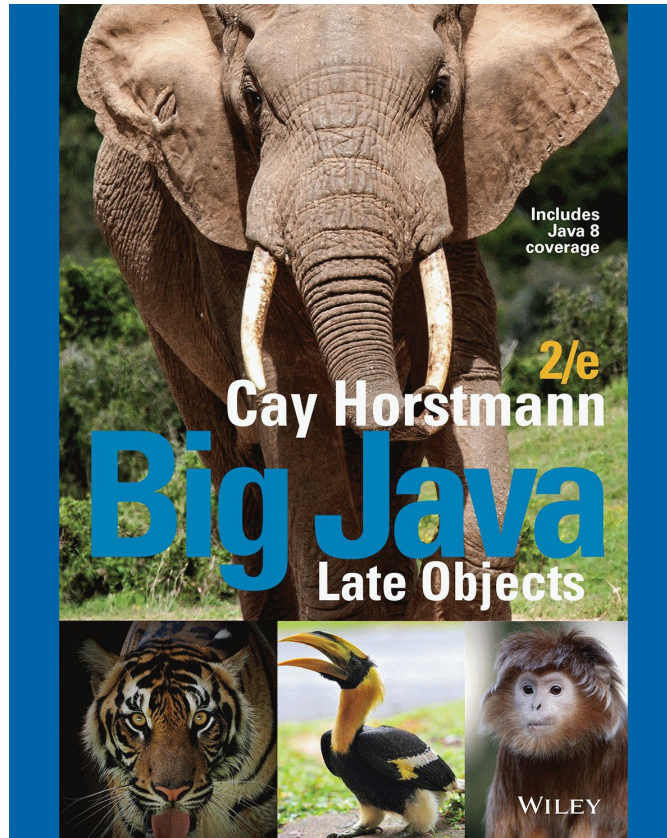Includes Java 8 coverage

2/e

Cay Horstmann

Big Java

Late Objects

WILEY

Chapter Goals

© Jan Pietruszka/iStockphoto.

- To learn about computers and programming
- To compile and run your first Java program
- To recognize compile-time and run-time errors
- To describe an algorithm with pseudocode

Computer Programs

- Computers are programmed to perform many different tasks.
- Computers execute very basic instructions in rapid succession.
- A computer program is a sequence of instructions and decisions.
- Programming is the act of designing and implementing computer programs.
- The physical computer and peripheral devices are collectively called the hardware.
- The programs the computer executes are called the software.

Self Check 1.1

What is required to play a music CD on a computer?

Answer: A program that reads the data on the CD and sends output to the speakers and the screen.

Self Check 1.2

Why is a CD player less flexible than a computer?

Answer: A CD player can do one thing — play music CDs. It cannot execute programs.
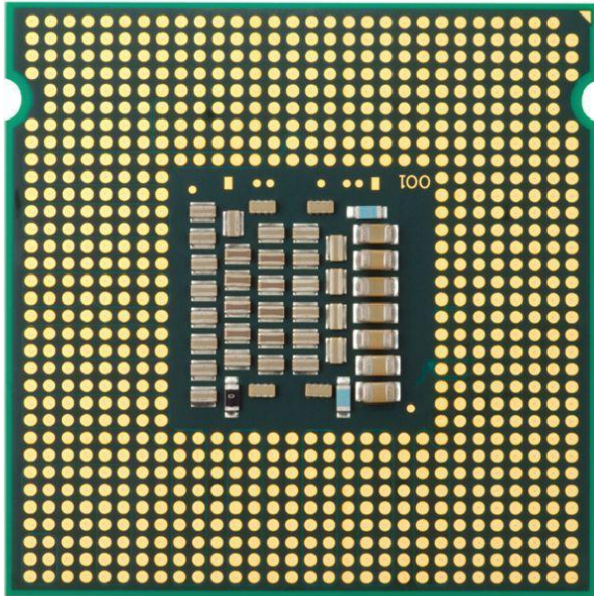
Self Check 1.3

What does a computer user need to know about programming in order to play a video game?

Answer: Nothing

The Anatomy of a Computer

- Central processing unit (CPU) performs
  - Program control
  - Data processing
- Storage
  - Memory (Primary storage)
  - Secondary storage
- Peripherals
  - To interact with human users
- Networks

Central Processing Unit

Figure 1 Central Processing Unit

A Hard Disk

© PhotoDisc, Inc./Getty Images, Inc.

Figure 2 Hard Disk
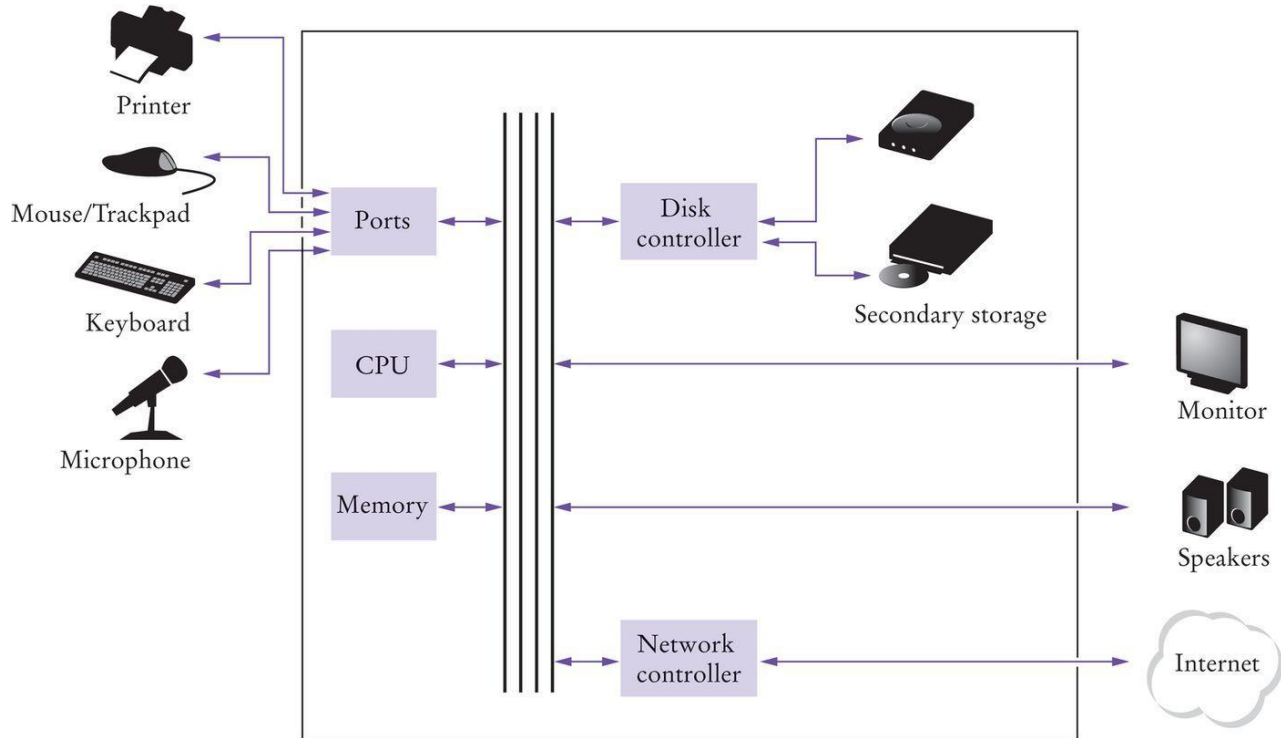
Schematic Diagram of a Computer

Figure 3 Schematic Design of a Personal Computer

Self Check 1.4

Where is a program stored when it is not currently running?

Answer: In secondary storage, typically a hard disk.

running --> RAM

Self Check 1.5

Which part of the computer carries out arithmetic operations, such as addition and multiplication?

Answer: The central processing unit.

Self Check 1.6

A modern smartphone is a computer, comparable to a desktop computer. Which components of a smartphone correspond to those shown in Figure 3 (Schematic Diagram of a Computer)?

> **Answer:** A smartphone has a CPU and memory, like any computer. A few smartphones have keyboards. Generally, the touchpad is used instead of a mouse. Secondary storage is in the form of a solid state drive. Of course, smartphones have a display, speaker, and microphone. The network connection uses the wireless radio to connect to a cell tower.
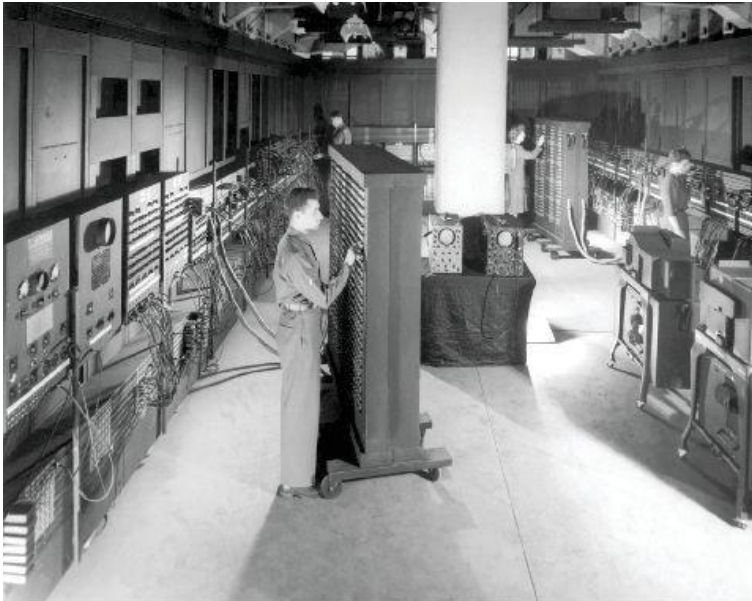
Computers are Everywhere

© Maurice Savage/Alamy Limited.

This transit card contains a computer.
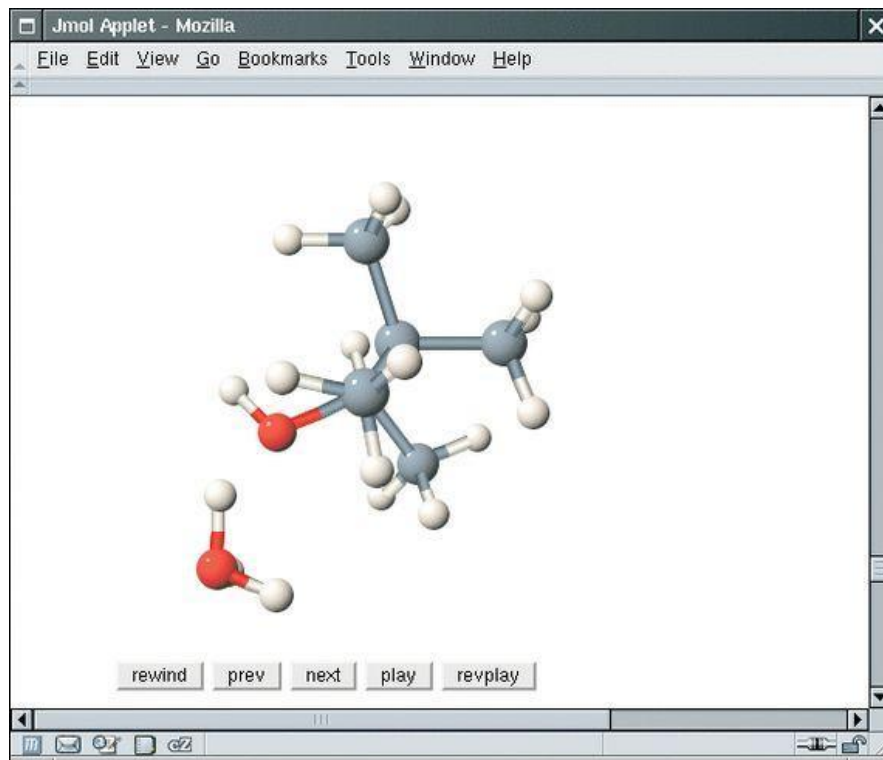
The ENIAC

© UPPA/Photoshot

The Eniac

The Java Programming Language

- Safe

- Portable

- Platform-independent
  - Distributed as instructions for a virtual machine

- Vast set of library packages

- Designed for the Internet

Applet on a Web Page

An Applet for Visualizing Molecules Running in a
Browser Window (http://jmol.sourceforge.net/)

Java Versions

Version	Year	Important New Features
1.0	1996	
1.1	1997	Inner classes
1.2	1998	Swing, Collections framework
1.3	2000	Performance enhancements
1.4	2002	Assertions, XML support
5	2004	Generic classes, enhanced `for` loop, auto-boxing, enumerations, annotations
6	2006	Library improvements
7	2011	Small language changes and library improvements
8	2014	Function expressions, streams, new date/time library

- Many more versions after the textbook was published!
- We will use **Java 11** in CS101

Self Check 1.7

What are the two most important benefits of the Java language?

Answer: Safety and portability.

Self Check 1.8

How long does it take to learn the entire Java library?

Answer: No one person can learn the entire library – it is too large.

Becoming Familiar with Your Programming Environment

- An editor is a program for entering and modifying text, such as a Java program.
- Java is case sensitive.
- Java compiler translates source code into class files.
- Class files contain instructions for the Java virtual machine.

Becoming Familiar with Your Programming Environment

1. Start the Java development environment.

2. Write a simple program.

3. Run the program.

4. Organize your work.

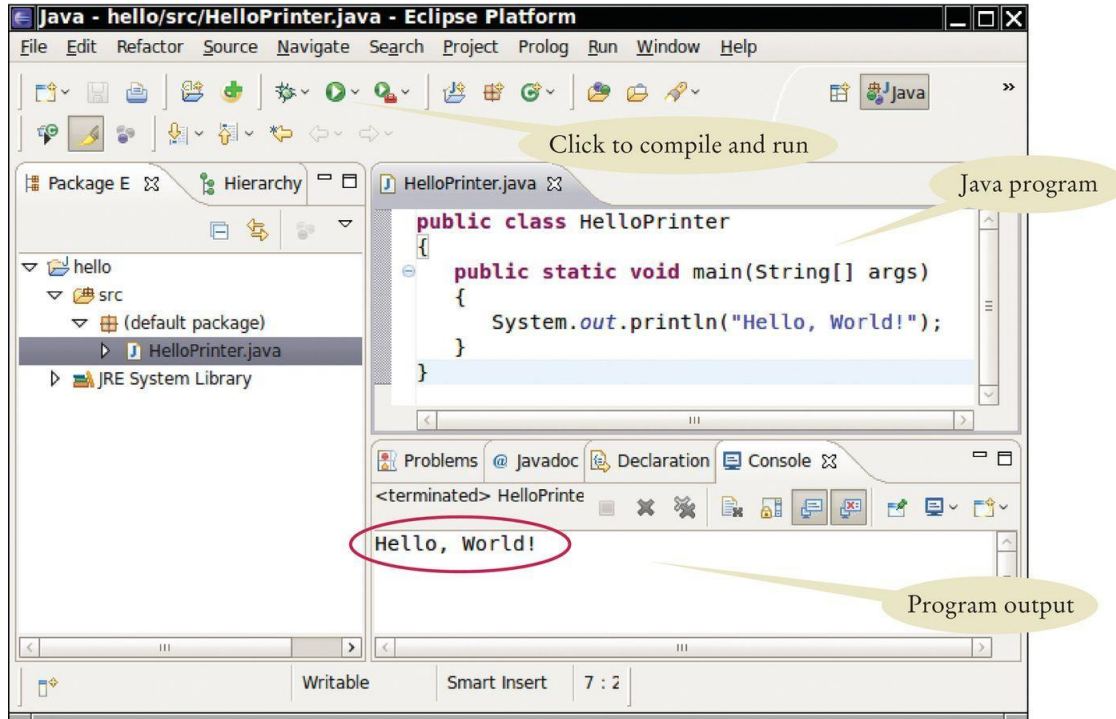# Becoming Familiar with Your Programming Environment
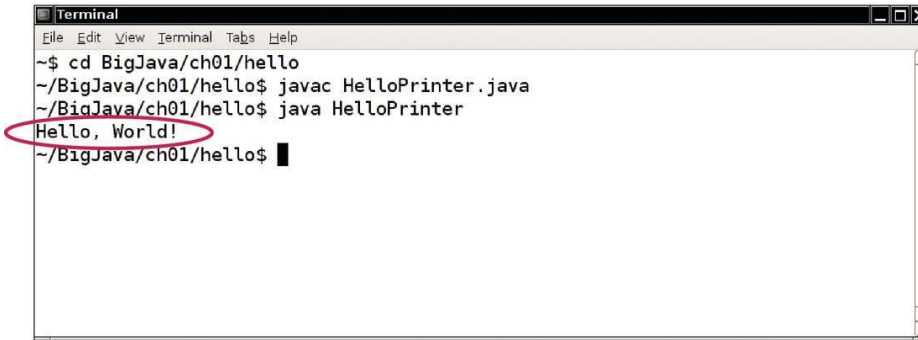
Figure 4 Running the `HelloPrinter` Program in an Integrated Development Environment

Becoming Familiar with Your Programming Environment

```
Terminal                                                    _ □ ✕
File Edit View Terminal Tabs Help
~$ cd BigJava/ch01/hello
~/BigJava/ch01/hello$ javac HelloPrinter.java
~/BigJava/ch01/hello$ java HelloPrinter
Hello, World!
~/BigJava/ch01/hello$ █
```

Figure 5 Running the `HelloPrinter` Program in a Console Window

Becoming Familiar with Your Programming Environment
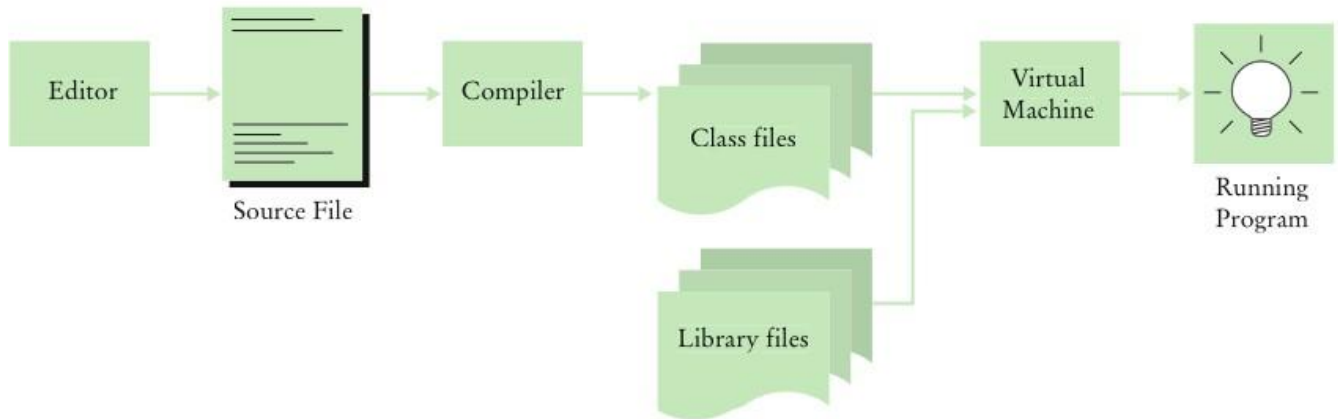
Figure 6 From Source Code to Running Program

Becoming Familiar with Your Programming Environment

- 📁 ch01
  - ▼ 📁 section_4
    - 📄 HelloPrinter.java
  - ▼ 📁 section_5
    - 📄 PrintTester.java
  - ▼ 📁 section_6
    - 📄 Error1.java
    - 📄 Error2.java
    - 📄 Error3.java
- 📁 ch02
  - ▼ 📁 how_to_1
    - 📄 VendingMachine.java
  - ▼ 📁 section_1
    - 📄 Volume1.java
  - ▼ 📁 section_2
    - 📄 Price.java
  - ▼ 📁 section_3
    - 📄 Volume2.java
  - ▼ 📁 section_4
    - 📄 Tiles.java
  - ▼ 📁 section_5
    - 📄 Initials.java
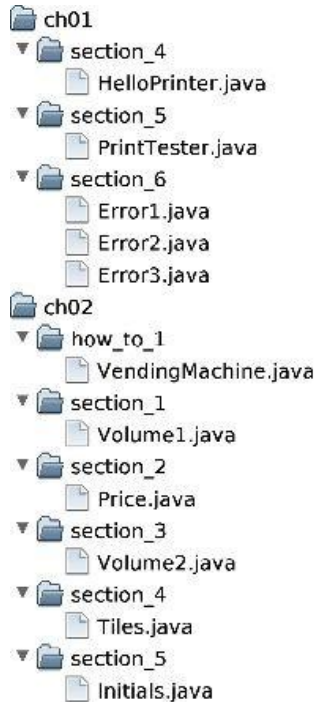
Figure 7 A Folder Hierarchy

Self Check 1.9

Where is the `HelloPrinter.java` file stored on your computer?

Answer: The answer varies among systems. A typical answer:

- `/home/dave/cs1/hello/HelloPrinter.java` or
- `c:\Users\Dave\Workspace\hello\HelloPrinter.java`

Self Check 1.10

What do you do to protect yourself from data loss when you work on programming projects?

Answer: You back up your files and folders.

Section_5/HelloPrinter.java

```java
1  public class HelloPrinter
2  {
3      public static void main(String[] args)
4      {
5      // Display a greeting in the console window
6        System.out.println("Hello, World!");
7    }
8
9  }
```

Analyzing Your First Program: Class Declaration

- Classes are the fundamental building blocks of Java programs:

- Declaration of a class called `HelloPrinter`

```
public class HelloPrinter
```

- In Java, every source file can contain, at most one public class.
- The name of the public class must match the name of the file containing the class:

    Class `HelloPrinter` must be contained in a file named `HelloPrinter.java`

Analyzing Your First Program: Methods

- Each class contains declarations of methods.
- Each method contains a sequence of instructions.
- A method contains a collection of programming instructions that describe how to carry out a particular task.
- A method is called by specifying the method and its arguments.

Analyzing Your First Program: main Method

- Every Java application contains a class with a `main` method

    When the application starts, the instructions in the `main` method are executed

- Declaring a main method

```
public static void main(String[] args)
{
    . . .
}
```

Analyzing Your First Program: Statements

- The *body* of the main method contains **statements**.

- Our method has a single statement:

```
System.out.println("Hello, World!");
```

- It prints a line of text:

```
Hello, World!
```

Analyzing Your First Program: Method Call

- A method call:

```
System.out.println("Hello, World!");
```

- A method call requires:

  1. The method you want to use (in this case, `System.out.println`)
  2. Any values the method needs to carry out its task enclosed in parentheses (in this case, `"Hello, World!"`)

- The technical term for such values is "arguments"

Syntax 1.1 Java Program

Every program contains at least one class. Choose a class name that describes the program action.

Every Java program contains a main **method** with this header.

```java
public class HelloPrinter
{
    public static void main(String[] args)
    {
        System.out.println("Hello, World!");
    }
}
```

The statements inside the main **method** are executed when the program runs.

Replace this statement when you write your own programs.

Each statement ends in a semicolon. See page 13.

Be sure to match the opening and closing braces.

Analyzing Your First Program: Strings

- **String:** a sequence of characters enclosed in double quotation marks:

```
"Hello, World!"
```

Analyzing Your First Program: Printing

- You can print numerical values

```
System.out.println(3 + 4);
```

    evaluates the expression 3 + 4
    displays the number 7.

- `System.out.println` method prints a string or a number and then starts a new line.

    The sequence of statements

    ```
    System.out.println("Hello");
    System.out.println("World!");
    ```

    Prints two lines

    ```
    Hello
    World!
    ```

- There is a second method, `System.out.print`, that you can use to print an item without starting a new line

Self Check 1.11

How do you modify the `HelloPrinter` program to greet you instead?

Answer: Change `World` to your name (here, Dave):

```
System.out.println("Hello, Dave!");
```

Self Check 1.12

How would you modify the `HelloPrinter` program to print the word "Hello" vertically?

Answer:

```
System.out.println("H");
System.out.println("e");
System.out.println("l");
System.out.println("l");
System.out.println("o");
```

Self Check 1.13

Would the program continue to work if you replaced line 7 with this statement?

```
System.out.println(Hello);
```

Answer: No. The compiler would look for an item whose name is `Hello`. You need to enclose `Hello` in quotation marks:

```
System.out.println("Hello");
```

Self Check 1.14

What does the following set of statements print?

```
System.out.print("My lucky number is");
System.out.println(3 + 4 + 5);
```

Answer: The printout is `My lucky number is 12`. It would be a good idea to add a space after the `is`.

Self Check 1.15

What do the following statements print?

```
System.out.println("Hello");
System.out.println("");
System.out.println("World");
```

Answer:

```
Hello
a blank line
World
```

Errors

- A compile-time error (syntax error)

  is a violation of the programming language rules
  detected by the compiler.

  ```
  System.ou.println("Hello, World!");
  ```

- A run-time error (logic error)

  causes a program to perform an action that the programmer did not intend.

  ```
  System.out.println("Hello, Word!");
  ```

Errors

- Exception - a type of run-time error
  - Generates an error message from the Java virtual machine
  - This statement

```
System.out.println(1 / 0)
```

  - Generates this run-time error message

```
"Division by zero"
```

Self Check 1.16

Suppose you omit the `""` characters around `Hello, World!` from the
`HelloPrinter.java`
program. Is this a compile-time error or a run-time error?

> **Answer:** This is a compile-time error. The compiler will complain that it
> does not know the meanings of the words `Hello` and `World`.

Self Check 1.17

Suppose you change `println` to `printline` in the `HelloPrinter.java` program. Is this a compile-time error or a run-time error?

Answer: This is a compile-time error. The compiler will complain that `System.out` does not have a method called `printline`.

Self Check 1.18

Suppose you change `main` to `hello` in the `HelloPrinter.java` program. Is this a compile- time error or a run-time error?

Answer: This is a run-time error. It is perfectly legal to give the name `hello` to a method, so the compiler won't complain. But when the program is run, the virtual machine will look for a `main` method and won't find one.

Self Check 1.19

When you used your computer, you may have experienced a program that "crashed" (quit spontaneously) or "hung" (failed to respond to your input). Is that behavior a compile-time error or a run-time error?

Answer: It is a run-time error. After all, the program had been compiled in order for you to run it.

Self Check 1.20

Why can't you test a program for run-time errors when it has compiler errors?

Answer: When a program has compiler errors, no class file is produced, and there is nothing to run.

Problem Solving: Algorithm Design

- **Algorithm:** A sequence of steps that is:

  unambiguous   clear and easy to understand

  executable

  terminating

An Algorithm for Solving an Investment Problem

- The problem:

  You put $10,000 into a bank account that earns 5 percent interest per year. How many years does it take for the account balance to be double the original?

- Calculating by hand

year	interest	balance
0		10000
1	10000.00 x 0.05 = 500.00	10000.00 + 500.00 = 10500.00
2	10500.00 x 0.05 = 525.00	10500.00 + 525.00 = 11025.00
3	11025.00 x 0.05 = 551.25	11025.00 + 551.25 = 11576.25
4	11576.25 x 0.05 = 578.81	11576.25 + 578.81 = 12155.06

An Algorithm for Solving an Investment Problem - continued

- The steps in the algorithm

  Start with a year value of 0, a column for the interest, and a balance of $10,000.

year	interest	balance
0		10000

  Repeat the following steps while the balance is less than $20,000

  Add 1 to the year value.
  Compute the interest as balance x 0.05 (i.e., 5 percent interest). Add the interest to the balance.

year	interest	balance
0		10000
1	500.00	10500.00
14	942.82	19799.32
(15)	989.96	20789.28

  Report the final year value as the answer.

Pseudocode

- **Pseudocode:** An informal description of of a sequence of steps for solving a problem   english/works in every language

    - Describe how a value is set or changed:

    ```
    total cost = purchase price + operating cost
    Multiply the balance value by 1.05.
    Remove the first and last character from the word.
    ```

    - Describe decisions and repetitions:

    ```
    If total cost 1 < total cost 2s
    While the balance is less than $20,000
    For each picture in the sequence
    ```
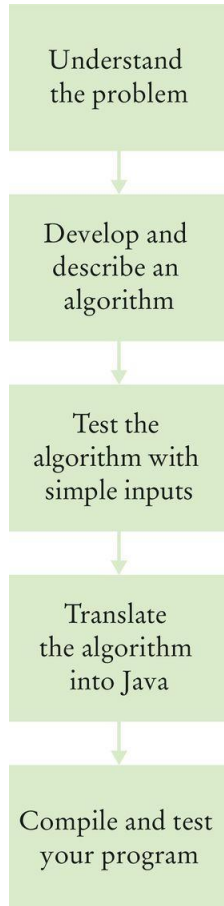
    - Use indentation to indicate which statements should be selected or repeated

    ```
    For each car
        operating cost = 10 x annual fuel cost
        total cost = purchase price + operating cost
    ```

    - Indicate results:

    ```
    Choose car1.
    Report the final year value as the answer.
    ```

From Algorithm to Programs

Understand the problem

↓

Develop and describe an algorithm

↓

Test the algorithm with simple inputs

↓

Translate the algorithm into Java

↓

Compile and test your program

Self Check 1.21

Suppose the interest rate was 20 percent. How long would it take for the investment to double?

Answer: 4 years:

```
0 10,000
1 12,000
2 14,400
3 17,280
4 20,736
```

Self Check 1.22

Suppose your cell phone carrier charges you $29.95 for up to 300 minutes of calls, and $0.45 for each additional minute, plus 12.5 percent taxes and fees. Give an algorithm to compute the monthly charge for a given number of minutes.

Answer:

Is the number of minutes at most 300?

a. If so, the answer is $29.95 × 1.125 = $33.70.

b. If not,

> 1. *Compute the difference: (number of minutes) – 300.*
>
> 2. *Multiply that difference by 0.45.*
>
> 3. *Add $29.95.*
>
> 4. *Multiply the total by 1.125. That is the answer.*

Self Check 1.23

Consider the following pseudocode for finding the most attractive photo from a sequence of photos:

```
Pick the first photo and call it "the best so far".
For each photo in the sequence
  If it is more attractive than the "best so far"
    Discard "the best so far".
    Call this photo "the best so far".
The photo called "the best so far" is the most attractive photo in the sequence.
```

Is this an algorithm that will find the most attractive photo?

Answer: No. The step If it is more attractive than the "best so far" is not executable because there is no objective way of deciding which of two photos is more attractive.

Self Check 1.24

Suppose each photo in Self Check 23 had a price tag. Give an algorithm for finding the most expensive photo.

Answer:

Pick the first photo and call it "the most expensive so far".
For each photo in the sequence
  If it is more expensive than "the most expensive so far"
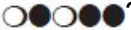   Discard "the most expensive so far".
    Call this photo "the most expensive so far".
The photo called "the most expensive so far" is the most expensive photo in the sequence

Self Check 1.25

Suppose you have a random sequence of black and white marbles and want to rearrange it so that the black and white marbles are grouped together. Consider this algorithm

Repeat until sorted
    Locate the first black marble that is preceded by a white marble, and switch them.

What does the algorithm do with the sequence ○●○●●? Spell out the steps until the algorithm stops.

Answer:

The first black marble that is preceded by a white one is marked in blue:

○●○●●

Switching the two yields

●○○●●

The next black marble to be switched is

●○○●●

yielding

●○●○●

The next steps are

●●○○●

●●○●○

●●●○○

Self Check 1.26

Suppose you have a random sequence of colored marbles. Consider this pseudocode:

> Repeat until sorted
>   Locate the first marble that is preceded by a marble of a different color, and switch them.

Why is this not an algorithm?

Answer: The sequence doesn't terminate. Consider the input ○●○●○. The first two marbles keep getting switched.