3. Java - Language Constructs I

Names and Identifiers, Variables, Assignments, Constants, Datatypes, Operations, Evaluation of Expressions, Type Conversions

Names and Identifiers

A program (that is, a class) needs a name

```
public class SudokuSolver { ...
```

- Convention for class names: use *CamelCase* → *Words are combined into one word, each starting with a capital letter*

Allowed names for “entities” in a program:

- Names begin with a *letter* or _ or *$*
- Then, sequence of *letters*, *numbers* or _ or *$*

Names - what is allowed

`_myName`	`me@home`
`TheCure`	`strictfp` ?! `49ers`
`__AN$WE4_1S_42__`	`side-swipe`
`$bling$`	`Ph.D's`

Keywords

The following words are already used by the language and cannot be used as names:

`abstract`	`continue`	`for`	`new`	`switch`
`assert`	`default`	`goto`	`package`	`synchronized`
`boolean`	`do`	`if`	`private`	`this`
`break`	`double`	`implements`	`protected`	`throw`
`byte`	`else`	`import`	`public`	`throws`
`case`	`enum`	`instanceof`	`return`	`transient`
`catch`	`extends`	`int`	`short`	`try`
`char`	`final`	`interface`	`static`	`void`
`class`	`finally`	`long`	`strictfp`	`volatile`
`const`	`float`	`native`	`super`	`while`

Variables and Constants

- Variables are *buckets* for a value
- Have a *data type* and a *name*
- The data type determines what kind of values are allowed in the variable

`int` x	`int` y	`float` f	`char` c
23	42	0.0f	'a'

Declaration in Java:

```
int x = 23, y = 42;
float f;
char c = 'a';
```

Initialization

Constants

- Keyword `final`
- The value of the variable can be set exactly once

Example

```
final int maxSize = 100;
```

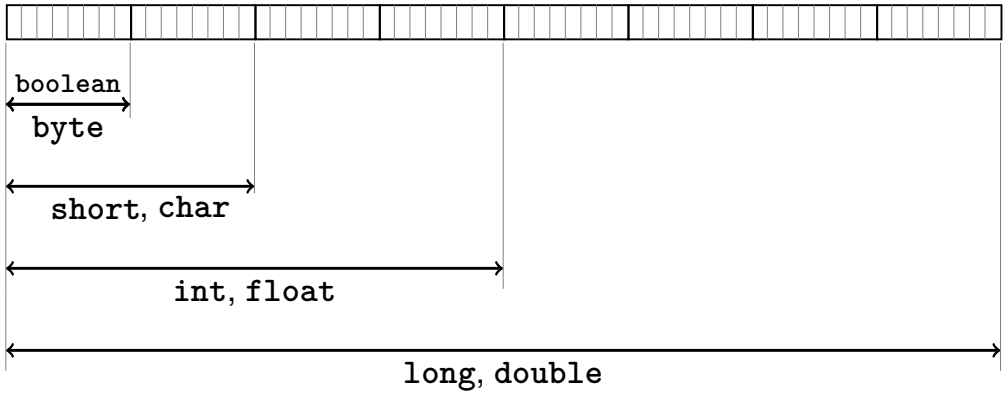
Hint: Always use `final`, unless the value actually needs to change over time.

Standard Types

Data Type	Definition	Value Range	Initial Value
`byte`	8-bit integer	$-128, \ldots, 127$	0
`short`	16-bit integer	$-32'768, \ldots, 32'767$	0
`int`	32-bit integer	$-2^{31}, \ldots, 2^{31}-1$	0
`long`	64-bit integer	$-2^{63}, \ldots, 2^{63}-1$	0L
`float`	32-bit floating point	$\pm 1.4E^{-45}, \ldots, \pm 3.4E^{+38}$	0.0f
`double`	64-bit floating point	$\pm 4.9E^{-324}, \ldots, \pm 1.7E^{+308}$	0.0d
`boolean`	logical value	`true`, `false`	`false`
`char`	unicode-16 character	'\u0000',...,'a','b',...,'\uFFFF'	'\u0000'
`String`	string	∞	`null`

Types and Memory Usage

Reminder: Memory cells contain 1 Byte $=$ 8 bit



Literals: Integer Numbers

- Type `int` (or `short`, `byte`)

`12` : value 12

`-3` : value -3

- Type `long`

`25_872_224L` : value $25'872'224$

Hint: Underscores between digits are allowed!

Literals: Floating Point Numbers

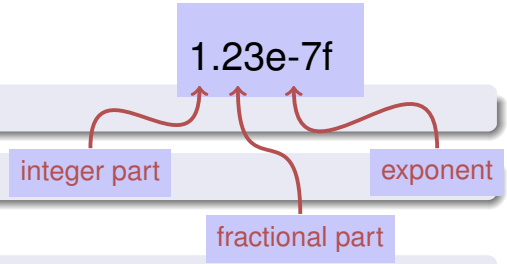
are different from integers by providing

- decimal comma

`1.0` : type `double`, value 1

`1.27f` : type `float`, value 1.27

- and / or exponent.



`1e3` : type `double`, value 1000

`1.23e-7` : type `double`, value $1.23 \cdot 10^{-7}$

`1.23e-7f` : type `float`, value $1.23 \cdot 10^{-7}$

Literals: Characters and Strings

- Individual characters:

`'a'` : Type `char`, value 97

- Strings:

`"Hello There!"` : Type `String`

`"a"` : Type `String`

Mind: Characters and Strings are two different things!

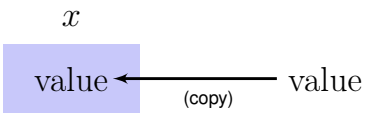
Character: In ASCII Table

0	<NUL>	32	<SPC>	64	@	96	`	128	Ä	160	†	192	¿	224	‡
1	<SOH>	33	!	65	A	97	a	129	Å	161	°	193	¡	225	·
2	<STX>	34	"	66	B	98	b	130	Ç	162	¢	194	¬	226	‚
3	<ETX>	35	#	67	C	99	c	131	É	163	£	195	√	227	„
4	<EOT>	36	$	68	D	100	d	132	Ñ	164	§	196	ƒ	228	‰
5	<ENQ>	37	%	69	E	101	e	133	Ö	165	•	197	≈	229	Â
6	<ACK>	38	&	70	F	102	f	134	Ü	166	¶	198	Δ	230	Ê
7	<BEL>	39	'	71	G	103	g	135	á	167	ß	199	«	231	Á
8	<BS>	40	(	72	H	104	h	136	à	168	®	200	»	232	Ë
9	<TAB>	41	)	73	I	105	i	137	â	169	©	201	…	233	È
10	<LF>	42	*	74	J	106	j	138	ä	170	™	202		234	Í
11	<VT>	43	+	75	K	107	k	139	ã	171	´	203	À	235	Î
12	<FF>	44	,	76	L	108	l	140	å	172	¨	204	Ã	236	Ï
13	<CR>	45	-	77	M	109	m	141	ç	173	≠	205	Õ	237	Ì
14	<SO>	46	.	78	N	110	n	142	é	174	Æ	206	Œ	238	Ó
15	<SI>	47	/	79	O	111	o	143	è	175	Ø	207	œ	239	Ô
16	<DLE>	48	0	80	P	112	p	144	ê	176	∞	208	–	240	
17	<DC1>	49	1	81	Q	113	q	145	ë	177	±	209	—	241	Ò
18	<DC2>	50	2	82	R	114	r	146	í	178	≤	210	“	242	Ú
19	<DC3>	51	3	83	S	115	s	147	ì	179	≥	211	”	243	Û
20	<DC4>	52	4	84	T	116	t	148	î	180	¥	212	‘	244	Ù
21	<NAK>	53	5	85	U	117	u	149	ï	181	µ	213	’	245	ı
22	<SYN	54	6	86	V	118	v	150	ñ	182	∂	214	÷	246	ˆ
23	<ETB>	55	7	87	W	119	w	151	ó	183	∑	215	◊	247	˜
24	<CAN>	56	8	88	X	120	x	152	ò	184	∏	216	ÿ	248	¯
25	<EM>	57	9	89	Y	121	y	153	ô	185	π	217	Ÿ	249	˘
26	<SUB>	58	:	90	Z	122	z	154	ö	186	∫	218	/	250	˙
27	<ESC>	59	;	91	[	123	{	155	õ	187	ª	219	€	251	°
28	<FS>	60	<	92	\	124	|	156	ú	188	º	220	‹	252	˛
29	<GS>	61	=	93	]	125	}	157	ù	189	Ω	221	›	253	˝
30	<RS>	62	>	94	^	126	~	158	û	190	æ	222	fi	254	¸
31	<US>	63	?	95	_	127	<DEL>	159	ü	191	ø	223	fl	255	ˇ

Value Assignment

Copies a value into variable x

- In pseudo code: $x \leftarrow \text{value}$
- In Java: x = value



"=" is the assignment operator *and not a comparison!*

Therefore, `int y = 42` is both a declaration + an assignment.

Value Assignment

Examples

```
int a = 3;
double b;

b = 3.141;

int c = a = 0;

String name = "Inf";
```

A *nested* assignment:
The expression `a = 0` stores the value `0` into variable `a`. *and then returns the value*

Arithmetic Binary Operators

Infix notation: x op y with the following operators

op: + − ∗ / %

modulo

- **Precedence**: Multiplication, division, and modulo first, then addition and subtraction
- **Associativity**: Evaluation from left to right

Arithmetic Binary Operators

- Division x / y: Integer division if x and y are integer.
- Division x / y: Floating-point division if x *or* y is a floating-poing number!

Examples

Integer division and modulo

- `5 / 3` evaluates to `1` `-5 / 3` evaluates to -1
- `5 % 3` evaluates to `2` `-5 % 3` evaluates to -2

Arithmetic Assignment

```
x = x + y
```

```
x += y
```

Examples:

```
x -= 3;       // x = x - 3
name += "x"   // name = name + "x"
num *= 2;     // num = num * 2
```

Analogous for $-$, $*$, `/`, `%`

Arithmetic Unary Operators

Prefix notation: `+` x or $-$ x

Precedence: Unary operators bind stronger than binary operators

Examples

Assuming `x` is 3

- `2 * -x` evaluates to -6
- `-x - +1` evaluates to -4

Increment/Decrement Operators

Increment operators `++x` and `x++` have the same effect:
$x \leftarrow x + 1$.But different return values:

- *Prefix operator* `++x` returns the *new* value:
  `a = ++x;` $\iff$ `x = x + 1; a = x;`
- *Postfix operator* `x++` returns the *old* value:
  `a = x++;` $\iff$ `temp = x; x = x + 1; a= temp;`

Precedence: Increment and decrement operators bind stronger than unary operators

Analogous for `x--` and `--x`.

Increment/Decrement Operators

Examples

Assuming `x` is initially set to 2

- `y = ++x * 3` evaluates to: `x` is 3 and `y` is 9
- `y = x++ * 3` evaluates to: `x` is 3 and `y` is 6

Expressions

- represent *computations*
- are either *primary*
- or *composed* . . .
- . . . from other expressions, using *operators*
- are statically typed

Analogy: Construction kit

Expressions

Examples

primary: “`-4.1d`” or “`x`” or `"Hi"`

composed: “`x + y`” or “`f * 2.1f`”

The type of “`12 * 2.1f`” is `float`

Celsius to Fahrenheit

```
public class Main {

    public static void main(String[] args) {
        Out.print("Celsius: ");
        int celsius = In.readInt();
        float fahrenheit = 9 * celsius / 5 + 32;
        Out.println("Fahrenheit: " + fahrenheit);
    }
}
```

Example: 15° Celsius are 59° Fahrenheit

Celsius to Fahrenheit - Analysis

```
9 * celsius / 5 + 32
```

- Arithmetic expression,
- contains three literals, one variable, three operator symbols

Where are the brackets in this expression?

Rule 1: Precedence

Multiplicative operators (*, /, %) have a higher precedence ("bind stronger") than additive operators (+, −).

Example

```
9 * celsius / 5 + 32
```

means

```
(9 * celsius / 5) + 32
```


Rule 2: Associativity

Arithmetic operators (*, /, %, +, −) are left-associative: in case of the same precedence, the evaluation happens from left to right.

Example

```
9 * celsius / 5 + 32
```

means

```
((9 * celsius) / 5) + 32
```


Rule 3: Arity

Unary operators +, − before binary operators +, −.

Example

```
9 * celsius / + 5 + 32
```

means

```
9 * celsius / (+5) + 32
```


Bracketing

Any expression can be bracketed unambiguously using the

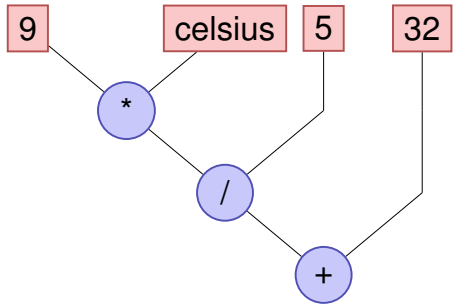
- associativities
- precedences
- arities (number of operands)

of the involved operators.

Expression Trees

Bracketing leads to an expression tree

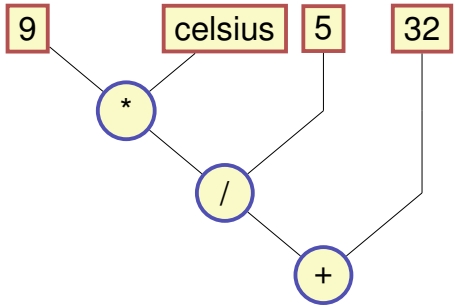
```
(((9 * celsius) / 5) + 32)
```



Evaluation Order

"From leafs to the root" in the expression tree

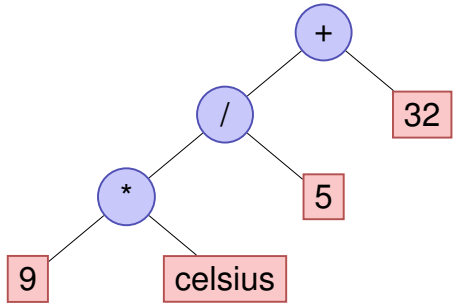
```
9 * celsius / 5 + 32
```



Expression Trees – Notation

Usual notation: root on top

```
9 * celsius / 5 + 32
```



Type System

Java festures a *static* type system:

- All types must be declared
- If possible, the compiler checks the typing ...
- ... otherwise it's checked at run-time

Advantages of a static type system

- *Fail-fast* Bugs in the program are often found already by the compiler
- Understandable code

Type errors

Example

```
int pi_ish;
float pi = 3.14f;

pi_ish = pi;
```

Compiler error:

```
./Root/Main.java:12: error: incompatible types: possible lossy conversion from float to int
        pi_ish = pi;
                 ^
```


Explicit Type Conversion

Example

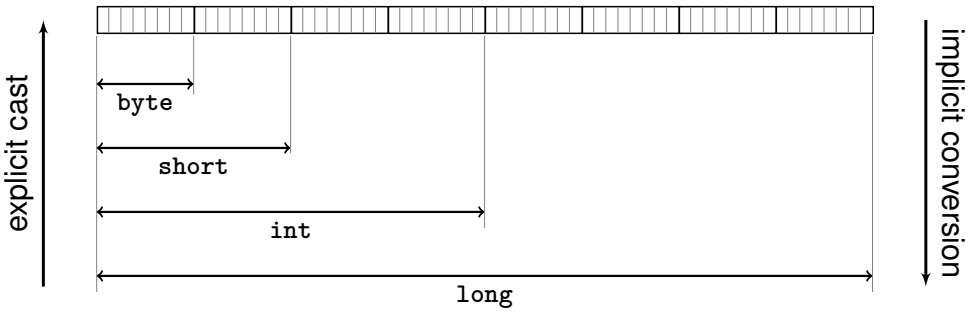
```
int pi_ish;
float pi = 3.14f;

pi_ish = (int) pi;
```

Explicit type conversion using casts (type)

- Statically type-correct, compiler is happy
- Run-time behavior: depends on the situation

  Here: loss of precision: `3.14` ⇒ `3`
- Can crash a program at run-time

Type Conversion - Visually for Integer Numbers



Potential loss of information when casting explicitly, because less memory available to represent the number

Mixed Expressions, Conversion

- Floating point numbers are more general than integers.
- In mixed expressions integers are converted to floating point numbers.

```
9 * celsius / 5  + 32
```

Type Conversions for Binary Operations

Numeric operands in a binary operation are being converted according to the following rules:

- If both operands have the same type, no conversion will happen
- If one operand is `double`, the other operand is converted to `double` as well
- If one operand is `float`, the other operand is converted to `float` as well
- If one operand is `long`, the other operand is converted to `long` as well
- Otherwise: Both operands are being converted to `int`