Building Java Programs

Chapter 1

Lecture 1-2: Static Methods

reading: 1.4 - 1.5

Comments

- **comment**: A note written in source code by the programmer to describe or clarify the code.
  - Comments are not executed when your program runs.

- Syntax:

  // **comment text, on one line**

  or,

  /* **comment text; may span multiple lines** */

- Examples:

```
// This is a one-line comment.

/* This is a very long
   multi-line comment. */
```

Using comments

- Where to place comments:
  - at the top of each file (a "comment header")
  - at the start of every method (seen later)
  - to explain complex pieces of code

- Comments are useful for:
  - Understanding larger, more complex programs.
  - Multiple programmers working together, who must understand each other's code.

Comments example

```
/* Suzy Student, CS 101, Fall 2019
   This program prints lyrics about ... something. */

public class BaWitDaBa {
    public static void main(String[] args) {
        // first verse
        System.out.println("Bawitdaba");
        System.out.println("da bang a dang diggy diggy");
        System.out.println();

        // second verse
        System.out.println("diggy said the boogy");
        System.out.println("said up jump the boogy");
    }
}
```

Static methods

reading: 1.4

self-check: 16-25

exercises: #5-10

videos: Ch. 1 #1

Algorithms

- **algorithm**: A list of steps for solving a problem.
- Example algorithm: "Bake sugar cookies"
  - Mix the dry ingredients.
  - Cream the butter and sugar.
  - Beat in the eggs.
  - Stir in the dry ingredients.
  - Set the oven temperature.
  - Set the timer.
  - Place the cookies into the oven.
  - Allow the cookies to bake.
  - Spread frosting and sprinkles onto the cookies.
  - ...

Problems with algorithms

- *lack of structure*: Many tiny steps; tough to remember.
- *redundancy*: Consider making a double batch...
  - Mix the dry ingredients.
  - Cream the butter and sugar.
  - Beat in the eggs.
  - Stir in the dry ingredients.
  - Set the oven temperature.
  - Set the timer.
  - Place the first batch of cookies into the oven.
  - Allow the cookies to bake.
  - Set the timer.
  - Place the second batch of cookies into the oven.
  - Allow the cookies to bake.
  - Mix ingredients for frosting.
  - ...

Structured algorithms

- **structured algorithm**: Split into coherent tasks.

  1 Make the cookie batter.
  - Mix the dry ingredients.
  - Cream the butter and sugar.
  - Beat in the eggs.
  - Stir in the dry ingredients.

  2 Bake the cookies.
  - Set the oven temperature.
  - Set the timer.
  - Place the cookies into the oven.
  - Allow the cookies to bake.

  3 Add frosting and sprinkles.
  - Mix the ingredients for the frosting.
  - Spread frosting and sprinkles onto the cookies.

  ...

Removing redundancy

- A well-structured algorithm can describe repeated tasks with less redundancy.

  1 Make the cookie batter.
  - Mix the dry ingredients.
  - ...

  2a Bake the cookies (first batch).
  - Set the oven temperature.
  - Set the timer.
  - ...

  2b Bake the cookies (second batch).

  3 Decorate the cookies.
  - ...

A program with redundancy

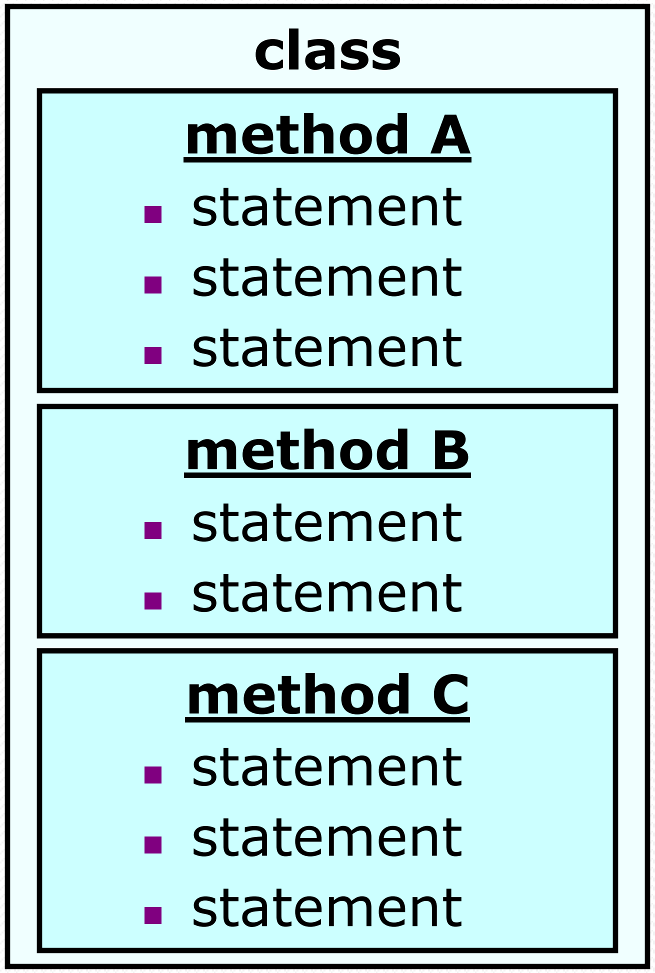
```
public class BakeCookies {
    public static void main(String[] args) {
        System.out.println("Mix the dry ingredients.");
        System.out.println("Cream the butter and sugar.");
        System.out.println("Beat in the eggs.");
        System.out.println("Stir in the dry ingredients.");
        System.out.println("Set the oven temperature.");
        System.out.println("Set the timer.");
        System.out.println("Place a batch of cookies into the oven.");
        System.out.println("Allow the cookies to bake.");
        System.out.println("Set the oven temperature.");
        System.out.println("Set the timer.");
        System.out.println("Place a batch of cookies into the oven.");
        System.out.println("Allow the cookies to bake.");
        System.out.println("Mix ingredients for frosting.");
        System.out.println("Spread frosting and sprinkles.");
    }
}
```

Static methods

- **static method**: A named group of statements.
  - denotes the *structure* of a program
  - eliminates *redundancy* by code reuse

  - **procedural decomposition**: dividing a problem into methods

- Writing a static method is like adding a new command to Java.



Using static methods

1. Design the algorithm.
   - Look at the structure, and which commands are repeated.
   - Decide what are the important overall tasks.

2. **Declare** (write down) the methods.
   - Arrange statements into groups and give each group a name.

3. **Call** (run) the methods.
   - The program's `main` method executes the other methods to perform the overall task.

Design of an algorithm

```
// This program displays a delicious recipe for baking cookies.
public class BakeCookies2 {
    public static void main(String[] args) {
        // Step 1: Make the cake batter.
        System.out.println("Mix the dry ingredients.");
        System.out.println("Cream the butter and sugar.");
        System.out.println("Beat in the eggs.");
        System.out.println("Stir in the dry ingredients.");

        // Step 2a: Bake cookies (first batch).
        System.out.println("Set the oven temperature.");
        System.out.println("Set the timer.");
        System.out.println("Place a batch of cookies into the oven.");
        System.out.println("Allow the cookies to bake.");

        // Step 2b: Bake cookies (second batch).
        System.out.println("Set the oven temperature.");
        System.out.println("Set the timer.");
        System.out.println("Place a batch of cookies into the oven.");
        System.out.println("Allow the cookies to bake.");

        // Step 3: Decorate the cookies.
        System.out.println("Mix ingredients for frosting.");
        System.out.println("Spread frosting and sprinkles.");
    }
}
```

Declaring a method

Gives your method a name so it can be executed

- Syntax:

```
public static void name() {
    statement;
    statement;
    ...
    statement;
}
```

- Example:

```
public static void printWarning() {
    System.out.println("This product causes cancer");
    System.out.println("in lab rats and humans.");
}
```

Calling a method

Executes the method's code

- Syntax:

  ```
  name();
  ```

  - You can call the same method many times if you like.

- Example:

  ```
  printWarning();
  ```

  - Output:

  ```
  This product causes cancer
  in lab rats and humans.
  ```

Program with static method

```
public class FreshPrince {
    public static void main(String[] args) {
        rap();                      // Calling (running) the rap method
        System.out.println();
        rap();                      // Calling the rap method again
    }

    // This method prints the lyrics to my favorite song.
    public static void rap() {
        System.out.println("Now this is the story all about how");
        System.out.println("My life got flipped turned upside-down");
    }
}
```

Output:

```
Now this is the story all about how
My life got flipped turned upside-down

Now this is the story all about how
My life got flipped turned upside-down
```

Final cookie program

```
// This program displays a delicious recipe for baking cookies.
public class BakeCookies3 {
    public static void main(String[] args) {
        makeBatter();
        bake();           // 1st batch
        bake();           // 2nd batch
        decorate();
    }

    // Step 1: Make the cake batter.
    public static void makeBatter() {
        System.out.println("Mix the dry ingredients.");
        System.out.println("Cream the butter and sugar.");
        System.out.println("Beat in the eggs.");
        System.out.println("Stir in the dry ingredients.");
    }

    // Step 2: Bake a batch of cookies.
    public static void bake() {
        System.out.println("Set the oven temperature.");
        System.out.println("Set the timer.");
        System.out.println("Place a batch of cookies into the oven.");
        System.out.println("Allow the cookies to bake.");
    }

    // Step 3: Decorate the cookies.
    public static void decorate() {
        System.out.println("Mix ingredients for frosting.");
        System.out.println("Spread frosting and sprinkles.");
    }
}
```

Methods calling methods

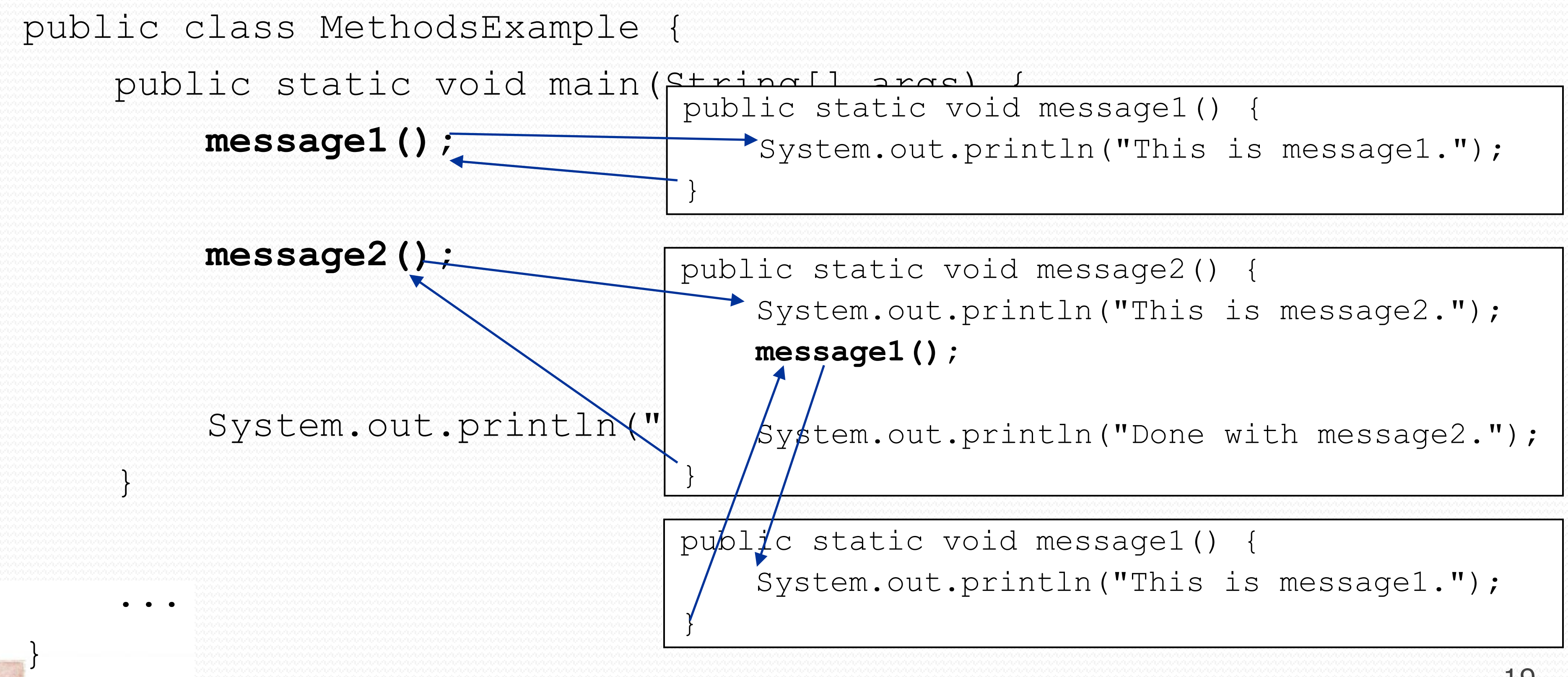
```
public class MethodsExample {
    public static void main(String[] args) {
        message1();
        message2();
        System.out.println("Done with main.");
    }

    public static void message1() {
        System.out.println("This is message1.");
    }

    public static void message2() {
        System.out.println("This is message2.");
        message1();
        System.out.println("Done with message2.");
    }
}
```

- Output:

```
This is message1.
This is message2.
This is message1.
Done with message2.
Done with main.
```

Control flow

- When a method is called, the program's execution...
  - "jumps" into that method, executing its statements, then
  - "jumps" back to the point where the method was called.



```
public class MethodsExample {
    public static void main(String[] args) {
        message1();

        message2();



        System.out.println("
    }

    ...
}
```

```
public static void message1() {
    System.out.println("This is message1.");
}
```

```
public static void message2() {
    System.out.println("This is message2.");
    message1();

    System.out.println("Done with message2.");
}
```

```
public static void message1() {
    System.out.println("This is message1.");
}
```

When to use methods

- Place statements into a static method if:
  - The statements are related structurally, and/or
  - The statements are repeated.

- You should not create static methods for:
  - An individual `println` statement.
  - Only blank lines. (Put blank `println`s in `main`.)
  - Unrelated or weakly related statements.
    (Consider splitting them into two smaller methods.)

Drawing complex figures with static methods

reading: 1.5
(Ch. 1 Case Study: `DrawFigures`)

exercises: #7-9
videos: Ch. 1 #2

Static methods question

- Write a program to print these figures using methods.

```
  ______
 /      \
/        \
\        /
 \______/

\        /
 \______/
+--------+

  ______
 /      \
/        \
|  STOP  |
\        /
 \______/

  ______
 /      \
/        \
+--------+
```

Development strategy

```
  ______
 /      \
/        \
\        /
 \______/

\        /
 \______/
+--------+

  ______
 /      \
/        \
|  STOP  |
\        /
 \______/

  ______
 /      \
/        \
+--------+
```

First version (unstructured):

- Create an empty program and `main` method.
- Copy the expected output into it, surrounding each line with `System.out.println` syntax.
- Run it to verify the output.

Program version 1

```
public class Figures1 {
    public static void main(String[] args) {
        System.out.println("  ______");
        System.out.println(" /      \\");
        System.out.println("/        \\");
        System.out.println("\\        /");
        System.out.println(" \\______/");
        System.out.println();
        System.out.println("\\        /");
        System.out.println(" \\______/");
        System.out.println("+--------+");
        System.out.println();
        System.out.println("  ______");
        System.out.println(" /      \\");
        System.out.println("/        \\");
        System.out.println("|  STOP  |");
        System.out.println("\\        /");
        System.out.println(" \\______/");
        System.out.println();
        System.out.println("  ______");
        System.out.println(" /      \\");
        System.out.println("/        \\");
        System.out.println("+--------+");
    }
}
```

Development strategy 2

```
  ______
 /      \
/        \
\        /
 \______/

\        /
 \______/
+--------+

  ______
 /      \
/        \
|  STOP  |
\        /
 \______/

  ______
 /      \
/        \
+--------+
```

Second version (structured, with redundancy):

- Identify the structure of the output.
- Divide the `main` method into static methods based on this structure.

Output structure

```
  ______
 /      \
/        \
\        /
 \______/
```

```
\        /
 \______/
+--------+
```

```
  ______
 /      \
/        \
|  STOP  |
\        /
 \______/
```

```
  ______
 /      \
/        \
+--------+
```

The structure of the output:

- initial "egg" figure
- second "teacup" figure
- third "stop sign" figure
- fourth "hat" figure

This structure can be represented by methods:

- `egg`
- `teaCup`
- `stopSign`
- `hat`

Program version 2

```
public class Figures2 {
    public static void main(String[] args) {
        egg();
        teaCup();
        stopSign();
        hat();
    }

    public static void egg() {
        System.out.println("  ______");
        System.out.println(" /      \\");
        System.out.println("/        \\");
        System.out.println("\\        /");
        System.out.println(" \\______/");
        System.out.println();
    }

    public static void teaCup() {
        System.out.println("\\        /");
        System.out.println(" \\______/");
        System.out.println("+--------+");
        System.out.println();
    }
    ...
```

Program version 2, cont'd.

```
    ...

    public static void stopSign() {
        System.out.println("  ______");
        System.out.println(" /      \\");
        System.out.println("/        \\");
        System.out.println("|  STOP  |");
        System.out.println("\\        /");
        System.out.println(" \\______/");
        System.out.println();
    }

    public static void hat() {
        System.out.println("  ______");
        System.out.println(" /      \\");
        System.out.println("/        \\");
        System.out.println("+--------+");
    }
}
```

Development strategy 3

```
  ______
 /      \
/        \
\        /
 \______/

\        /
 \______/
+--------+

  ______
 /      \
/        \
|  STOP  |
\        /
 \______/

  ______
 /      \
/        \
+--------+
```

<u>Third version (structured, without redundancy):</u>

- Identify redundancy in the output, and create methods to eliminate as much as possible.
- Add comments to the program.

Output redundancy

```
  ______
 /      \
/        \
\        /
 \______/

\        /
 \______/
+--------+

  ______
 /      \
/        \
|  STOP  |
\        /
 \______/

  ______
 /      \
/        \
+--------+
```

The redundancy in the output:

egg top:	reused on stop sign, hat
egg bottom:	reused on teacup, stop sign
divider line:	used on teacup, hat

This redundancy can be fixed by methods:

- `eggTop`
- `eggBottom`
- `line`

Program version 3

```
// Suzy Student, CSE 138, Spring 2094
// Prints several figures, with methods for structure and redundancy.
public class Figures3 {
    public static void main(String[] args) {
        egg();
        teaCup();
        stopSign();
        hat();
    }

    // Draws the top half of an an egg figure.
    public static void eggTop() {
        System.out.println("  ______");
        System.out.println(" /      \\");
        System.out.println("/        \\");
    }

    // Draws the bottom half of an egg figure.
    public static void eggBottom() {
        System.out.println("\\        /");
        System.out.println(" \\______/");
    }

    // Draws a complete egg figure.
    public static void egg() {
        eggTop();
        eggBottom();
        System.out.println();
    }

    ...
```

Program version 3, cont'd.

```
    ...
    // Draws a teacup figure.
    public static void teaCup() {
        eggBottom();
        line();
        System.out.println();
    }

    // Draws a stop sign figure.
    public static void stopSign() {
        eggTop();
        System.out.println("|  STOP  |");
        eggBottom();
        System.out.println();
    }

    // Draws a figure that looks sort of like a hat.
    public static void hat() {
        eggTop();
        line();
    }

    // Draws a line of dashes.
    public static void line() {
        System.out.println("+--------+");
    }
}
```

Data and expressions

reading: 2.1

self-check: 1-4

videos: Ch. 2 #1

Data types

- **type**: A category or set of data values.
  - Constrains the operations that can be performed on data
  - Many languages ask the programmer to specify types

  - Examples: integer, real number, string

- Internally, computers store everything as 1s and 0s

```
104    → 01101000
"hi"   → 01101000110101
```

Java's primitive types

- **primitive types**: 8 simple types for numbers, text, etc.
  - Java also has **object types**, which we'll talk about later

Name	**Description**	**Examples**
`int`	integers	`42, -3, 0, 926394`
`double`	real numbers	`3.1, -0.25, 9.4e3`
`char`	single text characters	`'a', 'X', '?', '\n'`
`boolean`	logical values	`true, false`

  - Why does Java distinguish integers vs. real numbers?

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.

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
```

What is the result?

```
45 % 6
2 % 2
8 % 20
11 % 0
```

- 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`

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

```
1 * 2 + 3 * 5 % 4
 \_/
  |
  2   + 3 * 5 % 4
         \_/
          |
  2   +  15   % 4
           \___/
             |
  2   +      3
   \________/
       |
       5
```

```
1 + 8 % 3 * 2 - 9
     \_/
      |
1 +   2   * 2 - 9
       \___/
         |
1 +      4    - 9
 \______/
    |
    5         - 9
     \_________/
          |
          -4
```

Precedence questions

- What values result from the following expressions?
  - `9 / 5`
  - `695 % 20`
  - `7 + 6 * 5`
  - `7 * 6 + 5`
  - `248 % 100 / 5`
  - `6 * 3 - 9 / 4`
  - `(5 - 7) * 4`
  - `6 + (18 % (17 - 12))`

Real numbers (type `double`)

- Examples: `6.022` , `-42.0` , `2.143e17`
  - 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
              \___/
                |
   4.8    +    9.0   / 2.0
                 \_____/
                    |
   4.8    +        4.5
      \____________/
             |
            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.

```
7 / 3 * 1.2 + 3 / 2
\_/
 |
 2    * 1.2 + 3 / 2
  \_____/
     |
    2.4     + 3 / 2
              \_/
               |
    2.4     +  1
     \__________/
          |
         3.4
```

```
2.0 + 10 / 3 * 2.5 - 6 / 4
      \___/
        |
2.0 +   3    * 2.5 - 6 / 4
        \______/
            |
2.0 +      7.5     - 6 / 4
                     \_/
                      |
2.0 +      7.5     -  1
\__________/
     |
    9.5            -  1
     \______________/
            |
           8.5
```

  - `3 / 2` is `1` above, not `1.5`.

String concatenation

- **string concatenation**: Using + between a string and another value to make a longer string.

```
"hello" + 42        is "hello42"
1 + "abc" + 2       is "1abc2"
"abc" + 1 + 2       is "abc12"
1 + 2 + "abc"       is "3abc"
"abc" + 9 * 3       is "abc27"
"1" + 1             is "11"
4 - 1 + "abc"       is "3abc"
```

- Use + to print a string and an expression's value together.
  - `System.out.println("Grade: " + (95.1 + 71.9) / 2);`
  - Output: `Grade: 83.5`