Unit 1: Using Objects and Methods Arithmetic Operations

Adapted from:

1) Building Java Programs: A Back to Basics Approach

by Stuart Reges and Marty Stepp

2) Runestone CSAwesome Curriculum

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`

```
   3          4          52
4 ) 14    10 ) 45    27 ) 1425
    12         40         135
     2          5          75
                          54
                          21
```

- 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

```
    3
4 ) 14
    12
    2
```

```
   43
5 ) 218
   20
   18
   15
    3
```

- 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(0 % 10 + " " + 11 % 0);
	System.out.println(8 % 10);
}
```

Output:

2 -1

3 0

0 ArithmeticException

8

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?

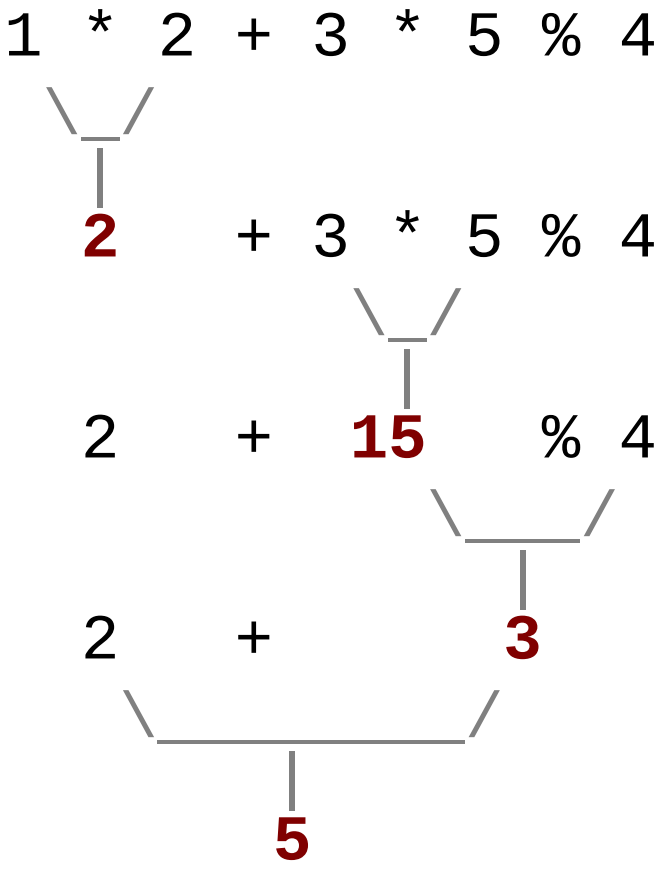
```
// a number is even if it has no remainder
// when divided by 2.
if(number % 2 == 0){
        …
}
// multiple of 3
if(number % 3 == 0){
        …
}
```

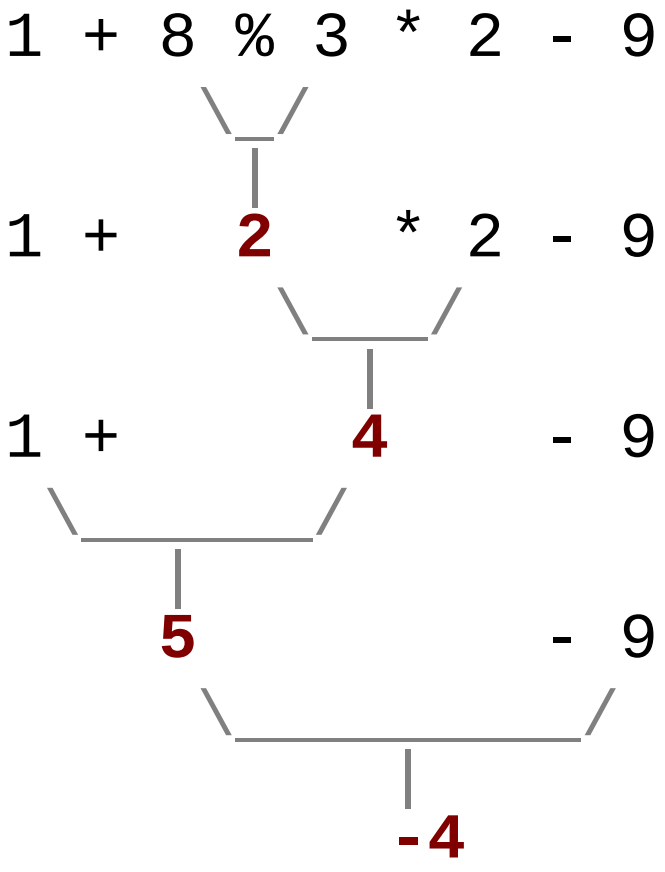
Precedence

- **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

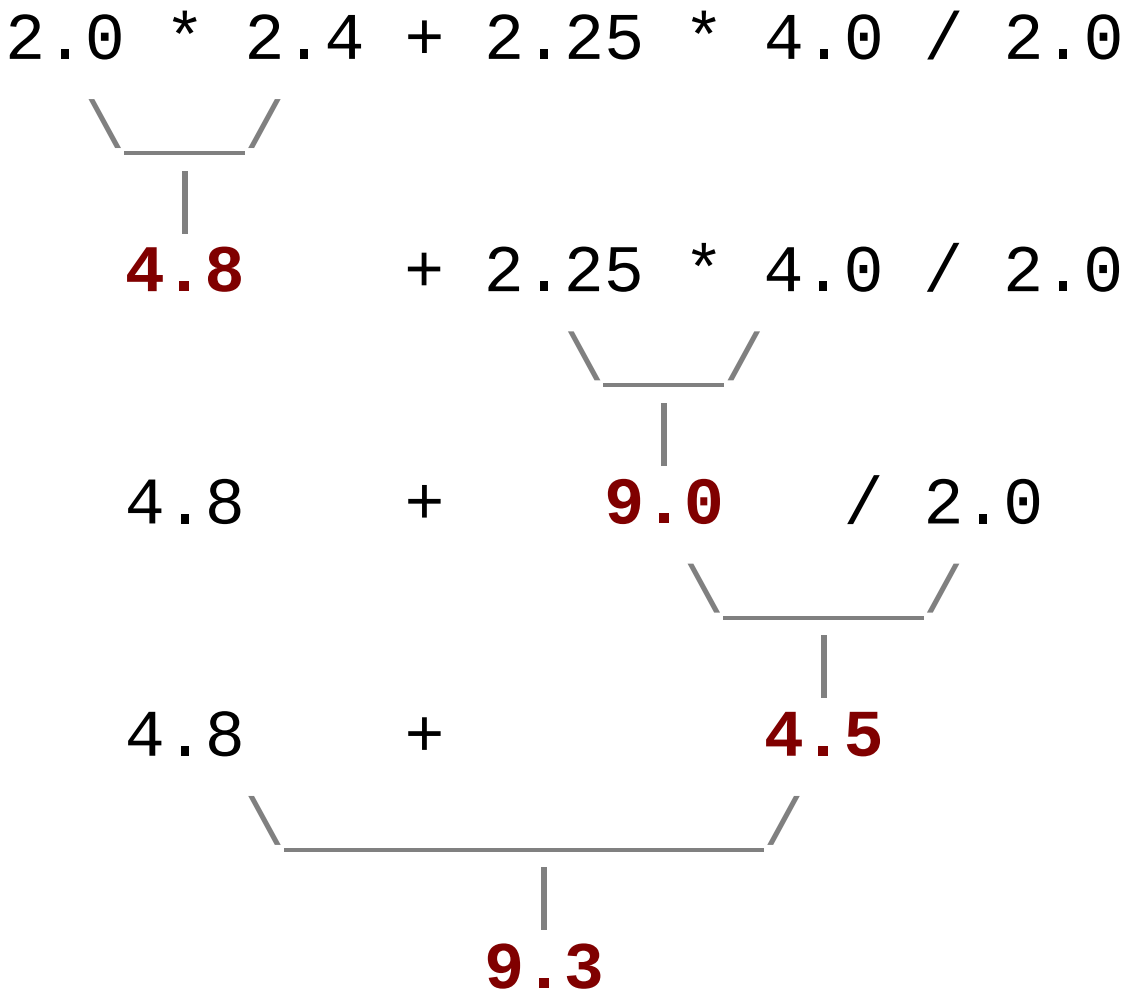




Real numbers (type `double`)

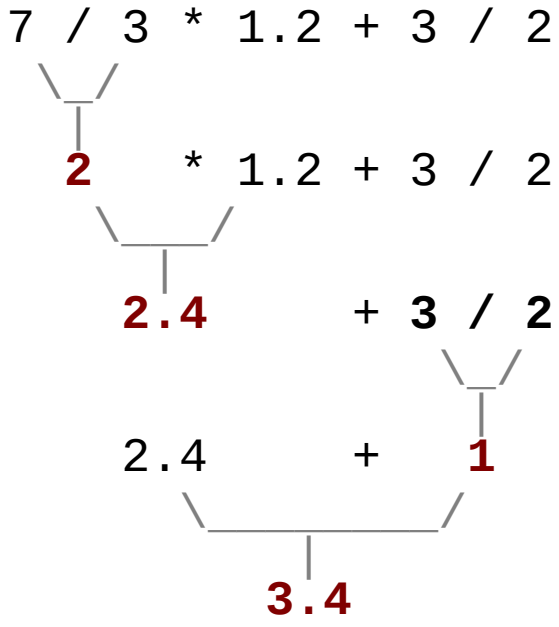
- Examples: `6.022`, `-42.0`, `2.143`
  - Placing `.0` or `.` after an integer makes it a `double`.
- The operators `+ - * / % ( )` all still work with `double`.
  - `/` produces an exact answer: `15.0 / 2.0` is `7.5`
  - Precedence is the same: `( )` before `* / %` before `+ -`

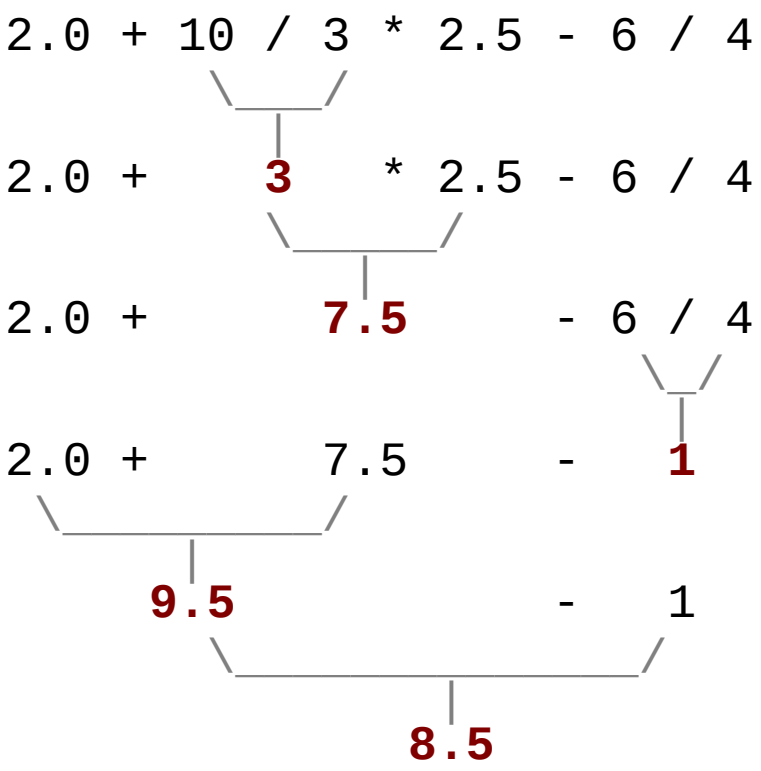
Real number example



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	Equivalent longer version
variable++;	**variable** = **variable** + 1;
variable--;	**variable** = **variable** - 1;

```
int x = 2;
x++;   // x = x + 1;
       // x now stores 3

double gpa = 2.5;
gpa--; // gpa = gpa - 1;
       // gpa now stores 1.5
```

Modify-and-assign

shortcuts to modify a variable's value

Shorthand	Equivalent longer version
`variable += value;`	`variable = variable + value;`
`variable -= value;`	`variable = variable - value;`
`variable *= value;`	`variable = variable * value;`
`variable /= value;`	`variable = variable / value;`
`variable %= value;`	`variable = variable % value;`

```
x += 3;// x = x + 3;

gpa -= 0.5;  // gpa = gpa - 0.5;

number *= 2; // 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

Mystery

Explain the values of the variables mystery1, mystery2 and mystery3.

```
public static void main(String[] args){
      Scanner console = new Scanner(System.in);
      System.out.print("Enter a 3-digit number: ");
      int num = console.nextInt();
      int mystery1 = num % 10;
      int mystery2 = num / 10 % 10;
      int mystery3 = num / 100;
}
```

Answer: mystery1 is the ones digit, mystery2 is the tens digit and mystery3 is the hundreds digit of num. For example if num is 159, mystery1 = 6, mystery2 = 5 and mystery3 = 1.

Lab 1

- Let {a1,a2,a3,…,an} be a list of n real numbers.
- The average of the list is **ave** = (a1+a2+…+an)/n.
- The variance of the list =
  $[(a1 - ave)^2 + (a2 - ave)^2 + \ldots + (an - ave)^2] / n.$
- 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

You may also use Math.pow(base, exponent). Math.pow(2, 3) is 8.0.

Lab 1

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

Sample Output: (Use Scanner for inputs)

Enter grade: 78
Enter grade: 80
Enter grade: 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 use Scanner for inputs.
   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