Arithmetic

`a + b`	*addition*
`a - b`	*subtraction*
`a * b`	*multiplication*
`a / b`	*division*
`a /. b`	*integer division*
`a^1|2`	*exponentiation to fractional power*

Comparisons

`a < b`	*less than*	
`a <= b`	*less than or equal to*	≤
`a == b`	*equal to*	
`a <> b`	*not equal to*	≠
`a >= b`	*greater than or equal to*	≥
`a > b`	*greater than*	

Logical operations

`a and b`	*logical AND*
`a or b`	*logical OR*
`a xor b`	*exclusive OR*
`not a`	*logical NOT*

Data types

`any`	*any type*	
`bits`	*bit string*	*(Not Yet)*
`bool`	*T, F, U or ERR*	
`bytes`	*byte string*	
`changelist`	*find/replace list*	
`color`	*color*	
`func`	*function pointer*	
`image`	*bitmap image*	
`meas`	*physical measurement*	
`num`	*number or enum*	
`ptr`	*pointer*	
`regexp`	*regular expression pattern*	
`sound`	*sound effect*	
`str`	*character string*	
`tree`	*a tree*	
`video`	*movie*	

Definitions and flow of control statements

```
assets (local:name) (remote:name)
    folder:name into:dest (pattern:str)
          index: head|tail|seq|name
    file:name (url:"...") label:name

const name (:type) = expression
style name = ...tokens...
type name = type_expression
var name (:type) (= expression)

family name base:name (abbrev: name)
    (dimensions: unit^n | n | nonlinear)
unit doz family:scalar ratio:1 doz = 12 each

record name
    field1 (:type)
    :recordname

if expression
    ..statements
elif expression
    ..statements
else
    ..statements

case expression
| 10, 12
    ..statements
|>10
    ..statements
else
    ..statements

loop index:id path:id val:id label:id
    count:id  rev:bool root:bool kind:kind
    from:expr to:expr (swap:bool) (by:expr)
    across:tree  across^2:tree  across^3:tree
    top_down:tree bottom_up:tree
    recursive:tree via:field
    sort: (index|val|field: id) (func: id)
    while:expr until:expr reps:expr trap:bool

continue (loopname)  exit (loopname) return (expr)
log (+/-) "msg" (on:flag) (cat:ident (level:num))
nop

block fill:color grad:gradient opacity:opacity
    corner:radius border:thick style color
    shadow:[{dx:n, dy:n, blur:n, color:c}]
```

Single value operations

`=`	*copy to left*	⇐
`=>`	*copy to right*	⇒
`+=>`	*add then copy*	+⇒
`-=>`	*subtract then copy*	-⇒
`*=>`	*multiply then copy*	*⇒
`/=>`	*divide then copy*	/⇒
`&=>`	*concatenate then copy*	&⇒

```
append expr => dest
insert expr => dest
prepend expr => dest
link a.rel <=> b.rel          .LINK follows
swap src <=> dest

dec dest
inc dest
toggle dest
touch dest
adr dest                      take address of a subtree
```

Tree operations

`dest <=== src`	*copy tree to left*	⇚
`copy src ===> dest`	*copy tree to right*	⇛
`prepend src ===> dest (index:ident)`		
`append src ===> dest (index:ident)`		
`insert src ===> dest`		
`merge src ===> dest`		
`move src ===> dest`		
`swap src <===> dest`		⇚⇛

`clear ===> dest`	
`remove ===> dest`	
`renum ===> dest`	
`trunc ===> dest`	

Other operations

`f |> g |> h`	*function chaining*	➤
`path ^^`	*pointer indirection*	↑
`ditto`	*repeat function parms*	

Calculation and drawing blocks

```
calc name ( `description`
    parm: type `description`
    ) : returntype

calc name ditto  // repeat the same parameters as function above
```

```
draw name
    layer axes:kind area:box inset:spec skew:expr
          rotate:expr translate:expr matrix:matrix
          pin:expr dpi:expr
```

Plain draw block with optional sub-layer

```
(horz|vert) (slice|scroll) name
    add expr units funcname (order:expr)
    skip expr units
```

Subdivide into horizontal or vertical slices (stack scrolls)

```
grid name
    horz slice
      add expr units funcname (order:expr)
      skip expr units
    vert slice
      add expr units funcname (order:expr)
      skip expr units
    under
          // optional code to draw underneath grid
    cell
          // code to draw each cell
    over
          // optional code to draw on top of table
```

Create a 2-dimensional grid

```
report name
    add expr units    // define raw columns
    skip expr units
    rowkind name      // define row kinds
      background
            // background drawing..
      span expr
            // drawing for this row section..
      skip expr

    build     // now build the rows
      add expr units row_id:expr (fieldname:expr)...
      skip expr units

track (eventkind)
    ...tracking logic for draw block...
```

Create a tabbed report that has a fine columnar grid, and each row can use a different set of the micro-columns

Block subdivision Units

```
al -- aliquots (proportions)
pc -- picas (1/12 of an inch, 2mm)
pt -- points (1/72 of an inch, 1/3mm)
px -- device pixels
```

Punctuation in identifiers

`$`, `_` (underscore), `*` (export marker suffix)

Comments

```
//          line comment
--          line comment
---         documentation comment
====        line comment

/* ... */   block comment
(* ... *)   block comment alternate

`comment`   metaprogramming comment
```

Required first line

```
beads level num (program | library
| monitor | system) name (export_all)
(ver literal) (title literal)
```

Preprocessor commands

```
@alias name = tokens...
@favorite
@index  "cat" / "subcat"
@option ..compiler options..
@partial func1(a) = func2(arg1, a, arg2)

@+          continue a line until @-

@if condition @then code
@elif condition @then code
@else code @endif

@< @>       indent, dedent for generated code
@;          line break for generated code
@(  @)      〔 〕 nested parentheses
```

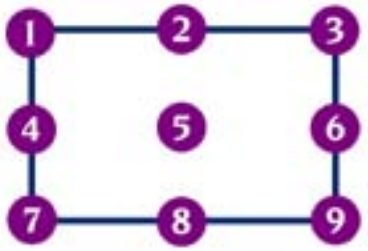
Alternate braces

```
@a{ @a}   【 】
@b{ @b)   « »
@c{ @c}   〈 〉
@d{ @d}   《 》
@e{ @e}   「 」
```

To calculate a rectangle given a series of constraints:

solve_rect(*basis:a_rect, pin, cx, cy, dx, dy, top_left, left, top, right, bottom, width, height, aspect, inset, inset_n, inset_s, inset_e, inset_w, inset_x, inset_y***):a_rect**

Rectangle pin positions



To calculate a point given a basis rectangle:

solve_point(*basis:a_rect, pin:num=5***):a_xy**

To calculate a value using linear interpolation, given an input value, an input range, and output range:

interpolate(*value, input1, input2, output1, output2, round=F, clamp=F***):num**

To convert a number into a string with optional overrides for thousands mark, decimal point, length, parentheses for negative, etc.:

to_str(*val, base=10, currency=F, currency_cc:="$", decimal_cc=".", thou=F, thou_cc=",", round_k=F, max=999, min=1, neg_paren=F, pos_plus=F, percent=F, digits=U, show_u=F, zero_pad=F***):str**

To draw text on the screen:

draw_str(box, text, xy, angle, bold, bord_color, bord_width, color, corner, fill, font, hide_u, html, indent, italic, just, leading, max_lines, metrics, opacity, rindent, sel, shadowc, shadowr, shadowx, shadowy, shrink, shrink_min, size, spacing, strike, und, vert, weight, wrap)

To draw a rectangle that can be stroked, filled with a color, pattern or gradient, with optional rounded corners:

draw_rect(box, fill, grad, tile, blur, bord_color, bord_pos, bord_width, corner, opacity, shadow)

To draw an oval (or circle if bounding box is square) that can be stroked and/or filled with a color, pattern or gradient:

draw_oval(box, fill, grad, tile, blur, bord_color, bord_pos, bord_width, opacity, shadow)

To draw a circle given a center point and radius or diameter, that can be stroked and/or filled:

draw_circle(xy, x, y, radius, diam, fill grad, tile, blur, bord_color, bord_pos, bord_width, opacity, shadow)

To draw a line. Line cap options are: **CAP_BUTT, CAP_ROUND, CAP_SQUARE***:*

draw_line(p1, p2, x1, y1, x2, y2, dx, dy, opacity, color, width, rel, cap)

To draw a bitmap image. The image can be sized to fit the specified box:

draw_image(image, box, xy, x, y, indent horz, vert, shrink, grow, aspect, origin, originx, originy, angle, corner, opacity, blend, filters)

To count how many items are in an array:

count(*array***):num**

Character string syntax

To concatenate use ampersand (&):

```
"hello" & "goodbye"
```

Use braces to embed an expression:

```
"total count is {count}"
```

Use triple quotes to define multiple line strings:

```
'''Love all,
trust a few,
do wrong to none'''
```

Use escape characters to access special characters or block special interpretation:

```
'my dog\'s name'
```

Localization suffixes look like this:

```
"my name"[123]
```

String escape sequences

{expr}	embedded expression
****	single backslash
\n	newline
\r	carriage return
\t	tab
\uAAAA	unicode character by hex code
\0	null character
\'	single quote (')
\"	double quote (")
_	space (explicit spaces in translations)
\~	non-breaking space
\-	em dash
\!	inverted exclamation (¡)
\?	inverted question mark (¿)
\<	left guillemet («)
\>	right guillemet (»)
\{	left brace (not embedded expr.)
\}	right brace (not embedded expr.)
\.	bullet (•)

String handling functions from the str library

subset(*str, from=1, to=U, len=U, rev=F***):str** *extract a substring from a string*

to_upper(*str***):str** *switch to all upper case letters*
to_lower(*str***):str** *switch to all lower case letters*

to_char(*num***):str** *convert unicode number to character*
from_char(*'c'***):num** *convert a the first character of a string to its unicode number*

pad_left(*str, len, pad=' '***):str** *pad a string on the left side to a specified length*
pad_right(*str, len, pad=' '***):str** *pad a string on the right side to a specified length*

to_str(*num, base=10, currency=F, currency_cc="$", decimal_cc=".", u_cc="?", thou=F, thou_cc=",", round_k=F, max=999, min=1, neg_paren=F, pos_plus=F, percent=F, zero_pad=F***):str**

str_begins(*haystack, needle***):bool** *test if a long string (haystack) begins with a small string (needle)*
str_del(*str, from=1, to=U, len=U, rev=F***):str** *remove a range of characters from a string*
str_ends(*haystack, needle***):bool** *test if a long string (haystack) ends with a small string (needle)*
str_find(*str, pattern, startpos=0, ignorecase=F, rev=F, regexp=F, count=1***):a_find**
str_ins(*starting, insert, to=U, len=U, rev=F***):str** *insert a string into another, maybe deleting some characters*
str_len(*str***):num** *get string length*
str_localize(*str, lang=U, index=U, qty=U, fallback=F***):str**
str_repeat(*str,ntimes***):str** *repeat a string*
str_replace (*haystack, needle, replacement, start=***0):str**
str_replace_multiple (*haystack, changes, trace=F***):str**
str_reverse(*str***):str** *reverse the characters in a string*
str_split_lines(*str,result,delimiter=***TAB)** *split a string into lines using delimiters*
str_split_lines_words(*str,result,delimiter=***TAB)** *split a string into lines and words*
str_split_words(*str,result, delimiter=***'')** *split a string into words*
str_strip_quotes(*str***):str** *strip single or double quotes from a string*
str_to_enum(*str***):num** *convert a string back to the enum, U if not found*
str_to_num(*str***):num** *convert a string into a number,* **ERR** *if incorrectly formatted*
str_to_tree(*json, tree***)** *convert a string into a tree*
str_trim*(str)* **:str** *trim a string on both left and right sides*

enum_to_str(*num***):str** *convert an enum into string form*
json_to_tree(*json, tree***)** *convert a JSON string into a tree*
meas_to_str(*meas, styles...***):str** *convert a units of measurement into string form*
tree_to_json(*tree, limit=INFINITY***):str** *convert a tree into a JSON-compatible string, with an optional term limit*
tree_to_str(*tree, limit=INFINITY***):str** *convert a tree into a string*

Constants

`T`	*True, on*
`F`	*False, off*
`U`	*undefined*
`ERR`	*error*
`INFINITY`	*positive infinity*
`-INFINITY`	*negative infinity*
`PI`	*π*
`TAU`	*2 π*
`E`	*euler's constant 2.718...*
`GOLDEN_RATIO`	*golden ratio 1.618...*
`BEEP : sound`	*system beep*
`META : tree`	*for introspection*

System Variables

`runtime : a_runtime`

System Records

`meas`	*mag, unit*
`a_date`	*date_year, date_month, date_day, date_hour, date_minute, date_second*
`a_event`	*evkind, when, x, y, z, global_x, global_y, keycode, unicode, is_shift, is_ctrl, is_alt, is_cmd*
`a_xy`	*x, y*
`a_xyz`	*x, y, z*
`a_rect`	*left, top, width, height*
`a_runtime`	*args, app_version, air_version, os_version, os_language, os_kind, cpu_kind, full_screen, window_horz, window_vert, screen_horz, screen_vert, screen_dpi, touch_kind, hardware_id, notch_height, notch_width, major_stepx, major_steps, micro_steps*

Math functions

`abs(`*n*`):num`
`distance(`*a_xy, a_xy*`):num`
`distance_xyz(`*a_xyz, a_xyz*`):num`
`exp(`*n*`):num`
`exp_minus_1(`*n*`):num`
`epsilon(`*n*`=1.0):num`
`fract(`*n*`):num`
`idiv(`*input, divisor,* `one=F):num`
`lg(`*n*`, base=E):num`
`min(`*a, b, ...*`):num`
`max(`*a, b, ...*`):num`
`mod(`*input, divisor,* `one=F, neg=F):num`
`next_float(`*n*`):num`
`power(`*base, exponent*`):num`
`prev_float(`*n*`):num`
`sign(`*n*`):num`
`sqrt(`*n*`):num`
`uzero(`*n*`):num`

Trigonometry functions

`arc_cos(`*n*`):Angle`
`arc_sin(`*n*`):Angle`
`arc_tan(`*n*`):Angle`
`arc_tan2(`*y, x*`):Angle`
`cos(`*angle*`):num`
`hypot(`*a, b*`):num`
`sin(`*meas*`):num`
`tan(`*meas*`):num`

Machine functions

`machine_spawn(`*name*`)`
`machine_pause(`*name*`)`
`machine_resume(`*name*`)`

Misc. functions

`halt(`*errcode*`=0)`
`type_of_val(`*val*`):num`
`type_of_ptr(`*path*`):num`

Tree functions

`tree_count(`*tree*`):num`
`tree_hi(`*tree*`):num`
`tree_lo(`*tree*`):num`
`tree_next_hi(`*tree*`):num`
`tree_next_lo(`*tree*`):num`
`tree_sibling_hi(`*ptr*`):ptr`
`tree_sibling_lo(`*ptr*`):ptr`
`tree_index(`*ptr, keys...*`):ptr`
`tree_deep_index(`*ptr, keys*`):tree`

Coordinate functions

`local_to_global(`*x,y*`):a_xy`
`global_to_local(`*x,y*`):a_xy`
`measure_table_column(`*kind,col*`):num`

Rounding functions

`round(`*n*`, multiple=1):num`
`round_up(`*n*`, multiple=1):num`
`round_down(`*n*`, multiple=1):num`
`round_zero(`*n*`, multiple=1):num`

Bool functions

`is_enum(`*n*`):bool`
`is_err_u(`*n*`):bool`
`is_err_enum(`*n*`):bool`
`is_even(`*n*`):bool`
`is_field_in_record(`*field, rec*`):bool`
`is_finite(`*n*`):bool`
`is_infinite(`*n*`):bool`
`is_landscape(`*a_rect*`):bool`
`is_numeric(`*n*`):bool`
`is_odd(`*n*`):bool`
`is_portrait(`*a_rect*`):bool`

Sound functions

`sound_pause()`
`sound_play(`*sound, loop, notify...*`)`
`sound_play_file(`*path*`)`
`sound_resume()`

File operations

`file_exists(`*path*`):bool`
`file_read_bytes(`*path*`):bytes`
`file_read_str(`*path*`):str`
`file_read_tree(`*path*`):tree`
`file_write_tree(`*path,tree*`):bool`
`launch_file(`*file*`)`
`launch_url(`*url*`)`
`path_extract_folder(`*pathstr*`):str`
`path_extract_file(`*pathstr*`):str`
`pick_dir(`*title, callback*`)`
`pick_file_open(`*title, callback, ...*`)`
`pick_file_save(`*title, callback*`)`

Time functions

`elapsed():num`
`now():num`
`seconds_to_date(`*sec,* `city=U)`
`date_to_seconds(`*a_date*`):num`
`days_in_month(`*yy,mm*`):num`
`day_of_week(`*date,* `...):num`
`day_of_year(`*yy,mm,dd*`):num`

Random functions

`random():num`
`random_color():color`
`random_range(`*start, stop*`):num`
`random_range_int(`*start, stop*`):num`
`random_parm(...items):any`
`random_word4():str`

Color functions

`rgb(`*r,g,b,a*`):color`
`rgb1(`*r,g,b,a*`):color`
`hsv(`*h,s,v*`):color`
`hsv_to_color(`*hsv*`):color`
`color_to_hsv(`*color*`):hsv`
`color_r(`*color*`):num ..g ..b`

Unit families and their units

Angle — *angle*
- deg
- gradian
- radian
- rev

Area — *len^2*
- acre
- hectare
- sq_cm
- sq_ft
- sq_in
- sq_mi
- sq_yd

Energy — *$len^2 \cdot mass / time^2$*
- BTU
- calorie
- ev
- gigajoule
- hp_hour
- joule
- kw_hr
- therm

Force — *$len \cdot mass / time^2$*
- lbf
- newton

Frequency — *1/time*
- hz
- rpm

Length — *len*
- angstrom
- cm
- dm
- foot
- inch
- km
- m
- mile
- mm
- nautmile
- nm
- um
- yard

Mass — *mass*
- grain
- gram
- kg
- ounce
- pound
- slug
- ton
- tonne
- troy_ounce
- troy_pound

Power — *$len^2 \cdot mass / time^3$*
- gigawatt
- hp
- kilowatt
- megawatt
- milliwatt
- watt

Pressure — *$mass / len \cdot time^2$*
- bar
- pascal
- psi
- torr

Scalar
- dozen
- each
- gross

Speed — *len / time*
- ft_per_min
- ft_per_sec
- km_per_hr
- m_per_min
- m_per_sec
- mi_per_hr

Temperature — *temp*
- deg_c
- deg_f
- deg_k

Time — *time*
- day
- hour
- microsec
- millisec
- minute
- month
- nanosec
- picosec
- sec
- week
- year

Volume — *len^3*
- cu_ft
- cu_yd
- cup
- gal
- l
- ml
- oz
- pint
- quart
- tbsp
- tsp

Literals

Use single braces to create a tree literal:

```
var t : tree = { name:"fred", age:12 }
```

Use single brackets to create an array literal, semicolons indicate go to next level:

```
var two_by_two = [ 2, 3; 4 6]
```

Use the [<...>] notation to create a literal that is an array of records; the first row is the names of the fields:

```
var people : []people <=== [<
    name, age
    "fred", 22
    "sarah", 44 >]
```

Use # to prefix a color literal:

`#aabbcca` *-- a hex color constant*

Implied variables

In draw blocks the implied variable `b:a_block` *is defined:*

```
record a_block
    box      : a_rect  // local bounds of the drawing area
    matrix   : tree    // current transform matrix in effect
    blabel   : str     // block label if any
    dest     : num     // FOR_PRINT, FOR_SCREEN, etc.

    // fields that are set inside a table
    row_kind : num  // TRACK, the kind of row we tapped on
    row_box  : a_rect // box for the whole row
    row_id   : num  // the unique id of the row
    col_id   : num  // the unique id of the column

    // fields that are set inside a grid and table
    cell     : a_point  // cell col and row (as .x, .y)
    cell_id  : a_point  // id of the cell
    ncols    : num  // number of columns in the grid
    nrows    : num  // number of rows in the grid or table
```

Regular expression definitions

regexp *name (ignore_case | global | multiline | starts | ends) (parm1:str parm2:str ...)*
...regular terms...