

Pointfrip Language Reference

2022-06-13

Naming Conventions

name	the name itself
<i>name</i>	the type / the class
(?)	Uncertainties
*	Footnote / Note

Data Types

<u>Data type</u>	<u>Syntax</u>	<u>Type identifier</u>
<i>data</i>		// General
<i>null</i>	()	_null
<i>int*</i>	[_123]	_integer
<i>real</i>	_31.415e_123	_real
<i>string</i>	"abc"	_string
<i>ident</i>	abc <u>or</u> +-*/	_ident
<i>prefix</i>	@...	_prefix
<i>index</i>	[abc]	_index
<i>array</i>	{a b c}	_array
<i>error</i>	(<i>index</i> _error)	_error
<i>table*/dict*</i>	(a x b y c z)	// In pairs
<i>list</i>	(a ; b ; c ;)	;
<i>object</i>	(<i>ident</i> :: a x b y c z)	::
<i>turtle</i>	(turtle ::)	// Object
<i>combi</i>	(<i>term</i> _combine .. <i>arg</i>)	_combine
<i>monad</i>	(<i>int</i> _act)	_act
<i>bool</i>	true <u>or</u> false	// Idents
etc...		

* note that *int*- and *dict*-literals require the constant combinator!

Comments

codetext // comment

Definition of Identifiers

ident == *term*

ident ≡ *term*

Script Structure

term definition1 definition2 definition3 ...

Ddot

prop = *head infix .. tail*

Include Files

coreimport == "Script1.txt" ; "Script2.txt" ; "Script3.txt" ; ... ;

userimport == "Script1.txt" ; "Script2.txt" ; "Script3.txt" ; ... ;

corepath?

userpath?

List/Dict Functions and Operators

$dict = (first_1 \text{ infix}_1 first_2 \text{ infix}_2 \dots first_m \text{ infix}_m)$

$list = (element_0 ; element_1 ; element_2 ; \dots ;)$

$[i] \circ list \quad \quad \quad -- \quad \quad element_i$

head $\circ dict \quad \quad \quad -- \quad \quad first$

head $\circ list \quad \quad \quad -- \quad \quad first$

First element of the list.

head $\circ object \quad \quad \quad --$

tail $\circ dict \quad \quad \quad -- \quad \quad rest$

tail $\circ list \quad \quad \quad -- \quad \quad rest$

List without the first element and first infix.

tail $\circ object \quad \quad \quad --$

infix $\circ dict \quad \quad \quad -- \quad \quad infix \text{ value}$

infix $\circ object \quad \quad \quad --$

prop $\circ first, infix, rest, \quad \quad \quad -- \quad \quad dict$

top $\circ dict \quad \quad \quad -- \quad \quad first$

top $\circ list \quad \quad \quad -- \quad \quad first$

pop $\circ dict \quad \quad \quad -- \quad \quad rest$

pop $\circ list \quad \quad \quad -- \quad \quad rest$

tag $\circ data \quad \quad \quad -- \quad \quad typus \quad \quad \quad // \text{ als typeof}$

tag $\circ dict \quad \quad \quad -- \quad \quad infix \text{ value}$

term $\circ combi \quad \quad \quad -- \quad \quad term \text{ value}$

arg $\circ combi \quad \quad \quad -- \quad \quad arg \text{ value}$

termoarg $\quad \quad \quad -- \quad \quad term \text{ o } arg$

first , rest $\quad \quad \quad -- \quad \quad list$

Appendleft

length $\circ dict \quad \quad \quad -- \quad \quad real$

length $\circ list \quad \quad \quad -- \quad \quad real$

length $\circ object \quad \quad \quad --$

Number of list items.

reverse $\circ dict \quad \quad \quad -- \quad \quad dict$

reverse $\circ list \quad \quad \quad -- \quad \quad list$

reverse $\circ object \quad \quad \quad --$

Reverses the list items.

data **distl** *list* -- *matrix*

list **distr** *data* -- *matrix*

dict ++ *dict* -- *dict*

list ++ *list* -- *list*

Concatenate the lists.

dict **take** *num* -- *dict*

list **take** *num* -- *list*

Takes the first *num* elements from the list.

dict **drop** *num* -- *dict*

list **drop** *num* -- *list*

Drops the first *num* elements in the list.

trans ° *matrix* -- *matrix*

transpose ° *matrix* -- *matrix*

num **pick** *list* -- *element*

num **sel** *list* -- *element*

last ° *list* --

(*num* **r**) ° *list* --

tailr ° *list* -- *list*

tailr ° *dict* -- *dict*

rotl ° *list* -- *list*

rotr ° *list* -- *list*

list **count** *data* -- *real*

data **make** *num* -- *list*

list **find** *data* -- *real*

iota ° *num* -- *list*

ι ° *num* -- *list*

Generates a list of numbers from 1 to *num*.

iota0 ° *num* -- *list*

Generates a list of numbers from 0 to *num*-1.

int **to** *int* -- *list*

real **to** *real* -- *list*

int **upto** *int* -- *list*

real **upto** *real* -- *list*

<i>int</i> downto <i>int</i>	--	list
<i>real</i> downto <i>real</i>	--	list
swap ° <i>x,y,list</i>	--	<i>y,x,list</i>

Math Functions and Operators

<i>int</i> + <i>int</i>	--	<i>int</i>
<i>real</i> + <i>real</i>	--	<i>real</i>

Addition of numbers.

<i>int</i> - <i>int</i>	--	<i>int</i>
<i>real</i> - <i>real</i>	--	<i>real</i>

Subtraction of numbers.

<i>int</i> * <i>int</i>	--	<i>int</i>
<i>real</i> * <i>real</i>	--	<i>real</i>
<i>int</i> × <i>int</i>	--	<i>int</i>
<i>real</i> × <i>real</i>	--	<i>real</i>

Multiplication of numbers.

<i>num</i> / <i>num</i>	--	<i>real</i>
<i>num</i> ÷ <i>num</i>	--	<i>real</i>

Division of numbers.

<i>int</i> ^ <i>int</i>	--	<i>int</i>
<i>real</i> ^ <i>real</i>	--	<i>real</i>

Power of numbers.

<i>int</i> idiv <i>int</i>	--	<i>int</i>
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Integer division

<i>int</i> imod <i>int</i>	--	<i>int</i>
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Integer modulo

pred ° <i>int</i>	--	<i>int</i>
pred ° <i>real</i>	--	<i>real</i>

Predecessor function

succ ° <i>int</i>	--	<i>int</i>
succ ° <i>real</i>	--	<i>real</i>

Successor function

sign ° <i>int</i>	--	<i>int</i>
sign ° <i>real</i>	--	<i>real</i>

Sign function

abs ° <i>int</i>	--	<i>int</i>
abs ° <i>real</i>	--	<i>real</i>

Absolute value function

neg ° <i>int</i>	--	<i>int</i>
neg ° <i>real</i>	--	<i>real</i>
_ ° <i>int</i>	--	<i>int</i>
_ ° <i>real</i>	--	<i>real</i>

Negation of a number.

round ° <i>num</i>	--	<i>int</i>
round ° <i>complex</i>	--	<i>int</i>

Rounding to an integer.

trunc ° <i>num</i>	--	<i>int</i>
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Truncate to an integer.

int ° <i>num</i>	--	<i>real</i>
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Integer part of the number as a real number.

frac ° <i>num</i>	--	<i>real</i>
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Fraction part of a real number.

float ° <i>num</i>	--	<i>real</i>
float ° <i>complex</i>	--	<i>real</i>

Conversion to the real number.

<i>num</i> roundto <i>num</i>	--	<i>real</i>
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exp ° <i>real</i>	--	<i>real</i>
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Exponential function

ln ° <i>real</i>	--	<i>real</i>
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Natural logarithm.

lg ° <i>real</i>	--	<i>real</i>
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Decadic logarithm.

ld ° <i>real</i>	--	<i>real</i>
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Binary logarithm.

sq ° <i>int</i>	--	<i>int</i>
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sq ° <i>real</i>	--	<i>real</i>
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Square of a number.

sqrt ° <i>num</i>	--	<i>real</i>
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Square root of a number.

pi	--	3.141592653589793
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Ludolph's number π

2pi	--	6.283185307179586
Scope of the unit circle.		
sin ° <i>real</i>	--	<i>real</i>
Sine function		
cos ° <i>real</i>	--	<i>real</i>
Cosine function		
tan ° <i>real</i>	--	<i>real</i>
Tangent function		
cot ° <i>real</i>	--	<i>real</i>
Cotangent function		
sec ° <i>real</i>	--	<i>real</i>
csc ° <i>real</i>	--	<i>real</i>
arcsin ° <i>real</i>	--	<i>real</i>
Arcsine function		
arccos ° <i>real</i>	--	<i>real</i>
Arccosine function		
arctan ° <i>real</i>	--	<i>real</i>
Arctangent function		
<i>num</i> arctan2 <i>num</i>	--	<i>real</i>
arccot ° <i>real</i>	--	<i>real</i>
arcsec ° <i>real</i>	--	<i>real</i>
arccsc ° <i>real</i>	--	<i>real</i>
sinh ° <i>real</i>	--	<i>real</i>
Hyperbolic sine function		
cosh ° <i>real</i>	--	<i>real</i>
Hyperbolic cosine function		
tanh ° <i>real</i>	--	<i>real</i>
Hyperbolic tangent function		
coth ° <i>real</i>	--	<i>real</i>
sech ° <i>real</i>	--	<i>real</i>
csch ° <i>real</i>	--	<i>real</i>

arsinh ° <i>real</i>	--	real	
arcosh ° <i>real</i>	--	real	
artanh ° <i>real</i>	--	real	
arcoth ° <i>real</i>	--	real	// Library "complex.txt"
arsech ° <i>real</i>	--	real	// Library "complex.txt"
arcsch ° <i>real</i>	--	real	// Library "complex.txt"
<i>real</i> root <i>real</i>	--	real	// Library "complex.txt"
deg ° <i>num</i>	--	<i>real</i>	
Radiant-to-Degree function			
rad ° <i>num</i>	--	<i>real</i>	
Degree-to-Radiant function			
hex ° <i>num</i>	-	<i>string</i>	
Number as hexadecimal string.			
<i>real</i> mod <i>real</i>	--	<i>real</i>	
Modulo of real numbers.			
sum ° <i>list</i>	--	<i>num</i>	
Sum of the list items.			
prod ° <i>list</i>	--	<i>num</i>	
Product of the list items.			
avg ° <i>list</i>	--	<i>real</i>	
Average value of the list items.			
integral			
dd			
zero ° <i>data</i>	--		
one ° <i>data</i>	--		
half ° <i>data</i>	--	...	// Library "complex.txt"

Dictionary Functions, Operators and Combinators

dict is a table for pattern matching treatment

dict = (value0 key0 value1 key1 value2 key2)

_super

Key for the super dictionary.

dict **get** key -- value

Get the *value* for the *key* from a *dict*.

dict **put** key,value, -- dict

Replaces the *value* to a *key* in the *dict*.

dict **iget** ident -- value

dict **iget** index -- value

API-Get for identical keys.

dict **iput** ident,value, -- dict

dict **iput** index,value, -- dict

API-Put for identical keys.

#ident ° *dict* -- value

(*ident _v*) ° *dict* -- value

Instance variable value.

(*ident* := *value*) ° *dict* -- dict

Substitution of an instance variable with a *value*.

func <- *key1* ; *key2* ; ... ;

func ← *key1* ; *key2* ; ... ;

Assign combinator, general.

func <- *key1* *isfunc1* *key2* *isfunc2*

func ← *key1* *isfunc1* *key2* *isfunc2*

Assign combinator, typed.

keys ° *dict* -- list

values ° *dict* -- list

Boolean Functions and Operators

bool = **true** or **false**

'true' -- *bool*
Value for true.

'false' -- *bool*
Value for false.

data = *data* -- *bool*
Check for equality.

data <> *data* -- *bool*
data != *data* -- *bool*
data ≠ *data* -- *bool*
Check for inequality.

data < *data* -- *bool*
Checks whether smaller.

data > *data* -- *bool*
Checks whether larger.

data <= *data* -- *bool*
Checks whether less than or equal.

data >= *data* -- *bool*
Checks whether greater than or equal to.

¬ ° *bool* -- *bool*
not ° *bool* -- *bool*
not ° *int* -- *int*
NOT function

bool **and** *bool* -- *bool*
int **and** *int* -- *int*
AND operator

bool **or** *bool* -- *bool*
int **or** *int* -- *int*
OR operator

bool **xor** *bool* -- *bool*
int **xor** *int* -- *int*
Exclusive-OR operator

isatom ° *data* -- *bool*

Checks whether the *data* is a basic data type. (?)

isprop ° *data* -- *bool*

Checks whether the *data* is a triple value. (?)

islist ° *data* -- *bool*

Checks whether the *data* is a list.

isbool ° *data* -- *bool*

Checks whether the *data* is a Boolean identifier.

isnum ° *data* -- *bool*

Checks whether the *data* is a number. Generic function.

iszero ° *data* -- *bool*

Checks whether the *data* is zero. Generic function.

ispos ° *data* -- *bool*

Checks whether the *data* is greater than zero. Generic function.

isneg ° *data* -- *bool*

Checks whether the *data* is less than zero. Generic function.

isnil (?)

ispreg (?)

isnull ° *data* -- *bool*

isint ° *data* -- *bool*

isreal ° *data* -- *bool*

isstring ° *data* -- *bool*

isident ° *data* -- *bool*

isprefix ° *data* -- *bool*

isindex ° *data* -- *bool*

isarray ° *data* -- *bool*

iscons ° *data* -- *bool*

iscombi ° *data* -- *bool*

isalt ° *data* -- *bool*

isobj ° *data* -- *bool*

isquote ° *data* -- *bool*

isivar ° *data* -- *bool*

isact ° *data* -- *bool*

Predicates to check the appropriate data type.

isbound ° *ident* -- *bool*

isbound ° *prefix* -- *bool*

Checks whether an identifier is bound.

isundef ° *data* -- *bool*
 Testing for `_undef`

iscomplex ° *complex* -- *bool*
 Checks whether it is a complex number. (?)

ismatrix ° *object* -- *bool*

isodd ° *int* -- *bool*
isodd ° *real* -- *bool*

object is ident -- *bool*
 Checks whether the *ident* is the same as the class identifier of the *object*. (?)

(ident hastag) ° *data* -- *bool* (?name)

Combinators for Program Execution (?)

combi = (*term* **_combine** .. *arg*)

func_s
 Single function evaluation

' *literal*
literal k
literal _q
 Constant combinator

f : *x*
 Application // to be used for closed and lift

func1 ° *func2*
func1 ° *func2*
func1 ° *func2* // unicode: 0x2218
 Composition of functions.

functional app *argument*
 Apply operator

func1 , *func2* , *func3* , ... ,
 Construction of lists.

test -> *then* | *else*
test → *then* | *else*
test -> *then* ; *else*
 Condition with Alternat/Cons

test -> func*

test → func*

while Loop

func loopif test

do-while Loop

(func do)°num,num,num,

functional for num,num,num,

list map functional

Map operator

(func aa)° list

(func α)° list

Apply-to-all combinator

list insl functional

Insertl operator

list insr functional

Insertr operator

fold ° 'expr,initakku,list, -- akku

(func \)° list

Insertr combinator

list filter functional

Filter operator

(list,arg1,arg2,...,) map0 functional

(func aa0)° list,arg1,arg2,...,

Combination of **aa** and **distr**, extended.

func1 ee func2

ee ° data,data,

Eval-Eval combinator for infix notation.

func1 swee func2

swee ° data,data,

Swap-Eval-Eval combinator

(func1 eea func2)° argum -- (x ; y ; argum ;)

(func dip)° list

(func dip)° object

Dip combinator (stolen from Joy)

(test **try** then | else) ° argument
in then/else with (testresult ; argument ;)

'expr **step** list,akku,

'expr **times** rep,akku,

ifnull

ifprop

data1 ?? data2 -- data

(func Y)

Y-Combinator...

quote ° data -- func

Quote functional

func1 **comp** func2 -- func

Compose functional

(func **any**) ° list -- bool

(func **all**) ° list -- bool

Misc Functions and Operators

undef -- error

Function is defined as undefined.

id ° argument -- argument

Identity function.

out ° argument -- argument

// *Side effect

Output for debugging.

data **min** data -- data

min ° data,data, -- data

Minimum of two values.

data **max** data -- data

max ° data,data, -- data

Maximum of two values.

name ° ident -- string

Print name of an identifier.

body ° *ident* -- *value*

The assigned *value* of an identifier.

address ° *data* -- *real*

Address value of the triple cell.

identlist -- *list*

List of all used identifiers. (?)

indexdict -- *dict*

Dict of all index types with integers.

maxcell -- *int*

pointersize -- *int*

win32 = [32], win64 = [64]

_reserve

Value for an unbound identifier.

_undef

Value for undefined.

gc ° *argument* -- *argument*

Turns on the garbage collector.

String Functions and Operators

substring ° *string,num,num,* -- *string*

string **concat** *string* -- *string*

string & *string* -- *string*

Concatenates the strings.

string **indexof** *substr* -- *real*

list **join** *sepstr* -- *string*

string **split** *sepstr* -- *list*

string **repeat** *num* -- *string*

string **delete** *num,num,* -- *string*

string **insert** *num,string,* -- *string*

length ° <i>string</i>	--	<i>real</i>	
Length of the string.			
<i>string</i> mid <i>num,num,</i>	--	<i>string</i>	
<i>string</i> left <i>num</i>	--	<i>string</i>	
<i>string</i> right <i>num</i>	--	<i>string</i>	
char ° <i>num</i>	--	<i>string</i>	
unicode ° <i>string</i>	--	<i>real</i>	
trim ° <i>string</i>	--	<i>string</i>	
Trims the <i>string</i> on the left and right side.			
triml ° <i>string</i>	--	<i>string</i>	
Trims the <i>string</i> on the left.			
trimr ° <i>string</i>	--	<i>string</i>	
Trims the <i>string</i> on the right.			
upper ° <i>string</i>	--	<i>string</i>	
AnsiUpperCase of the string.			
lower ° <i>string</i>	--	<i>string</i>	
AnsiLowerCase of the string.			
capitalize ° <i>string</i>	--	<i>string</i>	
parse ° <i>string</i>	--	<i>list</i>	
Precompiles the <i>string</i> into a <i>list</i> .			
value ° <i>string</i>	--	<i>data</i>	
Converts the <i>string</i> to a <i>data</i> type.			
string ° <i>data</i>	--	<i>string</i>	
Converts the <i>data</i> to its text representation.			
unpack ° <i>string</i>	--	<i>list</i>	
Splits the <i>string</i> into a list of individual string characters.			
pack ° <i>list</i>	--	<i>string</i>	
Concatenates the strings in the <i>list</i> .			
timetostring ° <i>real</i>	--	<i>string</i>	
datetostring ° <i>num</i>	--	<i>string</i>	
weekday ° <i>num</i>	--	<i>num</i>	(?)

OOP

```
object = (cap :: inst)           // Object classes

pair = object , parameter ,

self ° pair

para ° pair

index op func

index swop func

index fn func

(object (index cb func) parameter) ° argum --      method ° [0],[1],argum,

cap ° list           --      ( )
cap ° object         --      (cap ::)

ident obj list       --      (ident :: list)
ident obj dict       --      (ident :: dict)

ident new parameter

object as ident (?)   --      object

box ° primdata       --      object

unbox ° object        --      primdata

(func objdip) ° pair --      object

object == .. { ( ) ... .. }
Object class

list == .. { object ... .. }
List class

dict == .. { object ... .. }
Dict class
```

Monads and Effects

monad = (*int _act .. dict*) // absolute

monad = (*index _act .. dict*) // relative

it ° *dict* -- #_it ° *dict*

Result of a monad action. // monad ... name (?)

_it

Attribute for results of actions.

_self

Attribute for the first parameter for an action.

_para

Attribute for the second parameter for an action.

_bind

Attribute for the continuation term of an action.

_eff

Attribute for the effects of relative actions.

monad >> *term* -- *monad* // _bind := *term*

Adds the continuation *term* to the table of the monad.

int act dict -- *monad*

index act dict -- *monad*

monad act dict -- *monad*

Create a monad. The monad needs an absolute address for the action/or relative address for the effect method/or a parent monad. In addition, the monad needs a table with instance variables. The instance variables are passed on to the continuation after the action. (nested act possible)

monad eff array -- *monad*

monad eff ident -- *monad*

Adds the effects class to the monad's table.

monad var data -- *monad*

monad var dict -- *monad*

(*ident define data*) ° *dict* -- *monad*

//(prefix define data) ° *dict*

(*ident redefine data*) ° *dict* -- *monad*

//(prefix redefine data) ° *dict*

(*data showgraph*) ° *dict* -- *monad* // *+ (x eff 'io)

(*data showinfo*) ° *dict* -- *monad* // *+ (x eff 'io)

```

(data print) ° dict           --      monad           // *+ (x eff 'io)

(string input) ° dict         --      monad           // *+ (x eff 'io)
(string input string) ° dict

(fname loadtext) ° dict       --      monad           // *+ (x eff 'io)
Loads a string from a text file with path and filename of fname.
The string can be obtained from #_it .

(fname savetext string) ° dict --      monad           // *+ (x eff 'io)

(string run) ° dict           --      monad           // *+ (x eff 'io)

quit                        --      monad

time ° dict                 --      monad           // *+ (x eff 'io)

date ° dict                 --      monad           // *+ (x eff 'io)

beep ° dict                 --      monad           // *+ (x eff 'io)

io == .. { ... .. }
System effects class

```

Runtime Errors(?)

```

error = (index _error string ; ... ..)

index error string,        --      error

fail ° argument            --      error
Use for selector signatures(?)

stop ° argument            --      error
Generally, e.g. Program termination, etc

raise ° string             --      exception
An exception is thrown.

_error == .. { ... .. }
Class for redirects...

// try

```

Complex Numbers

```
complex = (complex :: real re real im)           // Library "complex.txt"

i          --      (complex :: 0 re 1 im)
Square root of _1

real j real          --      complex           // für schnelle Schreibweise

real cval real        --      complex

To form a complex number from real numbers.

re ° complex          --      real
Real part of the complex number.

im ° complex          --      real
Imaginary part of the complex number.

complex + complex      --      complex
Addition of complex numbers.

complex - complex      --      complex
Subtraction of complex numbers.

complex * complex      --      complex
complex × complex      --      complex
Multiplication of complex numbers.

complex / complex      --      complex
complex ÷ complex      --      complex
Division of complex numbers.

zero ° complex         --      (complex :: 0 re 0 im)

one ° complex          --      (complex :: 1 re 0 im)

half ° complex         --      (complex :: 0.5 re 0 im)

iszero ° complex       --      bool

isnum ° complex        --      true

complex = complex      --      bool

conj ° complex         --      complex

neg ° complex          --      complex

abs ° complex          --      real

phase ° complex        --      real           // wie Arg(z)
```

sq ° <i>complex</i>	--	complex	
exp ° <i>complex</i>	--	complex	
ln ° <i>complex</i>	--	complex	// Hauptzweig
lg ° <i>complex</i>	--	complex	// Log10(z)
ld ° <i>complex</i>	--	complex	// Log2(z)
<i>complex</i> ^ <i>complex</i>	--	complex	
<i>complex</i> root <i>complex</i>	--	complex	
sqrt ° <i>complex</i>	--	complex	
sin ° <i>complex</i>	--	complex	
cos ° <i>complex</i>	--	complex	
tan ° <i>complex</i>	--	complex	
cot ° <i>complex</i>	--	complex	
sec ° <i>complex</i>	--	complex	
csc ° <i>complex</i>	--	complex	
arcsin ° <i>complex</i>	--	complex	
arccos ° <i>complex</i>	--	complex	
arctan ° <i>complex</i>	--	complex	
arccot ° <i>complex</i>	--	complex	
arcsec ° <i>complex</i>	--	complex	
arccsc ° <i>complex</i>	--	complex	
sinh ° <i>complex</i>	--	complex	
cosh ° <i>complex</i>	--	complex	
tanh ° <i>complex</i>	--	complex	
coth ° <i>complex</i>	--	complex	
sech ° <i>complex</i>	--	complex	
csch ° <i>complex</i>	--	complex	

```

arsinh ° complex      --      complex
arcosh ° complex      --      complex
artanh ° complex      --      complex
arcoth ° complex      --      complex
arsech ° complex      --      complex
arcsch ° complex      --      complex
iscomplex ° object    --      bool

complex == .. { dict ... .. }
Complex-class with the complex methods.

```

Matrix Functions and Operators

```

matrix = (list ; list ; ... ;) oder
matrix = (matrix :: list ; list ; ... ;)           // Library "matrix.txt"

IP ° list,list,                                     // Backus Turing Lecture
list IP list

MM ° matrix,matrix,                                  // Backus Turing Lecture
matrix MM matrix

det ° matrix      --      real
inv ° matrix       --      matrix
matrix + matrix     --      matrix
matrix - matrix     --      matrix
matrix * matrix     --      matrix
matrix × matrix     --      matrix

trans ° matrix    --      matrix      // transpose
num scale matrix --      matrix      // (?) scalar
matrix each 'func  --      matrix      // (?)
sq ° matrix      --      matrix

```

```

zero ° matrix          --      matrix          // zeromatrix

one ° matrix           --      matrix          // idmatrix

num0 zeromatrix num1  --      matrix
Creates a num0×num1 matrix of zero values with the type of num0.

num0 onematrix num1  --      matrix
Creates a num0×num1 matrix of one values with the type of num0.

idmatrix ° num         --      matrix
Creates a num×num identity matrix with the type of num.

ismatrix ° data       --      bool

tomatrix ° list        --      matrix

num like data         --      num             // with type of data

matrix == .. { list ... .. }
Matrix-class for MM (*), det, inv, trans, add, sub, Aij, negifodd

```

Turtle Graphics

```

turtle = ( turtle :: list stack real x real y real angle
            bool pen num color num size num brush ) // Library "turtlegraphics.txt"

pair = (x , y ,)

// 2pi

initturtle
'turtle new           // recommended

pair moveto turtle

pair moverel turtle

real move turtle

real turnto turtle

real turn turtle

penup ° turtle

pendown ° turtle

```

num **pencolor** *turtle*

num **pensize** *turtle*

num **brushcolor** *turtle*

real **circle** *turtle*

rectangle ° *turtle* // rect

(*turtle* (**draw** eff 'io)) ° *dict* -- monad
For drawing the turtle trail.

#x ° *turtle* -- real

#y ° *turtle* -- real

#angle ° *turtle* -- real

etc

Attributes of the turtle object.

colors == '(... ...)

#red ° *colors* for the color value red.

turtle == .. { *dict* }

Turtle class,

own turtle classes can also be created through inheritance.

(*xlist* (**plot0** eff 'io) 0-y) ° *dict* -- monad