

Σ

A Library for ANSI Common Lisp

Christopher Mark Gore
<http://www.cgore.com>
cgore@cgore.com

INCOMPLETE DRAFT

Friday, February 28th, AD 2014

Contents

Copyright	ix
Introduction	xi
0.1 Getting Lisp	xi
0.2 Getting EMACS and SLIME	xi
0.3 Using the Library	xii
1 The sigma/behave Package	1
1.1 Macros	1
1.1.1 The behavior Macro	1
1.1.2 The spec Macro	2
1.1.3 The should Macro	2
1.1.4 The should-not Macro	3
1.1.5 The should-be-null Macro	3
1.1.6 The should-be-true Macro	4
1.1.7 The should-be-false Macro	4
1.1.8 The should-be-a Macro	5
1.1.9 The should= Macro	5
1.1.10The should-not= Macro	5
1.1.11The should/= Macro	6
1.1.12The should-not/= Macro	6
1.1.13The should< Macro	7
1.1.14The should-not< Macro	7
1.1.15The should> Macro	7
1.1.16The should-not> Macro	8
1.1.17The should<= Macro	8
1.1.18The should-not<= Macro	9
1.1.19The should>= Macro	9
1.1.20The should-not>= Macro	9
1.1.21The should-eq Macro	10
1.1.22The should-not-eq Macro	10
1.1.23The should-eql Macro	11
1.1.24The should-not-eql Macro	11
1.1.25The should-equal Macro	11

1.1.26	The should-not-equal Macro	12
1.1.27	The should-equalp Macro	12
1.1.28	The should-not-equalp Macro	13
1.1.29	The should-string= Macro	13
1.1.30	The should-not-string= Macro	13
1.1.31	The should-string/= Macro	14
1.1.32	The should-not-string/= Macro	14
1.1.33	The should-string< Macro	15
1.1.34	The should-not-string< Macro	15
1.1.35	The should-string> Macro	15
1.1.36	The should-not-string> Macro	16
1.1.37	The should-string<= Macro	16
1.1.38	The should-not-string<= Macro	17
1.1.39	The should-string>= Macro	17
1.1.40	The should-not-string>= Macro	17
1.1.41	The should-string-equal Macro	18
1.1.42	The should-not-string-equal Macro	18
1.1.43	The should-string-not-equal Macro	19
1.1.44	The should-not-string-not-equal Macro	19
1.1.45	The should-string-lessp Macro	19
1.1.46	The should-not-string-lessp Macro	20
1.1.47	The should-string-greaterp Macro	20
1.1.48	The should-not-string-greaterp Macro	21
1.1.49	The should-string-not-greaterp Macro	21
1.1.50	The should-not-string-not-greaterp Macro	22
1.1.51	The should-string-not-lessp Macro	22
1.1.52	The should-not-string-not-lessp Macro	22
2	The sigma/control Package	25
2.1	Macros	25
2.1.1	The aif Macro	25
2.1.2	The a?if Macro	26
2.1.3	The aand Macro	27
2.1.4	The a?and Macro	27
2.1.5	The alambda Macro	27
2.1.6	The a?lambda Macro	28
2.1.7	The ablock Macro	28
2.1.8	The a?block Macro	28
2.1.9	The acond Macro	28
2.1.10	The a?cond Macro	29
2.1.11	The awhen Macro	29
2.1.12	The a?when Macro	29
2.1.13	The awhile Macro	30
2.1.14	The a?while Macro	30
2.1.15	The deletef Macro	30
2.1.16	The do-while Macro	31

2.1.17	The do-until Macro	31
2.1.18	The for Macro	31
2.1.19	The forever Macro	32
2.1.20	The multicond Macro	32
2.1.21	The opf Macro	32
2.1.22	The swap Macro	33
2.1.23	The swap-unless Macro	33
2.1.24	The swap-when Macro	33
2.1.25	The until Macro	33
2.1.26	The while Macro	33
2.2	Functions	33
2.2.1	The compose Function	33
2.2.2	The conjoin Function	33
2.2.3	The curry Function	33
2.2.4	The disjoin Function	33
2.2.5	The function-alias Function	33
2.2.6	The operator-to-function Function	34
2.2.7	The rcompose Function	34
2.2.8	The rcurry Function	34
2.2.9	The unimplemented Function	34
2.3	Generics	34
2.3.1	The duplicate Generic	34
3	The sigma/hash Package	35
3.1	Macros	35
3.1.1	The sethash Macro	35
3.2	Functions	35
3.2.1	The populate-hash-table Function	35
3.2.2	The inchash Function	35
3.2.3	The dechash Function	35
3.2.4	The gethash-in Function	36
4	The sigma/numeric Package	37
4.1	Macros	37
4.1.1	The divf Macro	37
4.1.2	The multf Macro	37
4.2	Functions	38
4.2.1	The bit? Function	38
4.2.2	The choose Function	38
4.2.3	The factorial Function	38
4.2.4	The fractional-part Function	38
4.2.5	The fractional-value Function	38
4.2.6	The integer-range Function	38
4.2.7	The nonnegative? Function	38
4.2.8	The nonnegative-integer? Function	38
4.2.9	The positive-integer? Function	39

4.2.10	The product Function	39
4.2.11	The sum Function	39
4.2.12	The unsigned-integer? Function	39
4.3	Types	39
4.3.1	The nonnegative-float Type	39
4.3.2	The nonnegative-integer Type	39
4.3.3	The positive-float Type	39
4.3.4	The positive-integer Type	39
5	The sigma/os Package	41
5.1	Functions	41
5.1.1	The perl Function	41
5.1.2	The python Function	41
5.1.3	The read-file Function	41
5.1.4	The read-lines Function	41
5.1.5	The ruby Function	41
5.2	Parameters	41
5.2.1	The *perl-path* Parameter	41
5.2.2	The *python-path* Parameter	42
5.2.3	The *ruby-path* Parameter	42
6	The sigma/probability Package	43
6.1	Macros	43
6.1.1	The decaying-probability? Macro	43
6.2	Functions	43
6.2.1	The probability? Function	43
6.3	Types	43
6.3.1	The probability Type	43
7	The sigma/random Package	45
7.1	Macros	45
7.1.1	The nshuffle Macro	45
7.2	Functions	45
7.2.1	The gauss Function	45
7.2.2	The random-argument Function	45
7.2.3	The coin-toss Function	45
7.2.4	The random-in-range Function	45
7.2.5	The random-in-ranges Function	45
7.2.6	The random-range Function	46
7.2.7	The randomize-array Function	46
7.2.8	The random-array Function	46
7.3	Generics	46
7.3.1	The random-element Generic	46
7.3.2	The shuffle Generic	46

8	The sigma/sequence Package	47
8.1	Macros	47
8.1.1	The arefable? Macro	47
8.1.2	The nconcf Macro	47
8.1.3	The nthable? Macro	47
8.1.4	The set-nthcdr Macro	47
8.2	Functions	47
8.2.1	The array-values Function	47
8.2.2	The nth-from-end Function	47
8.2.3	The sequence? Function	48
8.2.4	The empty-sequence? Function	48
8.2.5	The join-symbol-to-all-following Function	48
8.2.6	The join-symbol-to-all-preceeding Function	48
8.2.7	The list-to-vector Function	49
8.2.8	The set-equal Function	49
8.2.9	The simple-vector-to-list Function	49
8.2.10	The sort-order Function	49
8.2.11	The the-last Function	49
8.2.12	The vector-to-list Function	49
8.3	Generics	49
8.3.1	The best Generic	49
8.3.2	The minimum Generic	49
8.3.3	The minimum? Generic	49
8.3.4	The maximum Generic	49
8.3.5	The maximum? Generic	49
8.3.6	The sort-on Generic	50
8.3.7	The slice Generic	50
8.3.8	The split Generic	50
8.3.9	The worst Generic	50
9	The sigma/string Package	51
9.1	Functions	51
9.1.1	The character-range Function	51
9.1.2	The character-ranges Function	52
9.1.3	The escape-tildes Function	52
9.1.4	The replace-char Function	52
9.1.5	The strcat Function	52
9.1.6	The strmult Function	52
9.1.7	The string-join Function	52
9.1.8	The stringify Function	52
9.1.9	The to-string Function	53
9.2	Methods	53
9.2.1	The split Methods	53

10 The time-series Package	55
10.1 Macros	55
10.1.1 The snap-index Macro	55
10.2 Functions	55
10.2.1 The array-raster-line Function	55
10.2.2 The distance Function	55
10.2.3 The norm Function	55
10.2.4 The raster-line Function	55
10.2.5 The similar-points? Function	55
10.2.6 The time-series? Function	56
10.2.7 The time-multiseries? Function	56
10.2.8 The tmsref Function	56
10.2.9 The tms-dimensions Function	56
10.2.10 The tms-raster-line Function	56
10.2.11 The tms-values Function	56
10.3 Types	56
10.3.1 The time-multiseries Type	56
11 The truth Package	57
11.1 Functions	57
11.1.1 The [?] Function	57
11.1.2 The toggle Function	57
11.2 Generics	57
11.2.1 The ? Generic	57
12 The sigma Package	59
12.1 Variables	59
12.1.1 The *sigma-packages* Variable	59
12.2 Functions	59
12.2.1 The use-all-sigma Function	59

Copyright

Copyright © 2005 – 2014, Christopher Mark Gore,

Soli Deo Gloria,

All rights reserved.

2317 South River Road, Saint Charles, Missouri 63303 USA.

Web: <http://www.cgore.com>

Email: cgore@cgore.com

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
- Neither the name of Christopher Mark Gore nor the names of other contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS “AS IS” AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Introduction

The Σ library is a generic library of mostly random useful code for ANSI Common Lisp. It is currently only really focused on SBCL, but patches to add support for other systems are more than welcome.

This library started out as a single file, `utilities.lisp`, that I personally used for shared generic code for all of my Lisp code. Most lispers have a similar file of some name, `utilities.lisp`, `misc.lisp`, `shared.lisp`, or even `stuff.lisp`, that is just a random collection of useful little generic macros and functions. Mine has grown over the years, and in 2012 I decided that I should try to make it useful to people other than myself.

You can download the library from GitHub at:

<https://github.com/cgore/sigma>

and I have some other information on it at my own website at:

<http://cgore.com/programming/lisp/sigma/>

0.1 Getting Lisp

Before using this library you need a working Lisp. I use and recommend SBCL, Steel Bank Common Lisp, which is available at:

<http://www.sbcl.org>

This is derived from CMUCL, Carnegie Mellon University Common Lisp, which is still under active development and is: available at:

<http://www.cons.org/cmucl/>

SBCL has information on getting started at:

<http://www.sbcl.org/getting.html>

If you are using Debian or a similar Linux distribution (including Ubuntu), you can just run as root:

```
apt-get install sbcl sbcl-doc sbcl-source
```

0.2 Getting EMACS and SLIME

After installing, the best way to interact with any Common Lisp is via SLIME, the Superior Lisp Interaction Mode for EMACS, which is avail-

able at:

`http://common-lisp.net/project/slime/`

This can be installed on Debian by:

```
apt-get install slime emacs emacs-goodies-el
```

0.3 Using the Library

First we need to clone the utilities.

```
mkdir -p /programming/lisp
cd /programming/lisp
git clone git@github.com:cgore/sigma.git
```

Now we need to make a directory for our project and symlink to the ASDF definition. There are other ways to load ASDF libraries, especially if you want to have them available globally; I strongly recommend you read the documentation to ASDF.

```
mkdir our-new-project
cd our-new-project
ln -s /programming/lisp/sigma/sigma.asd
```

Now we need to start up our Lisp REPL. The best way to do this for personal use is SLIME from within Emacs, but I will demonstrate using the shell itself here.

```
sbcl
```

Now we are in SBCL.

```
(require :asdf) ; Require ASDF
(require :sigma) ; Require the system via ASDF.
(sigma:use-all-sigma) ; This will pollute COMMON-LISP-USER
(sum (loop for i from 1 to 100 collect i)) ; Returns 5050 and
makes Euler sad.
```

Have fun!

Chapter 1

The `sigma/behave` Package

The `sigma/behave` package contains some useful code for confirming behavior of code, supporting a very basic form of *behavior-driven development*, BDD. The basic flow is to define the *behavior* of something, with multiple *specs* specified within that behavior specification, each consisting of various assertions, such as `should=`, `should-equal`, `should-not-equal`, and many others. If the behavior of the thing doesn't match the specified behavior, then there is some error.

1.1 Macros

1.1.1 The behavior Macro

The `behavior` macro is used to specify a block of expected behavior for a `thing`. It specifies an example group, loosely similar to the `describe` blocks in Ruby's RSpec. It takes a single argument, the `thing` we are trying to describe, and then a body of code to evaluate that is evaluated in an implicit `progn`. It is to be used around a set of examples, or around a set of assertions directly.

Syntax

```
(behavior thing &body body)
```

Arguments and Values

thing This is what we are describing the behavior of.

body This is an implicit `proc` to contain the behavior.

Examples

```
(behavior 'float
  (spec "is_an_Abelian_group"
    (let ((a (random 10.0))
          (b (random 10.0))
          (c (random 10.0))
          (e 1.0))
      (spec "closure"
        (should-be-a 'float (* a b)))
      (spec "associativity"
        (should= (* (* a b) c)
                  (* a (* b c))))
      (spec "identity_element"
        (should= a (* e a)))
      (spec "inverse_element"
        (let ((1/a (/ 1 a)))
          (should= (* 1/a a)
                    (* a 1/a)
                    1.0)))
      (spec "commutativity"
        (should= (* a b) (* b a))))))
```

1.1.2 The spec Macro

The `spec` macro is used to indicate a specification for a desired behavior. It will normally serve as a grouping for assertions or nested specs.

Syntax

```
(spec description &body body)
```

Arguments and Values

description This is a string to describe the specification.

body This is an implicit proc to contain the specification.

Examples

```
(spec "should_pass_some_tests"
  (should= 12 (foo 3.5))
  (should= 14 (foo 4.22)))
```

1.1.3 The should Macro

The `should` macro is the basic building block for most of the behavior checking. It asserts that `test` returns truthfully for the arguments.

Typically you will want to use one of the macros defined on top of `should` instead of using it directly, such as `should=`.

Syntax

```
(should test &rest arguments)
```

Arguments and Values

test This is the test predicate to evaluate.

arguments These are the arguments to the test predicate.

Examples

```
(should #'= 12 (* 3 4)) ; Passes  
(should #'< 4 (* 2 3)) ; Passes  
(should #'< 4 5 6 7)   ; Passes
```

1.1.4 The should-not Macro

The `should-not` macro is identical to the `should` macro, except that it inverts the result of the call with `not`.

Syntax

```
(should-not test &rest arguments)
```

Arguments and Values

test This is the test predicate to evaluate.

arguments These are the arguments to the test predicate.

Examples

```
(should-not #'< 12 4) ; Passes  
(should-not #'= 12 44) ; Passes
```

1.1.5 The should-be-null Macro

The `should-be-null` macro is a short-hand method for `(should #'null ...)`.

Syntax

```
(should-be-null &rest arguments)
```

Arguments and Values

arguments These are the arguments to `null`.

Examples

```
(should-be-null ()) ; Passes
(should-be-null nil) ; Passes
(should-be-null (not 12)) ; Passes
(should-be-null (and t t nil)) ; Passes
```

1.1.6 The `should-be-true` Macro

The `should-be-true` macro is a short-hand method for `(should #'identity ...)`.

Syntax

```
(should-be-true &rest arguments)
```

Arguments and Values

arguments These are the arguments to `identity`.

Examples

```
(should-be-true t) ; Passes
(should-be-true (not nil)) ; Passes
(should-be-true (or nil nil 12)) ; Passes
```

1.1.7 The `should-be-false` Macro

The `should-be-false` macro is a short-hand method for `(should #'not ...)`.

Syntax

```
(should-be-false &rest arguments)
```

Arguments and Values

arguments These are the arguments to `not`.

Examples

```
(should-be-false nil)
(should-be-false (not t))
(should-be-false (< 44 2))
```

1.1.8 The should-be-a Macro

The `should-be-a` macro specifies that one or more things should be of the type specified by `type`.

Syntax

```
(should-be-a type &rest things)
```

Arguments and Values

type This is the type to compare with via `typep`.

things These are the things to confirm the type of.

```
(should-be-a 'integer 1)           ; Passes
(should-be-a 'float 1)            ; Passes
(should-be-a 'integer 1 2 3 4 5 6 7 8 9) ; Passes
(should-be-a 'integer 1.0)        ; Fails
```

1.1.9 The should= Macro

The `should=` macro is a short-hand method for `(should #'= ...)`.

Syntax

```
(should= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `=`.

Examples

```
(should= 12 12)      ; Passes
(should= 12 12.0)    ; Passes
```

1.1.10 The should-not= Macro

The `should-not=` macro is a short-hand method for `(should-not #'= ...)`.

Syntax

```
(should-not= &rest arguments)
```

Arguments and Values

arguments These are the arguments to =.

Examples

```
(should-not= 12 12)    ; Fails  
(should-not= 12 12.0) ; Fails  
(should-not= 12 14)    ; Passes
```

1.1.11 The should/= Macro

The `should/=` macro is a short-hand method for `(should #'/= ...)`.

Syntax

```
(should/= &rest arguments)
```

Arguments and Values

arguments These are the arguments to /=.

Examples

```
(should/= 12 13)    ; Passes  
(should/= 12 12)    ; Fails  
(should/= 12 12.0) ; Fails
```

1.1.12 The should-not/= Macro

The `should-not/=` macro is a short-hand method for `(should-not #'/= ...)`.

Syntax

```
(should-not/= &rest arguments)
```

Arguments and Values

arguments These are the arguments to /=.

Examples

```
(should-not/= 12 13)    ; Fails  
(should-not/= 12 12)    ; Passes  
(should-not/= 12 12.0) ; Passes
```

1.1.13 The should< Macro

The `should<` macro is a short-hand method for `(should #'< ...)`.

Syntax

```
(should< &rest arguments)
```

Arguments and Values

arguments These are the arguments to `<`.

Examples

```
(should< 12 13) ; Passes  
(should< 13 12) ; Fails  
(should< 12 12) ; Fails
```

1.1.14 The should-not< Macro

The `should-not<` macro is a short-hand method for `(should-not #'< ...)`.

Syntax

```
(should-not< &rest arguments)
```

Arguments and Values

arguments These are the arguments to `<`.

Examples

```
(should-not< 12 13) ; Passes  
(should-not< 13 12) ; Fails  
(should-not< 12 12) ; Fails
```

1.1.15 The should> Macro

The `should>` macro is a short-hand method for `(should #'> ...)`.

Syntax

```
(should> &rest arguments)
```

Arguments and Values

arguments These are the arguments to >.

Examples

```
(should> 12 13) ; Fails  
(should> 13 12) ; Passes  
(should> 12 12) ; Fails
```

1.1.16 The should-not> Macro

The `should-not>` macro is a short-hand method for `(should-not #'> ...)`.

Syntax

```
(should-not> &rest arguments)
```

Arguments and Values

arguments These are the arguments to >.

Examples

```
(should-not> 12 13) ; Passes  
(should-not> 13 12) ; Fails  
(should-not> 12 12) ; Passes
```

1.1.17 The should<= Macro

The `should<=` macro is a short-hand method for `(should #'<= ...)`.

Syntax

```
(should<= &rest arguments)
```

Arguments and Values

arguments These are the arguments to <=.

Examples

```
(should<= 12 13) ; Passes
(should<= 13 12) ; Fails
(should<= 12 12) ; Passes
```

1.1.18 The should-not<= Macro

The `should-not<=` macro is a short-hand method for `(should-not #'<= ...)`.

Syntax

```
(should-not<= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `<=`.

Examples

```
(should-not<= 12 13) ; Fails
(should-not<= 13 12) ; Passes
(should-not<= 12 12) ; Fails
```

1.1.19 The should>= Macro

The `should>=` macro is a short-hand method for `(should #'>= ...)`.

Syntax

```
(should>= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `>=`.

Examples

```
(should>= 12 13) ; Fails
(should>= 13 12) ; Passes
(should>= 12 12) ; Passes
```

1.1.20 The should-not>= Macro

The `should-not>=` macro is a short-hand method for `(should-not #'>= ...)`.

Syntax

```
(should-not>= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `>=`.

Examples

```
(should-not>= 12 13) ; Passes  
(should-not>= 13 12) ; Fails  
(should-not>= 12 12) ; Fails
```

1.1.21 The should-eq Macro

The `should-eq` macro is a short-hand method for `(should #'eq ...)`.

Syntax

```
(should-eq &rest arguments)
```

Arguments and Values

arguments These are the arguments to `eq`.

Examples

```
(should-eq 12 12) ; Probably passes  
(should-eq 13 12) ; Fails  
(should-eq "foo" "foo") ; May pass, may fail.
```

1.1.22 The should-not-eq Macro

The `should-not-eq` macro is a short-hand method for `(should-not #'eq ...)`.

Syntax

```
(should-not-eq &rest arguments)
```

Arguments and Values

arguments These are the arguments to `eq`.

Examples

```
(should-not-eq 12 12)      ; Probably fails
(should-not-eq 13 12)      ; Passes
(should-not-eq "foo" "foo") ; May pass, may fail.
```

1.1.23 The should-eql Macro

The `should-eql` macro is a short-hand method for `(should #'eql ...)`.

Syntax

```
(should-eql &rest arguments)
```

Arguments and Values

arguments These are the arguments to `eql`.

Examples

```
(should-eql 12 12)      ; Passes
(should-eql 13 12)      ; Fails
(should-eql "foo" "foo") ; May pass, may fail.
```

1.1.24 The should-not-eql Macro

The `should-not-eql` macro is a short-hand method for `(should-not #'eql ...)`.

Syntax

```
(should-not-eql &rest arguments)
```

Arguments and Values

arguments These are the arguments to `eql`.

Examples

```
(should-not-eql 12 12)      ; Fails
(should-not-eql 13 12)      ; Passes
(should-not-eql "foo" "foo") ; May pass, may fail.
```

1.1.25 The should-equal Macro

The `should-equal` macro is a short-hand method for `(should #'equal ...)`.

Syntax

```
(should-equal &rest arguments)
```

Arguments and Values

arguments These are the arguments to `equal`.

Examples

```
(should-equal 12 12)           ; Passes  
(should-equal 13 12)           ; Fails  
(should-equal "foo" "foo")     ; Passes  
(should-equal "FOO" "foo")     ; Fails
```

1.1.26 The `should-not-equal` Macro

The `should-not-equal` macro is a short-hand method for `(should-not #'equal ...)`.

Syntax

```
(should-not-equal &rest arguments)
```

Arguments and Values

arguments These are the arguments to `equal`.

Examples

```
(should-not-equal 12 12)        ; Passes  
(should-not-equal 13 12)        ; Fails  
(should-not-equal "foo" "foo")  ; Fails  
(should-not-equal "FOO" "foo")  ; Passes
```

1.1.27 The `should-equalp` Macro

The `should-equalp` macro is a short-hand method for `(should #'equalp ...)`.

Syntax

```
(should-equalp &rest arguments)
```

Arguments and Values

arguments These are the arguments to `equalp`.

Examples

```
(should-equalp 12 12)           ; Passes
(should-equalp 13 12)           ; Fails
(should-equalp "foo" "foo")      ; Passes
(should-equalp "FOO" "foo")      ; Passes
```

1.1.28 The should-not-equalp Macro

The `should-not-equalp` macro is a short-hand method for `(should-not #'equalp ...)`.

Syntax

```
(should-not-equalp &rest arguments)
```

Arguments and Values

arguments These are the arguments to `equalp`.

Examples

```
(should-not-equalp 12 12)        ; Passes
(should-not-equalp 13 12)        ; Fails
(should-not-equalp "foo" "foo")   ; Passes
(should-not-equalp "FOO" "foo")   ; Fails
```

1.1.29 The should-string= Macro

The `should-string=` macro is a short-hand method for `(should #'string= ...)`.

Syntax

```
(should-string= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string=`.

Examples

```
(should-string= "foo" "foo")      ; Passes
(should-string= "FOO" "foo")      ; Fails
```

1.1.30 The should-not-string= Macro

The `should-not-string=` macro is a short-hand method for `(should-not #'string= ...)`.

Syntax

```
(should-not-string= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string=`.

Examples

```
(should-not-string= "foo" "foo") ; Fails  
(should-not-string= "FOO" "foo") ; Passes
```

1.1.31 The should-string/= Macro

The `should-string/=` macro is a short-hand method for `(should #'string/= ...)`.

Syntax

```
(should-string/= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string/=`.

Examples

```
(should-string/= "foo" "foo") ; Fails  
(should-string/= "FOO" "foo") ; Passes
```

1.1.32 The should-not-string/= Macro

The `should-not-string/=` macro is a short-hand method for `(should-not #'string/= ...)`.

Syntax

```
(should-not-string/= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string/=`.

Examples

```
(should-not-string/= "foo" "foo") ; Passes
(should-not-string/= "FOO" "foo") ; Fails
```

1.1.33 The should-string< Macro

The `should-string<` macro is a short-hand method for `(should #'string< ...)`.

Syntax

```
(should-string< &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string<`.

Examples

```
(should-string< "foo" "f") ; Fails
(should-string< "foo" "foo") ; Fails
(should-string< "foo" "FOOBAR") ; Fails
(should-string< "foo" "foobar") ; Passes
```

1.1.34 The should-not-string< Macro

The `should-not-string<` macro is a short-hand method for `(should-not #'string< ...)`.

Syntax

```
(should-not-string< &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string<`.

Examples

```
(should-not-string< "foo" "f") ; Passes
(should-not-string< "foo" "foo") ; Passes
(should-not-string< "foo" "foobar") ; Fails
```

1.1.35 The should-string> Macro

The `should-string>` macro is a short-hand method for `(should #'string> ...)`.

Syntax

```
(should-string> &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string>`.

Examples

```
(should-string> "foo" "f")           ; Passes  
(should-string> "foo" "foo")        ; Fails  
(should-string> "foo" "FOO")        ; Passes  
(should-string> "foo" "foobar")     ; Fails
```

1.1.36 The should-not-string> Macro

The `should-not-string>` macro is a short-hand method for `(should-not #'string> ...)`.

Syntax

```
(should-not-string> &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string>`.

Examples

```
(should-not-string> "foo" "f")       ; Fails  
(should-not-string> "foo" "foo")     ; Passes  
(should-not-string> "foo" "foobar")  ; Passes
```

1.1.37 The should-string<= Macro

The `should-string<=` macro is a short-hand method for `(should #'string<= ...)`.

Syntax

```
(should-string<= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string<=`.

Examples

```
(should-string<= "foo" "f")           ; Fails
(should-string<= "foo" "foo")        ; Passes
(should-string<= "foo" "foobar")     ; Passes
```

1.1.38 The should-not-string<= Macro

The `should-not-string<=` macro is a short-hand method for `(should-not #'string<= ...)`.

Syntax

```
(should-not-string<= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string<=`.

Examples

```
(should-not-string<= "foo" "f")       ; Passes
(should-not-string<= "foo" "foo")     ; Fails
(should-not-string<= "foo" "foobar")  ; Fails
```

1.1.39 The should-string>= Macro

The `should-string>=` macro is a short-hand method for `(should #'string>= ...)`.

Syntax

```
(should-string>= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string>=`.

Examples

```
(should-string>= "foo" "f")           ; Passes
(should-string>= "foo" "foo")         ; Passes
(should-string>= "foo" "foobar")     ; Fails
```

1.1.40 The should-not-string>= Macro

The `should-not-string>=` macro is a short-hand method for `(should-not #'string>= ...)`.

Syntax

```
(should-not-string>= &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string>=`.

Examples

```
(should-not-string>= "foo" "f")           ; Fails  
(should-not-string>= "foo" "foo")        ; Fails  
(should-not-string>= "foo" "foobar")     ; Passes
```

1.1.41 The should-string-equal Macro

The `should-string-equal` macro is a short-hand method for `(should #'string-equal ...)`.

Syntax

```
(should-string-equal &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string-equal`.

Examples

```
(should-string-equal "foo" "foo")         ; Passes  
(should-string-equal "FOO" "foo")        ; Passes  
(should-string-equal "foo" "foobar")     ; Fails
```

1.1.42 The should-not-string-equal Macro

The `should-not-string-equal` macro is a short-hand method for `(should-not #'string-equal ...)`.

Syntax

```
(should-not-string-equal &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string-equal`.

Examples

```
(should-not-string-equal "foo" "foo")      ; Fails  
(should-not-string-equal "FOO" "foo")      ; Fails  
(should-not-string-equal "foo" "foobar")   ; Passes
```

1.1.43 The should-string-not-equal Macro

The `should-string-not-equal` macro is a short-hand method for `(should #'string-not-equal ...)`.

Syntax

```
(should-string-not-equal &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string-not-equal`.

Examples

```
(should-string-not-equal "foo" "foo")      ; Fails  
(should-string-not-equal "FOO" "foo")      ; Fails  
(should-string-not-equal "foo" "foobar")   ; Passes
```

1.1.44 The should-not-string-not-equal Macro

The `should-not-string-not-equal` macro is a short-hand method for `(should-not #'string-not-equal ...)`.

Syntax

```
(should-not-string-not-equal &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string-not-equal`.

Examples

```
(should-not-string-not-equal "foo" "foo")   ; Passes  
(should-not-string-not-equal "FOO" "foo")   ; Passes  
(should-not-string-not-equal "foo" "foobar") ; Fails
```

1.1.45 The should-string-lessp Macro

The `should-string-lessp` macro is a short-hand method for `(should #'string-lessp ...)`.

Syntax

```
(should-string-lessp &rest arguments)
```

Arguments and Values

arguments These are the arguments to string-lessp.

Examples

```
(should-string-lessp "foo" "f")           ; Fails
(should-string-lessp "foo" "foo")         ; Fails
(should-string-lessp "foo" "FOOBAR")      ; Passes
(should-string-lessp "foo" "foobar")      ; Passes
```

1.1.46 The should-not-string-lessp Macro

The should-not-string-lessp macro is a short-hand method for (should-not #'string-lessp ...).

Syntax

```
(should-not-string-lessp &rest arguments)
```

Arguments and Values

arguments These are the arguments to string-lessp.

Examples

```
(should-not-string-lessp "foo" "f")       ; Passes
(should-not-string-lessp "foo" "foo")     ; Passes
(should-not-string-lessp "foo" "FOOBAR")  ; Fails
(should-not-string-lessp "foo" "foobar")  ; Fails
```

1.1.47 The should-string-greaterp Macro

The should-string-greaterp macro is a short-hand method for (should #'string-greaterp ...).

Syntax

```
(should-string-greaterp &rest arguments)
```

Arguments and Values

arguments These are the arguments to string-greaterp.

Examples

```
(should-string-greaterp "foo" "f")      ; Passes  
(should-string-greaterp "foo" "foo")    ; Fails  
(should-string-greaterp "foo" "FOO")    ; Fails  
(should-string-greaterp "foo" "foobar") ; Fails
```

1.1.48 The should-not-string-greaterp Macro

The `should-not-string-greaterp` macro is a short-hand method for `(should-not #'string-greaterp ...)`.

Syntax

```
(should-not-string-greaterp &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string-greaterp`.

Examples

```
(should-not-string-greaterp "foo" "f")      ; Fails  
(should-not-string-greaterp "foo" "foo")    ; Passes  
(should-not-string-greaterp "foo" "FOO")    ; Passes  
(should-not-string-greaterp "foo" "foobar") ; Passes
```

1.1.49 The should-string-not-greaterp Macro

The `should-string-not-greaterp` macro is a short-hand method for `(should #'string-not-greaterp ...)`.

Syntax

```
(should-string-not-greaterp &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string-not-greaterp`.

Examples

```
(should-string-not-greaterp "foo" "f")      ; Fails  
(should-string-not-greaterp "foo" "foo")    ; Passes  
(should-string-not-greaterp "foo" "FOO")    ; Passes  
(should-string-not-greaterp "foo" "foobar") ; Passes
```

1.1.50 The `should-not-string-not-greaterp` Macro

The `should-not-string-not-greaterp` macro is a short-hand method for `(should-not #'string-not-greaterp ...)`.

Syntax

```
(should-not-string-not-greaterp &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string-not-greaterp`.

Examples

```
(should-not-string-not-greaterp "foo" "f")           ; Passes
(should-not-string-not-greaterp "foo" "foo")         ; Fails
(should-not-string-not-greaterp "foo" "FOO")         ; Fails
(should-not-string-not-greaterp "foo" "foobar")      ; Fails
```

1.1.51 The `should-string-not-lessp` Macro

The `should-string-not-lessp` macro is a short-hand method for `(should #'string-not-lessp ...)`.

Syntax

```
(should-string-not-lessp &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string-not-lessp`.

Examples

```
(should-string-not-lessp "foo" "f")                 ; Passes
(should-string-not-lessp "foo" "foo")               ; Passes
(should-string-not-lessp "foo" "FOOBAR")            ; Fails
(should-string-not-lessp "foo" "foobar")            ; Fails
```

1.1.52 The `should-not-string-not-lessp` Macro

The `should-not-string-not-lessp` macro is a short-hand method for `(should-not #'string-not-lessp ...)`.

Syntax

```
(should-not-string-not-lessp &rest arguments)
```

Arguments and Values

arguments These are the arguments to `string-not-lessp`.

Examples

```
(should-not-string-not-lessp "foo" "f")           ; Fails  
(should-not-string-not-lessp "foo" "foo")         ; Fails  
(should-not-string-not-lessp "foo" "FOOBAR")      ; Passes  
(should-not-string-not-lessp "foo" "foobar")      ; Passes
```


Chapter 2

The `sigma/control` Package

The `sigma/control` package contains code for basic program control systems. These are mostly basic macros to add more complicated looping, conditionals, or similar. These are typically extensions to Common Lisp that are inspired by other programming languages. Thanks to the power of Common Lisp and its macro system, we can typically implement most features of any other language with little trouble.

2.1 Macros

2.1.1 The `aif` Macro

The `aif` macro is an anaphoric variation of the built-in `if` control structure. This is based on [1, p. 190]. The basic idea is to provide an anaphor (such as pronouns in English) for the conditional so that it can easily be referred to within the body of the conditional expression. The most natural pronoun in the English language for a thing is “it”, so that is what is used. If you need or want to use a different anaphor, use `a?if`. The most common use of `aif` is for when you want to do some additional computation with some time-consuming calculation, but only if it returned successfully.

Syntax

```
(aif conditional t-action &optional nil-action)
```

Arguments and Values

conditional The boolean conditional to select between the *t-action* and the *nil-action*.

t-action The action to evaluate if the *conditional* evaluate as true.

nil-action The action to evaluate if the *conditional* evaluates as nil.

Examples

```
(aif (big-long-calculation)
     (foo it)
     (format t "The_big-long-calculation_failed!~%"))
```

This is similar to the following, but with less typing:

```
(let ((it (big-long-calculation)))
  (if it
      (foo it)
      (format t "The_big-long-calculation_failed!~%")))
```

Or say you need to get a user name from a database call, which might be slow.

```
(aif (get-user-name)
     (format -t "Hello, ~A!~%" it)
     (format -t "You_aren't_logged_in,_go_away!~%"))
```

2.1.2 The a?if Macro

The *a?if* macro is a variation of *aif* that allows for the specification of the anaphor to use, instead of being restricted to just *it*, the default with *aif*. This is most often useful when you need to nest calls to anaphoric macros.

Syntax

```
(a?if anaphor conditional t-action &optional nil-action)
```

Arguments and Values

anaphor The result of the *conditional* will be stored in the variable specified as the anaphor.

conditional The boolean conditional to select between the *t-action* and the *nil-action*.

t-action The action to evaluate if the *conditional* evaluate as true.

nil-action The action to evaluate if the *conditional* evaluates as nil.

Examples

```
(a?if foo 'outer
  (a?if bar 'inner
    \(',foo ,bar))) ; Returns '(outer inner)
```

2.1.3 The aand Macro

The `aand` macro is an anaphoric variation of the built-in `and`. This is based on [1, p. 191]. It works in a similar manner to `aif`, defining `it` as the current argument for use in the next argument, reassigning it with each argument.

Syntax

```
(aand &rest arguments)
```

Examples

```
(aand 2          ; Sets 'it' to 2.
  (* 3 it)       ; Sets 'it' to 6.
  (* 4 it))      ; Returns 24.
```

2.1.4 The a?and Macro

The `a?and` macro is a variant of `aand` that allows for the specification of the anaphor to use, instead of being restricted to just `it`, the default with `aand`. This is most often useful when you need to nest calls to anaphoric macros.

Examples

```
(a?and foo 12 (* 2 foo) (* 3 foo)) ; Returns 72.

(a?and foo 1 2 3 'outer
  (a?and bar 4 5 6 'inner \(',foo ,bar))) ; Returns '(outer inner)
```

2.1.5 The alambda Macro

The `alambda` macro is an anaphoric variant of the built-in `lambda`. This is based on [1, p. 193]. It works in a similar manner to `aif` and `aand`, except it defines `self` instead of `it` as the default anaphor. This is useful so that you can write recursive lambdas.

```
(funcall (alambda (x) ; Simple recursive factorial example.
  (if (<= x 0)
    1
    (* x (self (1- x)))))
10))) ; Calculates 10!, inefficently.
```

2.1.6 The a?lambda Macro

The a?lambda macro is an variant of alambda that allows you to specify the anaphor to use, instead of just the default of it.

```
(funcall (a?lambda ! (x) ; Simple recursive factorial example.
  (if (<= x 0)
    1
    (* x (! (1- x)))))
10))) ; Calculates 10!, inefficently.
```

2.1.7 The ablock Macro

The ablock macro is an anaphoric variant of the built-in block. This is based on [1, p. 193]. It works in a similar manner to aand, defining the anaphor it for each argument to the block.

Examples

```
(let (w x y z)
  (ablock b
    (setf w 7)
    (setf x (* 2 it)) ; Twice w, 14.
    (setf y (* 3 it)) ; Thrice x, 42.
    (return-from b)   ; Leave the block.
    (setf z 123))     ; Never happens.
  (list w x y z))     ; Returns '(7 14 42 nil)
```

2.1.8 The a?block Macro

The a?block macro is an anaphoric variant of ablock that allows you to specify the anaphor to use, instead of just the default of it.

Examples

```
(let (w x y z)
  (a?block b foo
    (setf w 7)
    (setf x (* 2 foo)) ; Twice w, 14.
    (setf y (* 3 foo)) ; Thrice x, 42.
    (return-from b)   ; Leave the block.
    (setf z 123))     ; Never happens.
  (list w x y z))     ; Returns '(7 14 42 nil)
```

2.1.9 The acond Macro

The acond macro is an anaphoric variant of the built-in cond. This is based on [1, p. 191]. It works in a similar manner to aand, defining the anaphor it for each argument to the conditional.

Examples

```
(let (a b (c 3))
  (acond (a it)           ; No.
        (b it)           ; No.
        (c (* 4 it)))) ; Yes, returns 12 = 4*3, the value of c.
```

2.1.10 The a?cond Macro

The `a?cond` macro is an anaphoric variant of `acond` that allows you to specify the anaphor to use, instead of just the default of `it`.

Examples

```
(let (a b (c 3))
  (a?cond foo
    (a foo)           ; No.
    (b foo)           ; No.
    (c (* 4 foo)))) ; Yes, returns 12 = 4*3, the value of c.
```

2.1.11 The awhen Macro

The `awhen` macro is an anaphoric variant of `when` built-in. This is based on [1, p. 191]. It works in a similar manner to `aif`, defining `it` as the default anaphor. This is useful when the conditional is the result of a complicated computation, so you don't have to compute it twice or wrap the computation in a `let` block yourself.

Syntax

```
(awhen conditional &body body)
```

Examples

```
(awhen (get-user-name)
  (do-something-with-name it)
  (do-more-stuff)
  (format -t "Hello, ~A!~%" it))
```

2.1.12 The a?when Macro

The `a?when` macro is similar to the `awhen`, except that it allows you to specify the anaphor to use, instead of just the default of `it`.

Syntax

```
(a?when conditional &body body)
```

Examples

```
(a?when user (get-user-name)
  (do-something-with-name user)
  (do-more-stuff)
  (format -t "Hello, ~A!~%" user))
```

2.1.13 The awhile Macro

The `awhile` macro is an anaphoric variant of `while`. This is based on [1, p. 191]. This is useful if you need to consume input repeatedly for all input.

Syntax

```
(awhile expression &body body)
```

Examples

```
(awhile (get-input)
  (do-something it)) ; Operate on input for all input.
```

2.1.14 The a?while Macro

The `a?while` macro is a variant of `awhile` that allows you to specify the anaphor to use, instead of just the default `it`.

Syntax

```
(awhile anaphor expression &body body)
```

Examples

```
(awhile input (get-input)
  (do-something input)) ; Operate on input for all input.
```

2.1.15 The deletef Macro

The `deletef` macro deletes `item` from sequence `in-place`.

Syntax

```
(deletef item sequence &rest rest)
```

Examples

```
(let ((men '(good bad ugly)))
  (deletef 'bad men)
  (deletef 'ugly men)
  men) ; Only the good is left.
```

2.1.16 The do-while Macro

The `do-while` macro operates like a `do {BODY} while (CONDITIONAL)` in the C programming language.

Syntax

```
(do-while conditional &rest body)
```

Examples

```
(let ((t-minus 10))
  (do-while (<= 0 t-minus)
    (format t "~A_..." t-minus)
    (decf t-minus)))
(format t "Liftoff!")
```

2.1.17 The do-until Macro

The `do-until` macro operates like a `do {body} while (! conditional)` in the C programming language.

Syntax

```
(do-until conditional &rest body)
```

Examples

```
(let ((t-minus 10))
  (do-until (< t-minus 0)
    (format t "~A_..." t-minus)
    (decf t-minus)))
(format t "Liftoff!")
```

2.1.18 The for Macro

A `for` macro, much like the `for` in the C programming language.

Syntax

```
(for initial conditional step-action &rest body)
```

Examples

```
(for ((i 0))
  (< i 10)
  (incf i)
  (format t \ "%~A\"_i))
```

2.1.19 The forever Macro

The `forever` macro is just a way to say `(while t ...)` with a bit of added expressiveness and explicitness.

Examples

```
(forever (let ((in (read)))
  (if (eq in 'quit)
      (format t "I_can't_let_you_do_that,_Dave.")
      (format t "You_entered_~A" in))))
```

2.1.20 The multicond Macro

The `multicond` macro is much like `cond`, but where multiple clauses may be evaluated.

Examples

```
(let ((x 12))
  (multicond ((= x 12) ; This will evaluate.
              (format t "X_is_12!_My_favorite_number!~%"))
    ((< x 100) ; This will evaluate also.
              (format t "X_is_small.~%"))
    ((< x 0) ; But this one won't.
              (format t "X_is_negative.~%"))))
```

2.1.21 The opf Macro

The `opf` macro is a generic operate-and-store, along the lines of `incf` and `decf`, but allowing for any operation.

Syntax

```
(opf operator variable &rest arguments)
```

Examples

```
;;; Prints 1 ... 2 ... 4 ... 8 ... ... 65535 ... that's it!
(let ((x 1))
  (while (<= x (expt 2 16))
```

```
(format t "~A~..." x)
(opf #'* x 2))
(format t "~that's it!~%")
```

2.1.22 The swap Macro

...TO DO ...

2.1.23 The swap-unless Macro

...TO DO ...

2.1.24 The swap-when Macro

...TO DO ...

2.1.25 The until Macro

...TO DO ...

2.1.26 The while Macro

...TO DO ...

2.2 Functions

2.2.1 The compose Function

...TO DO ...

2.2.2 The conjoin Function

...TO DO ...

2.2.3 The curry Function

...TO DO ...

2.2.4 The disjoin Function

...TO DO ...

2.2.5 The function-alias Function

...TO DO ...

2.2.6 The operator-to-function Function

...TO DO ...

2.2.7 The rcompose Function

...TO DO ...

2.2.8 The rcurry Function

...TO DO ...

2.2.9 The unimplemented Function

...TO DO ...

2.3 Generics**2.3.1 The duplicate Generic**

...TO DO ...

Chapter 3

The `sigma/hash` Package

3.1 Macros

3.1.1 The `sethash` Macro

The `sethash` macro is shortcut for `setf gethash`.

3.2 Functions

3.2.1 The `populate-hash-table` Function

The `populate-hash-table` function makes initial construction of hash tables a lot easier, just taking in key/value pairs as the arguments to the function, and returning a newly-constructed hash table.

Examples

```
(populate-hash-table 'name "Valentinus"
                    'likes '(birds roses)
                    'dislikes '(beheadings epilepsy "false_idols")
                    'died 269)
```

3.2.2 The `inchash` Function

The `inchash` function will increment the value in *key* of the *hash*, initializing it to 1 if it isn't currently defined.

3.2.3 The `dechash` Function

The `dechash` function will decrement the value in *key* of the *hash*, initializing it to -1 if it isn't currently defined.

3.2.4 The `gethash-in` Function

The `gethash-in` function works like `gethash`, but allows for multiple keys to be specified at once, to work with nested hash tables.

Syntax

```
(gethash-in keys hash-table &optional default)
```

Arguments and Values

keys A list of objects.

hash-table A hash table.

default An object. The default is `nil`.

Returns

value An object.

present? A generalized boolean.

Examples

```
(let ((h (make-hash-table)))  
  (sethash 'a h 12)  
  (gethash-in '(a) h)) ; Returns 12
```

```
(let ((h (make-hash-table))  
      (i (make-hash-table)))  
  (sethash 'b i 123)  
  (sethash 'a h i)  
  (gethash-in '(a b) h 123)) ; Returns 123
```


Chapter 4

The sigma/numeric Package

4.1 Macros

4.1.1 The divf Macro

The `divf` macro is divide-and-store, along the lines of `incf` and `decf`, but with division instead. This is similar to `x /= something` in the C programming language.

Syntax

```
(divf variable &rest arguments)
```

Examples

```
;;; Prints 65536 ... 8 ... 4 ... 2 ... 1 ... 0 ... that's it!
(let ((x (expt 2 16)))
  (while (<= 0 x)
    (format t "~A_..." x)
    (divf x 2))
  (format t "_that's_it!~%"))
```

4.1.2 The multf Macro

The `multf` macro is multiply-and-store, along the lines of `incf` and `decf`, but with multiplication instead. This is similar to `x *= something` in the C programming language.

Syntax

```
(multf variable &rest arguments)
```

Examples

```

;;; Prints 1 ... 2 ... 4 ... 8 ... ... 65535 ... that's it!
(let ((x 1))
  (while (<= x (expt 2 16))
    (format t "~A~..." x)
    (multf x 2)))
(format t "~that's it!~%")

```

4.2 Functions**4.2.1 The bit? Function**

...TO DO ...

4.2.2 The choose Function

The *choose* function computes the binomial coefficient for n and k , typically spoken as n choose k , and usually written mathematically as $\binom{n}{k}$.

4.2.3 The factorial Function

The *factorial* function computes $n!$ for positive integers. NB, this isn't intelligent, and uses a loop instead of better approaches.

4.2.4 The fractional-part Function

...TO DO ...

4.2.5 The fractional-value Function

...TO DO ...

4.2.6 The integer-range Function

...TO DO ...

4.2.7 The nonnegative? Function

...TO DO ...

4.2.8 The nonnegative-integer? Function

...TO DO ...

4.2.9 The positive-integer? Function

...TO DO ...

4.2.10 The product Function

...TO DO ...

4.2.11 The sum Function

...TO DO ...

4.2.12 The unsigned-integer? Function

...TO DO ...

4.3 Types

4.3.1 The nonnegative-float Type

...TO DO ...

4.3.2 The nonnegative-integer Type

...TO DO ...

4.3.3 The positive-float Type

...TO DO ...

4.3.4 The positive-integer Type

...TO DO ...

Chapter 5

The sigma/os Package

5.1 Functions

5.1.1 The perl Function

...TO DO ...

5.1.2 The python Function

...TO DO ...

5.1.3 The read-file Function

...TO DO ...

5.1.4 The read-lines Function

...TO DO ...

5.1.5 The ruby Function

...TO DO ...

5.2 Parameters

5.2.1 The *perl-path* Parameter

...TO DO ...

5.2.2 The `*python-path*` Parameter

...TO DO ...

5.2.3 The `*ruby-path*` Parameter

...TO DO ...

Chapter 6

The sigma/probability Package

6.1 Macros

6.1.1 The decaying-probability? Macro

...TO DO ...

6.2 Functions

6.2.1 The probability? Function

...TO DO ...

6.3 Types

6.3.1 The probability Type

...TO DO ...

Chapter 7

The sigma/random Package

7.1 Macros

7.1.1 The nshuffle Macro

...TO DO ...

7.2 Functions

7.2.1 The gauss Function

...TO DO ...

7.2.2 The random-argument Function

...TO DO ...

7.2.3 The coin-toss Function

...TO DO ...

7.2.4 The random-in-range Function

...TO DO ...

7.2.5 The random-in-ranges Function

...TO DO ...

7.2.6 The random-range Function

...TO DO ...

7.2.7 The randomize-array Function

...TO DO ...

7.2.8 The random-array Function

...TO DO ...

7.3 Generics**7.3.1 The random-element Generic**

...TO DO ...

7.3.2 The shuffle Generic

...TO DO ...

Chapter 8

The sigma/sequence Package

8.1 Macros

8.1.1 The arefable? Macro

...TO DO ...

8.1.2 The nconcf Macro

...TO DO ...

8.1.3 The nthable? Macro

...TO DO ...

8.1.4 The set-nthcdr Macro

...TO DO ...

8.2 Functions

8.2.1 The array-values Function

...TO DO ...

8.2.2 The nth-from-end Function

...TO DO ...

8.2.3 The sequence? Function*...TO DO ...***8.2.4 The empty-sequence? Function***...TO DO ...***8.2.5 The join-symbol-to-all-following Function**

This function takes a symbol and a list, and for every occurrence of the symbol in the list, it joins it to the item following it. For example:

Syntax

```
(join-symbol-to-all-following symbol list)
```

Examples

```
(join-symbol-to-all-following :# '(:# 10 :# 20 :# 30))  
;; Returns '(:#10 :#20 :#30)
```

Affected By

```
*print-escape*, *print-radix*, *print-base*, *print-circle*,  
*print-pretty*, *print-level*, *print-length*, *print-case*,  
*print-gensym*, *print-array*.
```

8.2.6 The join-symbol-to-all-preceding Function

This function takes a symbol and a list, and for every occurrence of the symbol in the list, it joins it to the item preceding it. For example:

Syntax

```
(join-symbol-to-all-preceding symbol list)
```

Examples

```
(join-symbol-to-all-preceding :% '(10 :% 20 :% 30 :%))  
;; Returns '(:10% :20% :30%)
```

Affected By

```
*print-escape*, *print-radix*, *print-base*, *print-circle*,  
*print-pretty*, *print-level*, *print-length*, *print-case*,  
*print-gensym*, *print-array*.
```

8.2.7 The list-to-vector Function

...TO DO ...

8.2.8 The set-equal Function

...TO DO ...

8.2.9 The simple-vector-to-list Function

...TO DO ...

8.2.10 The sort-order Function

...TO DO ...

8.2.11 The the-last Function

...TO DO ...

8.2.12 The vector-to-list Function

...TO DO ...

8.3 Generics**8.3.1 The best Generic**

...TO DO ...

8.3.2 The minimum Generic

...TO DO ...

8.3.3 The minimum? Generic

...TO DO ...

8.3.4 The maximum Generic

...TO DO ...

8.3.5 The maximum? Generic

...TO DO ...

8.3.6 The sort-on Generic

...TO DO ...

8.3.7 The slice Generic

...TO DO ...

8.3.8 The split Generic

...TO DO ...

8.3.9 The worst Generic

...TO DO ...

Chapter 9

The `sigma/string` Package

The `String` package contains useful tools for working with strings.

9.1 Functions

9.1.1 The `character-range` Function

The `character-range` function returns a list of characters from the *start* to the *end* character. Note that this is returning a list, not a string.

Syntax

```
(character-range start end)  $\Rightarrow$  ' (start ... end)
```

Arguments and Values

start The character to start the range with, inclusive.

end The character to end the range with, inclusive.

Examples

```
(character-range #\a #\e)  $\Rightarrow$  ' (#\a #\b #\c #\d #\e)  
(character-range #\e #\a)  $\Rightarrow$  ' (#\a #\b #\c #\d #\e)
```

9.1.2 The character-ranges Function

The `character-ranges` function is a convenience wrapper for `character-range` function, concatenating several calls and making the resultant list contain only unique instances.

Syntax

```
(character-ranges start1 end1 ... ⇒ ' (character1 ...)
```

Arguments and Values

start_n The character to start the *n*th range with, inclusive.

end_n The character to end the *n*th range with, inclusive.

Examples

```
(character-ranges #\a #\c #\x #\z) ⇒ ' (#\a #\b #\c #\x #\y  
#\z)
```

```
(character-ranges #\a #\c #\a #\c) ⇒ ' (#\a #\b #\c)
```

9.1.3 The escape-tildes Function

...TO DO ...

9.1.4 The replace-char Function

...TO DO ...

9.1.5 The strcat Function

...TO DO ...

9.1.6 The strmult Function

...TO DO ...

9.1.7 The string-join Function

...TO DO ...

9.1.8 The stringify Function

...TO DO ...

9.1.9 The to-string Function

...TO DO ...

9.2 Methods

9.2.1 The split Methods

...TO DO ...

Chapter 10

The time-series Package

10.1 Macros

10.1.1 The snap-index Macro

...TO DO ...

10.2 Functions

10.2.1 The array-raster-line Function

...TO DO ...

10.2.2 The distance Function

...TO DO ...

10.2.3 The norm Function

...TO DO ...

10.2.4 The raster-line Function

...TO DO ...

10.2.5 The similar-points? Function

...TO DO ...

10.2.6 The `time-series?` Function

...TO DO ...

10.2.7 The `time-multiseries?` Function

...TO DO ...

10.2.8 The `tmsref` Function

...TO DO ...

10.2.9 The `tms-dimensions` Function

...TO DO ...

10.2.10 The `tms-raster-line` Function

...TO DO ...

10.2.11 The `tms-values` Function

...TO DO ...

10.3 Types**10.3.1 The `time-multiseries` Type**

...TO DO ...

Chapter 11

The truth Package

11.1 Functions

11.1.1 The `[?]` Function

...TO DO ...

11.1.2 The `toggle` Function

...TO DO ...

11.2 Generics

11.2.1 The `?` Generic

...TO DO ...

Chapter 12

The sigma Package

12.1 Variables

12.1.1 The `*sigma-packages*` Variable

...TO DO ...

12.2 Functions

12.2.1 The `use-all-sigma` Function

...TO DO ...

Bibliography

[1] GRAHAM, P. *On Lisp*. Prentice-Hall, 1993.