

Unit 1: Primitive Types

Arithmetic Operations

Adapted from:

- 1) Building Java Programs: A Back to Basics Approach
by Stuart Reges and Marty Stepp
- 2) Runestone CSAwesome Curriculum

This work is licensed under the
[Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-nc-sa/4.0/).

<https://longbaonguyen.github.io>

Expressions

- **expression:** A value or operation that computes a value.

- Examples: $1 + 4 * 5$
 $(7 + 2) * 6 / 3$
42

- The simplest expression is a *literal value*.
- A complex expression can use operators and parentheses.

Arithmetic operators

- **operator**: Combines multiple values or expressions.

+	addition
-	subtraction (or negation)
*	multiplication
/	division
%	modulus (a.k.a. remainder)

- As a program runs, its expressions are *evaluated*.
 - `1 + 1` evaluates to `2`
 - `System.out.println(3 * 4);` prints `12`
 - How would we print the text `3 * 4` ?

Integer division with /

- When we divide integers, the quotient is also an integer.

– 14 / 4 is 3, not 3.5

$$\begin{array}{r} \overline{3} \\ 4 \) \ 14 \\ \underline{12} \\ 2 \end{array}$$

$$\begin{array}{r} \overline{4} \\ 10 \) \ 45 \\ \underline{40} \\ 5 \end{array}$$

$$\begin{array}{r} \overline{52} \\ 27 \) \ 1425 \\ \underline{135} \\ 75 \\ \underline{54} \\ 21 \end{array}$$

- More examples:

– 32 / 5 is 6

– 84 / 10 is 8

– 156 / 100 is 1

– Dividing by 0 causes an error when your program runs. This error is also called an **ArithmeticException**.

Integer remainder with %

- The % operator computes the remainder from integer division.

– 14 % 4 **is 2**

– 218 % 5 **is 3**

$$\begin{array}{r} 3 \\ \hline 4 \) \ 14 \\ \underline{12} \\ \mathbf{2} \end{array}$$

$$\begin{array}{r} 43 \\ \hline 5 \) \ 218 \\ \underline{20} \\ 18 \\ \underline{15} \\ \mathbf{3} \end{array}$$

- Applications of % operator:

– Obtain last digit of a number: 230857 % 10 **is 7**

– Obtain last 4 digits: 658236489 % 10000 **is 6489**

– See whether a number is odd: 7 % 2 **is 1**, 42 % 2 **is 0**

% Example

```
public static void main(String[] args){  
    System.out.println(14 / 5 + " " -3 / 2);  
    System.out.println(45 % 6 + " " 2 % 2);  
    System.out.println(8 % 10 + " " 11 % 0);  
    System.out.println(-21 % 4); // probably not on AP  
    System.out.println(21 % -4); // probably not on AP  
}
```

Output:

2 -1

3 0

8 ArithmeticException

-1

1

Expressions

Find the exact change for 137 cents using quarters, dimes, nickels and cents. Use the least number of coins.

How many quarters? $137 / 25 = 5$ quarters (Integer Division!)

What's leftover? $137 \% 25 = 12$ cents

How many dimes? $12 / 10 = 1$ dime

What's leftover? $12 \% 10 = 2$ cents

How many nickels? $2 / 5 = 0$ nickels.

What's leftover? $2 \% 5 = 2$ cents.

How many pennies? $2 / 1 = 2$ pennies

Even or Odd

An important use of the % operator is to test for divisibility. For example, is a number even or odd? Is a number a multiple of 3?

```
// a number is even if it has no remainder
```

```
// when divided by 2.
```

```
if (number % 2 == 0) {
```

```
    ...
```

```
}
```

```
// multiple of 3
```

```
if (number % 3 == 0) {
```

```
    ...
```

```
}
```


Precedence

- **precedence:** Order in which operators are evaluated.

- Generally operators evaluate left-to-right.

1 - 2 - 3 is (1 - 2) - 3 which is -4

- But * / % have a higher level of precedence than + -

1 + 3 * 4 is 13

6 + 8 / 2 * 3
6 + 4 * 3
6 + 12

is 18

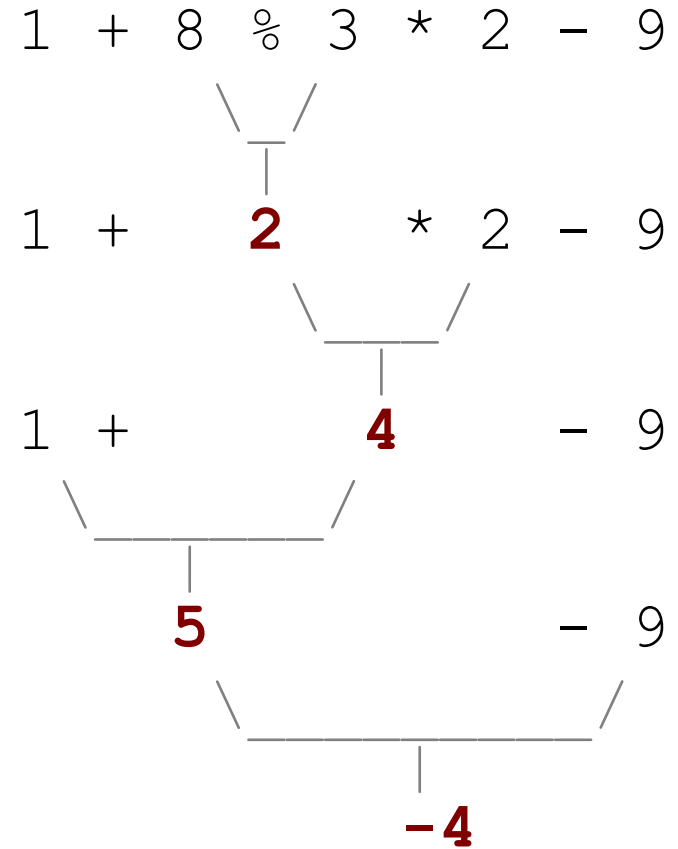
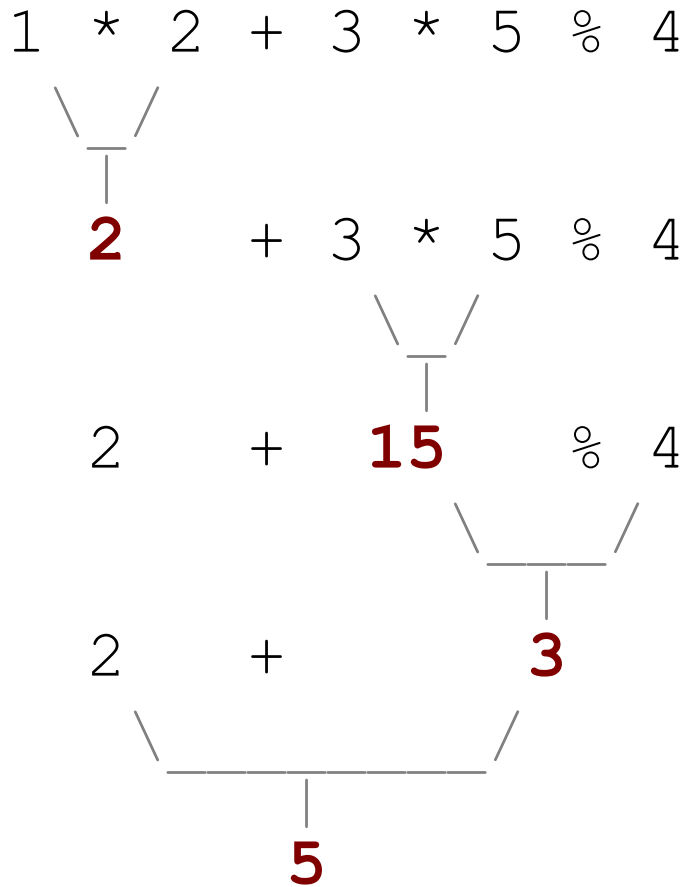
- Parentheses can force a certain order of evaluation:

(1 + 3) * 4 is 16

- Spacing does not affect order of evaluation

1+3 * 4-2 is 11

Precedence examples



Real numbers (type double)

- Examples: `6.022` , `-42.0` , `2.143`
 - Placing `.0` or `.` after an integer makes it a `double`.
- The operators `+` `-` `*` `/` `%` `()` all still work with `double`.
 - `/` produces an exact answer: `15.0 / 2.0` is `7.5`
 - Precedence is the same: `()` before `*` `/` `%` before `+` `-`

Real number example

2.0 * 2.4 + 2.25 * 4.0 / 2.0



4.8

+ 2.25 * 4.0 / 2.0



9.0

4.8

+

/ 2.0



4.5

4.8

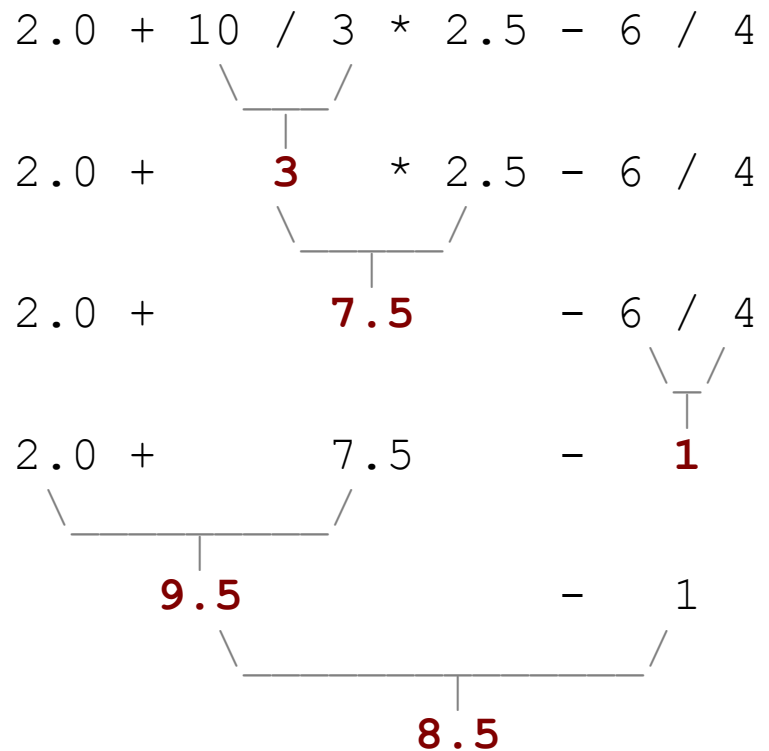
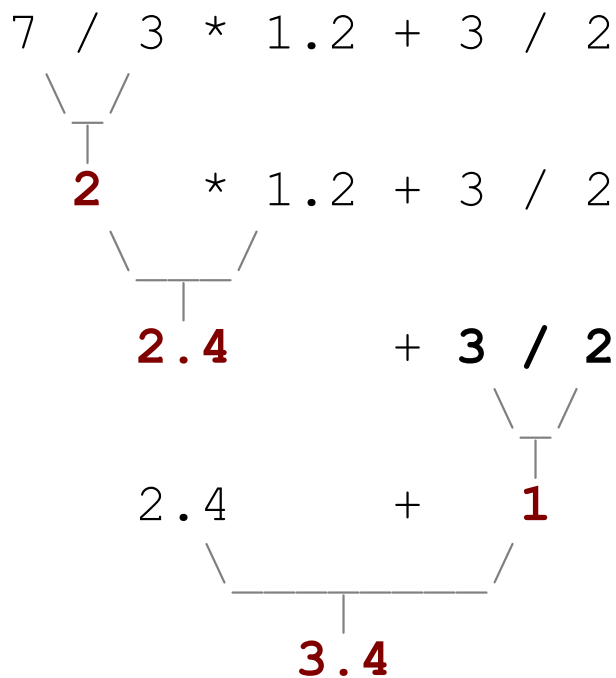
+



9.3

Mixing types

- When `int` and `double` are mixed, the result is a `double`.
 - $4.2 * 3$ is 12.6
- The conversion is per-operator, affecting only its operands.



$3 / 2$ is 1 above, not 1.5 .

Type casting

- **type cast:** A conversion from one type to another.
 - To promote an `int` into a `double` to get exact division from `/`
 - To truncate a `double` from a real number to an integer

- Syntax:

(type) expression

Examples:

```
double result = (double) 19 / 5;           // 3.8
int result2 = (int) result;                 // 3
int x = (int) Math.pow(10, 3);              // 1000
```

More about type casting

- Type casting has high precedence and only casts the item immediately next to it.

```
- double x = (double) 1 + 1 / 2;           // 1.0  
- double y = 1 + (double) 1 / 2;           // 1.5
```

- You can use parentheses to force evaluation order.
 - double average = **(double)** (a + b + c) / 3;
 - The code above cast the sum (a + b + c) into a double.
- A conversion to `double` can be achieved in other ways.
 - double average = 1.0 * (a + b + c) / 3;

Casting

```
public class Test{  
    public static void main(String[] args){  
        System.out.println(1 / 3);  
        System.out.println(1.0 / 3);  
        System.out.println(1 / 3.0);  
        System.out.println((double) 1 / 3);  
    }  
}
```

0

0.3333333333333333

0.3333333333333333

0.3333333333333333

Casting Example

```
public static void main(String[] args) {  
    double x = 4 / 3;  
    double y = (double) (125/10);  
    double z = (double) 28 / 5;  
    System.out.println(x + " " + y + " " + z);  
}
```

Output:

1.0 12.0 5.6

Round to the nearest integer

- casting can be used to round a number to its nearest integer .

```
double number = 7.0 / 3;
```

```
// round a positive number to its nearest integer
```

```
int nearestInt = (int)(number + 0.5);
```

```
double negNumber = -20.0 / 3;
```

```
// round a negative number to its nearest integer
```

```
int nearestNegInt = (int)(negNumber - 0.5);
```

What is the value of nearestInt and nearestNegInt?

Answer: 2 and -7

Increment and decrement

shortcuts to increase or decrease a variable's value by 1

Shorthand

variable++;

variable--;

```
int x = 2;
```

```
x++;
```

```
double gpa = 2.5;
```

```
gpa--;
```

Equivalent longer version

variable = **variable** + 1;

variable = **variable** - 1;

```
// x = x + 1;
```

```
// x now stores 3
```

```
// gpa = gpa - 1;
```

```
// gpa now stores 1.5
```

Modify-and-assign

shortcuts to modify a variable's value

Shorthand

variable += **value**;
variable -= **value**;
variable *= **value**;
variable /= **value**;
variable %= **value**;

Equivalent longer version

variable = **variable** + **value**;
variable = **variable** - **value**;
variable = **variable** * **value**;
variable = **variable** / **value**;
variable = **variable** % **value**;

x += 3;

gpa -= 0.5;

number *= 2;

// x = x + 3;

// gpa = gpa - 0.5;

// number = number * 2;

Code Tracing

What are the values of x, y and z after tracing through the following code?

```
int x = 0;  
int y = 5;  
int z = 1;  
x++;  
y -= 3;  
z = x + z;  
x = y * z;  
y %= 2;  
z--;
```

Answer: x = 4, y = 0, z = 1

Lab 1

- Let $\{a_1, a_2, a_3, \dots, a_n\}$ be a list of n real numbers.
- The average of the list is **ave** = $(a_1 + a_2 + \dots + a_n) / n$.
- The variance of the list =
$$[(a_1 - \text{ave})^2 + (a_2 - \text{ave})^2 + \dots + (a_n - \text{ave})^2] / n.$$
- The standard deviation of the list = the square root of the variance of the list.

HINT: Use `Math.sqrt()` for square root: `Math.sqrt(9)` is 3.0

Lab 1

For example, if the list is $\{78, 80, 77\}$.

Average = 78.33333333333333

Variance = 1.5555555555555556

Standard deviation = 1.247219128924647

Lab 1

Create a new repl on repl.it and follow the comments below to write a program that compute some statistics.

```
public class Statistics
{
    public static void main(String[] args)
    {
        // 1. Declare 3 int variables for grades and initialize them to 3 values
        // 2. Declare an int variable for the sum of the grades
        // 3. Declare a double variable for the average of the grades
        // 4. Write a formula to calculate the sum of the 3 grades
        // 5. Write a formula to calculate the average of the 3 grades from the
        //     sum using division and type casting.
        // 6. Print out the average
        // 7. Declare a double variable and calculate the variance
        // 8. Declare a double variable to compute the standard deviation.
        // 9. Print out the variance and standard deviation.
    }
}
```


Lab 2

Use the following template(or something similar) to write a program that gives exact change with the least number of coins for a given number of cents.

```
import java.util.*;

public static void main(String[] args){
    Scanner console = new Scanner(System.in);
    int totalCents = console.nextInt();
    int quarters, dimes, nickels, pennies;
    ....
    // your code here.

}
```

Suppose that the input above is 137. Then the output would be:

Output: 5 quarters, 1 dimes, 0 nickels, 2 pennies.

References

1) Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp

2) Runestone CSAwesome Curriculum:

<https://runestone.academy/runestone/books/published/csawesome/index.html>

For more tutorials/lecture notes in Java, Python, game programming, artificial intelligence with neural networks:

<https://longbaonguyen.github.io>