starting out with >>>

JAVA™ EARLY OBJECTS

FIFTH EDITION

TONY GADDIS

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LOCATION OF VIDEONOTES IN THE TEXT *(continued)*

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Early Objects

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Early Objects

FIFTH EDITION

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Contents in Brief

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Contents

Preface

Welcome to *Starting Out with Java: Early Objects,* Fifth Edition. This book is intended for a one-semester or a two-quarter CS1 course. Although it is written for students with no prior programming background, even experienced students will benefit from its depth of detail.

Early Objects, Late Graphics

The approach taken by this text can be described as "early objects, late graphics." The student is introduced to object-oriented programming (OOP) early in the book. The fundamentals of control structures, classes, and the OOP paradigm are thoroughly covered before moving on to graphics and more powerful applications of the Java language.

As with all the books in the *Starting Out With* series, the hallmark of this text is its clear, friendly, and easy-to-understand writing. In addition, it is rich in example programs that are concise and practical.

New to this edition:

- **A New Chapter on JavaFX:** New to this edition is *Chapter 14: Creating GUI Applications with JavaFX*. JavaFX is the next-generation toolkit for creating GUIs and graphical applications in Java and is bundled with Java 7 and Java 8. This new chapter introduces the student to the JavaFX library and shows how to use Scene Builder (a free download from Oracle) to visually design GUIs. The chapter is written in such a way that it is independent from the existing chapters on Swing and AWT. The instructor can choose to skip the Swing and AWT chapters and go straight to JavaFX, or cover all of the GUI chapters.
- **Rewritten Database Chapter:** The database chapter, which is now Chapter 16, has been rewritten with more examples and more detailed explanations of various database operations.
- **Coverage of `System.out.printf` Has Been Expanded:** The section on `System.out.printf` in Chapter 2 has been completely rewritten and expanded to include diagrams and coverage of additional format specifiers.
- **`System.out.printf` Is Primarily Used For Formatting Console Output:** In this edition, `System.out.printf` is used as the primary method for formatting output in console programs. The `DecimalFormat` class is still introduced, but it is used to format numbers in GUI applications.

- **Discussion of Nested Loops Has Been Expanded:** In Chapter 4 the section on nested loops has been expanded to include an *In the Spotlight* section highlighting the use of nested loops to print patterns.
- **Usage of Random Numbers Has Been Expanded:** In Chapter 4 the section on random numbers has been expanded and now includes *In the Spotlight* sections demonstrating how random numbers can be used to simulate the rolling of dice.
- **New Motivational Example of Classes Has Been Added to Chapter 6:** In Chapter 6, a new motivational example of classes has been added. The example shows how a variation of the game of Cho-Han can be simulated with classes that represent the players, a dealer, and the dice.
- **Multi-Catch Exception Handling:** A discussion of multi-catch exception handling has been added to Chapter 10.
- **Equipping Swing GUI Applications with a Static `main` Method is Introduced Earlier:** In Chapter 11, *GUI Applications—Part 1*, the topic of equipping a GUI class with a static `main` method has been moved to a point very early in the chapter.
- **New Exercises and Programming Problems:** New, motivational programming problems have been added to many of the chapters.

Organization of the Text

The text teaches Java step-by-step. Each chapter covers a major set of topics and builds knowledge as students progress through the book. Although the chapters can be easily taught in their existing sequence, there is some flexibility. Figure P-1 shows chapter dependencies. Each box represents a chapter or a group of chapters. A solid-line arrow points from one chapter to the chapter that must be covered previously. A dotted-line arrow indicates that only a section or minor portion of the chapter depends on another chapter.

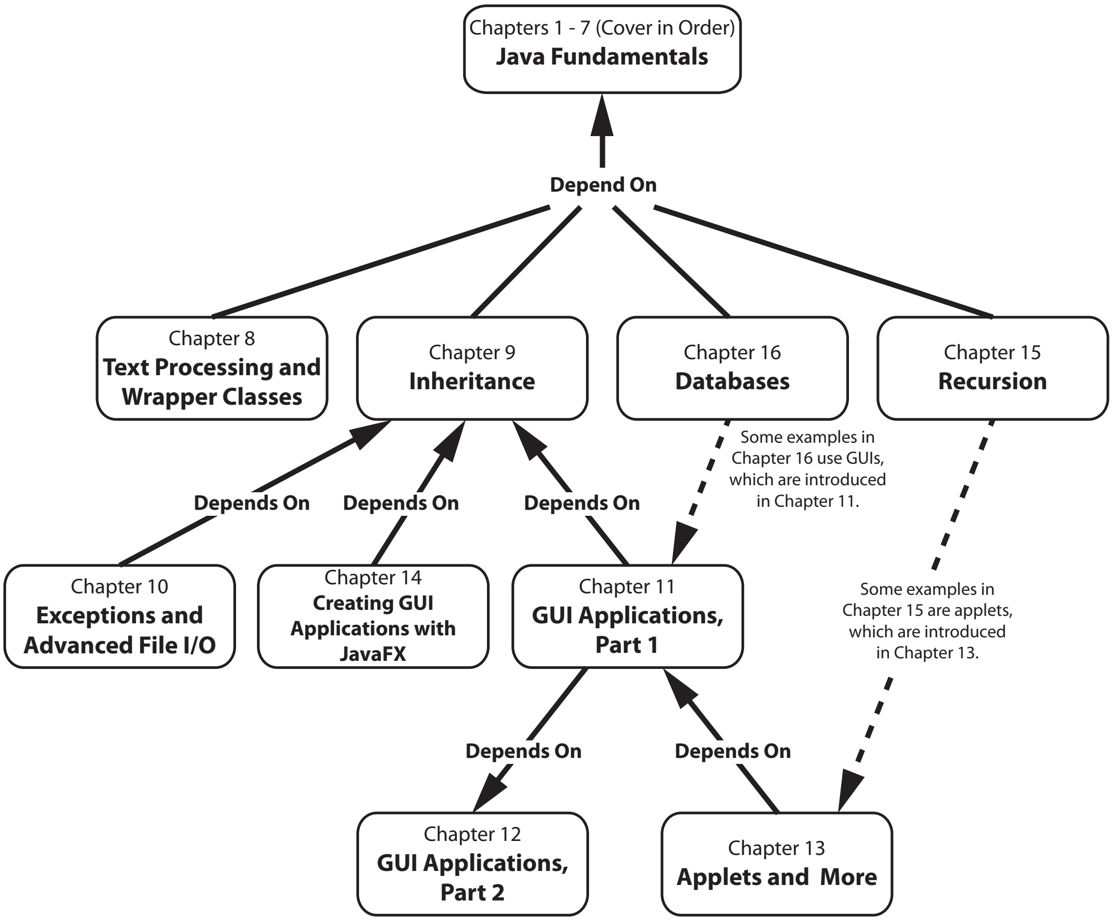
Brief Overview of Each Chapter

Chapter 1: Introduction to Computers and Java. This chapter provides an introduction to the field of computer science, and covers the fundamentals of hardware, software, and programming languages. The elements of a program, such as key words, variables, operators, and punctuation are discussed through the examination of a simple program. An overview of entering source code, compiling it, and executing it is presented. A brief history of Java is also given. The chapter concludes with a primer on OOP.

Chapter 2: Java Fundamentals. This chapter gets the student started in Java by introducing data types, identifiers, variable declarations, constants, comments, program output, and arithmetic operations. The conventions of programming style are also introduced. The student learns to read console input with the `Scanner` class, or as an option, through dialog boxes with `JOptionPane`.

Chapter 3: A First Look at Classes and Objects. This chapter introduces the student to classes. Once the student learns about fields and methods, UML diagrams are introduced as a design tool. The student learns to write simple `void` methods, as well as simple methods that return a value. Arguments and parameters are also discussed. Finally, the student learns how to write constructors, and the concept of the default constructor is discussed. A `BankAccount` class is presented as a case study, and a section on

Figure P-1 Chapter Dependencies


Chapters 1 - 7 (Cover in Order)
Java Fundamentals
Depend On
Chapter 8
Text Processing and Wrapper Classes
Chapter 9
Inheritance
Chapter 16
Databases
Chapter 15
Recursion
Depends On
Depends On
Depends On
Some examples in Chapter 16 use GUIs, which are introduced in Chapter 11.
Chapter 10
Exceptions and Advanced File I/O
Chapter 14
Creating GUI Applications with JavaFX
Chapter 11
GUI Applications, Part 1
Some examples in Chapter 15 are applets, which are introduced in Chapter 13.
Depends On
Depends On
Chapter 12
GUI Applications, Part 2
Chapter 13
Applets and More

object-oriented design is included. This section leads the students through the process of identifying classes and their responsibilities within a problem domain. There is also a section that briefly explains packages and the `import` statement.

Chapter 4: Decision Structures. Here the student explores relational operators and relational expressions and is shown how to control the flow of a program with the `if`, `if/else`, and `if/else if` statements. The conditional operator and the `switch` statement are also covered. This chapter also discusses how to compare `String` objects with the `equals`, `compareTo`, `equalsIgnoreCase`, and `compareToIgnoreCase` methods. Formatting numeric output with the `DecimalFormat` class is covered. An object-oriented case study shows how lengthy algorithms can be decomposed into several methods.

Chapter 5: Loops and Files. This chapter covers Java's repetition control structures. The `while` loop, `do-while` loop, and `for` loop are taught, along with common uses for these devices. Counters, accumulators, running totals, sentinels, and other application-related topics are discussed. Simple file operations for reading and writing text files are also covered.

Chapter 6: A Second Look at Classes and Objects. This chapter shows students how to write classes with added capabilities. Static methods and fields, interaction between objects, passing objects as arguments, and returning objects from methods are discussed. Aggregation and the "has a" relationship is covered, as well as enumerated types. A section on object-oriented design shows how to use CRC (class, responsibilities, and collaborations) cards to determine the collaborations among classes.

Chapter 7: Arrays and the `ArrayList` Class. In this chapter students learn to create and work with single and multidimensional arrays. Numerous array-processing techniques are demonstrated, such as summing the elements in an array, finding the highest and lowest values, and sequentially searching an array are also discussed. Other topics, including ragged arrays and variable-length arguments (varargs), are also discussed. The `ArrayList` class is introduced, and Java's generic types are briefly discussed and demonstrated.

Chapter 8: Text Processing and Wrapper Classes. This chapter discusses the numeric and character wrapper classes. Methods for converting numbers to strings, testing the case of characters, and converting the case of characters are covered. Autoboxing and unboxing are also discussed. More `String` class methods are covered, including using the `split` method to tokenize strings. The chapter also covers the `StringBuilder` and `StringTokenizer` classes.

Chapter 9: Inheritance. The study of classes continues in this chapter with the subjects of inheritance and polymorphism. The topics covered include superclass and subclass constructors, method overriding, polymorphism and dynamic binding, protected and package access, class hierarchies, abstract classes and methods, and interfaces.

Chapter 10: Exceptions and Advanced File I/O. In this chapter the student learns to develop enhanced error trapping techniques using exceptions. Handling an exception is covered, as well as developing and throwing custom exceptions. This chapter also discusses advanced techniques for working with sequential access, random access, text, and binary files.

Chapter 11: GUI Applications—Part 1. This chapter presents the basics of developing graphical user interface (GUI) applications with Swing. Fundamental Swing components and the basic concepts of event-driven programming are covered.

Chapter 12: GUI Applications—Part 2. This chapter continues the study of GUI application development. More advanced components, as well as menu systems and look-and-feel, are covered.

Chapter 13: Applets and More. Here the student applies his or her knowledge of GUI development to the creation of applets. In addition to using Swing applet classes, Abstract Windowing Toolkit classes are also discussed for portability. Drawing simple graphical shapes is also discussed.

Chapter 14: Creating GUI Applications with JavaFX. This chapter introduces JavaFX, which is the next generation library for creating graphical applications in Java. This chapter also shows how to use Scene Builder, a free screen designer from Oracle, to visually design GUIs. This chapter is written in such a way that it is independent from the existing chapters on Swing and AWT. You can choose to skip Chapters 11, 12, and 13, and go straight to Chapter 14, or cover all of the GUI chapters.

Chapter 15: Recursion. This chapter presents recursion as a problem-solving technique. Numerous examples of recursion are demonstrated.

Chapter 16: Databases. This chapter introduces the student to database programming. The basic concepts of database management systems and SQL are first presented. Then the student learns to use JDBC to write database applications in Java. Relational data is covered, and numerous example programs are presented throughout the chapter.

Appendix A. Getting Started with Alice

Appendixes B–M and **Case Studies 1-5** are available on the book's online resource page at www.pearsonhighered.com/gaddis.

Features of the Text

Concept Statements Each major section of the text starts with a concept statement. This statement summarizes the ideas of the section.

Example Programs The text has an abundant number of complete example programs, each designed to highlight the topic currently being studied. In most cases, these are practical, real-world examples. Source code for these programs is provided so that students can run the programs themselves.

Program Output After each example program there is a sample of its screen output. This immediately shows the student how the program should function.

Checkpoints

Checkpoints are questions placed throughout each chapter as a self-test study aid. Answers for all Checkpoint questions are found in Appendix L (available for download) so students can check how well they have learned a new topic. To download Appendix L, go to the Gaddis resource page at www.pearsonhighered.com/gaddis.

NOTE: Notes appear at appropriate places throughout the text. They are short explanations of interesting or often misunderstood points relevant to the topic at hand.

WARNING! Warnings are notes that caution the student about certain Java features, programming techniques, or practices that can lead to malfunctioning programs or lost data.

VidoeNotes. A series of online videos, developed specifically for this book, are available for viewing at www.pearsonhighered.com/gaddis. Icons appear throughout the text alerting the student to videos about specific topics.

Case Studies Case studies that simulate real-world applications appear in many chapters throughout the text, with complete code provided for each. These case studies are designed to highlight the major topics of the chapter in which they appear.

Review Questions and Exercises Each chapter presents a thorough and diverse set of review questions and exercises. They include Multiple Choice and True/False, Find the Error, Algorithm Workbench, and Short Answer.

Programming Challenges Each chapter offers a pool of programming challenges designed to solidify students' knowledge of topics at hand. In most cases the assignments present real-world problems to be solved.

In the Spotlight. Many of the chapters provide an *In the Spotlight* section that presents a programming problem, along with detailed, step-by-step analysis showing the student how to solve it.

Supplements

Companion Website

Many student resources are available for this book from the book's Companion Website. The following items are available at www.pearsonhighered.com/gaddis using the Access Code bound into the front of the book:

- The source code for each example program in the book
- Access to the book's companion VideoNotes
- Appendixes B–M (listed in the Table of Contents)
- A collection of five valuable Case Studies (listed in the Table of Contents)
- Links to download the Java™ Development Kit
- Links to download numerous programming environments, including jGRASP™, Eclipse™, TextPad™, NetBeans™, JCreator, and DrJava

Online Practice and Assessment with MyProgrammingLab

MyProgrammingLab helps students fully grasp the logic, semantics, and syntax of programming. Through practice exercises and immediate, personalized feedback, MyProgrammingLab improves the programming competence of beginning students who often struggle with the basic concepts and paradigms of popular high-level programming languages.

A self-study and homework tool, a MyProgrammingLab course consists of hundreds of small practice problems organized around the structure of this textbook. For students, the system automatically detects errors in the logic and syntax of their code submissions and offers targeted hints that enable students to figure out what went wrong—and why. For instructors, a comprehensive gradebook tracks correct and incorrect answers and stores the code inputted by students for review.

MyProgrammingLab is offered to users of this book in partnership with Turing's Craft, the makers of the CodeLab interactive programming exercise system. For a full demonstration, to see feedback from instructors and students, or to get started using MyProgrammingLab in your course, visit www.myprogramminglab.com.

Instructor Resources

The following supplements are available to qualified instructors only. Visit the Pearson Education Instructor Resource Center (www.pearsonhighered.com/irc) for information on how to access them:

- Answers to all Review Questions in the text
- Solutions for all Programming Challenges in the text
- PowerPoint presentation slides for every chapter
- Computerized test bank

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About the Author

Tony Gaddis is the principal author of the *Starting Out With* series of textbooks. Tony has nearly twenty years experience teaching computer science courses at Haywood Community College in North Carolina. He is a highly acclaimed instructor who was previously selected as the North Carolina Community College Teacher of the Year and has received the Teaching Excellence award from the National Institute for Staff and Organizational Development. Besides Java™ books, the Starting Out series includes introductory books using the C++ programming language, Microsoft® Visual Basic®, Microsoft® C#®, Python, Programming Logic and Design, Alice, and App Inventor, all published by Pearson.

CHAPTER 1

Introduction to Computers and Java

TOPICS

1.1 Introduction

This book teaches programming using Java. Java is a powerful language that runs on practically every type of computer. It can be used to create large applications or small programs, known as applets, that are part of a Web site. Before plunging right into learning Java, however, this chapter will review the fundamentals of computer hardware and software and then take a broad look at computer programming in general.

1.2 Why Program?

CONCEPT: Computers can do many different jobs because they are programmable.

Every profession has tools that make the job easier to do. Carpenters use hammers, saws, and measuring tapes. Mechanics use wrenches, screwdrivers, and ratchets. Electronics technicians use probes, scopes, and meters. Some tools are unique and can be categorized as belonging to a single profession. For example, surgeons have certain tools that are designed specifically for surgical operations. Those tools probably aren't used by anyone other than surgeons. There are some tools, however, that are used in several professions. Screwdrivers, for instance, are used by mechanics, carpenters, and many others.

The computer is a tool used by so many professions that it cannot be easily categorized. It can perform so many different jobs that it is perhaps the most versatile tool ever made. To the accountant, computers balance books, analyze profits and losses, and prepare tax reports. To the factory worker, computers control manufacturing machines and track production. To the mechanic, computers analyze the various systems in an automobile and pinpoint hard-to-find problems. The computer can do such a wide variety of tasks because it can be *programmed*. It is a machine specifically designed to follow instructions. Because of the computer's programmability, it doesn't belong to any single profession. Computers are designed to do whatever job their programs, or *software,* tell them to do.

Computer programmers do a very important job. They create software that transforms computers into the specialized tools of many trades. Without programmers, the users of computers would have no software, and without software, computers would not be able to do anything.

Computer programming is both an art and a science. It is an art because every aspect of a program should be carefully designed. Here are a few of the things that must be designed for any real-world computer program:

- The logical flow of the instructions
- The mathematical procedures
- The layout of the programming statements
- The appearance of the screens
- The way information is presented to the user
- The program's "user friendliness"
- Help systems and written documentation

There is also a science to programming. Because programs rarely work right the first time they are written, a lot of analyzing, experimenting, correcting, and redesigning is required. This demands patience and persistence of the programmer. Writing software demands discipline as well. Programmers must learn special languages such as Java because computers do not understand English or other human languages. Programming languages have strict rules that must be carefully followed.

Both the artistic and scientific nature of programming makes writing computer software like designing a car: Both cars and programs should be functional, efficient, powerful, easy to use, and pleasing to look at.

1.3 Computer Systems: Hardware and Software

CONCEPT: All computer systems consist of similar hardware devices and software components.

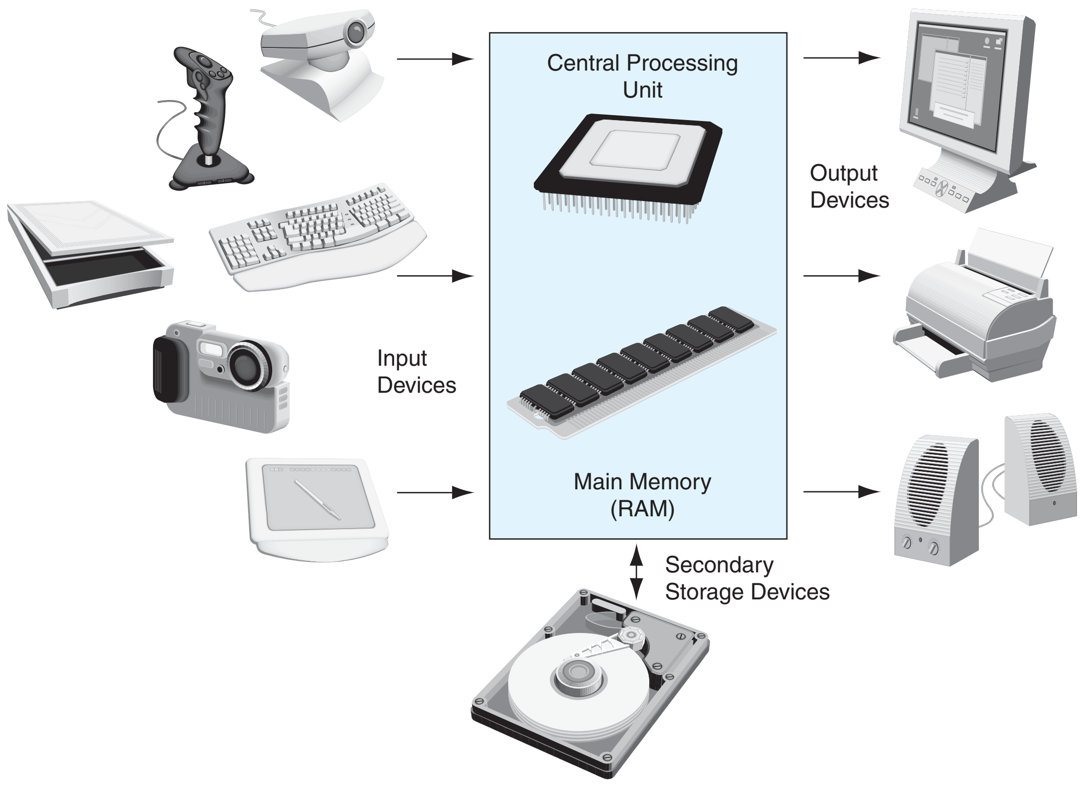
Hardware

Hardware refers to the physical components that a computer is made of. A computer, as we generally think of it, is not an individual device, but a system of devices. Like the instruments in a symphony orchestra, each device plays its own part. A typical computer system consists of the following major components:

- The central processing unit
- Main memory
- Secondary storage devices
- Input devices
- Output devices

The organization of a computer system is shown in Figure 1-1.

Figure 1-1 The organization of a computer system

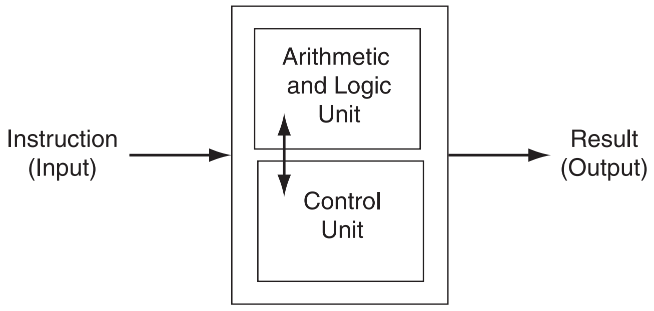


Let's take a closer look at each of these devices.

The CPU

At the heart of a computer is its *central processing unit*, or *CPU*. The CPU's job is to fetch instructions, follow the instructions, and produce some resulting data. Internally, the central processing unit consists of two parts: the *control unit* and the *arithmetic and logic unit (ALU)*. The control unit coordinates all of the computer's operations. It is responsible for determining where to get the next instruction and regulating the other major components of the computer with control signals. The arithmetic and logic unit, as its name suggests, is designed to perform mathematical operations. The organization of the CPU is shown in Figure 1-2.

Figure 1-2 The organization of the CPU



A program is a sequence of instructions stored in the computer's memory. When a computer is running a program, the CPU is engaged in a process known formally as the *fetch/decode/execute cycle*. The steps in the fetch/decode/execute cycle are as follows:

Fetch	The CPU's control unit fetches, from main memory, the next instruction in the sequence of program instructions.
Decode	The instruction is encoded in the form of a number. The control unit decodes the instruction and generates an electronic signal.
Execute	The signal is routed to the appropriate component of the computer (such as the ALU, a disk drive, or some other device). The signal causes the component to perform an operation.

These steps are repeated as long as there are instructions to perform.

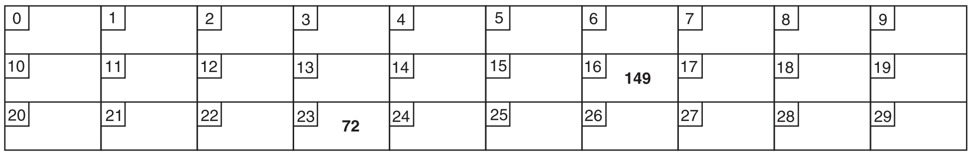
Main Memory

Commonly known as *random-access memory*, or *RAM*, the computer's main memory is a device that holds data. Specifically, RAM holds the sequences of instructions in the programs that are running and the data those programs are using.

Memory is divided into sections that hold an equal amount of data. Each section is made of eight "switches" that may be either on or off. A switch in the on position usually represents the number 1, although a switch in the off position usually represents the number 0. The computer stores data by setting the switches in a memory location to a pattern that represents a character or a number. Each of these switches is known as a *bit*, which stands for *binary digit*. Each section of memory, which is a collection of eight bits, is known as a *byte*. Each byte is assigned a unique number known as an *address*. The addresses are ordered from lowest to highest. A byte is identified by its address in much the same way a post office box is identified by an address. Figure 1-3 shows a series of bytes with their addresses. In the illustration, sample data is stored in memory. The number 149 is stored in the byte at address 16, and the number 72 is stored in the byte at address 23.

RAM is usually a volatile type of memory, used only for temporary storage. When the computer is turned off, the contents of RAM are erased.

Figure 1-3 Memory bytes and their addresses



Secondary Storage

Secondary storage is a type of memory that can hold data for long periods of time—even when there is no power to the computer. Programs are normally stored in secondary memory and loaded into main memory as needed. Important data, such as word processing documents, payroll data, and inventory figures, is saved to secondary storage as well.

The most common type of secondary storage device is the *disk drive*. A traditional disk drive stores data by magnetically encoding it onto a spinning circular disk. *Solid-state drives*, which store data in solid-state memory, are increasingly becoming popular. A solid-state drive has no moving parts and operates faster than a traditional disk drive. Most computers have some sort of secondary storage device, either a traditional disk drive or a solid-state drive, mounted inside their case. External drives are also available that connect to one of the computer's communication ports. External drives can be used to create backup copies of important data or to move data to another computer.

In addition to external drives, many types of devices have been created for copying data and for moving it to other computers. *Universal Serial Bus drives*, or *USB drives,* are small devices that plug into the computer's USB port and appear to the system as a disk drive. These drives do not actually contain a disk, however. They store data in a special type of memory known as *flash memory.* USB drives are inexpensive, reliable, and small enough to be carried in your pocket.

Optical devices such as the *CD* (compact disc) and the *DVD* (digital versatile disc) are also popular for data storage. Data is not recorded magnetically on an optical disc, but is encoded as a series of pits on the disc surface. CD and DVD drives use a laser to detect the pits and thus read the encoded data. Optical discs hold large amounts of data, and because recordable CD and DVD drives are now commonplace, they make a good medium for creating backup copies of data.

Input Devices

Input is any data the computer collects from the outside world. The device that collects the data and sends it to the computer is called an *input device*. Common input devices are the keyboard, mouse, scanner, microphone, Webcam, and digital camera. Disk drives, optical drives, and USB drives can also be considered input devices because programs and data are retrieved from them and loaded into the computer's memory.

Output Devices

Output is any data the computer sends to the outside world. It might be a sales report, a list of names, or a graphic image. The data is sent to an output device, which formats and presents it. Common output devices are monitors and printers. Disk drives, USB drives, and CD/DVD recorders can also be considered output devices because the CPU sends data to them in order to be saved.

Software

As previously mentioned, software refers to the programs that run on a computer. There are two general categories of software: operating systems and application software. An *operating system* is a set of programs that manages the computer's hardware devices and controls their processes. Most all modern operating systems are multitasking, which means they are capable of running multiple programs at once. Through a technique called *time sharing,* a multitasking system divides the allocation of hardware resources and the attention of the CPU among all the executing programs. UNIX, Linux, and modern versions of Windows and Mac OS are multitasking operating systems.

Application software refers to programs that make the computer useful to the user. These programs solve specific problems or perform general operations that satisfy the needs of the user. Word processing, spreadsheet, and database programs are all examples of application software.

Checkpoint

1.1 Why is the computer used by so many different people, in so many different professions?

1.2 List the five major hardware components of a computer system.

1.3 Internally, the CPU consists of what two units?

1.4 Describe the steps in the fetch/decode/execute cycle.

1.5 What is a memory address? What is its purpose?

1.6 Explain why computers have both main memory and secondary storage.

1.7 What does the term "multitasking" mean?

1.4 Programming Languages

CONCEPT: A program is a set of instructions a computer follows in order to perform a task. A programming language is a special language used to write computer programs.

What Is a Program?

Computers are designed to follow instructions. A computer program is a set of instructions that enable the computer to solve a problem or perform a task. For example, suppose we want the computer to calculate someone's gross pay. The following is a list of things the computer should do to perform this task.

1. Display a message on the screen: "How many hours did you work?"
2. Allow the user to enter the number of hours worked.
3. Once the user enters a number, store it in memory.
4. Display a message on the screen: "How much do you get paid per hour?"
5. Allow the user to enter an hourly pay rate.
6. Once the user enters a number, store it in memory.
7. Once both the number of hours worked and the hourly pay rate are entered, multiply the two numbers and store the result in memory.
8. Display a message on the screen that shows the amount of money earned. The message must include the result of the calculation performed in Step 7.

Collectively, these instructions are called an *algorithm*. An algorithm is a set of well-defined steps for performing a task or solving a problem. Notice that these steps are sequentially ordered. Step 1 should be performed before Step 2, and so forth. It is important that these instructions be performed in their proper sequence.

Although you and I might easily understand the instructions in the pay-calculating algorithm, it is not ready to be executed on a computer. A computer's CPU can only process instructions that are written in machine language. If you were to look at a machine language program, you would see a stream of binary numbers (numbers consisting of only 1s and 0s). The binary numbers form machine language instructions, which the CPU interprets as commands. Here is an example of what a machine language instruction might look like:

```
1011010000000101
```

As you can imagine, the process of encoding an algorithm in machine language is very tedious and difficult. In addition, each different type of CPU has its own machine language. If you wrote a machine language program for computer A and then wanted to run it on computer B, which has a different type of CPU, you would have to rewrite the program in computer B's machine language.

Programming languages, which use words instead of numbers, were invented to ease the task of programming. A program can be written in a programming language, which is much easier to understand than machine language, and then translated into machine language. Programmers use software to perform this translation. Many programming languages have been created. Table 1-1 lists a few of the well-known ones.

Table 1-1 Programming languages

Language	Description
BASIC	Beginners All-purpose Symbolic Instruction Code is a general-purpose, procedural programming language. It was originally designed to be simple enough for beginners to learn.
FORTRAN	FORmula TRANslator is a procedural language designed for programming complex mathematical algorithms.
COBOL	Common Business-Oriented Language is a procedural language designed for business applications.
Pascal	Pascal is a structured, general-purpose, procedural language designed primarily for teaching programming.
C	C is a structured, general-purpose, procedural language developed at Bell Laboratories.
C++	Based on the C language, C++ offers object-oriented features not found in C. C++ was also invented at Bell Laboratories.
C#	Pronounced "C sharp." It is a language invented by Microsoft for developing applications based on the Microsoft .NET platform.
Java	Java is an object-oriented language invented at Sun Microsystems and is now owned by Oracle. It may be used to develop stand-alone applications that operate on a single computer, applications that run over the Internet from a Web server, and applets that run in a Web browser.
JavaScript	JavaScript is a programming language that can be used in a Web site to perform simple operations. Despite its name, JavaScript is not related to Java.
Perl	A general-purpose programming language that is widely used on Internet servers.
PHP	A programming language used primarily for developing Web server applications and dynamic Web pages.
Python	Python is an object-oriented programming language that is used in both business and academia. Many popular Web sites have features that are developed in Python.
Ruby	Ruby is a simple but powerful object-oriented programming language. It can be used for a variety of purposes, from small utility programs to large Web applications.
Visual Basic	Visual Basic is a Microsoft programming language and software development environment that allows programmers to create Windows-based applications quickly.

A History of Java

In 1991 a team was formed at Sun Microsystems (a company that is now owned by Oracle) to speculate about the important technological trends that might emerge in the near future. The team, which was named the Green Team, concluded that computers would merge with consumer appliances. Their first project was to develop a handheld device named *7 (pronounced “star seven”) that could be used to control a variety of home entertainment devices. In order for the unit to work, it had to use a programming language that could be processed by all the devices it controlled. This presented a problem because different brands of consumer devices use different processors, each with its own machine language.

Because no such universal language existed, James Gosling, the team’s lead engineer, created one. Programs written in this language, which was originally named Oak, were not translated into the machine language of a specific processor, but were translated into an intermediate language known as *byte code*. Another program would then translate the byte code into machine language that could be executed by the processor in a specific consumer device.

Unfortunately, the technology developed by the Green Team was ahead of its time. No customers could be found, mostly because the computer-controlled consumer appliance industry was just beginning. But rather than abandoning their hard work and moving on to other projects, the team saw another opportunity: the Internet. The Internet is a perfect environment for a universal programming language such as Oak. It consists of numerous different computer platforms connected together in a single network.

To demonstrate the effectiveness of their language, which was renamed Java, the team used it to develop a Web browser. The browser, named HotJava, was able to download and run small Java programs known as applets. This gave the browser the capability to display animation and interact with the user. HotJava was demonstrated at the 1995 SunWorld conference before a wowed audience. Later the announcement was made that Netscape would incorporate Java technology into its Navigator browser. Other Internet companies rapidly followed, increasing the acceptance and the influence of the Java language. Today, Java is very popular for developing not only applets for the Internet, but also stand-alone applications.

Java Applications and Applets

There are two types of programs that may be created with Java: applications and applets. An application is a stand-alone program that runs on your computer. You have probably used several applications already, such as word processors, spreadsheets, database managers, and graphics programs. Although Java may be used to write these types of applications, other languages such as C, C++, and Visual Basic are also used.

In the previous section you learned that Java may also be used to create applets. The term *applet* refers to a small application, in the same way that the term *piglet* refers to a small pig. Unlike applications, an applet is designed to be transmitted over the Internet from a Web server, and then executed in a Web browser. Applets are important because they can be used to extend the capabilities of a Web page significantly.

Web pages are normally written in hypertext markup language (HTML). HTML is limited, however, because it merely describes the content and layout of a Web page. HTML does not have sophisticated abilities such as performing math calculations and interacting with the user. A Web designer can write a Java applet to perform operations that are normally performed by an application and embed it in a Web site. When someone visits the Web site, the applet is downloaded to the visitor's browser and executed.

Security

Any time content is downloaded from a Web server to a visitor's computer, security is an important concern. Because Java is a full-featured programming language, at first you might be suspicious of any Web site that transmits an applet to your computer. After all, couldn't a Java applet do harmful things, such as deleting the contents of the disk drive or transmitting private information to another computer? Fortunately, the answer is no. Web browsers run Java applets in a secure environment within your computer's memory and do not allow them to access resources, such as a disk drive, that are outside that environment.

1.5 What Is a Program Made of?

CONCEPT: There are certain elements that are common to all programming languages.

Language Elements

All programming languages have some things in common. Table 1-2 lists the common elements you will find in almost every language.

Table 1-2 The common elements of a programming language

Language Element	Description
Key Words	These are words that have a special meaning in the programming language. They may be used for their intended purpose only. Key words are also known as *reserved words*.
Operators	Operators are symbols or words that perform operations on one or more operands. An *operand* is usually an item of data, such as a number.
Punctuation	Most programming languages require the use of punctuation characters. These characters serve specific purposes, such as marking the beginning or ending of a statement, or separating items in a list.
Programmer-Defined Names	Unlike key words, which are part of the programming language, these are words or names that are defined by the programmer. They are used to identify storage locations in memory and parts of the program that are created by the programmer. Programmer-defined names are often called *identifiers*.
Syntax	These are rules that must be followed when writing a program. Syntax dictates how key words and operators may be used, and where punctuation symbols must appear.

Let's look at an example Java program and identify an instance of each of these elements. Code Listing 1-1 shows the code listing with each line numbered.