

# Oat v. 1 Language Specification

CS516

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## 1 Grammar

The following grammar defines the Oat syntax. All binary operations are *left associative* with precedence levels indicated numerically. Higher precedence operators bind tighter than lower precedence ones.

$prog$	$::=$	$prog$
		$decl_1 .. decl_i$
$decl$	$::=$	global declarations
		$gdecl$
		$fdecl$
$gdecl$	$::=$	global variable declarations
		<code>global <math>id = gexp</math>;</code>
$arg$	$::=$	arg
		$t\ id$
$args$	$::=$	args
		$arg_1, .., arg_n$
$fdecl$	$::=$	function declaration
		<code>retty <math>id(args)</math> block</code>
$block$	$::=$	blocks
		$\{stmt_1 .. stmt_n\}$
$t$	$::=$	types
		<code>int</code>
		<code>bool</code>
		<code>ref</code>
$ref$	$::=$	reference types
		<code>string</code>
		$t[]$

<i>F</i>	$::=$ $  \quad (t_0, \dots, t_n) \rightarrow retty$	function types
<i>retty</i>	$::=$ $  \quad \text{void}$ $  \quad t$	return types
<i>bop</i>	$::=$ $  \quad *$ $  \quad +$ $  \quad -$ $  \quad <<$ $  \quad >>$ $  \quad >>>$ $  \quad <$ $  \quad <=$ $  \quad >$ $  \quad >=$ $  \quad ==$ $  \quad !=$ $  \quad \&$ $  \quad  $ $  \quad [\&]$ $  \quad [ ]$	(left associative) binary operations multiplication (precedence 100) addition (precedence 90) subtraction (precedence 90) shift left (precedence 80) shift right logical (precedence 80) shift right arithmetic (precedence 80) less-than (precedence 70) less-than or equal (precedence 70) greater-than (precedence 70) greater-than or equal (precedence 70) equal (precedence 60) not equal (precedence 60) logical and (precedence 50) logical or (precedence 40) bit-wise and (precedence 30) bit-wise or (precedence 20)
<i>uop</i>	$::=$ $  \quad -$ $  \quad !$ $  \quad \sim$	unary operations
<i>gexp</i>	$::=$ $  \quad \text{integer}$ $  \quad \text{string}$ $  \quad \text{ref null}$ $  \quad \text{true}$ $  \quad \text{false}$ $  \quad \text{new } t [] \{gexp_1, \dots, gexp_n\}$	global initializers 64-bit integer literals C-style strings
<i>lhs</i>	$::=$ $  \quad id$ $  \quad exp_1 [exp_2]$	lhs expressions

<i>exp</i>	$::=$   <i>id</i>   <i>integer</i>   <i>string</i>   <i>ref null</i>   <i>true</i>   <i>false</i>   <i>exp</i> <sub>1</sub> [ <i>exp</i> <sub>2</sub> ]   <i>id</i> ( <i>exp</i> <sub>1</sub> , .., <i>exp</i> <sub><i>n</i></sub> )   <i>new t []</i> { <i>exp</i> <sub>1</sub> , .., <i>exp</i> <sub><i>n</i></sub> }   <i>new int</i> [ <i>exp</i> <sub>1</sub> ]   <i>new bool</i> [ <i>exp</i> <sub>1</sub> ]   <i>exp</i> <sub>1</sub> <i>bop</i> <i>exp</i> <sub>2</sub>   <i>uop exp</i>   ( <i>exp</i> )	expressions  64-bit integer literals C-style strings   Explicitly initialized array Default-initialize int array Default-initialize bool array
<i>vdecl</i>	$::=$   <i>var id = exp</i>	local declarations
<i>vdecls</i>	$::=$   <i>vdecl</i> <sub>1</sub> , .., <i>vdecl</i> <sub><i>n</i></sub>	decl list
<i>stmt</i>	$::=$   <i>lhs = exp</i> ;   <i>vdecl</i> ;   <i>return exp</i> ;   <i>return</i> ;   <i>id</i> ( <i>exp</i> <sub>1</sub> , .., <i>exp</i> <sub><i>n</i></sub> ) ;   <i>if_stmt</i>   <i>for</i> ( <i>vdecls</i> ; <i>exp</i> <sub>opt</sub> ; <i>stmt</i> <sub>opt</sub> ) <i>block</i>   <i>while</i> ( <i>exp</i> ) <i>block</i>	statements
<i>if_stmt</i>	$::=$   <i>if</i> ( <i>exp</i> ) <i>block</i> <i>else_stmt</i>	if statements
<i>else_stmt</i>	$::=$   $\epsilon$   <i>else block</i>   <i>else if_stmt</i>	else

## 2 Typing Rules

$\boxed{\vdash bop_1, \dots, bop_i : F}$

$\frac{}{\vdash +, *, -, <, >, >>, [\&], [!]: (\text{int}, \text{int}) \rightarrow \text{int}} \text{ TYP\_INTOps}$

$\frac{}{\vdash ==, !=, <=, >= : (\text{int}, \text{int}) \rightarrow \text{bool}} \text{ TYP\_CMPOps}$

$\frac{}{\vdash \&, | : (\text{bool}, \text{bool}) \rightarrow \text{bool}} \text{ TYP\_BOOLOps}$

$\boxed{\vdash uop : F}$

$\frac{}{\vdash ! : (\text{bool}) \rightarrow \text{bool}} \text{ TYP\_LOGNOT}$

$\frac{}{\vdash \sim : (\text{int}) \rightarrow \text{int}} \text{ TYP\_BITNEG}$

$\frac{}{\vdash - : (\text{int}) \rightarrow \text{int}} \text{ TYP\_NEG}$

$\boxed{G; L \vdash exp : t}$

$\frac{x:t \in L}{G; L \vdash x : t} \text{ TYP\_LOCAL}$

$\frac{}{G; L \vdash n : \text{int}} \text{ TYP\_INT}$

$\frac{}{G; L \vdash s : \text{string}} \text{ TYP\_STRING}$

$\frac{}{G; L \vdash \text{stringnull} : \text{string}} \text{ TYP\_NULLSTR}$

$\frac{}{G; L \vdash t[] \text{ null} : t[]} \text{ TYP\_NULLARR}$

$\frac{}{G; L \vdash \text{true} : \text{bool}} \text{ TYP\_TRUE}$

$\frac{}{G; L \vdash \text{false} : \text{bool}} \text{ TYP\_FALSE}$

$\frac{G; L \vdash exp_1 : t[] \quad G; L \vdash exp_2 : \text{int}}{G; L \vdash exp_1[exp_2] : t} \text{ TYP\_INDEX}$

$\frac{f:(t_1, \dots, t_i) \rightarrow t \in G \quad G; L \vdash exp_1 : t_1 \quad \dots \quad G; L \vdash exp_i : t_i}{G; L \vdash f(exp_1, \dots, exp_i) : t} \text{ TYP\_CALL}$

$\frac{G; L \vdash exp_1 : t \quad \dots \quad G; L \vdash exp_i : t}{G; L \vdash \text{new } t[] \{exp_1, \dots, exp_i\} : t[]} \text{ TYP\_ARRLIT}$

$\frac{G; L \vdash exp_1 : \text{int}}{G; L \vdash \text{new int } [exp_1] : t[]} \text{ TYP\_ARRZEROINT}$

$\frac{G; L \vdash exp_1 : \text{int}}{G; L \vdash \text{new bool } [exp_1] : t[]} \text{ TYP\_ARRZERBOOL}$

$\frac{\vdash bop : (t_1, t_2) \rightarrow t \quad G; L \vdash exp_1 : t_1 \quad G; L \vdash exp_2 : t_2}{G; L \vdash exp_1 \text{ bop } exp_2 : t} \text{ TYP\_BOP}$

$\frac{\vdash uop : (t) \rightarrow t \quad G; L \vdash exp : t}{G; L \vdash uop \text{ exp} : t} \text{ TYP\_UOP}$

$$\boxed{G; L_1 \vdash vdecl \Rightarrow L_2}$$

$$\frac{G; L \vdash exp : t \quad x \notin L}{G; L \vdash \text{var } x = exp \Rightarrow L, x : t} \quad \text{TYP\_DECL}$$

$$\boxed{G; L_0 \vdash vdecls \Rightarrow L_i}$$

$$\frac{G; L_0 \vdash vdecl_1 \Rightarrow L_1 \quad \dots \quad G; L_{i-1} \vdash vdecl_i \Rightarrow L_i}{G; L_0 \vdash vdecl_1, \dots, vdecl_i \Rightarrow L_i} \quad \text{TYP\_VDECLS}$$

$$\boxed{G; L_1; retty \vdash stmt \Rightarrow L_2}$$

$$\frac{G; L_1 \vdash vdecl \Rightarrow L_2}{G; L_1; t \vdash vdecl; \Rightarrow L_2} \quad \text{TYP\_SDECL}$$

$$\frac{G; L \vdash lhs : t \quad G; L \vdash exp_2 : t}{G; L; t \vdash lhs = exp_2; \Rightarrow L} \quad \text{TYP\_ASSN}$$

$$\frac{f : (t_1, \dots, t_i) \rightarrow \text{void} \in G \quad G; L \vdash exp_1 : t_1 \quad \dots \quad G; L \vdash exp_i : t_i}{G; L; t \vdash f(exp_1, \dots, exp_i); \Rightarrow L} \quad \text{TYP\_SCALL}$$

$$\frac{G; L \vdash exp : \text{bool} \quad G; L; t \vdash block_1 \quad G; L; t \vdash block_2}{G; L; t \vdash \text{if}(exp) block_1 \text{ else } block_2 \Rightarrow L} \quad \text{TYP\_IF}$$

$$\frac{G; L \vdash exp : \text{bool} \quad G; L; t \vdash block}{G; L; t \vdash \text{while}(exp) block \Rightarrow L} \quad \text{TYP\_WHILE}$$

$$\frac{G; L_1 \vdash vdecls \Rightarrow L_2 \quad G; L_2 \vdash exp : \text{bool} \quad G; L_2; t \vdash stmt \Rightarrow L_3 \quad G; L_2; t \vdash block}{G; L_1; t \vdash \text{for}(vdecls; exp_{opt}; stmt_{opt}) block \Rightarrow L_1} \quad \text{TYP\_FOR}$$

$$\frac{G; L \vdash exp : t}{G; L; t \vdash \text{return } exp; \Rightarrow L} \quad \text{TYP\_RETT}$$

$$\frac{}{G; L; \text{void} \vdash \text{return}; \Rightarrow L} \quad \text{TYP\_RETVoid}$$

$$\boxed{G; L; t \vdash block}$$

$$\frac{G; L_0; t \vdash stmt_1 \dots stmt_i \Rightarrow L_i}{G; L_0; t \vdash \{stmt_1 \dots stmt_i\}} \quad \text{TYP\_BLOCK}$$

$$\boxed{G; L_0; t \vdash stmt_1 \dots stmt_i \Rightarrow L_i}$$

$$\frac{G; L_0; t \vdash stmt_1 \Rightarrow L_1 \quad \dots \quad G; L_{i-1}; t \vdash stmt_i \Rightarrow L_i}{G; L_0; t \vdash stmt_1 \dots stmt_i \Rightarrow L_i} \quad \text{TYP\_STMTS}$$

$$\boxed{G_0 \vdash decl \Rightarrow G_1}$$

$$\frac{x \notin G \quad \cdot; \cdot \vdash gexp : t}{G \vdash \text{global } x = gexp; \Rightarrow G, x : t} \quad \text{TYP\_VDECL}$$

$$\frac{f \notin G}{G \vdash t f(t_1 x_1, \dots, t_i x_i) \text{ block} \Rightarrow G, f : (t_1, \dots, t_i) \rightarrow t} \quad \text{TYP\_FDECL}$$

$$\boxed{G_0 \vdash decl_1 .. decl_i \Rightarrow G_i}$$

$$\frac{G_0 \vdash decl_1 \Rightarrow G_1 \quad \dots \quad G_{i-1} \vdash decl_i \Rightarrow G_i}{G_0 \vdash decl_1 .. decl_i \Rightarrow G_i} \quad \text{TYP\_GLOBAL\_CTXT}$$

$$\boxed{G \vdash decl}$$

$$\frac{G; x_1 : t_1, \dots, x_i : t_i; t \vdash \text{block}}{G \vdash t f(t_1 x_1, \dots, t_i x_i) \text{ block}} \quad \text{TYP\_GFUN}$$

$$\frac{\cdot; \cdot \vdash gexp : t}{G \vdash \text{global } x = gexp;} \quad \text{TYP\_GVAR}$$

$$\boxed{\vdash prog}$$

$$\frac{G_0 \vdash decl_1 .. decl_i \Rightarrow G \quad G \vdash decl_1 \quad \dots \quad G \vdash decl_i}{\vdash decl_1 .. decl_i} \quad \text{TYP\_PROG}$$