

# **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

# 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

$$\begin{array}{r} \phantom{4} \underline{3} \\ 4 \ ) \ 14 \\ \phantom{0} \underline{12} \\ \phantom{00} 2 \end{array}$$

$$\begin{array}{r} \phantom{10} \underline{4} \\ 10 \ ) \ 45 \\ \phantom{00} \underline{40} \\ \phantom{000} 5 \end{array}$$

$$\begin{array}{r} \phantom{27} \underline{52} \\ 27 \ ) \ 1425 \\ \phantom{00} \underline{135} \\ \phantom{000} 75 \\ \phantom{0000} \underline{54} \\ \phantom{00000} 21 \end{array}$$

- 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(45 % 6);  
    System.out.println(2 % 2);  
    System.out.println(8 % 10);  
    System.out.println(11 % 0);  
    System.out.println(-21 % 4); // probably not on AP  
    System.out.println(21 % -4); // probably not on AP  
}
```

Output:

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

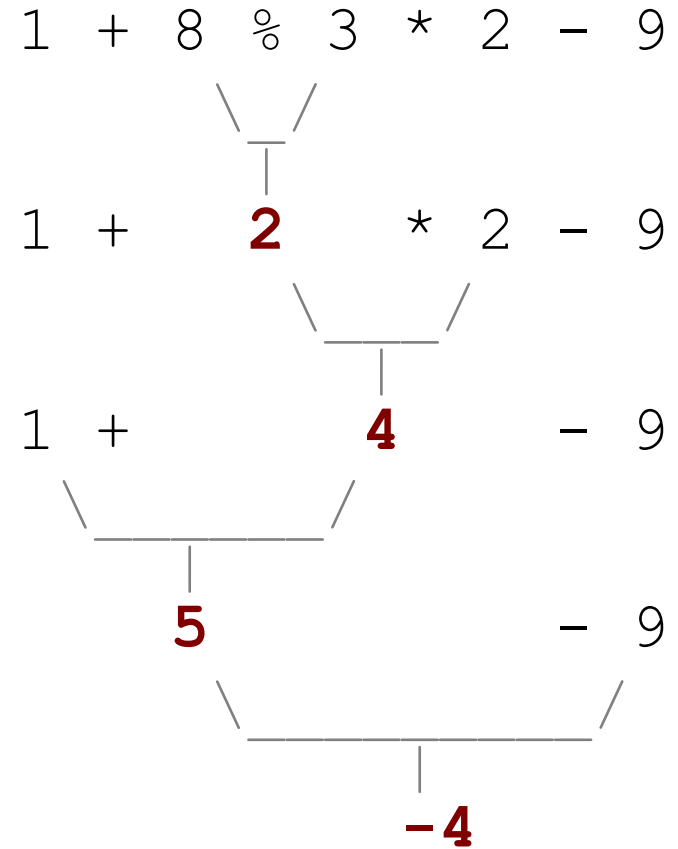
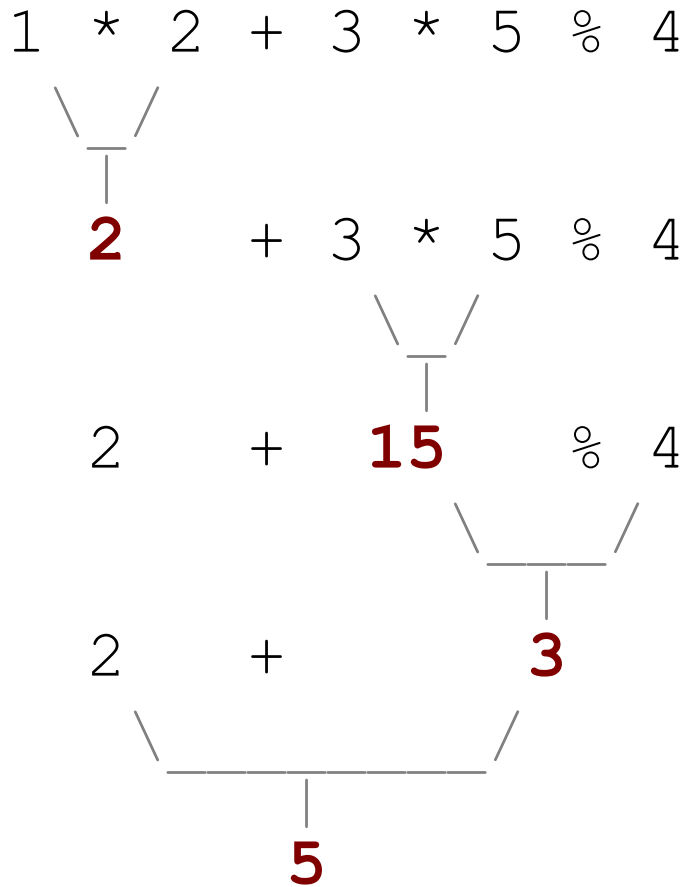
- Parentheses can force a certain order of evaluation:

(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

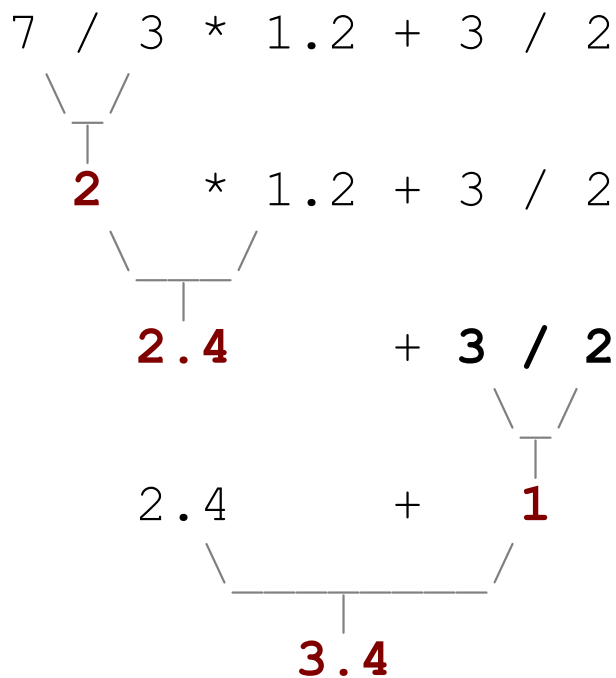
+



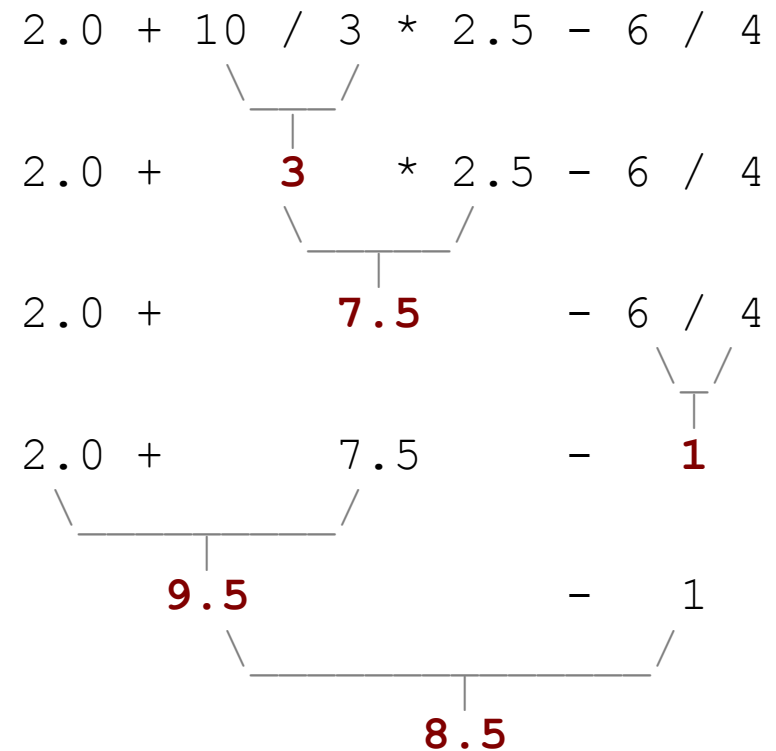
**9.3**

# 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](https://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. **Use intermediate variables to help your calculation.**

```
public static void main(String[] args){  
    int totalCents = 137; //137 can be any number  
    .....  
    // your code here.  
  
}
```

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>