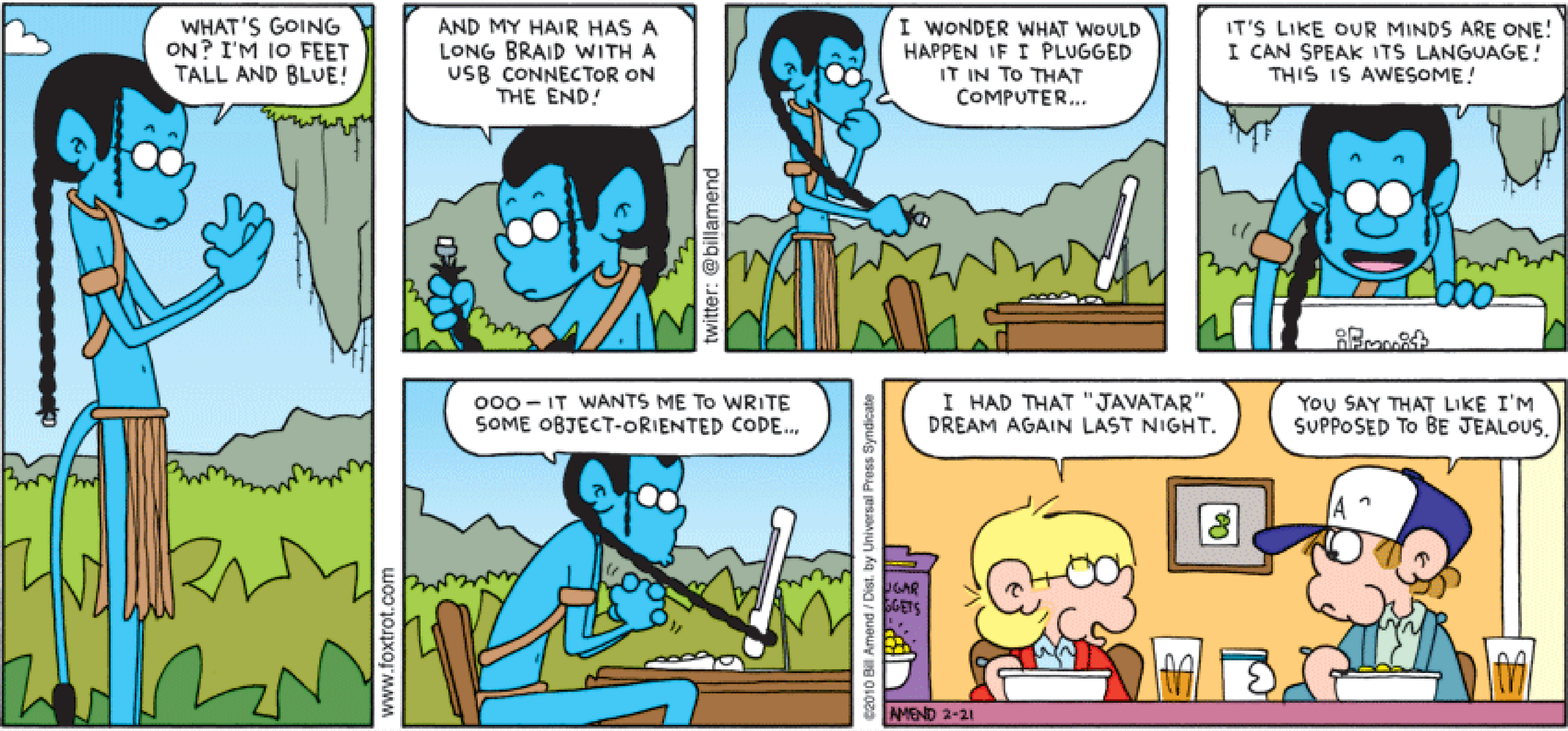
Building Java Programs

Chapter 1

Lecture 2: Static Methods

reading: 1.4 - 1.5

(Slides adapted from Stuart Reges, Hélène Martin, and Marty Stepp)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AND MY HAIR HAS A LONG BRAID WITH A USB CONNECTOR ON THE END!
twitter: @billamend
I WONDER WHAT WOULD HAPPEN IF I PLUGGED IT IN TO THAT COMPUTER...
IT'S LIKE OUR MINDS ARE ONE! I CAN SPEAK ITS LANGUAGE! THIS IS AWESOME!
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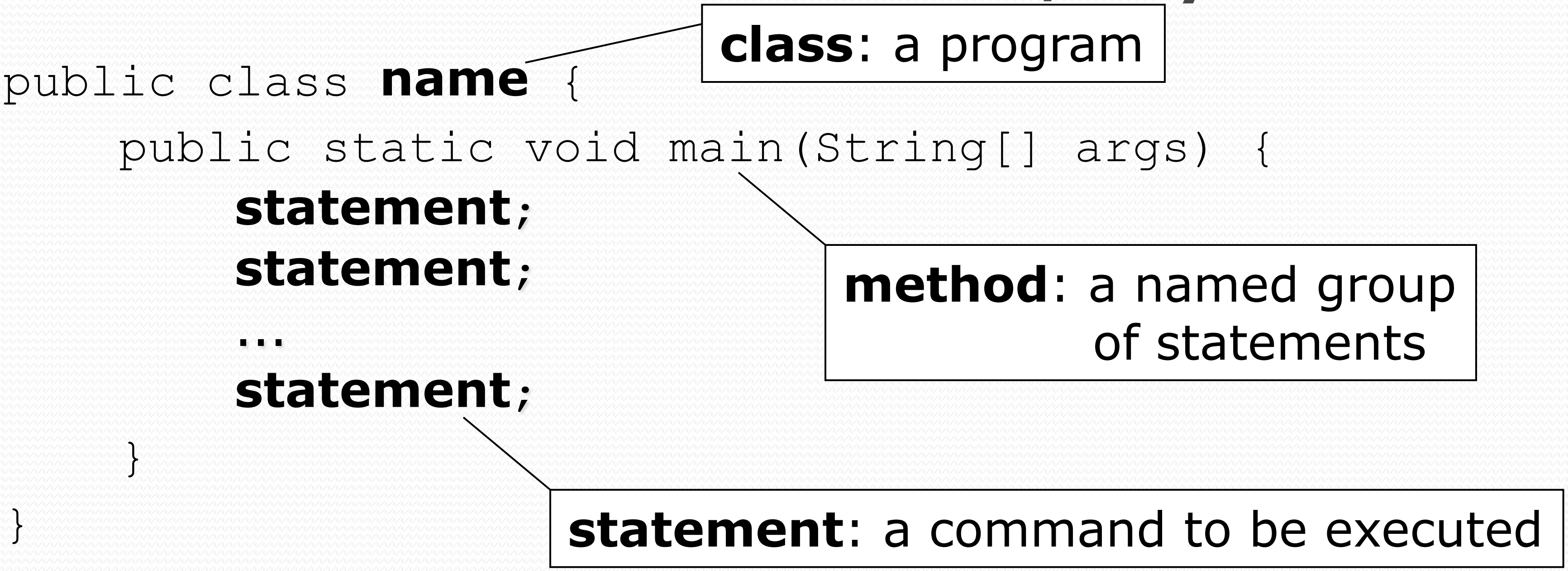
YOU SAY THAT LIKE I'M SUPPOSED TO BE JEALOUS.
AMEND 2-21

Recall: structure, syntax



```
public class name {
    public static void main(String[] args) {
        statement;
        statement;
        ...
        statement;
    }
}
```

class: a program

method: a named group of statements

statement: a command to be executed

- Every executable Java program consists of a **class**,
    - that contains a **method** named `main`,
        - that contains the **statements** (commands) to be executed.

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. */
```

Comments example

```
/* Suzy Student, CSE 142, Fall 2019
   Displays lyrics*/

public class Lyrics {
    public static void main(String[] args) {
        // first line
        System.out.println("When I first got into magic");
        System.out.println("it was an underground phenomenon");
        System.out.println();

        // second line
        System.out.println("Now everybody's like");
        System.out.println("pick a card, any card");
    }
}
```

Static methods

reading: 1.4

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 for 10 minutes.
  - 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 steps; tough to follow.
- *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 for 10 minutes.
  - Place the first batch of cookies into the oven.
  - Allow the cookies to bake.
  - Set the timer for 10 minutes.
  - 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 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 for 10 minutes.
  - Place the cookies into the oven.
  - Allow the cookies to bake.

  3 Decorate the cookies.
  - 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 for 10 minutes.
- ...

2b Bake the cookies (second batch).

- Repeat Step 2a

3 Decorate the cookies.

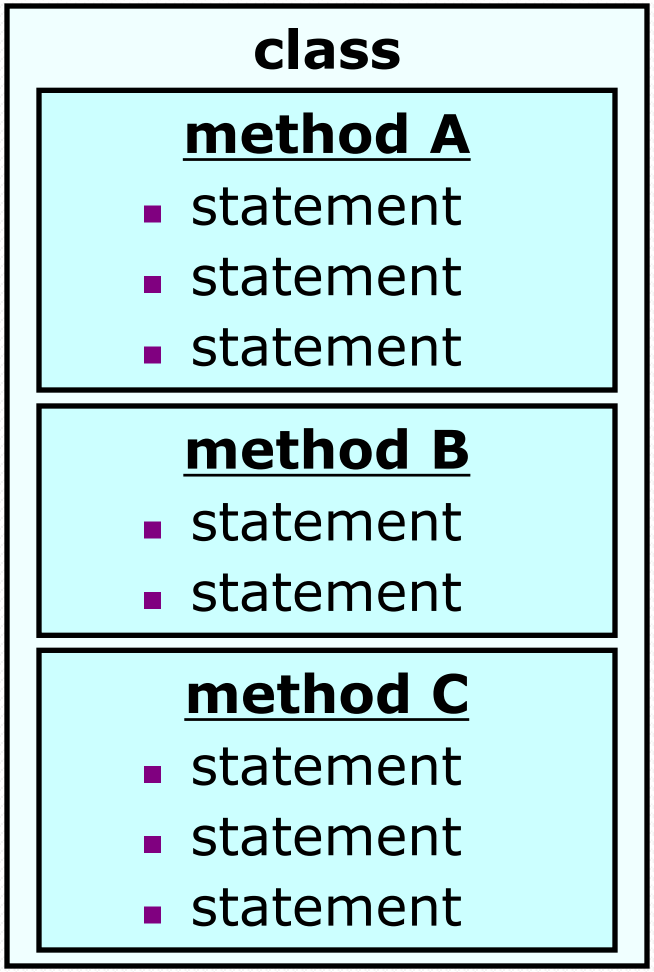
- ...

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.



class

method A
- statement
- statement
- statement

method B
- statement
- statement

method C
- statement
- statement
- statement

Using static methods

1. **Design** (think about) 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.

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
```

Methods calling methods

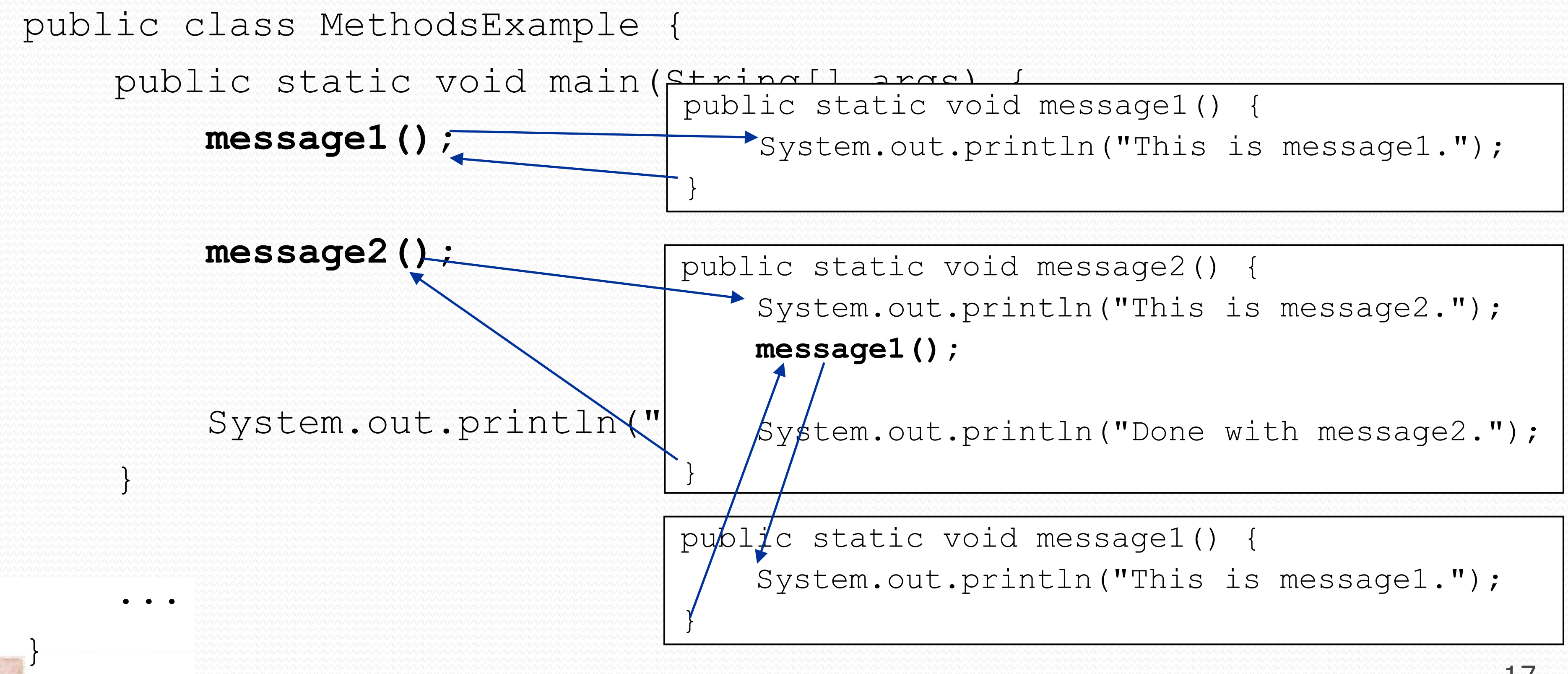
```
public class MethodsExample {
    public static void main(String[] args) {
        message1();
        message2();
        System.out.println("Done with main.");
    }

    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`)

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("+--------+");
    }
}
```

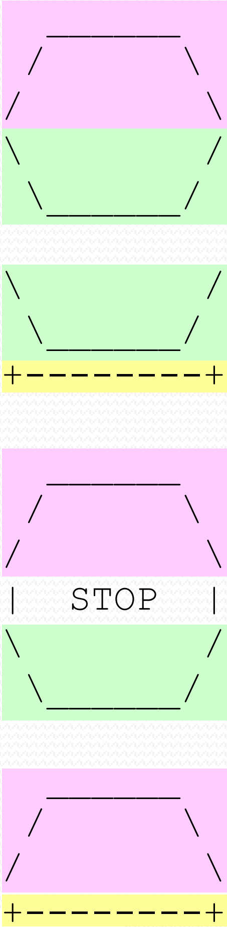
Development strategy 3

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

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

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

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

Third version (structured, without redundancy):

- 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.

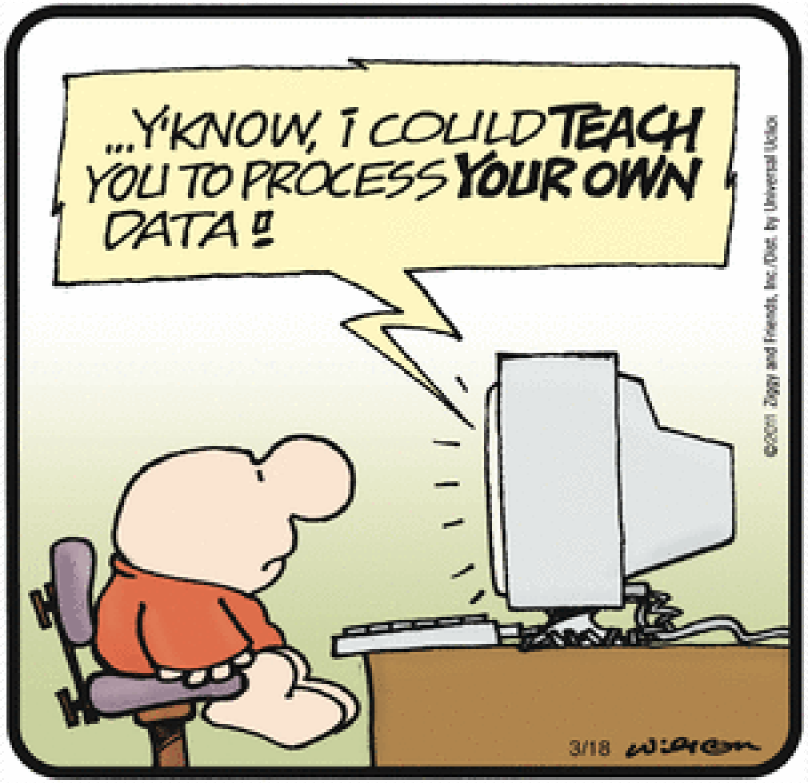
```
    ...
    // Draws a teacup figure.
    public static void teaCup() {
        eggBottom();
        line();
        System.out.println();
    }

    // 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("+--------+");
    }
}
```

Building Java Programs

Chapter 2

Lecture 2: Expressions

reading: 2.1


...Y'KNOW, I COULD TEACH YOU TO PROCESS YOUR OWN DATA!!
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Wilson

Data and expressions

reading: 2.1

Data types

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

```
104     → 01101000
"hi"    → 0110100001101001
h       → 01101000
```

- How are `h` and `104` differentiated?

- **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

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	(up to 2^{31} - 1)	`42, -3, 0, 926394`
`double`	real numbers	(up to 10^{308})	`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?

Integer or real number?

- Which category is more appropriate?

integer (`int`)	real number (`double`)

1. Temperature in degrees Celsius
2. The population of lemmings
3. Your grade point average
4. A person's age in years
5. A person's weight in pounds
6. A person's height in meters
7. Number of miles traveled
8. Number of dry days in the past month
9. Your locker number
10. Number of seconds left in a game
11. The sum of a group of integers
12. The average of a group of integers

- credit: Kate Deibel for these examples
- http://www.youtube.com/watch?v=3TdZHffwOF8&t=1m25s (for #10)

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`

$$\begin{array}{r} \mathbf{3} \\ 4\ )\overline{\ 14} \\ \underline{12} \\ 2 \end{array} \qquad \begin{array}{r} \mathbf{4} \\ 10\ )\overline{\ 45} \\ \underline{40} \\ 5 \end{array} \qquad \begin{array}{r} \mathbf{52} \\ 27\ )\overline{\ 1425} \\ \underline{135} \\ 75 \\ \underline{54} \\ 21 \end{array}$$

- More examples:
  - `32 / 5` is `6`
  - `84 / 10` is `8`
  - `156 / 100` is `1`

  - Dividing by 0 causes an error when your program runs.

Integer remainder with `%`

- The `%` operator computes the remainder from integer division.
  - `14 % 4`   is `2`
  - `218 % 5`   is `3`

```
      3            43
4 ) 14       5 ) 218
    12           20
     2            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`)

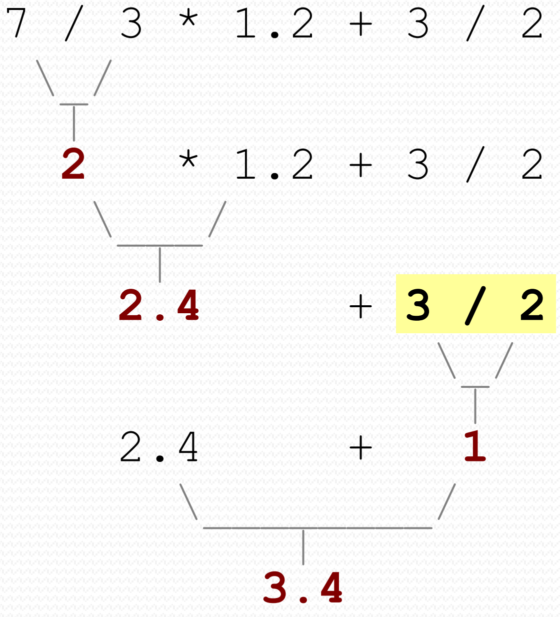
- Examples: `6.022` , `-42.0` , `2.143e17`
  - Placing `.0` or `.` after an integer makes it a `double`.
- The operators `+ - * / % ()` all still work with `double`.
  - `/` produces an exact answer: `15.0 / 2.0` is `7.5`
  - Precedence is the same: `()` before `* / %` before `+ -`

Real number example

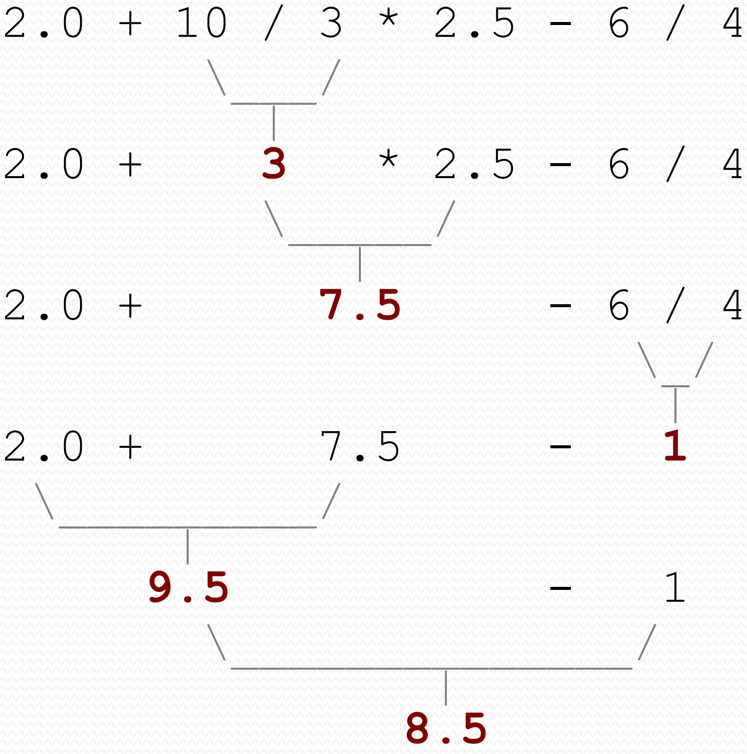
```
2.0 * 2.4 + 2.25 * 4.0 / 2.0
  \___/
    |
   4.8    + 2.25 * 4.0 / 2.0
              \___/
                |
   4.8    +    9.0   / 2.0
                 \_____/
                    |
   4.8    +        4.5
      \____________/
             |
            9.3
```

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`