Topic 13
procedural design and Strings

"Ugly programs are like ugly suspension bridges: they're much more liable to collapse than pretty ones, because the way humans (especially engineer-humans) perceive beauty is intimately related to our ability to process and understand complexity."

- Eric S. Raymond,

Author of *The Cathedral and the Bazaar*

Based on slides bu Marty Stepp and Stuart Reges
from http://www.buildingjavaprograms.com/

Nested `if/else` question

Formula for body mass index (BMI):

$$BMI = \frac{weight}{height^2} \times 703$$

- Write a program that produces output like the following:

```
This program reads data for two people and computes
their body mass index (BMI) and weight status.

Enter next person's information:
height (in inches)? 73.5
weight (in pounds)? 230
BMI = 29.93
overweight

Enter next person's information:
height (in inches)? 71
weight (in pounds)? 220.5
BMI = 30.75
obese

Difference = 0.82
```

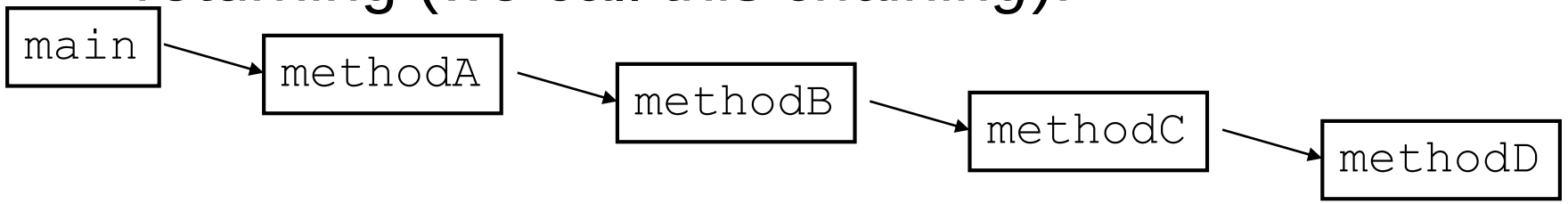
BMI	Weight class
below 18.5	underweight
18.5 - 24.9	normal
25.0 - 29.9	overweight
30.0 and up	obese

One-person, no methods

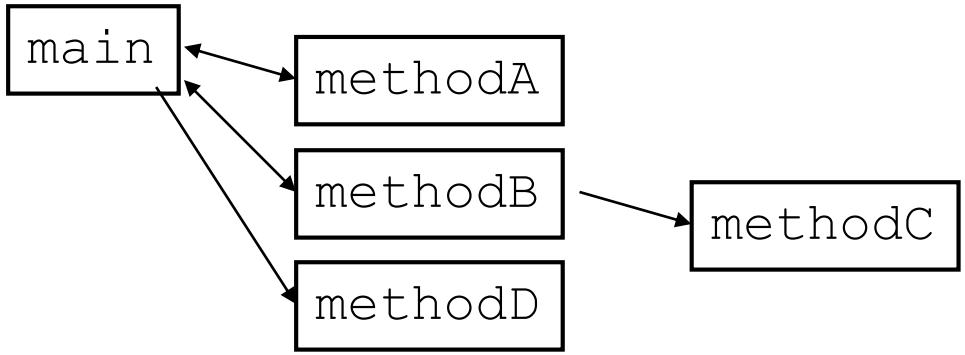
```
import java.util.*;

public class BMI {
    public static void main(String[] args) {
        System.out.println("This program reads ... (etc.)");
        Scanner console = new Scanner(System.in);

        System.out.println("Enter next person's information:");
        System.out.print("height (in inches)? ");
        double height = console.nextDouble();

        System.out.print("weight (in pounds)? ");
        double weight = console.nextDouble();

        double bmi = weight * 703 / height / height;

        System.out.printf("BMI = %.2f\n", bmi);
        if (bmi < 18.5) {
            System.out.println("underweight");
        } else if (bmi < 25) {
            System.out.println("normal");
        } else if (bmi < 30) {
            System.out.println("overweight");
        } else {
            System.out.println("obese");
        }
    }
}
```

"Chaining"

- `main` should be a concise summary of your program.
  - It is bad if each method calls the next without ever returning (we call this *chaining*):



- A better structure has `main` make most of the calls.
  - Methods must return values to `main` to be passed on later.



Bad "chain" code

```
public class BMI {
    public static void main(String[] args) {
        System.out.println("This program reads ... (etc.)");
        Scanner console = new Scanner(System.in);
        person(console);
    }

    public static void person(Scanner console) {
        System.out.println("Enter next person's information:");
        System.out.print("height (in inches)? ");
        double height = console.nextDouble();
        getWeight(console, height);
    }

    public static void getWeight(Scanner console, double height) {
        System.out.print("weight (in pounds)? ");
        double weight = console.nextDouble();
        computeBMI(console, height, weight);
    }

    public static void computeBMI(Scanner s, double h, double w) {
        ...
    }
}
```

Procedural heuristics

1. Each method should have a clear responsibility.

2. No method should do too large a share of the overall task.

3. Minimize coupling and dependencies between methods.

4. The main method should read as a concise summary of the overall set of tasks performed by the program.

5. Variables should be declared/used at the lowest level possible.

Better solution

```
// This program computes two people's body mass index (BMI) and
// compares them.
// The code uses Scanner for input, and parameters/returns.

import java.util.Scanner;

public class BMI {
    public static void main(String[] args) {
        introduction();
        Scanner console = new Scanner(System.in);
        double bmi1 = person(console);
        double bmi2 = person(console);

        // report overall results
        report(1, bmi1);
        report(2, bmi2);
        System.out.println("Difference   = "
                                    + Math.abs(bmi1 - bmi2));

    }

    // prints a welcome message explaining the program
    public static void introduction() {
        System.out.println("This program reads ...");
        // ...
    }
...
```

Better solution, cont'd.

```
    // reads information for one person, computes their BMI,and returns it
    public static double person(Scanner console) {
        System.out.println("Enter next person's information:");
        System.out.print("height (in inches)? ");
        double height = console.nextDouble();

        System.out.print("weight (in pounds)? ");
        double weight = console.nextDouble();
        System.out.println();

        return bmi(height, weight);
    }

    // Computes/returns a person's BMI based on their height and weight.
    public static double bmi(double height, double weight) {
        return weight * 703 / (height * height);
    }

    // Outputs information about a person's BMI and weight status.
    public static void report(int number, double bmi) {
        System.out.printf("Subject%5dBMI = %.2f\n", number, bmi);
        if (bmi < 18.5) {
            System.out.println("underweight");
        } else if (bmi < 25) {
            System.out.println("normal");
        } else if (bmi < 30) {
            System.out.println("overweight");
        } else {
            System.out.println("obese");
        }
    }
}
```

Strings

- **string**: An object storing a sequence of text characters.
  - Unlike most other objects, a `String` is not always created with `new`.

```
String name = "text";
String name = expression;
```

  - Examples:

```
String name = "Marla Singer";
int x = 3;
int y = 5;
String point = "(" + x + ", " + y + ")";
```

Indexes

- Characters of a string are numbered with 0-based *indexes*:

```
String name = "K. Scott";
```

index	0	1	2	3	4	5	6	7
character	K	.		S	c	o	t	t

  - First character's index : 0 (zero based indexing)
  - Last character's index : 1 less than the string's length
  - The individual characters are values of type `char` (another primitive data type)

`String` methods

Method name	Description
`indexOf(`**`str`**`)`	index where the start of the given string appears in this string (-1 if not found)
`length()`	number of characters in this string
`substring(`**`index1`**`, `**`index2`**`)` or `substring(`**`index1`**`)`	the characters in this string from *index1* (inclusive) to *index2* (exclusive); if *index2* is omitted, grabs till end of string
`toLowerCase()`	a new string with all lowercase letters
`toUpperCase()`	a new string with all uppercase letters

- These methods are called using the dot notation:

```
String student = "Olivia Scott";
System.out.println(student.length());  // 12
```

`String` method examples

```
// index      012345678901
String s1 = "Olivia Scott";
String s2 = "Isabelle Scott";
System.out.println(s2.length());   // 14
System.out.println(s1.indexOf("e"));  // -1
System.out.println(s2.indexOf("e"));  // 4
System.out.println(s1.substring(7, 10));// "Sco"
String s3 = s2.substring(4, 10);
System.out.println(s3.toLowerCase());// "elle s"
```

- Given the following string:

```
// index        01234567890123456789
String book = "Building Java Programs";
```

  - How would you extract the word `"Building"` ?
    (Write code that can extract the first word from any string.)

Clicker 1

- What is output by the following code?

```
String s1 = "Football";
String s2 = s1.substring(4, 8);
s2.substring(1);
System.out.print(s2);
```

A. Football
B. ball
C. all
D. No output due to syntax error.
E. No output due to runtime error.

Modifying strings

- Methods like `substring` and `toLowerCase` build and return a new string, rather than modifying the current string.

```
String s = "ut Longhorns";
s.toUpperCase();
System.out.println(s);   // ut Longhorns
```

- To modify a variable's value, you must reassign it:

```
String s = "ut Longhorns";
s = s.toUpperCase();
System.out.println(s); // UT LONGHORNS
```

Strings as user input

- `Scanner`'s `nextLine` method reads a word of input as a `String`.

```
Scanner console = new Scanner(System.in);
System.out.print("What is your first name? ");
String name = console.nextLine();
System.out.println(name + " has " + name.length() +
    " letters and starts with " + name.substring(0, 1));
```

Output:

```
What is your first name? Chamillionaire
Chamillionaire has 14 letters and starts with C
```

- The `nextLine` method reads a line of input as a `String`.

```
System.out.print("What is your address? ");
String address = console.nextLine();
```

Clicker 2

- What is output by the following code?

```
String s1 = "taxicab";
String s2 = "acables";
String s3 = s1.substring(4);
String s4 = s2.substring(1, 4);
if (s3.length() == s4.length())
    System.out.print("1");
else
    System.out.print("2");
if (s3 == s4)
    System.out.print("1");
else
    System.out.print("2");
```

A. 11
B. 12
C. 21
D. 22
E. No output due to syntax error

Comparing Strings

- Relational operators such as < and <= are undefined on objects in Java.
- == is defined but normally doesn't work as intended

```
Scanner console = new Scanner(System.in);
System.out.print("What is your name? ");
String name = console.next();
if (name == "Barney") {
    System.out.println("I love you, you love me,");
    System.out.println("We're a happy family!");
}
```

  - This code will compile, but it will not print the song.
  - == compares objects by *references* (seen later), so it often gives `false` even when two `String`s have the same letters.

The `equals` method

- Objects are compared using a method named `equals`.

```
Scanner console = new Scanner(System.in);
System.out.print("What is your name? ");
String name = console.next();
if (name.equals("Barney")) {
    System.out.println("Fred's Friend.");
    System.out.println("Purple Dinasuar.");
    System.out.println("In trouble.");
}
```

  - The `equals` method returns a value of type `boolean`, the type used in logical tests.

`String` test methods

Method	Description
`equals(`**str**`)`	whether two strings contain the same characters
`equalsIgnoreCase(`**str**`)`	whether two strings contain the same characters, ignoring upper vs. lower case
`startsWith(`**str**`)`	whether one contains other's characters at start
`endsWith(`**str**`)`	whether one contains other's characters at end
`contains(`**str**`)`	whether the given string is found within this one

```
String name = console.next();
if (name.startsWith("Prof")) {
    System.out.println("When are your office hours?");
} else if (name.endsWith("OBE")) {
    System.out.println("Yes Sir!");
}
```

Strings questions

- Write a ,method to determine if a String is a possible representation of a DNA strand
  - contains only A, C, T, and G
- Write a method to create a *Watson-Crick complement* given a String that represents a strand of DNA
  - replace A with T, C with G, and vice versa
- Given a String that represents a strand of DNA return the first substring that exists between "ATG" and either "TAG" or "TGA"
  - no overlap allowed

String Questions

- Write a method that returns the number of times a given character occurs in a String
- Write a method that returns the number of times the punctuation marks `.?!,:";'` occur in a String