SetlX-Quickreference

`asdf`	Element-Placeholder	`asdf`	exemplary Implementation
…	continual Element-List		
`asdf`	optional Element		

variables	`a;`	→ Names have to start with any letter and after that can contain any letters, numbers and _ → They are not statically typed
assignment	`a := b;`	→ if the number contains `.` it will be automatically recognized as a real number
strings	`"asdf"`	→ can be concatenated via + → the modifiers for lists (see below) are also useable for them
literal strings	`'asdf'`	→ turns of all processing, e.g. `'\n'` will be saved as \n in characters, rather than getting processed into a newline-character
undefined Ω	`om`	
placeholder	`_`	→ use it if you have to provide a variable for a call because of its syntax but actually don't need this variable

comments	`// asdf`
	`/* multiple-line`
	`   asdf */`	

		[
output	`print(asdf, asdf, …);`	→ you can insert expressions between two $, which will be evaluated when printing the output-string → print("The answer is $6*7$!");
input	`a := read("asdf");`	→ Prints the argument into the prompt and returns the user-input

rational numbers:

→ they work without overflows and in theory indefinitely accurate because they are stored as fractions
→ `1/3 + 1/2` would return `5/6`

different types of functions:

procedure	`asdf := procedure(v1, v2, …) {`
	`   ...`
	`   return r;`
	`};`	

cached / memorized procedure	`asdf := cachedProcedure(v1, …) {`
	`   ...`
	`   return r;`
	`};`
		→ speeds up computation by saving results of the function in-memory in a lookup-table
		→ only allowed for *pure functions*
		a pure functions **always** returns the same output if it is called with the same input

closure	`asdf := closure(v1, v2, …) {`
	`   ...`
	`   r := extVar * 2;`
	`   return r;`
	`};`
		→ works like a procedure
		→ additionally you are able to access variables which are defined outside the function

lambda procedure definition	`f := x |-> def;`
	`f := x |-> 1.0/(1+x);`
	`a := f(2);` ⊡ $a = 1/3$
		→ equals to $f\colon x \to def$ which equals to $f(x) = def$. In the non-mathmatical realm they are identical to `f := procedure(x) { return def; }`
		→ useable via `f(n);`

lambda closure-definition	`f := in |=> def;` `f := [in1, in2] |=> def;`	→ equivalent to `f := closure(in) { return def; }` → equivalent to `f := closure(in1, in2) { return def; }`
default argument	`fkt(a := 2) { ... }`	→ fkt = closure / procedure / cachedProcedure
call-by-reference	`fkt(rw a) { ... }`	→ fkt = closure / procedure / cachedProcedure → passes `a` as a reference (a "link" to the original variable) which allows the function to **r**ead and **w**rite the orginal variable
call	`f(arguments)`	

control structures:

If-branching	`if (test1) {`
	`    body1;`
	`} else if (test2) {`
	`    body2;`
	`} else {`
	`    body3;`
	`}`
		→ the brackets are always necessary!

switch-branching	`switch {`
	`    case test1 : body1;`
	`    case test2 : body2;`
	`    ...`
	`    default : body3;`
	`}`
		→ only one body gets executed

while-loop	`while (test) {`
	`    body;`
	`}`	

for-loop	`for (i in m) {`
	`    body;`
	`}`
		→ iterates through the elements of the set/list like `m[i]`

abort one iteration	`continue;`	
abort the loop completely	`break;`	

predefined real *("reelle")* *functions:*

trigonometric	`sin(x)`	
	`asin(x)`	equals to $sin^{-1}(x)$
	`sinh(x)`	sinus hyperbolises
	`cos(x)`	
	`acos(x)`	equals to $cos^{-1}(x)$
	`cosh(x)`	cosine hyperbolises
	`tan(x)`	
	`atan(x)`	equals to $tan^{-1}(x)$
	`tanh(x)`	tangent hyperbolises
exponential	`exp(a)`	equals to e^a
	`x ** a`	equals to x^a
logarithmic	`log(x)`	equals to $\ln(x)$ (natural logarithmic)
	`log10(x)`	equals to $log_{10}(x)$
absolute value	`abs(x)`	equals to $\|x\|$
sign	`signum(x)`	returns `-1.0` or `0.0` or `1.0`
square root	`sqrt(x)`	
3rd-root	`cbrt(x)`	
round up	`ceil(x)`	rounds up to the next integral number
round down	`floor(x)`	rounds down to the next integral number
round to nearest	`round(x)`	also known in German as "kaufmännisches Runden"

sets:

definition by enumeration	`{start .. stop}`	→ equals to $\{x \in \mathbb{Z} \mid start \le x \wedge x \le stop\}$ → any element is only contained once and elements are ordered by their value
definition by step-enumeration	`{start, second .. stop}`	→ equals to $\{start + n * step \mid n \in \mathbb{N}_0 \wedge start + n * step \le stop\}$ with $step = second - start$

definition by iterators	`{definition : ranges}`
	
	`{n * m : n in {2..10}, m in {2..10}};`
		→ the set then contains the non-trivial Solutions for the condition which meet the ranges for their elements
		→ equals to $\{n * m \mid n \in \mathbb{N} \wedge 2 \le n \wedge n \le 10 \wedge 2 \le m \wedge m \le 10\} = \{4, 6, 8, 9, 10, 12, 14, 15, 16, 18, 20, 21, 24, 25, 27, 28, 30, 32, 35, 36, 40, 42, 45, 48, 49, 50, 54, 56, 60, 63, 64, 70, 72, 80, 81, 90, 100\}$

additionally: selection	`{definition | condition}`	→ only elements which fulfil the additional condition are added to the set
summation	`+/m`	→ returns the sum of all elements in the set M
product	`*/m`	→ returns the product of all elements in the set M
element-count	`#m`	→ returns the number of elements contained in the set
union $a \cup b$	`a + b`	
intersection $a \cap b$	`a * b`	
difference a / b	`a - b`	
power 2^a	`2 ** a`	
Cartesian product $A \times B$	`a >< b`	
powerset	`pow(m)`	→ returns the set which contains all possible subsets of `m`
is a set	`isSet(a)`	→ returns `true` or `false`
is a subset $a \subseteq b$	`a <= b`	
is an element $a \in M$	`a in m`	
get the element with the highest value	`max(m)`	
get the element with the lowest value	`min(m)`	
take an element from the start / the end of the list	`fromE(m)` `fromB(m)`	→ Removes the element from the set!
take a (not pre-defined) element	`from(m)`	→ Returns a kind of random element from the set: At first, you don't know which one it will be. But if you run the program again, the order of the returned elements is exactly the same. → Removes the element from the set!
get a (not pre-defined) element	`arb(m)`	→ works like `from`, but doesn't remove the element from the set

get a (pseudo-) random element	`rnd(m)`
	`rnd(5)`
	`random()`
		→ bad for debugging
		→ computes a random non-negative number less or equal then 5, via the implicated call `rnd([1..5])`
		→ computes a random non-negative number froim the range `[0, 1]`

concatenate as a string	`join(l, s)` `join([1,2,3, "*")` ⍈ *"1*2*3"*	→ converts the elements of `l` into strings and concatenates them using the string `s` as a separator

general tuples / lists:

→ They can be defined and used just like sets. → { } in the definition then become [ ] they are definable through enumeration, Iterators and selection → e.g. a pair $\langle x,\ y\rangle$ is definable through `[x, y]` → differences to sets: elements are not ordered and can be contained multiple times and the following functions are additionally available

reverse it	`reverse(l)`	
sort it	`sort(l)`	→ sorts the elements in the list in ascending order of their values
check if a variable holds a list	`isList(a)`	→ returns `true` or `false`
element-reference	`m[i]`	→ returns the i[th] element out of the set (ordered ascending by value) `m[-1]` returns the last, `m[-2]` the pre-last element and so on → the counting of elements starts at 1!
Subset-reference	`m[a..b]`	→ returns the sub-set of `m` starting at index `a` and ending on index `b` → one of the limits can be omitted
appends `l` n-times it to itself	`l * n`	→ n needs to be a natural number or zero

relations:

definition of relations	`{[pair-Def] : Condition}` `{[n, n**2] : n in {1..10}};`	→ equals to the Function $x \to x^2$ on the set $\{n \in \mathbb{N} \mid 1 \leq n \ \wedge n \leq 10\}$ ⍰ {[1, 1], *[2, 4], [3, 9], [4, 16], [5, 25], [6, 36], [7, 49], [8, 64], [9, 81], [10, 100]}*
domain	`domain(m)`	
range	`range(m)`	

logical expressions:

<table>
<tr><td>boolean
test-operators</td><td><table><tr><td><code>==</code></td><td></td></tr><tr><td><code>!=</code></td><td></td></tr><tr><td><code><</code></td><td></td></tr><tr><td><code><=</code></td><td>also checks ⊆ at sets</td></tr><tr><td><code>></code></td><td></td></tr><tr><td><code>>=</code></td><td></td></tr><tr><td><code>in</code></td><td></td></tr><tr><td><code>notin</code></td><td></td></tr></table></td><td></td></tr>
<tr><td>test-junctures</td><td><table><tr><td><code>!</code></td><td>equals to ¬ strongest bind</td></tr><tr><td><code>&&</code></td><td>equals to ∧</td></tr><tr><td><code>||</code></td><td>equals to ⋁ weakest bind</td></tr></table></td><td></td></tr>
<tr><td>all-quantifier</td><td><code>forall(x in m | condition)</code></td><td>→ equal to $\forall x \in m : condition$</td></tr>
<tr><td>exists-quantifier</td><td><code>exists(x in m | condition)</code></td><td>→ equal to $\exists x \in m : condition$</td></tr>
<tr><td>implication</td><td><code>a => b</code></td><td></td></tr>
<tr><td>equivalence</td><td><code>a <==> b</code></td><td></td></tr>
<tr><td>antivalence</td><td><code>a <!=> b</code></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>convert strings</td><td><code>eval(expr)</code></td><td>→ the string expr has to be a string which can be parsed as a SetlX-Expression
→ the result of the evaluation of the represented expressions is them returned</td></tr>
</table>

terms:

symbolic Programs = programs/procedures which take functions (contained in strings) and manipulate them
a program which takes strings like `"x*3"` and finds the derivate of them

function symbols	`@Asdf`	→ the name has to start with @, followed by any letter. Apart from that it can contain any letters, numbers and _
	`@@@asdf`	→ used internally to define operators like +
terms	`@funcSymbol(value1, value2, ...)` `Adresse("Musterstr 1", 23456, "Musterstadt")`	→ Terms are never evaluated! They are only used to store data.
undefined	`@Nil()`	
get the function-symbol	`fct(Asdf(value))`	
get the values/ argument-list	`args(Asdf(value))`	

matching:

match-branches	`match  (Term0) {`
	`    case pattern1 : body1;`
	`    case pattern2 : body2;`
	`    ...`
	`    default : body3;`
	`}`
	
	`match (Pl(3, 5)) {`
	`   case Pl(t1, t2) : return"$t1+t2$ +";`
	`   case Mi(t1, t2) : return"$t1-t2$ -";`
	`}`
	`→ "8 via +"`
		→ Instead of a Term, a String or a List can also be matched
		→ The patterns have to contain placeholders for variables
		→ At the evaluation, SetlX tries to insert the values of `Term0` into these placeholders to create a (new) term which is equal to `Term0`.
		If this succeeds, the corresponding body gets executed (with the specified variables filled accordingly)..
		If not, the default-body gets executed.

(end of the lecture "Grundlagen und Logik")

vectors:

definition	`v1 := la_vector([1, 1/2, 1/3]);`
	`v2 := <<1 1/2 1/3>>;`
	
	`→ v1 == v2 == <<1.0 0.5 0.3333333333333>>`
	`   note: 1/3 is only printed rounded`
		→ only real valued vectors, but with any dimension, are supported
		→ all vectors are column-vectors, via concept
		→ it is possible to add a `,` between the values, altough this would archive nothing. The componets of a vector are really seperated by the whitspace between them

accessor	`v[i]`	→ gives the $i\text{-}th$ element of the vector back

addition / subtraction	`v := v1 + v2;`
	`v := v1 - v2;`
	`v += v1;`
	`v -= v2;`	

scalar *multiplication*	`v := <<1 1/2 1/3>> * (1/2);` `v *= (1/3);`	→ * is commutative
scalar product	`v := v1 * v2;`	
cross product	`v := v1 >< v2;`	→ only defined for three-dimensional products

matrices:

definition	`m1 := la_matrix( [[1,2],[3,4]] );` `m2 := << <<1 2>> <<3 4>> >>;`	→ only real valued matrices are supported
transforming vectors	`v := <<1 2 3>>;` `m1 := la_matrix(v);`	→ returns an $n \times 1$-matrix → the column-vector gets transformed into a one-row-matrix

addition / subtraction	`m := m1 + m2;`
	`m := m1 - m2;`
	`m += m1;`
	`m -= m2;`	

scalar *multiplication*	`m := << <<1 2>> <<3 4>> >> * (3);` `m *= (1/3);`	→ * is commutative
matrix multiplication	`a * b;` `a * v;`	→ possible if a is a $m \times n$-matrix and b is a $n \times k$-matrix (returns a $n \times k$-matrix) → if v is a n-dimensional vector, it automatically is interpreted as an nx1-matrix and the result will be converted to an m-dimensional vector
exponentiation	`a ** 2;`	→ only possible for square matrices
inverse	`a ** -1;`	→ only possible for non-singular matrices
transposing	`a!;`	
Dimension m	`#a;`	
Dimension n	`#a[1];`	
Determinant	`la_det(a);`	→ the result might be a small non-zero value, even if the matrix is really singular (due to rounding errors)

manual error-handling:

handling exceptions	`try {`
	`    ...   // normal statements`
	`} catch (e) {`
	`    ...   // error-handling`
	`}`
		→ also possible: `catchUsr` and `catchLng`

throwing exceptions	`throw("message");`	→ it is strongly advised to then use `catchUsr(e)` to handle the exception risen by `throw`, to avoid masking of exceptions thrown by the interpreter

debugging:

tracing	`trace(true);`
	`...`
	`trace(false);`
		→ all assignments written in this area, will be "documented" in the console-output

watch variables	`stop("message");`	→ stops the execution, prints the provided message, and waits until you press Enter without an input → if you enter `All`, the value of all available variables in the current scope will be printed
test assertions	`assert(condition, "message");`	→ if the condition evaluates to true, nothing happens → otherwise, the execution gets terminated and the provided message is printed