)
```

*Type parameters:* %source, %target

*Arguments:*

Name: v  
Type: (:mutable-vector %source)  
Description: A mutable vector for which to create an iterator

Name: consumer  
Type: (:consumer %source %target)  
Description: A consumer procedure

Name: iterator-inst  
Type: (:iterator-inst %source %target)  
Description: An iterator instance

*Result value:* Target object

*Result type:* %target

*Purity of the procedure:* pure

This procedure is used internally to create a mutable vector iterator.

## get-mutable-vector-iterator

*Syntax:*

```
(get-mutable-vector-iterator v)
```

*Type parameters:* %source

*Arguments:*

Name: v

Type: (:mutable-vector %source)

Description: A mutable vector for which to create an iterator

*Result value:* An iterator for the given mutable vector

*Result type:* (:iterator %source)

*Purity of the procedure:* pure

This procedure is used to create an iterator for a mutable vector.

## iter-map1

*Syntax:*

```
(iter-map1 proc iterator)
```

*Type parameters:* %source, %component

*Arguments:*

Name: proc

Type: (:procedure (%source) %component pure)

Description: A procedure to apply to the given iterator

Name: iterator

Type: (:iterator %source)



Description: An iterator to iterate the given procedure

*Result value:* A list constructed by applying the given procedure to the values yielded by the iterator

*Result type:* (:uniform-list %component)

*Purity of the procedure:* pure

This procedure maps the given procedure to each element yielded by the iterator and constructs a list from the result values.

## iter-map2

*Syntax:*

```
(iter-map2 proc iterator1 iterator2)
```

*Type parameters:* %source1, %source2, %component

*Arguments:*

Name: `proc`

Type: (:procedure (%source1 %source2) %component pure)

Description: A procedure to apply to the given iterator

Name: `iterator1`

Type: (:iterator %source1)

Description: An iterator to iterate the given procedure

Name: `iterator2`

Type: (:iterator %source2)

Description: Another iterator to iterate the given procedure

*Result value:* A list constructed by applying the given procedure to the values yielded by the iterators

*Result type:* (:uniform-list %component)

*Purity of the procedure:* pure

This procedure maps pairwise the given procedure to all the elements yielded by the iterators and constructs a list from the result values.

## iter-every1

*Syntax:*

```
(iter-every1 proc iterator)
```

*Type parameters:* %source

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%source) <boolean> pure)`  
 Description: A procedure to apply to the given iterator

Name: `iterator`  
 Type: `(:iterator %source)`  
 Description: An iterator to iterate the given procedure

*Result value:* `#t` iff the procedure is returns true for all iterated values

*Result type:* `<boolean>`

*Purity of the procedure:* pure

This procedure maps the given procedure to each element yielded by the iterator and returns `#t` iff all the results are `#t`. If some application returns `#f` the application is terminated and `#f` returned.

## iter-every2

*Syntax:*

```
(iter-every2 proc iterator1 iterator2)
```

*Type parameters:* %source1, %source2

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%source1 %source2) <boolean> pure)`  
 Description: A procedure to apply to the given iterator

Name: `iterator1`  
 Type: `(:iterator %source1)`  
 Description: An iterator to iterate the given procedure

Name: `iterator2`  
 Type: `(:iterator %source2)`

Description: Another iterator to iterate the given procedure

*Result value:* **#t** iff the procedure returns true for all iterated values

*Result type:* **<boolean>**

*Purity of the procedure:* pure

This procedure maps pairwise the given procedure to all the elements yielded by the iterators and returns **#t** iff all the results are **#t**. If some application returns **#f** the application is terminated and **#f** returned.



## Chapter 15

# Module (standard-library nonpure-iterator)

This module `nonpure` implements nonpure iterators analogous to the purely functional ones presented in the previous section. Nonpure iterators are needed in following cases:

- The operation done to the values yielded by iterators has side effects, e.g. printing.
- The generation of values for an iterator has side effects, e.g. reading values from a file.

### 15.1 Data Types

*Data type name:* `:nonpure-iterator`

*Type:* `<param-logical-type>`

*Number of type parameters:* 1

*Definition:* `(:param-proc (%target) ((:nonpure-consumer %source %target)) %target nonpure)`

*Description:* An iterator

*Data type name:* `:nonpure-iterator-inst`

*Type:* `<param-logical-type>`

*Number of type parameters:* 2

*Definition:* `(:procedure ((:nonpure-consumer %source %target)) %target nonpure)`

*Description:* An instance of an iterator for which the target type or the iteration is fixed

*Data type name:* `:nonpure-consumer`

*Type:* `<param-logical-type>`

*Number of type parameters:* 2

*Definition:* `(:procedure ((:maybe %source) <boolean> (:maybe (:nonpure-iterator-inst %source %target)))) %target nonpure)`

*Description:* A procedure that “consumes” values yielded by an iterator

## 15.2 Parametrized Methods

### nonpure-end-iter

*Syntax:*

```
(nonpure-end-iter consumer)
```

*Type parameters:* %source, %target

*Arguments:*

```
Name: consumer
Type: (:nonpure-consumer %source %target)
Description: A consumer procedure
```

*Result value:* Target object

*Result type:* %target

*Purity of the procedure:* nonpure

This procedure is used when the iterator reaches its end.

### gen-list-nonpure

*Syntax:*

```
(gen-list-nonpure l consumer iterator-inst)
```

*Type parameters:* %source, %target

*Arguments:*

```
Name: l
Type: (:uniform-list %source)
Description: A list for which to create an iterator
```

```
Name: consumer
Type: (:nonpure-consumer %source %target)
Description: A consumer procedure
```

```
Name: iterator-inst
```

Type: `(:nonpure-iterator-inst %source %target)`

Description: An iterator instance

*Result value:* Target object

*Result type:* `%target`

*Purity of the procedure:* nonpure

This procedure is used internally to create a list iterator.

## get-list-nonpure-iterator

*Syntax:*

```
(get-list-nonpure-iterator l)
```

*Type parameters:* `%source`

*Arguments:*

Name: `l`

Type: `(:uniform-list %source)`

Description: A list for which to create an iterator

*Result value:* An iterator for the given list

*Result type:* `(:nonpure-iterator %source)`

*Purity of the procedure:* nonpure

This procedure is used to create a list iterator.

## gen-mutable-vector-nonpure

*Syntax:*

```
(gen-mutable-vector-nonpure v consumer iterator-inst)
```

*Type parameters:* `%source, %target`

*Arguments:*

Name: `v`

Type: `(:mutable-vector %source)`

Description: A mutable vector for which to create an iterator

Name: `consumer`

Type: `(:nonpure-consumer %source %target)`

Description: A consumer procedure

Name: `iterator-inst`

Type: `(:nonpure-iterator-inst %source %target)`

Description: An iterator instance

*Result value:* Target object

*Result type:* `%target`

*Purity of the procedure:* nonpure

This procedure is used internally to create a mutable vector iterator.

## `get-mutable-vector-nonpure-iterator`

*Syntax:*

```
(get-mutable-vector-nonpure-iterator v)
```

*Type parameters:* `%source`

*Arguments:*

Name: `v`

Type: `(:mutable-vector %source)`

Description: A mutable vector for which to create an iterator

*Result value:* An iterator for the given mutable vector

*Result type:* `(:nonpure-iterator %source)`

*Purity of the procedure:* nonpure

This procedure is used to create an iterator for a mutable vector.

## `nonpure-iter-map1`

*Syntax:*

```
(nonpure-iter-map1 proc iterator)
```



*Type parameters:* %source, %component

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%source) %component nonpure)`  
 Description: A procedure to apply to the given iterator

Name: `iterator`  
 Type: `(:nonpure-iterator %source)`  
 Description: An iterator to iterate the given procedure

*Result value:* A list constructed by applying the given procedure to the values yielded by the iterator

*Result type:* `(:uniform-list %component)`

*Purity of the procedure:* nonpure

This procedure maps the given procedure to each element yielded by the iterator and constructs a list from the result values.

## nonpure-iter-map2

*Syntax:*

```
(nonpure-iter-map2 proc iterator1 iterator2)
```

*Type parameters:* %source1, %source2, %component

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%source1 %source2) %component nonpure)`  
 Description: A procedure to apply to the given iterator

Name: `iterator1`  
 Type: `(:nonpure-iterator %source1)`  
 Description: An iterator to iterate the given procedure

Name: `iterator2`  
 Type: `(:nonpure-iterator %source2)`  
 Description: Another iterator to iterate the given procedure

*Result value:* A list constructed by applying the given procedure to the values yielded by the iterators

*Result type:* (:uniform-list %component)

*Purity of the procedure:* nonpure

This procedure maps pairwise the given procedure to all the elements yielded by the iterators and constructs a list from the result values.

## nonpure-iter-every1

*Syntax:*

```
(nonpure-iter-every1 proc iterator)
```

*Type parameters:* %source

*Arguments:*

    Name: `proc`

    Type: (:procedure (%source) <boolean> nonpure)

    Description: A procedure to apply to the given iterator

    Name: `iterator`

    Type: (:nonpure-iterator %source)

    Description: An iterator to iterate the given procedure

*Result value:* `#t` iff the procedure is returns true for all iterated values

*Result type:* <boolean>

*Purity of the procedure:* nonpure

This procedure maps the given procedure to each element yielded by the iterator and returns `#t` iff all the results are `#t`. If some application returns `#f` the application is terminated and `#f` returned.

## nonpure-iter-every2

*Syntax:*

```
(nonpure-iter-every2 proc iterator1 iterator2)
```

*Type parameters:* %source1, %source2

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%source1 %source2) <boolean> nonpure)`  
 Description: A procedure to apply to the given iterator

Name: `iterator1`  
 Type: `(:nonpure-iterator %source1)`  
 Description: An iterator to iterate the given procedure

Name: `iterator2`  
 Type: `(:nonpure-iterator %source2)`  
 Description: Another iterator to iterate the given procedure

*Result value:* `#t` iff the procedure is returns true for all iterated values  
*Result type:* `<boolean>`

*Purity of the procedure:* nonpure

This procedure maps pairwise the given procedure to all the elements yielded by the iterators and returns `#t` iff all the results are `#t`. If some application returns `#f` the application is terminated and `#f` returned.

## nonpure-iter-for-each1

*Syntax:*

```
(nonpure-iter-for-each1 proc iterator)
```

*Type parameters:* `%source`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%source) <none> nonpure)`  
 Description: A procedure to apply to the given iterator

Name: `iterator`  
 Type: `(:nonpure-iterator %source)`  
 Description: An iterator to iterate the given procedure

No result value.

*Purity of the procedure:* nonpure

This procedure maps the given procedure to each element yielded by the iterator.

**nonpure-iter-for-each2***Syntax:*

```
(nonpure-iter-for-each2 proc iterator1 iterator2)
```

*Type parameters:* %source1, %source2*Arguments:*

Name: **proc**  
 Type: (:procedure (%source1 %source2) <none> nonpure)  
 Description: A procedure to apply to the given iterator

Name: **iterator1**  
 Type: (:nonpure-iterator %source1)  
 Description: An iterator to iterate the given procedure

Name: **iterator2**  
 Type: (:nonpure-iterator %source2)  
 Description: Another iterator to iterate the given procedure

No result value.

*Purity of the procedure:* nonpure

This procedure maps pairwise the given procedure to all the elements yielded by the iterators.

**gen-generator***Syntax:*

```
(gen-generator generator terminate? consumer iterator-inst)
```

*Type parameters:* %source, %target*Arguments:*

Name: **generator**  
 Type: (:procedure () %source nonpure)  
 Description: A generator from which to create an iterator

Name: **terminate?**

Type: `(:procedure (%source) <boolean> pure)`

Description: A procedure that determines when to end the iteration

Name: `consumer`

Type: `(:nonpure-consumer %source %target)`

Description: A consumer procedure

Name: `iterator-inst`

Type: `(:nonpure-iterator-inst %source %target)`

Description: An iterator instance

*Result value:* Target object

*Result type:* `%target`

*Purity of the procedure:* nonpure

This procedure is used internally to create an iterator from a generator.

## generator->iterator

*Syntax:*

```
(generator->iterator generator terminate?)
```

*Type parameters:* `%source`

*Arguments:*

Name: `generator`

Type: `(:procedure () %source nonpure)`

Description: A generator from which to create an iterator

Name: `terminate?`

Type: `(:procedure (%source) <boolean> pure)`

Description: A procedure that determines when to end the iteration

*Result value:* An iterator for the given generator

*Result type:* `(:nonpure-iterator %source)`

*Purity of the procedure:* nonpure

This procedure is used to create an iterator that obtains its values from a generator.



## Chapter 16

# Module (standard-library object-string-conversion)

This module contains procedures to compute string output for different objects.

### 16.1 Simple Methods

`general-object->string`

*Syntax:*

`(general-object->string obj)`

*Arguments:*

Name: `obj`  
Type: `<object>`  
Description: Any object

*Result value:* The name of the class of the object enclosed in square brackets

*Result type:* `<string>`

*Purity of the procedure:* pure

This procedure is used as the default implementation of generic procedure `object->string` in case no explicit method is defined.

`boolean->string`

*Syntax:*

```
(boolean->string obj)
```

*Arguments:*

Name: `obj`  
 Type: `<boolean>`  
 Description: A boolean value

*Result value:* `"#t"` or `"#f"`

*Result type:* `<string>`

*Purity of the procedure:* pure

## character->string

*Syntax:*

```
(character->string obj)
```

*Arguments:*

Name: `obj`  
 Type: `<character>`  
 Description: A character value

*Result value:* Return a string consisting of the given character

*Result type:* `<string>`

*Purity of the procedure:* pure

## integer->string

*Syntax:*

```
(integer->string obj)
```

*Arguments:*



Name: `obj`  
Type: `<integer>`  
Description: An integer value

*Result value:* Output string for the given value

*Result type:* `<string>`

*Purity of the procedure:* pure

## `null->string`

*Syntax:*

```
(null->string obj)
```

*Arguments:*

Name: `obj`  
Type: `<null>`  
Description: `null`

*Result value:* `()`

*Result type:* `<string>`

*Purity of the procedure:* pure

## `real->string`

*Syntax:*

```
(real->string obj)
```

*Arguments:*

Name: `obj`  
Type: `<real>`  
Description: A real value

*Result value:* Output string for the given value

*Result type:* `<string>`

*Purity of the procedure:* pure

## string->string

*Syntax:*

```
(string->string obj)
```

*Arguments:*

Name: obj  
 Type: <string>  
 Description: A string

*Result value:* The same string as the argument

*Result type:* <string>

*Purity of the procedure:* pure

## symbol->string

*Syntax:*

```
(symbol->string obj)
```

*Arguments:*

Name: obj  
 Type: <symbol>  
 Description: A symbol

*Result value:* Output string for the given value

*Result type:* <string>

*Purity of the procedure:* pure

## pair->string

*Syntax:*

```
(pair->string obj)
```

*Arguments:*

Name: `p`  
Type: `<pair>`  
Description: A pair

*Result value:* Output string for the given value

*Result type:* `<string>`

*Purity of the procedure:* pure

This procedure converts pairs, lists and tree structures implemented with pairs to strings. Method `object->string` is called recursively for the contents. This procedure should be safe for cyclic structures.

## `string->symbol`

*Syntax:*

```
(string->symbol str)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string

*Result value:* The argument string converted to a symbol

*Result type:* `<symbol>`

*Purity of the procedure:* pure

## `string->integer`

*Syntax:*

```
(string->integer str)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string

*Result value:* The argument string converted to an integer

*Result type:* `<integer>`

*Purity of the procedure:* pure

If the string cannot be converted to an integer an RTE exception is raised.

## string->real

*Syntax:*

```
(string->real str)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string

*Result value:* The argument string converted to a real

*Result type:* `<real>`

*Purity of the procedure:* pure

If the string cannot be converted to a real an RTE exception is raised.

## 16.2 Virtual Methods

```
object->string: (<object>) → <string> pure  =  general-object->string
object->string: (<integer>) → <string> pure  =  integer->string
object->string: (<real>) → <string> pure    =  real->string
object->string: (<string>) → <string> pure   =  string->string
object->string: (<symbol>) → <string> pure   =  symbol->string
object->string: (<null>) → <string> pure    =  null->string
object->string: (<character>) → <string> pure =  character->string
object->string: (<boolean>) → <string> pure  =  boolean->string
object->string: (<pair>) → <string> pure    =  pair->string
```

## Chapter 17

# Module (standard-library bytevector)

### 17.1 Data Types

*Data type name:* <bytevector>

*Type:* <class>

*Description:* A vector of bytes

### 17.2 Simple Methods

#### make-bytevector

*Syntax:*

```
(make-bytevector length fill)
```

*Arguments:*

Name: `length`

Type: <integer>

Description: The length of the new bytevector

Name: `fill`

Type: <integer>

Description: The value to fill the bytevector

*Result value:* A new bytevector

*Result type:* <bytevector>

*Purity of the procedure:* pure

Argument `fill` has to be in range -128 ... 255.

## bytevector

*Syntax:*

(bytevector byte-1 ... byte-n)

*Arguments:*

Name: `byte-k`

Type: `<integer>`

Description: The contents of the new bytevector

*Result value:* A new bytevector

*Result type:* `<bytevector>`

*Purity of the procedure:* pure

Arguments `byte-k` have to be in range 0 ... 255.

## native-endianness

*Syntax:*

(native-endianness)

No arguments.

*Result value:* The native endianness of the system

*Result type:* `<symbol>`

*Purity of the procedure:* pure

This procedure returns a symbol describing the native endianness of the system. The value can be e.g. `little` or `big`.

## bytevector-copy

*Syntax:*

`(bytevector-copy bytevector)`

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`  
Description: The bytevector to copy

*Result value:* A new bytevector

*Result type:* `<bytevector>`

*Purity of the procedure:* pure

This procedure creates a copy of the given bytevector.

## `bytevector-length`

*Syntax:*

`(bytevector-length bytevector)`

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`  
Description: A bytevector

*Result value:* The length of the bytevector

*Result type:* `<integer>`

*Purity of the procedure:* pure

## `bytevector-fill!`

*Syntax:*

`(bytevector-fill! bytevector value)`

*Arguments:*

Name: `bytevector`

Type: `<bytevector>`  
Description: A bytevector

Name: `value`  
Type: `<integer>`  
Description: An integer

No result value.

*Purity of the procedure:* nonpure

This procedure fills the bytevector with the given byte.

## **bytevector-copy!**

*Syntax:*

```
(bytevector-copy! source source-start target target-start count)
```

*Arguments:*

Name: `source`  
Type: `<bytevector>`  
Description: A bytevector to copy from

Name: `source-start`  
Type: `<integer>`  
Description: Source index to start copying

Name: `target`  
Type: `<bytevector>`  
Description: A bytevector where to copy

Name: `target-start`  
Type: `<integer>`  
Description: Target index to start copying

Name: `count`  
Type: `<integer>`  
Description: Number of bytes to copy

No result value.

*Purity of the procedure:* nonpure



This procedure copies `count` bytes from the source into the target. The source and the target may overlap.

## `u8-list->bytevector`

*Syntax:*

```
(u8-list->bytevector lst)
```

*Arguments:*

Name: `lst`  
Type: `(:uniform-list <integer>)`  
Description: A list of bytes

*Result value:* A bytevector

*Result type:* `<bytevector>`

*Purity of the procedure:* pure

This procedure creates the bytevector consisting of the elements of the list. The values of the list have to be in range 0 ... 255.

## `bytevector->u8-list`

*Syntax:*

```
(bytevector->u8-list bytevector)
```

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`  
Description: A bytevector

*Result value:* A list of integers

*Result type:* `(:uniform-list <integer>)`

*Purity of the procedure:* pure

This procedure creates a list consisting of the elements of the bytevector.

## bytevector-u8-ref

*Syntax:*

```
(bytevector-u8-ref bytevector index)
```

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`  
Description: A bytevector

Name: `index`  
Type: `<integer>`  
Description: The index where to fetch the value

*Result value:* The element at position `index` interpreted as an unsigned value

*Result type:* `<integer>`

*Purity of the procedure:* pure

## bytevector-s8-ref

*Syntax:*

```
(bytevector-s8-ref bytevector index)
```

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`  
Description: A bytevector

Name: `index`  
Type: `<integer>`  
Description: The index where to fetch the value

*Result value:* The element at position `index` interpreted as a signed value

*Result type:* `<integer>`

*Purity of the procedure:* pure

## bytevector-u16-ref

`bytevector-s16-ref`

`bytevector-u32-ref`

`bytevector-s32-ref`

`bytevector-u64-ref`

`bytevector-s64-ref`

*Syntax:*

`(bytevector-xxx-ref bytevector index endianness)`

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`  
Description: A bytevector

Name: `index`  
Type: `<integer>`  
Description: The index where to fetch the value

Name: `endianness`  
Type: `<symbol>`  
Description: The endianness of the bytevector

*Result value:* The element at position `index` interpreted as an integer value

*Result type:* `<integer>`

*Purity of the procedure:* pure

These procedures fetch unsigned or signed integer values from a bytevector.

`bytevector-u8-set!`

*Syntax:*

`(bytevector-u8-set! bytevector index value)`

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`

Description: A bytevector

Name: `index`

Type: `<integer>`

Description: The index where to set the value

Name: `value`

Type: `<integer>`

Description: The value to set

No result value.

*Purity of the procedure:* nonpure

The value has to be in range 0 ... 255.

## `bytevector-s8-set!`

*Syntax:*

`(bytevector-s8-set! bytevector index value)`

*Arguments:*

Name: `bytevector`

Type: `<bytevector>`

Description: A bytevector

Name: `index`

Type: `<integer>`

Description: The index where to set the value

Name: `value`

Type: `<integer>`

Description: The value to set

No result value.

*Purity of the procedure:* nonpure

The value has to be in range -128 ... 127.

## `bytevector-u16-set!`

## `bytevector-s16-set!`

`bytevector-u32-set!`

`bytevector-s32-set!`

`bytevector-u64-set!`

`bytevector-s64-set!`

*Syntax:*

```
(bytevector-xxx-set! bytevector index value endianness)
```

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`  
Description: A bytevector

Name: `index`  
Type: `<integer>`  
Description: The index where to set the value

Name: `value`  
Type: `<integer>`  
Description: The value to set

Name: `endianness`  
Type: `<symbol>`  
Description: The endianness of the bytevector

No result value.

*Purity of the procedure:* nonpure

`bytevector-ieee-single-ref`

*Syntax:*

```
(bytevector-ieee-single-ref bytevector index endianness)
```

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`

Description: A bytevector

Name: `index`

Type: `<integer>`

Description: The index where to fetch the value

Name: `endianness`

Type: `<symbol>`

Description: The endianness of the bytevector

*Result value:* The element at position `index` interpreted as an IEEE single real value

*Result type:* `<real>`

*Purity of the procedure:* pure

## bytevector-ieee-double-ref

*Syntax:*

(bytevector-ieee-double-ref bytevector index endianness)

*Arguments:*

Name: `bytevector`

Type: `<bytevector>`

Description: A bytevector

Name: `index`

Type: `<integer>`

Description: The index where to fetch the value

Name: `endianness`

Type: `<symbol>`

Description: The endianness of the bytevector

*Result value:* The element at position `index` interpreted as an IEEE double real value

*Result type:* `<real>`

*Purity of the procedure:* pure

## bytevector-ieee-single-set!

*Syntax:*

```
(bytevector-ieee-single-set! bytevector index value endianness)
```

*Arguments:*

Name: **bytevector**  
Type: **<bytevector>**  
Description: A bytevector

Name: **index**  
Type: **<integer>**  
Description: The index where to set the value

Name: **value**  
Type: **<real>**  
Description: The value to set

Name: **endianness**  
Type: **<symbol>**  
Description: The endianness of the bytevector

No result value.

*Purity of the procedure:* nonpure

## bytevector-ieee-double-set!

*Syntax:*

```
(bytevector-ieee-double-set! bytevector index value endianness)
```

*Arguments:*

Name: **bytevector**  
Type: **<bytevector>**  
Description: A bytevector

Name: **index**  
Type: **<integer>**  
Description: The index where to set the value

Name: `value`  
Type: `<real>`  
Description: The value to set

Name: `endianness`  
Type: `<symbol>`  
Description: The endianness of the bytevector

No result value.

*Purity of the procedure:* nonpure

## `string->utf8`

*Syntax:*

```
(string->utf8 str)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string

*Result value:* The string converted to UTF-8

*Result type:* `<bytevector>`

*Purity of the procedure:* pure

## `string->utf16`

*Syntax:*

```
(string->utf16 str endianness)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string



Name: `endianness`  
Type: `<symbol>`  
Description: The endianness of the string

*Result value:* The string converted to UTF-16

*Result type:* `<bytevector>`

*Purity of the procedure:* pure

## `string->utf32`

*Syntax:*

```
(string->utf32 str endianness)
```

*Arguments:*

Name: `str`  
Type: `<string>`  
Description: A string

Name: `endianness`  
Type: `<symbol>`  
Description: The endianness of the string

*Result value:* The string converted to UTF-32

*Result type:* `<bytevector>`

*Purity of the procedure:* pure

## `utf8->string`

*Syntax:*

```
(utf8->string bytevector)
```

*Arguments:*

Name: `bytevector`  
Type: `<bytevector>`  
Description: A bytevector containing UTF-8 data

*Result value:* The UTF-8 data converted to string

*Result type:* `<string>`

*Purity of the procedure:* pure

## utf16->string

*Syntax:*

```
(utf16->string bytevector endiannedd)
```

*Arguments:*

Name: `bytevector`

Type: `<bytevector>`

Description: A bytevector containing UTF-16 data

Name: `endianness`

Type: `<symbol>`

Description: The endianness of the bytevector

*Result value:* The UTF-16 data converted to string

*Result type:* `<string>`

*Purity of the procedure:* pure

## utf32->string

*Syntax:*

```
(utf16->string bytevector endiannedd)
```

*Arguments:*

Name: `bytevector`

Type: `<bytevector>`

Description: A bytevector containing UTF-32 data

Name: `endianness`

Type: `<symbol>`

Description: The endianness of the bytevector

*Result value:* The UTF-32 data converted to string

*Result type:* `<string>`

*Purity of the procedure:* pure



## Chapter 18

# Module (standard-library files)

### 18.1 Data Types

*Data type name:* <eof>

*Type:* <class>

*Description:* The class of an end-of-file object. The behaviour of end-of-file objects follows R7RS [2].

*Data type name:* <input-port>

*Type:* <class>

*Description:* An input port (input file)

*Data type name:* <output-port>

*Type:* <class>

*Description:* An output port (output file)

### 18.2 Simple Methods

#### make-eof

*Syntax:*

(make-eof )

No arguments.

*Result value:* And end-of-file object

*Result type:* <eof>

*Purity of the procedure:* nonpure

This procedure returns an end-of-file object. See the start of this section. This procedure is not pure since R7RS [2] does not guarantee the purity of the Scheme procedure `eof-object`.

## `eof?`

*Syntax:*

```
(eof? obj)
```

*Arguments:*

Name: `obj`  
Type: `<object>`  
Description: An arbitrary object

*Result value:* `#t` iff `obj` is an eof object

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## `open-input-file`

*Syntax:*

```
(open-input-file filename)
```

*Arguments:*

Name: `filename`  
Type: `<string>`  
Description: Name of the file to be opened

*Result value:* An object representing the opened file

*Result type:* `<input-port>`

This procedure opens an input file. If the operation fails an exception (`io-error` `error-opening-input-file` *filename*) is raised.

## `open-output-file`

*Syntax:*

```
(open-output-file filename)
```

*Arguments:*

Name: `filename`

Type: `<string>`

Description: Name of the file to be opened

*Result value:* An object representing the opened file

*Result type:* `<output-port>`

This procedure opens an output file. If the operation fails an exception (`io-error` `error-opening-output-file` *filename*) is raised.

## close-input-port

*Syntax:*

```
(close-input-port input-port)
```

*Arguments:*

Name: `input-port`

Type: `<input-port>`

Description: The input port to be closed

No result value.

## close-output-port

*Syntax:*

```
(close-output-port output-port)
```

*Arguments:*

Name: `output-port`

Type: `<output-port>`

Description: The output port to be closed

No result value.

## flush-all-ports

*Syntax:*

```
(flush-all-ports )
```

No arguments.

No result value.

*Purity of the procedure:* nonpure

Flush all ports.



## Chapter 19

# Module (standard-library text-file-io)

This module implements input and output for text files. This module also reexports module (standard-library files).

### 19.1 Simple Methods

#### character-ready?

*Syntax:*

```
(character-ready? input-port)
```

*Arguments:*

Name: `input-port`  
Type: `<input-port>`  
Description: The input port to check

*Result value:* `#t` iff there is a character ready in the given input port

*Result type:* `<boolean>`

On i/o error exception (`io-error character-ready?:runtime-error filename`) is raised.

#### current-input-port

*Syntax:*

`(current-input-port)`

No arguments.

*Result value:* The current input port

*Result type:* `<input-port>`

## `current-output-port`

*Syntax:*

`(current-output-port)`

No arguments.

*Result value:* The current output port

*Result type:* `<output-port>`

## `write-character`

*Syntax:*

`(write-character output-port ch)`

*Arguments:*

Name: `output-port`

Type: `<output-port>`

Description: An output port where to write

Name: `ch`

Type: `<character>`

Description: A character to be written

No result value.

This procedure writes the external representation of a character in the specified output port. If the operation fails an exception (`io-error` `error-displaying-object filename`) is raised.

## write-string

*Syntax:*

```
(write-string output-port str)
```

*Arguments:*

Name: `output-port`  
Type: `<output-port>`  
Description: An output port where to write

Name: `str`  
Type: `<string>`  
Description: A string to be written

No result value.

This procedure writes the external representation of a string into the specified output port. If the operation fails an exception (`io-error` `error-displaying-object filename`) is raised.

## write-line

*Syntax:*

```
(write-line output-port obj)
```

*Arguments:*

Name: `output-port`  
Type: `<output-port>`  
Description: An output port where to write

Name: `obj`  
Type: `<object>`  
Description: An object to be written

No result value.

This function uses the generic procedure `write` to write the object and prints a newline after that.

## display-character

*Syntax:*

```
(display-character output-port ch)
```

*Arguments:*

Name: `output-port`

Type: `<output-port>`

Description: An output port where to display

Name: `ch`

Type: `<character>`

Description: A character to be displayed

No result value.

This procedure displays a character into the given output port. If the operation fails an exception (`io-error error-displaying-object filename`) is raised.

## display-string

*Syntax:*

```
(display-string output-port str)
```

*Arguments:*

Name: `output-port`

Type: `<output-port>`

Description: An output port where to display

Name: `str`

Type: `<string>`

Description: A string to be displayed

No result value.

This procedure displays a string into the given output port. If the operation fails an exception (`io-error error-displaying-object filename`) is raised.

## display-line

*Syntax:*

```
(display-line output-port obj)
```

*Arguments:*

Name: `output-port`  
Type: `<output-port>`  
Description: An output port where to display

Name: `obj`  
Type: `<object>`  
Description: An object to be displayed

No result value.

This function uses the generic procedure `display` to display the object and prints a newline.

## `newline`

*Syntax:*

```
(newline output-port)
```

*Arguments:*

Name: `output-port`  
Type: `<output-port>`  
Description: An output port where to print

No result value.

This procedure prints a newline to the given output port. If the operation fails an exception (`io-error error-displaying-newline filename`) is raised.

## `peek-character`

*Syntax:*

```
(peek-character input-port)
```

*Arguments:*

Name: `input-port`  
 Type: `<input-port>`  
 Description: An input port where to read from

*Result value:* The read character or an eof object

*Result type:* `(:union <character> <eof>)`

This procedure peeks a character from an input port. On i/o error an exception (`io-error peek-character:io-error filename`) is raised.

## read

*Syntax:*

```
(read input-port)
```

*Arguments:*

Name: `input-port`  
 Type: `<input-port>`  
 Description: An input port where to read from

*Result value:* The object read or an eof object

*Result type:* `<object>`

This procedure reads a Theme-D expression from an input port. The Theme-D runtime environment checks that the result object does not contain any data types unknown to Theme-D. On i/o error an exception (`io-error read:io-error filename`) is raised. If a Scheme vector constant is encountered in the data raise exception (`io-error io:illegal-vector filename`). If a Scheme complex number is encountered in the data raise exception (`io-error io:illegal-complex-number filename`). On some other Scheme object whose data type is not known by Theme-D raise exception (`io-error io:illegal-data-type filename`).

## read-all

*Syntax:*

```
(read-all input-port)
```

*Arguments:*

Name: `input-port`  
 Type: `<input-port>`

Description: An input port where to read from

*Result value:* The objects read

*Result type:* <object>

This procedure uses procedure `read` to read all the expressions from the given input-port.

## read-character

*Syntax:*

```
(read-character input-port)
```

*Arguments:*

Name: `input-port`

Type: <input-port>

Description: An input port where to read from

*Result value:* The read character or an eof object

*Result type:* (:union <character> <eof>)

This procedure reads a character from an input port. On i/o error an exception (`io-error read-character:io-error filename`) is raised.

## read-line

*Syntax:*

```
(read-line input-port)
```

*Arguments:*

Name: `input-port`

Type: <input-port>

Description: An input port where to read from

*Result value:* Contents of a line

*Result type:* <string>

This procedure reads a single line from the given input port as a string. On i/o error an exception (`io-error read-character:io-error filename`) is raised.

## read-string

*Syntax:*

```
(read-string input-port)
```

*Arguments:*

Name: `input-port`

Type: `<input-port>`

Description: An input port where to read from

*Result value:* The contents of the file

*Result type:* `<string>`

This procedure reads the contents of the given input port as a single string.

## call-with-input-string

*Syntax:*

```
(call-with-input-string str proc)
```

*Arguments:*

Name: `str`

Type: `<string>`

Description: A string where to read from

Name: `proc`

Type: `(:procedure (<input-port>) <object> nonpure)`

Description: A procedure to call

*Result value:* The object returned by the procedure

*Result type:* `<object>`

This procedure creates an input port whose input comes from the argument string and passes it to the given procedure.

## call-with-output-string

*Syntax:*



```
(call-with-output-string proc)
```

*Arguments:*

Name: `proc`  
 Type: `(:procedure (<output-port>) <none> nonpure)`  
 Description: A procedure to call

*Result value:* A string consisting of the output of the procedure

*Result type:* `<string>`

This procedure creates an output port and passes it to the given procedure. A string consisting of the output of the procedure into the port is returned.

## 19.2 Virtual Methods

```
display: (<output-port> <object>) → <none>
display: (<output-port> <null>) → <none>
display: (<output-port> <boolean>) → <none>
display: (<output-port> <integer>) → <none>
display: (<output-port> <real>) → <none>
display: (<output-port> <string>) → <none>
display: (<output-port> <character>) → <none>
display: (<output-port> <symbol>) → <none>
display: (<output-port> <pair>) → <none>
```

These methods display an object as a string in the specified port.

```
write: (<output-port> <object>) → <none>
write: (<output-port> <null>) → <none>
write: (<output-port> <boolean>) → <none>
write: (<output-port> <integer>) → <none>
write: (<output-port> <real>) → <none>
write: (<output-port> <string>) → <none>
write: (<output-port> <character>) → <none>
write: (<output-port> <symbol>) → <none>
write: (<output-port> <pair>) → <none>
```

These methods write the external representation of an object to the specified port for primitive objects.

You may define methods `write` and `display` for your own classes. It is usually better to define method `object->string` instead of method `display`. Note that generic procedure `write` calls `display` by default.



## Chapter 20

# Module (standard-library console-io)

This module implements input and output for the standard input and standard output.

### 20.1 Simple Methods

#### console-character-ready?

*Syntax:*

```
(console-character-ready?)
```

No arguments.

*Result value:* `#t` iff there is a character ready in the standard input

*Result type:* `<boolean>`

#### console-display

*Syntax:*

```
(console-display obj)
```

*Arguments:*

Name: `obj`  
Type: `<object>`  
Description: An object to be displayed

No result value.

This function uses the procedure `atom-to-string` to obtain the string representation of the object and displays the string with procedure `console-display-string`.

## `console-display-character`

*Syntax:*

```
(console-display-character ch)
```

*Arguments:*

Name: `ch`  
Type: `<character>`  
Description: A character to be displayed

No result value.

## `console-display-line`

*Syntax:*

```
(console-display-line obj)
```

*Arguments:*

Name: `obj`  
Type: `<object>`  
Description: An object to be displayed

No result value.

This function uses the procedure `atom-to-string` to obtain the string representation of the object and displays the string with procedure `console-display-string`. A newline is displayed after the object.

## console-display-string

*Syntax:*

```
(console-display-string str)
```

*Arguments:*

Name: `str`

Type: `<string>`

Description: A string to be displayed

No result value.

## console-newline

*Syntax:*

```
(console-newline)
```

No arguments.

No result value.

This procedure prints a newline to the standard output.

## console-read

*Syntax:*

```
(console-read)
```

No arguments.

*Result value:* The object read or an eof object

*Result type:* `<object>`

The Theme-D runtime environment checks that the result object does not contain any data types unknown to Theme-D.

## console-read-character

*Syntax:*

```
(console-read-character)
```

No arguments.

*Result value:* The read character or an eof object

*Result type:* (:union <character> <eof>)

This procedure reads a character from the standard input.

## console-write

*Syntax:*

```
(console-write obj)
```

*Arguments:*

Name: `obj`

Type: <object>

Description: An object to be written

No result value.

This function uses the procedure `atom-to-string` to obtain the source code representation of the object and displays the string with procedure `console-display-string`.

## console-write-line

*Syntax:*

```
(console-write-line obj)
```

*Arguments:*

Name: `obj`

Type: <object>

Description: An object to be written

No result value.

This function uses the procedure `atom-to-string` to obtain the source code representation of the object and displays the string with procedure `console-display-string`. A newline is written after the object.





## Chapter 21

# Module (standard-library binary-file-io)

This module implements input and output for binary files. This module also reexports module (standard-library files). The input procedures return generally an EOF if there is nothing to read in the input port.

### 21.1 Simple Methods

#### get-u8

*Syntax:*

```
(get-u8 input-port)
```

*Arguments:*

Name: `input-port`

Type: `<input-port>`

Description: The input port to read

*Result value:* A byte read from the input port

*Result type:* `(:union <integer> <eof>)`

*Purity of the procedure:* nonpure

#### lookahead-u8

*Syntax:*`(lookahead-u8 input-port)`*Arguments:*

Name: `input-port`  
 Type: `<input-port>`  
 Description: The input port to read

*Result value:* A byte read from the input port*Result type:* `(:union <integer> <eof>)`*Purity of the procedure:* nonpure

This procedure reads a byte from the input stream without advancing the file position.

## `get-bytevector-n`

*Syntax:*`(get-bytevector-n input-port count)`*Arguments:*

Name: `input-port`  
 Type: `<input-port>`  
 Description: The input port to read

Name: `count`  
 Type: `<integer>`  
 Description: number of bytes to read

*Result value:* A bytevector read from the input port*Result type:* `(:union <bytevector> <eof>)`*Purity of the procedure:* nonpure

This procedure reads at most `count` bytes from the input port.

## `get-bytevector-n!`

*Syntax:*

```
(get-bytevector-n! input-port bytevector start count)
```

*Arguments:*

Name: `input-port`

Type: `<input-port>`

Description: The input port to read

Name: `bytevector`

Type: `<bytevector>`

Description: bytevector where to read

Name: `start`

Type: `<integer>`

Description: index where to start reading bytes

Name: `count`

Type: `<integer>`

Description: number of bytes to read

*Result value:* The number of bytes read or EOF

*Result type:* `(:union <integer> <eof>)`

*Purity of the procedure:* nonpure

This procedure reads at most `count` bytes from the input port.

## get-bytevector-some

*Syntax:*

```
(get-bytevector-some input-port)
```

*Arguments:*

Name: `input-port`

Type: `<input-port>`

Description: The input port to read

*Result value:* A bytevector read from the input port

*Result type:* `(:union <bytevector> <eof>)`

*Purity of the procedure:* nonpure

This procedure reads some bytes from the input port.

## get-bytevector-some!

*Syntax:*

```
(get-bytevector-some! input-port bytevector start count)
```

*Arguments:*

Name: `input-port`  
Type: `<input-port>`  
Description: The input port to read

Name: `bytevector`  
Type: `<bytevector>`  
Description: bytevector where to read

Name: `start`  
Type: `<integer>`  
Description: index where to start reading bytes

Name: `count`  
Type: `<integer>`  
Description: number of bytes to read

*Result value:* The number of bytes read or EOF

*Result type:* `(:union <integer> <eof>)`

*Purity of the procedure:* nonpure

This procedure reads at most `count` bytes from the input port.

## get-bytevector-all

*Syntax:*

```
(get-bytevector-all input-port)
```

*Arguments:*

Name: `input-port`  
Type: `<input-port>`

Description: The input port to read

*Result value:* A bytevector read from the input port

*Result type:* (:union <bytevector> <eof>)

*Purity of the procedure:* nonpure

This procedure reads all the bytes from the input port until end-of-file is reached. If no data is available EOF is returned.

## unget-bytevector

*Syntax:*

```
(unget-bytevector input-port bytevector start count)
```

*Arguments:*

Name: **input-port**

Type: <input-port>

Description: The input port to read

Name: **bytevector**

Type: <bytevector>

Description: bytevector to unget

Name: **start**

Type: <integer>

Description: index where to start reading bytes

Name: **count**

Type: <integer>

Description: number of bytes to read

No result value.

*Purity of the procedure:* nonpure

This procedure puts **count** bytes from **bytevector** starting from index **start** into the input port so that the inserted bytes are available for the subsequent read operations.

## put-u8

*Syntax:*

```
(put-u8 output-port octet)
```

*Arguments:*

Name: `output-port`  
 Type: `<output-port>`  
 Description: The output port to write

Name: `octet`  
 Type: `<integer>`  
 Description: octet to write

No result value.

*Purity of the procedure:* nonpure

This procedure writes the octet into the output port.

## put-bytevector

*Syntax:*

```
(put-bytevector output-port bytevector start count)
```

*Arguments:*

Name: `output-port`  
 Type: `<output-port>`  
 Description: The output port to write

Name: `bytevector`  
 Type: `<bytevector>`  
 Description: bytevector where to take the octets

Name: `start`  
 Type: `<integer>`  
 Description: index where to start

Name: `count`  
 Type: `<integer>`  
 Description: number of bytes to write

No result value.

*Purity of the procedure:* nonpure

This procedure writes **count** bytes starting from index **start** into the output port.

## put-whole-bytevector

*Syntax:*

```
(put-whole-bytevector output-port bytevector)
```

*Arguments:*

Name: **output-port**

Type: **<output-port>**

Description: The output port to write

Name: **bytevector**

Type: **<bytevector>**

Description: bytevector where to take the octets

No result value.

*Purity of the procedure:* nonpure

This procedure writes the contents of the bytevector into the output port.





## Chapter 22

# Module (standard-library system)

### 22.1 Simple Methods

#### `delete-file`

*Syntax:*

```
(delete-file str-filename)
```

*Arguments:*

Name: `str-filename`

Type: `<string>`

Description: The name of the file to be deleted

No result value.

*Purity of the procedure:* nonpure

This procedure deletes the named file. If the file does not exist an exception is raised.

#### `file-exists?`

*Syntax:*

```
(file-exists? str-filename)
```

*Arguments:*

Name: `str-filename`  
Type: `<string>`  
Description: The name of the file

*Result value:* Returns `#t` iff the file exists

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## `getenv`

*Syntax:*

```
(getenv str-var-name)
```

*Arguments:*

Name: `str-var-name`  
Type: `<string>`  
Description: The name of the environment variable

*Result value:* The value of the given environment variable

*Result type:* `(:alt-maybe <string>)`

*Purity of the procedure:* pure

If the environment variable does not exist return `#f`.

## `setenv`

*Syntax:*

```
(setenv str-var-name str-value)
```

*Arguments:*

Name: `str-var-name`  
Type: `<string>`  
Description: The name of the environment variable

Name: `str-value`

Type: `(:alt-maybe <string>)`

Description: The new value of the environment variable

No result value.

*Purity of the procedure:* nonpure

If `str-value` is `#f` remove the variable from the current environment.



## Chapter 23

# Module (standard-library rational)

### 23.1 Data Types

*Data type name:* <rational>

*Type:* <class>

*Description:* A rational number

Class <rational> is immutable, equal by value, and not inheritable.

*Data type name:* <rational-number>

*Type:* :union

*Description:* A rational valued number

Type <rational-number> is equal to the union of <rational> and <integer>.

### 23.2 Simple Methods

rational

*Syntax:*

(rational i-numer i-denom)

*Arguments:*

Name: i-numer

Type: <integer>

Description: The numerator

Name: `i-denom`  
Type: `<integer>`  
Description: The denominator

*Result value:* The quotient of `i-numer` and `i-denom`  
*Result type:* `<rational>`

*Purity of the procedure:* pure

This procedure returns the rational number in simplified form. If the denominator is zero a numerical overflow exception is raised.

## numerator

*Syntax:*

```
(numerator rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational number

*Result value:* The numerator of the argument  
*Result type:* `<integer>`

*Purity of the procedure:* pure

## denominator

*Syntax:*

```
(denominator rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational number

*Result value:* The denominator of the argument

*Result type:* <integer>

*Purity of the procedure:* pure

**rational=?**

*Syntax:*

```
(rational=? rat1 rat2)
```

*Arguments:*

Name: **rat1**  
Type: <rational>  
Description: A rational value to be compared

Name: **rat2**  
Type: <rational>  
Description: A rational value to be compared

*Result value:* **#t** iff **rat1** is equal to **rat2**

*Result type:* <boolean>

*Purity of the procedure:* pure

Rational numbers  $a/b$  and  $c/d$  are equal iff  $ad = bc$ .

**rational=**

*Syntax:*

```
(rational= rat1 rat2)
```

*Arguments:*

Name: **rat1**  
Type: <rational>  
Description: A rational value to be compared

Name: **rat2**  
Type: <rational>  
Description: A rational value to be compared

*Result value:* `#t` iff `rat1` is numerically equal to `rat2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

Rational numbers  $a/b$  and  $c/d$  are equal iff  $ad = bc$ .

## rational-integer=

*Syntax:*

```
(rational-integer= rat i)
```

*Arguments:*

Name: `rat`

Type: `<rational>`

Description: A rational value to be compared

Name: `i`

Type: `<integer>`

Description: An integer value to be compared

*Result value:* `#t` iff `rat` is numerically equal to `i`

*Result type:* `<boolean>`

Rational number  $a/b$  and integer  $c$  are equal iff  $a = bc$ .

*Purity of the procedure:* pure

## integer-rational=

*Syntax:*

```
(integer-rational= i rat)
```

*Arguments:*

Name: `i`

Type: `<integer>`

Description: An integer value to be compared



Name: `rat`  
Type: `<rational>`  
Description: A rational value to be compared

*Result value:* `#t` iff `i` is numerically equal to `rat`  
*Result type:* `<boolean>`

## `rational<`

*Syntax:*

```
(rational< rat1 rat2)
```

*Arguments:*

Name: `rat1`  
Type: `<rational>`  
Description: A rational value to be compared

Name: `rat2`  
Type: `<rational>`  
Description: A rational value to be compared

*Result value:* `#t` iff `rat1` is less than `rat2`  
*Result type:* `<boolean>`

*Purity of the procedure:* pure

## `rational-integer<`

*Syntax:*

```
(rational-integer< rat i)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value to be compared

Name: `i`

Type: `<integer>`

Description: An integer value to be compared

*Result value:* `#t` iff `rat` is less than `i`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## `integer-rational<`

*Syntax:*

`(integer-rational< i rat)`

*Arguments:*

Name: `i`

Type: `<integer>`

Description: An integer value to be compared

Name: `rat`

Type: `<rational>`

Description: A rational value to be compared

*Result value:* `#t` iff `i` is less than `rat`

*Result type:* `<boolean>`

## `rational<=`

*Syntax:*

`(rational<= rat1 rat2)`

*Arguments:*

Name: `rat1`

Type: `<rational>`

Description: A rational value to be compared

Name: `rat2`

Type: `<rational>`

Description: A rational value to be compared

*Result value:* #t iff `rat1` is less than or equal to `rat2`

*Result type:* <boolean>

*Purity of the procedure:* pure

## rational-integer<=

*Syntax:*

```
(rational-integer<= rat i)
```

*Arguments:*

Name: `rat`

Type: <rational>

Description: A rational value to be compared

Name: `i`

Type: <integer>

Description: An integer value to be compared

*Result value:* #t iff `rat` is less than or equal to `i`

*Result type:* <boolean>

*Purity of the procedure:* pure

## integer-rational<=

*Syntax:*

```
(integer-rational<= i rat)
```

*Arguments:*

Name: `i`

Type: <integer>

Description: An integer value to be compared

Name: `rat`

Type: `<rational>`

Description: A rational value to be compared

*Result value:* `#t` iff `i` is less than or equal to `rat`

*Result type:* `<boolean>`

`rational>`

*Syntax:*

`(rational> rat1 rat2)`

*Arguments:*

Name: `rat1`

Type: `<rational>`

Description: A rational value to be compared

Name: `rat2`

Type: `<rational>`

Description: A rational value to be compared

*Result value:* `#t` iff `rat1` is greater than `rat2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`rational-integer>`

*Syntax:*

`(rational-integer> rat i)`

*Arguments:*

Name: `rat`

Type: `<rational>`

Description: A rational value to be compared

Name: `i`

Type: `<integer>`

Description: An integer value to be compared

*Result value:* #t iff `rat` is greater than `i`

*Result type:* <boolean>

*Purity of the procedure:* pure

## `integer-rational>`

*Syntax:*

```
(integer-rational> i rat)
```

*Arguments:*

Name: `i`

Type: <integer>

Description: An integer value to be compared

Name: `rat`

Type: <rational>

Description: A rational value to be compared

*Result value:* #t iff `i` is greater than `rat`

*Result type:* <boolean>

## `rational>=`

*Syntax:*

```
(rational>= rat1 rat2)
```

*Arguments:*

Name: `rat1`

Type: <rational>

Description: A rational value to be compared

Name: `rat2`

Type: <rational>

Description: A rational value to be compared

*Result value:* #t iff `rat1` is greater than or equal to `rat2`

*Result type:* <boolean>

*Purity of the procedure:* pure

**rational-integer>=**

*Syntax:*

(rational-integer>= rat i)

*Arguments:*

Name: `rat`

Type: <rational>

Description: A rational value to be compared

Name: `i`

Type: <integer>

Description: An integer value to be compared

*Result value:* #t iff `rat` is greater than or equal to `i`

*Result type:* <boolean>

*Purity of the procedure:* pure

**integer-rational>=**

*Syntax:*

(integer-rational>= i rat)

*Arguments:*

Name: `i`

Type: <integer>

Description: An integer value to be compared

Name: `rat`

Type: <rational>

Description: A rational value to be compared

*Result value:* #t iff i is greater than or equal to rat

*Result type:* <boolean>

*Purity of the procedure:* pure

## simplify-rational

*Syntax:*

```
(simplify-rational rat)
```

*Arguments:*

Name: rat

Type: <rational>

Description: A rational value

*Result value:* The argument in the simplified form

*Result type:* <rational>

*Purity of the procedure:* pure

This procedure simplifies the rational number so that its numerator and denominator don't have a common divisor. See chapter 3.

## simplify-rational2

*Syntax:*

```
(simplify-rational2 rat)
```

*Arguments:*

Name: rat

Type: <rational>

Description: A rational value

*Result value:* The argument in the simplified form

*Result type:* <rational-number>

*Purity of the procedure:* pure

This procedure is similar to `simplify-rational` except when the argument is integer valued. In that case this procedure returns an integer. See chapter 3.

## `rat-integer-valued?`

*Syntax:*

```
(rat-integer-valued? rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* `#t` iff the argument is integer valued

*Result type:* `<boolean>`

*Purity of the procedure:* pure

A rational number is integer valued iff its denominator is 1 in the simplified form.

## `rat-sign`

*Syntax:*

```
(rat-sign rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The sign of the argument

*Result type:* `<integer>`

*Purity of the procedure:* pure

Return 0 if `rat = 0`, 1 if `rat > 0`, and -1 if `rat < 0`.



## integer->rational

*Syntax:*

```
(integer->rational i)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The argument converted to a rational number

*Result type:* `<rational>`

*Purity of the procedure:* pure

The numerator of the result is `i` and the denominator 1.

## rational->integer

*Syntax:*

```
(rational->integer rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The argument converted to an integer number

*Result type:* `<integer>`

*Purity of the procedure:* pure

If the argument is not integer valued an exception `rational->integer:not-an-integer` is raised.

## rat-zero

*Syntax:*

`(rat-zero)`

No arguments.

*Result value:* The rational number 0

*Result type:* `<rational>`

*Purity of the procedure:* pure

The numerator of the result is 0 and the denominator 1.

**rat-one**

*Syntax:*

`(rat-one)`

No arguments.

*Result value:* The rational number 1

*Result type:* `<rational>`

*Purity of the procedure:* pure

The numerator and the denominator of the result are 1.

**rat-zero?**

*Syntax:*

`(rat-zero? rat)`

*Arguments:*

Name: `rat`

Type: `<rational>`

Description: A rational value

*Result value:* `#t` iff the argument is equal to 0

*Result type:* `<boolean>`

*Purity of the procedure:* pure

A numerical overflow exception is raised if the denominator of the argument is 0.

## rat-one?

*Syntax:*

```
(rat-one? rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* `#t` iff the argument is equal to 1

*Result type:* `<boolean>`

*Purity of the procedure:* pure

A numerical overflow exception is raised if the denominator of the argument is 0.

## rational+

*Syntax:*

```
(rational+ rat1 rat2)
```

*Arguments:*

Name: `rat1`  
Type: `<rational>`  
Description: A rational value

Name: `rat2`  
Type: `<rational>`  
Description: A rational value

*Result value:* The sum of the arguments in the simplified form

*Result type:* `<rational>`

*Purity of the procedure:* pure

## rational-integer+

*Syntax:*

```
(rational-integer+ rat i)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The sum of the arguments in the simplified form

*Result type:* `<rational>`

*Purity of the procedure:* pure

## integer-rational+

*Syntax:*

```
(integer-rational+ i rat)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The sum of the arguments in the simplified form

*Result type:* `<rational>`

*Purity of the procedure:* pure

**rational-***Syntax:*

```
(rational- rat1 rat2)
```

*Arguments:*

Name: `rat1`  
Type: `<rational>`  
Description: A rational value

Name: `rat2`  
Type: `<rational>`  
Description: A rational value

*Result value:* The difference of the arguments in the simplified form*Result type:* `<rational>`*Purity of the procedure:* pure**rational-integer-***Syntax:*

```
(rational-integer- rat i)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The difference of the arguments in the simplified form*Result type:* `<rational>`*Purity of the procedure:* pure

## integer-rational-

*Syntax:*

```
(integer-rational- i rat)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The difference of the arguments in the simplified form

*Result type:* `<rational>`

*Purity of the procedure:* pure

## rational\*

*Syntax:*

```
(rational* rat1 rat2)
```

*Arguments:*

Name: `rat1`  
Type: `<rational>`  
Description: A rational value

Name: `rat2`  
Type: `<rational>`  
Description: A rational value

*Result value:* The product of the arguments in the simplified form

*Result type:* `<rational>`

*Purity of the procedure:* pure

**rational-integer\****Syntax:*

```
(rational-integer* rat i)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The product of the arguments in the simplified form*Result type:* `<rational>`*Purity of the procedure:* pure**integer-rational\****Syntax:*

```
(integer-rational* i rat)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The product of the arguments in the simplified form*Result type:* `<rational>`*Purity of the procedure:* pure

**rational/***Syntax:*

```
(rational/ rat1 rat2)
```

*Arguments:*

Name: **rat1**  
Type: **<rational>**  
Description: A rational value

Name: **rat2**  
Type: **<rational>**  
Description: A rational value

*Result value:* The quotient of the arguments in the simplified form*Result type:* **<rational>***Purity of the procedure:* pure

If the divisor is equal to 0 raise a numerical overflow exception.

**rational-integer/***Syntax:*

```
(rational-integer/ rat i)
```

*Arguments:*

Name: **rat**  
Type: **<rational>**  
Description: A rational value

Name: **i**  
Type: **<integer>**  
Description: An integer value

*Result value:* The quotient of the arguments in the simplified form*Result type:* **<rational>***Purity of the procedure:* pure

If the divisor is equal to 0 raise a numerical overflow exception.



## integer-rational/

*Syntax:*

```
(integer-rational/ i rat)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The quotient of the arguments in the simplified form

*Result type:* `<rational>`

*Purity of the procedure:* pure

If the divisor is equal to 0 raise a numerical overflow exception.

## rat-neg

*Syntax:*

```
(rat-neg rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The opposite of the argument

*Result type:* `<rational>`

*Purity of the procedure:* pure

## rat-abs

*Syntax:*

```
(rat-abs rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The absolute value of the argument

*Result type:* `<rational>`

*Purity of the procedure:* pure

## `rat-square`

*Syntax:*

```
(rat-square rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The square of the argument

*Result type:* `<rational>`

*Purity of the procedure:* pure

## `rat-inverse`

*Syntax:*

```
(rat-inverse rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The inverse of the argument

*Result type:* `<rational>`

*Purity of the procedure:* pure

If the argument is equal to 0 a numerical overflow exception is raised.

## `rat-nonneg-int-expt`

*Syntax:*

`(rat-nonneg-int-expt rat-base i-exponent)`

*Arguments:*

Name: `rat-base`  
Type: `<rational>`  
Description: A rational value

Name: `i-exponent`  
Type: `<integer>`  
Description: A nonnegative integer value

*Result value:* `rat-base` raised to the power `i-exponent`

*Result type:* `<rational>`

*Purity of the procedure:* pure

## `rat-int-expt`

*Syntax:*

`(rat-int-expt rat-base i-exponent)`

*Arguments:*

Name: `rat-base`  
Type: `<rational>`

Description: A rational value

Name: `i-exponent`

Type: `<integer>`

Description: An integer value

*Result value:* `rat-base` raised to the power `i-exponent`

*Result type:* `<rational>`

*Purity of the procedure:* pure

If `rat-base` is equal to 0 and `i-exponent` is negative raise a numerical overflow exception.

## `i-expt`

*Syntax:*

```
(i-expt i-base i-exponent)
```

*Arguments:*

Name: `i-base`

Type: `<integer>`

Description: An integer number

Name: `i-exponent`

Type: `<integer>`

Description: An integer number

*Result value:* `i-base` raised to the power `i-exponent`

*Result type:* `<rational-number>`

*Purity of the procedure:* pure

If the base is 0 and the exponent is negative raise a numerical overflow exception. If the exponent is nonnegative the result is always an `<integer>`.

## `rat-log10-exact`

*Syntax:*

```
(rat-log10-exact rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational number

*Result value:* The base 10 logarithm of the argument or `null` if the logarithm is not an integer

*Result type:* `(:maybe <integer>)`

*Purity of the procedure:* pure

This procedure is able compute logarithms of the negative integer powers of 10, too.

## `rat-log2-exact`

*Syntax:*

```
(rat-log2-exact rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational number

*Result value:* The base 2 logarithm of the argument or `null` if the logarithm is not an integer

*Result type:* `(:maybe <integer>)`

*Purity of the procedure:* pure

This procedure is able compute logarithms of the negative integer powers of 2, too.

## `rational-to-string`

*Syntax:*

```
(rational-to-string rat repr?)
```

*Arguments:*

Name: `rat`

Type: `<rational>`

Description: A rational value

Name: `repr?`

Type: `<boolean>`

Description: Should we write a representation or a user-friendly value

*Result value:* The argument value converted to a string

*Result type:* `<string>`

*Purity of the procedure:* pure

### 23.3 Virtual Methods

`equal?: (<rational> <rational>) → <boolean> pure = rational=?`

`=: (<rational> <rational>) → <boolean> pure = rational=`

`=: (<rational> <integer>) → <boolean> pure = rational-integer=`

`=: (<integer> <rational>) → <boolean> pure = integer-rational=`

`<: (<rational-number> <rational-number>) → <boolean> pure abstract`

`<: (<rational> <rational>) → <boolean> pure = rational<`

`<: (<rational> <integer>) → <boolean> pure = rational-integer<`

`<: (<integer> <rational>) → <boolean> pure = integer-rational<`

`<=: (<rational-number> <rational-number>) → <boolean> pure abstract`

`<=: (<rational> <rational>) → <boolean> pure = rational<=`

`<=: (<rational> <integer>) → <boolean> pure = rational-integer<=`

`<=: (<integer> <rational>) → <boolean> pure = integer-rational<=`

`>: (<rational-number> <rational-number>) → <boolean> pure abstract`

`>: (<rational> <rational>) → <boolean> pure = rational>`

`>: (<rational> <integer>) → <boolean> pure = rational-integer>`

`>: (<integer> <rational>) → <boolean> pure = integer-rational>`

`>=: (<rational-number> <rational-number>) → <boolean> pure abstract`

`>=: (<rational> <rational>) → <boolean> pure = rational>=`

`>=: (<rational> <integer>) → <boolean> pure = rational-integer>=`

`>=: (<integer> <rational>) → <boolean> pure = integer-rational>=`

`+: (<rational-number> <rational-number>) → <rational-number> pure abstract`

`+: (<rational> <rational>) → <rational> pure = rational+`

`+: (<rational> <integer>) → <rational> pure = rational-integer+`

```

+: (<integer> <rational>) → <rational> pure    =    integer-rational+

-: (<rational-number> <rational-number>) → <rational-number> pure
abstract
-: (<rational> <rational>) → <rational> pure    =    rational-
-: (<rational> <integer>) → <rational> pure    =    rational-integer-
-: (<integer> <rational>) → <rational> pure    =    integer-rational-

*: (<rational-number> <rational-number>) → <rational-number> pure
abstract
*: (<rational> <rational>) → <rational> pure    =    rational*
*: (<rational> <integer>) → <rational> pure    =    rational-integer*
*: (<integer> <rational>) → <rational> pure    =    integer-rational*

/: (<rational-number> <rational-number>) → <rational-number> pure
abstract
/: (<rational> <rational>) → <rational> pure    =    rational/
/: (<rational> <integer>) → <rational> pure    =    rational-integer/
/: (<integer> <rational>) → <rational> pure    =    integer-rational/

-: (<rational-number>) → <rational-number> pure abstract
-: (<rational>) → <rational> pure    =    rat-neg

abs: (<rational-number>) → <rational-number> pure abstract
abs: (<rational>) → <rational> pure    =    rat-abs

square: (<rational-number>) → <rational-number> pure abstract
square: (<rational>) → <rational> pure    =    rat-square

sign: (<rational-number>) → <rational-number> pure abstract
sign: (<rational>) → <integer> pure    =    rat-sign

atom-to-string: (<rational> <boolean>) → <string> pure    =    rational-to-string

```





## Chapter 24

# Module (standard-library real-math)

### 24.1 Data Types

*Data type name:* <real-number>

*Type:* :union

*Description:* A real valued number

Type <real-number> is equal to the union of <real>, <rational>, and <integer>.

### 24.2 Constants

The following constants are defined:

- `gl-r-pi`: The value  $\pi$
- `gl-r-pi/2`: The value  $\pi/2$
- `gl-r-pi/4`: The value  $\pi/4$
- `gl-r-1/pi`: The value  $1/\pi$
- `gl-r-2/pi`: The value  $2/\pi$
- `gl-r-2/sqrtpi`: The value  $1/\sqrt{\pi}$
- `gl-r-sqrt2`: The value  $\sqrt{2}$
- `gl-r-1/sqrt2`: The value  $1/\sqrt{2}$
- `gl-r-e`: The value  $e$  (Napier's constant)
- `gl-r-log2e`: The value  $\log_2 e$
- `gl-r-log10e`: The value  $\log_{10} e$
- `gl-r-ln2`: The value  $\ln 2$

- `gl-r-ln10`: The value  $\ln 10$
- `gl-r-pi/ln2`: The value  $\pi/\ln 2$
- `gl-r-pi/ln10`: The value  $\pi/\ln 10$

## 24.3 Simple Methods

### `rational->real`

*Syntax:*

```
(rational->real rat)
```

*Arguments:*

Name: `rat`  
 Type: `<rational>`  
 Description: A rational value

*Result value:* The rational value converted to a real value

*Result type:* `<real>`

*Purity of the procedure:* pure

### `real-rational=`

*Syntax:*

```
(real-rational= r rat)
```

*Arguments:*

Name: `r`  
 Type: `<real>`  
 Description: A real value to be compared

Name: `rat`  
 Type: `<rational>`  
 Description: A rational value to be compared

*Result value:* #t iff **r** is numerically equal to **rat**

*Result type:* <boolean>

*Purity of the procedure:* pure

## rational-real=

*Syntax:*

```
(rational-real= rat r)
```

*Arguments:*

Name: **rat**

Type: <rational>

Description: A rational value to be compared

Name: **r**

Type: <real>

Description: A real value to be compared

*Result value:* #t iff **rat** is numerically equal to **r**

*Result type:* <boolean>

*Purity of the procedure:* pure

## real-rational<

*Syntax:*

```
(real-rational< r rat)
```

*Arguments:*

Name: **r**

Type: <real>

Description: A real value to be compared

Name: **rat**

Type: <rational>

Description: A rational value to be compared

*Result value:* #t iff `r` is less than `rat`

*Result type:* <boolean>

*Purity of the procedure:* pure

## rational-real<

*Syntax:*

```
(rational-real< rat r)
```

*Arguments:*

Name: `rat`

Type: <rational>

Description: A rational value to be compared

Name: `r`

Type: <real>

Description: A real value to be compared

*Result value:* #t iff `rat` is less than `r`

*Result type:* <boolean>

*Purity of the procedure:* pure

## real-rational<=

*Syntax:*

```
(real-rational<= r rat)
```

*Arguments:*

Name: `r`

Type: <real>

Description: A real value to be compared

Name: `rat`

Type: <rational>

Description: A rational value to be compared

*Result value:* #t iff **r** is less than or equal to **rat**

*Result type:* <boolean>

*Purity of the procedure:* pure

**rational-real<=**

*Syntax:*

(rational-real<= rat r)

*Arguments:*

Name: **rat**

Type: <rational>

Description: A rational value to be compared

Name: **r**

Type: <real>

Description: A real value to be compared

*Result value:* #t iff **rat** is less than or equal to **r**

*Result type:* <boolean>

*Purity of the procedure:* pure

**real-rational>**

*Syntax:*

(real-rational> r rat)

*Arguments:*

Name: **r**

Type: <real>

Description: A real value to be compared

Name: **rat**

Type: `<rational>`

Description: A rational value to be compared

*Result value:* `#t` iff `r` is greater than `rat`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`rational-real>`

*Syntax:*

`(rational-real> rat r)`

*Arguments:*

Name: `rat`

Type: `<rational>`

Description: A rational value to be compared

Name: `r`

Type: `<real>`

Description: A real value to be compared

*Result value:* `#t` iff `rat` is greater than `r`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

`real-rational>=`

*Syntax:*

`(real-rational>= r rat)`

*Arguments:*

Name: `r`

Type: `<real>`

Description: A real value to be compared

Name: `rat`  
 Type: `<rational>`  
 Description: A rational value to be compared

*Result value:* `#t` iff `r` is greater than or equal to `rat`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## `rational-real>=`

*Syntax:*

```
(rational-real>= rat r)
```

*Arguments:*

Name: `rat`  
 Type: `<rational>`  
 Description: A rational value to be compared

Name: `r`  
 Type: `<real>`  
 Description: A real value to be compared

*Result value:* `#t` iff `rat` is greater than or equal to `r`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## `real-rational+`

*Syntax:*

```
(real-rational+ r rat)
```

*Arguments:*

Name: `r`  
 Type: `<real>`  
 Description: A real value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The sum of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

## `rational-real+`

*Syntax:*

```
(rational-real+ rat r)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The sum of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

## `real-rational-`

*Syntax:*

```
(real-rational- r rat)
```

*Arguments:*

Name: `r`  
Type: `<real>`



Description: A real value

Name: `rat`

Type: `<rational>`

Description: A rational value

*Result value:* The difference of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

## rational-real-

*Syntax:*

```
(rational-real- rat r)
```

*Arguments:*

Name: `rat`

Type: `<rational>`

Description: A rational value

Name: `r`

Type: `<real>`

Description: A real value

*Result value:* The difference of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

## real-rational\*

*Syntax:*

```
(real-rational* r rat)
```

*Arguments:*

Name: `r`

Type: `<real>`  
Description: A real value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The product of the arguments  
*Result type:* `<real>`

*Purity of the procedure:* pure

## `rational-real*`

*Syntax:*

```
(rational-real* rat r)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The product of the arguments  
*Result type:* `<real>`

*Purity of the procedure:* pure

## `real-rational/`

*Syntax:*

```
(real-rational/ r rat)
```

*Arguments:*

Name: `r`  
 Type: `<real>`  
 Description: A real value

Name: `rat`  
 Type: `<rational>`  
 Description: A rational value

*Result value:* The quotient of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

In case `rat` is equal to 0 return

- `inf`, if `rat > 0`
- `-inf`, if `rat < 0`
- `NaN`, if `rat = 0`

## rational-real/

*Syntax:*

`(rational-real/ rat r)`

*Arguments:*

Name: `rat`  
 Type: `<rational>`  
 Description: A rational value

Name: `r`  
 Type: `<real>`  
 Description: A real value

*Result value:* The quotient of the arguments

*Result type:* `<real>`

*Purity of the procedure:* pure

In case `r` is equal to 0 return

- `inf`, if `r > 0`
- `-inf`, if `r < 0`

- NaN, if  $r = 0$

## r-sqrt

*Syntax:*

(r-sqrt r)

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* Square root of the argument

*Result type:* **<real>**

*Purity of the procedure:* pure

If the argument is negative return NaN.

## r-expt

*Syntax:*

(r-expt x y)

*Arguments:*

Name: **x**  
Type: **<real>**  
Description: A real number

Name: **y**  
Type: **<real>**  
Description: A real number

*Result value:* **x** to the power of **y**

*Result type:* **<real>**

*Purity of the procedure:* pure

If **x** is less than 0 return NaN. If **x** is equal to 0 return 1.0.

**r-exp***Syntax:*`(r-exp r)`*Arguments:*Name: `r`Type: `<real>`

Description: A real number

*Result value:*  $e$  to the power of `r`*Result type:* `<real>`*Purity of the procedure:* pureNumber  $e$  is the base of natural logarithms (approx. 2.718).**r-log***Syntax:*`(r-log r)`*Arguments:*Name: `r`Type: `<real>`

Description: A real number

*Result value:* The natural logarithm of `r`*Result type:* `<real>`*Purity of the procedure:* pure

If the argument is 0.0 return -inf. If the argument is less than 0.0 return NaN.

**r-log10***Syntax:*

(r-log10 r)

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* The base 10 logarithm of **r**

*Result type:* **<real>**

*Purity of the procedure:* pure

If the argument is 0.0 return -inf. If the argument is less than 0.0 return NaN.

## **r-sin**

*Syntax:*

(r-sin r)

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* The sine of the argument

*Result type:* **<real>**

*Purity of the procedure:* pure

## **r-cos**

*Syntax:*

(r-cos r)

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* The cosine of the argument

*Result type:* **<real>**

*Purity of the procedure:* pure

## **r-tan**

*Syntax:*

**(r-tan r)**

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* The tangent of the argument

*Result type:* **<real>**

*Purity of the procedure:* pure

## **r-asin**

*Syntax:*

**(r-asin r)**

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* The arcsine of the argument

*Result type:* **<real>**

*Purity of the procedure:* pure

If the result is not real return NaN.

## **r-acos**

*Syntax:*

`(r-acos r)`

*Arguments:*

Name: `r`

Type: `<real>`

Description: A real number

*Result value:* The arccosine of the argument

*Result type:* `<real>`

*Purity of the procedure:* pure

If the result is not real return NaN.

## **r-atan**

*Syntax:*

`(r-atan r)`

*Arguments:*

Name: `r`

Type: `<real>`

Description: A real number

*Result value:* The arctangent of the argument

*Result type:* `<real>`

*Purity of the procedure:* pure

## **r-sinh**



*Syntax:*

`(r-sinh r)`

*Arguments:*

Name: `r`

Type: `<real>`

Description: A real number

*Result value:* The hyperbolic sine of the argument

*Result type:* `<real>`

*Purity of the procedure:* pure

## `r-cosh`

*Syntax:*

`(r-cosh r)`

*Arguments:*

Name: `r`

Type: `<real>`

Description: A real number

*Result value:* The hyperbolic cosine of the argument

*Result type:* `<real>`

*Purity of the procedure:* pure

## `r-tanh`

*Syntax:*

`(r-tanh r)`

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* The hyperbolic tangent of the argument  
*Result type:* **<real>**

*Purity of the procedure:* pure

## **r-asinh**

*Syntax:*

**(r-asinh r)**

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* The hyperbolic arcsine of the argument  
*Result type:* **<real>**

*Purity of the procedure:* pure

## **r-acosh**

*Syntax:*

**(r-acosh r)**

*Arguments:*

Name: **r**  
Type: **<real>**  
Description: A real number

*Result value:* The hyperbolic arccosine of the argument  
*Result type:* **<real>**

*Purity of the procedure:* pure

If the result is not real return NaN.

## **r-atanh**

*Syntax:*

```
(r-atanh r)
```

*Arguments:*

Name: r  
Type: <real>  
Description: A real number

*Result value:* The hyperbolic arctangent of the argument

*Result type:* <real>

*Purity of the procedure:* pure

If the result is not real return NaN.

## **r-atan2**

*Syntax:*

```
(r-atan2 y x)
```

*Arguments:*

Name: y  
Type: <real>  
Description: A real number  
  
Name: x  
Type: <real>  
Description: A real number

*Result value:* The angle between point (x, y) and the positive x axis (in radians)

*Result type:* <real>

*Purity of the procedure:* pure

## i-sqrt

*Syntax:*

```
(i-sqrt i)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer number

*Result value:* Square root of the argument

*Result type:* `(:union <real> <integer>)`

*Purity of the procedure:* pure

If the square root is integer valued it is converted to class `<integer>`.

## rat-sqrt

*Syntax:*

```
(rat-sqrt rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: A rational number

*Result value:* Square root of the argument

*Result type:* `(:union <real> <rational> <integer>)`

*Purity of the procedure:* pure

If the square root is rational or integer valued it is converted to class `<rational>` or `<integer>`, respectively.

## string->real-number

*Syntax:*

```
(string->real-number str)
```

*Arguments:*

Name: `str`  
 Type: `<string>`  
 Description: A string

*Result value:* The argument string converted to a real number

*Result type:* `<real-number>`

*Purity of the procedure:* pure

If the string cannot be converted to a real number an RTE exception is raised.

## 24.4 Virtual Methods

```
=: (<real-number> <real-number>) → <boolean>   pure abstract
=: (<real> <rational>) → <boolean> pure      =   real-rational=
=: (<rational> <real>) → <boolean> pure      =   rational-real=

<: (<real-number> <real-number>) → <boolean>   pure abstract
<: (<real> <rational>) → <boolean> pure      =   real-rational<
<: (<rational> <real>) → <boolean> pure      =   rational-real<
<=: (<real-number> <real-number>) → <boolean>   pure abstract
<=: (<real> <rational>) → <boolean> pure      =   real-rational<=
<=: (<rational> <real>) → <boolean> pure      =   rational-real<=
>: (<real-number> <real-number>) → <boolean>   pure abstract
>: (<real> <rational>) → <boolean> pure      =   real-rational>
>: (<rational> <real>) → <boolean> pure      =   rational-real>
>=: (<real-number> <real-number>) → <boolean>   pure abstract
>=: (<real> <rational>) → <boolean> pure      =   real-rational>=
>=: (<rational> <real>) → <boolean> pure      =   rational-real>=

+: (<real-number> <real-number>) → <real-number>   pure abstract
+: (<real> <rational>) → <real> pure      =   real-rational+
+: (<rational> <real>) → <real> pure      =   rational-real+
-: (<real-number> <real-number>) → <real-number>   pure abstract
-: (<real> <rational>) → <real> pure      =   real-rational-
-: (<rational> <real>) → <real> pure      =   rational-real-
*: (<real-number> <real-number>) → <real-number>   pure abstract
*: (<real> <rational>) → <real> pure      =   real-rational*
*: (<rational> <real>) → <real> pure      =   rational-real*
/: (<real-number> <real-number>) → <real-number>   pure abstract
/: (<real> <rational>) → <real> pure      =   real-rational/
/: (<rational> <real>) → <real> pure      =   rational-real/
```

```
-: (<real-number>) → <real-number>   pure abstract
abs: (<real-number>) → <real-number>   pure abstract
square: (<real-number>) → <real-number> pure abstract
sign: (<real-number>) → <integer>      pure abstract
```

## Chapter 25

# Module (standard-library complex)

### 25.1 Data Types

*Data type name:* <complex>

*Type:* <class>

*Description:* A complex number

Class <complex> is immutable, equal by value, and not inheritable.

### 25.2 Simple Methods

`real->complex`

*Syntax:*

`(real->complex r)`

*Arguments:*

Name: `r`

Type: <real>

Description: A real number

*Result value:* The complex number corresponding to the given real number

*Result type:* <complex>

*Purity of the procedure:* pure

## integer->complex

*Syntax:*

```
(integer->complex n)
```

*Arguments:*

Name: `n`  
Type: `<integer>`  
Description: An integer number

*Result value:* The complex number corresponding to the given integer number

*Result type:* `<complex>`

*Purity of the procedure:* pure

## rational->complex

*Syntax:*

```
(rational->complex rat)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: An integer number

*Result value:* The complex number corresponding to the given rational number

*Result type:* `<complex>`

*Purity of the procedure:* pure

## complex=?

*Syntax:*

```
(complex=? cx1 cx2)
```



*Arguments:*

Name: `cx1`  
Type: `<complex>`  
Description: A complex value to be compared

Name: `cx2`  
Type: `<complex>`  
Description: A complex value to be compared

*Result value:* `#t` iff `cx1` is equal to `cx2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**complex=**

*Syntax:*

```
(complex= cx1 cx2)
```

*Arguments:*

Name: `cx1`  
Type: `<complex>`  
Description: A complex value to be compared

Name: `cx2`  
Type: `<complex>`  
Description: A complex value to be compared

*Result value:* `#t` iff `cx1` is numerically equal to `cx2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**complex-integer=**

*Syntax:*

```
(complex-integer= cx i)
```

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value to be compared

Name: `i`  
Type: `<integer>`  
Description: An integer value to be compared

*Result value:* `#t` iff `cx` is numerically equal to `i`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**integer-complex=***Syntax:*

`(integer-complex= i cx)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value to be compared

Name: `cx`  
Type: `<complex>`  
Description: A complex value to be compared

*Result value:* `#t` iff `i` is numerically equal to `cx`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**complex-real=***Syntax:*

`(complex-real= cx r)`

*Arguments:*

Name: `cx`  
 Type: `<complex>`  
 Description: A complex value to be compared

Name: `r`  
 Type: `<real>`  
 Description: A real value to be compared

*Result value:* `#t` iff `cx` is numerically equal to `r`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**real-complex=**

*Syntax:*

`(real-complex= r cx)`

*Arguments:*

Name: `r`  
 Type: `<real>`  
 Description: A real value to be compared

Name: `cx`  
 Type: `<complex>`  
 Description: A complex value to be compared

*Result value:* `#t` iff `r` is numerically equal to `cx`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**complex-rational=**

*Syntax:*

`(complex-rational= cx rat)`

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value to be compared

Name: `rat`  
Type: `<rational>`  
Description: A rational value to be compared

*Result value:* `#t` iff `cx` is numerically equal to `rat`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**rational-complex=***Syntax:*

`(rational-complex= rat cx)`

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: An rational value to be compared

Name: `cx`  
Type: `<complex>`  
Description: A complex value to be compared

*Result value:* `#t` iff `rat` is numerically equal to `cx`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**complex+***Syntax:*

`(complex+ cx1 cx2)`

*Arguments:*

Name: `cx1`  
Type: `<complex>`  
Description: A complex value

Name: `cx2`  
Type: `<complex>`  
Description: A complex value

*Result value:* The sum of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `complex-integer+`

*Syntax:*

```
(complex-integer+ cx i)
```

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The sum of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `integer-complex+`

*Syntax:*

```
(integer-complex+ i cx)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The sum of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**complex-real+***Syntax:*

`(complex-real+ cx r)`

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The sum of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**real-complex+***Syntax:*

`(real-complex+ r cx)`

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The sum of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `complex-rational+`

*Syntax:*

```
(complex-rational+ cx rat)
```

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The sum of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `rational-complex+`

*Syntax:*

```
(rational-complex+ rat cx)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: An rational value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The sum of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**complex-***Syntax:*

```
(complex- cx1 cx2)
```

*Arguments:*

Name: `cx1`  
Type: `<complex>`  
Description: A complex value

Name: `cx2`  
Type: `<complex>`  
Description: A complex value

*Result value:* The difference of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**complex-integer-***Syntax:*

```
(complex-integer- cx i)
```



*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The difference of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `integer-complex-`

*Syntax:*

```
(integer-complex- i cx)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The difference of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `complex-real-`

*Syntax:*

```
(complex-real- cx r)
```

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The difference of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `real-complex-`

*Syntax:*

```
(real-complex- r cx)
```

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The difference of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `complex-rational-`

*Syntax:*

```
(complex-rational- cx rat)
```

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The difference of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `rational-complex-`

*Syntax:*

```
(rational-complex- rat cx)
```

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: An rational value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The difference of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `complex*`

*Syntax:*

```
(complex* cx1 cx2)
```

*Arguments:*

Name: `cx1`  
Type: `<complex>`  
Description: A complex value

Name: `cx2`  
Type: `<complex>`  
Description: A complex value

*Result value:* The product of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**complex-integer\****Syntax:*

`(complex-integer* cx i)`

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The product of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**integer-complex\****Syntax:*

`(integer-complex* i cx)`

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The product of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `complex-real*`

*Syntax:*

```
(complex-real* cx r)
```

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The product of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `real-complex*`

*Syntax:*

```
(real-complex* r cx)
```

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The product of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**complex-rational\****Syntax:*

`(complex-rational* cx rat)`

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The product of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**rational-complex\****Syntax:*

`(rational-complex* rat cx)`

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: An rational value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The product of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `complex/`

*Syntax:*

```
(complex/ cx1 cx2)
```

*Arguments:*

Name: `cx1`  
Type: `<complex>`  
Description: A complex value

Name: `cx2`  
Type: `<complex>`  
Description: A complex value

*Result value:* The quotient of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `complex-integer/`

*Syntax:*

```
(complex-integer/ cx i)
```

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `i`  
Type: `<integer>`  
Description: An integer value

*Result value:* The quotient of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `integer-complex/`

*Syntax:*

```
(integer-complex/ i cx)
```

*Arguments:*

Name: `i`  
Type: `<integer>`  
Description: An integer value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The quotient of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `complex-real/`

*Syntax:*

```
(complex-real/ cx r)
```



*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `r`  
Type: `<real>`  
Description: A real value

*Result value:* The quotient of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

`real-complex/`

*Syntax:*

`(real-complex/ r cx)`

*Arguments:*

Name: `r`  
Type: `<real>`  
Description: A real value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The quotient of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

`complex-rational/`

*Syntax:*

`(complex-rational/ cx rat)`

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex value

Name: `rat`  
Type: `<rational>`  
Description: A rational value

*Result value:* The quotient of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**rational-complex/**

*Syntax:*

`(rational-complex/ rat cx)`

*Arguments:*

Name: `rat`  
Type: `<rational>`  
Description: An rational value

Name: `cx`  
Type: `<complex>`  
Description: A complex value

*Result value:* The quotient of the arguments

*Result type:* `<complex>`

*Purity of the procedure:* pure

**c-neg**

*Syntax:*

`(c-neg c)`

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The opposite number of the given complex number

*Result type:* `<complex>`

*Purity of the procedure:* pure

## **c-abs**

*Syntax:*

`(c-abs c)`

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The absolute value of the given complex number

*Result type:* `<real>`

*Purity of the procedure:* pure

## **c-square**

*Syntax:*

`(c-square c)`

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The square of the given complex number

*Result type:* `<complex>`

*Purity of the procedure:* pure

## real-part

*Syntax:*

```
(real-part c)
```

*Arguments:*

Name: `c`

Type: `<complex>`

Description: A complex number

*Result value:* The real part of the given complex number

*Result type:* `<real>`

*Purity of the procedure:* pure

## imag-part

*Syntax:*

```
(imag-part c)
```

*Arguments:*

Name: `c`

Type: `<complex>`

Description: A complex number

*Result value:* The imaginary part of the given complex number

*Result type:* `<real>`

*Purity of the procedure:* pure

## simplify-complex

*Syntax:*

```
(simplify-complex c)
```

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The argument in simplified form

*Result type:* `(:union <complex> <real>)`

*Purity of the procedure:* pure

If the real part of the argument is zero this procedure returns the real part as `<real>`. Otherwise the argument is returned.

## make-polar

*Syntax:*

```
(make-polar magnitude angle)
```

*Arguments:*

Name: `magnitude`  
Type: `<real>`

Name: `angle`  
Type: `<real>`

*Result value:* The complex number having the given magnitude and angle

*Result type:* `<complex>`

*Purity of the procedure:* pure

## c-angle

*Syntax:*

(c-angle c)

*Arguments:*

Name: c  
Type: <complex>  
Description: A complex number

*Result value:* The angle of the given complex number

*Result type:* <real>

*Purity of the procedure:* pure

## r-complex-log

*Syntax:*

(r-complex-log r)

*Arguments:*

Name: r  
Type: <real>  
Description: A real number

*Result value:* The natural logarithm of r

*Result type:* <complex>

*Purity of the procedure:* pure

The result is computed correctly for the negative values of r, too.

## r-log-neg

*Syntax:*

(r-log-neg r)

*Arguments:*

Name: r

Type: `<real>`

Description: A negative real number

*Result value:* The natural logarithm of `r`

*Result type:* `<complex>`

*Purity of the procedure:* pure

The natural logarithm of a negative real number  $r$  is  $\ln r = \ln |r| + i\pi$ .

## `r-log10-neg`

*Syntax:*

```
(r-log10-neg r)
```

*Arguments:*

Name: `r`

Type: `<real>`

Description: A negative real number

*Result value:* The base 10 logarithm of `r`

*Result type:* `<complex>`

*Purity of the procedure:* pure

The base 10 logarithm of a negative real number  $r$  is  $\log_{10} r = \log_{10} |r| + i\pi / \ln 10$ .

## `r-complex-expt`

*Syntax:*

```
(r-complex-expt r-base r-exponent)
```

*Arguments:*

Name: `r-base`

Type: `<real>`

Description: A real number

Name: `r-exponent`

Type: `<real>`  
Description: A real number

*Result value:* `r-base` raised to the power of `r-exponent`  
*Result type:* `<complex>`

*Purity of the procedure:* pure

The result is computed correctly for the negative values of `r-base`, too.

## `complex-real-expt`

*Syntax:*

`(complex-real-expt cx-base r-exponent)`

*Arguments:*

Name: `cx-base`  
Type: `<complex>`  
Description: A complex number

Name: `r-exponent`  
Type: `<real>`  
Description: A real number

*Result value:* `cx-base` raised to the power of `r-exponent`  
*Result type:* `<complex>`

*Purity of the procedure:* pure

## `real-complex-expt`

*Syntax:*

`(real-complex-expt r-base cx-exponent)`

*Arguments:*

Name: `r-base`  
Type: `<real>`  
Description: A real number



Name: `cx-exponent`  
Type: `<complex>`  
Description: A complex number

*Result value:* `r-base` raised to the power of `cx-exponent`

*Result type:* `<complex>`

*Purity of the procedure:* pure

This procedure works for negative values of `r-base`, too.

## `c-exp2`

*Syntax:*

```
(c-exp2 cx)
```

*Arguments:*

Name: `cx`  
Type: `<complex>`  
Description: A complex number

*Result value:* 2 raised to the power of `cx-exponent`

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `c-nonneg-int-expt`

*Syntax:*

```
(c-nonneg-int-expt cx-base i-expt)
```

*Arguments:*

Name: `cx-base`  
Type: `<complex>`  
Description: A complex number

Name: `i-expt`

Type: `<integer>`

Description: A nonnegative integer number

*Result value:* `cx-base` raised to the power `i-expt`

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `c-int-expt`

*Syntax:*

`(c-int-expt cx-base i-expt)`

*Arguments:*

Name: `cx-base`

Type: `<complex>`

Description: A complex number

Name: `i-expt`

Type: `<integer>`

Description: An integer number

*Result value:* `cx-base` raised to the power `i-expt`

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `c-sqrt`

*Syntax:*

`(c-sqrt c)`

*Arguments:*

Name: `c`

Type: `<complex>`

Description: A complex number

*Result value:* Square root of the argument

*Result type:* <complex>

*Purity of the procedure:* pure

## c-expt

*Syntax:*

(c-expt x y)

*Arguments:*

Name: x

Type: <complex>

Description: A complex number

Name: y

Type: <complex>

Description: A complex number

*Result value:* x to the power of y

*Result type:* <complex>

*Purity of the procedure:* pure

## c-exp

*Syntax:*

(c-exp c)

*Arguments:*

Name: c

Type: <complex>

Description: A complex number

*Result value:* e to the power of r

*Result type:* <complex>

*Purity of the procedure:* pure

Number  $e$  is the base of natural logarithms (approx. 2.718).

## c-log

*Syntax:*

(c-log c)

*Arguments:*

Name: c  
Type: <complex>  
Description: A complex number

*Result value:* The natural logarithm of  $r$

*Result type:* <complex>

*Purity of the procedure:* pure

## c-log10

*Syntax:*

(c-log10 c)

*Arguments:*

Name: c  
Type: <complex>  
Description: A complex number

*Result value:* The base 10 logarithm of  $r$

*Result type:* <complex>

*Purity of the procedure:* pure

## c-sin

*Syntax:*

`(c-sin c)`

*Arguments:*

Name: `c`

Type: `<complex>`

Description: A complex number

*Result value:* The sine of the argument

*Result type:* `<complex>`

*Purity of the procedure:* pure

## **C-COS**

*Syntax:*

`(c-cos c)`

*Arguments:*

Name: `c`

Type: `<complex>`

Description: A complex number

*Result value:* The cosine of the argument

*Result type:* `<complex>`

*Purity of the procedure:* pure

## **C-TAN**

*Syntax:*

`(c-tan c)`

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The tangent of the argument

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `c-asin`

*Syntax:*

```
(c-asin c)
```

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The arcsine of the argument

*Result type:* `<complex>`

*Purity of the procedure:* pure

This procedure sometimes returns a value from a different branch compared to guile (2.2.2) `asin`. Our convention is similar to Octave (version 3.8.1).

## `c-acos`

*Syntax:*

```
(c-acos c)
```

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The arccosine of the argument

*Result type:* <complex>

This procedure sometimes returns a value from a different branch compared to guile (2.2.2) `acos`. Our convention is similar to Octave (version 3.8.1).

*Purity of the procedure:* pure

## c-atan

*Syntax:*

```
(c-atan c)
```

*Arguments:*

Name: `c`

Type: <complex>

Description: A complex number

*Result value:* The arctangent of the argument

*Result type:* <complex>

*Purity of the procedure:* pure

## c-sinh

*Syntax:*

```
(c-sinh c)
```

*Arguments:*

Name: `c`

Type: <complex>

Description: A complex number

*Result value:* The hyperbolic sine of the argument

*Result type:* <complex>

*Purity of the procedure:* pure

**c-cosh***Syntax:*

```
(c-cosh c)
```

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The hyperbolic cosine of the argument*Result type:* `<complex>`*Purity of the procedure:* pure**c-tanh***Syntax:*

```
(c-tanh c)
```

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The hyperbolic tangent of the argument*Result type:* `<complex>`*Purity of the procedure:* pure**c-asinh***Syntax:*

```
(c-asinh c)
```



*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The hyperbolic arcsine of the argument

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `c-acosh`

*Syntax:*

`(c-acosh c)`

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The hyperbolic arccosine of the argument

*Result type:* `<complex>`

*Purity of the procedure:* pure

## `c-atanh`

*Syntax:*

`(c-atanh c)`

*Arguments:*

Name: `c`  
Type: `<complex>`  
Description: A complex number

*Result value:* The hyperbolic arctangent of the argument

*Result type:* <complex>

*Purity of the procedure:* pure

This procedure sometimes returns a value from a different branch compared to guile (2.2.2) `atanh`. Our convention is similar to Octave (version 3.8.1).

## complex-to-string

*Syntax:*

```
(complex-to-string c)
```

*Arguments:*

Name: `c`  
 Type: <complex>  
 Description: A complex number

*Result value:* The complex number as a string

*Result type:* <string>

*Purity of the procedure:* pure

## 25.3 Virtual Methods

```
complex: (<real-number> <real-number>) → <complex>   pure abstract
complex: (<real> <real>) → <complex> pure
complex: (<real> <integer>) → <complex> pure
complex: (<real> <rational>) → <complex> pure
complex: (<integer> <real>) → <complex> pure
complex: (<integer> <integer>) → <complex> pure
complex: (<integer> <rational>) → <complex> pure
complex: (<rational> <real>) → <complex> pure
complex: (<rational> <integer>) → <complex> pure
complex: (<rational> <rational>) → <complex> pure
```

These methods construct a complex number from the real and imaginary parts given as arguments. The arguments are converted to <real> if necessary.

```
equal?: (<complex> <complex>) → <boolean> pure   =   complex=?

=: (<complex> <complex>) → <boolean> pure   =   complex=
=: (<complex> <integer>) → <boolean> pure   =   complex-integer=
=: (<integer> <complex>) → <boolean> pure   =   integer-complex=
```

```

=: (<complex> <real>) → <boolean> pure    =    complex-real=
=: (<real> <complex>) → <boolean> pure    =    real-complex=
=: (<complex> <rational>) → <boolean> pure =    complex-rational=
=: (<rational> <complex>) → <boolean> pure =    rational-complex=

+: (<complex> <complex>) → <complex> pure    =    complex+
+: (<complex> <integer>) → <complex> pure    =    complex-integer+
+: (<integer> <complex>) → <complex> pure    =    integer-complex+
+: (<complex> <real>) → <complex> pure      =    complex-real+
+: (<real> <complex>) → <complex> pure      =    real-complex+
+: (<complex> <rational>) → <complex> pure   =    complex-rational+
+: (<rational> <complex>) → <complex> pure   =    rational-complex+

-: (<complex> <complex>) → <complex> pure    =    complex-
-: (<complex> <integer>) → <complex> pure    =    complex-integer-
-: (<integer> <complex>) → <complex> pure    =    integer-complex-
-: (<complex> <real>) → <complex> pure      =    complex-real-
-: (<real> <complex>) → <complex> pure      =    real-complex-
-: (<complex> <rational>) → <complex> pure   =    complex-rational-
-: (<rational> <complex>) → <complex> pure   =    rational-complex-

*: (<complex> <complex>) → <complex> pure    =    complex*
*: (<complex> <integer>) → <complex> pure    =    complex-integer*
*: (<integer> <complex>) → <complex> pure    =    integer-complex*
*: (<complex> <real>) → <complex> pure      =    complex-real*
*: (<real> <complex>) → <complex> pure      =    real-complex*
*: (<complex> <rational>) → <complex> pure   =    complex-rational*
*: (<rational> <complex>) → <complex> pure   =    rational-complex*

/: (<complex> <complex>) → <complex> pure    =    complex/
/: (<complex> <integer>) → <complex> pure    =    complex-integer/
/: (<integer> <complex>) → <complex> pure    =    integer-complex/
/: (<complex> <real>) → <complex> pure      =    complex-real/
/: (<real> <complex>) → <complex> pure      =    real-complex/
/: (<complex> <rational>) → <complex> pure   =    complex-rational/
/: (<rational> <complex>) → <complex> pure   =    rational-complex/

-: (<complex>) → <complex> pure    =    c-neg
square: (<complex>) → <complex> pure    =    c-square
abs: (<complex>) → <real> pure    =    c-abs

atom-to-string: (<complex> <boolean>) → <string> pure    =    complex-to-string

```



## Chapter 26

# Module (standard-library math)

This module reexports modules `rational`, `real-math`, and `complex`.

### 26.1 Data Types

*Data type name:* `<number>`

*Type:* `:union`

*Description:* A number

Type `<number>` is equal to the union of `<complex>`, `<real>`, `<rational>`, and `<integer>`.

### 26.2 Simple Methods

#### `integer-valued?`

*Syntax:*

```
(integer-valued? x)
```

*Arguments:*

Name: `x`

Type: `<object>`

Description: An object

*Result value:* `#t` iff the argument is integer valued

*Result type:* `<boolean>`

*Purity of the procedure:* pure

An object is integer valued if one of the following holds:

- It is an `<integer>`
- It is an integer valued `<rational>`
- It is an integer valued `<real>`
- It is a `<complex>` whose imaginary part is 0.0 and real part is integer valued

## real-valued?

*Syntax:*

```
(real-valued? x)
```

*Arguments:*

Name: `x`  
Type: `<object>`  
Description: An object

*Result value:* `#t` iff the argument is real valued

*Result type:* `<boolean>`

*Purity of the procedure:* pure

An object is real valued if

- It is an `<integer>`,
- It is a `<rational>`,
- It is a `<real>`, or
- It is a `<complex>` whose imaginary part is 0.0

## rational-valued?

*Syntax:*

```
(rational-valued? x)
```

*Arguments:*

Name: `x`  
 Type: `<object>`  
 Description: An object

*Result value:* `#t` iff the argument is rational valued

*Result type:* `<boolean>`

*Purity of the procedure:* pure

An object is rational valued if

- It is an `<integer>`,
- It is a `<rational>`,
- It is an integer valued `<real>`, or
- It is a `<complex>` whose imaginary part is 0.0 and real part is integer valued

## exact?

*Syntax:*

`(exact? nr)`

*Arguments:*

Name: `nr`  
 Type: `<number>`  
 Description: A number

*Result value:* `#t` iff the argument is exact

*Result type:* `<boolean>`

*Purity of the procedure:* pure

A number is exact iff it is an `<integer>` or a `<rational>`.

## inexact?

*Syntax:*

(inexact? nr)

*Arguments:*

Name: nr  
Type: <number>  
Description: A number

*Result value:* #t iff the argument is inexact

*Result type:* <boolean>

*Purity of the procedure:* pure

A number is exact iff it is not exact, i.e, it is an <real> or a <complex>.

## real->exact

*Syntax:*

(real->exact r)

*Arguments:*

Name: r  
Type: <real>  
Description: A real number

*Result value:* The argument converted to a rational or an integer

*Result type:* <rational-number>

*Purity of the procedure:* pure

## complex->exact

*Syntax:*

(complex->exact cx)

*Arguments:*

Name: cx



Type: `<complex>`  
 Description: A complex number

*Result value:* The argument converted to a rational or an integer

*Result type:* `<rational-number>`

*Purity of the procedure:* pure

## `real->exact`

*Syntax:*

```
(real->exact r)
```

*Arguments:*

Name: `r`  
 Type: `<real>`  
 Description: A real number

*Result value:* The argument converted to a rational or an integer

*Result type:* `<rational-number>`

*Purity of the procedure:* pure

If the imaginary part of the argument is not 0.0 exception `complex->exact:invalid-argument` is raised.

## 26.3 Virtual Methods

```
exact->inexact: (<number>) → <number>   pure abstract
exact->inexact: (<real-number>) → <real-number>   pure abstract
exact->inexact: (<integer>) → <real> pure    =    integer->real
exact->inexact: (<rational>) → <real> pure    =    rational->real
```

```
exact->inexact: (<real>) → <real> pure
```

Returns the argument.

```
exact->inexact: (<complex>) → <complex> pure
```

Returns the argument.

```
inexact->exact: (<number>) → <rational-number>   pure abstract
inexact->exact: (<complex>) → <rational-number> pure    =    complex->exact
```

`inexact->exact: (<real>) → <rational-number> pure = real->exact`

`inexact->exact: (<rational>) → <rational> pure`

Returns the argument.

`inexact->exact: (<integer>) → <integer> pure`

Returns the argument.

`+: (<number> <number>) → <number> pure abstract`  
`-: (<number> <number>) → <number> pure abstract`  
`*: (<number> <number>) → <number> pure abstract`  
`/: (<number> <number>) → <number> pure abstract`

`-: (<number>) → <number> pure abstract`  
`abs: (<number>) → <real-number> pure abstract`  
`square: (<number>) → <number> pure abstract`

`sqrt: (<number>) → <number> pure abstract`  
`sqrt: (<integer>) → <number> pure`  
`sqrt: (<rational>) → <number> pure`  
`sqrt: (<real>) → (:union <real> <complex>) pure`  
`sqrt: (<complex>) → <complex> pure = c-sqrt`

These methods compute the square root of the argument. They return exact 0 when the argument is exact 0.

`expt: (<number> <number>) → <number> pure abstract`  
`expt: (<integer> <integer>) → <rational-number> pure`  
`expt: (<integer> <real>) → (:union <real> <complex>) pure`  
`expt: (<integer> <rational>) → <number> pure`  
`expt: (<integer> <complex>) → <complex> pure`  
`expt: (<real> <integer>) → (:union <real> <integer>) pure`  
`expt: (<real> <real>) → (:union <real> <complex>) pure`  
`expt: (<real> <rational>) → (:union <integer> <real> <complex>) pure`  
`expt: (<real> <complex>) → <complex> pure`  
`expt: (<rational> <integer>) → <rational> pure = rat-int-expt`  
`expt: (<rational> <real>) → (:union <integer> <real> <complex>) pure`  
`expt: (<rational> <rational>) → <number> pure`  
`expt: (<rational> <complex>) → <complex> pure`  
`expt: (<complex> <integer>) → (:union <complex> <integer>) pure`  
`expt: (<complex> <real>) → <complex> pure`  
`expt: (<complex> <rational>) → <complex> pure`  
`expt: (<complex> <complex>) → <complex> pure = c-expt`

These methods raise the first argument to the power of the second argument. If any of the arguments is equal to exact 0 the value 0 or 1 is returned in many cases.

`exp: (<number>) → <number> pure abstract`

```

exp: (<real-number>) → (:union <real> <integer>) pure abstract
exp: (<integer>) → (:union <real> <integer>) pure
exp: (<rational>) → (:union <real> <integer>) pure
exp: (<real>) → <real> pure = r-exp
exp: (<complex>) → <complex> pure = c-exp

```

These methods compute the exponential of the argument. They return exact 1 when the argument is exact 0.

```

log: (<number>) → <number> pure abstract
log: (<integer>) → (:union <integer> <real> <complex>) pure
log: (<rational>) → (:union <integer> <real> <complex>) pure
log: (<real>) → (:union <real> <complex>) pure
log: (<complex>) → <complex> pure = c-log

```

These methods compute the natural logarithm of the argument. They return exact 0 when the argument is exact 1.

```

log10: (<number>) → <number> pure abstract
log10: (<integer>) → (:union <integer> <real> <complex>) pure
log10: (<rational>) → (:union <integer> <real> <complex>) pure
log10: (<real>) → (:union <real> <complex>) pure
log10: (<complex>) → <complex> pure = c-log10

```

These methods compute the logarithm with base 10 of the argument. They return exact 0 when the argument is exact 1.

```

sin: (<number>) → <number> pure abstract
sin: (<real-number>) → (:union <real> <integer>) pure abstract
sin: (<integer>) → (:union <real> <integer>) pure
sin: (<rational>) → (:union <real> <integer>) pure
sin: (<real>) → <real> pure = r-sin
sin: (<complex>) → <complex> pure = c-sin

```

These methods compute the sine of the argument. They return exact 0 when the argument is exact 0.

```

cos: (<number>) → <number> pure abstract
cos: (<real-number>) → (:union <real> <integer>) pure abstract
cos: (<integer>) → (:union <real> <integer>) pure
cos: (<rational>) → (:union <real> <integer>) pure
cos: (<real>) → <real> pure = r-cos
cos: (<complex>) → <complex> pure = c-cos

```

These methods compute the cosine of the argument. They return exact 1 when the argument is exact 0.

```

tan: (<number>) → <number> pure abstract
tan: (<real-number>) → (:union <real> <integer>) pure abstract
tan: (<integer>) → (:union <real> <integer>) pure
tan: (<rational>) → (:union <real> <integer>) pure

```

```

tan: (<real>) → <real> pure    =    r-tan
tan: (<complex>) → <complex> pure    =    c-tan

```

These methods compute the tangent of the argument. They return exact 0 when the argument is exact 0.

```

asin: (<number>) → <number>    pure abstract
asin: (<integer>) → (:union <integer> <real> <complex>) pure
asin: (<rational>) → (:union <integer> <real> <complex>) pure
asin: (<real>) → (:union <real> <complex>) pure
asin: (<complex>) → <complex> pure    =    c-asin

```

These methods compute the arcsine of the argument. They return exact 0 when the argument is exact 0. See the note for `c-asin`, which may also apply when the argument is real.

```

acos: (<number>) → <number>    pure abstract
acos: (<integer>) → (:union <integer> <real> <complex>) pure
acos: (<rational>) → (:union <integer> <real> <complex>) pure
acos: (<real>) → (:union <real> <complex>) pure
acos: (<complex>) → <complex> pure    =    c-acos

```

These methods compute the arccosine of the argument. They return exact 0 when the argument is exact 1. See the note for `c-acos`, which may also apply when the argument is real.

```

atan: (<number>) → <number>    pure abstract
atan: (<real-number>) → <real-number>    pure abstract
atan: (<integer>) → (:union <real> <integer>) pure
atan: (<rational>) → (:union <real> <integer>) pure
atan: (<real>) → <real> pure    =    r-atan
atan: (<complex>) → <complex> pure    =    c-atan

```

These methods compute the arctangent of the argument. They return exact 0 when the argument is exact 0.

```

sinh: (<number>) → <number>    pure abstract
sinh: (<real-number>) → (:union <real> <integer>)    pure abstract
sinh: (<integer>) → (:union <real> <integer>) pure
sinh: (<rational>) → (:union <real> <integer>) pure
sinh: (<real>) → <real> pure    =    r-sinh
sinh: (<complex>) → <complex> pure    =    c-sinh

```

These methods compute the hyperbolic sine of the argument. They return exact 0 when the argument is exact 0.

```

cosh: (<number>) → <number>    pure abstract
cosh: (<real-number>) → (:union <real> <integer>)    pure abstract
cosh: (<integer>) → (:union <real> <integer>) pure
cosh: (<rational>) → (:union <real> <integer>) pure
cosh: (<real>) → <real> pure    =    r-cosh

```

`cosh: (<complex>) → <complex> pure = c-cosh`

These methods compute the hyperbolic cosine of the argument. They return exact 1 when the argument is exact 0.

```

tanh: (<number>) → <number> pure abstract
tanh: (<real-number>) → (:union <real> <integer>) pure abstract
tanh: (<integer>) → (:union <real> <integer>) pure
tanh: (<rational>) → (:union <real> <integer>) pure
tanh: (<real>) → <real> pure = r-tanh
tanh: (<complex>) → <complex> pure = c-tanh

```

These methods compute the hyperbolic tangent of the argument. They return exact 0 when the argument is exact 0.

```

asinh: (<number>) → <number> pure abstract
asinh: (<real-number>) → (:union <real> <integer>) pure abstract
asinh: (<integer>) → (:union <real> <integer>) pure
asinh: (<rational>) → (:union <real> <integer>) pure
asinh: (<real>) → <real> pure = r-asinh
asinh: (<complex>) → <complex> pure = c-asinh

```

These methods compute the inverse hyperbolic sine of the argument. They return exact 0 when the argument is exact 0.

```

acosh: (<number>) → <number> pure abstract
acosh: (<integer>) → (:union <integer> <real> <complex>) pure
acosh: (<rational>) → (:union <integer> <real> <complex>) pure
acosh: (<real>) → (:union <real> <complex>) pure
acosh: (<complex>) → <complex> pure = c-acosh

```

These methods compute the inverse hyperbolic cosine of the argument. They return exact 0 when the argument is exact 1.

```

atanh: (<number>) → <number> pure abstract
atanh: (<integer>) → (:union <integer> <real> <complex>) pure
atanh: (<rational>) → (:union <integer> <real> <complex>) pure
atanh: (<real>) → (:union <real> <complex>) pure
atanh: (<complex>) → <complex> pure = c-atanh

```

These methods compute the inverse hyperbolic tangent of the argument. They return exact 0 when the argument is exact 0. See the note for `c-atanh`, which may also apply when the argument is real.



## Chapter 27

# Module (standard-library extra-math)

This module implements wrapper procedures to many of the mathematical functions in standard C. Additionally, some helper procedures and methods are defined. This module works only for the target platform Guile.

### 27.1 Wrapper Procedures for Standard C Functions

The following procedures are wrappers to the corresponding functions in the standard C (without the prefix “r-”):

```
fmod: (<real> <real>) → <real> pure
r-remainder: (<real> <real>) → <real> pure
r-fma: (<real> <real> <real>) → <real> pure
fmin: (<real> <real>) → <real> pure
fmax: (<real> <real>) → <real> pure
fdim: (<real> <real>) → <real> pure
r-exp2: (<real>) → <real> pure
r-expm1: (<real>) → <real> pure
r-log2: (<real>) → <real> pure
r-log1p: (<real>) → <real> pure
logb: (<real>) → <real> pure
ilogb: (<real>) → <integer> pure
r-cbrt: (<real>) → <real> pure
r-hypot: (<real> <real>) → <real> pure
r-erf: (<real>) → <real> pure
r-erfc: (<real>) → <real> pure
r-lgamma: (<real>) → <real> pure
r-tgamma: (<real>) → <real> pure
r-nearbyint: (<real>) → <real> pure
rint: (<real>) → <real> pure
frexp: (<real>) → (:pair <real> <integer>) pure
ldexp: (<real> <integer>) → <real> pure
```

```

modf: (<real>) → (:pair <real> <real>) pure
r-nextafter: (<real> <real>) → <real> pure
r-copysign: (<real> <real>) → <real> pure
fpclassify: (<real>) → <integer> pure
r-isnormal?: (<real>) → <boolean> pure
r-signbit: (<real>) → <integer> pure

```

Procedure **frexp** returns the fraction of its argument in the head of the result and the exponent in the tail. Procedure **modf** returns the fractional part of its argument in the head of the result and the integer part in the tail. There are no wrappers for **isinf** and **isnan** since similar functions are defined in the core module. See e.g.

[https://en.wikipedia.org/wiki/C\\_mathematical\\_functions](https://en.wikipedia.org/wiki/C_mathematical_functions)

and the GNU libc Reference for further documentation.

## 27.2 Other Simple Methods

### r-log2-neg

*Syntax:*

```
(r-log2-neg r)
```

*Arguments:*

Name: **r**  
 Type: **<real>**  
 Description: A negative real number

*Result value:* The base 2 logarithm of **r**

*Result type:* **<complex>**

*Purity of the procedure:* pure

The base 2 logarithm of a negative real number  $r$  is  $\log_2 r = \log_2 |r| + i\pi / \ln 2$ .

### i-cbrt

*Syntax:*

```
(i-cbrt i)
```



*Arguments:*

Name: `i`  
 Type: `<integer>`  
 Description: An integer number

*Result value:* The cubic root of the argument

*Result type:* `(:union <real> <integer>)`

*Purity of the procedure:* pure

It seems that this procedure can't always detect integer valued results because of floating point errors.

## rat-cbrt

*Syntax:*

`(rat-cbrt rat)`

*Arguments:*

Name: `rat`  
 Type: `<rational>`  
 Description: A rational number

*Result value:* The cubic root of the argument

*Result type:* `(:union <real> <rational> <integer>)`

*Purity of the procedure:* pure

It seems that this procedure can't always detect integer or rational valued results because of floating point errors.

## 27.3 Virtual Methods

```
exp2: (<number>) → <number>   pure abstract
exp2: (<real-number>) → <real-number>   pure abstract
exp2: (<complex>) → <complex> pure
exp2: (<real>) → <real> pure    =    r-exp2
exp2: (<rational>) → <real-number> pure
exp2: (<integer>) → <rational-number> pure
```

These methods compute  $2^x$ .

```

expm1: (<number>) → <number>   pure abstract
expm1: (<real-number>) → <real-number>   pure abstract
expm1: (<complex>) → <complex> pure
expm1: (<real>) → <real> pure    =    r-expm1
expm1: (<rational>) → (:union <real> <integer>) pure
expm1: (<integer>) → (:union <real> <integer>) pure

```

These methods compute  $\exp x - 1$ .

```

log2: (<number>) → <number>   pure abstract
log2: (<complex>) → <complex> pure
log2: (<real>) → (:union <real> <complex>) pure
log2: (<rational>) → (:union <integer> <real> <complex>) pure
log2: (<integer>) → (:union <integer> <real> <complex>) pure

```

These methods compute  $\log_2 x$ .

```

log1p: (<number>) → <number>   pure abstract
log1p: (<complex>) → <complex> pure
log1p: (<real>) → (:union <complex> <real>) pure
log1p: (<rational>) → (:union <complex> <real> <integer>) pure
log1p: (<integer>) → (:union <complex> <real> <integer>) pure

```

These methods compute  $\ln(1 + x)$ .

```

cbrt: (<number>) → <number>   pure abstract
cbrt: (<real-number>) → <real-number>   pure abstract
cbrt: (<complex>) → <complex> pure
cbrt: (<real>) → <real> pure    =    r-cbrt
cbrt: (<rational>) → (:union <real> <rational> <integer>) pure
cbrt: (<integer>) → (:union <real> <integer>) pure

```

These methods compute the cubic root of  $x$ . They are defined for negative arguments, too.

```

hypot: (<real-number> <real-number>) → <real-number>   pure abstract
hypot: (<real> <real>) → <real> pure    =    r-hypot
hypot: (<real> <rational>) → <real> pure
hypot: (<real> <integer>) → <real> pure
hypot: (<rational> <real>) → <real> pure
hypot: (<rational> <rational>) → <real-number> pure
hypot: (<rational> <integer>) → <real-number> pure
hypot: (<integer> <real>) → <real> pure
hypot: (<integer> <rational>) → <real-number> pure
hypot: (<integer> <integer>) → (:union <real> <integer>) pure

```

These methods compute  $\sqrt{x^2 + y^2}$ .

```

erf: (<real-number>) → (:union <real> <integer>)   pure abstract
erf: (<real>) → <real> pure    =    r-erf
erf: (<rational>) → (:union <real> <integer>) pure

```

```
erf: (<integer>) → (:union <real> <integer>) pure
```

These methods compute  $\text{erf } x$  (the error function).

```
erfc: (<real-number>) → (:union <real> <integer>) pure abstract
erfc: (<real>) → <real> pure = r-erfc
erfc: (<rational>) → (:union <real> <integer>) pure
erfc: (<integer>) → (:union <real> <integer>) pure
```

These methods compute  $\text{erfc } x = 1 - \text{erf } x$  (the complementary error function).

```
lgamma: (<real-number>) → (:union <real> <integer>) pure abstract
lgamma: (<real>) → <real> pure = r-lgamma
lgamma: (<rational>) → (:union <real> <integer>) pure
lgamma: (<integer>) → (:union <real> <integer>) pure
```

These methods compute  $\ln |\Gamma(x)|$ .

```
tgamma: (<real-number>) → (:union <real> <integer>) pure abstract
tgamma: (<real>) → <real> pure = r-tgamma
tgamma: (<rational>) → (:union <real> <integer>) pure
tgamma: (<integer>) → (:union <real> <integer>) pure
```

These methods compute  $\Gamma(x)$  (the gamma function). For positive integers the exact value is computed as a factorial.



## Chapter 28

# Module (standard-library posix-math)

This module implements wrapper procedures to many of the mathematical functions in POSIX C not belonging to the C standard. Additionally, some methods are defined. This module works only for the target platform Guile.

See e.g.

[https://en.wikipedia.org/wiki/C\\_POSIX\\_library](https://en.wikipedia.org/wiki/C_POSIX_library)

and the GNU libc Reference for further documentation.

### 28.1 Wrapper Procedures for POSIX C Functions

r-j0: (<real>) → <real> pure  
r-j1: (<real>) → <real> pure  
r-jn: (<integer> <real>) → <real> pure

r-y0: (<real>) → <real> pure  
r-y1: (<real>) → <real> pure  
r-yn: (<integer> <real>) → <real> pure

### 28.2 Virtual Methods

j0: (<real-number>) → <real> pure abstract  
j0: (<real>) → <real> pure = r-j0  
j0: (<rational>) → <real> pure  
j0: (<integer>) → <real> pure

These methods compute the Bessel function j0.

```

j1: (<real-number>) → <real>   pure abstract
j1: (<real>) → <real> pure    =    r-j1
j1: (<rational>) → <real> pure
j1: (<integer>) → <real> pure

```

These methods compute the Bessel function j1.

```

jn: (<integer> <real-number>) → <real>   pure abstract
jn: (<integer> <real>) → <real> pure    =    r-jn
jn: (<integer> <rational>) → <real> pure
jn: (<integer> <integer>) → <real> pure

```

These methods compute the Bessel functions jn.

```

y0: (<real-number>) → <real>   pure abstract
y0: (<real>) → <real> pure    =    r-y0
y0: (<rational>) → <real> pure
y0: (<integer>) → <real> pure

```

These methods compute the Bessel function y0.

```

y1: (<real-number>) → <real>   pure abstract
y1: (<real>) → <real> pure    =    r-y1
y1: (<rational>) → <real> pure
y1: (<integer>) → <real> pure

```

These methods compute the Bessel function y1.

```

yn: (<integer> <real-number>) → <real>   pure abstract
yn: (<integer> <real>) → <real> pure    =    r-yn
yn: (<integer> <rational>) → <real> pure
yn: (<integer> <integer>) → <real> pure

```

These methods compute the Bessel functions yn.

## Chapter 29

# Module (standard-library matrix)

### 29.1 Data Types

*Data type name:* `:matrix`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* A matrix

*Data type name:* `:diagonal-matrix`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* A diagonal matrix

Note that the indices of the matrices have base zero.

### 29.2 Simple Methods

#### `construct-complex-matrix`

*Syntax:*

```
(construct-complex-matrix mx-re mx-im)
```

*Arguments:*

Name: `mx-re`

Type: `(:matrix <real>)`

Description: The real part of the result

Name: `mx-im`

Type: (:matrix <real>)

Description: The imaginary part of the result

*Result value:* A complex matrix with the given real and imaginary parts

*Result type:* (:matrix <complex>)

*Purity of the procedure:* pure

## construct-complex-matrix

*Syntax:*

```
(construct-complex-matrix mx-re mx-im)
```

*Arguments:*

Name: `mx-re`

Type: (:diagonal-matrix <real>)

Description: The real part of the result

Name: `mx-im`

Type: (:diagonal-matrix <real>)

Description: The imaginary part of the result

*Result value:* A complex diagonal matrix with the given real and imaginary parts

*Result type:* (:diagonal-matrix <complex>)

*Purity of the procedure:* pure

## 29.3 Parametrized Methods

### matrix=

*Syntax:*

```
(matrix= mx1 mx2)
```

*Type parameters:* %number



*Arguments:*

Name: `mx1`  
 Type: `(:matrix %number)`  
 Description: A matrix

Name: `mx2`  
 Type: `(:matrix %number)`  
 Description: A matrix

*Result value:* `#t` iff the arguments are numerically equal

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**diagonal-matrix=**

*Syntax:*

`(diagonal-matrix= mx1 mx2)`

*Type parameters:* `%number`

*Arguments:*

Name: `mx1`  
 Type: `(:diagonal-matrix %number)`  
 Description: A matrix

Name: `mx2`  
 Type: `(:diagonal-matrix %number)`  
 Description: A matrix

*Result value:* `#t` iff the arguments are numerically equal

*Result type:* `<boolean>`

*Purity of the procedure:* pure

**matrix-diagonal-matrix=**

*Syntax:*

```
(matrix-diagonal-matrix= mx1 mx2)
```

*Type parameters:* %number

*Arguments:*

Name: mx1  
Type: (:matrix %number)  
Description: A matrix

Name: mx2  
Type: (:diagonal-matrix %number)  
Description: A matrix

*Result value:* #t iff the arguments are numerically equal

*Result type:* <boolean>

*Purity of the procedure:* pure

## diagonal-matrix-matrix=

*Syntax:*

```
(diagonal-matrix-matrix= mx1 mx2)
```

*Type parameters:* %number

*Arguments:*

Name: mx1  
Type: (:diagonal-matrix %number)  
Description: A matrix

Name: mx2  
Type: (:matrix %number)  
Description: A matrix

*Result value:* #t iff the arguments are numerically equal

*Result type:* <boolean>

*Purity of the procedure:* pure

## column-vector

*Syntax:*

```
(column-vector lst)
```

*Type parameters:* %number

*Arguments:*

Name: `lst`  
Type: `(:uniform-list %number)`  
Description: The contents of the vector

*Result value:* A column vector constructed from the argument list

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

## diagonal-matrix

*Syntax:*

```
(diagonal-matrix lst)
```

*Type parameters:* %number

*Arguments:*

Name: `lst`  
Type: `(:uniform-list %number)`  
Description: The contents of the diagonal

*Result value:* A diagonal matrix constructed from the argument list

*Result type:* `(:diagonal-matrix %number)`

*Purity of the procedure:* pure

## diagonal-matrix\*

*Syntax:*

(diagonal-matrix\* mx1 mx2)

*Type parameters:* %number

*Arguments:*

Name: mx1  
Type: (:diagonal-matrix %number)  
Description: A diagonal matrix

Name: mx2  
Type: (:diagonal-matrix %number)  
Description: A diagonal matrix

*Result value:* Product of the given diagonal matrices

*Result type:* (:diagonal-matrix %number)

*Purity of the procedure:* pure

## diagonal-matrix+

*Syntax:*

(diagonal-matrix+ mx1 mx2)

*Type parameters:* %number

*Arguments:*

Name: mx1  
Type: (:diagonal-matrix %number)  
Description: A diagonal matrix

Name: mx2  
Type: (:diagonal-matrix %number)  
Description: A diagonal matrix

*Result value:* Sum of the given diagonal matrices

*Result type:* (:diagonal-matrix %number)

*Purity of the procedure:* pure

## diagonal-matrix-

*Syntax:*

```
(diagonal-matrix- mx1 mx2)
```

*Type parameters:* %number

*Arguments:*

Name: mx1  
Type: (:diagonal-matrix %number)  
Description: A diagonal matrix

Name: mx2  
Type: (:diagonal-matrix %number)  
Description: A diagonal matrix

*Result value:* Difference of the given diagonal matrices

*Result type:* (:diagonal-matrix %number)

*Purity of the procedure:* pure

## diagonal-matrix-copy

*Syntax:*

```
(diagonal-matrix-copy mx)
```

*Type parameters:* %number

*Arguments:*

Name: mx  
Type: (:diagonal-matrix %number)  
Description: A diagonal matrix

*Result value:* A copy of the given diagonal matrix

*Result type:* (:diagonal-matrix %number)

*Purity of the procedure:* pure

The contents of the argument and result matrices will be different objects.

## diagonal-matrix-ref

*Syntax:*

```
(diagonal-matrix-ref mx index)
```

*Type parameters:* %number

*Arguments:*

Name: `mx`  
Type: `(:diagonal-matrix %number)`  
Description: A diagonal matrix

Name: `index`  
Type: `<integer>`  
Description: Index to the element

*Result value:* An element of the diagonal matrix

*Result type:* %number

*Purity of the procedure:* pure

## diagonal-matrix-set!

*Syntax:*

```
(diagonal-matrix-set! mx index value)
```

*Type parameters:* %number

*Arguments:*

Name: `mx`  
Type: `(:diagonal-matrix %number)`  
Description: A diagonal matrix

Name: `index`  
Type: `<integer>`  
Description: Index to the element

Name: `value`  
Type: %number

Description: The new value of the element

No result value.

*Purity of the procedure:* nonpure

## make-column-vector

*Syntax:*

```
(make-column-vector len element-value)
```

*Type parameters:* %number

*Arguments:*

Name: `len`

Type: `<integer>`

Description: The length of the vector

Name: `element-value`

Type: %number

Description: A value to fill the vector

*Result value:* A column vector

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

## make-diagonal-matrix

*Syntax:*

```
(make-diagonal-matrix len element-value)
```

*Type parameters:* %number

*Arguments:*

Name: `len`

Type: `<integer>`

Description: The number of rows and columns in the diagonal matrix

Name: `element-value`

Type: `%number`

Description: A value to fill the diagonal

*Result value:* A diagonal matrix

*Result type:* `(:diagonal-matrix %number)`

*Purity of the procedure:* pure

## `make-matrix`

*Syntax:*

`(make-matrix rows columns element-value)`

*Type parameters:* `%number`

*Arguments:*

Name: `rows`

Type: `<integer>`

Description: Number of rows in the matrix

Name: `columns`

Type: `<integer>`

Description: Number of columns in the matrix

Name: `element-value`

Type: `%number`

Description: A value to fill the matrix

*Result value:* A matrix

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

## `make-row-vector`

*Syntax:*



```
(make-row-vector len element-value)
```

*Type parameters:* `%number`

*Arguments:*

Name: `len`  
 Type: `<integer>`  
 Description: The length of the vector

Name: `element-value`  
 Type: `%number`  
 Description: A value to fill the vector

*Result value:* A row vector

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

## matrix

*Syntax:*

```
(matrix lst)
```

*Type parameters:* `%number`

*Arguments:*

Name: `lst`  
 Type: `(:uniform-list (:uniform-list %number))`  
 Description: The contents of the matrix

*Result value:* A matrix constructed from the argument list

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

The argument type shall be a list of number lists. Each sublist gives the contents of one row in the matrix. All of the sublists must have equal lengths.

## matrix\*

*Syntax:*

```
(matrix* mx1 mx2)
```

*Type parameters:* %number

*Arguments:*

Name: mx1  
Type: (:matrix %number)  
Description: A matrix

Name: mx2  
Type: (:matrix %number)  
Description: A matrix

*Result value:* Product of the given matrices

*Result type:* (:matrix %number)

*Purity of the procedure:* pure

## matrix+

*Syntax:*

```
(matrix+ mx1 mx2)
```

*Type parameters:* %number

*Arguments:*

Name: mx1  
Type: (:matrix %number)  
Description: A matrix

Name: mx2  
Type: (:matrix %number)  
Description: A matrix

*Result value:* Sum of the given matrices

*Result type:* (:matrix %number)

*Purity of the procedure:* pure

**matrix-***Syntax:*

```
(matrix- mx1 mx2)
```

*Type parameters:* %number*Arguments:*

Name: mx1  
Type: (:matrix %number)  
Description: A matrix

Name: mx2  
Type: (:matrix %number)  
Description: A matrix

*Result value:* Difference of the given matrices*Result type:* (:matrix %number)*Purity of the procedure:* pure**matrix-copy***Syntax:*

```
(matrix-copy mx)
```

*Type parameters:* %number*Arguments:*

Name: mx  
Type: (:matrix %number)  
Description: A matrix

*Result value:* A copy of the given matrix*Result type:* (:matrix %number)*Purity of the procedure:* pure

The contents of the argument and result matrices will be different objects.

## row-vector

*Syntax:*

```
(row-vector lst)
```

*Type parameters:* %number

*Arguments:*

Name: `lst`  
Type: `(:uniform-list %number)`  
Description: The contents of the vector

*Result value:* A row vector constructed from the argument list

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

## matrix-conj

*Syntax:*

```
(matrix-conj mx)
```

*Type parameters:* %number

*Arguments:*

Name: `mx1`  
Type: `(:matrix %number)`  
Description: A matrix

*Result value:* Conjugate matrix of the argument

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

## transpose

*Syntax:*

`(transpose mx)`

*Type parameters:* `%number`

*Arguments:*

Name: `mx`  
Type: `(:matrix %number)`  
Description: A matrix

*Result value:* Transpose of the argument

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

## herm

*Syntax:*

`(herm mx)`

*Type parameters:* `%number`

*Arguments:*

Name: `mx`  
Type: `(:matrix %number)`  
Description: A matrix

*Result value:* Hermitian conjugate of the argument

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

## diag-of

*Syntax:*

`(diag-of mx)`

*Type parameters:* %number

*Arguments:*

Name: `mx`  
Type: `(:matrix %number)`  
Description: A matrix

*Result value:* Diagonal of the argument

*Result type:* `(:diagonal-matrix %number)`

*Purity of the procedure:* pure

Note that the argument need not be a square matrix.

## generate-matrix

*Syntax:*

```
(generate-matrix i-rows i-columns proc)
```

*Type parameters:* %number

*Arguments:*

Name: `i-rows`  
Type: `<integer>`  
Description: Number of rows in the matrix

Name: `i-columns`  
Type: `<integer>`  
Description: Number of columns in the matrix

Name: `proc`  
Type: `(:procedure (<integer> <integer>) %number pure)`  
Description: The procedure to generate the elements of the matrix

*Result value:* A matrix

*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

This method uses the argument procedure to generate a matrix. The indices of the elements are passed to the argument procedure.

## generate-diag-matrix

*Syntax:*

```
(generate-diag-matrix i-numel proc)
```

*Type parameters:* %number

*Arguments:*

Name: i-numel

Type: <integer>

Description: Number of elements in the diagonal matrix

Name: proc

Type: (:procedure (<integer>) %number pure)

Description: The procedure to generate the elements of the diagonal matrix

*Result value:* A diagonal matrix

*Result type:* (:diagonal-matrix %number)

*Purity of the procedure:* pure

This method uses the argument procedure to generate a diagonal matrix. The indices of the elements are passed to the argument procedure.

## matrix-map

*Syntax:*

```
(matrix-map proc mx)
```

*Type parameters:* %number

*Arguments:*

Name: proc

Type: (:procedure (%number) %number pure)

Description: The procedure to apply to the elements

Name: mx

Type: (:matrix %number)

Description: A matrix

*Result value:* A matrix

*Result type:* (:matrix %number)

*Purity of the procedure:* pure

The result matrix is constructed by applying the argument procedure to the elements of the argument matrix.

## matrix-map

*Syntax:*

```
(matrix-map proc mx)
```

*Type parameters:* %number

*Arguments:*

Name: proc

Type: (:procedure (%number) %number pure)

Description: The procedure to apply to the elements

Name: mx

Type: (:diagonal-matrix %number)

Description: A diagonal matrix

*Result value:* A diagonal matrix

*Result type:* (:diagonal-matrix %number)

*Purity of the procedure:* pure

The result matrix is constructed by applying the argument procedure to the elements of the argument matrix.

## matrix-map-w-ind

*Syntax:*

```
(matrix-map-w-ind proc mx)
```

*Type parameters:* %number

*Arguments:*



Name: `proc`  
 Type: `(:procedure (<integer> <integer> %number) %number pure)`  
 Description: The procedure to apply to the elements

Name: `mx`  
 Type: `(:matrix %number)`  
 Description: A matrix

*Result value:* A matrix  
*Result type:* `(:matrix %number)`

*Purity of the procedure:* pure

The result matrix is constructed by applying the argument procedure to the elements of the argument matrix. The indices of the elements are passed to the procedure, too.

## diag-matrix-map-w-ind

*Syntax:*

```
(diag-matrix-map-w-ind proc mx)
```

*Type parameters:* `%number`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (<integer> %number) %number pure)`  
 Description: The procedure to apply to the elements

Name: `mx`  
 Type: `(:diagonal-matrix %number)`  
 Description: A matrix

*Result value:* A diagonal matrix  
*Result type:* `(:diagonal-matrix %number)`

*Purity of the procedure:* pure

The result matrix is constructed by applying the argument procedure to the elements of the argument matrix. The indices of the elements are passed to the procedure, too.

## 29.4 Parametrized Virtual Methods

=

*Syntax:*

```
(= mx1 mx2)
```

*Type parameters:* %number

*Arguments:*

Name: mx1  
 Type: (:matrix %number) or (:diagonal-matrix %number)  
 Description: A matrix

Name: mx2  
 Type: (:matrix %number) or (:diagonal-matrix %number)  
 Description: A matrix

*Result value:* #t iff the arguments are numerically equal

*Result type:* <boolean>

*Purity of the procedure:* pure

All combinations of (:matrix %number) and (:diagonal-matrix %number) as argument types are supported.

\*

*Syntax:*

```
(* mx1 mx2)
```

*Type parameters:* %number

*Arguments:*

Name: mx1  
 Type: (:matrix %number) or (:diagonal-matrix %number)  
 Description: A matrix

Name: `mx2`  
 Type: `(:matrix %number)` or `(:diagonal-matrix %number)`  
 Description: A matrix

*Result value:* The product of the matrices

*Result type:* `%number`

*Purity of the procedure:* pure

All combinations of `(:matrix %number)` and `(:diagonal-matrix %number)` as argument types are supported.

**\***

*Syntax:*

`(* nr mx)`

*Type parameters:* `%number`

*Arguments:*

Name: `nr`  
 Type: `%number`  
 Description: A scalar

Name: `mx`  
 Type: `(:matrix %number)` or `(:diagonal-matrix %number)`  
 Description: A matrix

*Result value:* The product of the number and the matrix

*Result type:* `(:matrix %number)` or `(:diagonal-matrix %number)`

*Purity of the procedure:* pure

The result type is the same as the type of argument `mx`.

**\***

*Syntax:*

`(* mx nr)`

*Type parameters:* %number

*Arguments:*

Name: **mx**  
 Type: (:matrix %number) or (:diagonal-matrix %number)  
 Description: A matrix

Name: **nr**  
 Type: %number  
 Description: A scalar

*Result value:* The product of the matrix and the number

*Result type:* (:matrix %number) or (:diagonal-matrix %number)

*Purity of the procedure:* pure

The result type is the same as the type of argument **mx**.

/

*Syntax:*

(/ **mx nr**)

*Type parameters:* %number

*Arguments:*

Name: **mx**  
 Type: (:matrix %number) or (:diagonal-matrix %number)  
 Description: A matrix

Name: **nr**  
 Type: %number  
 Description: A scalar

*Result value:* The quotient of the matrix and the number

*Result type:* (:matrix %number) or (:diagonal-matrix %number)

*Purity of the procedure:* pure

The result type is the same as the type of argument **mx**.

+

*Syntax:*

```
(+ mx1 mx2)
```

*Type parameters:* %number

*Arguments:*

Name: mx1

Type: (:matrix %number) or (:diagonal-matrix %number)

Description: A matrix

Name: mx2

Type: (:matrix %number) or (:diagonal-matrix %number)

Description: A matrix

*Result value:* The sum of the matrices

*Result type:* %number

*Purity of the procedure:* pure

All combinations of (:matrix %number) and (:diagonal-matrix %number) as argument types are supported.

–

*Syntax:*

```
(- mx)
```

*Type parameters:* %number

*Arguments:*

Name: mx

Type: (:matrix %number) or (:diagonal-matrix %number)

Description: A matrix

*Result value:* The opposite matrix

*Result type:* %number

*Purity of the procedure:* pure

The result type is the same as the type of argument `mx`.

—

*Syntax:*

```
(- mx1 mx2)
```

*Type parameters:* `%number`

*Arguments:*

Name: `mx1`  
 Type: `(:matrix %number)` or `(:diagonal-matrix %number)`  
 Description: A matrix

Name: `mx2`  
 Type: `(:matrix %number)` or `(:diagonal-matrix %number)`  
 Description: A matrix

*Result value:* The difference of the matrices

*Result type:* `%number`

*Purity of the procedure:* pure

All combinations of `(:matrix %number)` and `(:diagonal-matrix %number)` as argument types are supported.

## matrix-ref

*Syntax:*

```
(matrix-ref mx row column)
```

*Type parameters:* `%number`

*Arguments:*

Name: `mx`  
 Type: `(:matrix %number)`  
 Description: A matrix

Name: `row`

Type: `<integer>`  
 Description: Row index

Name: `column`  
 Type: `<integer>`  
 Description: Column index

*Result value:* The element of the matrix at the given position

*Result type:* `%number`

*Purity of the procedure:* pure

## **matrix-ref**

*Syntax:*

```
(matrix-ref mx row column)
```

*Type parameters:* `%number`

*Arguments:*

Name: `mx`  
 Type: `(:diagonal-matrix %number)`  
 Description: A matrix

Name: `row`  
 Type: `<integer>`  
 Description: Row index

Name: `column`  
 Type: `<integer>`  
 Description: Column index

*Result value:* The element of the matrix at the given position

*Result type:* `%number`

*Purity of the procedure:* pure

Note that elements outside the diagonal are zero.

## **matrix-set!**

*Syntax:*

```
(matrix-set! mx row column element-value)
```

*Type parameters:* %number

*Arguments:*

Name: `mx`  
Type: `(:matrix %number)`  
Description: A matrix

Name: `row`  
Type: `<integer>`  
Description: Row index

Name: `column`  
Type: `<integer>`  
Description: Column index

Name: `element-value`  
Type: `%number`  
Description: The new value at the specified position

No result value.

*Purity of the procedure:* nonpure

## **matrix-set!**

*Syntax:*

```
(matrix-set! mx row column element-value)
```

*Type parameters:* %number

*Arguments:*

Name: `mx`  
Type: `(:diagonal-matrix %number)`  
Description: A matrix

Name: `row`  
Type: `<integer>`



Description: Row index

Name: `column`

Type: `<integer>`

Description: Column index

Name: `element-value`

Type: `%number`

Description: The new value at the specified position

No result value.

*Purity of the procedure:* nonpure

The row and column indices have to be equal.

## number-of-columns

*Syntax:*

```
(number-of-columns mx)
```

*Type parameters:* `%number`

*Arguments:*

Name: `mx`

Type: `(:matrix %number)`

Description: A matrix

*Result value:* Number of columns in the matrix

*Result type:* `<integer>`

*Purity of the procedure:* pure

## number-of-columns

*Syntax:*

```
(number-of-columns mx)
```

*Type parameters:* `%number`

*Arguments:*

Name: `mx`  
Type: `(:diagonal-matrix %number)`  
Description: A matrix

*Result value:* Length of the diagonal

*Result type:* `<integer>`

*Purity of the procedure:* pure

## number-of-rows

*Syntax:*

`(number-of-rows mx)`

*Type parameters:* `%number`

*Arguments:*

Name: `mx`  
Type: `(:matrix %number)`  
Description: A matrix

*Result value:* Number of rows in the matrix

*Result type:* `<integer>`

*Purity of the procedure:* pure

## number-of-rows

*Syntax:*

`(number-of-rows mx)`

*Type parameters:* `%number`

*Arguments:*

Name: `mx`

Type: (:diagonal-matrix %number)

Description: A matrix

*Result value:* Length of the diagonal

*Result type:* <integer>

*Purity of the procedure:* pure

## conj

*Syntax:*

(conj mx)

*Type parameters:* %number

*Arguments:*

Name: mx1

Type: (:matrix %number)

Description: A matrix

*Result value:* Conjugate matrix of the argument

*Result type:* (:matrix %number)

*Purity of the procedure:* pure



## Chapter 30

# Module (standard-library bvm-matrix-base)

### 30.1 Data Types

*Data type name:* `:bvm-matrix`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* A matrix stored as double precision numbers

*Data type name:* `:bvm-single-matrix`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* A matrix stored as single precision numbers

*Data type name:* `<bvm-matrix>`

*Definition:* `(:bvm-matrix <real>)`

*Data type name:* `<bvm-complex-matrix>`

*Definition:* `(:bvm-matrix <complex>)`

*Data type name:* `<bvm-single-matrix>`

*Definition:* `(:bvm-single-matrix <real>)`

*Data type name:* `<bvm-single-complex-matrix>`

*Definition:* `(:bvm-single-matrix <complex>)`

Note that the indices of the matrices have base zero.

### 30.2 Simple Methods

`bvm-ref: (<bvm-matrix> <integer> <integer>) → <real> pure`

`bvm-ref: (<bvm-complex-matrix> <integer> <integer>) → <complex> pure`

`bvm-ref: (<bvm-single-matrix> <integer> <integer>) → <real> pure`

`bvm-ref: (<bvm-single-complex-matrix> <integer> <integer>) → <complex>  
pure`

*Arguments:*

`mx` : a matrix  
`i1` : row index  
`i2` : column index

Return the element of the matrix at the given indices.

```
bvm-set!: (<bvm-matrix> <integer> <integer> <real>) → <none>
bvm-set!: (<bvm-complex-matrix> <integer> <integer> <complex>) → <none>
bvm-set!: (<bvm-single-matrix> <integer> <integer> <real>) → <none>
bvm-set!: (<bvm-single-complex-matrix> <integer> <integer> <complex>)
→ <none>
```

*Arguments:*

`mx` : a matrix  
`i1` : row index  
`i2` : column index  
`value` : new value of the element

These methods set the element of the argument matrix at the given indices to the new value.

```
bvm-make-matrix: (<integer> <integer> <real>) → <bvm-matrix> pure
bvm-make-matrix: (<integer> <integer> <complex>) → <bvm-complex-matrix>
pure
bvm-make-single-matrix: (<integer> <integer> <real>) → <bvm-single-matrix>
pure
bvm-make-single-matrix: (<integer> <integer> <complex>) → <bvm-single-complex-matrix>
pure
```

*Arguments:*

`i-rows` : number of rows  
`i-columns` : number of columns  
`element-value` : the initial value of the elements

These methods return a matrix filled with the given value.

```
construct-complex-matrix: (<bvm-matrix> <bvm-matrix>) → <bvm-complex-matrix>
pure
construct-complex-matrix: (<bvm-single-matrix> <bvm-single-matrix>)
→ <bvm-single-complex-matrix> pure
```

*Arguments:*

`mx-re` : the real part  
`mx-im` : the imaginary part

These procedures construct a complex matrix with given real and imaginary parts.

```
->real-matrix: (<bvm-matrix>) → <bvm-matrix> pure
->real-matrix: (<bvm-single-matrix>) → <bvm-matrix> pure
->single-matrix: (<bvm-matrix>) → <bvm-single-matrix> pure
->single-matrix: (<bvm-single-matrix>) → <bvm-single-matrix> pure
->complex-matrix: (<bvm-matrix>) → <bvm-complex-matrix> pure
->complex-matrix: (<bvm-single-matrix>) → <bvm-complex-matrix> pure
->complex-matrix: (<bvm-complex-matrix>) → <bvm-complex-matrix> pure
->complex-matrix: (<bvm-single-complex-matrix>) → <bvm-complex-matrix>
pure
->single-complex-matrix: (<bvm-matrix>) → <bvm-complex-matrix> pure
->single-complex-matrix: (<bvm-single-matrix>) → <bvm-complex-matrix>
pure
->single-complex-matrix: (<bvm-complex-matrix>) → <bvm-complex-matrix>
pure
->single-complex-matrix: (<bvm-single-complex-matrix>) → <bvm-complex-matrix>
pure
```

These procedures convert the argument matrix to another type.

```
bvm+: (<bvm-matrix> <bvm-matrix>) → <bvm-matrix> pure
bvm+: (<bvm-complex-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure
bvm+: (<bvm-single-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure
bvm+: (<bvm-single-complex-matrix> <bvm-single-complex-matrix>) →
<bvm-single-complex-matrix> pure
```

These procedures compute the sum of the arguments.

```
bvm-: (<bvm-matrix> <bvm-matrix>) → <bvm-matrix> pure
bvm-: (<bvm-complex-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure
bvm-: (<bvm-single-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure
bvm-: (<bvm-single-complex-matrix> <bvm-single-complex-matrix>) →
<bvm-single-complex-matrix> pure
```

These procedures compute the difference of the arguments.

```
bvm-: (<bvm-matrix>) → <bvm-matrix> pure
bvm-: (<bvm-complex-matrix>) → <bvm-complex-matrix> pure
bvm-: (<bvm-single-matrix>) → <bvm-single-matrix> pure
```

```
bvm-: (<bvm-single-complex-matrix>) → <bvm-single-complex-matrix>
pure
```

These procedures compute the opposite matrix of the argument.

```
bvm-copy: (<bvm-matrix>) → <bvm-matrix> pure
bvm-copy: (<bvm-complex-matrix>) → <bvm-complex-matrix> pure
bvm-copy: (<bvm-single-matrix>) → <bvm-single-matrix> pure
bvm-copy: (<bvm-single-complex-matrix>) → <bvm-single-complex-matrix>
pure
```

These procedures copy the argument so that the contents of the result are stored in a separate memory area.

```
bvm-fill!: (<bvm-matrix> <real>) → <none>
bvm-fill!: (<bvm-complex-matrix> <complex>) → <none>
bvm-fill!: (<bvm-single-matrix> <real>) → <none>
bvm-fill!: (<bvm-single-complex-matrix> <complex>) → <none>
```

These procedures fill the argument matrix with the given value.

```
real-part: (<bvm-complex-matrix>) → <bvm-matrix> pure
real-part: (<bvm-single-complex-matrix>) → <bvm-single-matrix> pure
imag-part: (<bvm-complex-matrix>) → <bvm-matrix> pure
imag-part: (<bvm-single-complex-matrix>) → <bvm-single-matrix> pure
```

These procedures compute the real and imaginary parts of the argument.

```
bvm=: (<bvm-matrix> <bvm-matrix>) → <boolean> pure
bvm=: (<bvm-complex-matrix> <bvm-complex-matrix>) → <boolean> pure
bvm=: (<bvm-single-matrix> <bvm-single-matrix>) → <boolean> pure
bvm=: (<bvm-single-complex-matrix> <bvm-single-complex-matrix>) →
<boolean> pure
```

These procedures return **#t** iff the argument matrices are identical. If the argument sizes are different return **#f**.

```
bvm*: (<real> <bvm-matrix>) → <bvm-matrix> pure
bvm*: (<bvm-matrix> <real>) → <bvm-matrix> pure
bvm*: (<complex> <bvm-complex-matrix>) → <bvm-complex-matrix> pure
bvm*: (<bvm-complex-matrix> <complex>) → <bvm-complex-matrix> pure
bvm*: (<real> <bvm-single-matrix>) → <bvm-single-matrix> pure
bvm*: (<bvm-single-matrix> <real>) → <bvm-single-matrix> pure
bvm*: (<complex> <bvm-single-complex-matrix>) → <bvm-single-complex-matrix>
```



```

pure
bvm*: (<bvm-single-complex-matrix> <complex>) → <bvm-single-complex-matrix>
pure

```

These procedures compute the product of a scalar and a matrix.

```

bvm-column-vector: ((:uniform-list <real>)) → <bvm-matrix> pure
bvm-column-vector: ((:uniform-list <complex>)) → <bvm-complex-matrix>
pure
bvm-single-column-vector: ((:uniform-list <real>)) → <bvm-single-matrix>
pure
bvm-single-column-vector: ((:uniform-list <complex>)) → <bvm-single-complex-matrix>
pure
bvm-row-vector: ((:uniform-list <real>)) → <bvm-matrix> pure
bvm-row-vector: ((:uniform-list <complex>)) → <bvm-complex-matrix>
pure
bvm-single-row-vector: ((:uniform-list <real>)) → <bvm-single-matrix>
pure
bvm-single-row-vector: ((:uniform-list <complex>)) → <bvm-single-complex-matrix>
pure

```

These procedures construct column and row vectors (matrices).

### 30.3 Parametrized Methods

```

bvm-matrix: ((:uniform-list (:uniform-list %number))) → (:bvm-matrix
%number) pure
bvm-single-matrix: ((:uniform-list (:uniform-list %number))) → (:bvm-single-matrix
%number) pure

```

These procedures make a matrix so that its elements are taken from a list structure.

```

bvm-rows: ((:bvm-matrix %number)) → <integer> pure
bvm-rows: ((:bvm-single-matrix %number)) → <integer> pure
bvm-columns: ((:bvm-matrix %number)) → <integer> pure
bvm-columns: ((:bvm-single-matrix %number)) → <integer> pure

```

These procedures return the number of rows and columns in a matrix.

```

bvm*: ((:bvm-matrix %number) (:bvm-matrix %number)) → (:bvm-matrix
%number) pure
bvm*: ((:bvm-single-matrix %number) (:bvm-single-matrix %number)) →
(:bvm-single-matrix %number) pure

```

These procedures compute matrix products.

```
transpose: ((:bvm-matrix %number)) → (:bvm-matrix %number) pure
transpose: ((:bvm-single-matrix %number)) → (:bvm-single-matrix %number)
pure
```

These procedures compute the transpose of a matrix.

```
bvm-conj: ((:bvm-matrix %number)) → (:bvm-matrix %number) pure
bvm-conj: ((:bvm-single-matrix %number)) → (:bvm-single-matrix %number)
pure
```

These procedures compute the complex conjugate of a matrix.

```
herm: ((:bvm-matrix %number)) → (:bvm-matrix %number) pure
herm: ((:bvm-single-matrix %number)) → (:bvm-single-matrix %number)
pure
```

These procedures compute the Hermitian conjugate of a matrix.

```
bvm-generate-matrix: (<integer> <integer> (:procedure (<integer> <integer>)
%number pure)) → (:bvm-matrix %number) pure
```

This procedure generates a matrix using a procedure that takes matrix indices as its arguments.

```
bvm-generate-single-matrix: (<integer> <integer> (:procedure (<integer>
<integer>) %number pure)) → (:bvm-single-matrix %number) pure
```

This procedure generates a single precision matrix using a procedure that takes matrix indices as its arguments.

```
matrix-map: ((:procedure (%number) %number pure) (:bvm-matrix %number))
→ (:bvm-matrix %number) pure
matrix-map: ((:procedure (%number) %number pure) (:bvm-single-matrix
%number)) → (:bvm-single-matrix %number) pure
```

These procedures map the argument procedure to the elements of the argument matrix.

```

matrix-map-w-ind: ((:procedure (<integer> <integer> %number) %number
pure) (:bvm-matrix %number)) → (:bvm-matrix %number) pure
matrix-map-w-ind: ((:procedure (<integer> <integer> %number) %number
pure) (:bvm-single-matrix %number)) → (:bvm-single-matrix %number)
pure

```

These procedures map the argument procedure to the elements of the argument matrix. The element indices are passed to the argument procedure, too.

## 30.4 Virtual Simple Methods

```

matrix-ref: (<bvm-matrix> <integer> <integer>) → <real> pure (bvm-ref)
matrix-ref: (<bvm-complex-matrix> <integer> <integer>) → <complex>
pure (bvm-ref)
matrix-ref: (<bvm-single-matrix> <integer> <integer>) → <real> pure
(bvm-ref)
matrix-ref: (<bvm-single-complex-matrix> <integer> <integer>) → <complex>
pure (bvm-ref)

```

```

matrix-set!: (<bvm-matrix> <integer> <integer> <real>) → <none> pure
(bvm-set!)
matrix-set!: (<bvm-complex-matrix> <integer> <integer> <complex>) →
<none> pure (bvm-set!)
matrix-set!: (<bvm-single-matrix> <integer> <integer> <real>) → <none>
pure (bvm-set!)
matrix-set!: (<bvm-single-complex-matrix> <integer> <integer> <complex>)
→ <none> pure (bvm-set!)

```

```

+: (<bvm-matrix> <bvm-matrix>) → <bvm-matrix> pure (bvm+)
+: (<bvm-complex-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure (bvm+)
+: (<bvm-single-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure (bvm+)
+: (<bvm-single-complex-matrix> <bvm-single-complex-matrix>) → <bvm-single-complex-matrix>
pure (bvm+)

```

```

-: (<bvm-matrix> <bvm-matrix>) → <bvm-matrix> pure (bvm-)
-: (<bvm-complex-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure (bvm-)
-: (<bvm-single-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure (bvm-)
-: (<bvm-single-complex-matrix> <bvm-single-complex-matrix>) → <bvm-single-complex-matrix>
pure (bvm-)

```

```

-: (<bvm-matrix>) → <bvm-matrix> pure    (bvm-)
-: (<bvm-complex-matrix>) → <bvm-complex-matrix> pure    (bvm-)
-: (<bvm-single-matrix>) → <bvm-single-matrix> pure    (bvm-)
-: (<bvm-single-complex-matrix>) → <bvm-single-complex-matrix> pure
(bvm-)

*: (<real> <bvm-matrix>) → <bvm-matrix> pure    (bvm*)
*: (<bvm-matrix> <real>) → <bvm-matrix> pure    (bvm*)
*: (<complex> <bvm-complex-matrix>) → <bvm-complex-matrix> pure    (bvm*)
*: (<bvm-complex-matrix> <complex>) → <bvm-complex-matrix> pure    (bvm*)
*: (<real> <bvm-single-matrix>) → <bvm-single-matrix> pure    (bvm*)
*: (<bvm-single-matrix> <real>) → <bvm-single-matrix> pure    (bvm*)
*: (<complex> <bvm-single-complex-matrix>) → <bvm-single-complex-matrix>
pure    (bvm*)
*: (<bvm-single-complex-matrix> <complex>) → <bvm-single-complex-matrix>
pure    (bvm*)

=: (<bvm-matrix> <bvm-matrix>) → <boolean> pure    (bvm=)
=: (<bvm-complex-matrix> <bvm-complex-matrix>) → <boolean> pure    (bvm=)
=: (<bvm-single-matrix> <bvm-single-matrix>) → <boolean> pure    (bvm=)
=: (<bvm-single-complex-matrix> <bvm-single-complex-matrix>) → <boolean>
pure    (bvm=)

```

## 30.5 Parametrized Virtual Methods

```

number-of-rows: ((:bvm-matrix %number)) → <integer> pure    (bvm-rows)
number-of-rows: ((:bvm-single-matrix %number)) → <integer> pure    (bvm-rows)
number-of-columns: ((:bvm-matrix %number)) → <integer> pure    (bvm-columns)
number-of-columns: ((:bvm-single-matrix %number)) → <integer> pure
(bvm-columns)

*: ((:bvm-matrix %number) (:bvm-matrix %number)) → (:bvm-matrix %number)
pure    (bvm*)
*: ((:bvm-single-matrix %number) (:bvm-single-matrix %number)) → (:bvm-single-matrix
%number) pure    (bvm*)

conj: ((:bvm-matrix %number)) → (:bvm-matrix %number) pure    (bvm-conj)
conj: ((:bvm-single-matrix %number)) → (:bvm-single-matrix %number)
pure    (bvm-conj)

```

## Chapter 31

# Module (standard-library bvm-diag-matrix)

### 31.1 Data Types

*Data type name:* `:bvm-diag-matrix`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* A diagonal matrix stored as double precision numbers

*Data type name:* `:bvm-single-diag-matrix`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* A diagonal matrix stored as single precision numbers

*Data type name:* `<bvm-diag-matrix>`

*Definition:* `(:bvm-diag-matrix <real>)`

*Data type name:* `<bvm-complex-diag-matrix>`

*Definition:* `(:bvm-diag-matrix <complex>)`

*Data type name:* `<bvm-single-diag-matrix>`

*Definition:* `(:bvm-single-diag-matrix <real>)`

*Data type name:* `<bvm-single-complex-diag-matrix>`

*Definition:* `(:bvm-single-diag-matrix <complex>)`

### 31.2 Simple Methods

`bvm-ref: (<bvm-diag-matrix> <integer> <integer>) → <real> pure`

`bvm-ref: (<bvm-complex-diag-matrix> <integer> <integer>) → <complex>  
pure`

`bvm-ref: (<bvm-single-diag-matrix> <integer> <integer>) → <real> pure`

`bvm-ref: (<bvm-single-complex-diag-matrix> <integer> <integer>) →  
<complex> pure`

*Arguments:*

`mx` : a diagonal matrix

i1 : row index  
i2 : column index

Return the element of the matrix at the given indices. If the indices are not equal return zero.

```
bvm-set!: (<bvm-diag-matrix> <integer> <integer> <real>) → <none>
bvm-set!: (<bvm-complex-diag-matrix> <integer> <integer> <complex>)
→ <none>
bvm-set!: (<bvm-single-diag-matrix> <integer> <integer> <real>) →
<none>
bvm-set!: (<bvm-single-complex-diag-matrix> <integer> <integer> <complex>)
→ <none>
```

*Arguments:*

mx : a diagonal matrix  
i1 : row index  
i2 : column index  
value : new value of the element

These methods set the element of the argument matrix at the given indices to the new value. If the indices are not equal raise an exception.

```
diagonal-matrix-ref: (<bvm-diag-matrix> <integer>) → <real> pure
diagonal-matrix-ref: (<bvm-complex-diag-matrix> <integer>) → <complex>
pure
diagonal-matrix-ref: (<bvm-single-diag-matrix> <integer>) → <real>
pure
diagonal-matrix-ref: (<bvm-single-complex-diag-matrix> <integer>) →
<complex> pure
```

*Arguments:*

mx : a diagonal matrix  
i : index (for both row and column)

Return the element of the matrix at the given index.

```
diagonal-matrix-set!: (<bvm-diag-matrix> <integer> <real>) → <none>
diagonal-matrix-set!: (<bvm-complex-diag-matrix> <integer> <complex>)
→ <none>
diagonal-matrix-set!: (<bvm-single-diag-matrix> <integer> <real>) →
<none>
diagonal-matrix-set!: (<bvm-single-complex-diag-matrix> <integer> <complex>)
→ <none>
```

*Arguments:*

**mx** : a diagonal matrix  
**i** : index (for both row and column)  
**value** : new value of the element

These methods set the element of the argument matrix at the given index to the new value.

```

bvm-make-diag-matrix: (<integer> <real>) → <bvm-diag-matrix> pure
bvm-make-diag-matrix: (<integer> <complex>) → <bvm-complex-diag-matrix>
pure
bvm-make-single-diag-matrix: (<integer> <real>) → <bvm-single-diag-matrix>
pure
bvm-make-single-diag-matrix: (<integer> <complex>) → <bvm-single-complex-diag-matrix>
pure

```

*Arguments:*

**i-numel** : number of elements  
**element-value** : the initial value of the elements

These methods return a diagonal matrix filled with the given value.

```

construct-complex-diag-matrix: (<bvm-diag-matrix> <bvm-diag-matrix>)
→ <bvm-complex-diag-matrix> pure
construct-complex-diag-matrix: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>)
→ <bvm-single-complex-diag-matrix> pure

```

*Arguments:*

**mx-re** : the real part  
**mx-im** : the imaginary part

These procedures construct a complex diagonal matrix with given real and imaginary parts.

```

->real-diag-matrix: (<bvm-diag-matrix>) → <bvm-diag-matrix> pure
->real-diag-matrix: (<bvm-single-diag-matrix>) → <bvm-diag-matrix>
pure
->single-diag-matrix: (<bvm-diag-matrix>) → <bvm-single-diag-matrix>
pure
->single-diag-matrix: (<bvm-single-diag-matrix>) → <bvm-single-diag-matrix>
pure
->complex-diag-matrix: (<bvm-diag-matrix>) → <bvm-complex-diag-matrix>
pure
->complex-diag-matrix: (<bvm-single-diag-matrix>) → <bvm-complex-diag-matrix>
pure
->complex-diag-matrix: (<bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure
->complex-diag-matrix: (<bvm-single-complex-diag-matrix>) → <bvm-complex-diag-matrix>

```

```

pure
->single-complex-diag-matrix: (<bvm-diag-matrix>) → <bvm-complex-diag-matrix>
pure
->single-complex-diag-matrix: (<bvm-single-diag-matrix>) → <bvm-complex-diag-matrix>
pure
->single-complex-diag-matrix: (<bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure
->single-complex-diag-matrix: (<bvm-single-complex-diag-matrix>) →
<bvm-complex-diag-matrix> pure

```

These procedures convert the argument diagonal matrix to another type.

```

bvm+: (<bvm-diag-matrix> <bvm-diag-matrix>) → <bvm-diag-matrix> pure
bvm+: (<bvm-complex-diag-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure
bvm+: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>) → <bvm-single-diag-matrix>
pure
bvm+: (<bvm-single-complex-diag-matrix> <bvm-single-complex-diag-matrix>)
→ <bvm-single-complex-diag-matrix> pure

bvm+: (<bvm-diag-matrix> <bvm-matrix>) → <bvm-matrix> pure
bvm+: (<bvm-complex-diag-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure
bvm+: (<bvm-single-diag-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure
bvm+: (<bvm-single-complex-diag-matrix> <bvm-single-complex-matrix>)
→ <bvm-single-complex-matrix> pure

bvm+: (<bvm-matrix> <bvm-diag-matrix>) → <bvm-matrix> pure
bvm+: (<bvm-complex-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-matrix>
pure
bvm+: (<bvm-single-matrix> <bvm-single-diag-matrix>) → <bvm-single-matrix>
pure
bvm+: (<bvm-single-complex-matrix> <bvm-single-complex-diag-matrix>)
→ <bvm-single-complex-matrix> pure

```

These procedures compute the sum of the arguments.

```

bvm-: (<bvm-diag-matrix> <bvm-diag-matrix>) → <bvm-diag-matrix> pure
bvm-: (<bvm-complex-diag-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure
bvm-: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>) → <bvm-single-diag-matrix>
pure
bvm-: (<bvm-single-complex-diag-matrix> <bvm-single-complex-diag-matrix>)
→ <bvm-single-complex-diag-matrix> pure

bvm-: (<bvm-diag-matrix> <bvm-matrix>) → <bvm-matrix> pure

```



```

bvm-: (<bvm-complex-diag-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure
bvm-: (<bvm-single-diag-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure
bvm-: (<bvm-single-complex-diag-matrix> <bvm-single-complex-matrix>)
→ <bvm-single-complex-matrix> pure

bvm-: (<bvm-matrix> <bvm-diag-matrix>) → <bvm-matrix> pure
bvm-: (<bvm-complex-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-matrix>
pure
bvm-: (<bvm-single-matrix> <bvm-single-diag-matrix>) → <bvm-single-matrix>
pure
bvm-: (<bvm-single-complex-matrix> <bvm-single-complex-diag-matrix>)
→ <bvm-single-complex-matrix> pure

```

These procedures compute the difference of the arguments.

```

bvm-: (<bvm-diag-matrix>) → <bvm-diag-matrix> pure
bvm-: (<bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix> pure
bvm-: (<bvm-single-diag-matrix>) → <bvm-single-diag-matrix> pure
bvm-: (<bvm-single-complex-diag-matrix>) → <bvm-single-complex-diag-matrix>
pure

```

These procedures compute the opposite matrix of the argument.

```

bvm*: (<bvm-diag-matrix> <bvm-diag-matrix>) → <bvm-diag-matrix> pure
bvm*: (<bvm-complex-diag-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure
bvm*: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>) → <bvm-single-diag-matrix>
pure
bvm*: (<bvm-single-complex-diag-matrix> <bvm-single-complex-diag-matrix>)
→ <bvm-single-complex-diag-matrix> pure

bvm*: (<bvm-diag-matrix> <bvm-matrix>) → <bvm-matrix> pure
bvm*: (<bvm-complex-diag-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure
bvm*: (<bvm-single-diag-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure
bvm*: (<bvm-single-complex-diag-matrix> <bvm-single-complex-matrix>)
→ <bvm-single-complex-matrix> pure

bvm*: (<bvm-matrix> <bvm-diag-matrix>) → <bvm-matrix> pure
bvm*: (<bvm-complex-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-matrix>
pure
bvm*: (<bvm-single-matrix> <bvm-single-diag-matrix>) → <bvm-single-matrix>
pure
bvm*: (<bvm-single-complex-matrix> <bvm-single-complex-diag-matrix>)

```

→ <bvm-single-complex-matrix> pure

These procedures compute the matrix product of the arguments.

```

bvm*: (<real> <bvm-diag-matrix>) → <bvm-diag-matrix> pure
bvm*: (<bvm-diag-matrix> <real>) → <bvm-diag-matrix> pure
bvm*: (<complex> <bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure
bvm*: (<bvm-complex-diag-matrix> <complex>) → <bvm-complex-diag-matrix>
pure
bvm*: (<real> <bvm-single-diag-matrix>) → <bvm-single-diag-matrix>
pure
bvm*: (<bvm-single-diag-matrix> <real>) → <bvm-single-diag-matrix>
pure
bvm*: (<complex> <bvm-single-complex-diag-matrix>) → <bvm-single-complex-diag-matrix>
pure
bvm*: (<bvm-single-complex-diag-matrix> <complex>) → <bvm-single-complex-diag-matrix>
pure

```

These procedures compute the product of a scalar and a diagonal matrix.

```

bvm-copy: (<bvm-diag-matrix>) → <bvm-diag-matrix> pure
bvm-copy: (<bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure
bvm-copy: (<bvm-single-diag-matrix>) → <bvm-single-diag-matrix> pure
bvm-copy: (<bvm-single-complex-diag-matrix>) → <bvm-single-complex-diag-matrix>
pure

```

These procedures copy the argument so that the contents of the result are stored in a separate memory area.

```

bvm-fill!: (<bvm-diag-matrix> <real>) → <none>
bvm-fill!: (<bvm-complex-diag-matrix> <complex>) → <none>
bvm-fill!: (<bvm-single-diag-matrix> <real>) → <none>
bvm-fill!: (<bvm-single-complex-diag-matrix> <complex>) → <none>

```

These procedures fill the argument matrix with the given value.

```

real-part: (<bvm-complex-diag-matrix>) → <bvm-diag-matrix> pure
real-part: (<bvm-single-complex-diag-matrix>) → <bvm-single-diag-matrix>
pure
imag-part: (<bvm-complex-diag-matrix>) → <bvm-diag-matrix> pure
imag-part: (<bvm-single-complex-diag-matrix>) → <bvm-single-diag-matrix>
pure

```

These procedures compute the real and imaginary parts of the argument.

```

bvm=: (<bvm-diag-matrix> <bvm-diag-matrix>) → <boolean> pure
bvm=: (<bvm-complex-diag-matrix> <bvm-complex-diag-matrix>) → <boolean>
pure
bvm=: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>) → <boolean>
pure
bvm=: (<bvm-single-complex-diag-matrix> <bvm-single-complex-matrix>)
→ <boolean> pure

bvm=: (<bvm-diag-matrix> <bvm-matrix>) → <boolean> pure
bvm=: (<bvm-complex-diag-matrix> <bvm-complex-matrix>) → <boolean>
pure
bvm=: (<bvm-single-diag-matrix> <bvm-single-matrix>) → <boolean> pure
bvm=: (<bvm-single-complex-diag-matrix> <bvm-single-complex-matrix>)
→ <boolean> pure

bvm=: (<bvm-matrix> <bvm-diag-matrix>) → <boolean> pure
bvm=: (<bvm-complex-matrix> <bvm-complex-diag-matrix>) → <boolean>
pure
bvm=: (<bvm-single-matrix> <bvm-single-diag-matrix>) → <boolean> pure
bvm=: (<bvm-single-complex-matrix> <bvm-single-complex-diag-matrix>)
→ <boolean> pure

```

These procedures return **#t** iff the argument matrices are identical. If the argument sizes are different return **#f**.

```

bvm-conj: (<bvm-diag-matrix>) → <bvm-diag-matrix> pure
bvm-conj: (<bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure
bvm-conj: (<bvm-single-diag-matrix>) → <bvm-single-diag-matrix> pure
bvm-conj: (<bvm-single-complex-diag-matrix>) → <bvm-single-complex-diag-matrix>
pure

```

These procedures compute the conjugate of the argument.

```

transpose: (<bvm-diag-matrix>) → <bvm-diag-matrix> pure
transpose: (<bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure
transpose: (<bvm-single-diag-matrix>) → <bvm-single-diag-matrix> pure
transpose: (<bvm-single-complex-diag-matrix>) → <bvm-single-complex-diag-matrix>
pure

```

These procedures compute the transpose of the argument.

```

herm: (<bvm-diag-matrix>) → <bvm-diag-matrix> pure
herm: (<bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix> pure
herm: (<bvm-single-diag-matrix>) → <bvm-single-diag-matrix> pure
herm: (<bvm-single-complex-diag-matrix>) → <bvm-single-complex-diag-matrix>
pure

```

These procedures compute the Hermitian conjugate of the argument.

```

diag-of: (<bvm-matrix>) → <bvm-diag-matrix> pure
diag-of: (<bvm-complex-matrix>) → <bvm-complex-diag-matrix> pure
diag-of: (<bvm-single-matrix>) → <bvm-single-diag-matrix> pure
diag-of: (<bvm-single-complex-matrix>) → <bvm-single-complex-diag-matrix>
pure

```

These procedures return the diagonal of the argument. Note that the argument need not be a square matrix.

```

bvm-generate-diag-matrix: (<integer> (:procedure (<integer>) <real>
pure)) → <bvm-diag-matrix> pure
bvm-generate-diag-matrix: (<integer> (:procedure (<integer>) <complex>
pure)) → <bvm-complex-diag-matrix> pure

bvm-generate-single-diag-matrix: (<integer> (:procedure (<integer>)
<real> pure)) → <bvm-single-diag-matrix> pure
bvm-generate-single-diag-matrix: (<integer> (:procedure (<integer>)
<complex> pure)) → <bvm-single-complex-diag-matrix> pure

```

These procedures generate a diagonal matrix using a procedure that takes matrix index as its argument.

```

matrix-map: ((:procedure (<real>) <real> pure) <bvm-diag-matrix>) →
<bvm-diag-matrix> pure
matrix-map: ((:procedure (<complex>) <complex> pure) <bvm-complex-diag-matrix>)
→ <bvm-complex-diag-matrix> pure
matrix-map: ((:procedure (<real>) <real> pure) <bvm-single-diag-matrix>)
→ <bvm-single-diag-matrix> pure
matrix-map: ((:procedure (<complex>) <complex> pure) <bvm-single-complex-diag-matrix>)
→ <bvm-single-complex-diag-matrix> pure

```

These procedures map the argument procedure to the elements of the argument matrix.

```

diag-matrix-map-w-ind: ((:procedure (<integer> <real>) <real> pure)
<bvm-diag-matrix>) → <bvm-diag-matrix> pure
diag-matrix-map-w-ind: ((:procedure (<integer> <complex>) <complex>

```

```

pure) <bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix> pure
diag-matrix-map-w-ind: ((:procedure (<integer> <real>) <real> pure)
<bvm-single-diag-matrix>) → <bvm-single-diag-matrix> pure
diag-matrix-map-w-ind: ((:procedure (<integer> <complex>) <complex>
pure) <bvm-single-complex-diag-matrix>) → <bvm-single-complex-diag-matrix>
pure

```

These procedures map the argument procedure to the elements of the argument matrix. The element index is passed to the argument procedure, too.

## 31.3 Parametrized Methods

```

bvm-diag-matrix: ((:uniform-list %number)) → (:bvm-diag-matrix %number)
pure
bvm-single-diag-matrix: ((:uniform-list %number)) → (:bvm-single-diag-matrix
%number) pure

```

These procedures make a diagonal matrix so that its elements are taken from a list.

```

bvm-rows: ((:bvm-diag-matrix %number)) → <integer> pure
bvm-rows: ((:bvm-single-diag-matrix %number)) → <integer> pure
bvm-columns: ((:bvm-diag-matrix %number)) → <integer> pure
bvm-columns: ((:bvm-single-diag-matrix %number)) → <integer> pure

```

These procedures return the number of rows and columns (i.e. the number of elements) in a diagonal matrix.

```

diag-matrix-numel: ((:bvm-diag-matrix %number)) → <integer> pure
diag-matrix-numel: ((:bvm-single-diag-matrix %number)) → <integer>
pure

```

These procedures return the number of elements in a diagonal matrix.

```

diag->normal-matrix: ((:bvm-diag-matrix %number)) → (:bvm-matrix %number)
pure
diag->normal-matrix: ((:bvm-single-diag-matrix %number)) → (:bvm-single-matrix
%number) pure

```

These procedures convert a diagonal matrix to a normal matrix.

## 31.4 Simple Virtual Methods

```

matrix-ref: (<bvm-diag-matrix> <integer> <integer>) → <real> pure
(bvm-ref)
matrix-ref: (<bvm-complex-diag-matrix> <integer> <integer>) → <complex>
pure (bvm-ref)
matrix-ref: (<bvm-single-diag-matrix> <integer> <integer>) → <real>
pure (bvm-ref)
matrix-ref: (<bvm-single-complex-diag-matrix> <integer> <integer>)
→ <complex> pure (bvm-ref)

```

```

matrix-set!: (<bvm-diag-matrix> <integer> <integer> <real>) → <none>
pure (bvm-set!)
matrix-set!: (<bvm-complex-diag-matrix> <integer> <integer> <complex>)
→ <none> pure (bvm-set!)
matrix-set!: (<bvm-single-diag-matrix> <integer> <integer> <real>)
→ <none> pure (bvm-set!)
matrix-set!: (<bvm-single-complex-diag-matrix> <integer> <integer>
<complex>) → <none> pure (bvm-set!)

```

```

+: (<bvm-diag-matrix> <bvm-diag-matrix>) → <bvm-diag-matrix> pure
(bvm+)
+: (<bvm-complex-diag-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure (bvm+)
+: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>) → <bvm-single-diag-matrix>
pure (bvm+)
+: (<bvm-single-complex-diag-matrix> <bvm-single-complex-diag-matrix>)
→ <bvm-single-complex-diag-matrix> pure (bvm+)

```

```

+: (<bvm-diag-matrix> <bvm-matrix>) → <bvm-matrix> pure (bvm+)
+: (<bvm-complex-diag-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure (bvm+)
+: (<bvm-single-diag-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure (bvm+)
+: (<bvm-single-complex-diag-matrix> <bvm-single-complex-matrix>) →
<bvm-single-complex-matrix> pure (bvm+)

```

```

+: (<bvm-matrix> <bvm-diag-matrix>) → <bvm-matrix> pure (bvm+)
+: (<bvm-complex-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-matrix>
pure (bvm+)
+: (<bvm-single-matrix> <bvm-single-diag-matrix>) → <bvm-single-matrix>
pure (bvm+)
+: (<bvm-single-complex-matrix> <bvm-single-complex-diag-matrix>) →
<bvm-single-complex-matrix> pure (bvm+)

```

```

-: (<bvm-diag-matrix> <bvm-diag-matrix>) → <bvm-diag-matrix> pure

```

```

(bvm-)
-: (<bvm-complex-diag-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure    (bvm-)
-: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>) → <bvm-single-diag-matrix>
pure    (bvm-)
-: (<bvm-single-complex-diag-matrix> <bvm-single-complex-diag-matrix>)
→ <bvm-single-complex-diag-matrix> pure    (bvm-)

-: (<bvm-diag-matrix> <bvm-matrix>) → <bvm-matrix> pure    (bvm-)
-: (<bvm-complex-diag-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure    (bvm-)
-: (<bvm-single-diag-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure    (bvm-)
-: (<bvm-single-complex-diag-matrix> <bvm-single-complex-matrix>) →
<bvm-single-complex-matrix> pure    (bvm-)

-: (<bvm-matrix> <bvm-diag-matrix>) → <bvm-matrix> pure    (bvm-)
-: (<bvm-complex-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-matrix>
pure    (bvm-)
-: (<bvm-single-matrix> <bvm-single-diag-matrix>) → <bvm-single-matrix>
pure    (bvm-)
-: (<bvm-single-complex-matrix> <bvm-single-complex-diag-matrix>) →
<bvm-single-complex-matrix> pure    (bvm-)

-: (<bvm-diag-matrix>) → <bvm-diag-matrix> pure    (bvm-)
-: (<bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix> pure    (bvm-)
-: (<bvm-single-diag-matrix>) → <bvm-single-diag-matrix> pure    (bvm-)
-: (<bvm-single-complex-diag-matrix>) → <bvm-single-complex-diag-matrix>
pure    (bvm-)

*: (<bvm-diag-matrix> <bvm-diag-matrix>) → <bvm-diag-matrix> pure
(bvm*)
*: (<bvm-complex-diag-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure    (bvm*)
*: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>) → <bvm-single-diag-matrix>
pure    (bvm*)
*: (<bvm-single-complex-diag-matrix> <bvm-single-complex-diag-matrix>)
→ <bvm-single-complex-diag-matrix> pure    (bvm*)

*: (<bvm-diag-matrix> <bvm-matrix>) → <bvm-matrix> pure    (bvm*)
*: (<bvm-complex-diag-matrix> <bvm-complex-matrix>) → <bvm-complex-matrix>
pure    (bvm*)
*: (<bvm-single-diag-matrix> <bvm-single-matrix>) → <bvm-single-matrix>
pure    (bvm*)
*: (<bvm-single-complex-diag-matrix> <bvm-single-complex-matrix>) →
<bvm-single-complex-matrix> pure    (bvm*)

```

```

*: (<bvm-matrix> <bvm-diag-matrix>) → <bvm-matrix> pure (bvm*)
*: (<bvm-complex-matrix> <bvm-complex-diag-matrix>) → <bvm-complex-matrix>
pure (bvm*)
*: (<bvm-single-matrix> <bvm-single-diag-matrix>) → <bvm-single-matrix>
pure (bvm*)
*: (<bvm-single-complex-matrix> <bvm-single-complex-diag-matrix>) →
<bvm-single-complex-matrix> pure (bvm*)

*: (<real> <bvm-diag-matrix>) → <bvm-diag-matrix> pure (bvm*)
*: (<bvm-diag-matrix> <real>) → <bvm-diag-matrix> pure (bvm*)
*: (<complex> <bvm-complex-diag-matrix>) → <bvm-complex-diag-matrix>
pure (bvm*)
*: (<bvm-complex-diag-matrix> <complex>) → <bvm-complex-diag-matrix>
pure (bvm*)
*: (<real> <bvm-single-diag-matrix>) → <bvm-single-diag-matrix> pure
(bvm*)
*: (<bvm-single-diag-matrix> <real>) → <bvm-single-diag-matrix> pure
(bvm*)
*: (<complex> <bvm-single-complex-diag-matrix>) → <bvm-single-complex-diag-matrix>
pure (bvm*)
*: (<bvm-single-complex-diag-matrix> <complex>) → <bvm-single-complex-diag-matrix>
pure (bvm*)

=: (<bvm-diag-matrix> <bvm-diag-matrix>) → <boolean> pure (bvm=)
=: (<bvm-complex-diag-matrix> <bvm-complex-diag-matrix>) → <boolean>
pure (bvm=)
=: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>) → <boolean>
pure (bvm=)
=: (<bvm-single-complex-diag-matrix> <bvm-single-complex-diag-matrix>)
→ <boolean> pure (bvm=)

=: (<bvm-diag-matrix> <bvm-matrix>) → <boolean> pure (bvm=)
=: (<bvm-complex-diag-matrix> <bvm-complex-matrix>) → <boolean> pure
(bvm=)
=: (<bvm-single-diag-matrix> <bvm-single-matrix>) → <boolean> pure
(bvm=)
=: (<bvm-single-complex-diag-matrix> <bvm-single-complex-matrix>) →
<boolean> pure (bvm=)

=: (<bvm-matrix> <bvm-diag-matrix>) → <boolean> pure (bvm=)
=: (<bvm-complex-matrix> <bvm-complex-diag-matrix>) → <boolean> pure
(bvm=)
=: (<bvm-single-matrix> <bvm-single-diag-matrix>) → <boolean> pure
(bvm=)
=: (<bvm-single-complex-matrix> <bvm-single-complex-diag-matrix>) →
<boolean> pure (bvm=)

```



```

conj: (<bvm-diag-matrix> <bvm-diag-matrix>) → <boolean> pure    (bvm-conj)
conj: (<bvm-complex-diag-matrix> <bvm-complex-diag-matrix>) → <boolean>
pure    (bvm-conj)
conj: (<bvm-single-diag-matrix> <bvm-single-diag-matrix>) → <boolean>
pure    (bvm-conj)
conj: (<bvm-single-complex-diag-matrix> <bvm-single-complex-diag-matrix>)
→ <boolean> pure    (bvm-conj)

```

## 31.5 Parametrized Virtual Methods

```

number-of-rows: ((:bvm-diag-matrix %number)) → <integer> pure    (bvm-rows)
number-of-rows: ((:bvm-single-diag-matrix %number)) → <integer> pure
(bvm-rows)
number-of-columns: ((:bvm-diag-matrix %number)) → <integer> pure    (bvm-columns)
number-of-columns: ((:bvm-single-diag-matrix %number)) → <integer>
pure    (bvm-columns)

```



## Chapter 32

# Module (standard-library dynamic-list)

### 32.1 Simple Methods

#### d-append0

*Syntax:*

```
(d-append0 lst)
```

*Arguments:*

Name: `lst`

Type: `<object>`

Description: A list consisting of lists

*Result value:* A list constructed by concatenating the argument lists

*Result type:* `<object>`

*Purity of the procedure:* pure

The lists are concatenated in the order they are given.

#### d-append2

*Syntax:*

```
(d-append2 lst1 lst2)
```

*Arguments:*

Name: `lst1`  
Type: `<object>`  
Description: A list

Name: `lst2`  
Type: `<object>`  
Description: A list

*Result value:* A list constructed by concatenating the argument lists

*Result type:* `<object>`

*Purity of the procedure:* pure

## d-append

*Syntax:*

```
(d-append lst-1 ... lst-n)
```

*Arguments:*

Name: `lst-k`  
Type: `<object>`  
Description: A list

*Result value:* A list constructed by concatenating the argument lists

*Result type:* `<object>`

*Purity of the procedure:* pure

The lists are concatenated in the order they are given.

## d-car

*Syntax:*

```
(d-car obj)
```

*Arguments:*

Name: `obj`  
Type: `<object>`  
Description: An object

*Result value:* The head of the pair

*Result type:* `<object>`

*Purity of the procedure:* pure

If the argument is not a pair an exception is raised.

## **d-cdr**

*Syntax:*

`(d-cdr obj)`

*Arguments:*

Name: `obj`  
Type: `<object>`  
Description: An object

*Result value:* The tail of the pair

*Result type:* `<object>`

*Purity of the procedure:* pure

If the argument is not a pair an exception is raised.

## **d-caar**

*Syntax:*

`(d-caar x)`

*Arguments:*

Name: `x`  
Type: `<object>`  
Description: An object

*Result value:* A value

*Result type:* <object>

*Purity of the procedure:* pure

Expression (d-caar x) is equivalent to (d-car (d-car x)).

## d-cadr

*Syntax:*

(d-cadr x)

*Arguments:*

Name: x

Type: <object>

Description: An object

*Result value:* A value

*Result type:* <object>

*Purity of the procedure:* pure

Expression (d-cadr x) is equivalent to (d-car (d-cdr x)).

## d-cdar

*Syntax:*

(d-cdar x)

*Arguments:*

Name: x

Type: <object>

Description: An object

*Result value:* A value

*Result type:* <object>

*Purity of the procedure:* pure

Expression `(d-cdar x)` is equivalent to `(d-cdr (d-car x))`.

## `d-cddr`

*Syntax:*

```
(d-cddr x)
```

*Arguments:*

Name: `x`  
Type: `<object>`  
Description: An object

*Result value:* A value

*Result type:* `<object>`

*Purity of the procedure:* pure

Expression `(d-cddr x)` is equivalent to `(d-cdr (d-cdr x))`.

## `d-caddr`

*Syntax:*

```
(d-caddr x)
```

*Arguments:*

Name: `x`  
Type: `<object>`  
Description: An object

*Result value:* A value

*Result type:* `<object>`

*Purity of the procedure:* pure

Expression `(d-caddr x)` is equivalent to `(d-car (d-cdr (d-cdr x)))`.

## `d-cdddr`

*Syntax:*

```
(d-cdddr x)
```

*Arguments:*

Name: `x`  
Type: `<object>`  
Description: An object

*Result value:* A value

*Result type:* `<object>`

*Purity of the procedure:* pure

Expression `(d-cdddr x)` is equivalent to `(d-cdr (d-cdr (d-cdr x)))`.

## d-cadddr

*Syntax:*

```
(d-cadddr x)
```

*Arguments:*

Name: `x`  
Type: `<object>`  
Description: An object

*Result value:* A value

*Result type:* `<object>`

*Purity of the procedure:* pure

Expression `(d-cadddr x)` is equivalent to `(d-car (d-cdr (d-cdr (d-cdr x))))`.

## d-drop-right

*Syntax:*

```
(d-drop-right lst i-count)
```



*Arguments:*

Name: `lst`  
Type: `<object>`  
Description: A list

Name: `i-count`  
Type: `<integer>`  
Description: Count of elements to be dropped

*Result value:* A list with specified number of elements dropped away from the end

*Result type:* `<object>`

*Purity of the procedure:* pure

## d-drop

*Syntax:*

```
(d-drop lst i-count)
```

*Arguments:*

Name: `lst`  
Type: `<object>`  
Description: A list

Name: `i-count`  
Type: `<integer>`  
Description: Count of elements to be dropped

*Result value:* A list with specified number of elements dropped away from the beginning

*Result type:* `<object>`

*Purity of the procedure:* pure

## d-exists?

*Syntax:*

```
(d-exists? pred lst-1 ... lst-n)
```

*Arguments:*

Name: `pred`  
 Type: `(:procedure ((rest <object>)) <boolean> pure)`  
 Description: A predicate

Name: `lst-k`  
 Type: `<object>`  
 Description: A list

*Result value:* `#t` iff the predicate returns `#t` for any elementwise application to lists `lst-k`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## d-exists-nonpure?

*Syntax:*

```
(d-exists-nonpure? pred lst-1 ... lst-n)
```

*Arguments:*

Name: `pred`  
 Type: `(:procedure ((rest <object>)) <boolean> nonpure)`  
 Description: A predicate

Name: `lst-k`  
 Type: `<object>`  
 Description: A list

*Result value:* `#t` iff the predicate returns `#t` for any elementwise application to lists `lst-k`

*Result type:* `<boolean>`

*Purity of the procedure:* nonpure

## d-exists0?

*Syntax:*

```
(d-exists0? pred lists)
```

*Arguments:*

Name: `pred`  
Type: `(:procedure ((rest <object>)) <boolean> pure)`  
Description: A predicate

Name: `lists`  
Type: `<object>`  
Description: A list of lists

*Result value:* `#t` iff the predicate returns `#t` for any elementwise application to the lists

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## d-exists-nonpure0?

*Syntax:*

```
(d-exists-nonpure0? pred lists)
```

*Arguments:*

Name: `pred`  
Type: `(:procedure ((rest <object>)) <boolean> nonpure)`  
Description: A predicate

Name: `lists`  
Type: `<object>`  
Description: A list of lists

*Result value:* `#t` iff the predicate returns `#t` for any elementwise application to the lists

*Result type:* `<boolean>`

*Purity of the procedure:* nonpure

## d-exists1?

*Syntax:*

```
(d-exists1? pred lst)
```

*Arguments:*

Name: `pred`  
Type: `(:procedure ((rest <object>)) <boolean> pure)`  
Description: A predicate

Name: `lst`  
Type: `<object>`  
Description: A list

*Result value:* `#t` iff the predicate returns `#t` for any element of the list

*Result type:* `<boolean>`

*Purity of the procedure:* `pure`

## d-exists-nonpure1?

*Syntax:*

```
(d-exists-nonpure1? pred lst)
```

*Arguments:*

Name: `pred`  
Type: `(:procedure ((rest <object>)) <boolean> nonpure)`  
Description: A predicate

Name: `lst`  
Type: `<object>`  
Description: A list

*Result value:* `#t` iff the predicate returns `#t` for any element of the list

*Result type:* `<boolean>`

*Purity of the procedure:* `nonpure`

## d-exists2?

*Syntax:*

```
(d-exists2? pred lst1 lst2)
```

*Arguments:*

Name: `pred`  
Type: `(:procedure (<object> <object>) <boolean> pure)`  
Description: A predicate

Name: `lst1`  
Type: `<object>`  
Description: A list

Name: `lst2`  
Type: `<object>`  
Description: A list

*Result value:* `#t` iff the predicate returns `#t` for any pairwise application to `lst-1` and `lst-2`

*Result type:* `<boolean>`

*Purity of the procedure:* `pure`

## d-exists-nonpure2?

*Syntax:*

```
(d-exists-nonpure2? pred lst1 lst2)
```

*Arguments:*

Name: `pred`  
Type: `(:procedure (<object> <object>) <boolean> nonpure)`  
Description: A predicate

Name: `lst1`  
Type: `<object>`  
Description: A list

Name: `lst2`  
Type: `<object>`

Description: A list

*Result value:* **#t** iff the predicate returns **#t** for any pairwise application to **lst-1** and **lst-2**

*Result type:* <boolean>

*Purity of the procedure:* nonpure

## d-for-all?

*Syntax:*

```
(d-for-all? pred lst-1 ... lst-n)
```

*Arguments:*

Name: **pred**

Type: (:procedure ((rest <object>)) <boolean> pure)

Description: A predicate

Name: **lst-k**

Type: <object>

Description: A list

*Result value:* **#t** iff the predicate returns **#t** for all the elementwise applications to lists **lst-k**

*Result type:* <boolean>

*Purity of the procedure:* pure

## d-for-all-nonpure?

*Syntax:*

```
(d-for-all-nonpure? pred lst-1 ... lst-n)
```

*Arguments:*

Name: **pred**

Type: (:procedure ((rest <object>)) <boolean> nonpure)

Description: A predicate

Name: `lst-k`  
Type: `<object>`  
Description: A list

*Result value:* `#t` iff the predicate returns `#t` for all the elementwise applications to lists `lst-k`

*Result type:* `<boolean>`

*Purity of the procedure:* nonpure

## d-for-all0?

*Syntax:*

```
(d-for-all0? pred lists)
```

*Arguments:*

Name: `pred`  
Type: `(:procedure ((rest <object>)) <boolean> pure)`  
Description: A predicate

Name: `lists`  
Type: `<object>`  
Description: A list of lists

*Result value:* `#t` iff the predicate returns `#t` for all the elementwise applications to the lists

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## d-for-all-nonpure0?

*Syntax:*

```
(d-for-all-nonpure0? pred lists)
```

*Arguments:*

Name: `pred`  
 Type: `(:procedure ((rest <object>)) <boolean> nonpure)`  
 Description: A predicate

Name: `lists`  
 Type: `<object>`  
 Description: A list of lists

*Result value:* `#t` iff the predicate returns `#t` for all the elementwise applications to the lists

*Result type:* `<boolean>`

*Purity of the procedure:* nonpure

## d-for-all1?

*Syntax:*

```
(d-for-all1? pred lst)
```

*Arguments:*

Name: `pred`  
 Type: `(:procedure ((rest <object>)) <boolean> pure)`  
 Description: A predicate

Name: `lst`  
 Type: `<object>`  
 Description: A list

*Result value:* `#t` iff the predicate returns `#t` for all elements of the list

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## d-for-all-nonpure1?

*Syntax:*

```
(d-for-all-nonpure1? pred lst)
```



*Arguments:*

Name: `pred`  
Type: `(:procedure ((rest <object>)) <boolean> nonpure)`  
Description: A predicate

Name: `lst`  
Type: `<object>`  
Description: A list

*Result value:* `#t` iff the predicate returns `#t` for all elements of the list

*Result type:* `<boolean>`

*Purity of the procedure:* nonpure

## `d-for-all2?`

*Syntax:*

```
(d-for-all2? pred lst1 lst2)
```

*Arguments:*

Name: `pred`  
Type: `(:procedure (<object> <object>) <boolean> pure)`  
Description: A predicate

Name: `lst1`  
Type: `<object>`  
Description: A list

Name: `lst2`  
Type: `<object>`  
Description: A list

*Result value:* `#t` iff the predicate returns `#t` for all the pairwise applications to `lst-1` and `lst-2`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## `d-for-all-nonpure2?`

*Syntax:*

```
(d-for-all-nonpure2? pred lst1 lst2)
```

*Arguments:*

Name: `pred`  
 Type: `(:procedure (<object> <object>) <boolean> nonpure)`  
 Description: A predicate

Name: `lst1`  
 Type: `<object>`  
 Description: A list

Name: `lst2`  
 Type: `<object>`  
 Description: A list

*Result value:* `#t` iff the predicate returns `#t` for all the pairwise applications to `lst-1` and `lst-2`

*Result type:* `<boolean>`

*Purity of the procedure:* `nonpure`

## d-for-each

*Syntax:*

```
(d-for-each proc lst-1 ... lst-n)
```

*Arguments:*

Name: `proc`  
 Type: `(:procedure (<object>) <none> nonpure)`  
 Description: A procedure to be applied into the given lists

Name: `lst-k`  
 Type: `<object>`  
 Description: A list

No result value.

*Purity of the procedure:* `nonpure`

This procedure is similar to `for-each`, see section 8.2. The given procedure is applied to the given lists and the results are discarded.

## d-for-each0

*Syntax:*

```
(d-for-each0 proc lists)
```

*Arguments:*

Name: `proc`  
Type: `(:procedure (<object>) <none> nonpure)`  
Description: A procedure to be applied into the given lists

Name: `lists`  
Type: `<object>`  
Description: A list of lists

No result value.

*Purity of the procedure:* nonpure

The given procedure is applied to the given lists and the results are discarded.

## d-for-each1

*Syntax:*

```
(d-for-each1 proc lst)
```

*Arguments:*

Name: `proc`  
Type: `(:procedure (<object>) <none> nonpure)`  
Description: A procedure to be applied into the given list

Name: `lst`  
Type: `<object>`  
Description: A list

No result value.

*Purity of the procedure:* nonpure

This procedure applies the given procedure to the given list and discards the results.

## d-length

*Syntax:*

```
(d-length lst)
```

*Arguments:*

Name: `lst`  
Type: `<object>`  
Description: A list

*Result value:* Number of elements in the list

*Result type:* `<integer>`

*Purity of the procedure:* pure

## d-list

*Syntax:*

```
(d-list obj-1 ... obj-n)
```

*Arguments:*

Name: `obj-k`  
Type: `<object>`  
Description: An object

*Result value:* A list constructed from the arguments

*Result type:* `<object>`

*Purity of the procedure:* pure

## d-list-ref

*Syntax:*

```
(d-list-ref lst index)
```

*Arguments:*

Name: `lst`  
Type: `<object>`  
Description: A list

Name: `index`  
Type: `<integer>`  
Description: Index to the list

*Result value:* The object at the specified position in the given list

*Result type:* `<object>`

*Purity of the procedure:* pure

## d-map-car

*Syntax:*

```
(d-map-car lst)
```

*Arguments:*

Name: `lst`  
Type: `<object>`  
Description: Lists to take arguments from

*Result value:* A list constructed by taking the first element of each component list of `lst`

*Result type:* `<list>`

*Purity of the procedure:* pure

## d-map-cdr

*Syntax:*

```
(d-map-cdr lst)
```

*Arguments:*

Name: `lst`

Type: `<object>`

Description: Lists to take arguments from

*Result value:* A list constructed by taking the tail of each component list of `lst`

*Result type:* `<list>`

*Purity of the procedure:* pure

## **d-reverse**

*Syntax:*

```
(d-reverse lst)
```

*Arguments:*

Name: `lst`

Type: `<object>`

Description: A list

*Result value:* A list consisting of the elements of `lst` in reverse order

*Result type:* `<object>`

*Purity of the procedure:* pure

## **d-take-right**

*Syntax:*

```
(d-take-right lst i-count)
```

*Arguments:*

Name: `lst`

Type: `<object>`

Description: A list

Name: `i-count`

Type: `<integer>`

Description: Count of elements to be taken

*Result value:* A list consisting of the specified number of elements from the end of the argument list

*Result type:* `<object>`

*Purity of the procedure:* pure

## **d-take**

*Syntax:*

```
(d-take lst i-count)
```

*Arguments:*

Name: `lst`

Type: `<object>`

Description: A list

Name: `i-count`

Type: `<integer>`

Description: Count of elements to be taken

*Result value:* A list consisting of the specified number of elements from the beginning of the argument list

*Result type:* `<object>`

*Purity of the procedure:* pure

## **list?**

*Syntax:*

```
(list? x)
```

*Arguments:*

Name: `x`  
 Type: `<object>`  
 Description: An object

*Result value:* Returns `#t` iff `x` is a list.

*Result type:* `<boolean>`

## 32.2 Parametrized Methods

### d-map

*Type parameters:* `%type`

*Syntax:*

```
(d-map proc lst-1 ... lst-n)
```

*Arguments:*

Name: `proc`  
 Type: `(:procedure ((rest <object>)) %type pure)`  
 Description: A procedure to be applied into the given list

Name: `lst-k`  
 Type: `<object>`  
 Description: A list

*Result value:* A list constructed by applying the procedure to the elements of the lists

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

This procedure is similar to `map`, see section 8.2.

### d-map0

*Type parameters:* `%type`

*Syntax:*



```
(d-map0 proc lists)
```

*Arguments:*

Name: `proc`  
 Type: `(:procedure ((rest <object>)) %type pure)`  
 Description: A procedure to be applied into the given list

Name: `lists`  
 Type: `<object>`  
 Description: A list of lists

*Result value:* A list constructed by applying the procedure to the elements of the lists

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

## d-map1

*Syntax:*

```
(d-map1 proc lst)
```

*Type parameters:* `%type`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (<object>) %type pure)`  
 Description: A procedure to be applied into the given list

Name: `lst`  
 Type: `<object>`  
 Description: A list

*Result value:* A list constructed by applying the procedure to each element of the list

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

## d-map2

*Syntax:*

```
(d-map2 proc lst1 lst2)
```

*Type parameters:* %type

*Arguments:*

Name: `proc`  
Type: `(:procedure (<object> <object>) %type pure)`  
Description: A procedure to be applied into the given lists

Name: `lst1`  
Type: `<object>`  
Description: A list

Name: `lst2`  
Type: `<object>`  
Description: A list

*Result value:* A list constructed by applying the procedure pairwise to each element of the lists

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* pure

## d-map-nonpure

*Syntax:*

```
(d-map-nonpure proc lst-1 ... lst-n)
```

*Type parameters:* %type

*Arguments:*

Name: `proc`  
Type: `(:procedure ((rest <object>)) %type nonpure)`  
Description: A procedure to be applied into the given lists

Name: `lst`

Type: `<object>`  
 Description: A list

*Result value:* A list constructed by applying the procedure to the elements of the lists

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* nonpure

This procedure is similar to `map-nonpure`, see section 8.2.

## d-map-nonpure0

*Syntax:*

```
(d-map-nonpure0 proc lists)
```

*Type parameters:* `%type`

*Arguments:*

Name: `proc`  
 Type: `(:procedure ((rest <object>)) %type nonpure)`  
 Description: A procedure to be applied into the given lists

Name: `lists`  
 Type: `<object>`  
 Description: A list of lists

*Result value:* A list constructed by applying the procedure to the elements of the lists

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* nonpure

## d-map-nonpure1

*Syntax:*

```
(d-map-nonpure1 proc lst)
```

*Type parameters:* `%type`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (<object>) %type nonpure)`  
 Description: A procedure to be applied into the given list

Name: `lst`  
 Type: `<object>`  
 Description: A list

*Result value:* A list constructed by applying the procedure to each element of the list

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* nonpure

## d-map-nonpure2

*Syntax:*

```
(d-map-nonpure2 proc lst1 lst2)
```

*Type parameters:* `%type`

*Arguments:*

Name: `proc`  
 Type: `(:procedure (<object> <object>) %type nonpure)`  
 Description: A procedure to be applied into the given lists

Name: `lst1`  
 Type: `<object>`  
 Description: A list

Name: `lst2`  
 Type: `<object>`  
 Description: A list

*Result value:* A list constructed by applying the procedure pairwise to each element of the lists

*Result type:* `(:uniform-list %type)`

*Purity of the procedure:* nonpure

## d-fold1

*Syntax:*

```
(d-fold1 proc x-init l)
```

*Type parameters:* %result

*Arguments:*

Name: `proc`  
Type: `(:procedure (<object> %result) %result pure)`  
Description: A procedure to apply

Name: `x-init`  
Type: %result  
Description: Initial value for folding

Name: `l`  
Type: `<object>`  
Description: A list to fold

*Result value:* A list constructed by folding the argument list with the argument procedure

*Result type:* %result

*Purity of the procedure:* pure

Each `proc` call is `(proc elem previous)` where `elem` is from `l` and `previous` is the return value from the previous call to `proc`, or the given `x-init` for the first call. Procedure `d-fold1` works through the list elements from first to last.

## d-fold-right1

*Syntax:*

```
(d-fold-right1 proc x-init l)
```

*Type parameters:* %result

*Arguments:*

Name: `proc`  
Type: `(:procedure (<object> %result) %result pure)`

Description: A procedure to apply

Name: `x-init`

Type: `%result`

Description: Initial value for folding

Name: `l`

Type: `<object>`

Description: A list to fold

*Result value:* A list constructed by folding the argument list with the argument procedure

*Result type:* `%result`

*Purity of the procedure:* pure

Each `proc` call is `(proc elem previous)` where `elem` is from `l` and `previous` is the return value from the previous call to `proc`, or the given `x-init` for the first call. Procedure `d-fold-right1` works through the list elements from last to first.

## Chapter 33

# Module (standard-library mutable-pair)

### 33.1 Data Types

*Data type name:* `:mpair`

*Type:* `<param-class>`

*Number of type parameters:* 2

*Description:* A mutable pair

*Data type name:* `:mutable-alist`

*Type:* `<param-logical-type>`

*Number of type parameters:* 2

*Description:* An association list consisting of mutable pairs

*Data type name:* `:nonempty-mutable-alist`

*Type:* `<param-logical-type>`

*Number of type parameters:* 2

*Description:* A nonempty association list consisting of mutable pairs

### 33.2 Parametrized Methods

#### **mcons**

*Syntax:*

```
(mcons x1 x2)
```

*Type parameters:* `%type1`, `%type2`

*Arguments:*

Name: `x1`  
Type: `%type1`  
Description: An object

Name: `x2`  
Type: `%type2`  
Description: An object

*Result value:* A mutable pair consisting of the arguments

*Result type:* `(:mpair %type1 %type2)`

*Purity of the procedure:* pure

## `mcar`

*Syntax:*

`(mcar p)`

*Type parameters:* `%type1`, `%type2`

*Arguments:*

Name: `p`  
Type: `(:mpair %type1 %type2)`  
Description: A mutable pair

*Result value:* The head of the argument

*Result type:* `%type1`

*Purity of the procedure:* pure

## `mcdr`

*Syntax:*

`(mcdr p)`

*Type parameters:* `%type1`, `%type2`

*Arguments:*



Name: `p`  
Type: `(:mpair %type1 %type2)`  
Description: A mutable pair

*Result value:* The tail of the argument

*Result type:* `%type2`

*Purity of the procedure:* pure

### **m-set-car!**

*Syntax:*

```
(m-set-car! p x)
```

*Type parameters:* `%type1`, `%type2`

*Arguments:*

Name: `p`  
Type: `(:mpair %type1 %type2)`  
Description: A mutable pair

Name: `x`  
Type: `%type1`  
Description: An object

No result value.

*Purity of the procedure:* nonpure

Set the head of the mutable pair `p` to value `x`.

### **m-set-cdr!**

*Syntax:*

```
(m-set-cdr! p x)
```

*Type parameters:* `%type1`, `%type2`

*Arguments:*

Name: **p**  
 Type: **(:mpair %type1 %type2)**  
 Description: A mutable pair

Name: **x**  
 Type: **%type2**  
 Description: An object

No result value.

*Purity of the procedure:* nonpure

Set the tail of the mutable pair **p** to value **x**.

## **m-assoc**

*Syntax:*

**(m-assoc key alist default)**

*Type parameters:* **%key**, **%value**, **%default**

*Arguments:*

Name: **key**  
 Type: **%key**  
 Description: The key to be searched

Name: **alist**  
 Type: **(:mutable-alist %key %value)**  
 Description: A mutable association list

Name: **default**  
 Type: **%default**  
 Description: The default value

*Result value:* The association corresponding to **key**

*Result type:* **(:union (:mpair %key %value) %default)**

*Purity of the procedure:* pure

If no association is found **default** is returned.

**mpair->string**

*Syntax:*

```
(mpair->string p)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: p  
 Type: (:mpair %type1 %type2)  
 Description: A mutable pair

*Result value:* The mutable pair converted to a string

*Result type:* <string>

*Purity of the procedure:* pure

### 33.3 Parametrized Virtual Methods

```
object->string: ((:mpair %type1 %type2)) → <string> pure = mpair->string
```



## Chapter 34

# Module (standard-library singleton)

### 34.1 Data Types

*Data type name:* `:singleton`

*Type:* `<param-logical-type>`

*Number of type parameters:* 1

*Description:* A singleton object

A singleton is an object containing a single value.

### 34.2 Parametrized Methods

#### `make-singleton`

*Syntax:*

```
(make-singleton element)
```

*Type parameters:* `%type`

*Arguments:*

Name: `element`

Type: `%type`

Description: An object

*Result value:* A new singleton object containing the given value

*Result type:* `(:singleton %type)`

*Purity of the procedure:* pure

## singleton-get-element

*Syntax:*

```
(singleton-get-element sgt)
```

*Type parameters:* %type

*Arguments:*

Name: `sgt`  
Type: `(:singleton %type)`  
Description: A singleton

*Result value:* The value contained in the argument object

*Result type:* %type

*Purity of the procedure:* pure

## singleton-set-element!

*Syntax:*

```
(singleton-set-element! sgt new-element)
```

*Type parameters:* %type

*Arguments:*

Name: `sgt`  
Type: `(:singleton %type)`  
Description: A singleton

Name: `new-element`  
Type: %type  
Description: The new element value

No result value.

*Purity of the procedure:* nonpure

The element of the singleton `sgt` is set to `new-element`.





## Chapter 35

# Module (standard-library hash-table0)

This module is deprecated and works only for Guile target platform. You should use module (standard-library hash-table) instead.

When a hash table is used the hash procedure and the equality predicate used by the association procedure must be compatible with each other, i.e. the hash procedure shall never compute different hash values for objects that are equal by the equality predicate.

When you create object, string, or symbol hash tables you have to manually dispatch the value type. For example to create a string hash table with symbols as the value type use code

```
((param-proc-dispatch make-string-hash-table-with-size <symbol>)
 100)
```

### 35.1 Data Types

*Data type name:* <raw-hash-table>

*Type:* <class>

*Description:* The low-level guile hash table class. This class should not be used directly.

*Data type name:* :hash-proc

*Type:* parametrized procedure class

*Number of type parameters:* 1

*Description:* The type of a hash procedure. The type parameter is the type of the values to be hashed.

*Data type name:* :assoc-proc

*Type:* parametrized procedure class

*Number of type parameters:* 2

*Description:* The type of an association procedure for hash tables. The first type parameter is the type of the key and the second the type of the values with

which the keys are associated.

*Data type name:* `:hash-table`

*Type:* `<param-class>`

*Number of type parameters:* 2

*Description:* The parametrized class for hash tables. The first parameter is the type of the keys and the second the type of the values with which the keys are associated.

*Data type name:* `:object-hash-table`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* The parametrized class for hash tables for which the keys are arbitrary objects. The type parameter is the type of the associated values.

The hash procedure of an object hash table is compatible with the association procedure `assoc-objects1` with the following key types:

- symbols
- booleans
- characters
- strings
- user defined nonprimitive classes
- pairs
- vectors (all four kinds of vectors)

Procedure `assoc-objects1` uses equivalence predicate `equal-objects?`. Note that if you use this class with string or pair keys the keys are considered equal if they are the same object.

*Data type name:* `:string-hash-table`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* The parametrized class for hash tables for which the keys are strings. The type parameter is the type of the associated values.

*Data type name:* `:symbol-hash-table`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* The parametrized class for hash tables for which the keys are symbols. The type parameter is the type of the associated values.

## 35.2 Simple Methods

### object-hash

*Syntax:*

`(object-hash obj size)`

*Arguments:*

Name: `obj`

Type: `<object>`

Description: The object for which the hash value is computed

Name: `size`

Type: `<integer>`

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* `<integer>`

*Purity of the procedure:* pure

## string-hash

*Syntax:*

`(string-hash str size)`

*Arguments:*

Name: `str`

Type: `<string>`

Description: The string for which the hash value is computed

Name: `size`

Type: `<integer>`

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* `<integer>`

*Purity of the procedure:* pure

## hashq

*Syntax:*

```
(hashq x size)
```

*Arguments:*

Name: `x`

Type: `<object>`

Description: The object for which the hash value is computed

Name: `size`

Type: `<integer>`

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* `<integer>`

*Purity of the procedure:* pure

This procedure computes a hash value with Scheme procedure `hashq`. This procedure is compatible with the Scheme predicate `eq?`. See [2, chapter 6.1].

## hashv

*Syntax:*

```
(hashv x size)
```

*Arguments:*

Name: `x`

Type: `<object>`

Description: The object for which the hash value is computed

Name: `size`

Type: `<integer>`

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* `<integer>`

*Purity of the procedure:* pure

This procedure computes a hash value with Scheme procedure `hashv`. This procedure is compatible with the Scheme predicate `eqv?`. See [2, chapter 6.1].

## `hash-contents`

*Syntax:*

```
(hash-contents x size)
```

*Arguments:*

Name: `x`

Type: `<object>`

Description: The object for which the hash value is computed

Name: `size`

Type: `<integer>`

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* `<integer>`

*Purity of the procedure:* pure

This procedure computes a hash value with Scheme procedure `hash`. This procedure is compatible with the Scheme predicate `equal?` (not the similar Theme-D predicate). See [2, chapter 6.1].

## 35.3 Parametrized Methods

### `make-object-hash-table`

*Syntax:*

```
(make-object-hash-table dummy)
```

*Type parameters:* `%value`

*Arguments:*

Name: `dummy`

Type: (:maybe %value)

Description: A dummy argument determining the value type

*Result value:* An object hash table

*Result type:* (:object-hash-table %value)

*Purity of the procedure:* pure

## make-object-hash-table-with-size

*Syntax:*

```
(make-object-hash-table-with-size dummy i-size)
```

*Type parameters:* %value

*Arguments:*

Name: dummy

Type: (:maybe %value)

Description: A dummy argument determining the value type

Name: i-size

Type: <integer>

Description: Size of the hash table

*Result value:* An object hash table with given size

*Result type:* (:object-hash-table %value)

*Purity of the procedure:* pure

## make-string-hash-table

*Syntax:*

```
(make-string-hash-table dummy)
```

*Type parameters:* %value

*Arguments:*

Name: `dummy`  
Type: `(:maybe %value)`  
Description: A dummy argument determining the value type

*Result value:* A string hash table

*Result type:* `(:string-hash-table %value)`

*Purity of the procedure:* pure

## `make-string-hash-table-with-size`

*Syntax:*

```
(make-string-hash-table-with-size dummy i-size)
```

*Type parameters:* `%value`

*Arguments:*

Name: `dummy`  
Type: `(:maybe %value)`  
Description: A dummy argument determining the value type

Name: `i-size`  
Type: `<integer>`  
Description: Size of the hash table

*Result value:* A string hash table with given size

*Result type:* `(:string-hash-table %value)`

*Purity of the procedure:* pure

## `make-symbol-hash-table`

*Syntax:*

```
(make-symbol-hash-table dummy)
```

*Type parameters:* `%value`

*Arguments:*

Name: `dummy`  
Type: `(:maybe %value)`  
Description: A dummy argument determining the value type

*Result value:* A symbol hash table  
*Result type:* `(:symbol-hash-table %value)`

*Purity of the procedure:* pure

## `make-symbol-hash-table-with-size`

*Syntax:*

```
(make-symbol-hash-table-with-size dummy i-size)
```

*Type parameters:* `%value`

*Arguments:*

Name: `dummy`  
Type: `(:maybe %value)`  
Description: A dummy argument determining the value type

Name: `i-size`  
Type: `<integer>`  
Description: Size of the hash table

*Result value:* A symbol hash table with given size  
*Result type:* `(:symbol-hash-table %value)`

*Purity of the procedure:* pure

## `hash-clear!`

*Syntax:*

```
(hash-clear! hashtable)
```

*Type parameters:* `%key`, `%value`



*Arguments:*

Name: `hashtable`  
Type: `(:hash-table %key %value)`  
Description: A hash table

No result value.

*Purity of the procedure:* nonpure

This procedure removes all the element from the argument hash table.

## hash-count-elements

*Syntax:*

`(hash-count-elements hashtable)`

*Type parameters:* `%key`, `%value`

*Arguments:*

Name: `hashtable`  
Type: `(:hash-table %key %value)`  
Description: A hash table

*Result value:* The number of elements in the hash table

*Result type:* `<integer>`

*Purity of the procedure:* pure

## hash-exists?

*Syntax:*

`(hash-exists? hashtable key)`

*Type parameters:* `%key`, `%value`

*Arguments:*

Name: `hashtable`

Type: (:hash-table %key %value)

Description: A hash table

Name: `key`

Type: %key

Description: Key to be searched

*Result value:* Returns `#t` iff the given key is found from the hash table

*Result type:* <boolean>

*Purity of the procedure:* pure

## hash-for-each

*Syntax:*

```
(hash-for-each proc hashtable)
```

*Type parameters:* %key, %value

*Arguments:*

Name: `proc`

Type: (:procedure (%key %value) <none> nonpure)

Description: The procedure to be called

Name: `hashtable`

Type: (:hash-table %key %value)

Description: A hash table

No result value.

*Purity of the procedure:* nonpure

This procedure calls the given procedure for all elements in the hash table.

## hash-ref

*Syntax:*

```
(hash-ref hashtable key default)
```

*Type parameters:* %key, %value, %default

*Arguments:*

Name: `hashtable`  
 Type: `(:hash-table %key %value)`  
 Description: A hash table

Name: `key`  
 Type: %key  
 Description: Key to be searched

Name: `default`  
 Type: %default  
 Description: The default value

*Result value:* The value associated with the given key in the hash table. Returns `default` if the key is not found.

*Result type:* `(:union %value %default)`

*Purity of the procedure:* pure

## hash-remove!

*Syntax:*

```
(hash-remove! hashtable key)
```

*Type parameters:* %key, %value

*Arguments:*

Name: `hashtable`  
 Type: `(:hash-table %key %value)`  
 Description: A hash table

Name: `key`  
 Type: %key  
 Description: Key to be defined

No result value.

*Purity of the procedure:* nonpure

This procedure removes the given key from the hash table. If the key is not

found the procedure does nothing.

## hash-set!

*Syntax:*

```
(hash-set! hashtable key value)
```

*Type parameters:* %key, %value

*Arguments:*

Name: hashtable  
Type: (:hash-table %key %value)  
Description: A hash table

Name: key  
Type: %key  
Description: Key to be defined

Name: value  
Type: %value  
Description: Value to be associated

No result value.

*Purity of the procedure:* nonpure

This procedure associates the given key with the given value in the hash table.

## make-hash-table

*Syntax:*

```
(make-hash-table proc-hash proc-assoc)
```

*Type parameters:* %key, %value

*Arguments:*

Name: proc-hash  
Type: (:hash-proc %key)

Description: A procedure to compute hash values

Name: `proc-assoc`

Type: `(:assoc-proc %key %value)`

Description: A procedure to associate keys and values

*Result value:* A hash table

*Result type:* `(:hash-table %key %value)`

*Purity of the procedure:* pure

## make-hash-table-with-size

*Syntax:*

```
(make-hash-table-with-size proc-hash proc-assoc i-size)
```

*Type parameters:* `%key`, `%value`

*Arguments:*

Name: `proc-hash`

Type: `(:hash-proc %key)`

Description: A procedure to compute hash values

Name: `proc-assoc`

Type: `(:assoc-proc %key %value)`

Description: A procedure to associate keys and values

Name: `i-size`

Type: `<integer>`

Description: Size of the hash table

*Result value:* A hash table with given size

*Result type:* `(:hash-table %key %value)`

*Purity of the procedure:* pure

## assoc1

*Syntax:*

```
(assoc1 key lst)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: **key**

Type: %type1

Description: The key to be searched

Name: **lst**

Type: (:alist %key %value)

Description: The association list from which the object is searched

*Result value:* The association or #f if none is found.

*Result type:* (:union (:pair %type2 %type2) <boolean>)

*Purity of the procedure:* pure

This procedure uses the equivalence predicate `equal?`.

## assoc-values1

*Syntax:*

```
(assoc-values1 key lst)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: **key**

Type: %type1

Description: The key to be searched

Name: **lst**

Type: (:alist %key %value)

Description: The association list from which the object is searched

*Result value:* The association or #f if none is found.

*Result type:* (:union (:pair %type2 %type2) <boolean>)

*Purity of the procedure:* pure

This procedure uses the equivalence predicate `equal-values?`.

## assoc-objects1

*Syntax:*

```
(assoc-objects1 key lst)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `key`

Type: %type1

Description: The key to be searched

Name: `lst`

Type: (:alist %key %value)

Description: The association list from which the object is searched

*Result value:* The association or `#f` if none is found.

*Result type:* (:union (:pair %type2 %type2) <boolean>)

*Purity of the procedure:* pure

This procedure uses the equivalence predicate `equal-objects?`.

## assoc-contents1

*Syntax:*

```
(assoc-contents1 key lst)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `key`

Type: %type1

Description: The key to be searched

Name: `lst`

Type: (:alist %key %value)

Description: The association list from which the object is searched

*Result value:* The association or `#f` if none is found.

*Result type:* (:union (:pair %type2 %type2) <boolean>)

*Purity of the procedure:* pure

This procedure uses the equivalence predicate `equal-contents?`.



## Chapter 36

# Modules (standard-library hash-table) and (standard-library hash-table-opt)

### 36.1 Data Types

For module `hash-table-opt` the following three types are simple procedure classes.

*Data type name:* `:hash-proc`

*Type:* parametrized procedure class

*Number of type parameters:* 1

*Description:* The type of a hash procedure. The type parameter is the type of the values to be hashed.

*Data type name:* `:assoc-proc`

*Type:* parametrized procedure class

*Number of type parameters:* 2

*Description:* The type of an association procedure for hash tables. The first type parameter is the type of the key and the second the type of the values with which the keys are associated.

*Data type name:* `:alist-delete-proc`

*Type:* parametrized procedure class

*Number of type parameters:* 2

*Description:* The type of a procedure used to delete objects from an association list. The first type parameter is the type of the key and the second the type of the values with which the keys are associated.

*Data type name:* `:hash-table`

*Type:* `<param-class>`

*Number of type parameters:* 2

*Description:* The parametrized class for hash tables. The first parameter is the type of the keys and the second the type of the values with which the keys are associated.

*Data type name:* `:object-hash-table`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* The parametrized class for hash tables for which the keys are arbitrary objects. The type parameter is the type of the associated values.

The hash procedure of an object hash table is compatible with the association procedure `assoc-objects1` with the following key types:

- symbols
- booleans
- characters
- strings
- user defined nonprimitive classes
- pairs
- vectors (all four kinds of vectors)

Procedure `assoc-objects1` uses equivalence predicate `equal-objects?`. Note that if you use this class with string or pair keys the keys are considered equal if they are the same object.

*Data type name:* `:string-hash-table`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* The parametrized class for hash tables for which the keys are strings. The type parameter is the type of the associated values.

*Data type name:* `:symbol-hash-table`

*Type:* `<param-class>`

*Number of type parameters:* 1

*Description:* The parametrized class for hash tables for which the keys are symbols. The type parameter is the type of the associated values.

## 36.2 Simple Methods

### `object-hash`

*Syntax:*

```
(object-hash obj size)
```

*Arguments:*

Name: `obj`

Type: `<object>`

Description: The object for which the hash value is computed

Name: **size**

Type: **<integer>**

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* **<integer>**

*Purity of the procedure:* pure

## string-hash

*Syntax:*

```
(string-hash str size)
```

*Arguments:*

Name: **str**

Type: **<string>**

Description: The string for which the hash value is computed

Name: **size**

Type: **<integer>**

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* **<integer>**

*Purity of the procedure:* pure

## hashq

*Syntax:*

```
(hashq x size)
```

*Arguments:*

Name: `x`

Type: `<object>`

Description: The object for which the hash value is computed

Name: `size`

Type: `<integer>`

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* `<integer>`

*Purity of the procedure:* pure

This procedure computes a hash value with Scheme procedure `hashq`. This procedure is compatible with the Scheme predicate `eq?`. See [2, chapter 6.1].

## hashv

*Syntax:*

```
(hashv x size)
```

*Arguments:*

Name: `x`

Type: `<object>`

Description: The object for which the hash value is computed

Name: `size`

Type: `<integer>`

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* `<integer>`

*Purity of the procedure:* pure

This procedure computes a hash value with Scheme procedure `hashv`. This procedure is compatible with the Scheme predicate `eqv?`. See [2, chapter 6.1].

## hash-contents

*Syntax:*

```
(hash-contents x size)
```

*Arguments:*

Name: **x**

Type: **<object>**

Description: The object for which the hash value is computed

Name: **size**

Type: **<integer>**

Description: The size of the hash table for which the hash value is computed.

*Result value:* Hash value

*Result type:* **<integer>**

## 36.3 Parametrized Methods

### make-hash-table

*Syntax:*

```
(make-hash-table proc-hash proc-assoc proc-delete)
```

*Type parameters:* **%key**, **%value**

*Arguments:*

Name: **proc-hash**

Type: **(:hash-proc %key)**

Description: A procedure to compute hash values

Name: **proc-assoc**

Type: **(:assoc-proc %key %value)**

Description: A procedure to associate keys and values

Name: **proc-delete**

Type: **(:alist-delete-proc %key %value)**

Description: A procedure to delete an element from an association list

*Result value:* A hash table

*Result type:* (:hash-table %key %value)

*Purity of the procedure:* pure

## make-hash-table-with-size

*Syntax:*

```
(make-hash-table proc-hash proc-assoc proc-delete i-size)
```

*Type parameters:* %key, %value

*Arguments:*

Name: `proc-hash`

Type: (:hash-proc %key)

Description: A procedure to compute hash values

Name: `proc-assoc`

Type: (:assoc-proc %key %value)

Description: A procedure to associate keys and values

Name: `proc-delete`

Type: (:alist-delete-proc %key %value)

Description: A procedure to delete an element from an association list

Name: `i-size`

Type: <integer>

Description: The size of the hash table

*Result value:* A hash table with the given size

*Result type:* (:hash-table %key %value)

*Purity of the procedure:* pure

## make-object-hash-table

*Syntax:*

```
(make-object-hash-table dummy)
```

*Type parameters:* %value

*Arguments:*

Name: dummy  
Type: (:maybe %value)  
Description: A dummy argument determining the value type

*Result value:* An object hash table

*Result type:* (:object-hash-table %value)

*Purity of the procedure:* pure

## make-object-hash-table-with-size

*Syntax:*

```
(make-object-hash-table-with-size dummy i-size)
```

*Type parameters:* %value

*Arguments:*

Name: dummy  
Type: (:maybe %value)  
Description: A dummy argument determining the value type

Name: i-size  
Type: <integer>  
Description: Size of the hash table

*Result value:* An object hash table with given size

*Result type:* (:object-hash-table %value)

*Purity of the procedure:* pure

## make-string-hash-table

*Syntax:*

```
(make-string-hash-table dummy)
```

*Type parameters:* %value

*Arguments:*

Name: dummy  
 Type: (:maybe %value)  
 Description: A dummy argument determining the value type

*Result value:* A string hash table  
*Result type:* (:string-hash-table %value)

*Purity of the procedure:* pure

## make-string-hash-table-with-size

*Syntax:*

```
(make-string-hash-table-with-size dummy i-size)
```

*Type parameters:* %value

*Arguments:*

Name: dummy  
 Type: (:maybe %value)  
 Description: A dummy argument determining the value type

Name: i-size  
 Type: <integer>  
 Description: Size of the hash table

*Result value:* A string hash table with given size  
*Result type:* (:string-hash-table %value)

*Purity of the procedure:* pure

## make-symbol-hash-table

*Syntax:*

```
(make-symbol-hash-table dummy)
```



*Type parameters:* %value

*Arguments:*

Name: dummy  
Type: (:maybe %value)  
Description: A dummy argument determining the value type

*Result value:* A symbol hash table

*Result type:* (:symbol-hash-table %value)

*Purity of the procedure:* pure

## make-symbol-hash-table-with-size

*Syntax:*

```
(make-symbol-hash-table-with-size dummy i-size)
```

*Type parameters:* %value

*Arguments:*

Name: dummy  
Type: (:maybe %value)  
Description: A dummy argument determining the value type

Name: i-size  
Type: <integer>  
Description: Size of the hash table

*Result value:* A symbol hash table with given size

*Result type:* (:symbol-hash-table %value)

*Purity of the procedure:* pure

## hash-clear!

*Syntax:*

```
(hash-clear! hashtable)
```

*Type parameters:* %key, %value

*Arguments:*

Name: hashtable  
 Type: (:hash-table %key %value)  
 Description: A hash table

No result value.

*Purity of the procedure:* nonpure

This procedure removes all the element from the argument hash table.

## hash-exists?

*Syntax:*

```
(hash-exists? hashtable key)
```

*Type parameters:* %key, %value

*Arguments:*

Name: hashtable  
 Type: (:hash-table %key %value)  
 Description: A hash table

Name: key  
 Type: %key  
 Description: Key to be searched

*Result value:* Returns #t iff the given key is found from the hash table

*Result type:* <boolean>

*Purity of the procedure:* pure

## hash-for-each

*Syntax:*

```
(hash-for-each proc hashtable)
```

*Type parameters:* %key, %value

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%key %value) <none> nonpure)`  
 Description: The procedure to be called

Name: `hashtable`  
 Type: `(:hash-table %key %value)`  
 Description: A hash table

No result value.

*Purity of the procedure:* nonpure

This procedure calls the given procedure for all elements in the hash table.

## `hash-map->list`

*Syntax:*

```
(hash-map->list proc hashtable)
```

*Type parameters:* %key, %value, %result

*Arguments:*

Name: `proc`  
 Type: `(:procedure (%key %value) %result pure)`  
 Description: The procedure to be called

Name: `hashtable`  
 Type: `(:hash-table %key %value)`  
 Description: A hash table

*Result value:* A list consisting of the applications of the procedure

*Result type:* `(:uniform-list %result)`

*Purity of the procedure:* pure

This procedure calls the given procedure for all elements in the hash table and returns a list consisting of the results of the calls.

## hash-map->list-nonpure

*Syntax:*

```
(hash-map->list-nonpure proc hashtable)
```

*Type parameters:* %key, %value, %result

*Arguments:*

Name: `proc`  
Type: `(:procedure (%key %value) %result nonpure)`  
Description: The procedure to be called

Name: `hashtable`  
Type: `(:hash-table %key %value)`  
Description: A hash table

*Result value:* A list consisting of the applications of the procedure

*Result type:* `(:uniform-list %result)`

*Purity of the procedure:* nonpure

This procedure calls the given procedure for all elements in the hash table and returns a list consisting of the results of the calls.

## hash-ref

*Syntax:*

```
(hash-ref hashtable key default)
```

*Type parameters:* %key, %value, %default

*Arguments:*

Name: `hashtable`  
Type: `(:hash-table %key %value)`  
Description: A hash table

Name: `key`  
Type: `%key`  
Description: Key to be searched

Name: `default`  
Type: `%default`  
Description: The default value

*Result value:* The value associated with the given key in the hash table. Returns `default` if the key is not found.

*Result type:* `(:union %value %default)`

*Purity of the procedure:* pure

## `hash-remove!`

*Syntax:*

```
(hash-remove! hashtable key)
```

*Type parameters:* `%key`, `%value`

*Arguments:*

Name: `hashtable`  
Type: `(:hash-table %key %value)`  
Description: A hash table

Name: `key`  
Type: `%key`  
Description: Key to be defined

No result value.

*Purity of the procedure:* nonpure

This procedure removes the given key from the hash table. If the key is not found the procedure does nothing.

## `hash-set!`

*Syntax:*

```
(hash-set! hashtable key value)
```

*Type parameters:* `%key`, `%value`

*Arguments:*

Name: `hashtable`  
 Type: `(:hash-table %key %value)`  
 Description: A hash table

Name: `key`  
 Type: `%key`  
 Description: Key to be defined

Name: `value`  
 Type: `%value`  
 Description: Value to be associated

No result value.

*Purity of the procedure:* nonpure

This procedure associates the given key with the given value in the hash table.

## hash-count

*Syntax:*

`(hash-count pred hashtable)`

*Type parameters:* `%key`, `%value`

*Arguments:*

Name: `pred`  
 Type: `(:binary-predicate %key %value)`  
 Description: A binary predicate

Name: `hashtable`  
 Type: `(:hash-table %key %value)`  
 Description: A hash table

*Result value:* The number of elements satisfying the predicate in the hash table

*Result type:* `<integer>`

*Purity of the procedure:* pure

## hash-count-elements

*Syntax:*

```
(hash-count-elements hashtable)
```

*Type parameters:* %key, %value

*Arguments:*

Name: `hashtable`  
Type: `(:hash-table %key %value)`  
Description: A hash table

*Result value:* The number of elements in the hash table

*Result type:* `<integer>`

*Purity of the procedure:* pure

## hash-search-first

*Syntax:*

```
(hash-search-first pred ht x-default)
```

*Type parameters:* %key, %value, %default

*Arguments:*

Name: `pred`  
Type: `(:binary-predicate %key %value)`  
Description: A binary predicate

Name: `ht`  
Type: `(:hash-table %key %value)`  
Description: A hash table

Name: `x-default`  
Type: `%default`  
Description: The default return value

*Result value:* The first element satisfying the predicate in the hash table

*Result type:* `(:union %value %default)`

*Purity of the procedure:* pure

If no element satisfies the predicate value `x-default` is returned.

## **assoc1**

*Syntax:*

```
(assoc1 key lst)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `key`  
 Type: %type1  
 Description: The key to be searched

Name: `lst`  
 Type: (:alist %key %value)  
 Description: The association list from which the object is searched

*Result value:* The association or `#f` if none is found.

*Result type:* (:union (:pair %type2 %type2) <boolean>)

*Purity of the procedure:* pure

This procedure uses the equivalence predicate `equal?`.

## **assoc-values1**

*Syntax:*

```
(assoc-values1 key lst)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: `key`  
 Type: %type1  
 Description: The key to be searched



Name: `lst`  
 Type: `(:alist %key %value)`  
 Description: The association list from which the object is searched

*Result value:* The association or `#f` if none is found.

*Result type:* `(:union (:pair %type2 %type2) <boolean>)`

*Purity of the procedure:* pure

This procedure uses the equivalence predicate `equal-values?`.

## assoc-objects1

*Syntax:*

```
(assoc-objects1 key lst)
```

*Type parameters:* `%type1`, `%type2`

*Arguments:*

Name: `key`  
 Type: `%type1`  
 Description: The key to be searched

Name: `lst`  
 Type: `(:alist %key %value)`  
 Description: The association list from which the object is searched

*Result value:* The association or `#f` if none is found.

*Result type:* `(:union (:pair %type2 %type2) <boolean>)`

*Purity of the procedure:* pure

This procedure uses the equivalence predicate `equal-objects?`.

## assoc-contents1

*Syntax:*

```
(assoc-contents1 key lst)
```

*Type parameters:* %type1, %type2

*Arguments:*

Name: key  
 Type: %type1  
 Description: The key to be searched

Name: lst  
 Type: (:alist %key %value)  
 Description: The association list from which the object is searched

*Result value:* The association or #f if none is found.

*Result type:* (:union (:pair %type2 %type2) <boolean>)

*Purity of the procedure:* pure

This procedure uses the equivalence predicate `equal-contents?`.

## Chapter 37

# Module (standard-library command-line-parser)

### 37.1 Data Types

*Data type name:* <argument-descriptor>

*Type:* <class>

*Description:* A descriptor for a command-line argument

*Data type name:* <argument-descriptor-list>

*Type:* :union

*Description:* A list of argument descriptors

*Data type name:* <argument-handler>

*Type:* :procedure

*Description:* A procedure to handle an argument

An object of type <argument-descriptor> has the following fields:

- **x-name:** The name of the argument, either a character or a string.
- **takes-argument?:** A boolean value, #t iff the option takes an argument.
- **proc-handler:** A handler procedure for the option, type <argument-handler>.

A procedure of type <argument-handler> takes a single <string> argument, which is the argument passed to the command line option. If the option does not take any arguments the argument is an empty string.

See example program `command-line-demo.thp` for the usage of this module.

### 37.2 Simple Methods

`parse-command-line`

*Syntax:*

```
(parse-command-line l-command-line l-argdescs proc-handle-proper-args)
```

*Arguments:*

Name: `l-command-line`  
 Type: `(:uniform-list <string>)`  
 Description: The command line arguments

Name: `l-arg-descs`  
 Type: `<argument-descriptor-list>`  
 Description: List of argument descriptors

Name: `proc-handle-proper-args`  
 Type: `(:procedure ((:uniform-list <string>)) <none> nonpure)`  
 Description: A procedure to handle non-option arguments

No result value.

*Purity of the procedure:* nonpure

This procedure parses the command line arguments using the given argument descriptors and non-option argument handler.

## Chapter 38

# Module (standard-library statprof)

This is a wrapper module for guile profiler `statprof`. Note that all features of `statprof` are not supported. A simple use of `statprof` would look like this:

```
(statprof-reset 0 50000 #f)
(statprof-start)
(do-something)
(statprof-stop)
(statprof-display)
```

See guile documentation for further information.

### 38.1 Simple Methods

#### `statprof-start`

*Syntax:*

```
(statprof-start)
```

No arguments.

No result value.

*Purity of the procedure:* nonpure

Start profiling.

## statprof-stop

*Syntax:*

```
(statprof-stop)
```

No arguments.

No result value.

*Purity of the procedure:* nonpure

Stop profiling.

## statprof-reset

*Syntax:*

```
(statprof-reset sample-seconds sample-microseconds count-calls?)
```

*Arguments:*

Name: `sample-seconds`

Type: `<integer>`

Description: Seconds for the sampler interval

Name: `sample-microseconds`

Type: `<integer>`

Description: Microseconds for the sampler interval

Name: `count-calls?`

Type: `<boolean>`

Description: `#t` to count procedure calls

No result value.

*Purity of the procedure:* nonpure

Reset the profiler.

## statprof-display

*Syntax:*

```
(statprof-display)
```

No arguments.

No result value.

*Purity of the procedure:* nonpure

Display a summary of the statistics collected.





## Chapter 39

# Module (standard-library plugins)

Note that this module supports only dynamically loaded modules created by linking Theme-D module bodies to plugins. See test plugin `test913` and test program `test914` for a simple example of plugin usage.

### 39.1 Data Types

*Data type name:* `<module>`

*Type:* `<class>`

*Description:* A dynamically loaded Guile module

### 39.2 Simple Methods

#### `load-module`

*Syntax:*

```
(load-module l-s-module)
```

*Arguments:*

Name: `l-s-module`

Type: `(:uniform-list <symbol>)`

Description: The name of the module to be loaded

*Result value:* A module object or `#f`

*Result type:* `(:alt-maybe <module>)`

*Purity of the procedure:* nonpure

This method loads a Guile module and returns an object representing it. If the module is not found return `#f`.

## load-plugin

*Syntax:*

```
(load-plugin l-s-plugin)
```

*Arguments:*

Name: `l-s-plugin`  
Type: `(:uniform-list <symbol>)`  
Description: The name of the plugin to be loaded

*Result value:* A module object

*Result type:* `<module>`

*Purity of the procedure:* nonpure

This method loads a Theme-D plugin and returns an object representing it. If the module is not found raise exception `plugin-not-found`. If the module is not a proper Theme-D plugin file raise exception `not-a-plugin-file`.

## module-var-exists?

*Syntax:*

```
(module-var-exists? module s-var)
```

*Arguments:*

Name: `module`  
Type: `<module>`  
Description: A dynamically loaded module

Name: `s-var`  
Type: `<symbol>`  
Description: The name of a variable

*Result value:* `#t` iff `module` defines variable `s-var`

*Result type:* `<boolean>`

*Purity of the procedure:* pure

## module-ref

*Syntax:*

```
(module-ref module s-var)
```

*Arguments:*

Name: `module`  
Type: `<module>`  
Description: A dynamically loaded module

Name: `s-var`  
Type: `<symbol>`  
Description: The name of a variable

*Result value:* The value of the variable `s-var` in `module`

*Result type:* `<object>`

*Purity of the procedure:* pure

## dyn-call

*Syntax:*

```
(dyn-call proc x-1 ... x-n)
```

*Arguments:*

Name: `proc`  
Type: `<object>`  
Description: A procedure defined in some plugin

Name: `x-k`  
Type: `<object>`  
Description: The value of an argument

*Result value:* The result of the procedure call

*Result type:* <object>

*Purity of the procedure:* nonpure

The procedure is evaluated using the given arguments and the obtained value is returned. The procedure must return a valid Theme-D object.

## **dyn-call-no-result**

*Syntax:*

```
(dyn-call-no-result proc x-1 ... x-n)
```

*Arguments:*

Name: **proc**

Type: <object>

Description: A procedure defined in some plugin

Name: **x-k**

Type: <object>

Description: The value of an argument

No result value.

*Purity of the procedure:* nonpure

The procedure is evaluated using the given arguments. No value is returned.

## **dyn-apply**

*Syntax:*

```
(dyn-apply proc 1-args)
```

*Arguments:*

Name: **proc**

Type: <object>

Description: A procedure defined in some plugin

Name: **1-args**

Type: (:uniform-list <object>)

Description: The argument values

*Result value:* The result of the procedure call

*Result type:* <object>

*Purity of the procedure:* nonpure

The procedure is evaluated using the given argument list and the obtained value is returned. The procedure must return a valid Theme-D object.

## dyn-apply-no-result

*Syntax:*

```
(dyn-apply-no-result proc l-args)
```

*Arguments:*

Name: `proc`

Type: <object>

Description: A procedure defined in some plugin

Name: `l-args`

Type: (:uniform-list <object>)

Description: The argument values

No result value.

*Purity of the procedure:* nonpure

The procedure is evaluated using the given argument list. No value is returned.

## get-exported-var-name

*Syntax:*

```
(get-exported-var-name s-source-name)
```

*Arguments:*

Name: `s-source-name`

Type: <symbol>

Description: A name of a variable

*Result value:* The internal name of the variable

*Result type:* <symbol>

*Purity of the procedure:* pure

This method returns the internal plugin name corresponding to an ordinary variable name (not a generic procedure). The result name is computed by adding prefix `_x_` into the source name.

## get-exported-ngp-name

*Syntax:*

```
(get-exported-ngp-name s-source-name)
```

*Arguments:*

Name: `s-source-name`

Type: <symbol>

Description: A name of a normal generic procedure

*Result value:* The internal name of the variable

*Result type:* <symbol>

*Purity of the procedure:* pure

This method returns the internal plugin name corresponding to a name of a normal generic procedure. The result name is computed by adding prefix `_n_` into the source name.

## get-exported-vgp-name

*Syntax:*

```
(get-exported-vgp-name s-source-name)
```

*Arguments:*

Name: `s-source-name`

Type: <symbol>

Description: A name of a normal generic procedure

*Result value:* The internal name of the variable

*Result type:* <symbol>

*Purity of the procedure:* pure

This method returns the internal plugin name corresponding to a name of a virtual generic procedure. The result name is computed by adding prefix `_v_` into the source name.

## plugin-exported-normal-vars

*Syntax:*

```
(plugin-exported-normal-vars plugin)
```

*Arguments:*

Name: `plugin`

Type: <module>

Description: A plugin module

*Result value:* List of ordinary variables exported by the plugin

*Result type:* (:uniform-list <symbol>)

*Purity of the procedure:* pure

## plugin-exported-ngps

*Syntax:*

```
(plugin-exported-ngps plugin)
```

*Arguments:*

Name: `plugin`

Type: <module>

Description: A plugin module

*Result value:* List of normal generic procedures exported by the plugin

*Result type:* (:uniform-list <symbol>)

*Purity of the procedure:* pure

## plugin-exported-vgps

*Syntax:*

```
(plugin-exported-vgps plugin)
```

*Arguments:*

Name: `plugin`  
Type: `<module>`  
Description: A plugin module

*Result value:* List of virtual generic procedures exported by the plugin

*Result type:* `(:uniform-list <symbol>)`

*Purity of the procedure:* pure



## Chapter 40

# Module (standard-library raw-vector)

### 40.1 Data Types

*Data type name:* <raw-vector>

*Type:* <class>

*Description:* A vector of objects

This data type represents a native Scheme vector.

### 40.2 Simple Methods

#### raw-vector-ref

*Syntax:*

```
(raw-vector-ref rv i)
```

*Arguments:*

Name: rv

Type: <raw-vector>

Description: A raw vector

Name: i

Type: <integer>

Description: Index to the vector

*Result value:* The element of the vector at the given index

*Result type:* <object>

*Purity of the procedure:* pure

## raw-vector-set!

*Syntax:*

```
(raw-vector-set! rv i x-element)
```

*Arguments:*

Name: `rv`  
Type: <raw-vector>  
Description: A raw vector

Name: `i`  
Type: <integer>  
Description: Index to the vector

Name: `x-element`  
Type: <object>  
Description: An object

No result value.

*Purity of the procedure:* nonpure

Set the vector element at index `i` to value `x-element`.

## raw-vector-length

*Syntax:*

```
(raw-vector-length rv)
```

*Arguments:*

Name: `rv`  
Type: <raw-vector>  
Description: A raw vector

*Result value:* The length of the vector

*Result type:* <integer>

*Purity of the procedure:* pure

## raw-vector

*Syntax:*

```
(raw-vector item-1 ... item-n)
```

*Arguments:*

Name: `item-k`

Type: <object>

Description: A vector item

*Result value:* A new Scheme vector

*Result type:* <raw-vector>

*Purity of the procedure:* pure

## make-raw-vector

*Syntax:*

```
(make-raw-vector length fill)
```

*Arguments:*

Name: `length`

Type: <integer>

Description: The length of the new vector

Name: `fill`

Type: <object>

Description: The value to fill the vector

*Result value:* A new Scheme vector

*Result type:* <raw-vector>

*Purity of the procedure:* pure

## **raw-vector->list**

*Syntax:*

```
(raw-vector->list rv)
```

*Arguments:*

Name: **rv**  
Type: **<raw-vector>**  
Description: A raw vector

*Result value:* A list consisting of the elements of the vector

*Result type:* **<list>**

*Purity of the procedure:* pure

The elements of the list are ordered in the same order as the vector elements.

## **40.3 Parametrized Procedures**

### **\_vector-with-raw-contents**

*Syntax:*

```
(_vector-with-raw-contents rv)
```

*Type parameters:* **%type**

*Arguments:*

Name: **rv**  
Type: **<raw-vector>**  
Description: A raw vector

*Result value:* A vector with given internal representation

*Result type:* **(:vector %type)**

*Purity of the procedure:* pure

If the raw vector contains elements that are not instances of `%type` an exception is raised. Changing an element of `rv` after this method is called is an error and may cause unpredictable behaviour.

### `_mutable-vector-with-raw-contents`

*Syntax:*

```
(_mutable-vector-with-raw-contents rv)
```

*Type parameters:* `%type`

*Arguments:*

Name: `rv`  
 Type: `<raw-vector>`  
 Description: A raw vector

*Result value:* A mutable vector with given internal representation

*Result type:* `(:mutable-vector %type)`

*Purity of the procedure:* pure

If the raw vector contains elements that are not instances of `%type` an exception is raised. Setting an element of `rv` to a value that is not an instance of `%type` after this method is called is an error and may cause unpredictable behaviour.

## 40.4 Parametrized Methods

### `_vector-raw-contents`

*Syntax:*

```
(_vector-raw-contents v)
```

*Type parameters:* `%type`

*Arguments:*

Name: `v`  
 Type: `(:vector %type)`  
 Description: A vector

*Result value:* The internal representation of the vector

*Result type:* `<raw-vector>`

*Purity of the procedure:* pure

Changing the elements of the result raw vector is an error and it may cause unpredictable behaviour.

## `_mutable-vector-raw-contents`

*Syntax:*

```
(_mutable-vector-raw-contents v)
```

*Type parameters:* `%type`

*Arguments:*

Name: `v`  
 Type: `(:mutable-vector %type)`  
 Description: A mutable vector

*Result value:* The internal representation of the mutable vector

*Result type:* `<raw-vector>`

*Purity of the procedure:* pure

Changing an element of the result raw vector so that the new element is not an instance of `%type` is an error and may cause unpredictable behaviour.

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