

Module 1

Java Fundamentals

CRITICAL SKILLS

- 1.1 Know the history and philosophy of Java
- 1.2 Understand Java's contribution to the Internet
- 1.3 Understand the importance of bytecode
- 1.4 Know the Java buzzwords
- 1.5 Understand the foundational principles of object-oriented programming
- 1.6 Create, compile, and run a simple Java program
- 1.7 Use variables
- 1.8 Use the **if** and **for** control statements
- 1.9 Create blocks of code
- 1.10 Understand how statements are positioned, indented, and terminated
- 1.11 Know the Java keywords
- 1.12 Understand the rules for Java identifiers

The rise of the Internet and the World Wide Web fundamentally reshaped computing. In the past, the cyber landscape was dominated by stand-alone PCs. Today, nearly all PCs are connected to the Internet. The Internet, itself, was transformed—originally offering a convenient way to share files and information, today it is a vast, distributed computing universe. With these changes came a new way to program: Java.

Java is the preeminent language of the Internet, but it is more than that. Java revolutionized programming, changing the way that we think about both the form and the function of a program. To be a professional programmer today implies the ability to program in Java—it is that important. In the course of this book, you will learn the skills needed to master it.

The purpose of this module is to introduce you to Java, including its history, its design philosophy, and several of its most important features. By far, the hardest thing about learning a programming language is the fact that no element exists in isolation. Instead, the components of the language work in conjunction with each other. This interrelatedness is especially pronounced in Java. In fact, it is difficult to discuss one aspect of Java without involving others. To help overcome this problem, this module provides a brief overview of several Java features, including the general form of a Java program, some basic control structures, and operators. It does not go into too many details but, rather, concentrates on the general concepts common to any Java program.

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1.1

The Origins of Java

Computer language innovation is driven forward by two factors: improvements in the art of programming and changes in the computing environment. Java is no exception. Building upon the rich legacy inherited from C and C++, Java adds refinements and features that reflect the current state of the art in programming. Responding to the rise of the online environment, Java offers features that streamline programming for a highly distributed architecture.

Java was conceived by James Gosling, Patrick Naughton, Chris Warth, Ed Frank, and Mike Sheridan at Sun Microsystems in 1991. This language was initially called “Oak” but was renamed “Java” in 1995. Somewhat surprisingly, the original impetus for Java was not the Internet! Instead, the primary motivation was the need for a platform-independent language that could be used to create software to be embedded in various consumer electronic devices, such as toasters, microwave ovens, and remote controls. As you can probably guess, many different types of CPUs are used as controllers. The trouble was that most computer languages are designed to be compiled for a specific target. For example, consider C++.

Although it is possible to compile a C++ program for just about any type of CPU, to do so requires a full C++ compiler targeted for that CPU. The problem, however, is that compilers are expensive and time-consuming to create. In an attempt to find a better solution, Gosling

and others worked on a portable, cross-platform language that could produce code that would run on a variety of CPUs under differing environments. This effort ultimately led to the creation of Java.

About the time that the details of Java were being worked out, a second, and ultimately more important, factor emerged that would play a crucial role in the future of Java. This second force was, of course, the World Wide Web. Had the Web not taken shape at about the same time that Java was being implemented, Java might have remained a useful but obscure language for programming consumer electronics. However, with the emergence of the Web, Java was propelled to the forefront of computer language design, because the Web, too, demanded portable programs.

Most programmers learn early in their careers that portable programs are as elusive as they are desirable. While the quest for a way to create efficient, portable (platform-independent) programs is nearly as old as the discipline of programming itself, it had taken a back seat to other, more pressing problems. However, with the advent of the Internet and the Web, the old problem of portability returned with a vengeance. After all, the Internet consists of a diverse, distributed universe populated with many types of computers, operating systems, and CPUs. What was once an irritating but a low-priority problem had become a high-profile necessity.

By 1993 it became obvious to members of the Java design team that the problems of portability frequently encountered when creating code for embedded controllers are also found when attempting to create code for the Internet. This realization caused the focus of Java to switch from consumer electronics to Internet programming. So, while it was the desire for an architecture-neutral programming language that provided the initial spark, it was the Internet that ultimately led to Java's large-scale success.

How Java Relates to C and C++

Java is directly related to both C and C++. Java inherits its syntax from C. Its object model is adapted from C++. Java's relationship with C and C++ is important for several reasons. First, many programmers are familiar with the C/C++ syntax. This makes it easy for a C/C++ programmer to learn Java and, conversely, for a Java programmer to learn C/C++.

Second, Java's designers did not "reinvent the wheel." Instead, they further refined an already highly successful programming paradigm. The modern age of programming began with C. It moved to C++, and now to Java. By inheriting and building upon that rich heritage, Java provides a powerful, logically consistent programming environment that takes the best of the past and adds new features required by the online environment. Perhaps most important, because of their similarities, C, C++, and Java define a common, conceptual framework for the professional programmer. Programmers do not face major rifts when switching from one language to another.

One of the central design philosophies of both C and C++ is that the programmer is in charge! Java also inherits this philosophy. Except for those constraints imposed by the Internet environment, Java gives you, the programmer, full control. If you program well, your programs

reflect it. If you program poorly, your programs reflect that, too. Put differently, Java is not a language with training wheels. It is a language for professional programmers.

Java has one other attribute in common with C and C++: it was designed, tested, and refined by real, working programmers. It is a language grounded in the needs and experiences of the people who devised it. There is no better way to produce a top-flight professional programming language.

Because of the similarities between Java and C++, especially their support for object-oriented programming, it is tempting to think of Java as simply the “Internet version of C++.” However, to do so would be a mistake. Java has significant practical and philosophical differences. Although Java was influenced by C++, it is not an enhanced version of C++. For example, it is neither upwardly nor downwardly compatible with C++. Of course, the similarities with C++ are significant, and if you are a C++ programmer, you will feel right at home with Java. Another point: Java was not designed to replace C++. Java was designed to solve a certain set of problems. C++ was designed to solve a different set of problems. Both will coexist for many years to come.

How Java Relates to C#

Recently a new language called C# has come on the scene. Created by Microsoft to support its .NET Framework, C# is closely related to Java. In fact, many of C#'s features were directly adapted from Java. Both Java and C# share the same general C++-style syntax, support distributed programming, and utilize the same object model. There are, of course, differences between Java and C#, but the overall “look and feel” of these languages is very similar. This means that if you already know C#, then learning Java will be especially easy. Conversely, if C# is in your future, then your knowledge of Java will come in handy.

Given the similarity between Java and C#, one might naturally ask, “Will C# replace Java?” The answer is No. Java and C# are optimized for two different types of computing environments. Just as C++ and Java will co-exist for a long time to come, so will C# and Java.



Progress Check

1. Java is useful for the Internet because it can produce _____ programs.
 2. Java is the direct descendent of what languages?
-

-
1. portable
 2. C and C++.

Java's Contribution to the Internet

The Internet helped catapult Java to the forefront of programming, and Java, in turn, has had a profound effect on the Internet. The reason for this is quite simple: Java expands the universe of objects that can move about freely in cyberspace. In a network, there are two very broad categories of objects that are transmitted between the server and your personal computer: passive information and dynamic, active programs. For example, when you read your e-mail, you are viewing passive data. Even when you download a program, the program's code is still only passive data until you execute it. However, a second type of object can be transmitted to your computer: a dynamic, self-executing program. Such a program is an active agent on the client computer, yet it is initiated by the server. For example, a program might be provided by the server to properly display the data that it is sending.

As desirable as dynamic, networked programs are, they also present serious problems in the areas of security and portability. Prior to Java, cyberspace was effectively closed to half of the entities that now live there. As you will see, Java addresses those concerns and, in doing so, has defined a new form of program: the applet.

Java Applets

An *applet* is a special kind of Java program that is designed to be transmitted over the Internet and automatically executed by a Java-compatible Web browser. Furthermore, an applet is downloaded on demand, just like an image, sound file, or video clip. The important difference is that an applet is an *intelligent program*, not just an animation or media file. In other words, an applet is a program that can react to user input and dynamically change—not just run the same animation or sound over and over.

As exciting as applets are, they would be nothing more than wishful thinking if Java were not able to address the two fundamental problems associated with them: security and portability. Before continuing, let's define what these two terms mean relative to the Internet.

Security

As you are almost certainly aware, every time you download a "normal" program, you are risking a viral infection. Prior to Java, most users did not download executable programs frequently, and those that did, scanned them for viruses prior to execution. Even so, most users still worried about the possibility of infecting their systems with a virus or allowing a malicious program to run wild in their systems. (A malicious program might gather private information, such as credit card numbers, bank account balances, and passwords by searching the contents of your computer's local file system.) Java answers these concerns by providing a *firewall* between a networked application and your computer.

When using a Java-compatible web browser, it is possible to safely download Java applets without fear of viral infection. The way that Java achieves this is by confining a Java program to the Java execution environment and not allowing it access to other parts of the computer. (You will see how this is accomplished, shortly.) Frankly, the ability to download applets with confidence that no harm will be done to the client computer is the single most important aspect of Java.

Portability

As discussed earlier, many types of computers and operating systems are connected to the Internet. For programs to be dynamically downloaded to all of the various types of platforms, some means of generating portable executable code is needed. As you will soon see, the same mechanism that helps ensure security also helps create portability. Indeed, Java's solution to these two problems is both elegant and efficient.

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Java's Magic: The Bytecode

The key that allows Java to solve both the security and the portability problems just described is that the output of a Java compiler is *not* executable code. Rather, it is bytecode. *Bytecode* is a highly optimized set of instructions designed to be executed by the Java run-time system, which is called the Java Virtual Machine (JVM). That is, the Java Virtual Machine is an *interpreter for bytecode*. This may come as a bit of a surprise. As you know, most modern languages, such as C++, are designed to be compiled, not interpreted—mostly because of performance concerns. However, the fact that a Java program is executed by the JVM helps solve the major problems associated with downloading programs over the Internet. Here is why.

Translating a Java program into bytecode makes it much easier to run a program in a wide variety of environments. The reason is straightforward: only the Java Virtual Machine needs to be implemented for each platform. Once the run-time package exists for a given system, any Java program can run on it. Remember that although the details of the JVM will differ from platform to platform, all understand the same Java bytecode. If a Java program were compiled to native code, then different versions of the same program would have to exist for each type of CPU connected to the Internet. This is, of course, not a feasible solution. Thus, the interpretation of bytecode is the easiest way to create truly portable programs.

The fact that a Java program is interpreted also helps make it secure. Because the execution of every Java program is under the control of the JVM, the JVM can contain the program and prevent it from generating side effects outside the system. Safety is also enhanced by certain restrictions that exist in the Java language.

When a program is interpreted, it generally runs substantially slower than the same program would run if compiled to executable code. However, with Java, the differential between the

two is not so great. The use of bytecode makes it possible for the Java run-time system to execute programs much faster than you might expect.

Although Java was designed for interpretation, there is technically nothing about Java that prevents on-the-fly compilation of bytecode into native code. For this reason, Sun began supplying its HotSpot technology not long after Java's initial release. HotSpot provides a JIT (Just In Time) compiler for bytecode. When a JIT compiler is part of the JVM, it compiles bytecode into executable code in real time, on a piece-by-piece, demand basis. It is important to understand that it is not possible to compile an entire Java program into executable code all at once because Java performs various checks that can be performed only at run time. Instead, the JIT compiles code as it is needed, during execution. Furthermore, not all sequences of bytecode are compiled—only those that will benefit from compilation. The remaining code is simply interpreted. The just-in-time approach still yields a significant performance boost, though. Even when dynamic compilation is applied to bytecode, the portability and safety features will still apply, because the run-time system (which performs the compilation) will still be in charge of the execution environment.

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1.4

The Java Buzzwords

No overview of Java is complete without a look at the Java buzzwords. Although the fundamental forces that necessitated the invention of Java are portability and security, other factors played an important role in molding the final form of the language. The key considerations were summed up by the Java design team in the following list of buzzwords.

Simple	Java has a concise, cohesive set of features that makes it easy to learn and use.
Secure	Java provides a secure means of creating Internet applications.
Portable	Java programs can execute in any environment for which there is a Java run-time system.
Object-oriented	Java embodies the modern, object-oriented programming philosophy.
Robust	Java encourages error-free programming by being strictly typed and performing run-time checks.
Multithreaded	Java provides integrated support for multithreaded programming.
Architecture-neutral	Java is not tied to a specific machine or operating system architecture.
Interpreted	Java supports cross-platform code through the use of Java bytecode.
High performance	The Java bytecode is highly optimized for speed of execution.
Distributed	Java was designed with the distributed environment of the Internet in mind.
Dynamic	Java programs carry with them substantial amounts of run-time type information that is used to verify and resolve accesses to objects at run time.

Ask the Expert

Q: To address the issues of portability and security, why was it necessary to create a new computer language such as Java; couldn't a language like C++ be adapted? In other words, couldn't a C++ compiler that outputs bytecode be created?

A: While it would be possible for a C++ compiler to generate bytecode rather than executable code, C++ has features that discourage its use for the creation of applets—the most important feature being C++'s support for pointers. A *pointer* is the address of some object stored in memory. Using a pointer, it would be possible to access resources outside the program itself, resulting in a security breach. Java does not support pointers, thus eliminating this problem.



Progress Check

1. What is an applet?
2. What is Java bytecode?
3. The use of bytecode helps solve what two Internet programming problems?

CRITICAL SKILL

1.5

Object-Oriented Programming

At the center of Java is object-oriented programming (OOP). The object-oriented methodology is inseparable from Java, and all Java programs are, to at least some extent, object-oriented. Because of OOP's importance to Java, it is useful to understand OOP's basic principles before you write even a simple Java program.

OOP is a powerful way to approach the job of programming. Programming methodologies have changed dramatically since the invention of the computer, primarily to accommodate the increasing complexity of programs. For example, when computers were first invented, programming was done by toggling in the binary machine instructions using the computer's front panel. As long as programs were just a few hundred instructions long, this approach worked. As programs grew, assembly language was invented so that a programmer could deal

1. An applet is a small program that is dynamically downloaded over the Web.
2. A highly optimized set of instructions that can be interpreted by the Java Interpreter.
3. Portability and security.

with larger, increasingly complex programs, using symbolic representations of the machine instructions. As programs continued to grow, high-level languages were introduced that gave the programmer more tools with which to handle complexity. The first widespread language was, of course, FORTRAN. Although FORTRAN was a very impressive first step, it is hardly a language that encourages clear, easy-to-understand programs.

The 1960s gave birth to structured programming. This is the method encouraged by languages such as C and Pascal. The use of structured languages made it possible to write moderately complex programs fairly easily. Structured languages are characterized by their support for stand-alone subroutines, local variables, rich control constructs, and their lack of reliance upon the GOTO. Although structured languages are a powerful tool, even they reach their limit when a project becomes too large.

Consider this: At each milestone in the development of programming, techniques and tools were created to allow the programmer to deal with increasingly greater complexity. Each step of the way, the new approach took the best elements of the previous methods and moved forward. Prior to the invention of OOP, many projects were nearing (or exceeding) the point where the structured approach no longer works. Object-oriented methods were created to help programmers break through these barriers.

Object-oriented programming took the best ideas of structured programming and combined them with several new concepts. The result was a different way of organizing a program. In the most general sense, a program can be organized in one of two ways: around its code (what is happening) or around its data (what is being affected). Using only structured programming techniques, programs are typically organized around code. This approach can be thought of as “code acting on data.”

Object-oriented programs work the other way around. They are organized around data, with the key principle being “data controlling access to code.” In an object-oriented language, you define the data and the routines that are permitted to act on that data. Thus, a data type defines precisely what sort of operations can be applied to that data.

To support the principles of object-oriented programming, all OOP languages, including Java, have three traits in common: encapsulation, polymorphism, and inheritance. Let's examine each.

Encapsulation

Encapsulation is a programming mechanism that binds together code and the data it manipulates, and that keeps both safe from outside interference and misuse. In an object-oriented language, code and data can be bound together in such a way that a self-contained *black box* is created. Within the box are all necessary data and code. When code and data are linked together in this fashion, an object is created. In other words, an object is the device that supports encapsulation.

Within an object, code, data, or both may be *private* to that object or *public*. Private code or data is known to and accessible by only another part of the object. That is, private code or data cannot be accessed by a piece of the program that exists outside the object. When code

or data is public, other parts of your program can access it even though it is defined within an object. Typically, the public parts of an object are used to provide a controlled interface to the private elements of the object.

Java's basic unit of encapsulation is the *class*. Although the class will be examined in great detail later in this book, the following brief discussion will be helpful now. A class defines the form of an object. It specifies both the data and the code that will operate on that data. Java uses a class specification to construct *objects*. Objects are instances of a class. Thus, a class is essentially a set of plans that specify how to build an object.

The code and data that constitute a class are called *members* of the class. Specifically, the data defined by the class are referred to as *member variables* or *instance variables*. The code that operates on that data is referred to as *member methods* or just *methods*. *Method* is Java's term for a subroutine. If you are familiar with C/C++, it may help to know that what a Java programmer calls a *method*, a C/C++ programmer calls a *function*.

Polymorphism

Polymorphism (from the Greek, meaning "many forms") is the quality that allows one interface to access a general class of actions. The specific action is determined by the exact nature of the situation. A simple example of polymorphism is found in the steering wheel of an automobile. The steering wheel (i.e., the interface) is the same no matter what type of actual steering mechanism is used. That is, the steering wheel works the same whether your car has manual steering, power steering, or rack-and-pinion steering. Therefore, once you know how to operate the steering wheel, you can drive any type of car.

The same principle can also apply to programming. For example, consider a stack (which is a first-in, last-out list). You might have a program that requires three different types of stacks. One stack is used for integer values, one for floating-point values, and one for characters. In this case, the algorithm that implements each stack is the same, even though the data being stored differs. In a non-object-oriented language, you would be required to create three different sets of stack routines, with each set using different names. However, because of polymorphism, in Java you can create one general set of stack routines that works for all three specific situations. This way, once you know how to use one stack, you can use them all.

More generally, the concept of polymorphism is often expressed by the phrase "one interface, multiple methods." This means that it is possible to design a generic interface to a group of related activities. Polymorphism helps reduce complexity by allowing the same interface to be used to specify a *general class of action*. It is the compiler's job to select the *specific action* (i.e., method) as it applies to each situation. You, the programmer, don't need to do this selection manually. You need only remember and utilize the general interface.

Inheritance

Inheritance is the process by which one object can acquire the properties of another object. This is important because it supports the concept of hierarchical classification. If you think

about it, most knowledge is made manageable by hierarchical (i.e., top-down) classifications. For example, a Red Delicious apple is part of the classification *apple*, which in turn is part of the *fruit* class, which is under the larger class *food*. That is, the *food* class possesses certain qualities (edible, nutritious, etc.) which also, logically, apply to its subclass, *fruit*. In addition to these qualities, the *fruit* class has specific characteristics (juicy, sweet, etc.) that distinguish it from other food. The *apple* class defines those qualities specific to an apple (grows on trees, not tropical, etc.). A Red Delicious apple would, in turn, inherit all the qualities of all preceding classes, and would define only those qualities that make it unique.

Without the use of hierarchies, each object would have to explicitly define all of its characteristics. Using inheritance, an object need only define those qualities that make it unique within its class. It can inherit its general attributes from its parent. Thus, it is the inheritance mechanism that makes it possible for one object to be a specific instance of a more general case.

Progress Check

1. Name the principles of OOP.
2. What is the basic unit of encapsulation in Java?

Ask the Expert

Q: You state that object-oriented programming is an effective way to manage large programs. However, it seems that it might add substantial overhead to relatively small ones. Since you say that all Java programs are, to some extent, object-oriented, does this impose a penalty for smaller programs?

A: No. As you will see, for small programs, Java's object-oriented features are nearly transparent. Although it is true that Java follows a strict object model, you have wide latitude as to the degree to which you employ it. For smaller programs, their "object-orientedness" is barely perceptible. As your programs grow, you will integrate more object-oriented features effortlessly.

1. Encapsulation, polymorphism, and inheritance.
2. The class.

Obtaining the Java Development Kit

Now that the theoretical underpinning of Java has been explained, it is time to start writing Java programs. Before you can compile and run those programs, however, you must have a Java development system installed on your computer. The one used by this book is the standard JDK (Java Development Kit), which is available from Sun Microsystems. Several other Java development packages are available from other companies, but we will be using the JDK because it is available to all readers. It also constitutes the final authority on what is and isn't proper Java. At the time of this writing, the current release of the JDK is the Java 2 Platform Standard Edition version 5 (J2SE 5). Because J2SE 5 contains many new features that are not supported by earlier versions of Java, it is necessary to use J2SE 5 (or later) to compile and run the programs in this book.

The JDK can be downloaded free of charge from www.java.sun.com. Just go to the download page and follow the instructions for the type of computer that you have. After you have installed the JDK, you will be ready to compile and run programs. The JDK supplies two primary programs. The first is **javac.exe**, which is the Java compiler. The second is **java.exe**, which is the standard Java interpreter, and is also referred to as the *application launcher*.

One other point: the JDK runs in the command prompt environment. It is not a windowed application.

CRITICAL SKILL**1.6**

A First Simple Program

Let's start by compiling and running the short sample program shown here.

```
/*
   This is a simple Java program.

   Call this file Example.java.
*/
class Example {
    // A Java program begins with a call to main().
    public static void main(String args[]) {
        System.out.println("Java drives the Web.");
    }
}
```

You will follow these three steps:

1. Enter the program.
2. Compile the program.
3. Run the program.

Entering the Program

The programs shown in this book are available from Osborne's Web site: www.osborne.com. However, if you want to enter the programs by hand, you are free to do so. In this case, you must enter the program into your computer using a text editor, not a word processor. Word processors typically store format information along with text. This format information will confuse the Java compiler. If you are using a Windows platform, you can use WordPad or any other programming editor that you like.

For most computer languages, the name of the file that holds the source code to a program is arbitrary. However, this is not the case with Java. The first thing that you must learn about Java is that *the name you give to a source file is very important*. For this example, the name of the source file should be **Example.java**. Let's see why.

In Java, a source file is officially called a *compilation unit*. It is a text file that contains one or more class definitions. The Java compiler requires that a source file use the **.java** filename extension. Notice that the file extension is four characters long. As you might guess, your operating system must be capable of supporting long filenames. This means that Windows 95, 98, NT, XP, and 2000 work just fine, but Windows 3.1 doesn't.

As you can see by looking at the program, the name of the class defined by the program is also **Example**. This is not a coincidence. In Java, all code must reside inside a class. By convention, the name of that class should match the name of the file that holds the program. You should also make sure that the capitalization of the filename matches the class name. The reason for this is that Java is case sensitive. At this point, the convention that filenames correspond to class names may seem arbitrary. However, this convention makes it easier to maintain and organize your programs.

Compiling the Program

To compile the **Example** program, execute the compiler, **javac**, specifying the name of the source file on the command line, as shown here:

```
C:\>javac Example.java
```

The **javac** compiler creates a file called **Example.class** that contains the bytecode version of the program. Remember, bytecode is not executable code. Bytecode must be executed by a Java Virtual Machine. Thus, the output of **javac** is not code that can be directly executed.

To actually run the program, you must use the Java interpreter, **java**. To do so, pass the class name **Example** as a command-line argument, as shown here:

```
C:\>java Example
```

When the program is run, the following output is displayed:

```
Java drives the Web.
```

When Java source code is compiled, each individual class is put into its own output file named after the class and using the **.class** extension. This is why it is a good idea to give your Java source files the same name as the class they contain—the name of the source file will match the name of the **.class** file. When you execute the Java interpreter as just shown, you are actually specifying the name of the class that you want the interpreter to execute. It will automatically search for a file by that name that has the **.class** extension. If it finds the file, it will execute the code contained in the specified class.

The First Sample Program Line by Line

Although **Example.java** is quite short, it includes several key features that are common to all Java programs. Let's closely examine each part of the program.

The program begins with the following lines:

```
/*  
    This is a simple Java program.  
  
    Call this file Example.java.  
*/
```

This is a *comment*. Like most other programming languages, Java lets you enter a remark into a program's source file. The contents of a comment are ignored by the compiler. Instead, a comment describes or explains the operation of the program to anyone who is reading its source code. In this case, the comment describes the program and reminds you that the source file should be called **Example.java**. Of course, in real applications, comments generally explain how some part of the program works or what a specific feature does.

Java supports three styles of comments. The one shown at the top of the program is called a *multiline comment*. This type of comment must begin with `/*` and end with `*/`. Anything between these two comment symbols is ignored by the compiler. As the name suggests, a multiline comment may be several lines long.

The next line of code in the program is shown here:

```
class Example {
```

This line uses the keyword **class** to declare that a new class is being defined. As mentioned, the class is Java's basic unit of encapsulation. **Example** is the name of the class. The class definition begins with the opening curly brace (`{`) and ends with the closing curly brace (`}`). The elements between the two braces are members of the class. For the moment, don't worry too much about the details of a class except to note that in Java, all program activity occurs *within one*. This is one reason why all Java programs are (at least a little bit) object-oriented.

The next line in the program is the *single-line comment*, shown here:

```
// A Java program begins with a call to main().
```

This is the second type of comment supported by Java. A *single-line comment* begins with a `//` and ends at the end of the line. As a general rule, programmers use multiline comments for longer remarks and single-line comments for brief, line-by-line descriptions.

The next line of code is shown here:

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

This line begins the `main()` method. As mentioned earlier, in Java, a subroutine is called a *method*. As the comment preceding it suggests, this is the line at which the program will begin executing. All Java applications begin execution by calling `main()`. The exact meaning of each part of this line cannot be given now, since it involves a detailed understanding of several other of Java's features. However, since many of the examples in this book will use this line of code, let's take a brief look at each part now.

The **public** keyword is an *access specifier*. An access specifier determines how other parts of the program can access the members of the class. When a class member is preceded by **public**, then that member can be accessed by code outside the class in which it is declared. (The opposite of **public** is **private**, which prevents a member from being used by code defined outside of its class.) In this case, `main()` must be declared as **public**, since it must be called by code outside of its class when the program is started. The keyword **static** allows `main()` to be called before an object of the class has been created. This is necessary since `main()` is called by the Java interpreter before any objects are made. The keyword **void** simply tells the compiler that `main()` does not return a value. As you will see, methods may also return values. If all this seems a bit confusing, don't worry. All of these concepts will be discussed in detail in subsequent modules.

As stated, `main()` is the method called when a Java application begins. Any information that you need to pass to a method is received by variables specified within the set of parentheses that follow the name of the method. These variables are called *parameters*. If no parameters are required for a given method, you still need to include the empty parentheses. In `main()` there is only one parameter, **String args[]**, which declares a parameter named **args**. This is an array of objects of type **String**. (*Arrays* are collections of similar objects.) Objects of type **String** store sequences of characters. In this case, **args** receives any command-line arguments present when the program is executed. This program does not make use of this information, but other programs shown later in this book will.

The last character on the line is the `{`. This signals the start of `main()`'s body. All of the code included in a method will occur between the method's opening curly brace and its closing curly brace.

The next line of code is shown here. Notice that it occurs inside `main()`.

```
System.out.println("Java drives the Web.");
```

This line outputs the string "Java drives the Web." followed by a new line on the screen. Output is actually accomplished by the built-in `println()` method. In this case, `println()`

displays the string which is passed to it. As you will see, **println()** can be used to display other types of information, too. The line begins with **System.out**. While too complicated to explain in detail at this time, briefly, **System** is a predefined class that provides access to the system, and **out** is the output stream that is connected to the console. Thus, **System.out** is an object that encapsulates console output. The fact that Java uses an object to define console output is further evidence of its object-oriented nature.

As you have probably guessed, console output (and input) is not used frequently in real-world Java programs and applets. Since most modern computing environments are windowed and graphical in nature, console I/O is used mostly for simple utility programs and for demonstration programs. Later in this book, you will learn other ways to generate output using Java, but for now, we will continue to use the console I/O methods.

Notice that the **println()** statement ends with a semicolon. All statements in Java end with a semicolon. The reason that the other lines in the program do not end in a semicolon is that they are not, technically, statements.

The first **}** in the program ends **main()**, and the last **}** ends the **Example** class definition.

One last point: Java is case sensitive. Forgetting this can cause you serious problems. For example, if you accidentally type **Main** instead of **main**, or **PrintLn** instead of **println**, the preceding program will be incorrect. Furthermore, although the Java compiler *will* compile classes that do not contain a **main()** method, it has no way to execute them. So, if you had mistyped **main**, the compiler would still compile your program. However, the Java interpreter would report an error because it would be unable to find the **main()** method.



Progress Check

1. Where does a Java program begin execution?
 2. What does **System.out.println()** do?
 3. What is the name of the Java compiler? Of the Java interpreter?
-

-
1. **main()**
 2. Outputs information to the console.
 3. The standard Java compiler is **javac.exe**; the interpreter is **java.exe**.

Handling Syntax Errors

If you have not yet done so, enter, compile, and run the preceding program. As you may know from your previous programming experience, it is quite easy to accidentally type something incorrectly when entering code into your computer. Fortunately, if you enter something incorrectly into your program, the compiler will report a *syntax error* message when it tries to compile it. The Java compiler attempts to make sense out of your source code no matter what you have written. For this reason, the error that is reported may not always reflect the actual cause of the problem. In the preceding program, for example, an accidental omission of the opening curly brace after the `main()` method causes the compiler to report the following sequence of errors.

```
Example.java:8: ';' expected
    Public static void main(String args[])
                                   ^
Example.java:11 'class' or 'interface' expected
}
^
Example.java:13: 'class' or 'interface' expected
^
Example.java:8: missing method body, or declare abstract
    Public static void main(String args[])
                                   ^
```

Clearly, the first error message is completely wrong because what is missing is not a semicolon, but a curly brace.

The point of this discussion is that when your program contains a syntax error, you shouldn't necessarily take the compiler's messages at face value. The messages may be misleading. You may need to "second-guess" an error message in order to find the real problem. Also, look at the last few lines of code in your program that precede the line being flagged. Sometimes an error will not be reported until several lines after the point at which the error actually occurred.

CRITICAL SKILL

1.7

A Second Simple Program

Perhaps no other construct is as important to a programming language as the assignment of a value to a variable. A *variable* is a named memory location that can be assigned a value. Further, the value of a variable can be changed during the execution of a program. That is, the content of a variable is changeable, not fixed.

The following program creates two variables called **var1** and **var2**.

```
/*
  This demonstrates a variable.

  Call this file Example2.java.
*/
class Example2 {
  public static void main(String args[]) {
    int var1; // this declares a variable ← Declare variables.
    int var2; // this declares another variable

    var1 = 1024; // this assigns 1024 to var1 ← Assign a variable a value.

    System.out.println("var1 contains " + var1);

    var2 = var1 / 2;

    System.out.print("var2 contains var1 / 2: ");
    System.out.println(var2);
  }
}
```

When you run this program, you will see the following output:

```
var1 contains 1024
var2 contains var1 / 2: 512
```

This program introduces several new concepts. First, the statement

```
int var1; // this declares a variable
```

declares a variable called **var1** of type integer. In Java, all variables must be declared before they are used. Further, the type of values that the variable can hold must also be specified. This is called the *type* of the variable. In this case, **var1** can hold integer values. These are whole number values. In Java, to declare a variable to be of type integer, precede its name with the keyword **int**. Thus, the preceding statement declares a variable called **var1** of type **int**.

The next line declares a second variable called **var2**.

```
int var2; // this declares another variable
```

Notice that this line uses the same format as the first line except that the name of the variable is different.

In general, to declare a variable you will use a statement like this:

```
type var-name;
```

Here, *type* specifies the type of variable being declared, and *var-name* is the name of the variable. In addition to **int**, Java supports several other data types.

The following line of code assigns **var1** the value 1024:

```
var1 = 1024; // this assigns 1024 to var1
```

In Java, the assignment operator is the single equal sign. It copies the value on its right side into the variable on its left.

The next line of code outputs the value of **var1** preceded by the string "var1 contains ":

```
System.out.println("var1 contains " + var1);
```

In this statement, the plus sign causes the value of **var1** to be displayed after the string that precedes it. This approach can be generalized. Using the + operator, you can chain together as many items as you want within a single **println()** statement.

The next line of code assigns **var2** the value of **var1** divided by 2:

```
var2 = var1 / 2;
```

This line divides the value in **var1** by 2 and then stores that result in **var2**. Thus, after the line executes, **var2** will contain the value 512. The value of **var1** will be unchanged. Like most other computer languages, Java supports a full range of arithmetic operators, including those shown here:

+	Addition
-	Subtraction
*	Multiplication
/	Division

Here are the next two lines in the program:

```
System.out.print("var2 contains var1 / 2: ");
System.out.println(var2);
```

Two new things are occurring here. First, the built-in method **print()** is used to display the string "var2 contains var1 / 2: ". This string is *not* followed by a new line. This means that when the next output is generated, it will start on the same line. The **print()** method is just like **println()**, except that it does not output a new line after each call. Second, in the call to **println()**,

notice that **var2** is used by itself. Both **print()** and **println()** can be used to output values of any of Java's built-in types.

One more point about declaring variables before we move on: It is possible to declare two or more variables using the same declaration statement. Just separate their names by commas. For example, **var1** and **var2** could have been declared like this:

```
int var1, var2; // both declared using one statement
```

Another Data Type

In the preceding program, a variable of type **int** was used. However, a variable of type **int** can hold only whole numbers. Thus, it cannot be used when a fractional component is required. For example, an **int** variable can hold the value 18, but not the value 18.3. Fortunately, **int** is only one of several data types defined by Java. To allow numbers with fractional components, Java defines two floating-point types: **float** and **double**, which represent single- and double-precision values, respectively. Of the two, **double** is the most commonly used.

To declare a variable of type **double**, use a statement similar to that shown here:

```
double x;
```

Here, **x** is the name of the variable, which is of type **double**. Because **x** has a floating-point type, it can hold values such as 122.23, 0.034, or -19.0.

To better understand the difference between **int** and **double**, try the following program:

```
/*
   This program illustrates the differences
   between int and double.

   Call this file Example3.java.
*/
class Example3 {
    public static void main(String args[]) {
        int var; // this declares an int variable
        double x; // this declares a floating-point variable

        var = 10; // assign var the value 10

        x = 10.0; // assign x the value 10.0

        System.out.println("Original value of var: " + var);
        System.out.println("Original value of x: " + x);
    }
}
```

```

System.out.println(); // print a blank line ←————— Output a blank line.

// now, divide both by 4
var = var / 4;
x = x / 4;

System.out.println("var after division: " + var);
System.out.println("x after division: " + x);
}
}

```

The output from this program is shown here:

```

Original value of var: 10
Original value of x: 10.0

var after division: 2 ←———— Fractional component lost
x after division: 2.5 ←———— Fractional component preserved

```

As you can see, when **var** is divided by 4, a whole-number division is performed, and the outcome is 2—the fractional component is lost. However, when **x** is divided by 4, the fractional component is preserved, and the proper answer is displayed.

There is one other new thing to notice in the program. To print a blank line, simply call **println()** without any arguments.

Ask the Expert

Q: Why does Java have different data types for integers and floating-point values? That is, why aren't all numeric values just the same type?

A: Java supplies different data types so that you can write efficient programs. For example, integer arithmetic is faster than floating-point calculations. Thus, if you don't need fractional values, then you don't need to incur the overhead associated with types **float** or **double**. Second, the amount of memory required for one type of data might be less than that required for another. By supplying different types, Java enables you to make best use of system resources. Finally, some algorithms require (or at least benefit from) the use of a specific type of data. In general, Java supplies a number of built-in types to give you the greatest flexibility.

Project 1-1 Converting Gallons to Liters

`GalToLit.java`

Although the preceding sample programs illustrate several important features of the Java language, they are not very useful. Even though you do not know much about Java at this point, you can still put what you have learned to work to create a practical program. In this project, we will create a program that converts gallons to liters.

The program will work by declaring two **double** variables. One will hold the number of the gallons, and the second will hold the number of liters after the conversion. There are 3.7854 liters in a gallon. Thus, to convert gallons to liters, the gallon value is multiplied by 3.7854. The program displays both the number of gallons and the equivalent number of liters.

Step by Step

1. Create a new file called **GalToLit.java**.
2. Enter the following program into the file:

```
/*
   Project 1-1

   This program converts gallons to liters.

   Call this program GalToLit.java.
*/
class GalToLit {
    public static void main(String args[]) {
        double gallons; // holds the number of gallons
        double liters; // holds conversion to liters

        gallons = 10; // start with 10 gallons

        liters = gallons * 3.7854; // convert to liters

        System.out.println(gallons + " gallons is " + liters + " liters.");
    }
}
```

3. Compile the program using the following command line:

```
C>javac GalToLit.java
```

4. Run the program using this command:

```
C>java GalToLit
```

You will see this output:

```
10.0 gallons is 37.854 liters.
```

5. As it stands, this program converts 10 gallons to liters. However, by changing the value assigned to **gallons**, you can have the program convert a different number of gallons into its equivalent number of liters.



Progress Check

1. What is Java's keyword for the integer data type?
2. What is **double**?

CRITICAL SKILL

1.8

Two Control Statements

Inside a method, execution proceeds from one statement to the next, top to bottom. However, it is possible to alter this flow through the use of the various program control statements supported by Java. Although we will look closely at control statements later, two are briefly introduced here because we will be using them to write sample programs.

The if Statement

You can selectively execute part of a program through the use of Java's conditional statement: the **if**. The Java **if** statement works much like the IF statement in any other language. Its simplest form is shown here:

```
if(condition) statement;
```

Here, *condition* is a Boolean expression. If *condition* is true, then the statement is executed. If *condition* is false, then the statement is bypassed. Here is an example:

```
if(10 < 11) System.out.println("10 is less than 11");
```

In this case, since 10 is less than 11, the conditional expression is true, and **println()** will execute. However, consider the following:

```
if(10 < 9) System.out.println("this won't be displayed");
```

In this case, 10 is not less than 9. Thus, the call to **println()** will not take place.

1. **int**

2. The keyword for the **double** floating-point data type.

1

Java Fundamentals

Project
1-1

Converting Gallons to Liters

Java defines a full complement of relational operators that may be used in a conditional expression. They are shown here:

Operator	Meaning
<	Less than
<=	Less than or equal
>	Greater than
>=	Greater than or equal
==	Equal to
!=	Not equal

Notice that the test for equality is the double equal sign.

Here is a program that illustrates the **if** statement:

```
/*
   Demonstrate the if.

   Call this file IfDemo.java.
*/
class IfDemo {
    public static void main(String args[]) {
        int a, b, c;

        a = 2;
        b = 3;

        if(a < b) System.out.println("a is less than b");

        // this won't display anything
        if(a == b) System.out.println("you won't see this");

        System.out.println();

        c = a - b; // c contains -1

        System.out.println("c contains -1");
        if(c >= 0) System.out.println("c is non-negative");
        if(c < 0) System.out.println("c is negative");

        System.out.println();

        c = b - a; // c now contains 1
```



```
        System.out.println("c contains 1");
        if(c >= 0) System.out.println("c is non-negative");
        if(c < 0) System.out.println("c is negative");
    }
}
```

The output generated by this program is shown here:

```
a is less than b

c contains -1
c is negative

c contains 1
c is non-negative
```

Notice one other thing in this program. The line

```
int a, b, c;
```

declares three variables, **a**, **b**, and **c**, by use of a comma-separated list. As mentioned earlier, when you need two or more variables of the same type, they can be declared in one statement. Just separate the variable names by commas.

The for Loop

You can repeatedly execute a sequence of code by creating a *loop*. Java supplies a powerful assortment of loop constructs. The one we will look at here is the **for** loop. The simplest form of the **for** loop is shown here:

```
for(initialization; condition; iteration) statement;
```

In its most common form, the *initialization* portion of the loop sets a loop control variable to an initial value. The *condition* is a Boolean expression that tests the loop control variable. If the outcome of that test is true, the **for** loop continues to iterate. If it is false, the loop terminates. The *iteration* expression determines how the loop control variable is changed each time the loop iterates. Here is a short program that illustrates the **for** loop:

```
/*
 Demonstrate the for loop.

 Call this file ForDemo.java.
```

```
*/
class ForDemo {
    public static void main(String args[]) {
        int count;

        for(count = 0; count < 5; count = count+1) ← This loop iterates five times.
            System.out.println("This is count: " + count);

        System.out.println("Done!");
    }
}
```

The output generated by the program is shown here:

```
This is count: 0
This is count: 1
This is count: 2
This is count: 3
This is count: 4
Done!
```

In this example, **count** is the loop control variable. It is set to zero in the initialization portion of the **for**. At the start of each iteration (including the first one), the conditional test **count < 5** is performed. If the outcome of this test is true, the **println()** statement is executed, and then the iteration portion of the loop is executed. This process continues until the conditional test is false, at which point execution picks up at the bottom of the loop.

As a point of interest, in professionally written Java programs, you will almost never see the iteration portion of the loop written as shown in the preceding program. That is, you will seldom see statements like this:

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

The reason is that Java includes a special increment operator that performs this operation more efficiently. The increment operator is **++** (that is, two plus signs back to back). The increment operator increases its operand by one. By use of the increment operator, the preceding statement can be written like this:

```
count++;
```

Thus, the **for** in the preceding program will usually be written like this:

```
for(count = 0; count < 5; count++)
```

You might want to try this. As you will see, the loop still runs exactly the same as it did before.

Java also provides a decrement operator, which is specified as `--`. This operator decreases its operand by one.

Progress Check

1. What does the **if** statement do?
2. What does the **for** statement do?
3. What are Java's relational operators?

CRITICAL SKILL

1.9

Create Blocks of Code

Another key element of Java is the *code block*. A code block is a grouping of two or more statements. This is done by enclosing the statements between opening and closing curly braces. Once a block of code has been created, it becomes a logical unit that can be used any place that a single statement can. For example, a block can be a target for Java's **if** and **for** statements. Consider this **if** statement:

```
if (w < h) { ← Start of block
    v = w * h;
    w = 0;
} ← End of block
```

Here, if **w** is less than **h**, both statements inside the block will be executed. Thus, the two statements inside the block form a logical unit, and one statement cannot execute without the other also executing. The key point here is that whenever you need to logically link two or more statements, you do so by creating a block. Code blocks allow many algorithms to be implemented with greater clarity and efficiency.

1. The **if** is Java's conditional statement.
2. The **for** is one of Java's loop statements.
3. The relational operators are `=`, `!=`, `<`, `>`, `<=`, and `>=`.

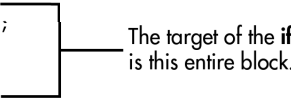
Here is a program that uses a block of code to prevent a division by zero:

```
/*
 Demonstrate a block of code.

 Call this file BlockDemo.java.
*/
class BlockDemo {
    public static void main(String args[]) {
        double i, j, d;

        i = 5;
        j = 10;

        // the target of this if is a block
        if(i != 0) {
            System.out.println("i does not equal zero");
            d = j / i;
            System.out.print("j / i is " + d);
        }
    }
}
```



The output generated by this program is shown here:

```
i does not equal zero
j / i is 2.0
```

In this case, the target of the **if** statement is a block of code and not just a single statement. If the condition controlling the **if** is true (as it is in this case), the three statements inside the block will be executed. Try setting **i** to zero and observe the result.

As you will see later in this book, blocks of code have additional properties and uses. However, the main reason for their existence is to create logically inseparable units of code.

Ask the Expert

Q: Does the use of a code block introduce any run-time inefficiencies? In other words, does Java actually execute the { and }?

A: No. Code blocks do not add any overhead whatsoever. In fact, because of their ability to simplify the coding of certain algorithms, their use generally increases speed and efficiency. Also, the { and } exist only in your program's source code. Java does not, per se, execute the { or }.

Semicolons and Positioning

In Java, the semicolon is a statement *terminator*. That is, each individual statement must be ended with a semicolon. It indicates the end of one logical entity.

As you know, a block is a set of logically connected statements that are surrounded by opening and closing braces. A block is *not* terminated with a semicolon. Since a block is a group of statements, with a semicolon after each statement, it makes sense that a block is not terminated by a semicolon; instead, the end of the block is indicated by the closing brace.

Java does not recognize the end of the line as a terminator. For this reason, it does not matter where on a line you put a statement. For example,

```
x = y;  
y = y + 1;  
System.out.println(x + " " + y);
```

is the same as the following, to Java.

```
x = y; y = y + 1; System.out.println(x + " " + y);
```

Furthermore, the individual elements of a statement can also be put on separate lines. For example, the following is perfectly acceptable:

```
System.out.println("This is a long line of output" +  
    x + y + z +  
    "more output");
```

Breaking long lines in this fashion is often used to make programs more readable. It can also help prevent excessively long lines from wrapping.

Indentation Practices

You may have noticed in the previous examples that certain statements were indented. Java is a free-form language, meaning that it does not matter where you place statements relative to each other on a line. However, over the years, a common and accepted indentation style has developed that allows for very readable programs. This book follows that style, and it is recommended that you do so as well. Using this style, you indent one level after each opening brace, and move back out one level after each closing brace. Certain statements encourage some additional indenting; these will be covered later.

Progress Check

1. How is a block of code created? What does it do?
2. In Java, statements are terminated by a _____.
3. All Java statements must start and end on one line. True or False?

Project 1-2 Improving the Gallons-to-Liters Converter

`GalToLitTable.java` You can use the **for** loop, the **if** statement, and code blocks to create an improved version of the gallons-to-liters converter that you developed in the first project. This new version will print a table of conversions, beginning with 1 gallon and ending at 100 gallons. After every 10 gallons, a blank line will be output. This is accomplished through the use of a variable called **counter** that counts the number of lines that have been output. Pay special attention to its use.

Step by Step

1. Create a new file called **GalToLitTable.java**.
2. Enter the following program into the file.

```

/*
   Project 1-2

   This program displays a conversion
   table of gallons to liters.

   Call this program "GalToLitTable.java".
*/
class GalToLitTable {
    public static void main(String args[]) {
        double gallons, liters;
        int counter;                               Line counter is initially set to zero.

        counter = 0;
        for(gallons = 1; gallons <= 100; gallons++) {
            liters = gallons * 3.7854; // convert to liters

```

1. A block is started by a { . It is ended by a } . A block creates a logical unit of code.
2. Semicolon.
3. False.

```

        System.out.println(gallons + " gallons is " +
                           liters + " liters.");
        counter++;
        // every 10th line, print a blank line
        if(counter == 10) {
            System.out.println();
            counter = 0; // reset the line counter
        }
    }
}

```

Increment the line counter with each loop iteration.

If counter is 10, output a blank line.

- 3.** Compile the program using the following command line:

```
C>javac GalToLitTable.java
```

- 4.** Run the program using this command:

```
C>java GalToLitTable
```

Here is a portion of the output that you will see:

```

1.0 gallons is 3.7854 liters.
2.0 gallons is 7.5708 liters.
3.0 gallons is 11.356200000000001 liters.
4.0 gallons is 15.1416 liters.
5.0 gallons is 18.927 liters.
6.0 gallons is 22.712400000000002 liters.
7.0 gallons is 26.4978 liters.
8.0 gallons is 30.2832 liters.
9.0 gallons is 34.0686 liters.
10.0 gallons is 37.854 liters.

11.0 gallons is 41.6394 liters.
12.0 gallons is 45.424800000000005 liters.
13.0 gallons is 49.2102 liters.
14.0 gallons is 52.9956 liters.
15.0 gallons is 56.781 liters.
16.0 gallons is 60.5664 liters.
17.0 gallons is 64.3518 liters.
18.0 gallons is 68.1372 liters.
19.0 gallons is 71.9226 liters.
20.0 gallons is 75.708 liters.

21.0 gallons is 79.493400000000001 liters.
22.0 gallons is 83.2788 liters.
23.0 gallons is 87.0642 liters.

```

(continued)

```

24.0 gallons is 90.84960000000001 liters.
25.0 gallons is 94.635 liters.
26.0 gallons is 98.4204 liters.
27.0 gallons is 102.2058 liters.
28.0 gallons is 105.9912 liters.
29.0 gallons is 109.7766 liters.
30.0 gallons is 113.562 liters.

```

CRITICAL SKILL

1.11

The Java Keywords

Fifty keywords are currently defined in the Java language (see Table 1-1). These keywords, combined with the syntax of the operators and separators, form the definition of the Java language. These keywords cannot be used as names for a variable, class, or method.

The keywords **const** and **goto** are reserved but not used. In the early days of Java, several other keywords were reserved for possible future use. However, the current specification for Java defines only the keywords shown in Table 1-1.

The **enum** keyword is quite new. It was added by J2SE 5. In addition to the keywords, Java reserves the following: **true**, **false**, and **null**. These are values defined by Java. You may not use these words for the names of variables, classes, and so on.

CRITICAL SKILL

1.12

Identifiers in Java

In Java an identifier is a name given to a method, a variable, or any other user-defined item. Identifiers can be from one to several characters long. Variable names may start with any letter of the alphabet, an underscore, or a dollar sign. Next may be either a letter, a digit, a dollar sign, or an underscore. The underscore can be used to enhance the readability of a variable

abstract	assert	boolean	break	byte	case
catch	char	class	const	continue	default
do	double	else	enum	extends	final
finally	float	for	goto	if	implements
import	instanceof	int	interface	long	native
new	package	private	protected	public	return
short	static	strictfp	super	switch	synchronized
this	throw	throws	transient	try	void
volatile	while				

Table 1-1 The Java Keywords

name, as in `line_count`. Uppercase and lowercase are different; that is, to Java, `myvar` and `MyVar` are separate names. Here are some examples of acceptable identifiers:

Test	x	y2	MaxLoad
\$up	_top	my_var	sample23

Remember, you can't start an identifier with a digit. Thus, `12x` is invalid, for example.

You cannot use any of the Java keywords as identifier names. Also, you should not assign the name of any standard method, such as `println`, to an identifier. Beyond these two restrictions, good programming practice dictates that you use identifier names that reflect the meaning or usage of the items being named.



Progress Check

1. Which is the keyword: `for`, `For`, or `FOR`?
2. A Java identifier can contain what type of characters?
3. Are `index21` and `Index21` the same identifier?

The Java Class Libraries

The sample programs shown in this module make use of two of Java's built-in methods: `println()` and `print()`. These methods are members of the `System` class, which is a class predefined by Java that is automatically included in your programs. In the larger view, the Java environment relies on several built-in class libraries that contain many built-in methods that provide support for such things as I/O, string handling, networking, and graphics. The standard classes also provide support for windowed output. Thus, Java as a totality is a combination of the Java language itself, plus its standard classes. As you will see, the class libraries provide much of the functionality that comes with Java. Indeed, part of becoming a Java programmer is learning to use the standard Java classes. Throughout this book, various elements of the standard library classes and methods are described. However, the Java library is something that you will also want to explore more on your own.

1. The keyword is `for`. In Java, all keywords are in lowercase.
2. Letters, digits, the underscore, and the \$.
3. No; Java is case sensitive.