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# *Language Syntax*

***version 3.0.5524 beta (and up)***

*Live/current version at*
*skookumscript.com/docs/v3.0/lang/syntax/*

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*Better coding through mad science.*

Combined syntactical and lexical rules for SkookumScript in modified Extended Backus-Naur Form (EBNF).
Production rules in *italics*. Terminals **`coloured and in bold`** and literal strings '`quoted`'. Optional groups: [ ]. Repeating groups of zero or more: { }. Repeating groups of n or more: { }$^{n+}$. Mandatory groups: ( ). Alternatives (exclusive or): |. Disjunction (inclusive or): V.

## Expressions:

*expression* = *literal* | *variable-primitive* | *identifier* | *invocation* | *type-primitive* | *flow-control*

## Literals:

*literal* = *boolean-literal* | *integer-literal* | *real-literal* | *string-literal* | *symbol-literal* | *list-literal* | *closure*
*boolean-literal* = '`true`' | '`false`'
*integer-literal*[1] = ['`-`'] *digits-lead* ['`r`' *big-digit* {[*number-separator*] *big-digit*}]
*real-literal*[2] = ['`-`'] *digits-lead* V ('`.`' *digits-tail*) [*real-exponent*]
*real-exponent* = '`E`' | '`e`' ['`-`'] *digits-lead*
*digits-lead*[3] = '`0`' | (*non-zero-digit* {['`_`'] *digit*})
*digits-tail* = *digit* {['`_`'] *digit*})
*string-literal* = *simple-string* {*ws* '`+`' *ws* *simple-string*}
*simple-string* = '`"`' {*character*} '`"`'
*symbol-literal* = '`'`' {*character*}$^{0\text{-}255}$ '`'`'
*list-literal*[4] = [(*list-class constructor-name invocation-args*) | *class-name*]
'`{`' *ws* [*expression* {*ws* ['`,`' *ws*] *expression*} *ws*] '`}`'
*closure*[5] = ('`^`' ['`_`' *ws*] [*expression ws*]) V (*parameters ws*) *code-block*

## Variable Primitives:

*variable-primitive* = *create-temporary* | *bind*
*create-temporary* = *define-temporary* [*ws binding*]
*define-temporary* = '`!`' *ws variable-name*
*bind*[6] = *variable-identifier ws binding*
*binding*[7] = '`:`' *ws expression*

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[1] '`r`' indicates *digits-lead* is (r)adix/base from 1 to 36 – default 10 (decimal) if omitted. Ex: **`2r`** binary & **`16r`** hex. Valid *big-digit*(s) vary by the radix used. See *math-operator* footnote on how to differentiate subtract from negative *integer-literal*.

[2] Can use just *digits-lead* if **`Real`** type can be inferred from context otherwise the *digits-tail* fractional or *real-exponent* part is needed. See *math-operator* footnote on how to differentiate subtract from negative *real-literal*.

[3] '`_`' visually separates parts of the number and ignored by the compiler.

[4] Item type determined via optional *list-class* constructor or specified class. If neither supplied, then item type inferred using desired type and if desired type not known, then types of initial items used and if no items, then **`Object`** used.

[5] Optional '`^`', *parameters* or both must be provided (unless used in *closure-tail-args* where both optional). Optional *expression* (may not be *code-block*, *closure* or *routine-identifier*) captured and used as receiver/this for *code-block* – if omitted **`this`** inferred. Optional '`_`' indicates it is durational (like coroutine) – if not present durational/immediate inferred via *code-block*. Parameter types, return type, scope, whether surrounding **`this`** or temporary/parameter variables are used and captured may all be inferred if omitted.

[6] Compiler gives warning if *bind* used in *code-block* of a *closure* since it will be binding to captured variable not original variable in surrounding context. May not be used as an argument.

[7] [Stylisticly prefer no *ws* prior to '`:`' – though not enforcing it via compiler.]

## Identifiers:

*identifier*[1] = *variable-identifier* | *reserved-identifier* | *class-name* | *object-id*
*variable-identifier*[2] = *variable-name* | ([*expression ws* '.' *ws*] *data-name*)
*variable-name*[3] = *instance-name* ['?']
*data-name*[4] = '@' | '@@' *variable-name*
*reserved-identifier* = 'nil' | 'this' | 'this_class' | 'this_code' | 'this_mind'
*object-id*[5] = [*class-name*] '@' ['?' | '#'] *symbol-literal*
*invoke-name* = *method-name* | *coroutine-name*
*method-name*[6] = *variable-name* | *constructor-name* | *destructor-name* | *class-name*
*constructor-name* = '!' [*instance-name*]
*destructor-name*[7] = '!!'
*coroutine-name* = '_' *instance-name*
*instance-name* = *lowercase* {*alphanumeric*}
*class-name* = *uppercase* {*alphanumeric*}

## Invocations:

*invocation* = *invoke-call* | *invoke-cascade* | *apply-operator* | *invoke-operator* | *index-operator* | *instantiation*
*invoke-call*[8] = ([*expression ws* '.' *ws*] *invoke-selector*) | *operator-call*
*invoke-cascade* = *expression ws* '.' *ws* '[' {*ws invoke-selector* | *operator-selector*}$^{2+}$ *ws* ']'
*apply-operator*[9] = *expression ws* '%' | '%>' *invoke-selector*
*invoke-operator*[10] = *expression bracketed-args*
*index-operator*[11] = *expression* '{' *ws expression ws* '}' [*ws binding*]
*instantiation*[12] = [*class-instance*] | *expression* '!' [*instance-name*] *invocation-args*
*invoke-selector* = [*scope*] *invoke-name invocation-args*
*scope* = *class-name* '@'
*operator-call*[13] = (*prefix-operator ws expression*) | (*expression ws operator-selector*)
*operator-selector* = *postfix-operator* | (*binary-operator ws expression*)
*prefix-operator*[14] = 'not' | '-'
*binary-operator* = *math-operator* | *compare-op* | *logical-operator* | ':='
*math-operator*[15] = '+' | '+=' | '-' | '-=' | '*' | '*=' | '/' | '/='

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[1] Scoping not necessary - instance names may not be overridden and classes and implicit identifiers effectively have global scope.

[2] Optional *expression* can be used to access data member from an object - if omitted, `this` is inferred.

[3] Optional '?' used as convention to indicate predicate variable or method of return type **`Boolean`** (**`true`** or **`false`**).

[4] '@' indicates instance data member and '@@' indicates class instance data member.

[5] If *class-name* absent, **`Actor`** inferred or desired type if known. If optional '?' present and object not found at runtime then result is **`nil`** else assertion error occurs. Optional '#' indicates no lookup - just return name identifier validated by class type.

[6] A method using *class-name* allows explicit conversion similar to *class-conversion* except that the method is always called.

[7] Destructor calls are only valid in the scope of another destructor's code block.

[8] If an *invoke-call*'s optional *expression* (the receiver) is omitted, then either '`this.`' is implicitly inferred or if no match is found for the *invoke-selector* and the desired type is known, then the class of the desired type is implicitly inferred. (For example, if a **`Real`** object is expected then '`Real.`' is inferred and **`Real`** class methods can be used for the *invoke-selector*.)

[9] If **`List`**, each item (or none if empty) sent call - coroutines called using **`%`** - **`sync`**, **`%>`** - **`race`** respectively and returns itself (the list). If non-list it executes like a normal invoke call - i.e. '**`%`**' is synonymous to '**`.`**' except that if **`nil`** the call is ignored, then the normal result or **`nil`** respectively is returned.

[10] Akin to **`expr.invoke(…)`** or **`expr._invoke(…)`** depending if *expression* immediate or durational - *and* if enough context is available the arguments are compile-time type-checked plus adding any default arguments.

[11] Gets item (or sets item if *binding* present) at specified index object. Syntactic sugar for **`at()`** or **`at_set()`**.

[12] If *class-instance* can be inferred then it may be omitted. *expression* used rather than *class-instance* provides lots of syntactic sugar: **`expr!ctor()`** is alias for **`ExprClass!ctor(expr)`** - ex: **`num!copy`** equals **`Integer!copy(num)`**; brackets are optional for *invocation-args* if it can have just the first argument; a constructor-name of **`!`** is an alias for **`!copy`** - ex: **`num!`** equals **`Integer!copy(num)`**; and if **`expr!ident`** does not match a constructor it will try **`ExprClass!copy(expr).ident`** - ex: **`str!uppercase`** equals **`String!copy(str).uppercase`**.

[13] Every operator has a named equivalent. For example **`:=`** and **`assign()`**. Operators do *not* have special order of precedence - any order other than left to right must be indicated by using code block brackets (**`[`** and **`]`**).

[14] See math-operator footnote about subtract on how to differentiate from a negation '**`-`**' prefix operator.

[15] In order to be recognized as single subtract '**`-`**' *expression* and not an *expression* followed by a second *expression* that starts with a minus sign, the minus symbol '**`-`**' must either have whitespace following it or no whitespace on either side.

*compare-op* = '=' | '~=' | '>' | '>=' | '<' | '<='
*logical-operator*[1] = 'and' | 'or' | 'xor' | 'nand' | 'nor' | 'nxor'
*postfix-operator* = '++' | '--'
*invocation-args*[2] = [*bracketed-args*] | *closure-tail-args*
*bracketed-args* = '(' *ws* [*send-args ws*] ['**;**' *ws return-args ws*] ')'
*closure-tail-args*[3] = *ws send-args ws closure* [*ws* '**;**' *ws return-args*]
*send-args* = [*argument*] {*ws* ['**,**' *ws*] [*argument*]}
*return-args* = [*return-arg*] {*ws* ['**,**' *ws*] [*return-arg*]}
*argument* = [*named-spec ws*] *expression*
*return-arg*[4] = [*named-spec ws*] *variable-identifier* | *define-temporary*
*named-spec*[5] = *variable-name ws* '**:**'

## Type Primitives:

*type-primitive* = *class-cast* | *class-conversion*
*class-cast*[6] = *expression ws* '**<>**' [*class-desc*]
*class-conversion*[7] = *expression ws* '**>>**' [*class-name*]

## Flow Control:

*flow-control* = *code-block* | *conditional* | *case* | *when* | *unless* | *nil-coalescing* | *loop* | *loop-exit* | *concurrent*
*code-block* = '**[**' *ws* [*expression* {*wsr expression*} *ws*] '**]**'
*conditional* = '**if**' {*ws expression ws code-block*}$^{1+}$ [*ws else-block*]
*case* = '**case**' *ws expression* {*ws expression ws code-block*}$^{1+}$ [*ws else-block*]
*else-block* = '**else**' *ws code-block*
*when* = *expression ws* '**when**' *ws expression*
*unless* = *expression ws* '**unless**' *ws expression*
*nil-coalescing*[8] = *expression ws* '**??**' *ws expression*
*loop*[9] = '**loop**' [*ws instance-name*] *ws code-block*
*loop-exit*[10] = '**exit**' [*ws instance-name*]
*concurrent* = *sync* | *race* | *branch* | *divert*
*sync*[11] = '**sync**' *ws code-block*
*race*[12] = '**race**' *ws code-block*
*branch*[13] = '**branch**' *ws expression*
*change*[14] = '**change**' *ws expression ws expression*

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1 Like other identifiers – whitespace is required when next to other identifier characters.

2 *bracketed-args* may be omitted if the invocation can have zero arguments

3 Routines with last send parameter as mandatory closure may omit brackets '**()**' and closure arguments may be simple *code-block* (omitting '**^**' and parameters and inferring from parameter). Default arguments indicated via comma '**,**' separators.

4 If a temporary is defined in the *return-arg*, it has scope for the entire surrounding code block.

5 Used at end of argument list and only followed by other named arguments. Use compatible **`List`** object for group argument. Named arguments evaluated in parameter index order regardless of call order since defaults may reference earlier parameters.

6 Compiler *hint* that expression evaluates to specified class – otherwise error. *class-desc* optional if desired type can be inferred. If *expression* is *variable-identifier* then parser updates type context. [Debug: runtime ensures class specified is received.]

7 Explicit conversion to specified class. *class-name* optional if desired type inferable. Ex: **`42>>String`** calls convert method **`Integer@String()`** i.e. **`42.String()`** - whereas **`"hello">>String`** generates no extra code and is equivalent to **`"hello"`**.

8 **`expr1??expr2`** is essentially equivalent to **`if expr1.nil? [expr2] else [expr1<>TypeNoneRemoved]`**.

9 The optional *instance-name* names the loop for specific reference by a *loop-exit* which is useful for nested loops.

10 A *loop-exit* is valid only in the code block scope of the loop that it references.

11 2+ durational expressions run concurrently and next *expression* executed when *all* expressions returned (result **`nil`**, return args bound in order of expression completion).

12 2+ durational expressions run concurrently and next *expression* executed when *fastest* expression returns (result **`nil`**, return args of fastest expression bound) and other expressions are *aborted*.

13 Durational expression run concurrently with surrounding context and the next *expression* executed immediately (result **`InvokedCoroutine`**). *expression* is essentially a closure with captured temporary variables to ensure temporal scope safety. Any return arguments will be bound to the captured variables.

14 Rather than inheriting the caller's updater **`Mind`** object, durational expressions in the second expression are updated by the mind object specified by the first expression.

## File Names and Bodies:

*method-filename*[1] = *method-name* '()' ['C'] '.sk'
*method-file*[2] = *ws* {*annotation wsr*} *parameters* [*ws code-block*] *ws*

*coroutine-filename* = *coroutine-name* '()' '.sk'
*coroutine-file*[3] = *ws* {*annotation wsr*} *parameter-list* [*ws code-block*] *ws*

*data-filename*[4] = '!Data' ['C'] '.sk'
*data-file* = *ws* [*data-definition* {*wsr data-definition*} *ws*]
*data-definition*[5] = {*annotation wsr*} [*class-desc wsr*] '!' *data-name*

*annotation*[6] = '&' *instance-name*

*object-id-filename*[7] = *class-name* ['-' {printable}] '.sk' '-' | '~' 'ids'
*object-id-file*[8] = {*ws symbol-literal* | *raw-object-id*} *ws*
*raw-object-id*[9] = {printable}[1-255] *end-of-line*

## Parameters:

*parameters*[10] = *parameter-list* [*ws class-desc*]
*parameter-list* = '(' *ws* [*send-params ws*] [';' ws return-params ws] ')'
*send-params* = *parameter* {*ws* [',' *ws*] *parameter*}
*return-params* = *param-specifier* {*ws* [',' *ws*] *param-specifier* }
*parameter* = *unary-param* | *group-param*
*unary-param*[11] = *param-specifier* [*ws binding*]
*param-specifier*[12] = [*class-desc wsr*] *variable-name*
*group-param* = *group-specifier*
*group-specifier*[13] = '{' *ws* [*class-desc* {*wsr class-desc*} *ws*] '}' *ws instance-name*

## Class Descriptors:

*class-desc* = *class-unary* | *class-union*
*class-unary* = *class-instance* | *meta-class*
*class-instance* = *class-name* | *list-class* | *invoke-class*
*meta-class* = '<' *class-name* '>'
*class-union*[14] = '<' *class-unary* {'|' *class-unary*}[1+] '>'
*invoke-class*[15] = ['_' | '+'] *parameters*
*list-class*[16] = List '{' *ws* [*class-desc ws*] '}'

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[1] If optional '?' is used in query/predicate method name, use '-Q' as a substitute since question mark not valid in filename.

[2] Only immediate calls are permissible in the code block. If *code-block* is absent, it is defined in C++.

[3] If *code-block* is absent, it is defined in C++.

[4] A file name appended with 'C' indicates that the file describes class members rather than instance members.

[5] *class-desc* is compiler hint for expected type of member variable. If class omitted, **Object** inferred or **Boolean** if *data-name* ends with '?'. If *data-name* ends with '?' and *class-desc* is specified it must be **Boolean**.

[6] The context / file where an *annotation* is placed limits which values are valid.

[7] Starts with the object id class name then optional source/origin tag (assuming a valid file title) – for example: Trigger-WorldEditor, Trigger-JoeDeveloper, Trigger-Extra, Trigger-Working, etc. A dash '-' in the file extension indicates an id file that is a compiler dependency and a tilde '~' in the file extension indicates that is not a compiler dependency

[8] Note: if *symbol-literal* used for id then leading whitespace, escape characters and empty symbol ('') can be used.

[9] Must have at least 1 character and may not have leading whitespace (*ws*), single quote ('') nor *end-of-line* character.

[10] Optional *class-desc* is return class – if type not specified **Object** is inferred (or **Boolean** type for predicates or **Auto_** type for closures) for nested parameters / code blocks and **InvokedCoroutine** is inferred for coroutine parameters.

[11] The optional *binding* indicates the parameter has a default argument (i.e. supplied *expression*) when argument is omitted.

[12] If optional *class-desc* is omitted **Object** is inferred or **Auto_** for closures or **Boolean** if *variable-name* ends with '?'. If *variable-name* ends with '?' and *class-desc* is specified it must be **Boolean**.

[13] **Object** inferred if no classes specified. Class of resulting list bound to *instance-name* is class union of all classes specified.

[14] Indicates that the class is any one of the classes specified and which in particular is not known at compile time.

[15] '_' indicates durational (like coroutine), '+' indicates durational/immediate and lack of either indicates immediate (like method). Class 'Closure' matches any closure interface. Identifiers and defaults used for parameterless closure arguments.

[16] List is any **List** derived class. If *class-desc* in item class descriptor is omitted, **Object** is inferred when used as a type or the item type is deduced when used with a *list-literal*. A *list-class* of any item type can be passed to a simple untyped **List** class.

## Whitespace:

*wsr*[1] = {*whitespace*}[1+]
*ws* = {*whitespace*}
*whitespace* = *whitespace-char* | *comment*
*whitespace-char* = ' ' | `formfeed` | `newline` | `carriage-return` | `horiz-tab` | `vert-tab`
*end-of-line* = `newline` | `carriage-return` | `end-of-file`
*comment* = *single-comment* | *multi-comment*
*single-comment* = '`//`' {`printable`} *end-of-line*
*multi-comment* = '`/*`' {`printable`} [*multi-comment* {`printable`}] '`*/`'

## Characters and Digits:

*character* = *escape-sequence* | `printable`
*escape-sequence*[2] = '`\`' *integer-literal* | `printable`
*alphanumeric* = *alphabetic* | *digit* | '_'
*alphabetic* = *uppercase* | *lowercase*
*lowercase* = '`a`' | … | '`z`'
*uppercase* = '`A`' | … | '`Z`'
*digits* = '`0`' | (*non-zero-digit* {*digit*})
*digit* = '`0`' | *non-zero-digit*
*non-zero-digit* = '`1`' | '`2`' | '`3`' | '`4`' | '`5`' | '`6`' | '`7`' | '`8`' | '`9`'
*big-digit* = *digit* | *alphabetic*

[1] *wsr* is an abbreviation for (w)hite (s)pace (r)equired.

[2] Special escape characters: '`n`' - newline, '`t`' - tab, '`v`' - vertical tab, '`b`' - backspace, '`r`' - carriage return, '`f`' - formfeed, and '`a`' - alert. All other characters resolve to the same character including '`\`', '`"`', and '`'`'.