Module 2:
Elementary Programming

The Basics of Java

Motivations

- In the preceding module, you learned how to create, compile, and run a Java program.
- Starting from this module, you will learn how to solve practical problems programmatically.
  - Through these problems, you will learn Java primitive data types and related subjects, such as variables, constants, data types, operators, expressions, and input and output.

Objectives

- To write Java programs to perform simple computations (§2.2).
- To obtain input from the console using the **Scanner** class (§2.3).
- To use identifiers to name variables, constants, methods, and classes (§2.4).
- To use variables to store data (§§2.5–2.6).
- To program with assignment statements and assignment expressions (§2.6).
- To use constants to store permanent data (§2.7).
- To name classes, methods, variables, and constants by following their naming conventions (§2.8).
- To explore Java numeric primitive data types: **byte**, **short**, **int**, **long**, **float**, and **double** (§2.9.1).
- To read a **byte**, **short**, **int**, **long**, **float**, or **double** value from the keyboard (§2.9.2).
- To perform operations using operators **+**, **-**, *****, /, and **%** (§2.9.3).
- To perform exponent operations using **Math.pow(a, b)** (§2.9.4).
- To write integer literals, floating-point literals, and literals in scientific notation (§2.10).
- To write and evaluate numeric expressions (§2.11).
- To obtain the current system time using **System.currentTimeMillis()** (§2.12).
- To use augmented assignment operators (§2.13).
- To distinguish between postincrement and preincrement and between postdecrement and predecrement (§2.14).
- To cast the value of one type to another type (§2.15).
- To describe the software development process and apply it to develop the loan payment program (§2.16).
- To write a program that converts a large amount of money into smaller units (§2.17).
- To avoid common errors and pitfalls in elementary programming (§2.18).

Writing a Simple Program

- Write a program that will calculate the area of a circle.
- Remember:
  - Step 1: Problem-solving Phase
  - Step 2: Implementation Phase

Writing a Simple Program

- Write a program that will calculate the area of a circle.
- **Step 1**: Design your algorithm
  1. Get the radius of the circle.
  2. Compute the area using the following formula:
     - area = radius x radius x π
  3. Display the result

Writing a Simple Program

- Write a program that will calculate the area of a circle.
- **Step 2**: Implementation (code the algorithm)

```
public class ComputeArea {
   public static void main(String[] args) {
      // Step 1: get radius

      // Step 2: calculate area

      // Step 3: display the result
   }
}
```

Writing a Simple Program

- ☞ Write a program that will calculate the area of a circle.
- ☞ **Step 2**: Implementation (code the algorithm)
  - – In order to store the radius, the program must declare a symbol called a **variable**.
  - – A variable represents a value stored in the computer's memory
  - – You should choose good names for variables
    - ◆ Do not choose "x" or "y"…these have no meaning
    - ◆ Choose names with meaning…"area" or "radius"

Writing a Simple Program

- ☞ Write a program that will calculate the area of a circle.
- ☞ **Step 2**: Implementation (code the algorithm)
  - What value do you want to store in *radius*?
  - What about *area*?
    - ◆ Integer? Real number? Something else maybe?
  - The variable's **data type** is the kind of data that you can store in that particular variable.
  - So when you **declare** (create) a variable, you must state its data type and the variable name.

Writing a Simple Program

- ☞ Write a program that will calculate the area of a circle.
- ☞ **Step 2**: Implementation (code the algorithm)
  - – Java provides simple data types for integers, real numbers, characters, and Boolean types.
  - – These basic data types are known as **primitives**.
  - – Here are two example primitive data types:
    - ◆ `int` : used to store an integer
    - ◆ `double` : used to store a real number

Writing a Simple Program

- Write a program that will calculate the area of a circle.
- **Step 2**: Implementation (code the algorithm)

```
public class ComputeArea {
   public static void main(String[] args) {
      double radius, area;
      // Step 1: get radius

      // Step 2: calculate area

      // Step 3: display the result

   }
}
```

Writing a Simple Program

- Write a program that will calculate the area of a circle.
- **Step 2**: Implementation (code the algorithm)
  - Now, we set a value for radius.
    - Later we will learn how to ask the user to input the value for radius!
  - We then perform the calculation to get the area.
  - And we print/display the result.

Writing a Simple Program

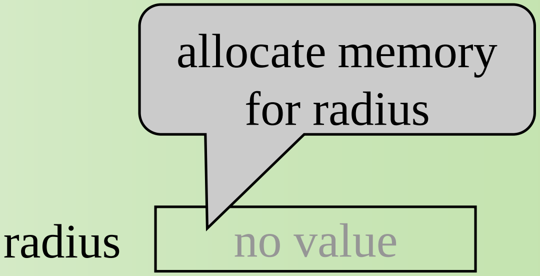
- ☞ Write a program that will calculate the area of a circle.
- ☞ **Step 2**: Implementation (code the algorithm)

```
public class ComputeArea {
   public static void main(String[] args) {
      double radius, area;
      // Step 1: set radius
      radius = 20;
      // Step 2: calculate area
      area = radius * radius * 3.14159;

      // Step 3: display the result
      System.out.println(“The area for the circle of radius ” +
         radius + “ is ” + area + “.”);
   }
}
```

animation

Trace a Program Execution

```
public class ComputeArea {
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```

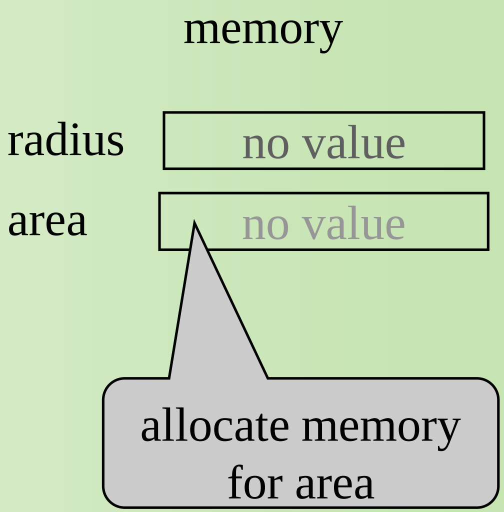


allocate memory for radius

animation

Trace a Program Execution

```
public class ComputeArea {
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```



memory

radius no value

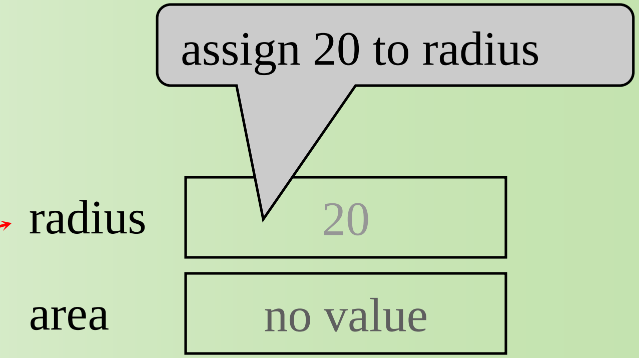
area no value

allocate memory for area

animation

Trace a Program Execution

```
public class ComputeArea {
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```

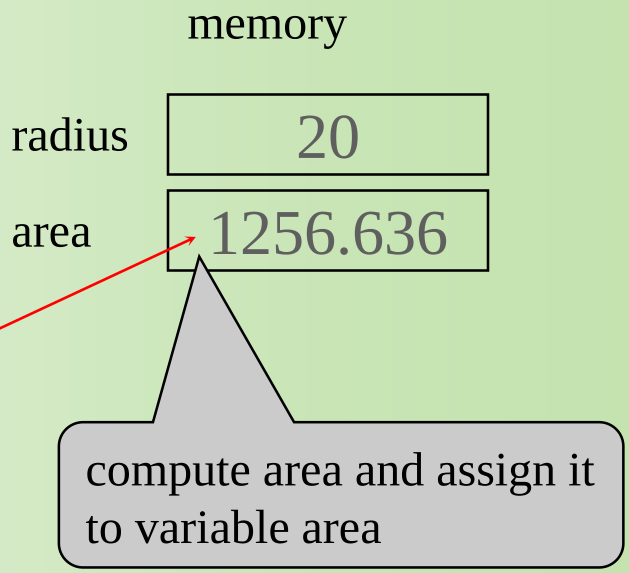


assign 20 to radius

animation

Trace a Program Execution

```
public class ComputeArea {
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```



compute area and assign it to variable area

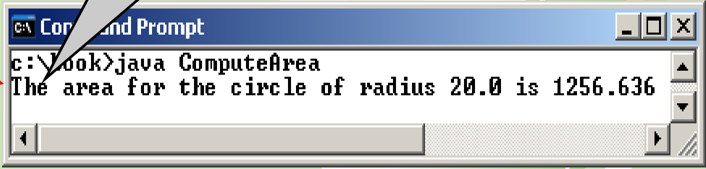
Trace a Program Execution

```
public class ComputeArea {
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```

memory

radius	20
area	1256.636

print a message to the console



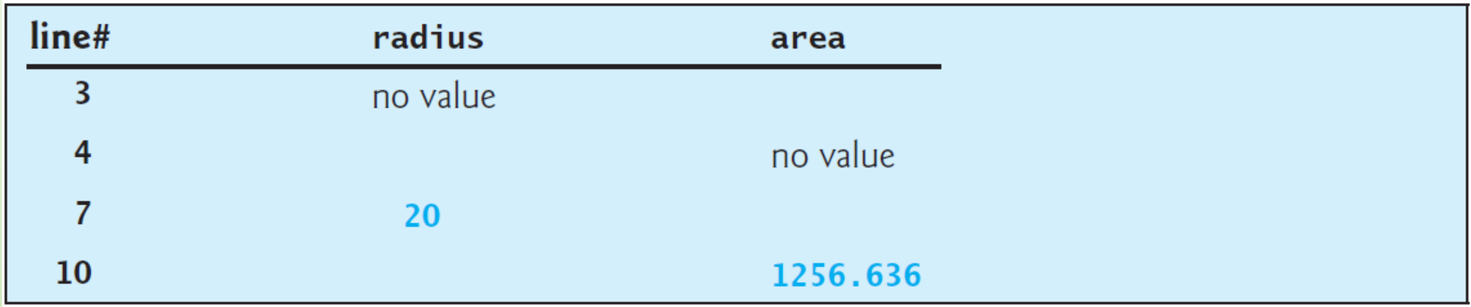
```
c:\book>java ComputeArea
The area for the circle of radius 20.0 is 1256.636
```

Writing a Simple Program

- Discussion:
  - Variables such as radius and area refer to memory locations
  - Each variable has a name, a type, a size, and value
  - Line 3 says that radius can store a double value.
    - But the value is not defined until you assign a value.
  - Line 7 assigns the value 20 into radius.
  - Similarly, line 4 declares the variable area.
  - Line 10 then assigns a value into area.

Writing a Simple Program

- Discussion:
  - The following table shows the value in memory for the variables area and radius as the program is executed.



line#	radius	area
3	no value	
4		no value
7	20	
10		1256.636

  - This method of reviewing a program is called "*tracing a program*".
  - Helps you to understand how programs work.

Writing a Simple Program

- Discussion:
  - The plus sign (+) has two meanings in Java:
    - Addition
    - Concatenation (combining two strings together)
  - The plus sign (+) in lines 13-14 is called a string concatenation operator.
    - It combines two strings into one string.
    - If a string is concatenated with a number, the number is converted into a string and then concatenated with the other string.
- See sample program: `StringPractice.java`

Writing a Simple Program

- ☞ Discussion:
  - In Java, a string cannot be written across multiple lines in the source code.
  - The following statement would result in a **compile error**:

```
System.out.println(“Introduction to Java Programming, by
   Y. Daniel Liang”);
```

  - To fix the error, break the string into separate substrings and use concatenation (+) to combine:

```
System.out.println(“Introduction to Java Programming, ” +
   “ by Y. Daniel Liang”);
```

Reading Input from the Console

- ☞ In the last example, the radius was fixed.
- ☞ Your program can be better, and more interactive, by letting the user enter the radius.
- ☞ Java uses the Scanner class for console input
  - `System.out` refers to the standout output device
    - ◆ By default, standard output is the monitor
  - `System.in` refers to the standard input device
    - ◆ By default, standard input is the keyboard

Reading Input from the Console

- Java uses the Scanner class for console input
  - So how do you read from the keyboard?
  - You make a Scanner object!
  - And you tell this Scanner object to read from System.in (they keyboard)
  - Here is the code:

```
Scanner input = new Scanner(System.in);
```

Reading Input from the Console

```
Scanner input = new Scanner(System.in);
```

- `new Scanner(System.in)` creates an object of the Scanner type.
- `Scanner input` says that input is a variable whose type is Scanner.
- The whole line creates a Scanner object and then saves the reference of this object into the variable called `input`.
- Now, we can use this new Scanner object.
  - Specifically, this Scanner object has helpful methods that allow us to read/scan data from the user.

Reading Input from the Console

- Methods of Scanner object:
  - We can invoke a method on the Scanner object.
  - What does this mean?
  - It means we are asking the Scanner object to perform a specific task.
  - Example:
    - We can invoke the `nextDouble()` method
    - This allows us to read a double value from the input

```
double radius = input.nextDouble();
```

Reading Input from the Console

☞ Summary:

- Create a Scanner object:

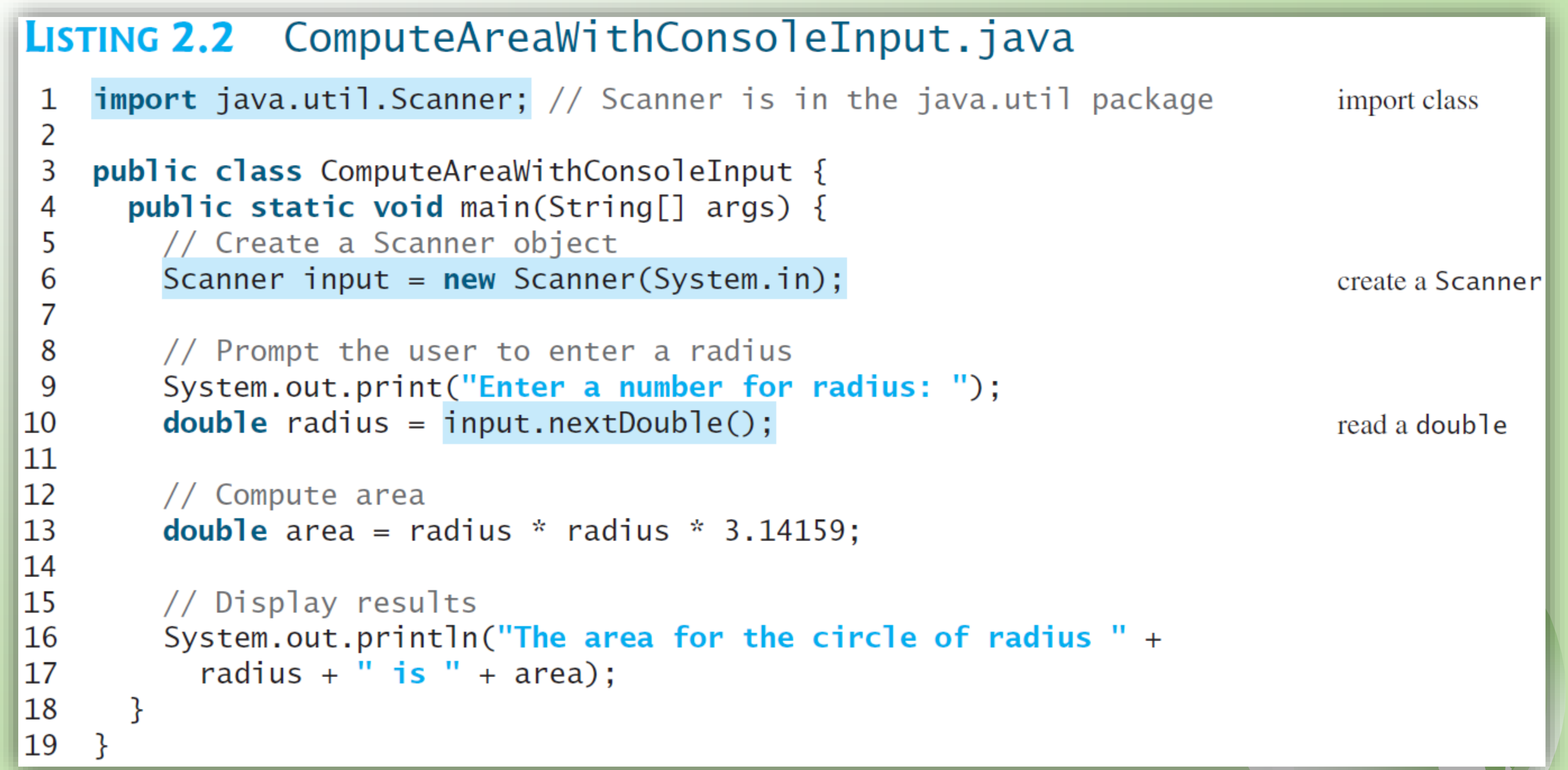
```
Scanner input = new Scanner(System.in);
```

- Use the method nextDouble() to read a double value from the user/keyboard:

```
double radius = input.nextDouble();
```

- Now, let us revisit the Compute Area of a Circle
- We will get the radius from the user…

Program 2: Compute Area with Console/User Input



LISTING 2.2 ComputeAreaWithConsoleInput.java

```java
import java.util.Scanner; // Scanner is in the java.util package

public class ComputeAreaWithConsoleInput {
  public static void main(String[] args) {
    // Create a Scanner object
    Scanner input = new Scanner(System.in);

    // Prompt the user to enter a radius
    System.out.print("Enter a number for radius: ");
    double radius = input.nextDouble();

    // Compute area
    double area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```

import class

create a Scanner

read a double

- ☞ See sample program: `AreaCircle.java`

Program 2: Compute Area with Console/User Input

- Discussion:
  - Before you can use the Scanner class, you must **import** it!
  - The Scanner class is in the `java.util` package.
  - We import this on Line 1 of the program.
  - Notice that we do this import before we start coding our actual class.

Program 2: Compute Area with Console/User Input

☞ Discussion:

- There are two types of import statements:
  - ◆ Specific import: specifies a single class that should be imported
    - Example:
      `import java.util.Scanner;`
  - ◆ Wildcard import: imports all the classes in a package by using the asterisk as the wildcard.
    - Example:
      `import java.util.*;`
- You can use either methods to import classes.
- The choice is up to you! You are the programmer!

Program 3: Compute Average

- Write a program to get three values from the user and compute their average.
- Remember:
  - Step 1: Problem-solving Phase
  - Step 2: Implementation Phase

Program 3: Compute Average

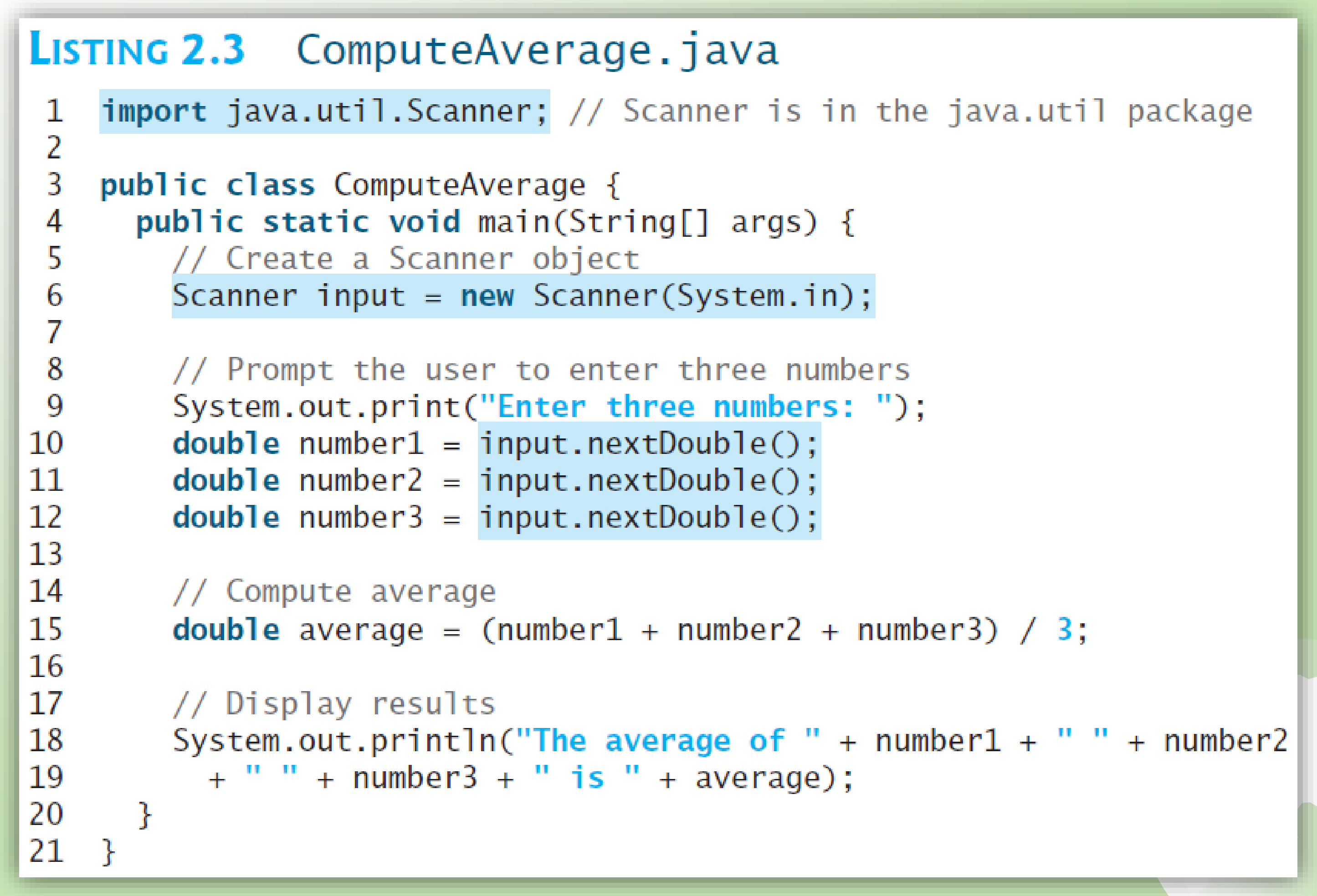
- Write a program to get three values from the user and compute their average.
- **Step 1**: Design your algorithm
  1. Get three numbers from the user.
     - Use Scanner object
  2. Compute the average of the three numbers:
     - average = (num1 + num2 + num3) / 3
  3. Display the result

Program 3: Compute Average

- Write a program to get three values from the user and compute their average.
- **Step 2**: Implementation (code the algorithm)

```
import java.util.Scanner;

public class ComputeAverage {
   public static void main(String[] args) {
      Scanner input = new Scanner(System.in);
      // Step 1: ask user to enter three values

      // Step 2: calculate average

      // Step 3: display the results

   }
}
```

Program 3: Compute Average



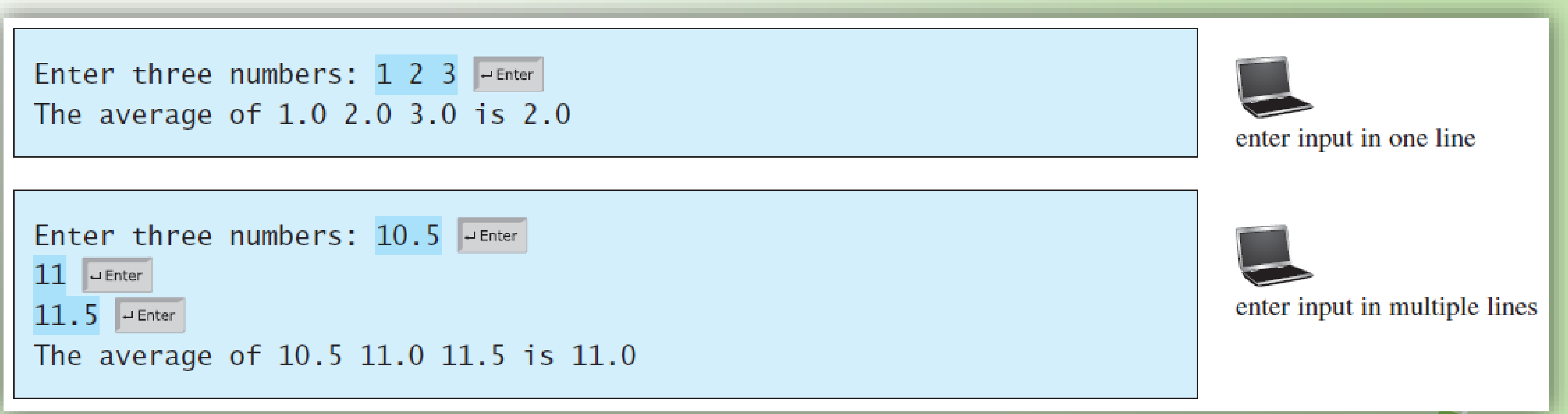
LISTING 2.3 ComputeAverage.java

```java
import java.util.Scanner; // Scanner is in the java.util package

public class ComputeAverage {
  public static void main(String[] args) {
    // Create a Scanner object
    Scanner input = new Scanner(System.in);

    // Prompt the user to enter three numbers
    System.out.print("Enter three numbers: ");
    double number1 = input.nextDouble();
    double number2 = input.nextDouble();
    double number3 = input.nextDouble();

    // Compute average
    double average = (number1 + number2 + number3) / 3;

    // Display results
    System.out.println("The average of " + number1 + " " + number2
      + " " + number3 + " is " + average);
  }
}
```

- See sample program: `AverageFourNumbers.java`

Program 3: Compute Average

- Example runs of the program:



```
Enter three numbers: 1 2 3 ↵Enter
The average of 1.0 2.0 3.0 is 2.0
```

```
Enter three numbers: 10.5 ↵Enter
11 ↵Enter
11.5 ↵Enter
The average of 10.5 11.0 11.5 is 11.0
```

Identifiers

- What is an identifier?
- Identifiers are the names that identify elements of your program, such as classes, methods, and variables.
  - An identifier is a sequence of characters that consist of letters, digits, underscores (_), and dollar signs ($).
  - An identifier must start with a letter, an underscore (_), or a dollar sign ($). It cannot start with a digit.
  - An identifier cannot be a reserved word. (See Appendix A, “Java Keywords,” for a list of reserved words).
  - An identifier cannot be `true`, `false`, or `null`.
  - An identifier can be of any length.

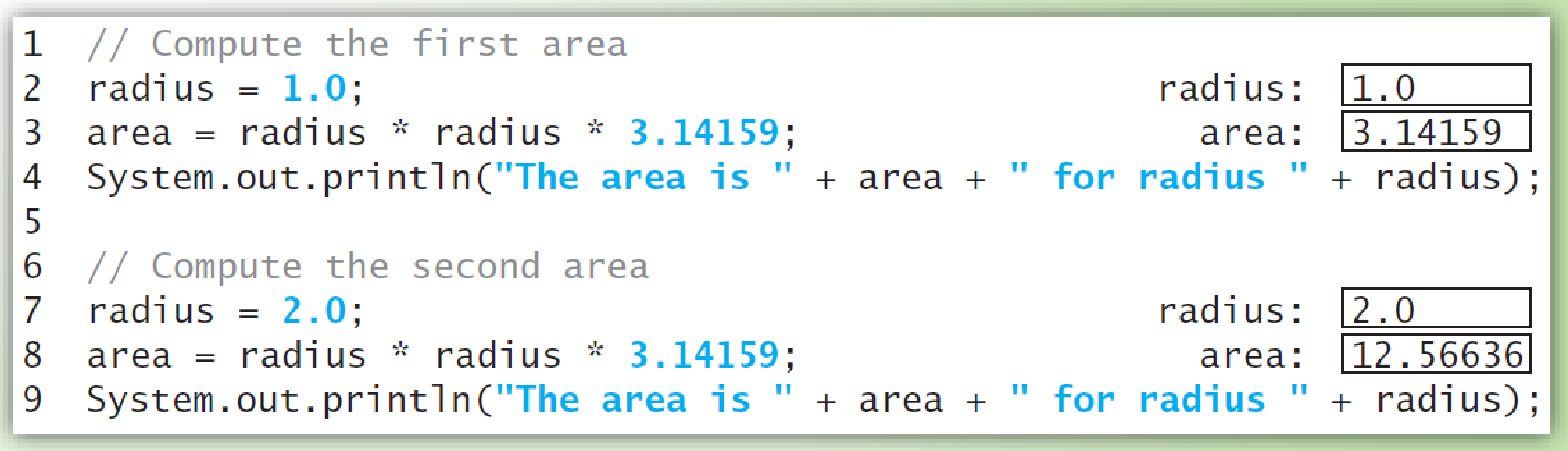
Identifiers

- Examples of legal identifiers:
  - area, radius, ComputeArea, $2, average
- Examples of illegal identifiers:
  - 2A and d+4
    - These two do not follow the rules
    - Java will report that you have a syntax error!
- Note: Java is case sensitive
  - area, Area, and AREA all are different identifiers

Variables

- Variables are used to represent values that may be changed in the program.
  - In the previous programs, we used variables to store values
    - area, radius, average, etc.
- They are called variables because their values can be changed!

Variables



```
1  // Compute the first area
2  radius = 1.0;                                        radius: 1.0
3  area = radius * radius * 3.14159;                      area: 3.14159
4  System.out.println("The area is " + area + " for radius " + radius);
5
6  // Compute the second area
7  radius = 2.0;                                        radius: 2.0
8  area = radius * radius * 3.14159;                      area: 12.56636
9  System.out.println("The area is " + area + " for radius " + radius);
```

☞ Discussion:

- radius is initially 1.0 (line 2)
- then changed to 2.0 (line 7)
- area is computer as 3.14159 (line 3)
- then changed to 12.56636 (line 8)

Declaring Variables

☞ Syntax for declaring a variable:

```
datatype variableName;
```

☞ Examples:

```
int x;              // Declare x to be an
                    // integer variable;

double radius; // Declare radius to
                    // be a double variable;

char a;             // Declare a to be a
                    // character variable;
```

Declaring Variables

- If variables are of the dame data type, they can be declared together:

```
datatype var1, var2, var3,…, varn;
```

- Example:

```
int i, j, k;
```

- Variables often have initial values
- You can declare and initialize in one step:

```
int count = 1;
double pi = 3.14159;
```

Declaring Variables

- You can also use shorthand form to declare and initialize variables of the same type together:
- Example:

```
int i = 62, j = 78, k = 35;
```

- Tip:
  - A variable must be declared before it can be assigned a value, and a value must be assigned to the variable before it can be used.
  - Try to declare and initialize in one step.
    - This makes program easier to read and helps to avoid errors

Assignment Statements

- After a variable has been declared, we can give that variable a value.
- This is called "**assigning a value**" to the variable.
- In Java, we do this with the *assignment statement*.
  - The equal sign (=) is used as the *assignment operator*.
  - The syntax for assignment statement is as follows:

```
variable = value;
```

or

```
variable = expression;
```

Assignment Statements

- Sometimes we assign an exact values into variables:
  - Examples:

```
int y = 1;                 // assign 1 to y
double w = 3.0;            // assign 3.0 to w
```

- Other times we assign the value of an expression into the variable:
  - Examples:

```
int x = 5 * (3 / 2);
double area = radius * radius * 3.14159;
```

Assignment Statements

- If a value is assigned to multiple variables, you can use this syntax:

```
i = j = k = 5;
```

- This is equivalent to:

```
k = 5;
j = k;
i = j;
```

Assignment Statements

- You can also use the same variable on both sides of the assignment statement
- Example:

```
x = x + 1;
```

  - First, the right side of the assignment is calculated.
  - Then, the new value is assigned into the variable on the left (x).
    - So if the value of x was 7 before the statement is executed, then x will become 8 after the statement is executed.

- See sample program: `VariablePractice.java`

Assignment Statements

- Note: in an assignment statement, the data type of the variable on the left must be compatible with the data type of the value on the right.
- Example:

```
int x = 1.0;
```

  - This would be illegal!
  - The data type of x is an int.
  - You cannot assign a double value (1.0) into an int variable unless you use type casting.
    - Type casting is coming later…

Named Constants

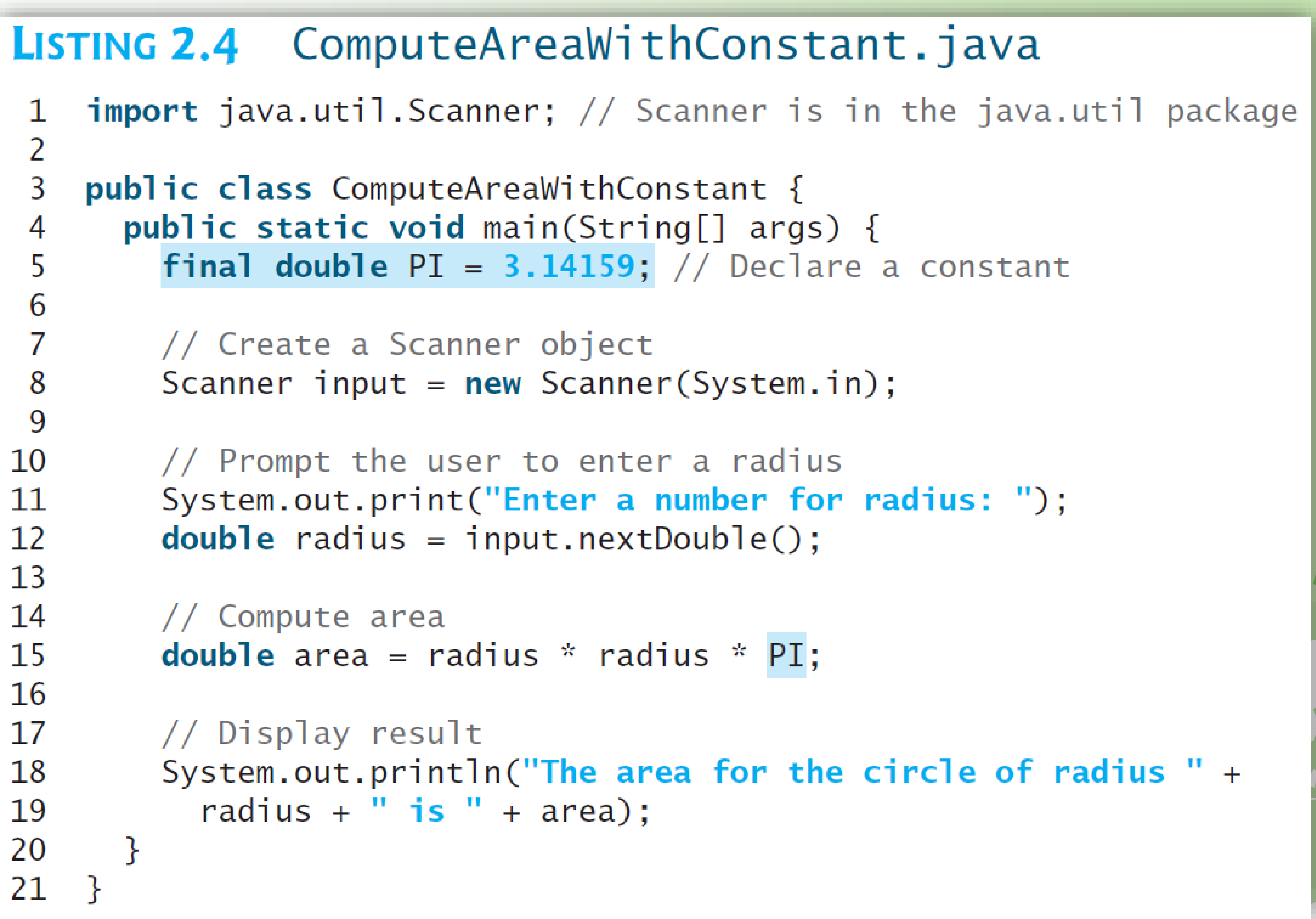
- A named constant is an identifier that represents a permanent value.
  - The value of a variable can change during execution of a program.
  - However, a *named constant*, or simply *constant*, represents a permanent data that **never** changes.
  - Here is the syntax:

    ```
    final datatype CONSTANTNAME = value;
    ```

  - Example:

    ```
    final double PI = 3.14159;
    final int SIZE = 15;
    ```

Program 4: Compute Area with a Constant



LISTING 2.4 ComputeAreaWithConstant.java

```
import java.util.Scanner; // Scanner is in the java.util package

public class ComputeAreaWithConstant {
  public static void main(String[] args) {
    final double PI = 3.14159; // Declare a constant

    // Create a Scanner object
    Scanner input = new Scanner(System.in);

    // Prompt the user to enter a radius
    System.out.print("Enter a number for radius: ");
    double radius = input.nextDouble();

    // Compute area
    double area = radius * radius * PI;

    // Display result
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```

Named Constants

- So what are the benefits of using constants?
  1. You don’t have to repeatedly type the same value if it is used multiple times
  2. If you have to change the value, you only need to change it in a single location in the code
     - Instead of changing it at all locations
  3. A descriptive name for a constant makes the program easier to read

Naming Conventions

- ☞ Choose meaningful and descriptive names.
  - Do not use abbreviations
- ☞ Variables and method names:
  - Use lowercase. If the name consists of several words, concatenate all in one, use lowercase for the first word, and capitalize the first letter of each subsequent word in the name.
  - For example, the variables `radius` and `area`, and the method `computeArea`.

Naming Conventions

- ☞ Class names:
  - – Capitalize the first letter of each word in the name.
  - – For example, the class name `ComputeArea`.
- ☞ Constants:
  - – Capitalize all letters in constants, and use underscores to connect words.
  - – For example, the constants `PI` and `MAX_VALUE`
- ☞ Do you have to follow these rules?
  - – No. But it makes your program MUCH easier to read!!!

Numerical Data Types

- Every data type has a range of possible values that it can have/hold
- Whenever you make a variable or constant, the compiler will allocate (create) memory based on the data type requested
- Java provides eight primitive data types
- The following table lists the six numeric data types and their ranges and storage sizes

Numerical Data Types

Name	Range	Storage Size
`byte`	-2^{7} to $2^{7} - 1$ (-128 to 127)	8-bit signed
`short`	-2^{15} to $2^{15} - 1$ (-32768 to 32767)	16-bit signed
`int`	-2^{31} to $2^{31} - 1$ (-2147483648 to 2147483647)	32-bit signed
`long`	-2^{63} to $2^{63} - 1$ (i.e., -9223372036854775808 to 9223372036854775807)	64-bit signed
`float`	Negative range: -3.4028235E+38 to -1.4E-45 Positive range: 1.4E-45 to 3.4028235E+38	32-bit IEEE 754
`double`	Negative range: -1.7976931348623157E+308 to -4.9E-324 Positive range: 4.9E-324 to 1.7976931348623157E+308	64-bit IEEE 754

Numerical Data Types

☞ Example:

- The largest value you can save into an integer data type is 2,147,483,647.
  - ◆ This is just over 2 billion
- So what if you try to store a value larger than this into an integer data type?

```
int x = 2147483648;
```

- Answer: you will get an error.
- This will not work.
- Solution: use a different data type
  - ◆ double, float, long

Numerical Data Types

- Java uses four data types for integers:
  - byte, short, int, long
- Which should you use?
  - Choose the type that is most appropriate for your variable.
  - Long is usually unnecessary for most int types
    - It is larger than needed.
- Normal usage:
  - `int` is normally used for integers
  - `double` is normally used for real numbers

Number Literals

- A *literal* is a constant value that appears directly in the program.
- For example, 34, 1,000,000, and 5.0 are literals in the following statements:

```
int i = 34;

long x = 1000000;

double d = 5.0;
```

Integer Literals

- An integer literal can be assigned to an integer variable as long as it can fit into the variable.
- A compilation error would occur if the literal were too large for the variable to hold.
- For example, the statement

```
byte b = 1000;
```

  - would cause a compilation error
  - 1000 cannot be stored in a variable of the byte type.
  - The range for byte is -128 to 127
    - Anything smaller or larger will result in an error!

Integer Literals

- An integer literal is assumed to be of the int type
  - The range for `int` is between -2^{31} (-2147483648) to $2^{31}–1$ (2147483647).
  - If you want an `int`, but you need to store a larger number, then you should use the type `long`
  - To denote an integer literal of the long type, append it with the letter L or l.
    - L is preferred because l (lowercase L) can easily be confused with 1 (the digit one).

Floating-Point Literals

- ☞ Floating-point literals are written with a decimal point.
  - – By default, a floating-point literal is treated as a double type value.
  - – For example, 5.0 is considered a double value, not a float value.
  - – You can make a number a float by appending the letter f or F, and make a number a double by appending the letter d or D.
    - ◆ For example, you can use 100.2f or 100.2F for a float number, and 100.2d or 100.2D for a double number.

double vs. float

The double type values are more accurate than the float type values. For example,

```
System.out.println("1.0 / 3.0 is " + 1.0 / 3.0);
```

displays $\texttt{1.0 / 3.0 is 0.}\underbrace{\texttt{3333333333333333}}_{\text{16 digits}}$

```
System.out.println("1.0F / 3.0F is " + 1.0F / 3.0F);
```

displays $\texttt{1.0F / 3.0F is 0.}\underbrace{\texttt{3333333}}_{\text{7 digits}}\texttt{4}$

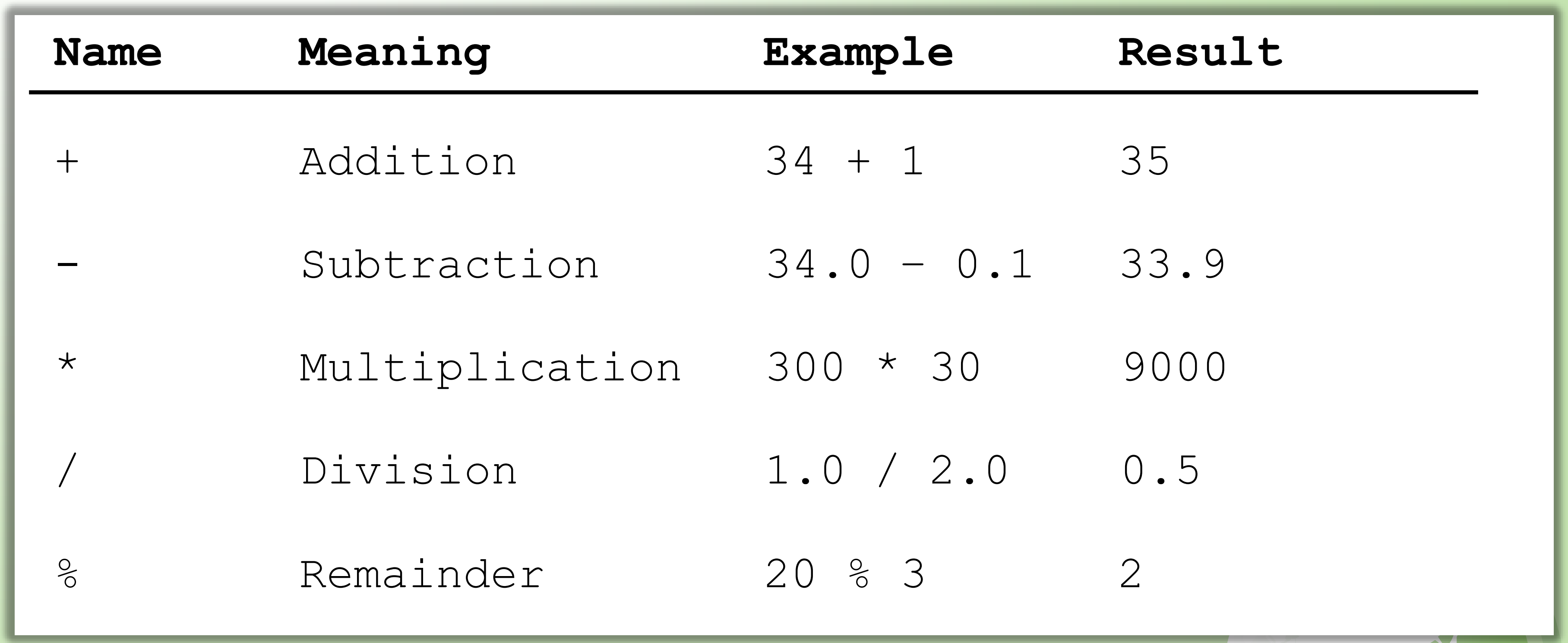
Reading Numbers from the Keyboard

```
Scanner input = new Scanner(System.in);
int value = input.nextInt();
```

Method	Description
`nextByte()`	reads an integer of the `byte` type.
`nextShort()`	reads an integer of the `short` type.
`nextInt()`	reads an integer of the `int` type.
`nextLong()`	reads an integer of the `long` type.
`nextFloat()`	reads a number of the `float` type.
`nextDouble()`	reads a number of the `double` type.

```
double grade = input.nextDouble();
```

Numeric Operators



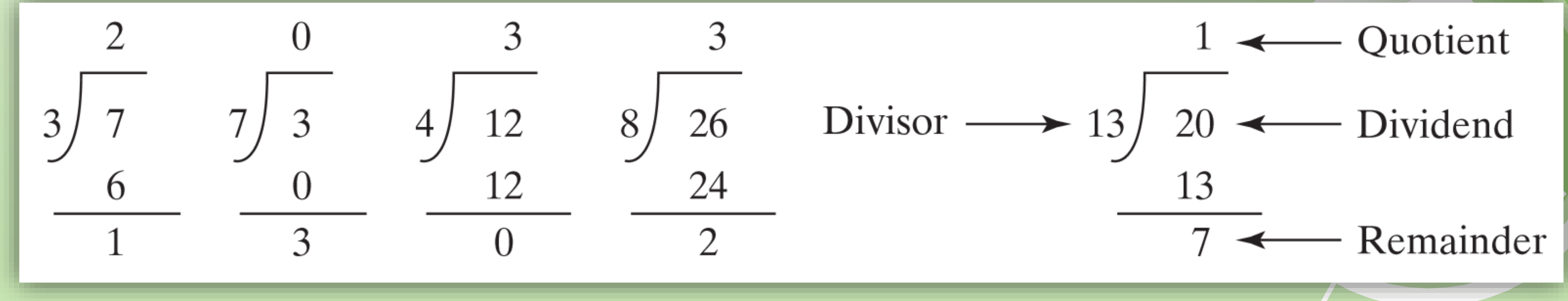
Name	Meaning	Example	Result
+	Addition	34 + 1	35
-	Subtraction	34.0 - 0.1	33.9
*	Multiplication	300 * 30	9000
/	Division	1.0 / 2.0	0.5
%	Remainder	20 % 3	2

Integer Division

- “Normal” division: 7 / 2 = 3.5
- In Computer Science, when we say division, majority of the time, we mean integer division.
  - When both operands of a division are integers, we will use integer division.
- What is integer division?
  - Easiest to explain with examples:
    - 5 / 2 = 2   12 / 5 = 2
    - 7 / 2 = 3   15 / 4 = 3
    - 15 / 2 = 7   33 / 8 = 4

Remainder Operator

- The % operator is known as the **remainder** operator, or also as the **modulo** operator
  - This operator will give the remainder after division
  - Examples:
    - 7 % 3 = 1 3 % 7 = 3
    - 12 % 4 = 0 26 % 8 = 2
    - 20 % 13 = 7

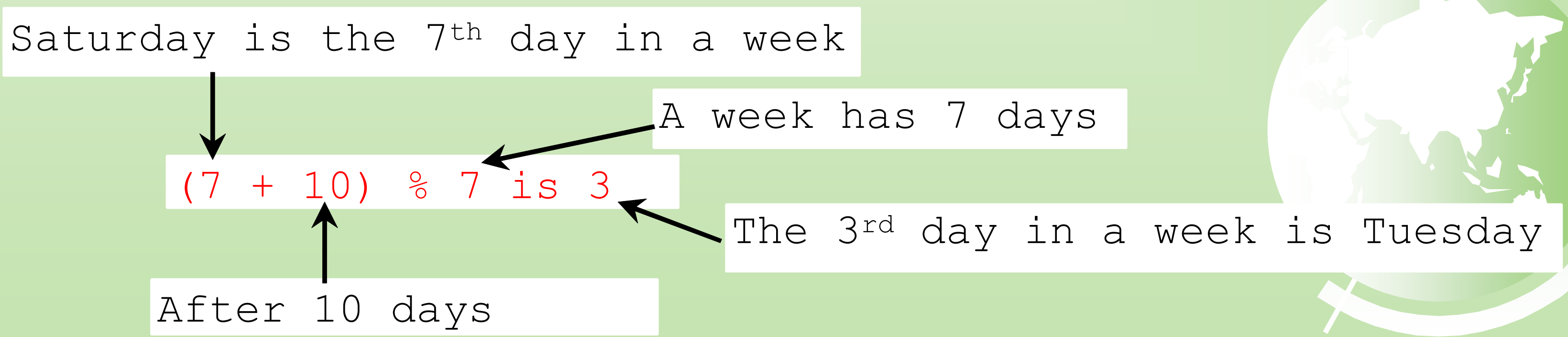


Remainder Operator

- Remainder is very useful in programming.
- For example, an even number % 2 is always 0
- An odd number % 2 is always 1
- So you can use this property to determine whether a number is even or odd.
- You can also mod by other values to achieve valuable results.

Remainder Operator

- Example:
  - If today is Saturday, it will be Saturday again in 7 days. Suppose you and your friends will meet in 10 days. What day is it in 10 days?
  - Let us assume Sunday is the 1st day of the week.
  - We can find that in 10 days, the day will be Tuesday by using the following equation:



Saturday is the 7th day in a week

A week has 7 days

```
(7 + 10) % 7 is 3
```

The 3rd day in a week is Tuesday

After 10 days

Program 5: Convert Time

- Write a program to get an amount of time from the user in seconds. Then your program should convert this time into minutes and the remaining seconds.
- Remember:
  - Step 1: Problem-solving Phase
  - Step 2: Implementation Phase

Program 5: Convert Time

- **Step 1**: Problem-solving Phase
  - If you are given seconds, how do you then calculate the minutes and remaining seconds?
    - Example:
      - Given 624 seconds, how do we calculate the minutes?
      - We divide by 60!
        - We see how many complete 60s are in 624.
        - Answer: 10 of them. 10x60 = 600.
      - So in 624 seconds, there are a full 10 minutes.
      - After we remove those 10 minutes, how many seconds are remaining?
        - 624 – (10x60) = 24 seconds remaining
        - We can use mod! 624%60 = 24 seconds remaining.

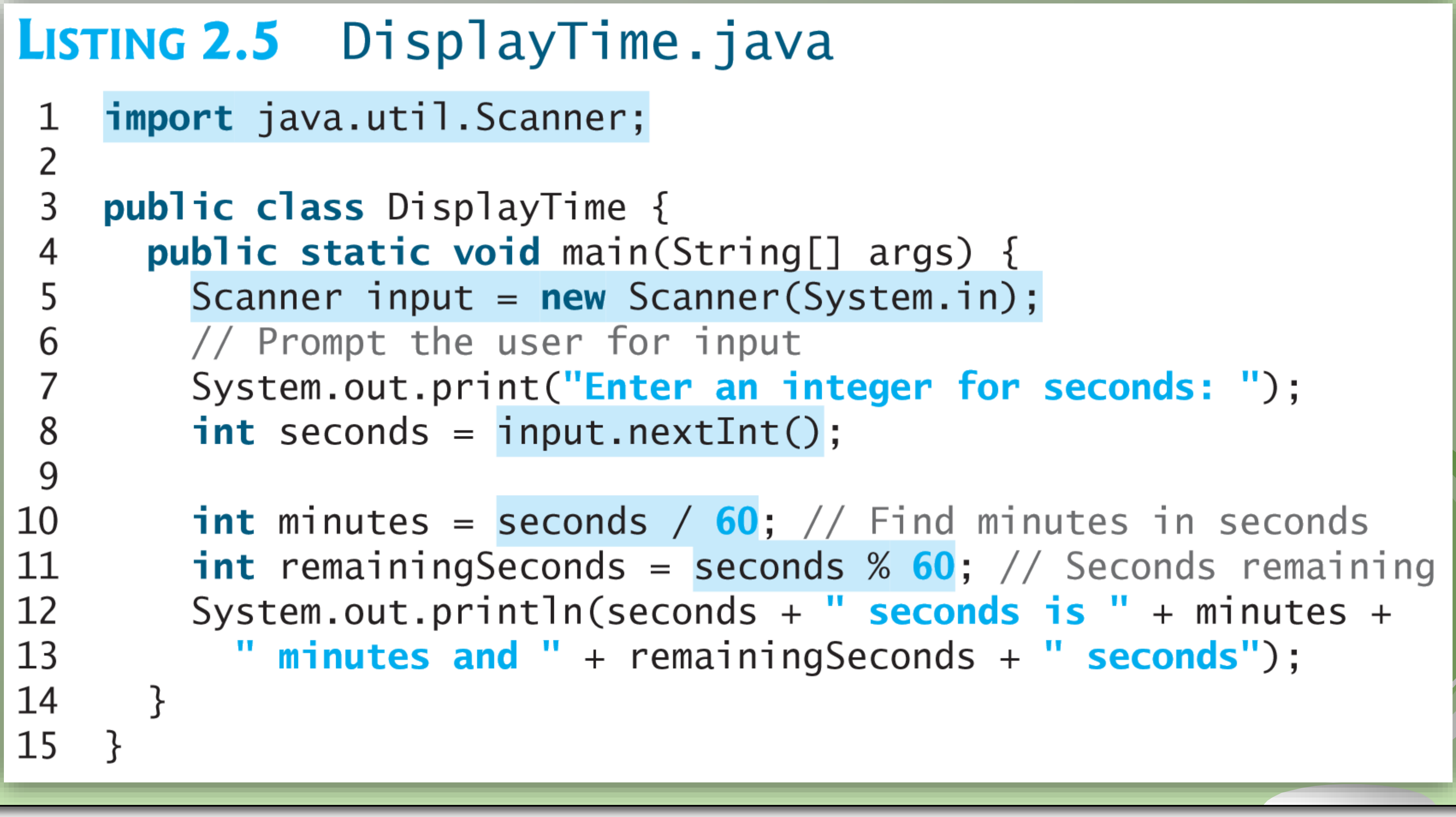
Program 5: Convert Time

- **Step 1**: Design your algorithm

  1. Get amount of seconds from the user.
     - Use Scanner object
     - Save as an int
  2. Compute the minutes and seconds remaining:
     - From these seconds, determine the number of minutes
     - Example:
       - 150 seconds => 2 minutes and 30 seconds
       - 315 seconds => 5 minutes and 15 seconds
         - 315 / 60 = 5 and 315 % 60 = 15
  3. Display the result

Program 5: Convert Time

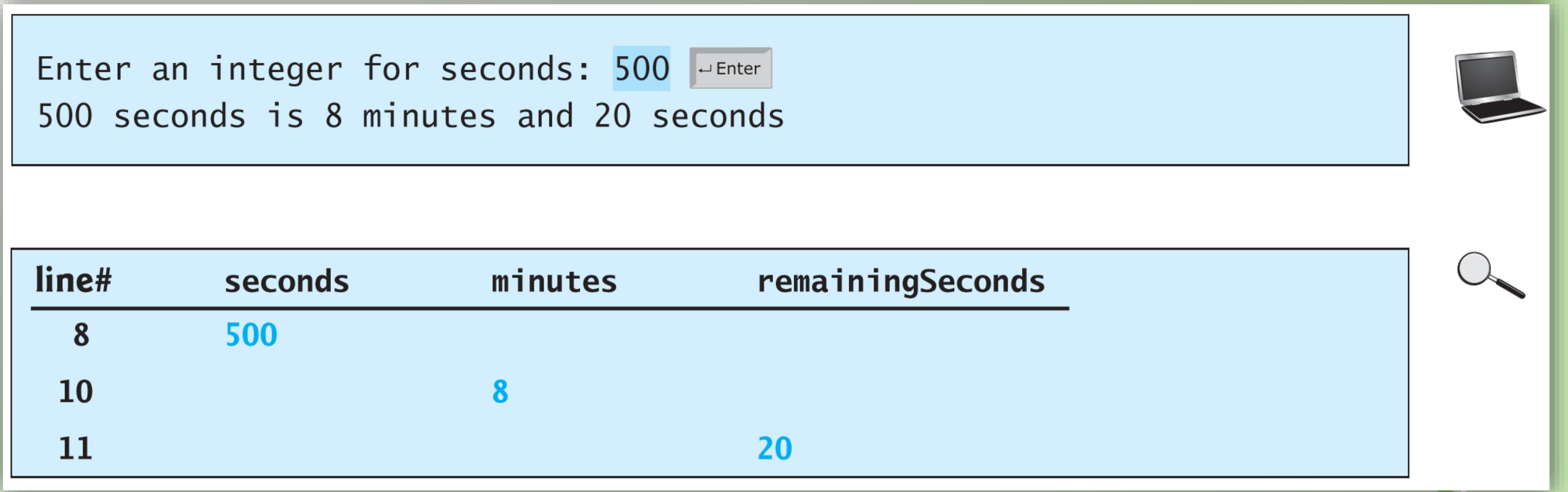
- **Step 2**: Implementation



LISTING 2.5 DisplayTime.java

```java
import java.util.Scanner;

public class DisplayTime {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);
    // Prompt the user for input
    System.out.print("Enter an integer for seconds: ");
    int seconds = input.nextInt();

    int minutes = seconds / 60; // Find minutes in seconds
    int remainingSeconds = seconds % 60; // Seconds remaining
    System.out.println(seconds + " seconds is " + minutes +
      " minutes and " + remainingSeconds + " seconds");
  }
}
```

Program 5: Convert Time



```
Enter an integer for seconds: 500 ↵Enter
500 seconds is 8 minutes and 20 seconds
```

line#	seconds	minutes	remainingSeconds
8	500		
10		8	
11			20

☞ See sample program: `TimeCalculation.java`

NOTE

☞ Calculations involving floating-point numbers are approximated because these numbers are not stored with complete accuracy.

- For example:

```
System.out.println(1.0-0.1-0.1-0.1-0.1-0.1);
```

  - displays 0.5000000000000001, not 0.5, and

```
System.out.println(1.0 - 0.9);
```

  - displays 0.09999999999999998, not 0.1.

- Integers are stored precisely.
- Therefore, calculations with integers yield a precise integer result.

Exponent Operations

```
System.out.println(Math.pow(2, 3));
// Displays 8.0
System.out.println(Math.pow(2, 5));
// Displays 32.0
System.out.println(Math.pow(4, 0.5));
// Displays 2.0
System.out.println(Math.pow(2.5, 2));
// Displays 6.25
System.out.println(Math.pow(2.5, -2));
// Displays 0.16
```

Scientific Notation

- ☞ Floating-point literals can also be specified in scientific notation
- ☞ Example:
  - – 1.23456e+2, same as 1.23456e2, is equivalent to 123.456
  - – and 1.23456e-2 is equivalent to 0.0123456
  - – E (or e) represents an exponent and it can be either in lowercase or uppercase.

Arithmetic Expressions

- Java expressions are written the same way as normal arithmetic expressions.
- Example:

$$\boxed{\frac{3+4x}{5} - \frac{10(y-5)(a+b+c)}{x} + 9(\frac{4}{x} + \frac{9+x}{y})}$$

- is translated into

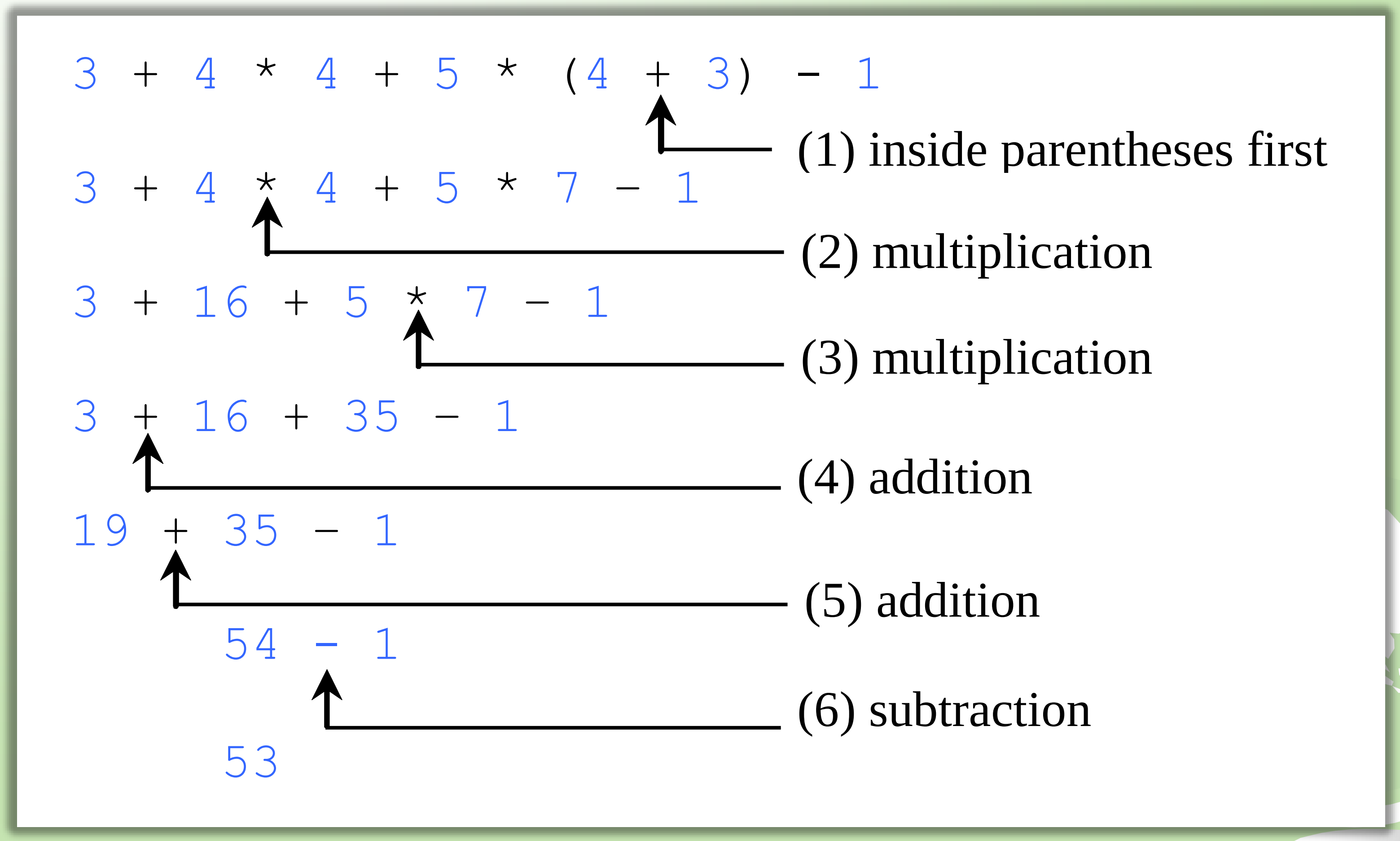
```
(3+4*x)/5 – 10*(y-5)*(a+b+c)/x + 9*(4/x + (9+x)/y)
```

How to Evaluate an Expression

- Summary: you can safely apply the arithmetic rule for evaluating a Java expression
  - Operators inside parenthesis are evaluated first
    - Parenthesis can be nested
    - Expression in inner parenthesis is evaluated first
  - Use normal operator precedence
    - Multiplication, division, and remainder are done first
      - if an expression has several multiplication, division, and remainder operators, you evaluate them from left to right
    - Addition and subtraction are done last
      - and again, if an expression has several addition and subtraction operators, you evaluate them from left to right

How to Evaluate an Expression

- Example of how an expression is evaluated:



3 + 4 * 4 + 5 * (4 + 3) - 1

(1) inside parentheses first

3 + 4 * 4 + 5 * 7 – 1

(2) multiplication

3 + 16 + 5 * 7 – 1

(3) multiplication

3 + 16 + 35 – 1

(4) addition

19 + 35 – 1

(5) addition

54 - 1

(6) subtraction

53

Program 6: Convert Temperature

- Write a program that converts a temperature in Fahrenheit into Celsius.
  - You will need the following formula:

$$celsius = (\tfrac{5}{9})(fahrenheit - 32)$$

- Remember:
  - Step 1: Problem-solving Phase
  - Step 2: Implementation Phase

Program 6: Convert Temperature

☞ **Step 1**: Design your algorithm

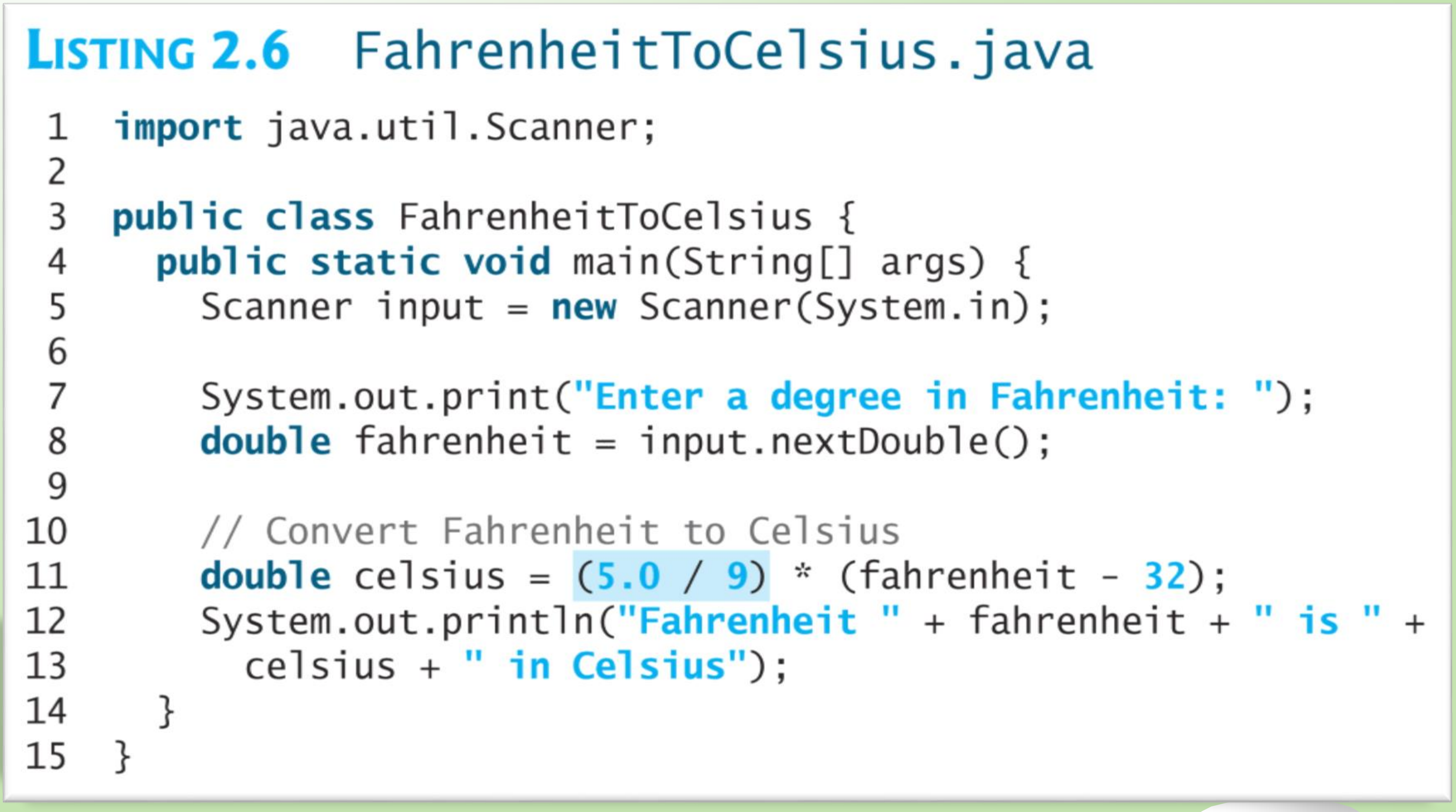
1. Get temperature in Fahrenheit from the user.
   - Use Scanner object
   - Save temperature as an int
2. Compute the temperature into Celsuis:
   - Use formula: $celsius = (\frac{5}{9})(fahrenheit - 32)$
   - But write the formula in Java:

```
celsius = (5.0 / 9) * (fahrenheit – 32);
```

3. Display the result

Program 6: Convert Temperature

- **Step 2**: Implementation



LISTING 2.6 FahrenheitToCelsius.java

```java
import java.util.Scanner;

public class FahrenheitToCelsius {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);

    System.out.print("Enter a degree in Fahrenheit: ");
    double fahrenheit = input.nextDouble();

    // Convert Fahrenheit to Celsius
    double celsius = (5.0 / 9) * (fahrenheit - 32);
    System.out.println("Fahrenheit " + fahrenheit + " is " +
      celsius + " in Celsius");
  }
}
```

Program 6: Convert Temperature

- Discussion: be careful when dividing integers
  – Notice the formula has 5 divided by 9

$$celsius = (\tfrac{5}{9})(fahrenheit - 32)$$

  – What happens if we write this formula as:

```
celsius = (5 / 9) * (fahrenheit – 32);
```

  – (5 / 9) evaluates to zero!
    - Integer division!

  – So we use (5.0 / 9) instead, which gives a number

- See sample program: `TempConvert.java`

Program 7: Show Current Time

- Write a program that displays current time in GMT in the format hour:minute:second such as 1:45:19.

- Remember:
  - Step 1: Problem-solving Phase
  - Step 2: Implementation Phase

Program 7: Show Current Time

- ☞ **Step 1**: Problem-solving Phase
  - Remember how you print to the screen?
    - You use the method println
    - This method is inside the System class

      `System.out.println`
  - Well, there are many beneficial methods inside this System class.
  - Java provides a method to return the current time

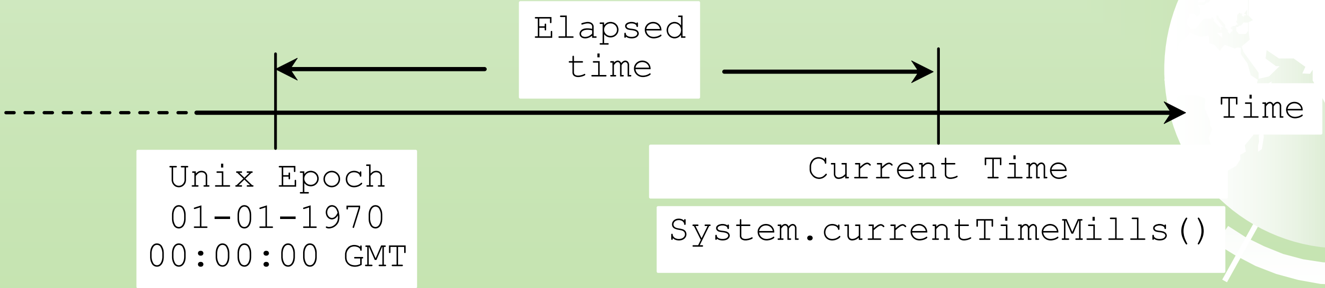
    `System.currentTimeMillis()`
    - This method returns the current time, in milliseconds, in milliseconds since midnight, January 1, 1970 GMT.

Program 7: Show Current Time

☞ **Step 1**: Problem-solving Phase

`System.currentTimeMillis()`

- This method returns the current time, in milliseconds, in milliseconds since midnight, January 1, 1970 GMT.
- Why this specific date?
- This was known as the *UNIX epoch*
  - The point in time when UNIX started
    - Important? Not really. Just a neat fact!



Program 7: Show Current Time

☞ **Step 1**: Problem-solving Phase

`System.currentTimeMillis()`

- So this method returns the number of milliseconds since 1970.
- That's a **LOT** of milliseconds
- It's 2015…so 45 years since 1970
- $45\ years\ \times \frac{365\ days}{1\ year} \times \frac{24\ hours}{1\ day} \times \frac{3600\ seconds}{1\ hour} \times \frac{1000\ ms}{1\ second}$
- Now take a calculator…
  - That comes to **1,419,210,000,000 milliseconds**

– The point: this methods returns a HUGE number

- So how can we calculate the time from this number???

Program 7: Show Current Time

- **Step 1**: Problem-solving Phase
  1. Get the total milliseconds since midnight, January 1, 1970 by invoking:
     - `System.currentTimeMillis();`
       - – Example: 1203183068328 milliseconds
  2. Obtain the total number of seconds by dividing totalMilliseconds by 1000
     - `totalSeconds = totalMilliseconds / 1000;`
       - – Example: 1203183068328 ms / 1000 = 1203183068 seconds
  3. Compute the current seconds from totalSeconds
     - `currentSeconds = totalSeconds % 60;`
       - – Example: 1203183068 % 60 = 8, which is the current second

Program 7: Show Current Time

- **Step 1**: Problem-solving Phase

4. Obtain the total minutes, `totalMinutes`, by dividing totalSeconds by 60
   - `totalMinutes = totalSeconds / 60;`
     - Example: 1203183068 seconds / 60 = 20053051 minutes
5. Compute the current minute from totalMinutes mod 60
   - `currentMinute = totalMinutes % 60;`
     - Example: 20053051 minutes % 60 = 31, the current minute

Program 7: Show Current Time

- **Step 1**: Problem-solving Phase

  6. Obtain the total hours, totalHours, by dividing totalMinutes by 60
     - `totalHours = totalMinutes / 60;`
       - Example: 20053051 minutes / 60 = 334217 hours
  7. Compute the current hour from totalHours % 24
     - `currentHour = totalHours % 24;`
       - Example: 334217 hours % 24 = 17, which is the current hour

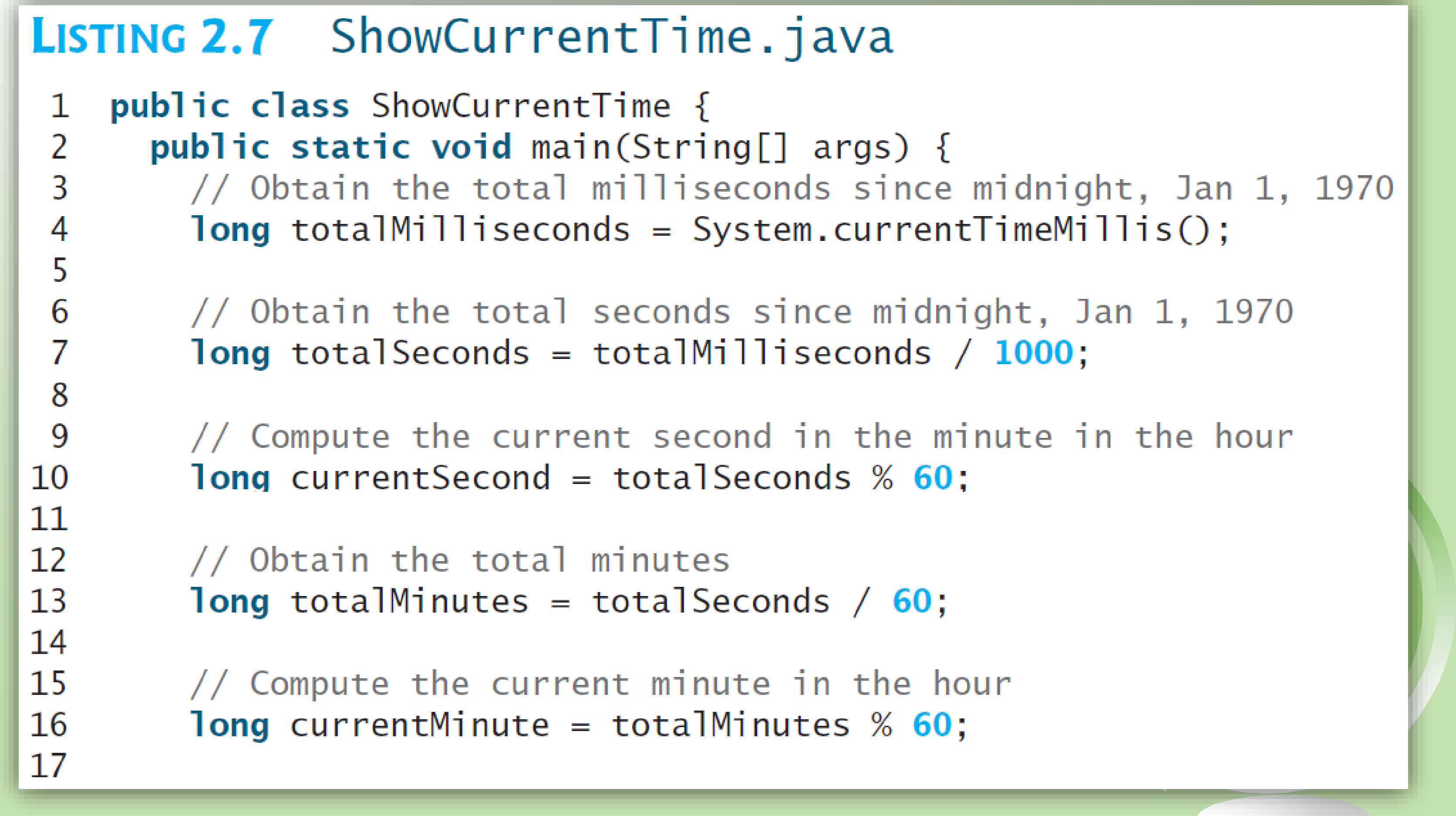
- The final time:
  - 17:31:8 GMT, or 5:31 PM and 8 seconds

Program 7: Show Current Time

- **Step 1**: Problem-solving Phase
  - All these numbers are HUGE
  - The `int` data type is not large enough
  - All variables should be declared as the **`long`** data type for this program

Program 7: Show Current Time

- **Step 2**: Implementation

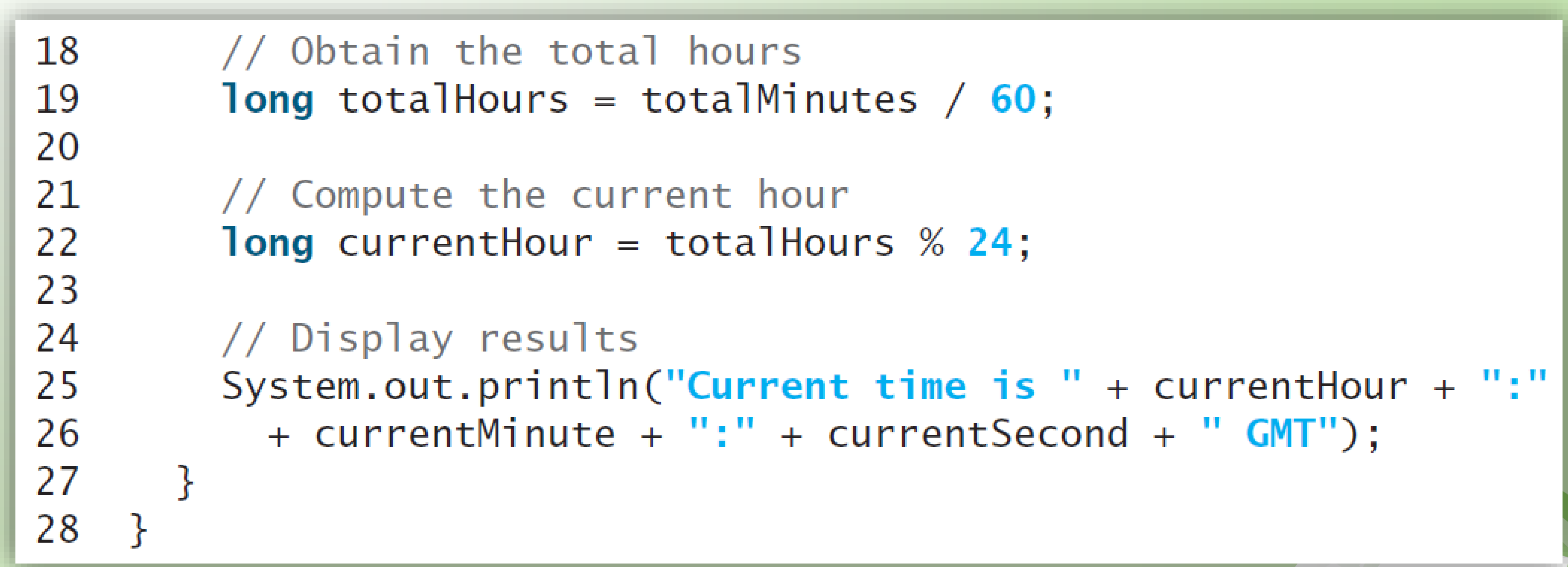


LISTING 2.7 ShowCurrentTime.java

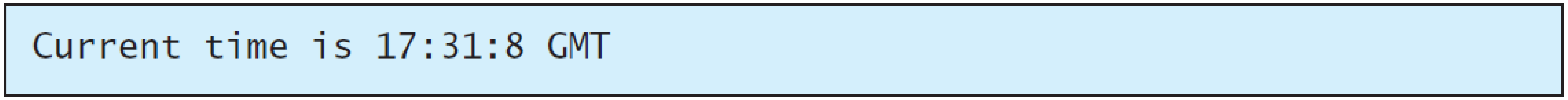
```java
public class ShowCurrentTime {
  public static void main(String[] args) {
    // Obtain the total milliseconds since midnight, Jan 1, 1970
    long totalMilliseconds = System.currentTimeMillis();

    // Obtain the total seconds since midnight, Jan 1, 1970
    long totalSeconds = totalMilliseconds / 1000;

    // Compute the current second in the minute in the hour
    long currentSecond = totalSeconds % 60;

    // Obtain the total minutes
    long totalMinutes = totalSeconds / 60;

    // Compute the current minute in the hour
    long currentMinute = totalMinutes % 60;

```

Program 7: Show Current Time

☞ **Step 2**: Implementation



```
    // Obtain the total hours
    long totalHours = totalMinutes / 60;

    // Compute the current hour
    long currentHour = totalHours % 24;

    // Display results
    System.out.println("Current time is " + currentHour + ":"
      + currentMinute + ":" + currentSecond + " GMT");
  }
}
```



```
Current time is 17:31:8 GMT
```

Augmented Assignment Operators

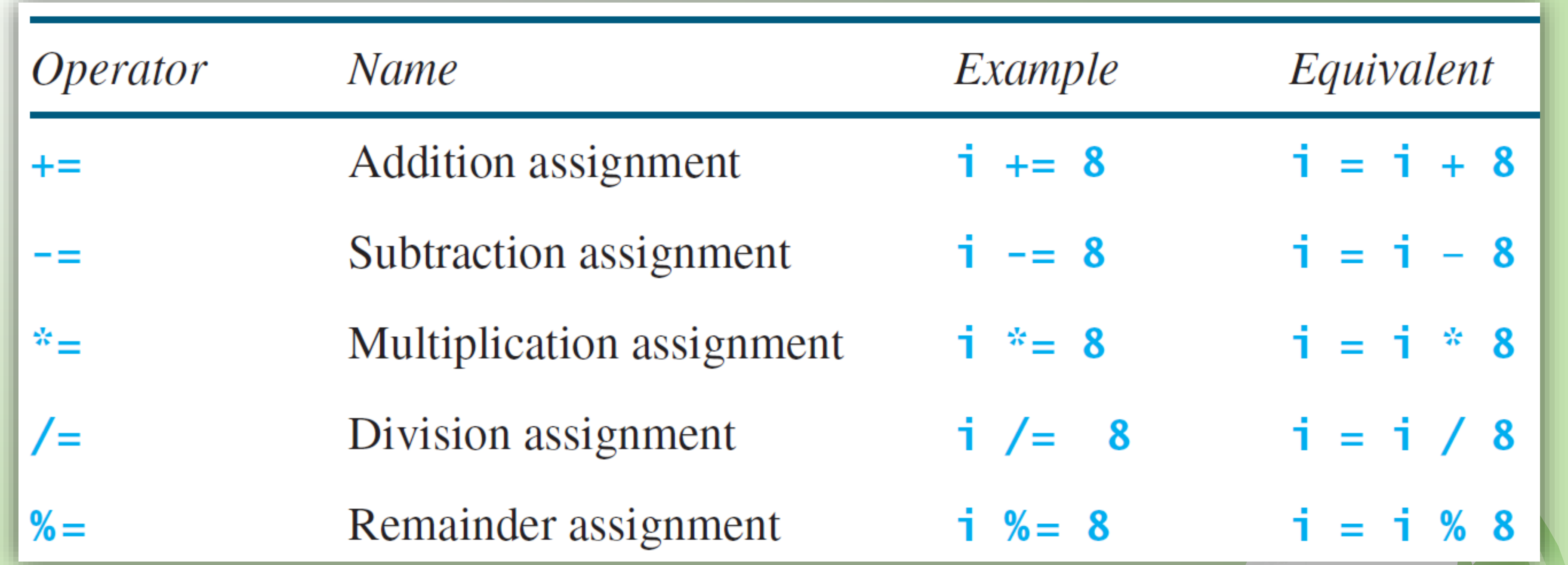
- ☞ Very often, we use the current value of a variable, we modify it, and then save it back to the same variable.
  - Example:

```
count = count + 1;
```

  - Java allows you to combine this addition and assignment into one operator, which is called the augmented assignment operator.
  - Example:

```
count += 1;
```

Augmented Assignment Operators



Operator	*Name*	*Example*	*Equivalent*
`+=`	Addition assignment	`i += 8`	`i = i + 8`
`-=`	Subtraction assignment	`i -= 8`	`i = i - 8`
`*=`	Multiplication assignment	`i *= 8`	`i = i * 8`
`/=`	Division assignment	`i /=  8`	`i = i / 8`
`%=`	Remainder assignment	`i %= 8`	`i = i % 8`

Augmented Assignment Operators

- The augmented assignment operator is performed last after all the other operators in the expression are evaluate
  - Example:

    ```
    x /= 4 + 5.5 * 1.5;
    ```

    is same as

    ```
    x = x / (4 + 5.5 * 1.5);
    ```

  - Caution: there are no spaces in the augmented operators
    - For example, **+ =** should be **+=** (with no space)

Increment and Decrement Operators

- Another common expression is to simply increment (increase) a variable by one
  - Such as x = x + 1;
  - Because this is so common, Java gives you special increment and decrement operators
    - Increment operator: `++`
    - Decrement operator: `--`
  - Examples:

```
int i = 3, j = 3;
i++;  // i becomes 4
j--;  // j becomes 2
```

Increment and Decrement Operators

- More details:
  - `i++` is pronounced as **i** plus plus
  - `i--` is pronounced as **i** minus minus
- – These two operators are known as postincrement and postdecrement
- – Why?
  - Because the operators (`++` and `--`) are placed after the variable
- – The operators can also be placed before the variable

Increment and Decrement Operators

- ☞ More details:
  - – The operators can also be placed before the variable

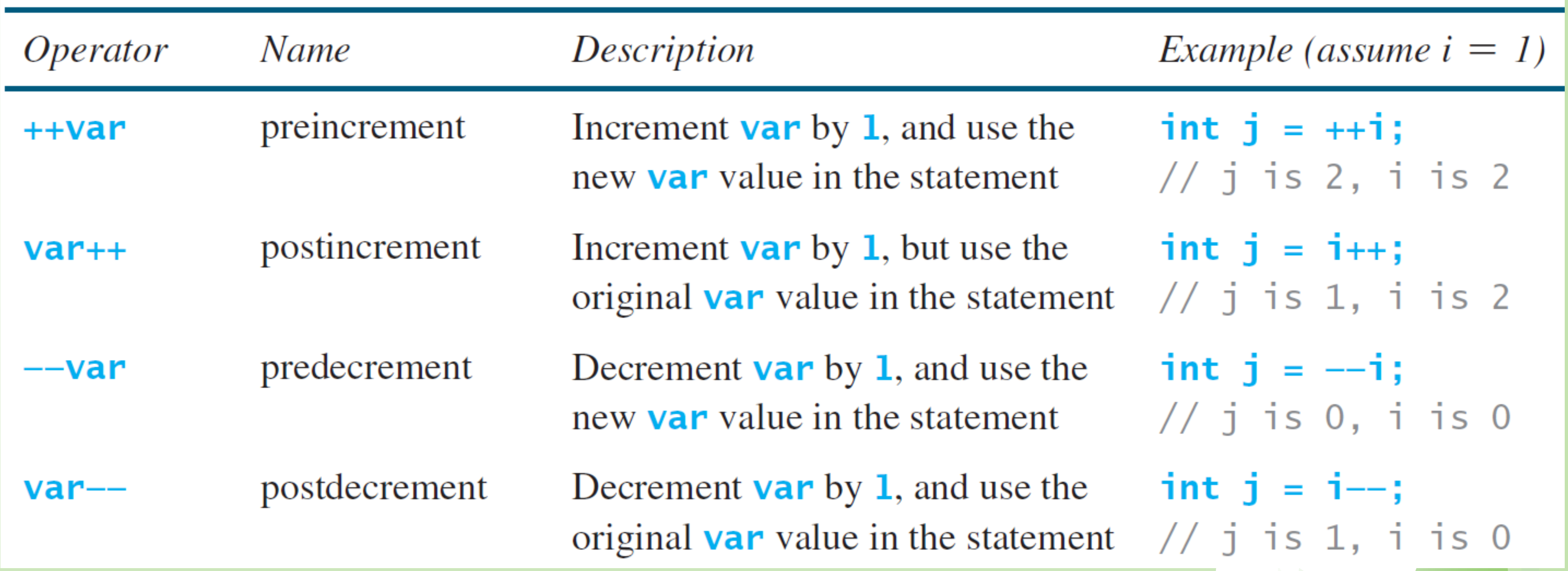
```
int i = 3, j = 3;
++i;  // i becomes 4
--j;  // j becomes 2
```

  - – Again, ++i increments i, and --j decrements j
  - – In this small example, result is the same
    - ◆ Meaning i++ and ++i both increase i from 3 to 4.
    - ◆ And both --j and j– decrease j from 3 to 2.

Increment and Decrement Operators

- More details:
  - If the statement is ONLY doing increment or decrement, the effect of j++ and ++j is the same.
  - However, the effect changes when these operators are used in other types of statements.
    - Specifically:
      - ++i: the increment is done <u>before</u> evaluating an expression
      - i++: the increment is done <u>after</u> evaluated an expression
  - Study the following table and examine the results…

Increment and Decrement Operators



Operator	*Name*	*Description*	*Example (assume i = 1)*

`++var`	preincrement	Increment `var` by `1`, and use the new `var` value in the statement	`int j = ++i;`
			`// j is 2, i is 2`

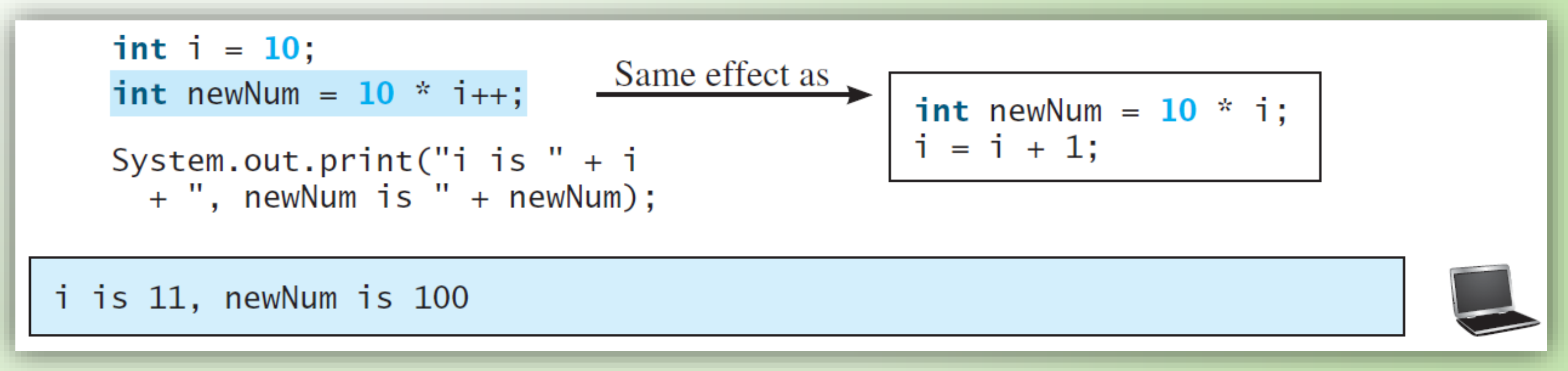
`var++`	postincrement	Increment `var` by `1`, but use the original `var` value in the statement	`int j = i++;`
			`// j is 1, i is 2`

`--var`	predecrement	Decrement `var` by `1`, and use the new `var` value in the statement	`int j = --i;`
			`// j is 0, i is 0`

`var--`	postdecrement	Decrement `var` by `1`, and use the original `var` value in the statement	`int j = i--;`
			`// j is 1, i is 0`

Increment and Decrement Operators

- Consider the following code:



```
int i = 10;
int newNum = 10 * i++;

System.out.print("i is " + i
  + ", newNum is " + newNum);
```

Same effect as

```
int newNum = 10 * i;
i = i + 1;
```

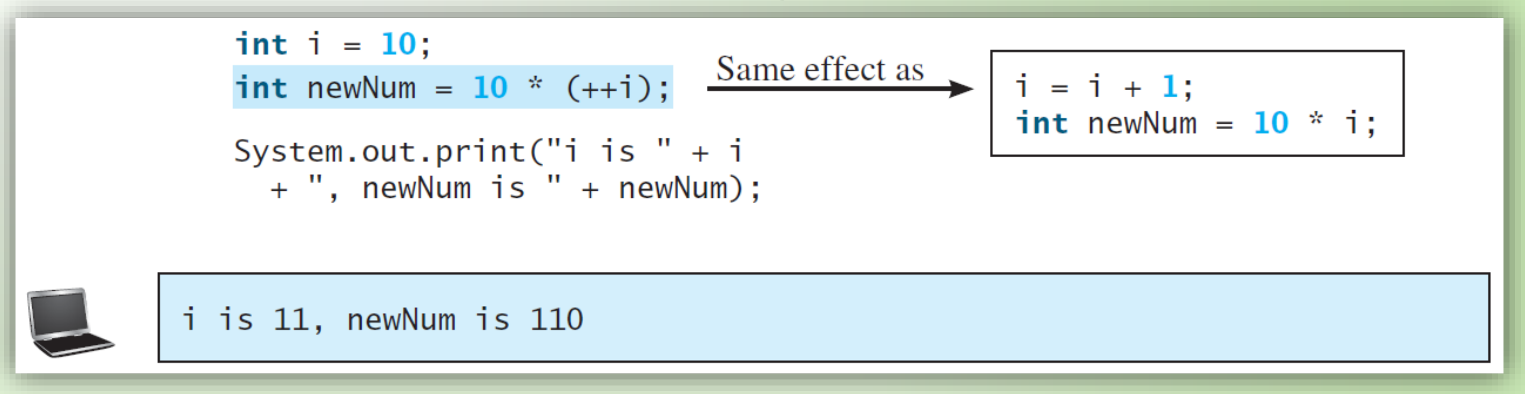
```
i is 11, newNum is 100
```

– Details:

- Here, we first get the value of i (which is 10) and calculate `newNum`.
- Then, we increment i.
  – i is not incremented until AFTER the expression is evaluated.

Increment and Decrement Operators

☞ Consider the following code:



```
int i = 10;
int newNum = 10 * (++i);

System.out.print("i is " + i
  + ", newNum is " + newNum);
```

Same effect as

```
i = i + 1;
int newNum = 10 * i;
```

```
i is 11, newNum is 110
```

– Details:

- Here, we first increment i
- Then, after i is incremented, we calculate `newNum`

Increment and Decrement Operators

- Another example:
  - Consider the following code:

```
double x = 1.0;
double y = 5.0;
double z = x-- + (++y);
```

  - What is the value of x, y, and z after are three lines are executed?
    - **x** becomes **0.0**
    - **y** becomes **6.0**
    - **z** becomes **7.0**

Increment and Decrement Operators

☞ More details:

- Using increment and decrement operators makes expressions short
  - but it also makes them complex and difficult to read
- Avoid using these operators in expressions that modify multiple variables, or the same variable for multiple times such as this:

```
int k = ++i + i;
```

  - Is this legal?
    - Yes. But it is confusing!
    - Message: don’t use increment/decrement like this.

Numeric Type Conversions

- Can you perform binary operations with operands of different types?
  - Meaning, can we add an integer literal with a double literal?
  - Answer: YES.
    - If you add an integer with a floating-point number, Java automatically coverts the int to a floating point value.
  - Example:
    - 3 * 4.5 is the same as
    - 3.0 * 4.5

Numeric Type Conversions

- ☞ Details:
  - – You can always assign a value to a numeric variable just so long as the value is within the limits/range of the data type.
  - – Example:
    - ◆ You can save an int into a double, because the double is much wider (larger) than the int

```
int x = 4;
double y;
y = x;
```

    - ◆ This is allowed, because x can easily “fit” into y.

Numeric Type Conversions

- Details:
  - However, you cannot assign a value to a variable of a data type with a smaller range of values.
    - Unless you use *type casting*
  - ***Casting*** is an operation that coverts a value of one data type into a value of another data type
    - Casting a type with a small range to a type with a larger range is known as "widening a type"
    - Casting a type with a large range to a type from a smaller range is known as "narrowing a type"

Numeric Type Conversions

☞ Casting:

- Java will automatically widen a type, but you must request a narrowing explicitly
- Syntax:
  - specify the target type in parentheses, followed by the variable’s name or the value to be cast
- Example:

```
System.out.println((int)1.7);
```

  - 1 gets printed.
  - Why? Because 1.7 was converted into an int.

Numeric Type Conversions

- ☞ Casting:
  - – Example:

```
System.out.println((double)1/2);
```

    - ◆ 0.5 gets printed.
    - ◆ Why? Because 1 is cast into 1.0. Then 1.0 is divided by 2.
  - – Example:

```
System.out.println(1 / 2);
```

    - ◆ Be careful!
    - ◆ Here, 0 (zero) gets printed. Why? 1 and 2 are both inters and the result should be an integer.

Type Casting

Implicit casting

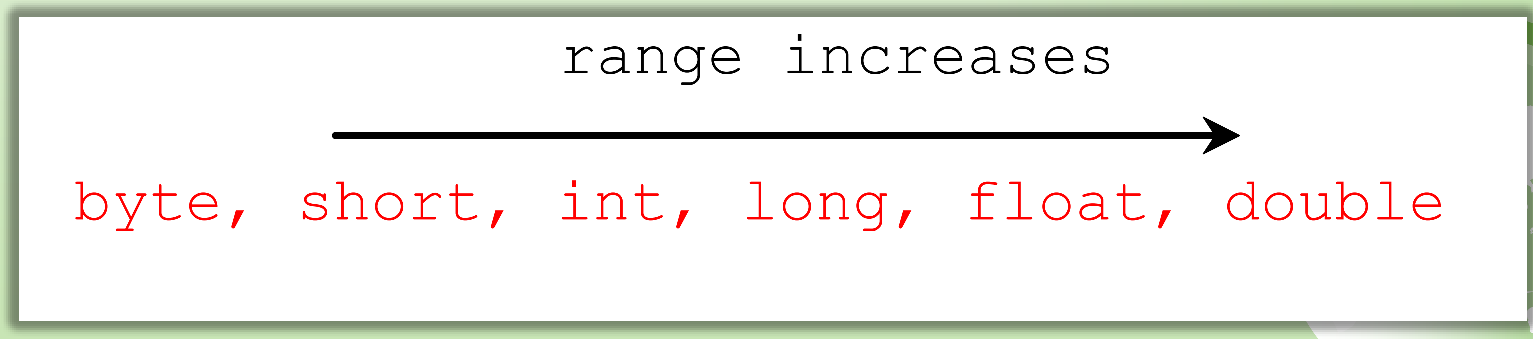
```
double d = 3; //
```
(type widening)

Explicit casting

```
int i = (int)3.0; //
```
(type narrowing)

```
int i = (int)3.9; //
```
(Fraction part is truncated)

What is wrong? `int x = 5 / 2.0;`



range increases

byte, short, int, long, float, double

☞ See sample program: `JavaBasics.java`

Conversion Rules

When performing a binary operation involving two operands of different types, Java automatically converts the operand based on the following rules:

1. If one of the operands is double, the other is converted into double.
2. Otherwise, if one of the operands is float, the other is converted into float.
3. Otherwise, if one of the operands is long, the other is converted into long.
4. Otherwise, both operands are converted into int.

Program 8: Sales Tax

- Write a program that reads a purchase amount from the user, calculates the sales tax, and then displays the result.
  - But we want to print the tax with only two decimal places
- Remember:
  - Step 1: Problem-solving Phase
  - Step 2: Implementation Phase

Program 8: Sales Tax

☞ **Step 1**: Design your algorithm

1. Get purchase amount from user.
   - Use Scanner object
   - Save `purchaseAmount` as a double
2. Compute the tax:
   - Use a simple tax rate (6%)
   - Use the formula:
     - tax = purchaseAmount * 0.06
3. Display the result
   - Print the result, but show only two decimal places

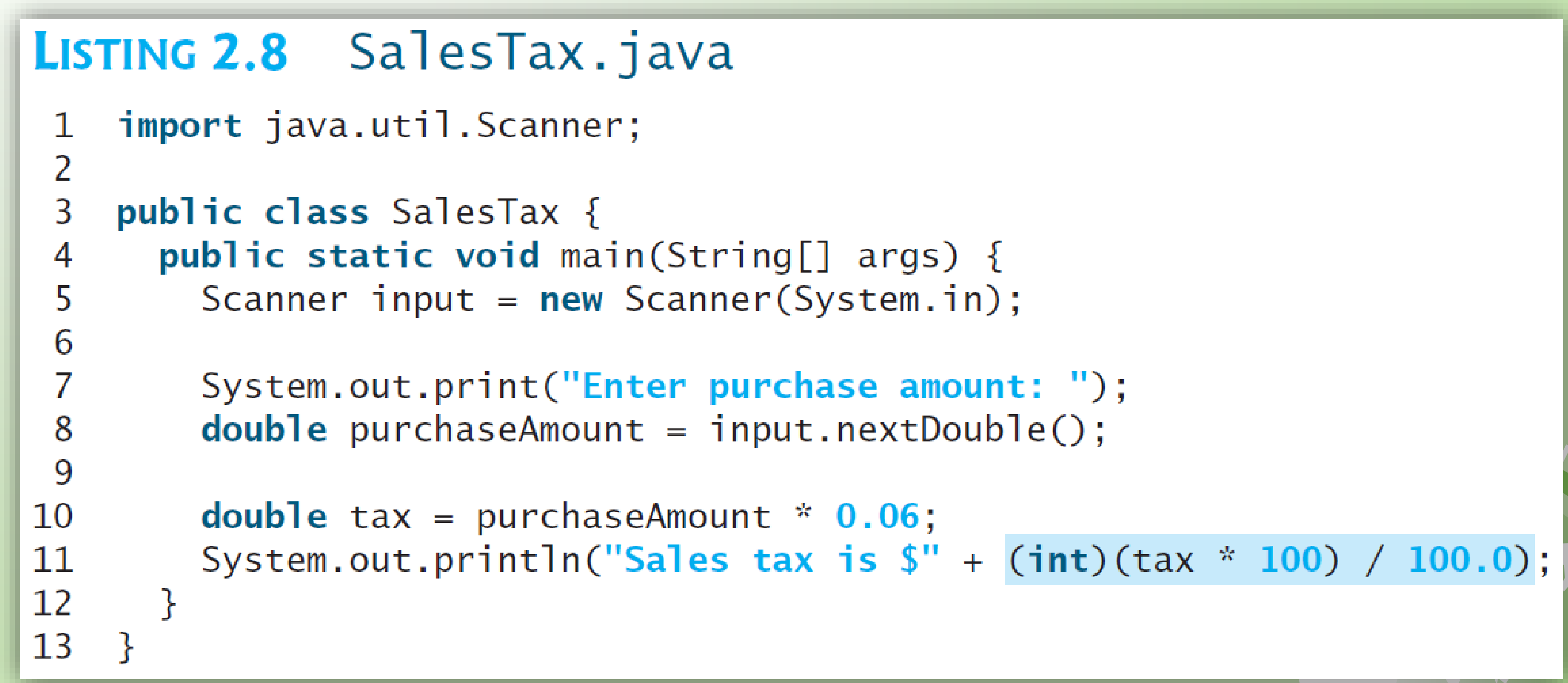
Program 8: Sales Tax

☞ Example:

- If `purchaseAmount` is entered as 197.55
- Then the sales tax is evaluated as 197.55 * 0.06
  - ◆ This equals **11.853**
- So how do we display this with only two decimals?
  1. Multiply 11.853 by 100
     - 11.853 * 100 = **1185.3**
  2. Cast the result as an integer
     - Now 1185.3 becomes **1185** (the .3 is removed)
  3. Now, divide by 100.0, which is a double
     - And we get **11.85**

Program 8: Sales Tax

- ☞ **Step 2**: Implementation



LISTING 2.8 SalesTax.java

```java
import java.util.Scanner;

public class SalesTax {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);

    System.out.print("Enter purchase amount: ");
    double purchaseAmount = input.nextDouble();

    double tax = purchaseAmount * 0.06;
    System.out.println("Sales tax is $" + (int)(tax * 100) / 100.0);
  }
}
```

- ☞ See sample program: `SalesTax.java`

Casting in an Augmented Expression

- In Java, an **augmented expression** of the form **x1 op= x2** is implemented as
  - **x1 = (T)(x1 op x2)**
    - where **T** is the type for **x1**.

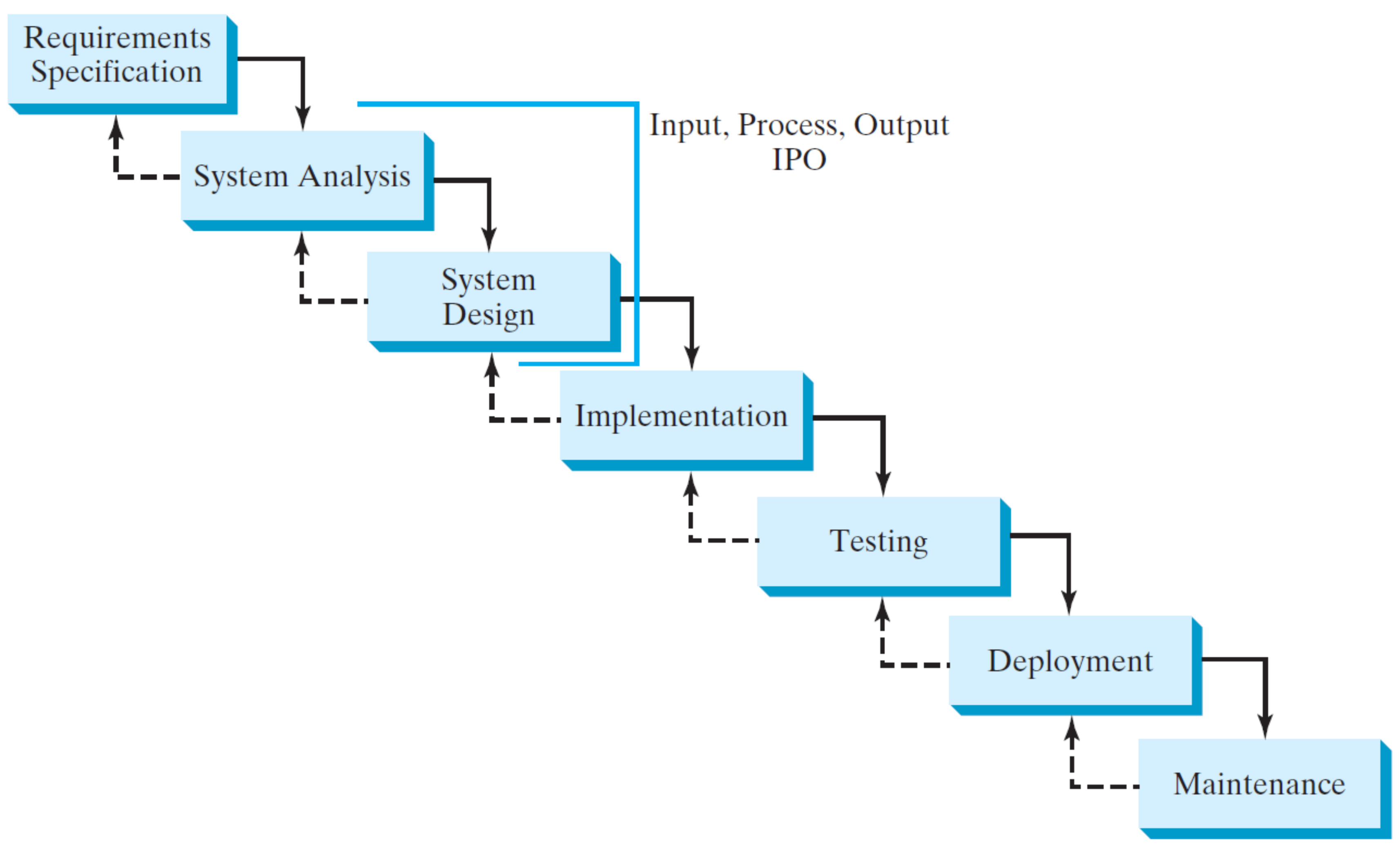
Here, OP means operation.

- Example

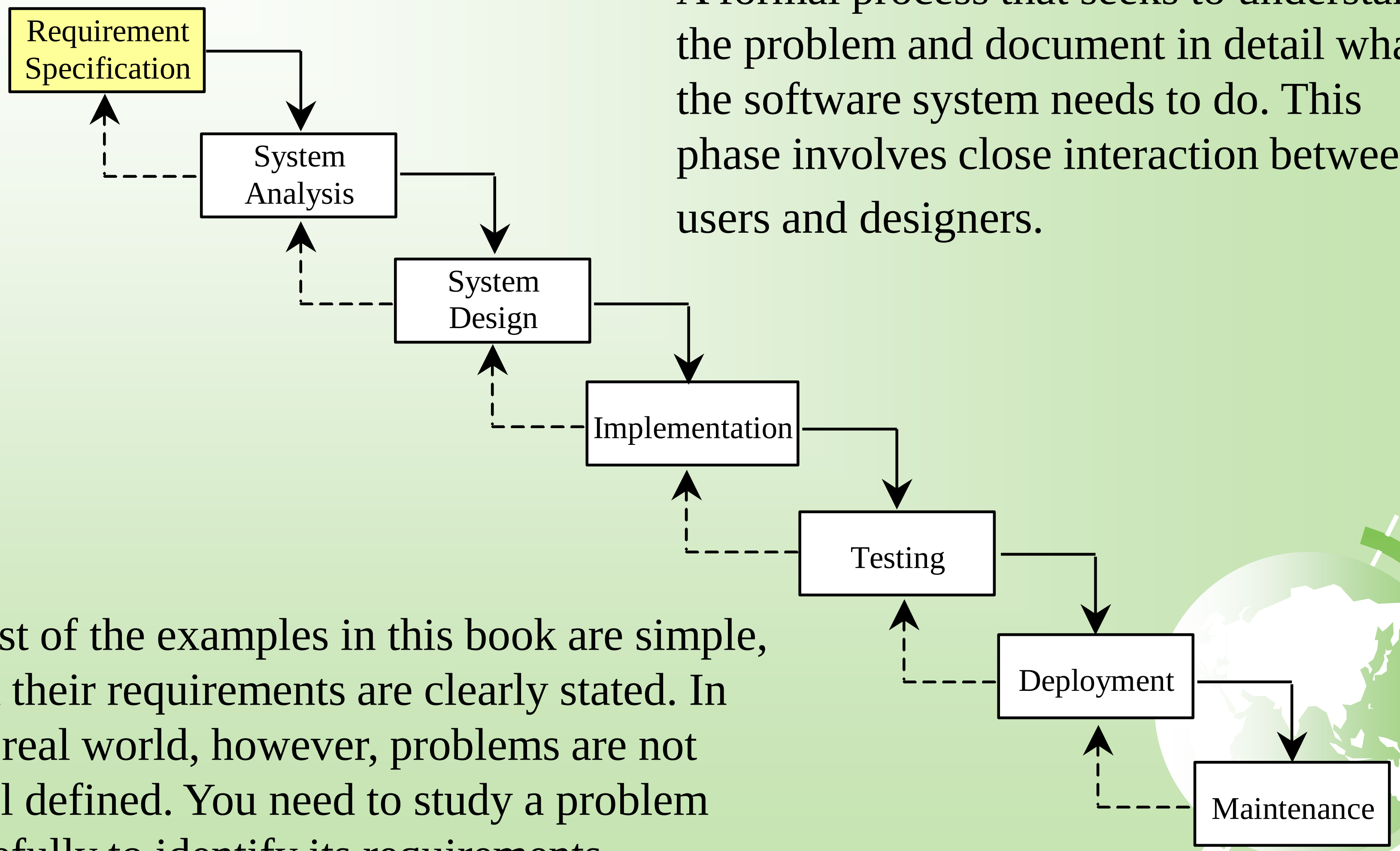
```
int sum = 0;
sum += 4.5; // sum becomes 4 after this statement
```

  - This is equivalent to:
    - `sum = (int)(sum + 4.5);`

Software Development Process



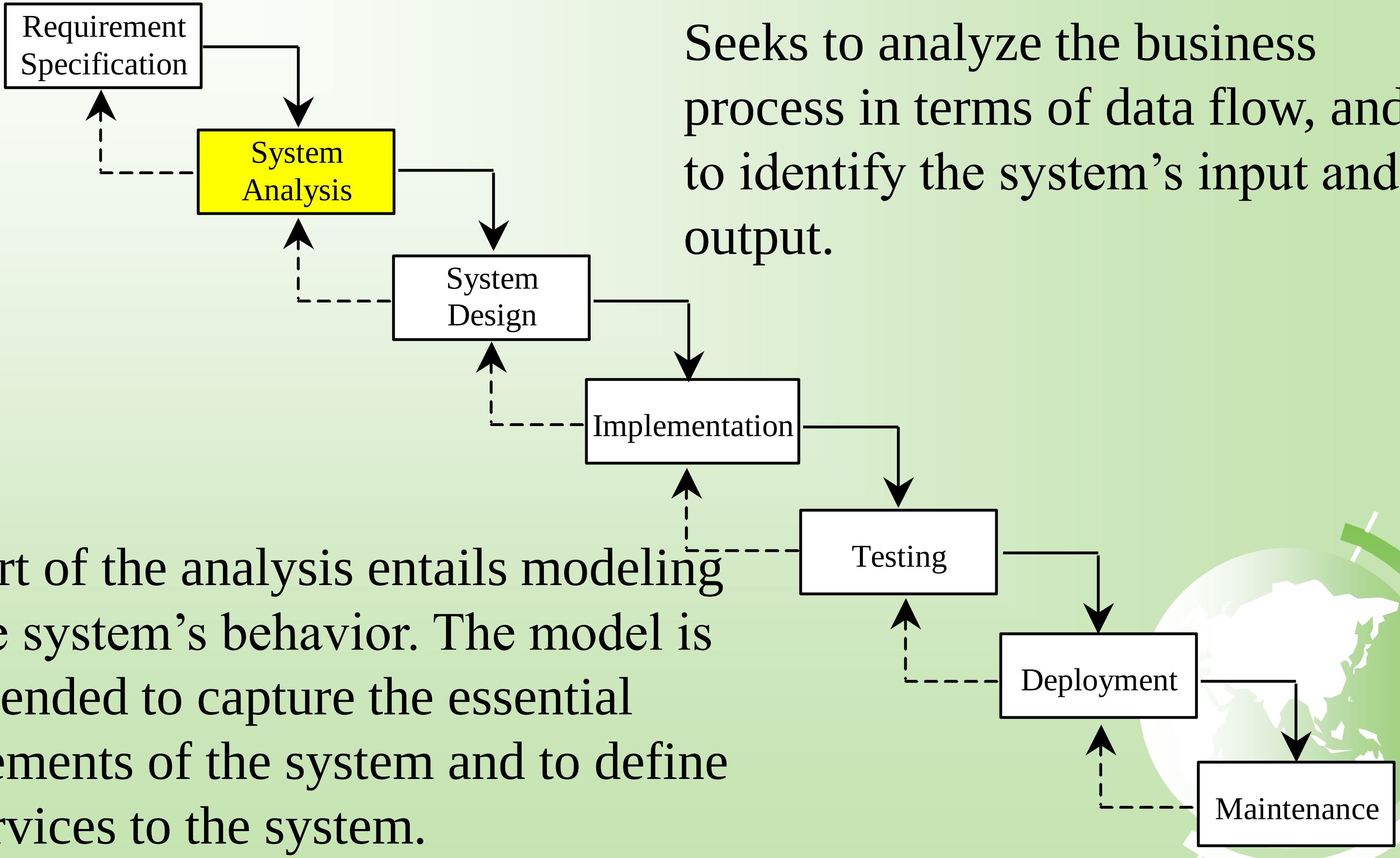
Requirement Specification



A formal process that seeks to understand the problem and document in detail what the software system needs to do. This phase involves close interaction between users and designers.

Most of the examples in this book are simple, and their requirements are clearly stated. In the real world, however, problems are not well defined. You need to study a problem carefully to identify its requirements.

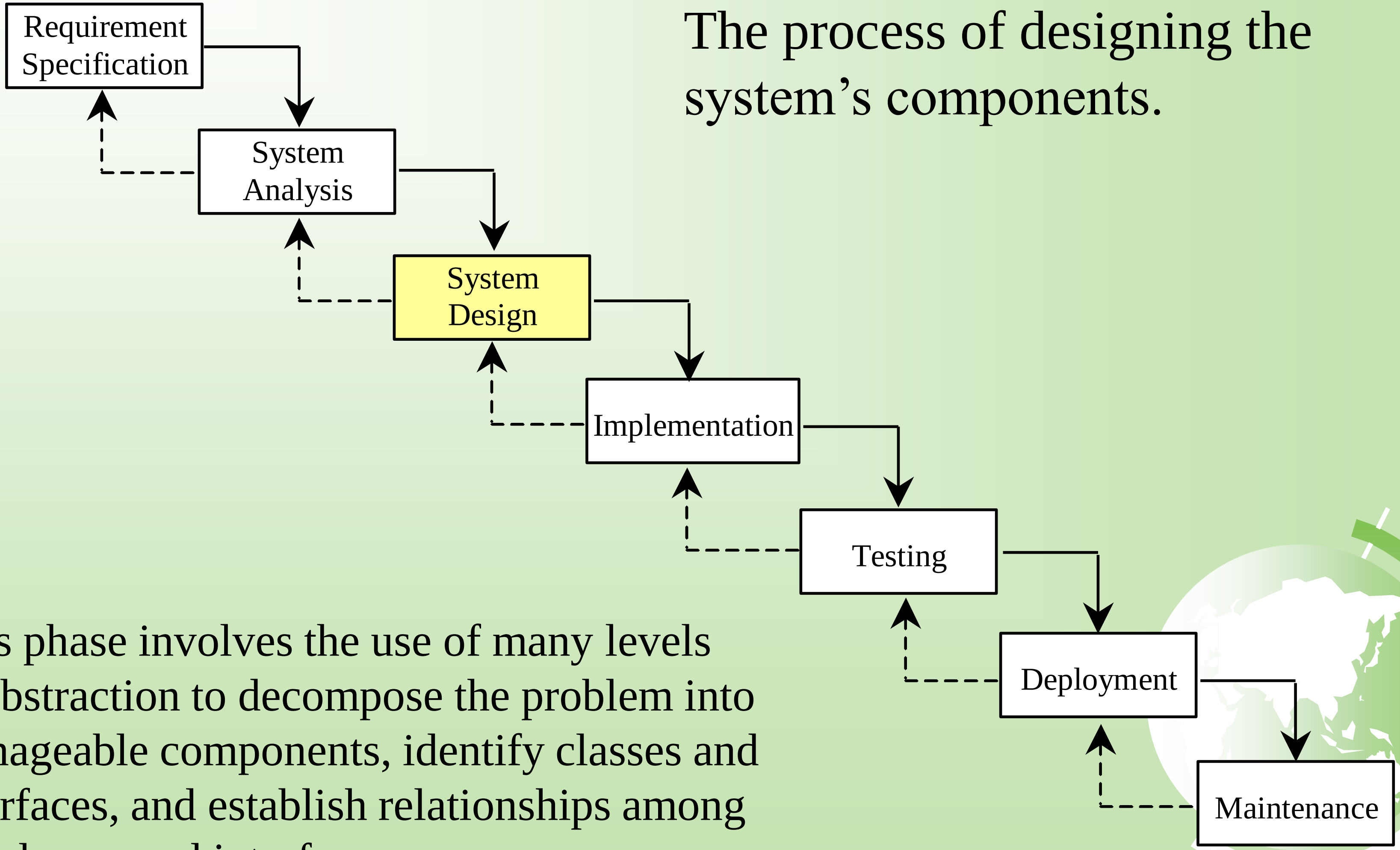
System Analysis



Seeks to analyze the business process in terms of data flow, and to identify the system’s input and output.

Part of the analysis entails modeling the system’s behavior. The model is intended to capture the essential elements of the system and to define services to the system.

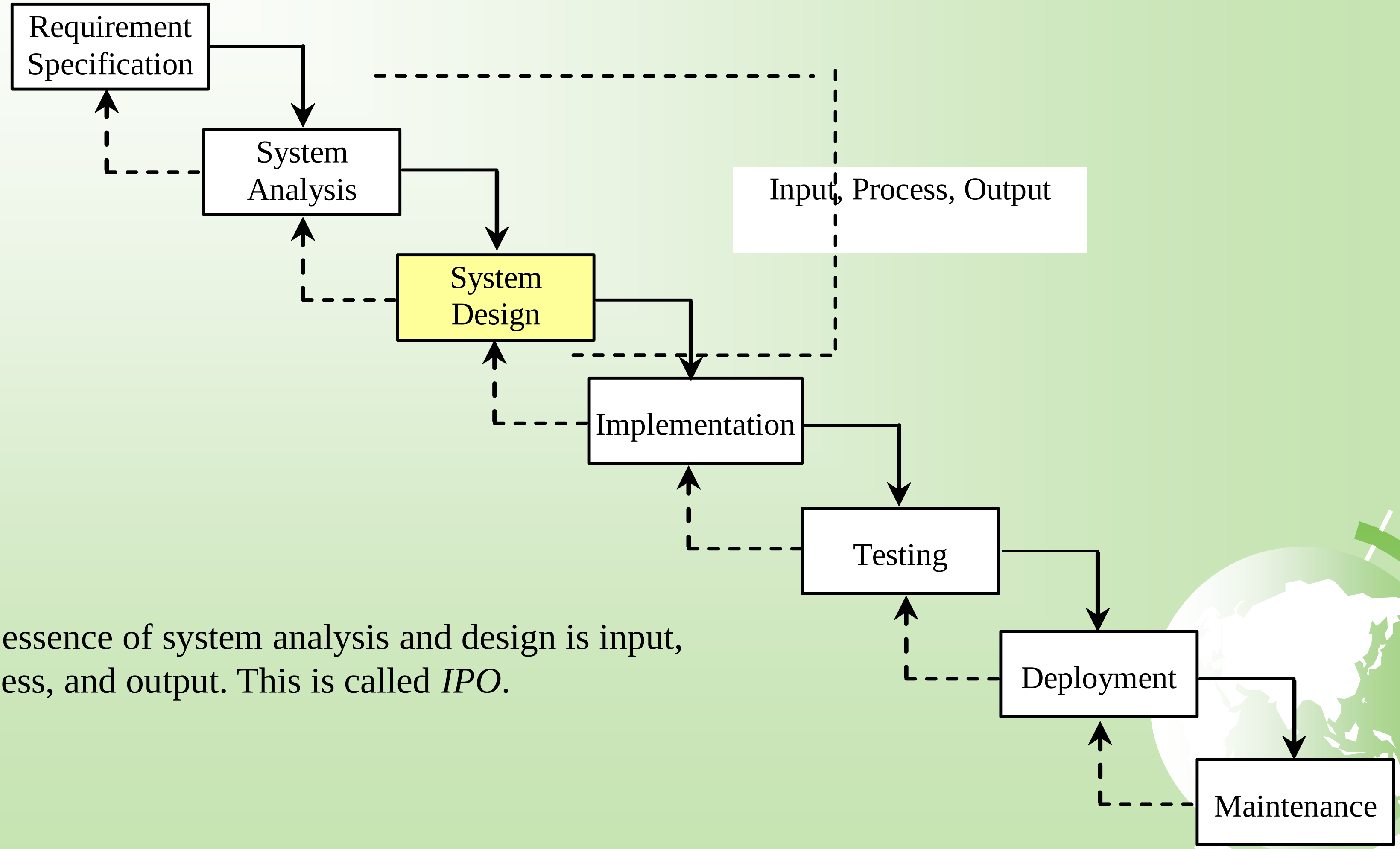
System Design



The process of designing the system’s components.

This phase involves the use of many levels of abstraction to decompose the problem into manageable components, identify classes and interfaces, and establish relationships among the classes and interfaces.

IPO

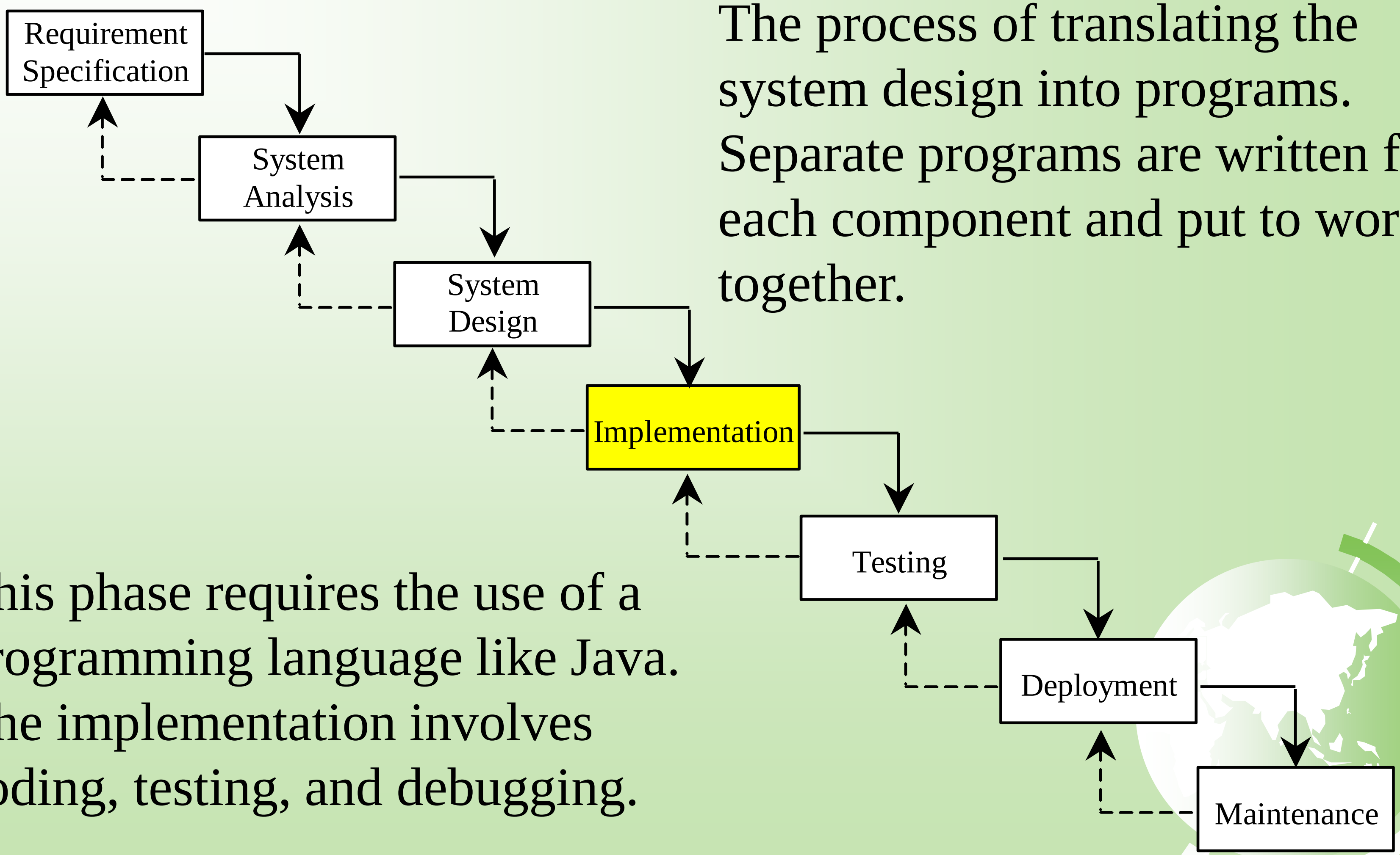


Input, Process, Output

The essence of system analysis and design is input, process, and output. This is called *IPO*.

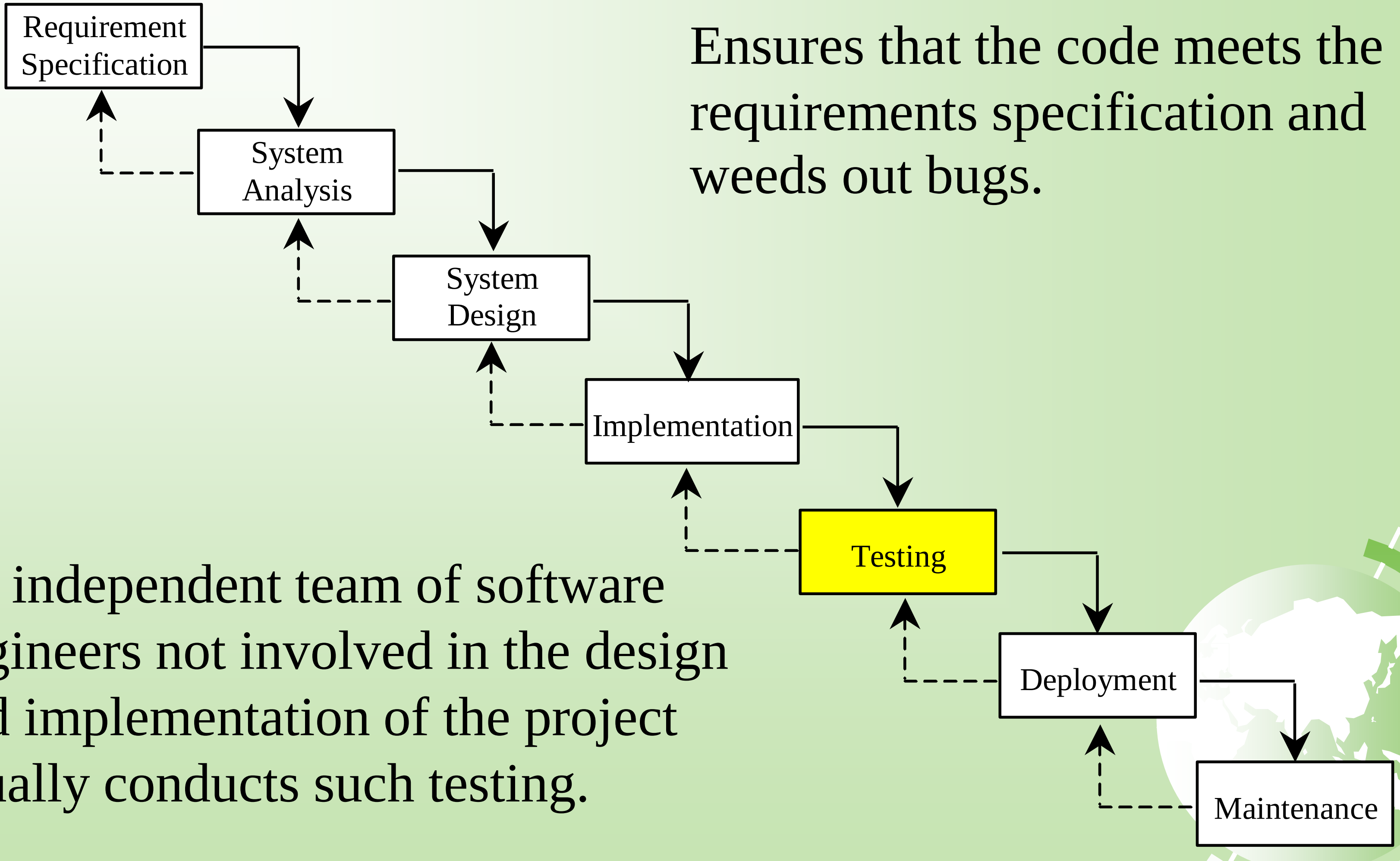
Implementation

The process of translating the system design into programs. Separate programs are written for each component and put to work together.



This phase requires the use of a programming language like Java. The implementation involves coding, testing, and debugging.

Testing

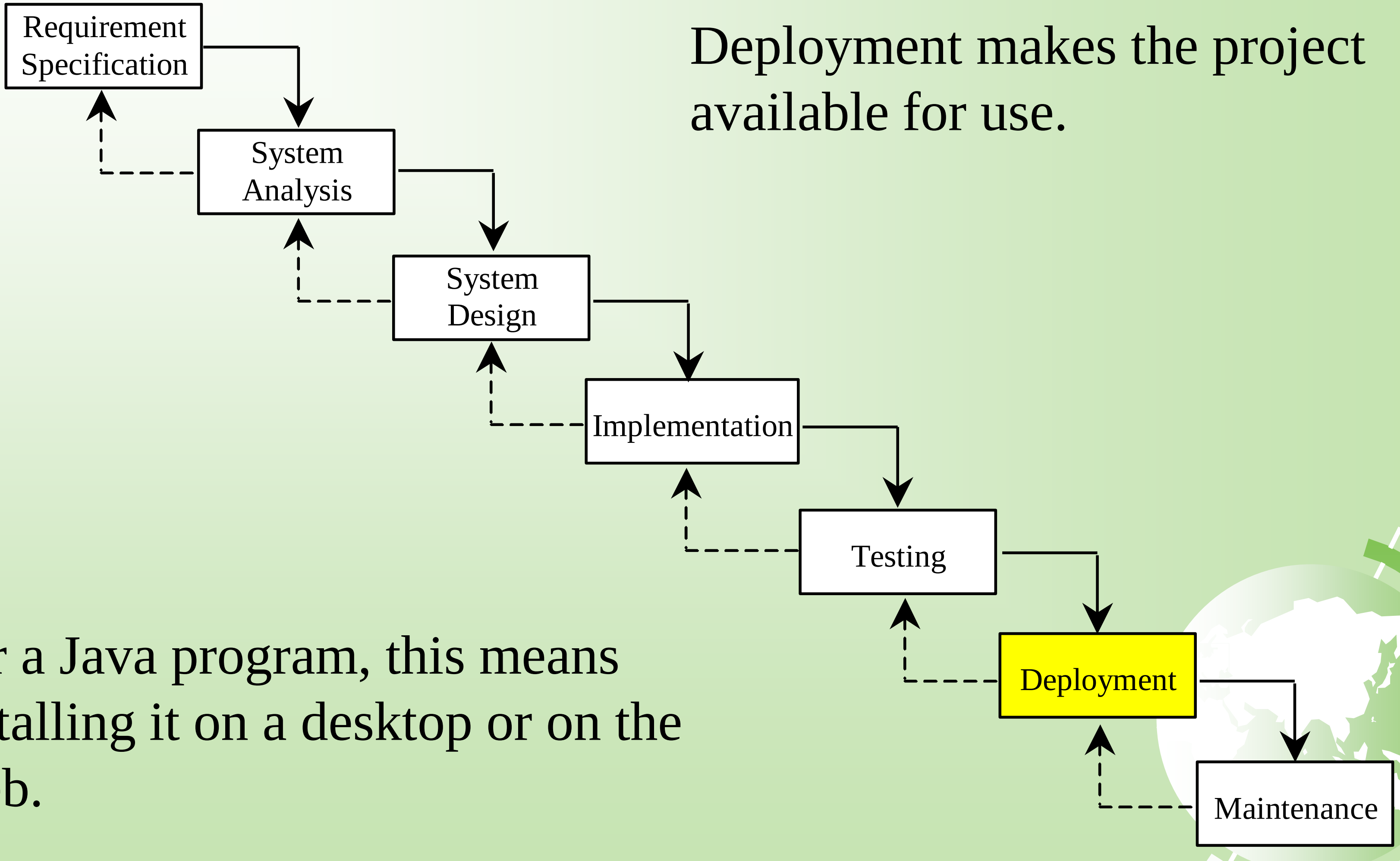


Ensures that the code meets the requirements specification and weeds out bugs.

An independent team of software engineers not involved in the design and implementation of the project usually conducts such testing.

Deployment

Deployment makes the project available for use.



Requirement Specification

System Analysis

System Design

Implementation

Testing

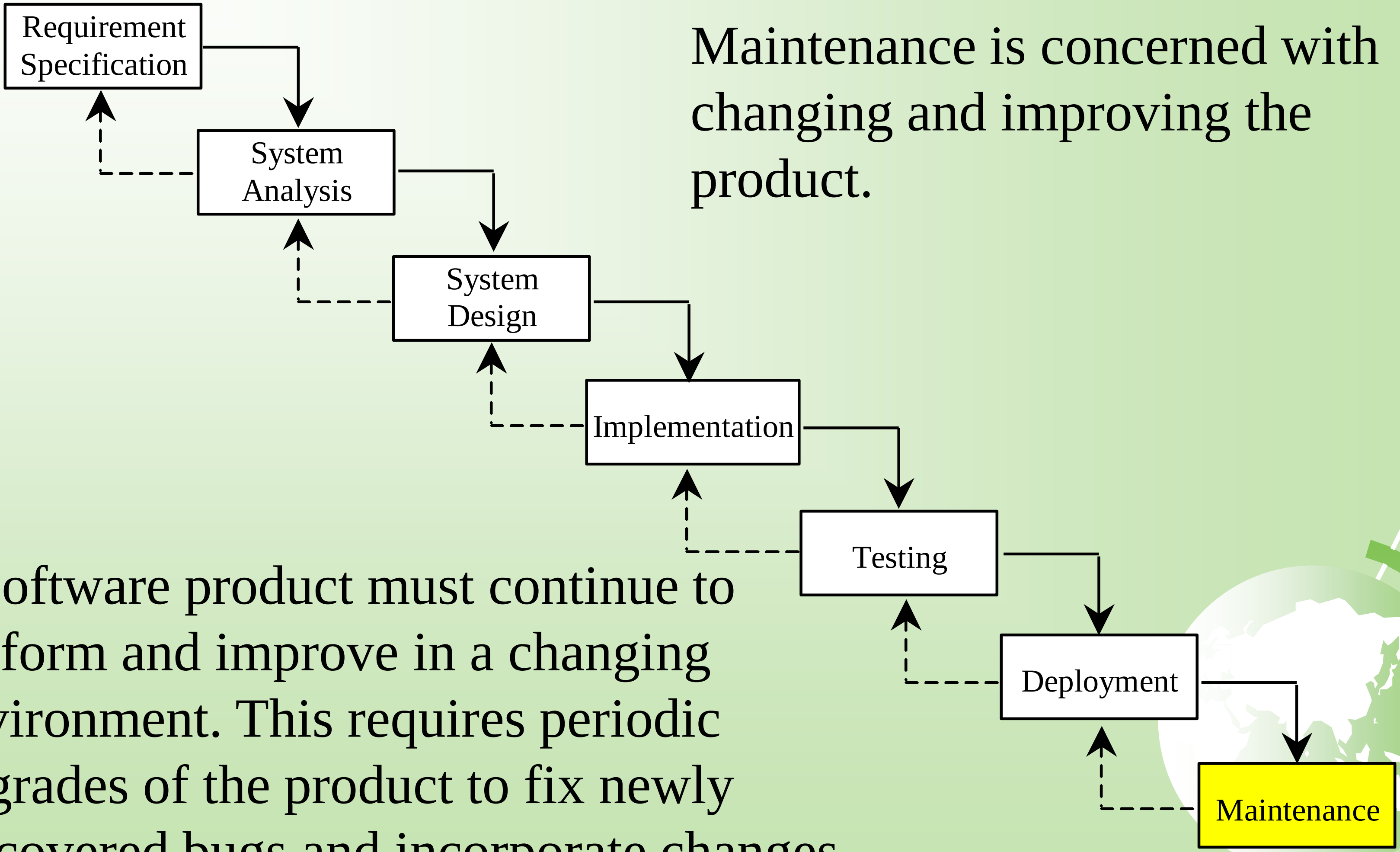
Deployment

Maintenance

For a Java program, this means installing it on a desktop or on the Web.

Maintenance

Maintenance is concerned with changing and improving the product.



A software product must continue to perform and improve in a changing environment. This requires periodic upgrades of the product to fix newly discovered bugs and incorporate changes.

Program 9: Money Units

- Write a program that asks the user for an amount of money in dollars and cents. Then your program should output a report listing the number of dollars, quarters, dimes, nickels, and pennies (and in that order) in your program.
- Remember:
  - Step 1: Problem-solving Phase
  - Step 2: Implementation Phase

Program 9: Money Units

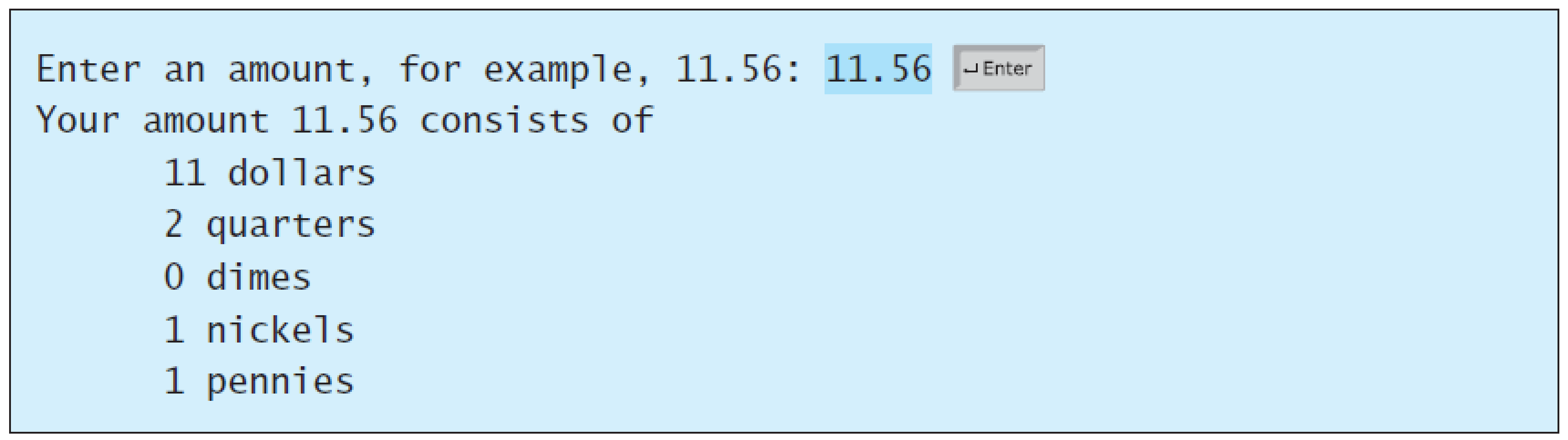
- **Step 1**: Problem-solving Phase
  - A reminder about U.S. monetary units:
    - 1 dollar = 100 cents (or pennies)
    - 1 quarter = 25 cents
    - 1 dime = 10 cents
    - 1 nickel = 5 cents
  - So if you need to give someone 42 cents in change, you should give:
    - One quarter, one dime, one nickel, and two pennies

Program 9: Money Units

☞ **Step 1**: Problem-solving Phase

– First step: UNDERSTAND the problem!

– So let us look at an example run:



```
Enter an amount, for example, 11.56: 11.56
Your amount 11.56 consists of
      11 dollars
      2 quarters
      0 dimes
      1 nickels
      1 pennies
```

– Is it clear what the problem is asking of us?

◆ Make sure you understand the question before starting

Program 9: Money Units

- **Step 1**: Problem-solving Phase
  1. Get the total amount of money by asking the user to enter a double value
     - `money = input.nextDouble();`
       - Example: $11.56
  2. Convert this amount into cents (multiply by 100)
     - `totalCents = (int)money*100;`
       - Example: 11.56 * 100 = 1156

Program 9: Money Units

- **Step 1**: Problem-solving Phase

  3. Get the total number of <u>**dollars**</u> by now dividing by 100. And get remaining cents by using totalCents % 100.
     - `totalDollars = totalCents / 100;`
       - Example: 1156 / 100 = 11
     - `remainingCents = totalCents % 100;`
       - Example: 1156 % 100 = 56

Program 9: Money Units

- **Step 1**: Problem-solving Phase

4. Get the total # of **quarters** by dividing `remainingCents` by 25. And then recalculate `remainingCents`.

   - `totalQuarters = remainingCents / 25;`
     - Example: 56 / 25 = 2
   - `remainingCents = remainingCents % 25;`
     - Example: 56 % 25 = 6

Program 9: Money Units

- **Step 1**: Problem-solving Phase
  5. Get the total # of **dimes** by dividing `remainingCents` by 10. And then recalculate `remainingCents`.
     - `totalDimes = remainingCents / 10;`
       - Example: 6 / 10 = 0
     - `remainingCents = remainingCents % 10;`
       - Example: 6 % 10 = 6

- So nothing changed at this step
  - `remainingCents` is still 6.

Program 9: Money Units

- ☞ **Step 1**: Problem-solving Phase

  6. Get the total # of nickels by dividing `remainingCents` by 5. And then recalculate `remainingCents`.

     - ◆ `totalDimes = remainingCents / 5;`
       - – Example: 6 / 5 = 1
     - ◆ `remainingCents = remainingCents % 5;`
       - – Example: 6 % 5 = 1

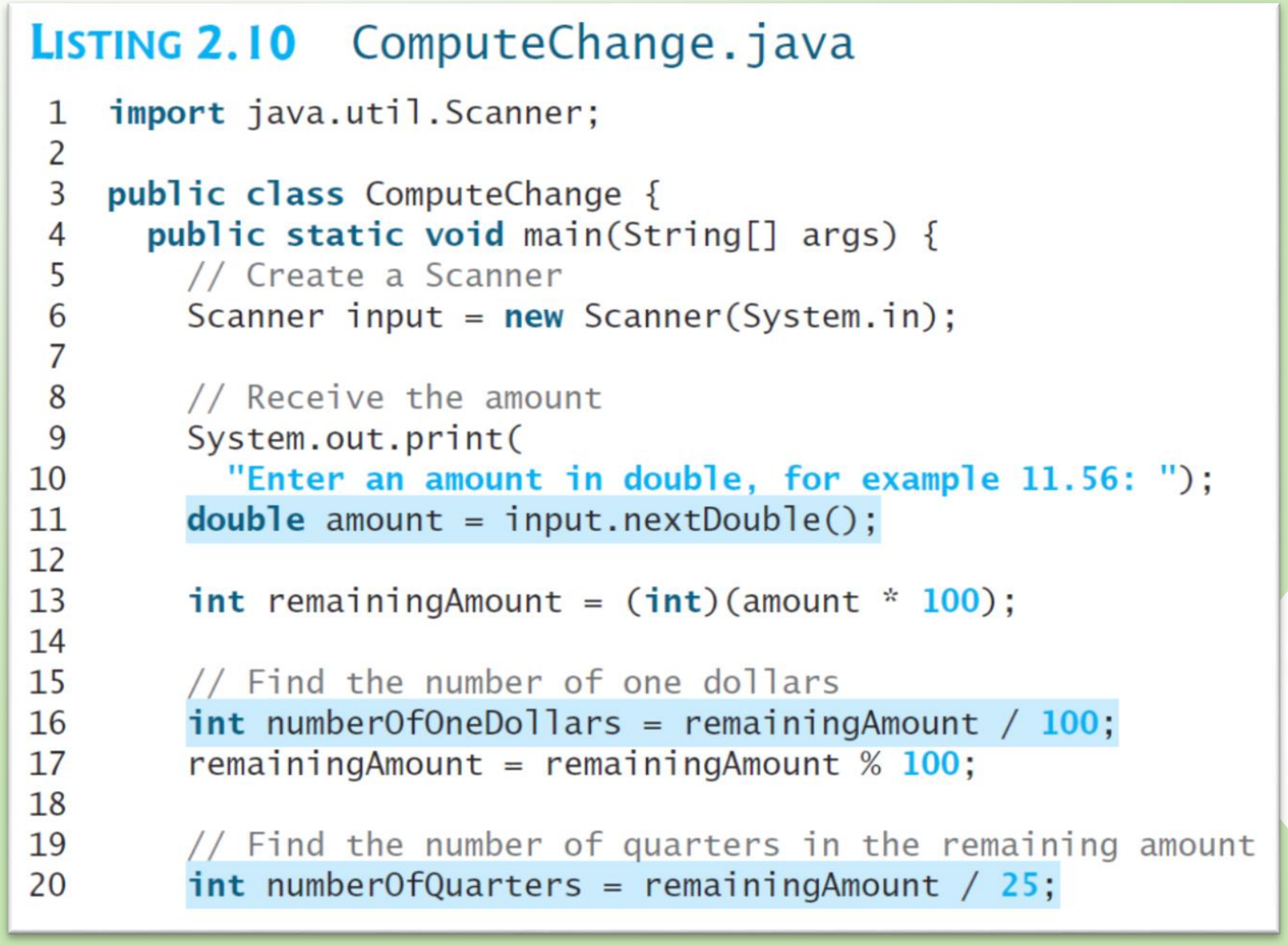
Program 9: Money Units

- **Step 1**: Problem-solving Phase

7. The value stored in `remainingCents` is the number of pennies left over
8. Display the result!

Program 9: Money Units

- ☞ **Step 2**: Implementation

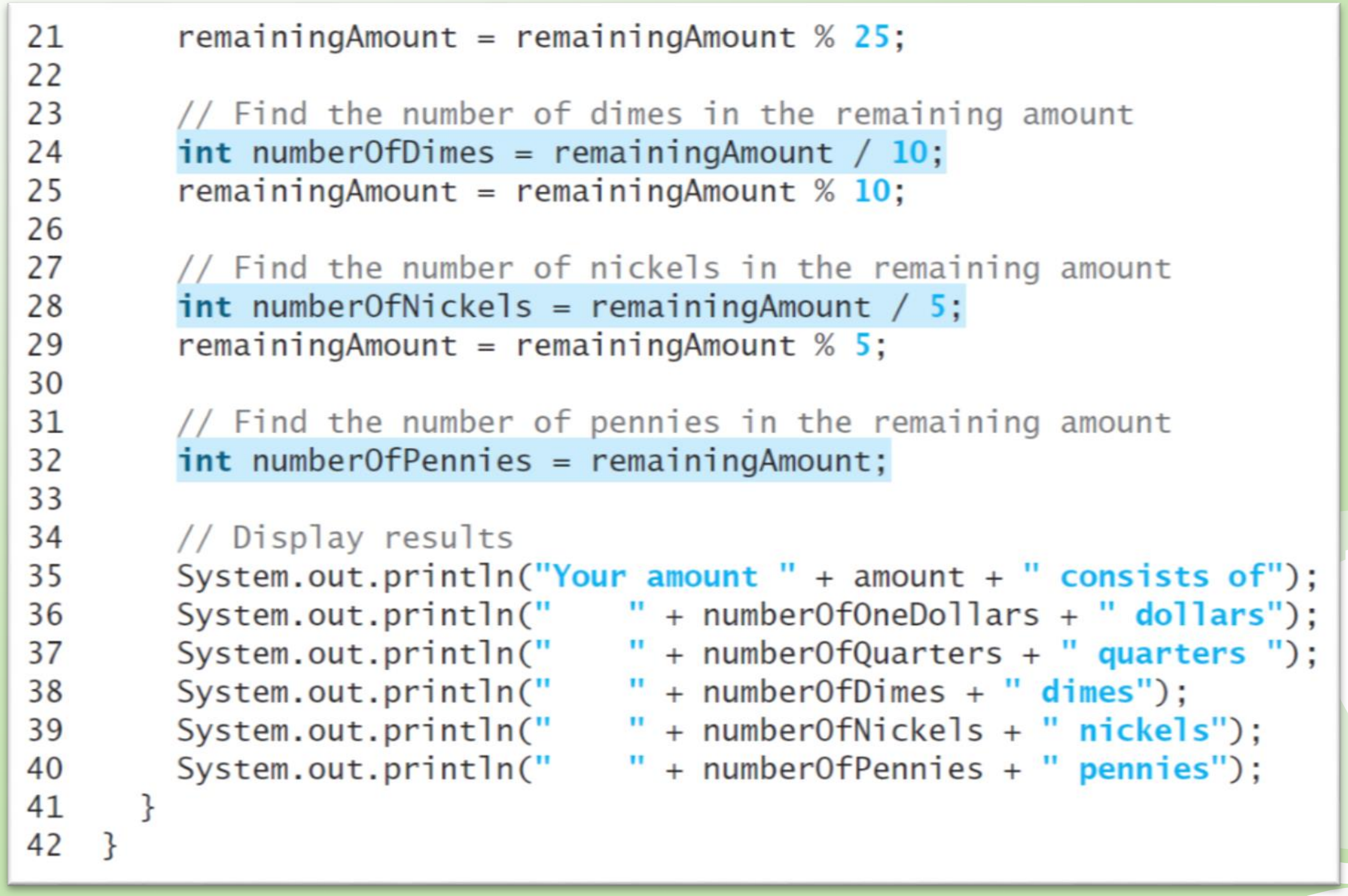


LISTING 2.10 ComputeChange.java

```java
import java.util.Scanner;

public class ComputeChange {
  public static void main(String[] args) {
    // Create a Scanner
    Scanner input = new Scanner(System.in);

    // Receive the amount
    System.out.print(
      "Enter an amount in double, for example 11.56: ");
    double amount = input.nextDouble();

    int remainingAmount = (int)(amount * 100);

    // Find the number of one dollars
    int numberOfOneDollars = remainingAmount / 100;
    remainingAmount = remainingAmount % 100;

    // Find the number of quarters in the remaining amount
    int numberOfQuarters = remainingAmount / 25;
```

Program 9: Money Units

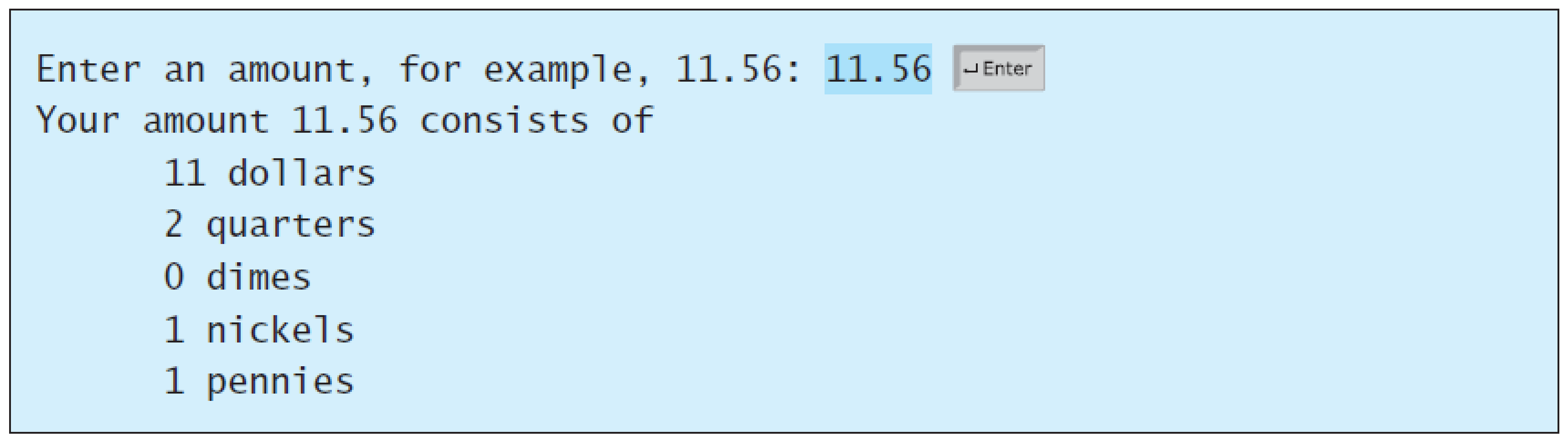
- **Step 2**: Implementation



```
    remainingAmount = remainingAmount % 25;

    // Find the number of dimes in the remaining amount
    int numberOfDimes = remainingAmount / 10;
    remainingAmount = remainingAmount % 10;

    // Find the number of nickels in the remaining amount
    int numberOfNickels = remainingAmount / 5;
    remainingAmount = remainingAmount % 5;

    // Find the number of pennies in the remaining amount
    int numberOfPennies = remainingAmount;

    // Display results
    System.out.println("Your amount " + amount + " consists of");
    System.out.println("    " + numberOfOneDollars + " dollars");
    System.out.println("    " + numberOfQuarters + " quarters ");
    System.out.println("    " + numberOfDimes + " dimes");
    System.out.println("    " + numberOfNickels + " nickels");
    System.out.println("    " + numberOfPennies + " pennies");
  }
}
```

Program 9: Money Units

- **Run the program:**



```
Enter an amount, for example, 11.56: 11.56
Your amount 11.56 consists of
      11 dollars
      2 quarters
      0 dimes
      1 nickels
      1 pennies
```

- See sample program: `PrintMoney.java`

Common Errors and Pitfalls

- Common Error # 1: Undeclared/Uninitialized Variables and Unused Variables
  - a variable must be declared and a value assigned to it before you use it.
  - Common errors include not declaring or not initializing a variable
  - Example:

```
double interestRate = 0.05;
double interest = interestrate * 45;
```

  - Java is case sensitive. In the 2nd line, `interestrate` is not defined, because the R is not capitalized

Common Errors and Pitfalls

- Common Error #2: Integer Overflow
  - Remember: numbers are stored with a limited number of digits
  - If you try to save a value that is too large for a variable, an overflow error will occur
  - Example:
    - `int value = 2147483647; // allowed`
      - but this number is the biggest possible int, therefore…
    - `value++; // will result in an error`

Common Errors and Pitfalls

- Common Error #3: Round-off Errors
  - a round-off error, also called a rounding error, is the difference between the exact mathematical value of a number and the approximated value that was calculated.
  - Example:
    - 1/3 is approximately 0.333 if you use three decimals
    - and it is 0.3333333 if you use seven decimal places
    - The number of digits you can store is limited
    - So having round-off errors is inevitable (a guarantee!)

Common Errors and Pitfalls

- Common Error #3: Round-off Errors
  - Calculations with floating-point numbers are also approximated
    - Because they are not stored with complete accuracy
  - Example:

    -
      ```
      System.out.println(1.0 - 0.1 - 0.1 - 0.1 - 0.1 - 0.1);
      ```
      - The output should be 0.5, but the output is really 0.5000000000000001

    -
      ```
      System.out.println(1.0 - 0.9);
      ```
      - The output should be 0.1, but the output is really 0.09999999999999998
  - Message: use integers for exact/precise results!

Common Errors and Pitfalls

- Common Error #4: Unintended Integer Division
  - Perhaps you want “normal” division
    - Example: 3 / 2 = 1.5
  - However, if both operands are integers, Java will automatically use integer division
  - If you do not want integer division, you should make one of the operands a floating-point number

```
int number1 = 1;
int number2 = 2;
double average = (number1 + number2) / 2;
System.out.println(average);
```

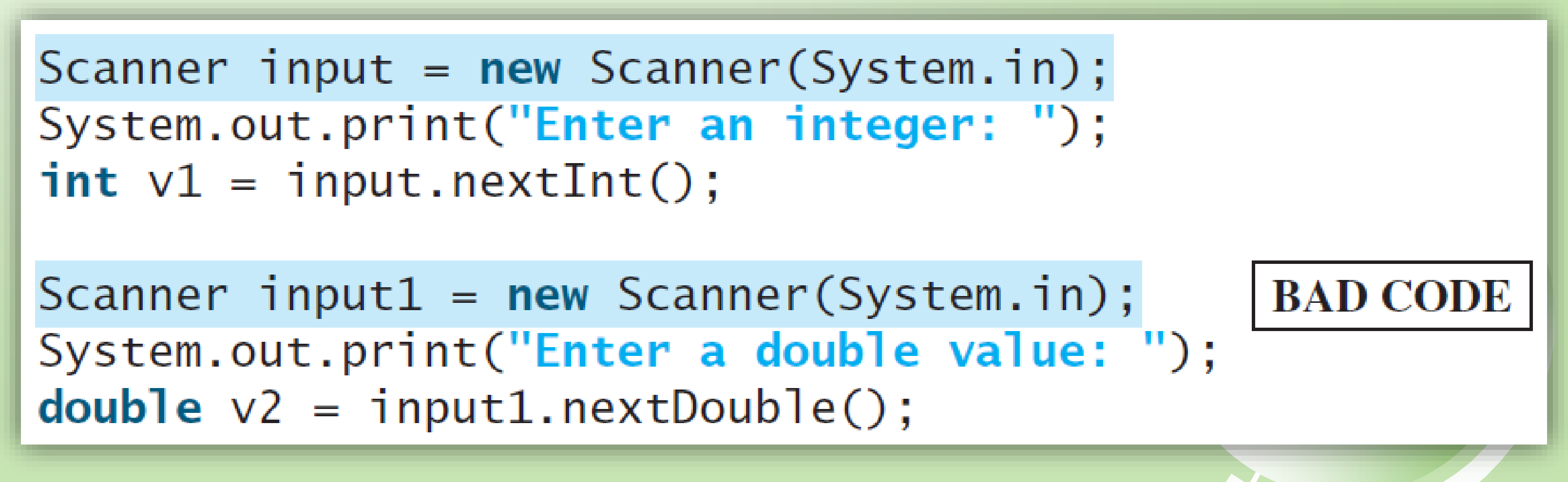
(a)

```
int number1 = 1;
int number2 = 2;
double average = (number1 + number2) / 2.0;
System.out.println(average);
```

(b)

Common Errors and Pitfalls

- Common Pitfall #1: Repeated Input Objects
  - New programmers often make many Scanner objects each time they want input
    - This is a mistake!
  - See the code below:

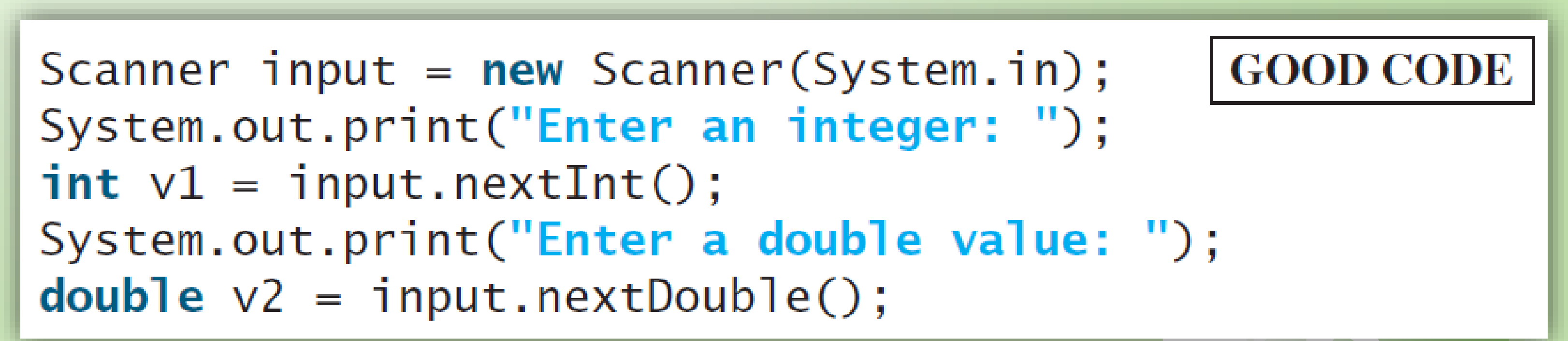


```
Scanner input = new Scanner(System.in);
System.out.print("Enter an integer: ");
int v1 = input.nextInt();

Scanner input1 = new Scanner(System.in);
System.out.print("Enter a double value: ");
double v2 = input1.nextDouble();
```

BAD CODE

Common Errors and Pitfalls

- Common Pitfall #1: Repeated Input Objects
  - The code is not wrong, but it is inefficient (slow)
  - It creates two input objects, which is a waste
  - The correct code is below:



GOOD CODE

```
Scanner input = new Scanner(System.in);
System.out.print("Enter an integer: ");
int v1 = input.nextInt();
System.out.print("Enter a double value: ");
double v2 = input.nextDouble();
```

Module 2:
Elementary Programming

The Basics of Java