

Introduction to Computers and Programming

TOPICS

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| 1.1 Introduction | 1.4 How a Program Works |
| 1.2 Hardware and Software | 1.5 Using Python |
| 1.3 How Computers Store Data | |

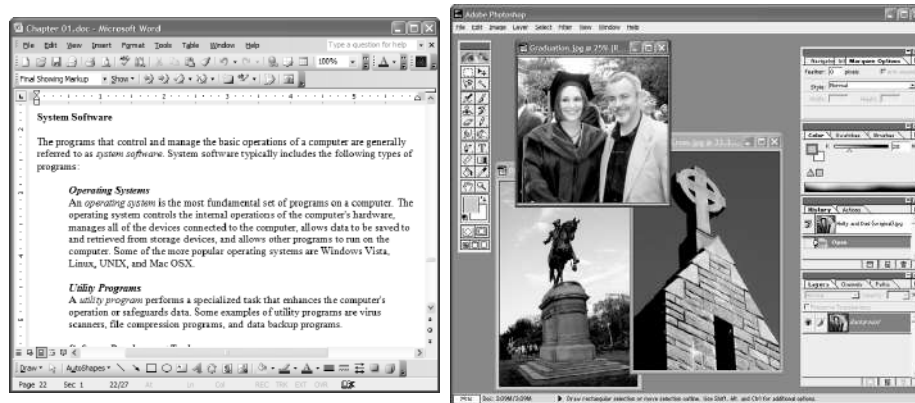
1.1

Introduction

Think about some of the different ways that people use computers. In school, students use computers for tasks such as writing papers, searching for articles, sending email, and participating in online classes. At work, people use computers to analyze data, make presentations, conduct business transactions, communicate with customers and coworkers, control machines in manufacturing facilities, and do many other things. At home, people use computers for tasks such as paying bills, shopping online, communicating with friends and family, and playing computer games. And don't forget that cell phones, iPods®, BlackBerries®, car navigation systems, and many other devices are computers too. The uses of computers are almost limitless in our everyday lives.

Computers can do such a wide variety of things because they can be programmed. This means that computers are not designed to do just one job, but to do any job that their programs tell them to do. A *program* is a set of instructions that a computer follows to perform a task. For example, Figure 1-1 shows screens from two commonly used programs, Microsoft Word and Adobe Photoshop. Microsoft Word is a word processing program that allows you to create, edit, and print documents with your computer. Adobe Photoshop is an image editing program that allows you to work with graphic images, such as photos taken with your digital camera.

Programs are commonly referred to as *software*. Software is essential to a computer because it controls everything the computer does. All of the software that we use to make our computers useful is created by individuals working as programmers or software developers. A *programmer*, or *software developer*, is a person with the training and skills necessary to design, create, and test computer programs. Computer programming is an exciting and rewarding career. Today, you will find programmers' work used in business, medicine, government, law enforcement, agriculture, academics, entertainment, and many other fields.

Figure 1-1 A word processing program and an image editing program

This book introduces you to the fundamental concepts of computer programming using the Python language. Before we begin exploring those concepts, you need to understand a few basic things about computers and how they work. This chapter will build a solid foundation of knowledge that you will continually rely on as you study computer science. First, we will discuss the physical components that computers are commonly made of. Next, we will look at how computers store data and execute programs. Finally, we will get a quick introduction to the software that you will use to write Python programs.

1.2 Hardware and Software

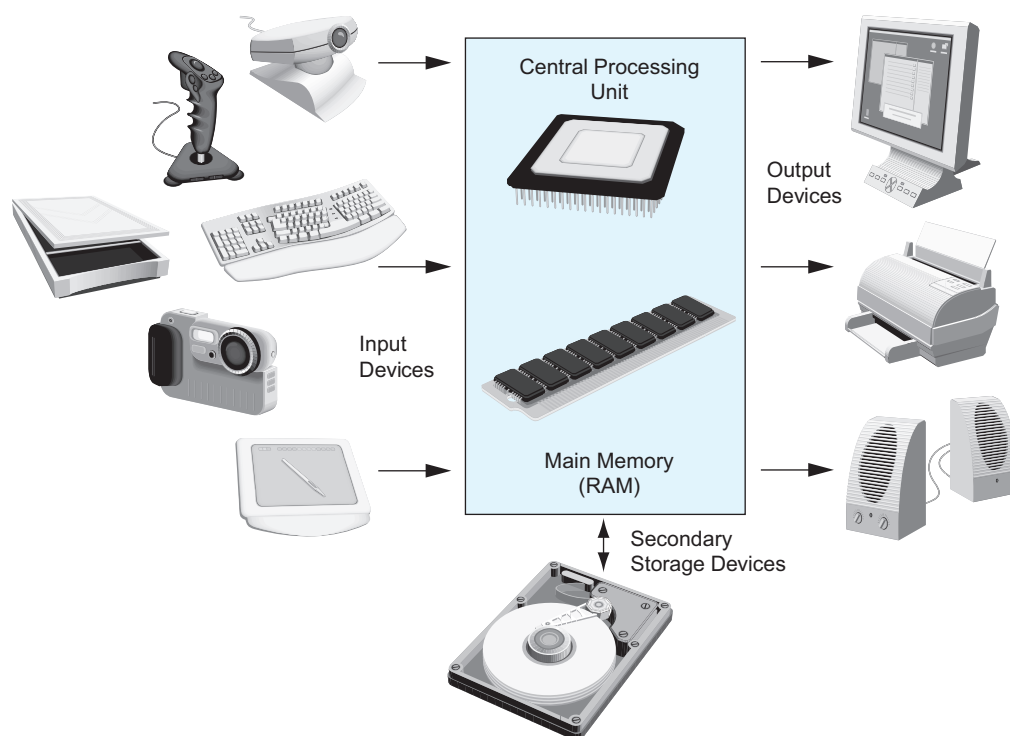
CONCEPT: The physical devices that a computer is made of are referred to as the computer's hardware. The programs that run on a computer are referred to as software.

Hardware

The term *hardware* refers to all of the physical devices, or *components*, that a computer is made of. A computer is not one single device, but a system of devices that all work together. Like the different instruments in a symphony orchestra, each device in a computer plays its own part.

If you have ever shopped for a computer, you've probably seen sales literature listing components such as microprocessors, memory, disk drives, video displays, graphics cards, and so on. Unless you already know a lot about computers, or at least have a friend that does, understanding what these different components do might be challenging. As shown in Figure 1-2, a typical computer system consists of the following major components:

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

Figure 1-2 Typical components of a computer system

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

The CPU

When a computer is performing the tasks that a program tells it to do, we say that the computer is *running* or *executing* the program. The *central processing unit*, or *CPU*, is the part of a computer that actually runs programs. The CPU is the most important component in a computer because without it, the computer could not run software.

In the earliest computers, CPUs were huge devices made of electrical and mechanical components such as vacuum tubes and switches. Figure 1-3 shows such a device. The two women in the photo are working with the historic ENIAC computer. The *ENIAC*, which is considered by many to be the world's first programmable electronic computer, was built in 1945 to calculate artillery ballistic tables for the U.S. Army. This machine, which was primarily one big CPU, was 8 feet tall, 100 feet long, and weighed 30 tons.

Today, CPUs are small chips known as *microprocessors*. Figure 1-4 shows a photo of a lab technician holding a modern microprocessor. In addition to being much smaller than the old electromechanical CPUs in early computers, microprocessors are also much more powerful.

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Figure 1-3 The ENIAC computer (courtesy of U.S. Army Historic Computer Images)

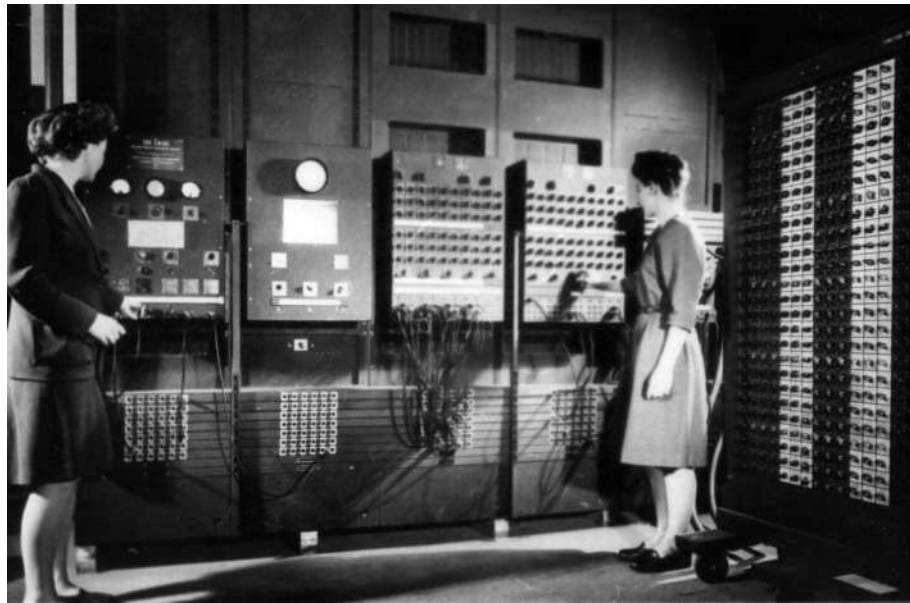


Figure 1-4 A lab technician holds a modern microprocessor (photo courtesy of Intel Corporation)



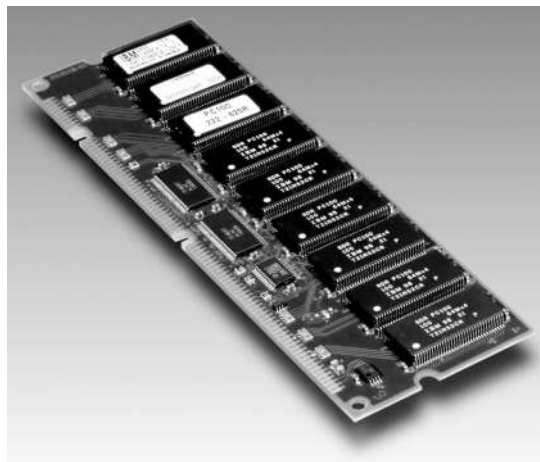
Main Memory

You can think of *main memory* as the computer's work area. This is where the computer stores a program while the program is running, as well as the data that the program is working with. For example, suppose you are using a word processing program to write an

essay for one of your classes. While you do this, both the word processing program and the essay are stored in main memory.

Main memory is commonly known as *random-access memory*, or *RAM*. It is called this because the CPU is able to quickly access data stored at any random location in RAM. RAM is usually a *volatile* type of memory that is used only for temporary storage while a program is running. When the computer is turned off, the contents of RAM are erased. Inside your computer, RAM is stored in chips, similar to the ones shown in Figure 1-5.

Figure 1-5 Memory chips (photo courtesy of IBM Corporation)



Secondary Storage Devices

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 records, is saved to secondary storage as well.

The most common type of secondary storage device is the disk drive. A *disk drive* stores data by magnetically encoding it onto a circular disk. Most computers have a disk drive mounted inside their case. External disk drives, which connect to one of the computer's communication ports, are also available. External disk drives can be used to create backup copies of important data or to move data to another computer.

In addition to external disk drives, many types of devices have been created for copying data, and for moving it to other computers. For many years floppy disk drives were popular. A *floppy disk drive* records data onto a small floppy disk, which can be removed from the drive. Floppy disks have many disadvantages, however. They hold only a small amount of data, are slow to access data, and can be unreliable. The use of floppy disk drives has declined dramatically in recent years, in favor of superior devices such as USB drives. *USB drives* are small devices that plug into the computer's USB (universal serial bus) port, and

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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, which are also known as *memory sticks* and *flash 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 are good mediums for creating backup copies of data.

Input Devices

Input is any data the computer collects from people and from other devices. The component that collects the data and sends it to the computer is called an *input device*. Common input devices are the keyboard, mouse, scanner, microphone, and digital camera. Disk drives and optical 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 produces for people or for other devices. 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 video displays and printers. Disk drives and CD recorders can also be considered output devices because the system sends data to them in order to be saved.

Software

If a computer is to function, software is not optional. Everything that a computer does, from the time you turn the power switch on until you shut the system down, is under the control of software. There are two general categories of software: system software and application software. Most computer programs clearly fit into one of these two categories. Let's take a closer look at each.

System Software

The programs that control and manage the basic operations of a computer are generally referred to as *system software*. System software typically includes the following types of programs:

Operating Systems An *operating system* is the most fundamental set of programs on a computer. The operating system controls the internal operations of the computer's hardware, manages all of the devices connected to the computer, allows data to be saved to and retrieved from storage devices, and allows other programs to run on the computer. Figure 1-6 shows screens from three popular operating systems: Windows Vista, Mac OS X, and Linux.

Figure 1-6 Screens from the Windows Vista, Mac OS X, and Fedora Linux operating systems

Utility Programs A *utility program* performs a specialized task that enhances the computer's operation or safeguards data. Examples of utility programs are virus scanners, file compression programs, and data backup programs.

Software Development Tools *Software development tools* are the programs that programmers use to create, modify, and test software. Assemblers, compilers, and interpreters are examples of programs that fall into this category.

Application Software

Programs that make a computer useful for everyday tasks are known as *application software*. These are the programs that people normally spend most of their time running on their computers. Figure 1-1, at the beginning of this chapter, shows screens from two commonly used applications: Microsoft Word, a word processing program, and Adobe Photoshop, an image editing program. Some other examples of application software are spreadsheet programs, email programs, web browsers, and game programs.



Checkpoint

- 1.1 What is a program?
- 1.2 What is hardware?
- 1.3 List the five major components of a computer system.
- 1.4 What part of the computer actually runs programs?

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- 1.5 What part of the computer serves as a work area to store a program and its data while the program is running?
- 1.6 What part of the computer holds data for long periods of time, even when there is no power to the computer?
- 1.7 What part of the computer collects data from people and from other devices?
- 1.8 What part of the computer formats and presents data for people or other devices?
- 1.9 What fundamental set of programs control the internal operations of the computer's hardware?
- 1.10 What do you call a program that performs a specialized task, such as a virus scanner, a file compression program, or a data backup program?
- 1.11 Word processing programs, spreadsheet programs, email programs, web browsers, and game programs belong to what category of software?

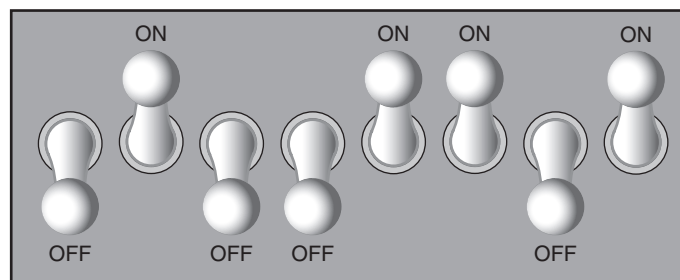
1.3 How Computers Store Data

CONCEPT: All data that is stored in a computer is converted to sequences of 0s and 1s.

A computer's memory is divided into tiny storage locations known as *bytes*. One byte is only enough memory to store a letter of the alphabet or a small number. In order to do anything meaningful, a computer has to have lots of bytes. Most computers today have millions, or even billions, of bytes of memory.

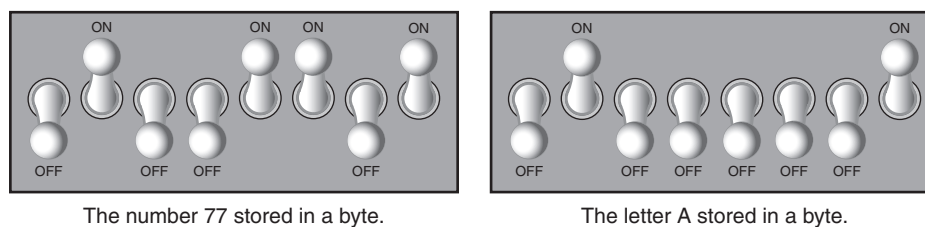
Each byte is divided into eight smaller storage locations known as bits. The term *bit* stands for *binary digit*. Computer scientists usually think of bits as tiny switches that can be either on or off. Bits aren't actual "switches," however, at least not in the conventional sense. In most computer systems, bits are tiny electrical components that can hold either a positive or a negative charge. Computer scientists think of a positive charge as a switch in the *on* position, and a negative charge as a switch in the *off* position. Figure 1-7 shows the way that a computer scientist might think of a byte of memory: as a collection of switches that are each flipped to either the on or off position.

Figure 1-7 Think of a byte as eight switches



When a piece of data is stored in a byte, the computer sets the eight bits to an on/off pattern that represents the data. For example, the pattern shown on the left in Figure 1-8 shows how the number 77 would be stored in a byte, and the pattern on the right shows how the letter A would be stored in a byte. We explain below how these patterns are determined.

Figure 1-8 Bit patterns for the number 77 and the letter A



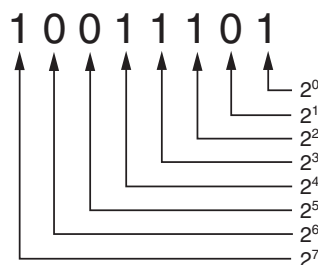
Storing Numbers

A bit can be used in a very limited way to represent numbers. Depending on whether the bit is turned on or off, it can represent one of two different values. In computer systems, a bit that is turned off represents the number 0 and a bit that is turned on represents the number 1. This corresponds perfectly to the *binary numbering system*. In the binary numbering system (or *binary*, as it is usually called) all numeric values are written as sequences of 0s and 1s. Here is an example of a number that is written in binary:

10011101

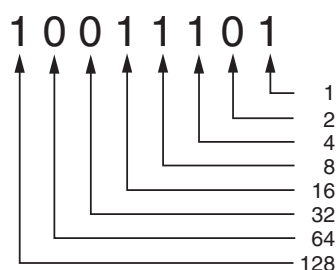
The position of each digit in a binary number has a value assigned to it. Starting with the rightmost digit and moving left, the position values are 2^0 , 2^1 , 2^2 , 2^3 , and so forth, as shown in Figure 1-9. Figure 1-10 shows the same diagram with the position values calculated. Starting with the rightmost digit and moving left, the position values are 1, 2, 4, 8, and so forth.

Figure 1-9 The values of binary digits as powers of 2



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Figure 1-10 The values of binary digits



To determine the value of a binary number you simply add up the position values of all the 1s. For example, in the binary number 10011101, the position values of the 1s are 1, 4, 8, 16, and 128. This is shown in Figure 1-11. The sum of all of these position values is 157. So, the value of the binary number 10011101 is 157.

Figure 1-11 Determining the value of 10011101

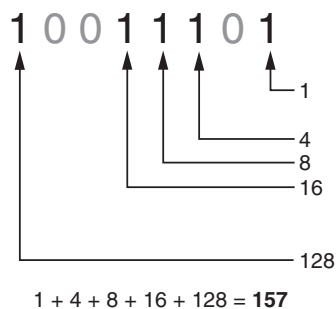


Figure 1-12 shows how you can picture the number 157 stored in a byte of memory. Each 1 is represented by a bit in the on position, and each 0 is represented by a bit in the off position.

Figure 1-12 The bit pattern for 157

