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

- Eric S. Raymond,

Author of *The Cathedral and the Bazaar*

---

**Formula for body mass index (BMI):**

\[
BMI = \frac{\text{weight}}{\text{height}^2} \times 703
\]

- Write a program that produces output like the following:

  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

---

**One-person, no methods**

```java
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):
    ```java
    main
    ├── methodA
    │   └── methodB
    │       └── methodC
    │           └── methodD
    │               └── methodE
    │                   └── methodF
    └── methodG
    ``

- A better structure has main make most of the calls.
  - Methods must return values to main to be passed on later.
    ```java
    main
    ├── methodA
    │   └── methodB
    │       └── methodC
    │           └── methodD
    ```
Bad "chain" code

```java
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 set of responsibilities.
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

```java
// 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.*; // so that I can use Scanner

public class BMI {
    public static void main(String[] args) {
        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
        System.out.println("This program reads ... ");
    }
```

Better solution, cont'd.

```java
// reads information for one person, computes their BMI, and returns
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);
}
```

```java
// 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;
}
```

```java
// Outputs information about a person's BMI and weight status.
public static void report(int number, double bmi) {
    System.out.printf("Subject #%dBMI = %.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 { // obese
        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`.
    
    ```java
    String name = "text";
    String name = expression;
    ```

  - Examples:
    ```java
    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:
  ```java
  String name = "K. Scott";
  ```
  ```text
<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>character</td>
<td>K</td>
<td>.</td>
<td>s</td>
<td>c</td>
<td>o</td>
<td>t</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
  ```
  - 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

<table>
<thead>
<tr>
<th>Method name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>indexOf( <code>str</code>)</td>
<td>index where the start of the given string appears in this string (-1 if not found)</td>
</tr>
<tr>
<td>length()</td>
<td>number of characters in this string</td>
</tr>
<tr>
<td>replace( <code>str1, str2</code>)</td>
<td>replaces occurrences of <code>str1</code> with <code>str2</code></td>
</tr>
<tr>
<td>substring(index1, index2) or substring(index1)</td>
<td>the characters in this string from <code>index1</code> (inclusive) to <code>index2</code> (exclusive); if <code>index2</code> is omitted, grabs till end of string</td>
</tr>
<tr>
<td>toLowerCase()</td>
<td>a new string with all lowercase letters</td>
</tr>
<tr>
<td>toUpperCase()</td>
<td>a new string with all uppercase letters</td>
</tr>
</tbody>
</table>

These methods are called using the dot notation:

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

String method examples

```java
// 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:
  ```java
  // index 0123456789012345678901
  String book = "Building Java Programs";
  ```
  - How would you extract the word "Building"?
    (Write code that can extract the first word from any string.)
Clicker Question 1

What is output by the following code?

String s1 = "Football";
String s2 = s1.substring(4, 8);
s2.substring(1);
System.out.println(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 Question 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.
- == 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 Strings 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 Dinasaaur.");
    System.out.println("In trouble.");
}

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

String test methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>equals(str)</td>
<td>whether two strings contain the same characters</td>
</tr>
<tr>
<td>equalsIgnoreCase(str)</td>
<td>whether two strings contain the same characters, ignoring upper vs. lower case</td>
</tr>
<tr>
<td>startsWith(str)</td>
<td>whether one contains other's characters at start</td>
</tr>
<tr>
<td>endsWith(str)</td>
<td>whether one contains other's characters at end</td>
</tr>
<tr>
<td>contains(str)</td>
<td>whether the given string is found within this one</td>
</tr>
</tbody>
</table>

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