Chapter 2 Elementary Programming

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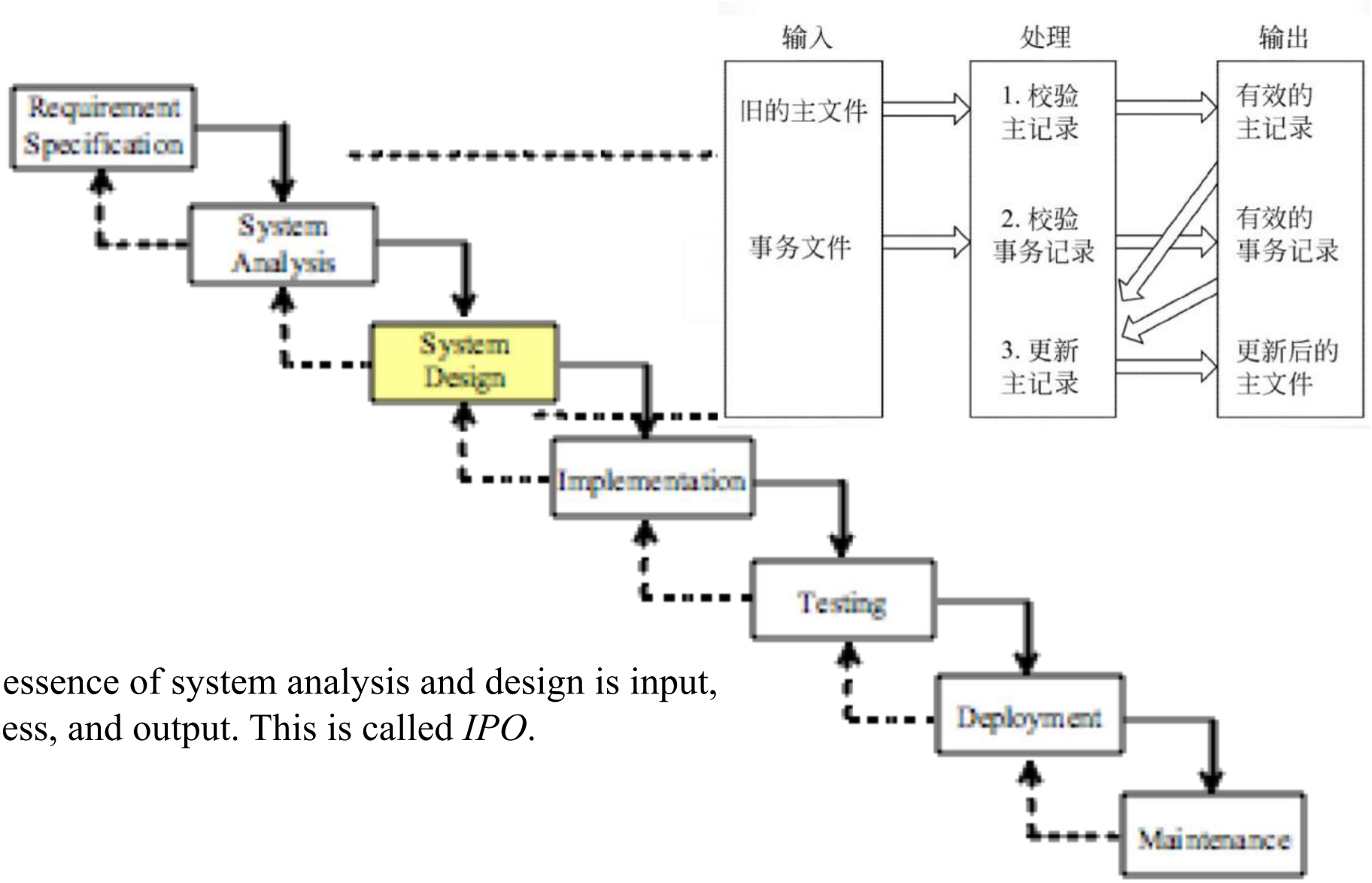
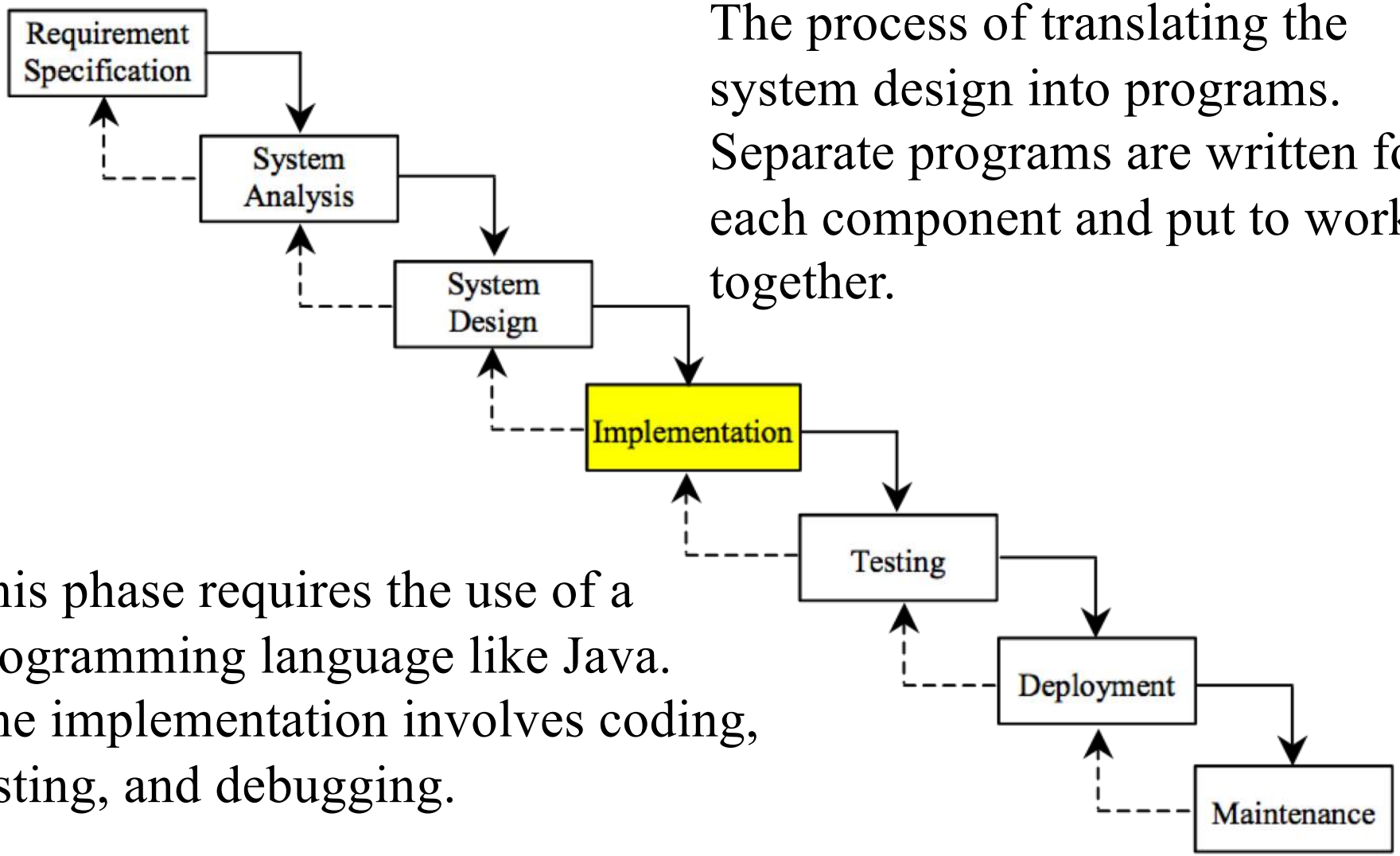
IPO *



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.

Introducing Programming with an Example

Ex 2.1 Computing the Area of a Circle

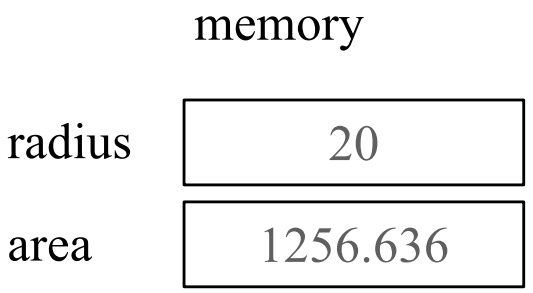
ComputeAreaWithConsoleInput

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {

    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);
  }
}
```



Identifiers

- **An identifier is a sequence of characters that consist of letters, digits, underscores (_), and dollar signs ($).**
  - **Character. isJavaIdentifierPart() returns `true`**
  - **In Unicode Charsets: Characters bigger than 0xC0**
- **An identifier must start with a letter, an underscore (_), or a dollar sign ($). It cannot start with a digit.**
  - **Character.isJavaIdentifierStart() returns `true`**
- **An identifier cannot be a reserved word.**
- **An identifier cannot be `true`, `false`, or `null`.**
- **An identifier can be of any length.**

- **Correct Identifiers:**
  - **Body , _test , $hello**
- **Wrong Identifiers:**
  - **5Test , hello* , world# , class**

Keywords

Some noteworthy points regarding Java keywords:

- **const** and **goto** are resevered words but not used.
- **true**, **false** and **null** are literals, not keywords.
- all keywords are in lower-case.

var is not a keyword, but rather an identifier with special meaning as the type of a local variable declaration

The following table shows the keywords grouped by category:

Category	Keywords
Access modifiers	**private, protected, public**
Class, method, variable modifiers	**abstract, class, extends, final, implements, interface, native, new, static, strictfp, synchronized, transient, volatile**
Flow control	**break, case, continue, default, do, else, for, if, instanceof, return, switch, while**
Package control	**import, package**
Primitive types	**boolean, byte, char, double, float, int, long, short**
Error handling	**assert, catch, finally, throw, throws, try**
Enumeration	**enum**
Others	**super, this, void**
Unused	**const, goto**

Variables

```
// Compute the first area
radius = 1.0;
area = radius * radius * 3.14159;
System.out.println("The area is " +
  area + " for radius "+radius);

// Compute the second area
radius = 2.0;
area = radius * radius * 3.14159;
System.out.println("The area is " +
  area + " for radius "+radius);
```

Declaring Variables

```
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;
```

var is a type name, which was introduced in Java 10

Assignment Statements

```
x = 1;              // Assign 1 to x;
radius = 1.0;       // Assign 1.0 to radius;
a = 'A';            // Assign 'A' to a;
```

Declaring and Initializing in One Step

- `int x = 1;`
- `double d = 1.4;`

Named Constants

```
final datatype CONSTANTNAME = VALUE;

final double PI = 3.14159;
final int SIZE = 3;
```

Naming Conventions

- **Choose meaningful and descriptive names.**

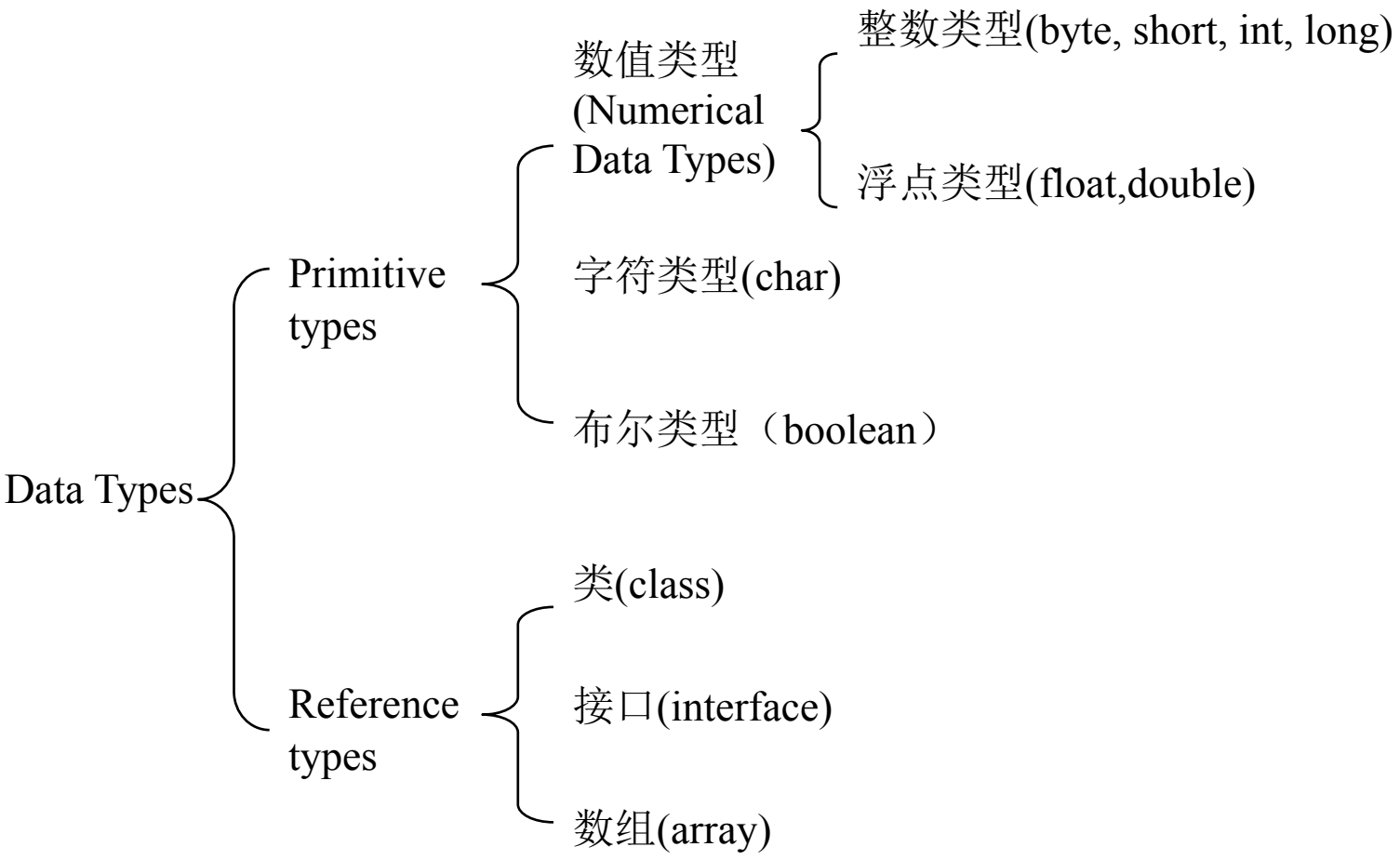
- **variables and method names:**
  - **Use lowercase. If the name consists of several words, concatenate all in one, use lowercase for the first word, and capitalize the first letter of each subsequent word in the name. For example, the variables `radius` and `area`, and the method `computeArea`.**

Naming Conventions, cont.

- **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 constant `PI and` MAX_VALUE**

Data Types


Data Types
Primitive types
数值类型 (Numerical Data Types)
整数类型(byte, short, int, long)
浮点类型(float,double)
字符类型(char)
布尔类型（boolean）
Reference types
类(class)
接口(interface)
数组(array)

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

There is NO UNSIGNED integer type in Java

Integer

- **Decimal： 124，-100；**
- **Octal： 0 as prefix, followed by 0~7 : ex. 0134；**
- **Hexadecimal： 0x or 0X as prefix, followed by 0~9 or A~F。**

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.

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

+, -, *, /, and %

5 / 2 yields an integer 2.

5.0 / 2 yields a double value 2.5

5 % 2 yields 1 (the remainder of the division)

Problem: Displaying Time

Write a program that obtains minutes and remaining seconds from seconds.

DisplayTime

Floating-Point numbers

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

calculations with integers yield a precise integer result.

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);
```


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

Exponent Operations

```
System.out.println(Math.pow(2, 3));
// Displays 8.0
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
```

Number Literals

A *literal* is a constant value that appears directly in the program.

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.

An integer literal is assumed to be of the int type, whose value is between -2^{31} (-2147483648) to $2^{31}-1$ (2147483647).

Integer literal of the long type, append it with the letter L or l.

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.

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.

100.2f or 100.2F for a float number

100.2d or 100.2D for a double number

Scientific Notation

Floating-point literals can also be specified in scientific notation,

1.23456e+2, or 1.23456e2, is equivalent to 123.456

1.23456e-2 is equivalent to 0.0123456

Arithmetic Expressions

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

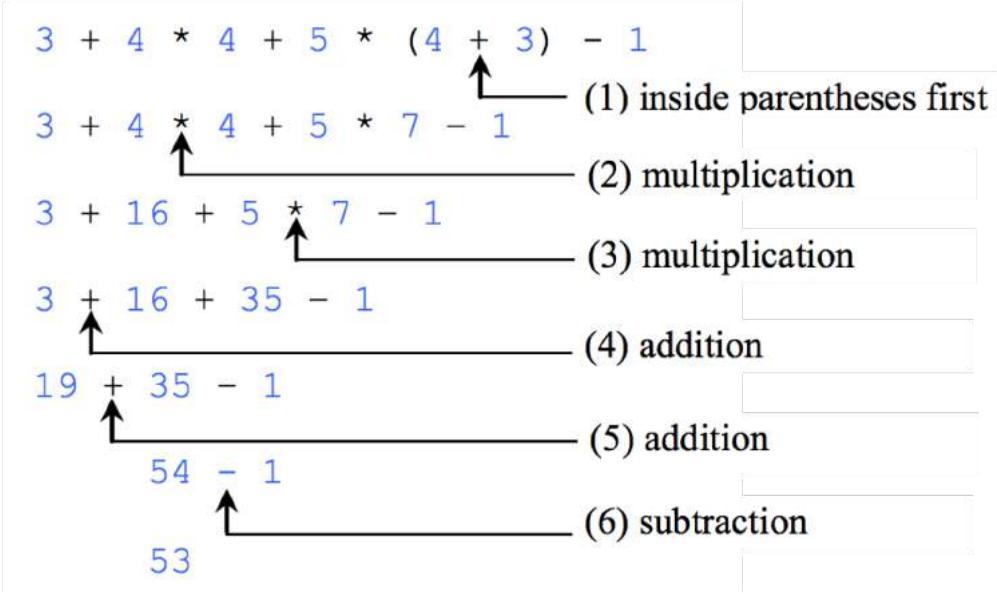
is translated to

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

How to Evaluate an Expression

You can safely apply the arithmetic rule for evaluating a Java expression.

The result of a Java expression and its corresponding arithmetic expression are the same.



Problem: Converting Temperatures

Write a program that converts a Fahrenheit degree to Celsius using the formula:

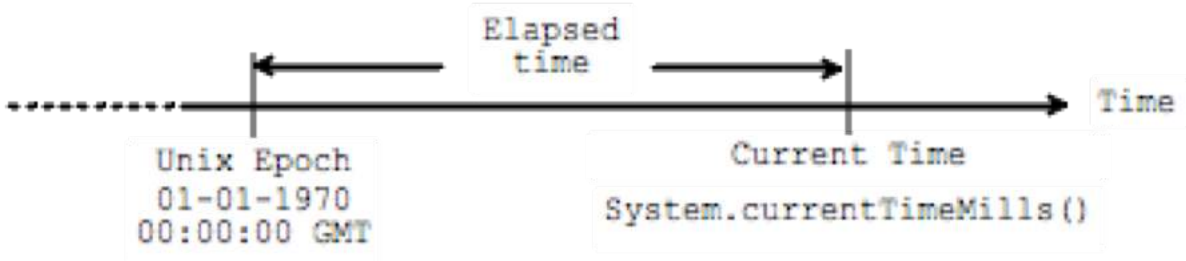
$$celsius = (\frac{5}{9})(fahrenheit - 32)$$

Note: you have to write
celsius = (5.0 / 9) * (fahrenheit – 32)

Problem: Showing Current Time

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

Using *currentTimeMillis()* method in *System* class returns the current time in milliseconds since the midnight, January 1, 1970 GMT.



ShowCurrentTime.java

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`

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, cont.

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

Same effect as

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

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

Same effect as

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

Increment and Decrement Operators, cont.

Using increment and decrement operators makes expressions short, but it also makes them complex and difficult to read.

int k = ++i + i.

Numeric Type Conversion

Consider the following statements:

```
byte i = 100;
long k = i * 3 + 4;
double d = i * 3.1 + k / 2;
```

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. An integer literal can be assigned to an integer variable as long as it can fit into the variable.
5. Otherwise, both operands are converted into int.

Type Casting

Implicit casting

`double d = 3;` (type widening)

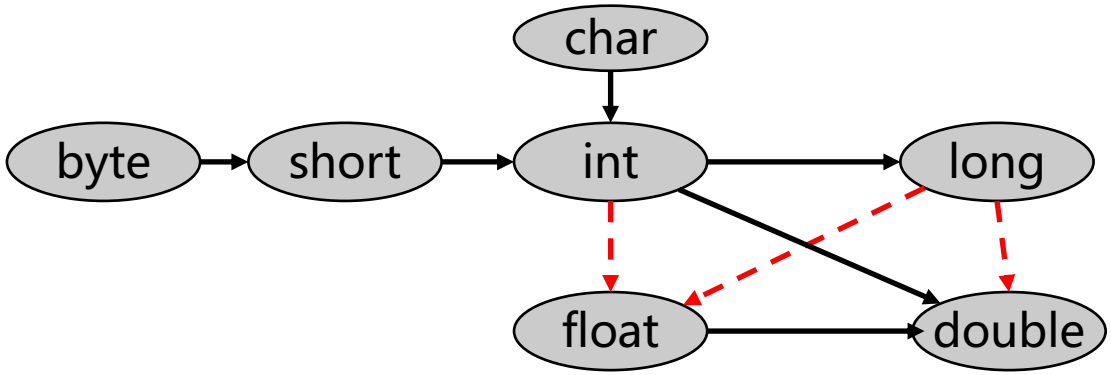
Explicit casting

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

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

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

Narrowing ---------- --->Widening
byte , short , char---> int--> long--> float--> double



Casting in an Augmented Expression

An augmented expression of the form x1 op= x2 is implemented as x1 = (T)(x1 op x2), where T is the type for x1.

Therefore

```
int sum = 0;
sum += 4.5;
```

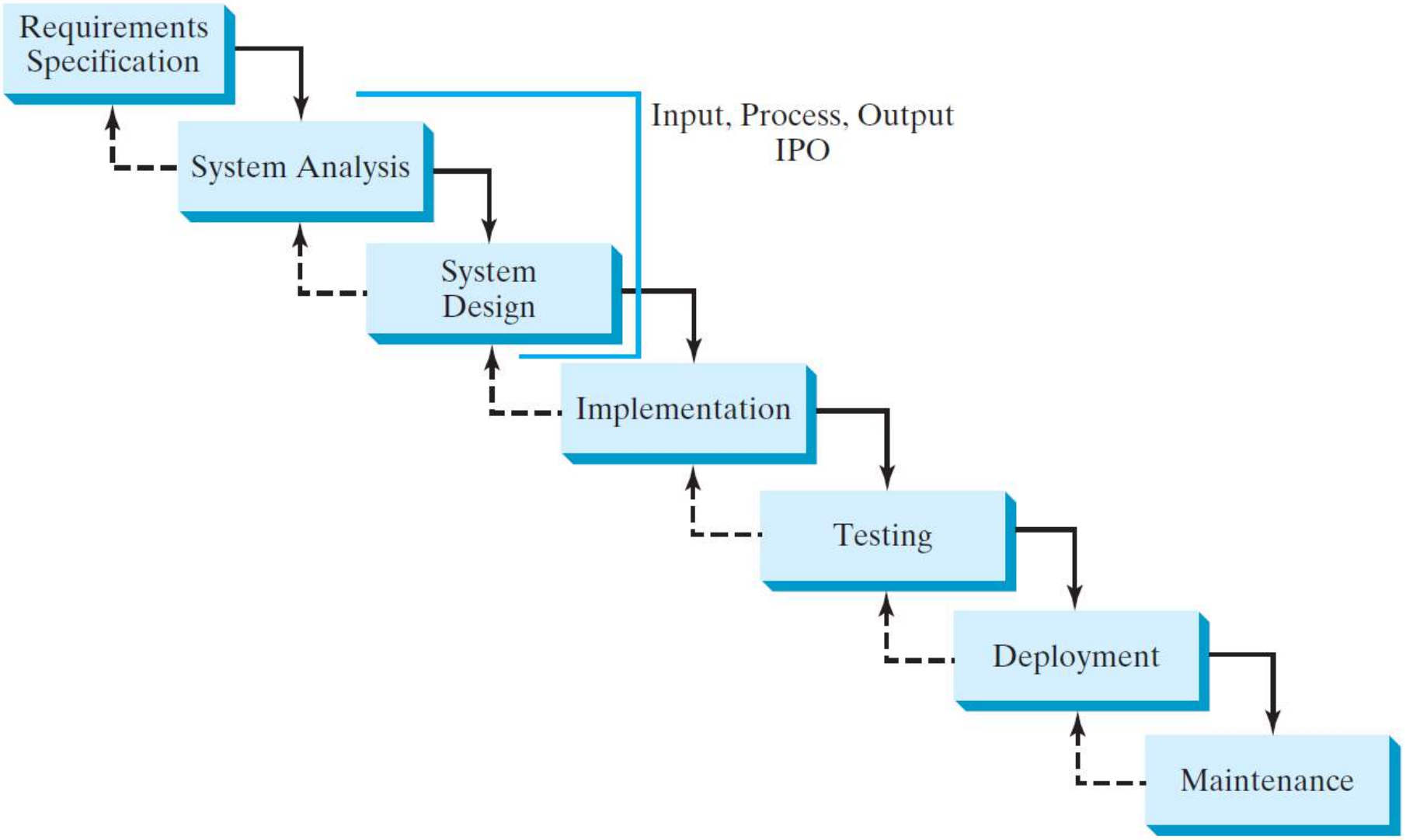
is correct

sum **+=** ***4.5*** is equivalent to ***sum = (int)(sum + 4.5)***
// sum becomes 4 after this statement

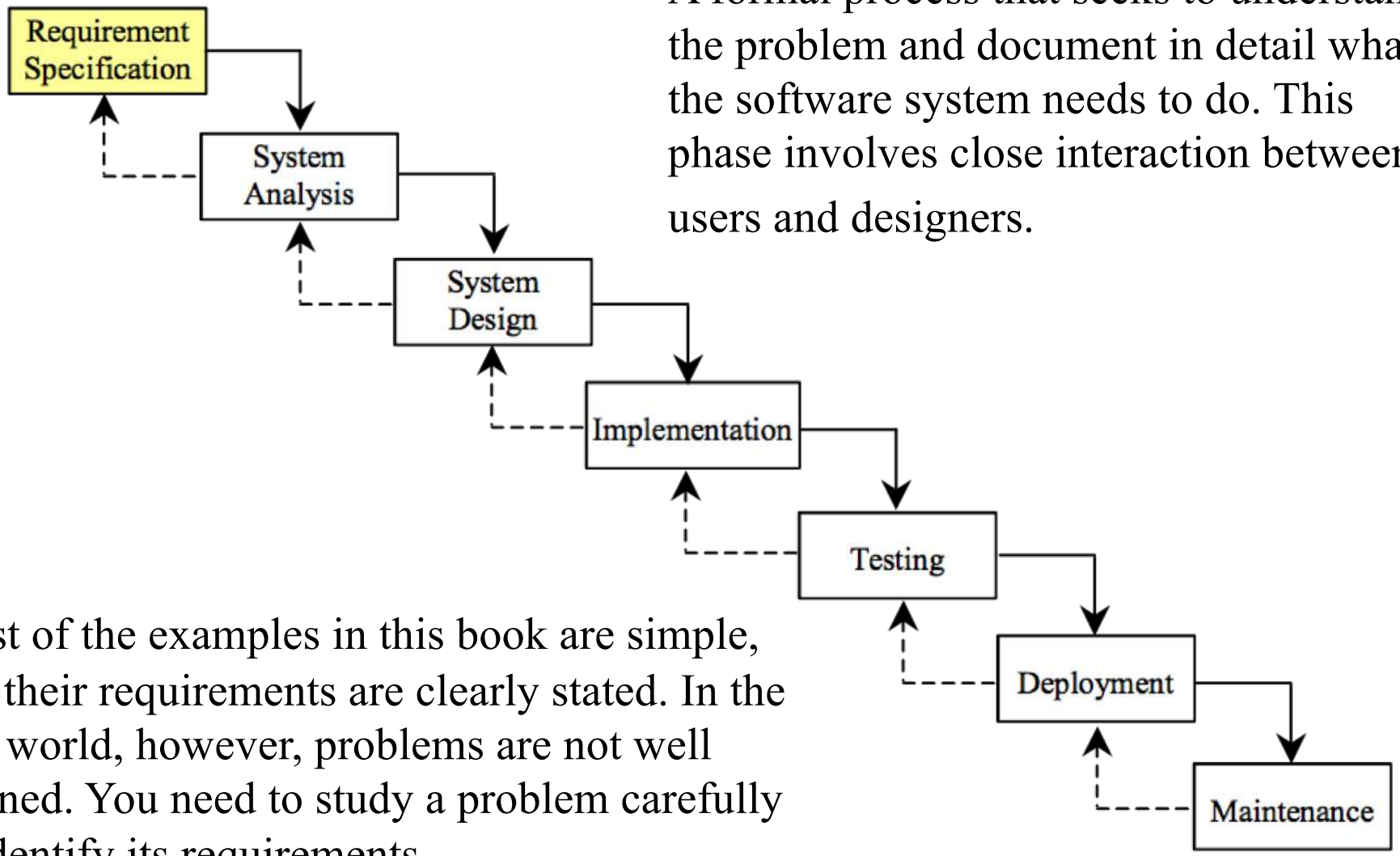
Boolean type and operators

- ***boolean b=false;***
- ***true and false are literals***

Software Development Process *



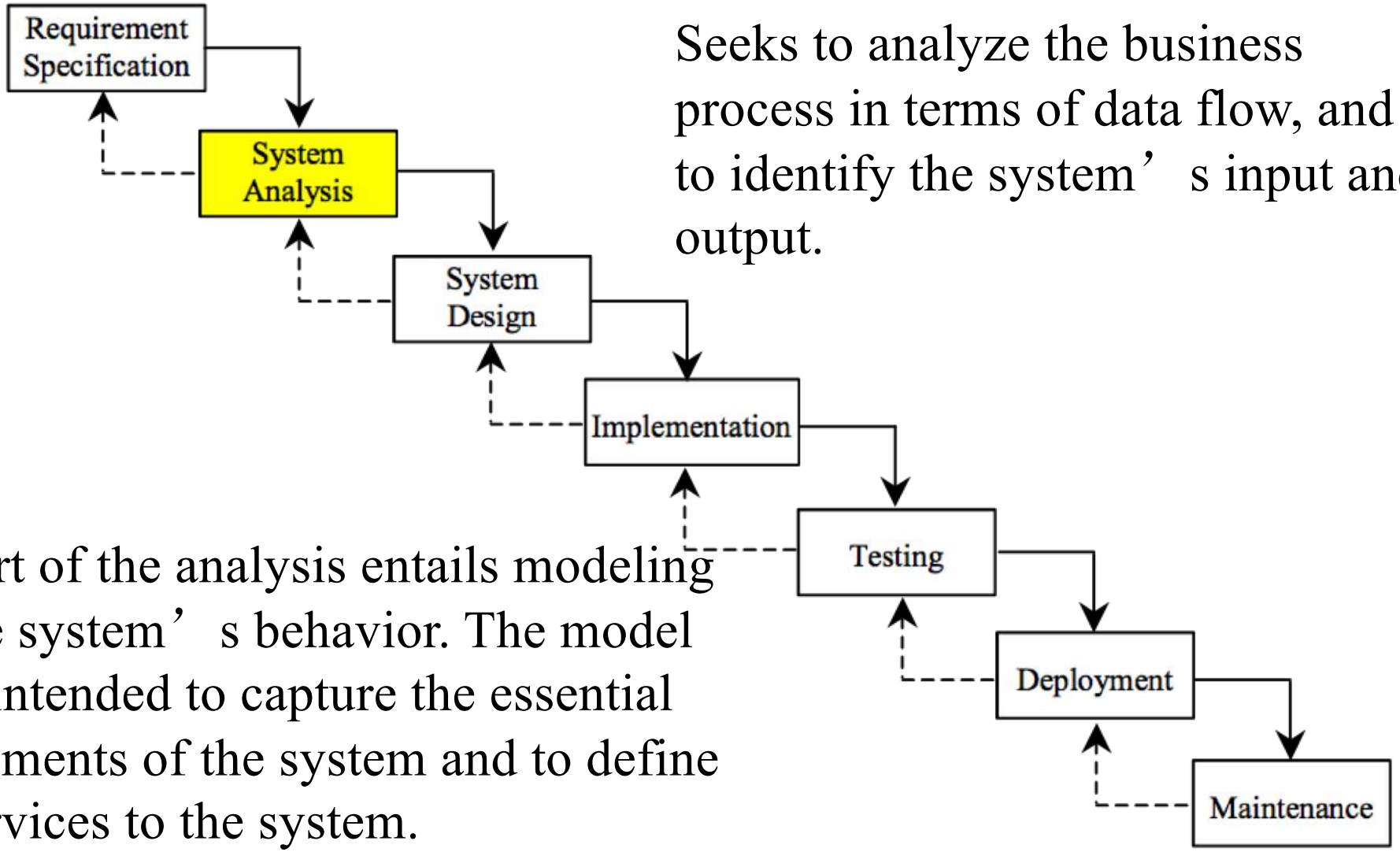
Requirement Specification *



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.

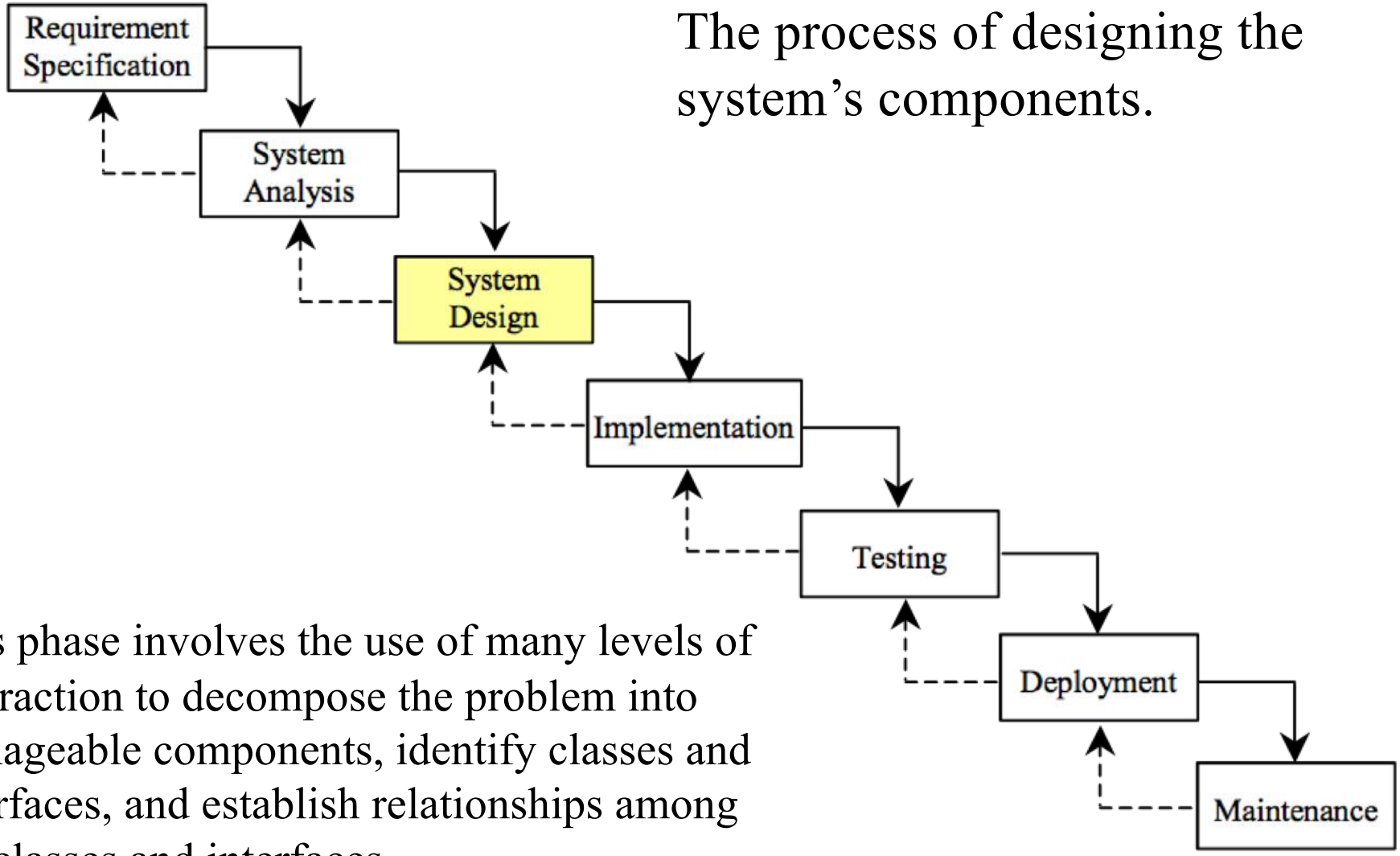
System Analysis *



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.

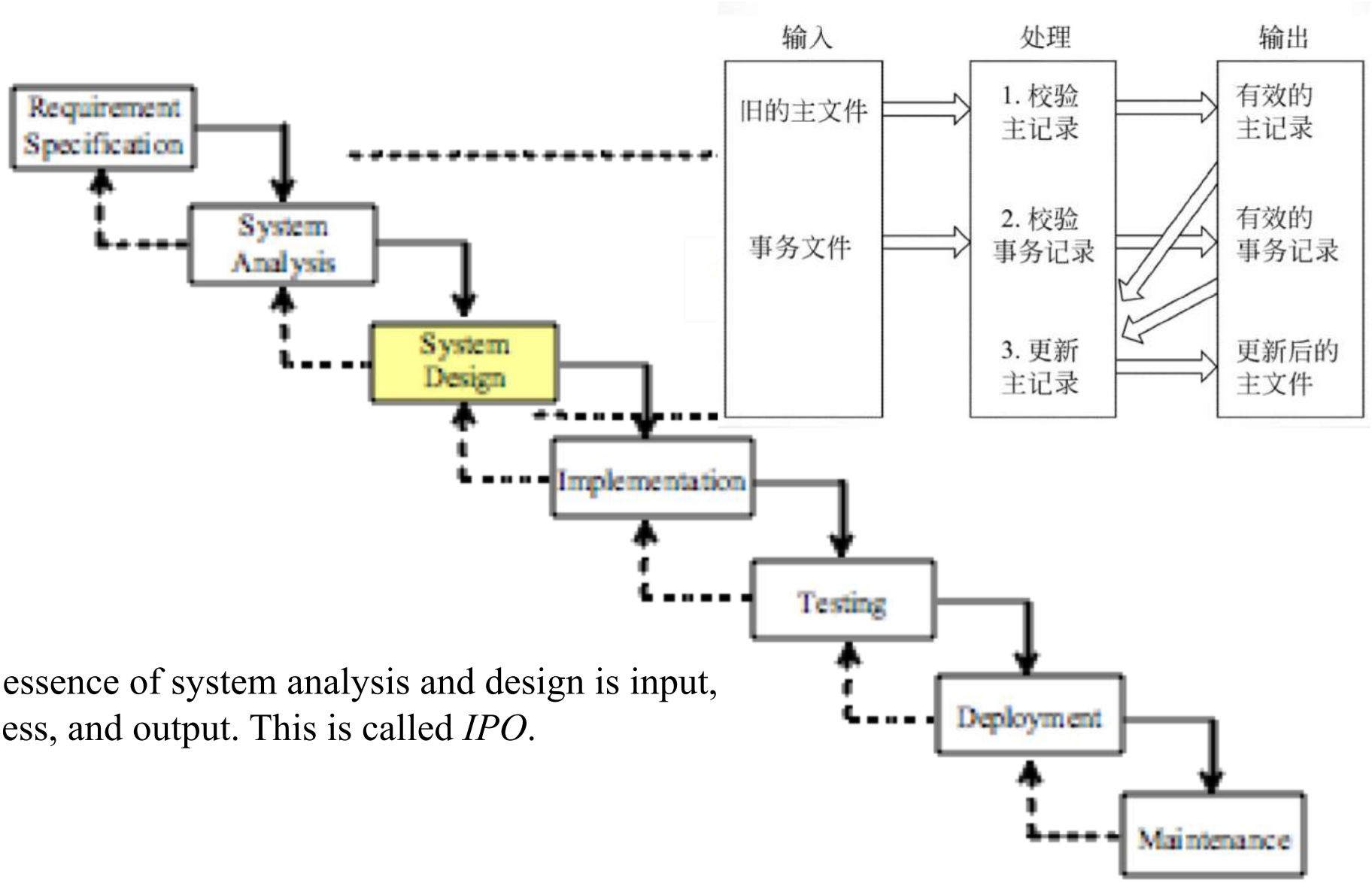
System Design *



The process of designing the system's components.

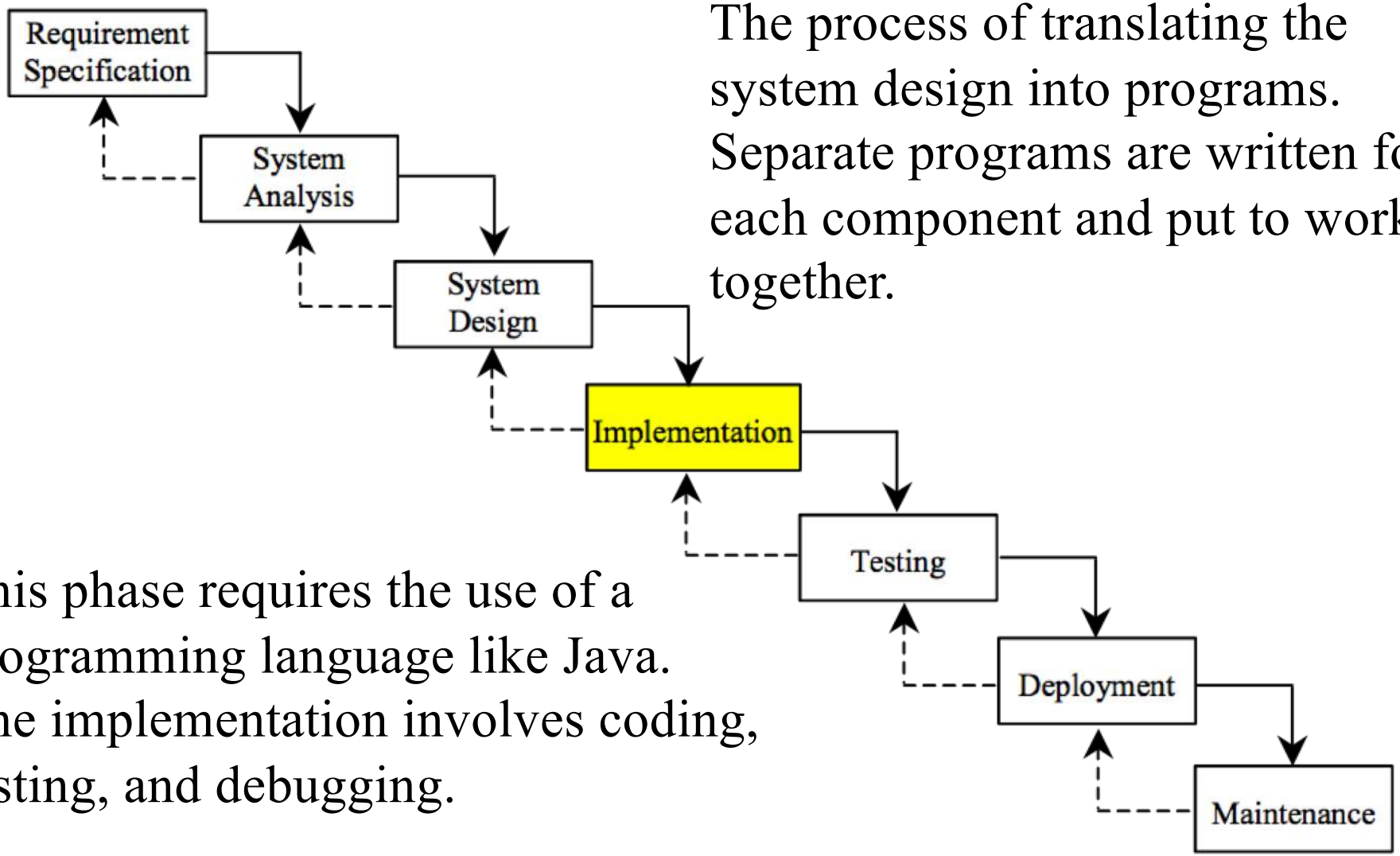
This phase involves the use of many levels of abstraction to decompose the problem into manageable components, identify classes and interfaces, and establish relationships among the classes and interfaces.

IPO *



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

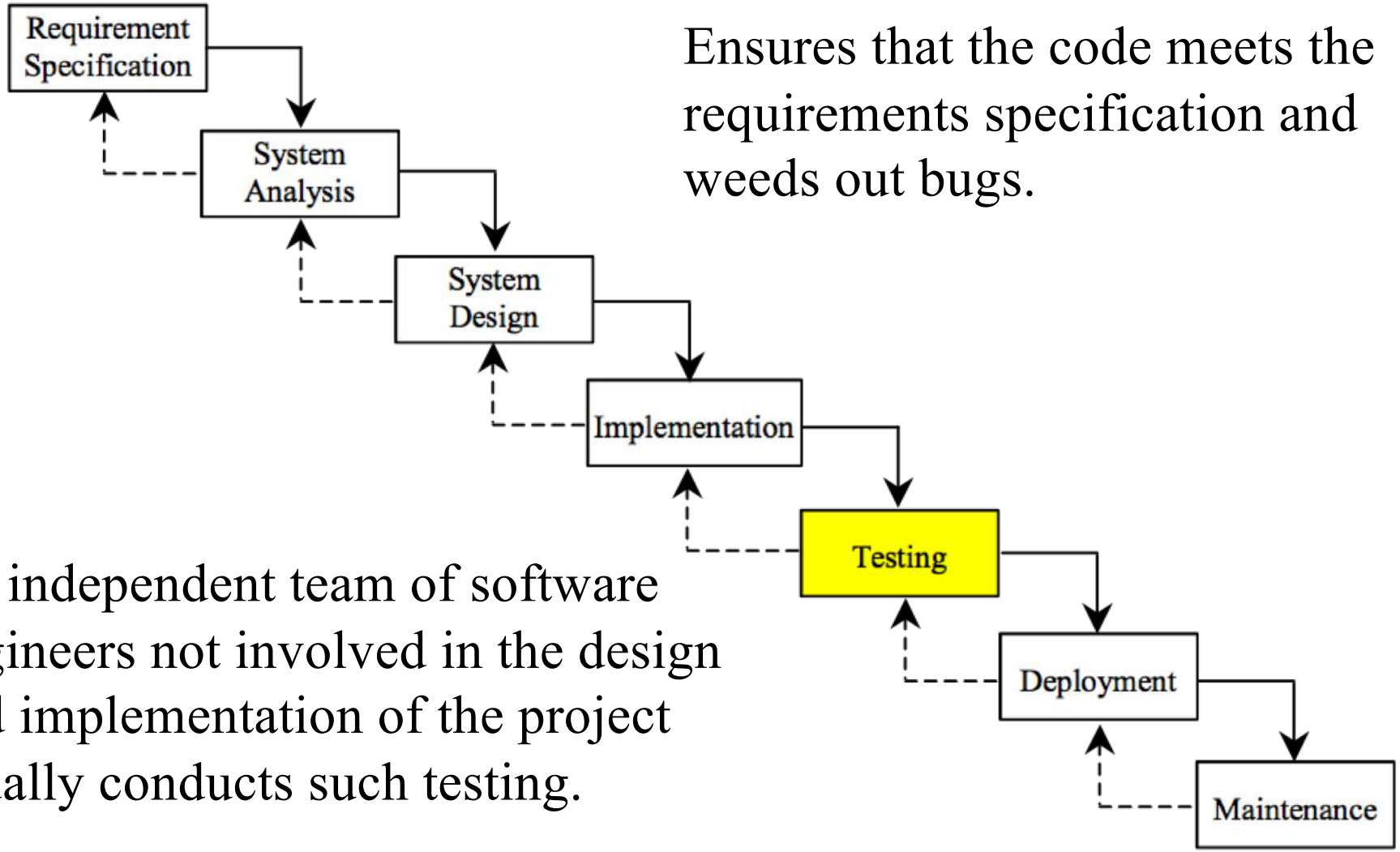
Implementation *



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.

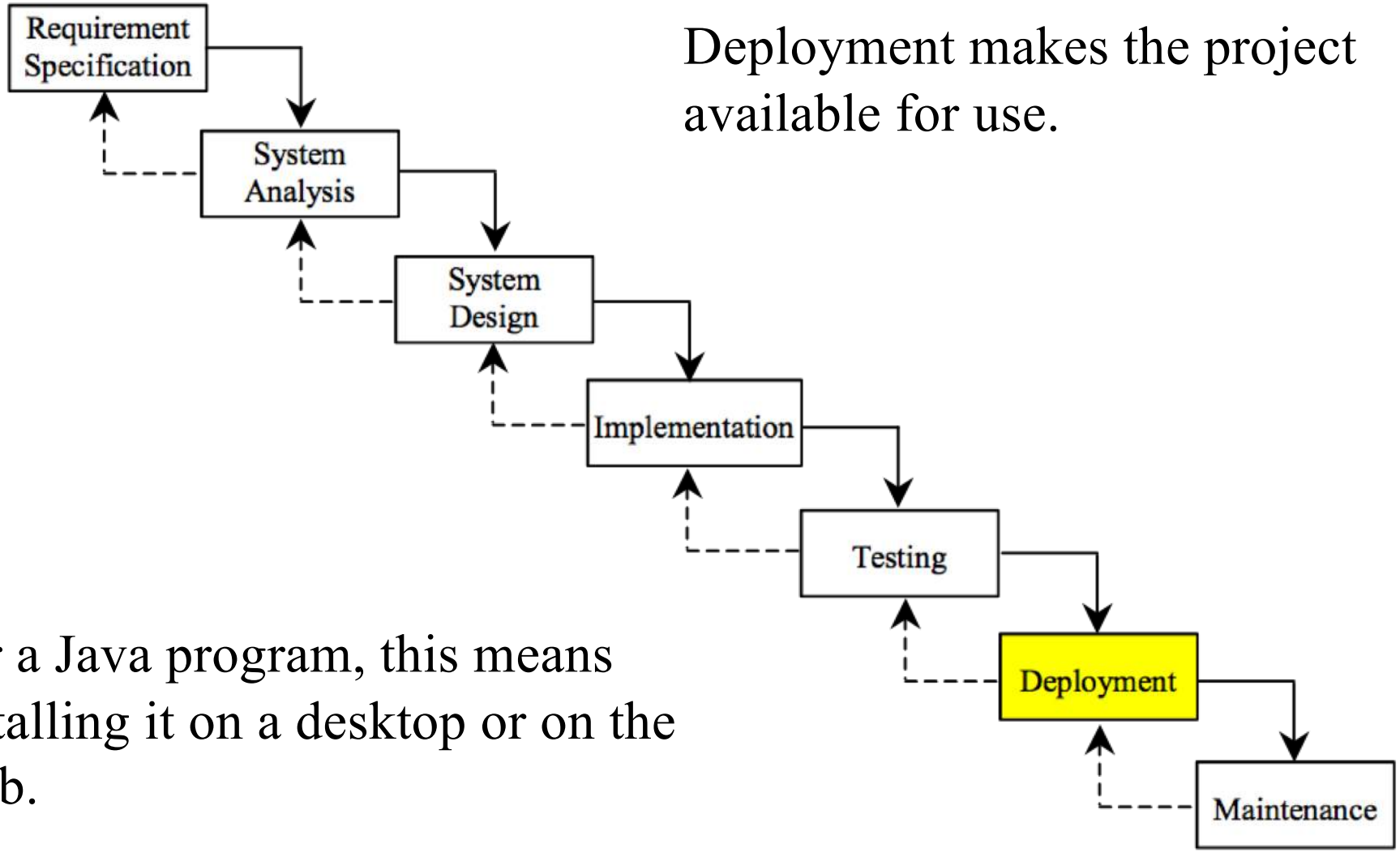
Testing *



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.

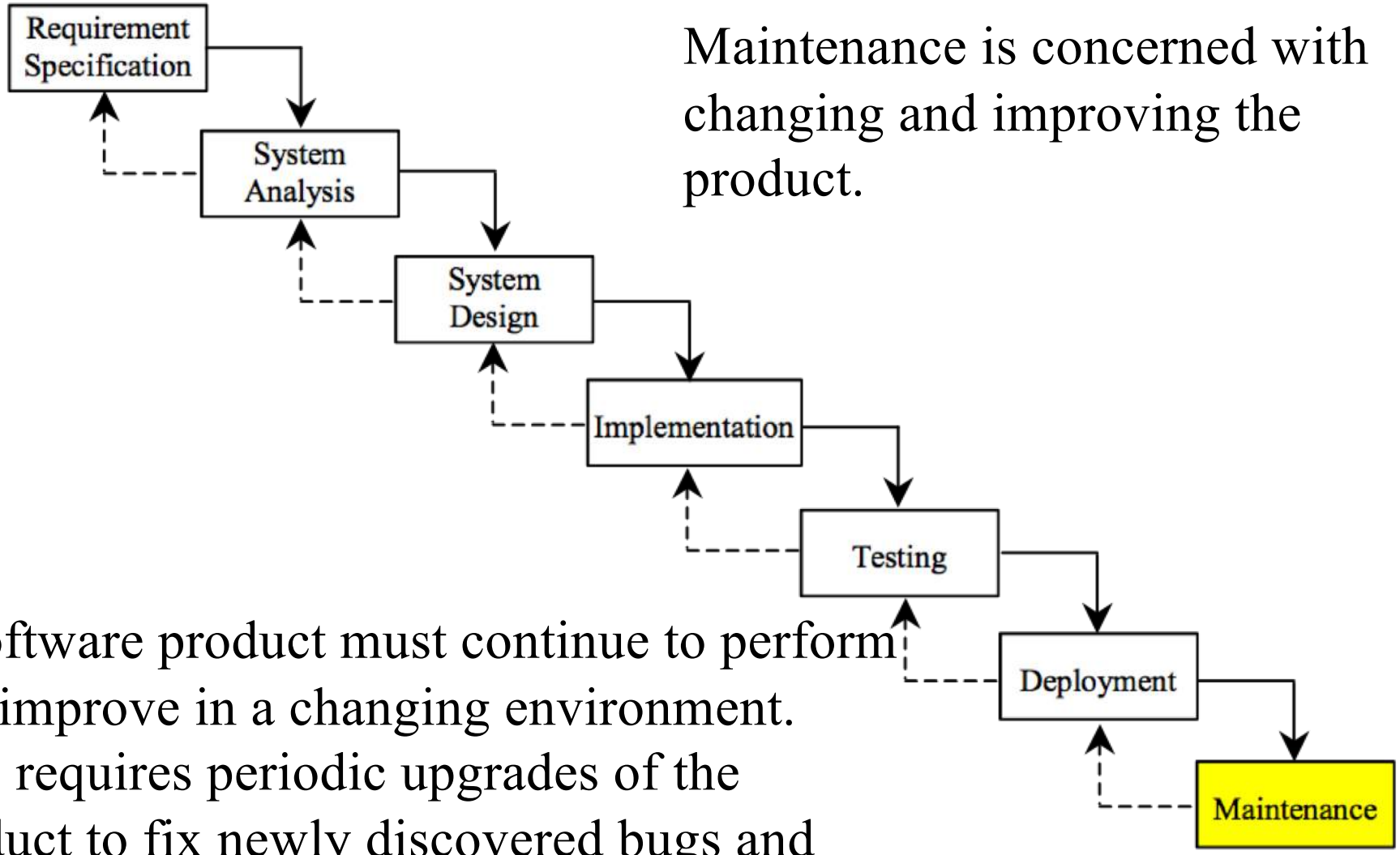
Deployment *



Deployment makes the project available for use.

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.

Problem:
Computing Loan Payments

This program lets the user enter the interest rate, number of years, and loan amount, and computes monthly payment and total payment.

$$monthlyPayment = \frac{loanAmount \times monthlyInterestRate}{1 - \frac{1}{(1 + monthlyInterestRate)^{numberOfYears \times 12}}}$$

Problem: Monetary Units

This program lets the user enter the amount in decimal representing dollars and cents and output a report listing the monetary equivalent in single dollars, quarters, dimes, nickels, and pennies.

Supplement reading: Common Errors and Pitfalls

- Common Error 1: Undeclared/Uninitialized Variables and Unused Variables
- Common Error 2: Integer Overflow
- Common Error 3: Round-off Errors
- Common Error 4: Unintended Integer Division
- Common Error 5: Redundant Input Objects

- Common Pitfall 1: Redundant Input Objects

Common Error 1: Undeclared/Uninitialized Variables and Unused Variables

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

Common Error 2: Integer Overflow

```
int value = 2147483647 + 1;
// value will actually be -2147483648
```

Common Error 3: Round-off Errors

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

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

Common Error 4: Unintended Integer Division

```
int number1 = 1;
int number2 = 2;
double average=(number1+number2) / 2;
double average=(number1+number2) / 2.0;
```

Common Pitfall 1: Redundant Input Objects

```
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();
```