

# SetlX-Quickreference

**asdf** Element-Placeholder      asdf    exemplary Implementation  
 ...                                  continual Element-List  
**asdf**                               optional Element

variables	<b>a</b> ;	→ Name has to start with a lowercase letter. Apart from that it can contain any letters, numbers and _ → They can't get statically typed
assignment	<b>a</b> := <b>b</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 off 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( <b>asdf</b> , <b>asdf</b> , ...);	→ you can insert expressions like \$3+2\$ which will be evaluated when printing the output-string
input	<b>a</b> := 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	<b>asdf</b> := procedure( <b>v1</b> , <b>v2</b> , ...) { ... return <b>r</b> ; };	
cached / memorized procedure	<b>asdf</b> := cachedProcedure( <b>v1</b> , ...) { ... return <b>r</b> ; };	→ speeds up computation by saving results of the function in-memory in a lookup-table → only allowed for <i>pure functions</i> a pure functions <b>always</b> returns the same output if it is called with the same input
closure	<b>asdf</b> := closure( <b>v1</b> , <b>v2</b> , ...) { ... <b>r</b> := extVar * 2; return <b>r</b> ; };	→ works like a procedure → additionally you are able to access variables which are defined outside the function
lambda procedure definition	<b>f</b> := <b>x</b>  -> <b>definition</b> ; <b>f</b> := <b>x</b>  -> 1.0/(1+x); <b>a</b> := <b>f</b> (2); <b>a</b> = 1/3	→ equals to $f: x \rightarrow definition$ which equals to $f(x) = definition$ → useable via <b>f(n)</b> ;
lambda closure- definition	<b>f</b> := <b>in</b>  => <b>expression</b> ; <b>f</b> := [ <b>in1</b> , <b>in2</b> ]  => <b>expression</b> ;	→ equivalent to <b>f</b> := closure( <b>in</b> ) { return <b>expression</b> ; } → equivalent to <b>f</b> := closure( <b>in1</b> , <b>in2</b> ) { return <b>expression</b> ; }
default argument	closure( <b>a</b> := 2) { ... }	
call	<b>f</b> (arguments);	

## control structures:

If-branching	if ( <b>test1</b> ) { <b>body1</b> ; } else if ( <b>test2</b> ) { <b>body2</b> ; } else { <b>body3</b> ; }	→ the brackets are always necessary!
switch-branching	switch {	→ only one body gets executed

	<pre>         case test1 : body1;         case test2 : body2;         ...         default : body3;     } </pre>	
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while-loop	<pre> while (test) {     body; } </pre>	
for-loop	<pre> for (i in m) {     body; } </pre>	→ iterates through the elements of the set/list like <code>m[i]</code>
abort one iteration	<code>continue;</code>	
abort the loop completely	<code>break;</code>	

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

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

### sets:

definition by enumeration	<code>{start .. stop}</code>	→ equals to $\{x \in \mathbb{Z} \mid start \leq x \wedge x \leq stop\}$ → any element is only contained once and elements are ordered by their value
definition by step-enumeration	<code>{start, second .. stop}</code>	→ equals to $\{start + n * step \mid n \in \mathbb{N}_0 \wedge start + n * step \leq stop\}$ with $step = second - start$
definition by iterators	<pre> {definition : ranges} {n * m : n in {2..10}, m in {2..10}}; </pre>	→ the set then contains the non-trivial Solutions for the condition which meet the ranges for their elements → equals to $\{n * m \mid n \in \mathbb{N} \wedge 2 \leq n \wedge n \leq 10 \wedge 2 \leq m \wedge m \leq 10\} = \{4, 6, 8, 9, 10, 12, 14, 15, 16, 18, 20, 21, 24, 25, 27, 28, 30, 32, 35, 36, 40, 42, 45, 48, 49, 50, 54, 56, 60, 63, 64, 70, 72, 80, 81, 90, 100\}$
additionally: selection	<code>{definition   condition}</code>	→ only elements which fulfil the additional condition are added to the set
summation	<code>+ / m</code>	→ returns the sum of all elements in the set M

product	$\ast / m$	→ 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 $a \cap b$	$a \ast b$	
difference $a / b$	$a - b$	
power $2^a$	$2 \ast \ast a$	
Cartesian product $A \times B$	$a >< b$	
powerset	$\text{pow}(m)$	→ returns the set which contains all possible subsets of m

is a subset $a \subseteq b$	$a <= b$	
is an element $a \in M$	$a \text{ in } m$	
get the element with the highest value	$\text{max}(m)$	
get the element with the lowest value	$\text{min}(m)$	
take a (not pre-defined) element	$\text{from}(m)$	→ 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	$\text{arb}(m)$	→ works like from, but doesn't remove the element from the set
get a (pseudo-) random element	$\text{rnd}(m)$ $\text{rnd}(5)$	→ bad for debugging → computes a random natural number less or equal then 5, via the implicated call $\text{rnd}([1..5])$

### 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

reverse it	$\text{reverse}(l)$	
sort it	$\text{sort}(l)$	→ sorts the elements in the list in ascending order of their values
element-reference	$m[i]$	→ returns the $i^{\text{th}}$ 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
append it to itself	$n \ast l$	
concatenate them as a string	$\text{join}(l, s)$ $\text{join}([1, 2, 3, ""], "1*2*3")$	→ converts the elements of l into strings and concatenates them using the string s as a separator

### relations:

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

### logical expressions:

boolean test-operators	$==$	
	$!=$	

	<	
	<=	also checks $\subseteq$ at sets
	>	
	>=	
	in	
test-junctures	!	equals to $\neg$ strongest bind
	&&	equals to $\wedge$
		equals to $\vee$ weakest bind
all-quantifier	forall( <i>x</i> in <i>m</i>   <i>condition</i> )	→ equal to $\forall x \in m : condition$
exists-quantifier	exists( <i>x</i> in <i>m</i>   <i>condition</i> )	→ equal to $\exists x \in m : condition$
implication	<i>a</i> => <i>b</i>	
equivalence	<i>a</i> <==> <i>b</i>	
antivalence	<i>a</i> <!=> <i>b</i>	
convert strings	eval( <i>expr</i> )	→ the string <i>expr</i> has to be a string which can be parsed as a SetIX-Expression → the result of the evaluation of the represented expressions is them returned

### 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	A	→ the name has to start with a uppercase letter. Apart from that it can contain any letters, numbers and _
	^Asdf	→ used internally to define operators like +
	@asdf	→ used to case (lowercase) built-in functions into a function-symbol
terms	funcSymbol( <i>value1</i> , <i>value2</i> , ...) Adresse("Musterstr 1", 23456, "Musterstadt")	→ Terms are never evaluated! They are only used to store data.
undefined	Nil();	
get the function-symbol	fct(Asdf( <i>value</i> ))	
get the values/argument-list	args(Asdf( <i>value</i> ))	

### matching:

match-branches	<pre> 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 +" </pre>	→ Instead of a Term, a String or a List can also be matched → The patterns have to contain placeholders for variables → At the evaluation, SetIX 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.
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(end of the lecture "Grundlagen und Logik")

### vectors:

definition	<pre> v1 := la_vector([1, 1/2, 1/3]); v2 := &lt;&lt;1 1/2 1/3&gt;&gt;; → v1 == v2 == &lt;&lt;1.0 0.5 0.333333333333&gt;&gt; note: 1/3 is only printed rounded </pre>	→ only real valued vectors, but with any dimension, are supported → all vectors are column-vectors, via concept
accessor	v[i]	→ gives the <i>i</i> -th element of the vector back
addition / subtraction	<pre> v := v1 + v2; v := v1 - v2; v += v1; v -= v2; </pre>	
scalar multiplication	<pre> v := &lt;&lt;1 1/2 1/3&gt;&gt; * (1/2); v *= (1/3); </pre>	→ * is commutative
scalar product	v := v1 * v2;	
cross product	v := v1 >< v2;	→ only defined for three-dimensional products

### matrices:

definition	<pre>m1 := la_matrix( [[1,2],[3,4]] ); m2 := &lt;&lt; &lt;&lt;1 2&gt;&gt; &lt;&lt;3 4&gt;&gt; &gt;&gt;; → m1 == m2 == &lt;&lt; &lt;&lt;1.0 2.0&gt;&gt; &lt;&lt;3.0 4.0&gt;&gt; &gt;&gt;</pre>	→ only real valued matrices are supported
transforming vectors	<pre>v := &lt;&lt;1 2 3&gt;&gt;; m1 := la_matrix(v);</pre>	→ returns an $n \times 1$ -matrix → the column-vector gets transformed into a one-row-matrix
addition / subtraction	<pre>m := m1 + m2; m := m1 - m2; m += m1; m -= m2;</pre>	
scalar multiplication	<pre>m := &lt;&lt; &lt;&lt;1 2&gt;&gt; &lt;&lt;3 4&gt;&gt; &gt;&gt; * (3); m *= (1/3);</pre>	→ * is commutative
matrix multiplication	<pre>a * b; a * v;</pre>	→ only possible if a is a $m \times n$ -matrix and b is a $n \times k$ -matrix (returning 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	<pre>a ** 2;</pre>	→ only possible for square matrices
inverse	<pre>a ** -1;</pre>	→ only possible for non-singular matrices
transposing	<pre>a!;</pre>	
Dimension $m$	<pre>#a;</pre>	
Dimension $n$	<pre>#a[1];</pre>	
Determinant	<pre>la_det(a);</pre>	→ 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	<pre>try {     ... // normal statements } catch (e) {     ... // error-handling }</pre>	→ a → b → also possible: catchUsr and catchLng
throwing exceptions	<pre>throw(e); throw("Left boundary a has to be less than right boundary b!");</pre>	→ 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