SECTION 2.1

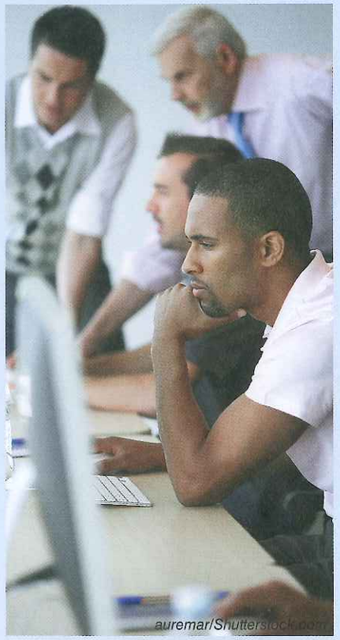
Types of Computers and Components

Essential Question

How has the evolution of computers impacted your life?

The term *computer* covers a wide variety of multipurpose devices that handle input, process data, store data, and produce usable output according to sets of stored instructions. Computers vary extensively according to size, use, cost, and capability.

The path of computer development from the 1940s forward has been to increase processing speed, increase storage capacity, decrease energy consumption, decrease component size, and invent devices to solve a wider variety of problems. A popular description of the trend to smaller, better, and faster computers was created by Gordon Moore. In 1965, he noticed that the number of components on a computer chip had doubled every two years since 1958. The trend, now known as Moore's law, can be applied to many aspects of computing, from processor speed to computer price and the resolution of monitors.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Terms

arithmetic/logic unit (ALU)
booting
central processing unit (CPU)
clock speed
computer system
control unit
firmware
floating point operations per second (FLOPS)
hardware
input
input device
mainframe computers
memory
millions of instructions per second (MIPS)
motherboard
operating system (OS)
output
peripheral devices
personal computer
port
processing
random-access memory (RAM)
read-only memory (ROM)
server
storage
supercomputers
universal serial bus (USB)

Learning Goals

After completing this section, you will be able to:

- List the categories of computers.
- Identify basic parts and functions of a computer.
- Explain the purpose of an operating system.

Categories of Computers

Historically, computers were grouped in one of three categories based on size: mainframes, minicomputers, or microcomputers. A mainframe is a very large, high-processing computer that is used for big computing needs. A minicomputer is a computer of midrange size and performance between a microcomputer and a mainframe. A microcomputer is a computer based on a microchip for the central processing unit (CPU).

The distinctions between the historical categories have become blurred so much that the term minicomputer is rarely used today. This is because the capability of microcomputers, smallest of the three, has significantly expanded. Today, computers are usually categorized based on usage and cost as well as size:

- supercomputers
- mainframes
- servers
- personal computers and mobile devices

Note that these are the categories of computers, which should not be confused with the four phases of the digital revolution discussed in Chapter 1.

FYI

There are many ways to classify computers. Other classifications or applications include the SETI project, ROCKS clusters and cluster computing, and the DWave quantum computer

Supercomputers

Supercomputers have processing power that can handle complex jobs beyond the scope of other computer systems. Supercomputers are the fastest computers. Examples of projects undertaken by supercomputers include breaking codes, molecular modeling, atmospheric modeling, and climate predictions. The tasks analyze enormous amounts of data. Supercomputers can be used to simulate global weather patterns, results from earthquakes, and consequences from nuclear explosions. Scientists and engineers are the primary users of supercomputers.

The speed of supercomputers is usually measured in **floating point operations per second (FLOPS).** *Floating point* means numbers containing decimal fractions. Figure 2-1 shows the constantly increased capability of supercomputers over the years.

The Chinese have built one of the fastest supercomputers in the world. The Tianhe-2 (Milky Way-2) computer operates at a speed of 38.6 petaFLOPS. The prefix *peta* means 10^{15}, so this is 38,600,000,000,000,000 FLOPS. The number of calculations this system can perform in one hour would require 300 years if every person on earth contributed to the project using a calculator. The current listing of the world's fastest supercomputers can be found on the Top 500 website (www.top500.org).

Mainframes

Mainframe computers provide centralized storage, processing, and overall management of large amounts of data. While supercomputers are used for crunching data and numbers, mainframes are used to process

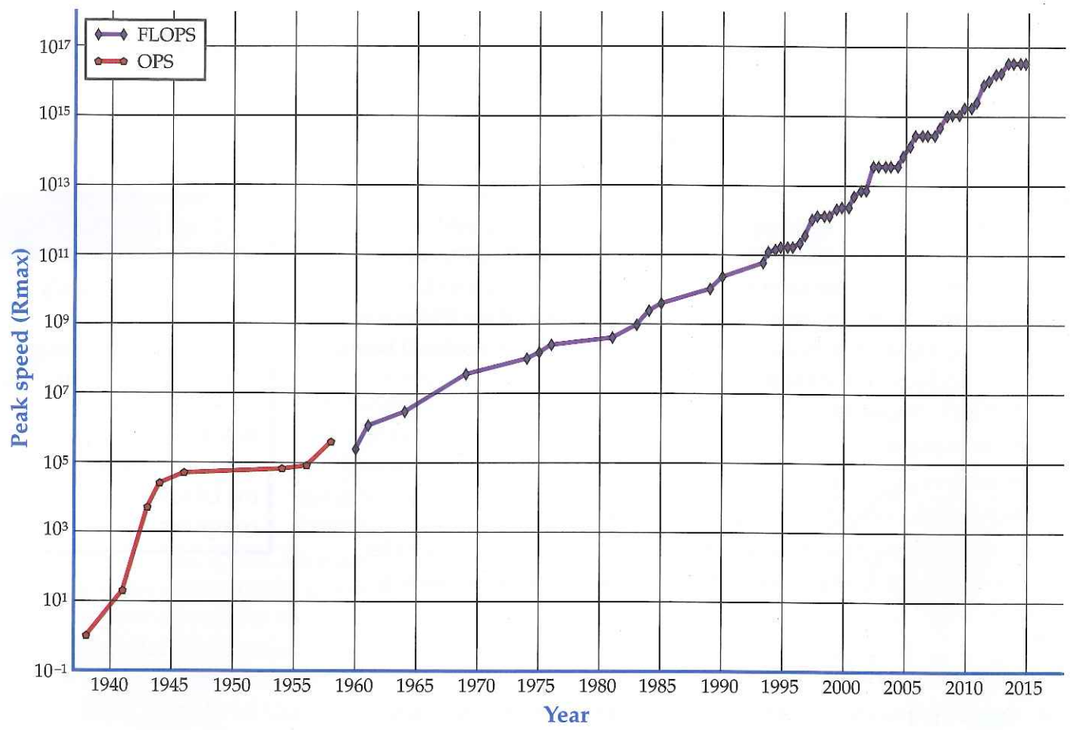

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Figure 2-1. The capability of supercomputers has constantly increased over the years.

and store business transactions. The speed of mainframes is measured in **millions of instructions per second (MIPS)**.

Mainframes are built to tackle data-intensive, detailed transactions in the business world. Typical business operations include updating a database for inventory control of supplies, scheduling airline reservations, or managing bank transactions.

Servers

Computing Fundamentals 2.2.1

A server is a special type of computer found on a network. A **server** stores data and responds when requested by other computers in the network. It allows other computers on the network to share programs and data. Sharing data makes it possible for many users on the network to see and access each other's information. A server generally handles backing up the stored data for all users so that data can be retrieved if a part of the system malfunctions.

Personal Computers and Mobile Devices

Computing Fundamentals 2.2.2, 2.2.3, 2.2.4, 2.2.5, 2.2.6

A **personal computer** is a processing device designed to meet the needs of an individual user, whether in the home, a business, or a school. It has a screen, a mouse, and a keyboard and is generally connected to the

Internet, as shown in Figure 2-2. Personal computers vary in their speed, size, and portability. They come in the forms of desktop models, laptops and related models, and mobile devices.

Desktop Computers

Desktop computers are larger than other personal computers and are intended to be used as a stationary device because they need a constant source of electricity. Their components include a box that holds the CPU, the memory, and the cards that communicate with other devices; a keyboard; a monitor; and usually a mouse. Many are also equipped with network capabilities. Additional devices may support external media, such as DVDs, or a printer. A wide range of devices may be added to a desktop computer by means of adapter ports, such as the universal serial bus (USB). Because of the tall box containing the CPU and expansion cards, desktop computers are sometimes called tower computers.

FYI

Some desktop computers combine the monitor with the box that holds the CPU and devices. These are called all-in-one computers.

Laptop Computers

Laptop computers are single-unit, portable devices that run on a battery. Laptop computers are light enough to carry and small enough to fit on a lap. Ultimately the battery must be recharged at an electrical outlet.

The single unit contains a keyboard, a pointing stick or touch pad, a monitor, the CPU, and the memory. Internal chips may control USB ports and wireless network support. Additional devices may be connected to a laptop.

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Figure 2-2. A personal computer has a screen, mouse, and keyboard in addition to the CPU unit.

Depending on the size, the model may be a laptop, notebook, or netbook computer. Other terms are used for various configurations in this category, such as subnotebook and convertible. The convertible is a cross between a laptop computer and a tablet mobile device.

michaeljung/Shutterstock.com

Figure 2-3. A tablet computer is usually the size of a textbook, but thinner.

Mobile Devices

Mobile devices are smaller and lighter than laptop computers. They are battery-operated like a laptop, but limited to the number of devices that can be connected to them. Another difference is mobile devices use a touch screen for input instead of a keyboard or touchpad. Mobile devices rely on wireless transmission of data to printers or to other users. Mobile devices vary in configuration, from tablet computers to smarthpones.

Tablet computers are roughly the height and width of a textbook, as shown in Figure 2-3. However, there are many variations in size. Many different terms are used to describe the tablet based on size, including tablet, mini tablet, and phablet. The phablet is a cross between a tablet and a smartphone.

The smartphone is a computer and a cellular telephone in one device. The smartphone is able to wirelessly connect to the Internet for expanded capabilities such as streaming movies and web surfing. Computer programs for the smartphone are called apps and are downloaded from the web. Common apps provide weather updates, e-mail and messaging, games, social networking, and more.

FYI

A streaming device is a popular peripheral for a tablet or smartphone. It allows the device display to be shown on a television.

Other mobile devices are developed to meet special needs. Some are used by service technicians to communicate to their offices while they are working in your home. Packages shipped by commercial carriers are scanned and tracked by a PDA. Other devices include wearable computers, portable media players, e-book readers, and GPS.

Computing Fundamentals
3.3.1

Basic Parts and Functions of a Computer

No matter the size or use for a computer, all computers contain the same basic types of components. **Hardware** is the physical components of the computer. Generally speaking, there are four main hardware components to a computer:

- input device
- memory
- processor
- output device

This is the minimum hardware for a computer. If a device does not have all four components, it is not a computer.

All computers are also basically the same in terms of functions, which are parallel to the basic hardware. A computer is defined by these four basic capabilities or functions:

- accept data input
- store data
- process data
- produce output

This is the minimum functional definition of a computer. If a device does not have all four functions, it is not a computer. A computer with its attached devices is called a **computer system**.

Attached devices that are not critical to computer operation are called **peripheral devices**, or *peripherals*. Each peripheral has its own methods for connection and for handling input or output. There is no universal standard for all peripherals on how they handle input or output. For this reason, the manufacturer of each device must supply code called a driver that communicates with the operating system. Device drivers are discussed in Chapter 3.

Ethics

Computer Ethics

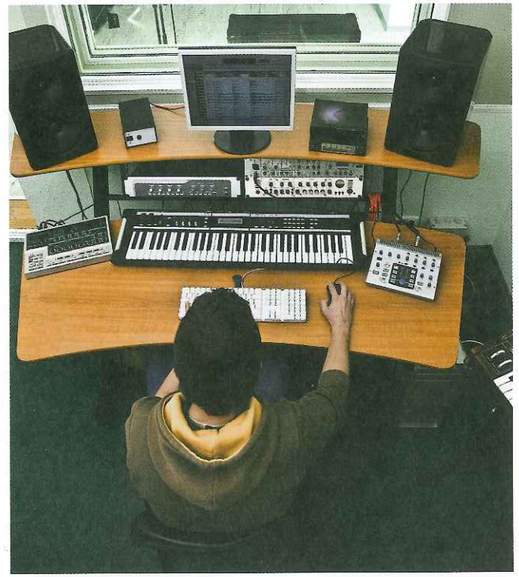
While you are at work or school, it is important to be respectful in your use of computer equipment. The computer is available for your use as a tool for research or to accomplish a task. It is unethical to use the computer to download copyrighted material or harass others.

Input

The **input** function translates data from the human world into computer data. Input can be described as data that are entered, scanned, or otherwise sent to a computer system. The data can originate from a person, the environment, or another computer. Examples of input are:

- adding words and numbers into documents;
- setting the temperature in a thermostat containing an embedded computer;
- activating a sensor in a computerized house alarm system;
- scanning a photograph;
- recording a video with a camcorder;
- loading an MP3 file; and
- sending an e-mail or tweet.

An **input device** provides the computer with data on which it can act, as shown in Figure 2-4. The input device is the basis of interaction with a computer. Data can be entered from a keyboard, keypad, touch pad, mouse, scanner, camera, microphone, or game controller. These are all input devices. Users can see and feel many input devices, but how the computer uses the data input is more mysterious because that takes place inside the box itself without any visible moving parts.



Sheftsoff Women Girls/Shutterstock.com

Figure 2-4. This musician is using several input devices, including a mouse, computer keyboard, and MIDI music keyboard.

An input device can be human-operated, an environmental trigger, another computer, or one of many other devices. For example, a sensor may detect changes in the environment, such as an increase in temperature, and provide that as data to a computer system, which in turn regulates the temperature of a room. The sensor in this example is an input device.

Storage

Computing Fundamentals 2.1.2, 2.3.2

Storage is where data are kept by the computer so the information can be viewed, played, or otherwise used. The most familiar storage locations are the computer system's memory and hard disk drive, but flash drives and other forms of external storage devices are also common.

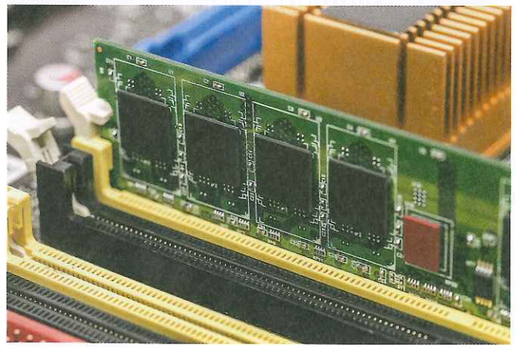
Memory is the part of the computer that stores information for immediate processing. It stores the code for the computer programs, data used for the programs, results from executing the programs, and much more. Some memory is *involatile*, which means it is kept even when the computer is turned off. The basic startup program in a computer is stored in persistent memory. Other memory is *volatile*, which means it is erased when the power is off. There are two types of memory.

- random-access memory
- read-only memory

Random-Access Memory

Random-access memory (RAM) is memory that can be changed. This hardware holds instructions that the processor can immediately use. RAM is what most users think of when the word *memory* is mentioned.

As various programs are used, the constantly changing instructions are loaded into RAM. When the computer is turned off, all data and instructions that were stored in RAM are erased. Therefore, RAM is volatile memory. It is just a temporary holding area for data and instructions.



Radu Bercan/Shutterstock.com

Figure 2-5. The green board is a RAM unit, which holds many RAM chips. The RAM chips are black in this example. The metal feet are hidden because the chips are surface mounted.

The physical chips that hold RAM look like small black rectangles with many pairs of metal feet, as shown in Figure 2-5. If a computer needs more memory, additional chips can be easily installed.

Read-Only Memory

Read-only memory (ROM) is memory that cannot be changed. ROM contains static information the computer will always need to operate. This information cannot be subject to variation. This includes the instructions that tell the system what steps to take during start-up. ROM holds its information even if the computer is turned off, which means it is involatile memory.

Measuring Memory

The capacity of memory is measured in how many bytes it can hold. One byte holds enough information for one character. Figure 2-6 describes the prefixes for various quantities of bytes and the approximate data storage capacity.

Processing

Computing Fundamentals 2.1.1, 2.3.2

Processing of the data takes place between the input and the output. **Processing** is the transformation of input data and acting on those data.

In principle, processing is very simple: additions and decisions. These two instructions are used to load programs and data, to follow instructions, and to produce output. More complex actions are developed using these two basic functions. The result is called *the instruction set* for a central processing unit. The basic instruction set is different for each central processing unit.

Central Processing Unit

The **central processing unit (CPU)** is the device that fetches coded instructions, decodes them, and then runs or executes them. The CPU is also called a *microprocessor* or *chip*. Although it is about the size of a thumbnail, the CPU contains billions of circuits. See Figure 2-7. Many computers contain multiple CPUs. The CPU often has a large heat sink

Metric Symbols	Number of bytes*	Equivalent sizes
byte	1	One character.
kilobyte (KB)	1 thousand bytes	One short letter or memo.
megabyte (MB)	1 million bytes	A typical high-resolution photo is about 2.5MB. The information in 40 paperback books (a stack about three feet high) is about 50MB.
gigabyte (GB)	1 billion bytes	One hour of a feature film is about 1.5GB. The information in 800 paperback books (a stack about 650 feet high) is about 20GB.
terabyte (TB)	1 trillion bytes	The information in 800,000 paperback books (a stack about 10 miles high) is about 1TB. Library of Congress archives contain 160TB.
petabyte (PB)	1,000 terabytes	Seventy-seven million CDs each containing 700MB is 50PB.
exabyte (EB)	1,000 petabytes	All words ever spoken by human beings are about 5EB.
zettabyte (ZB)	1,000 exabytes	The information in 174 newspapers received daily by every person on Earth is about 4ZB.

*Note: there are actually 1024 bytes in a kilobyte, so these values are rounded.

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Figure 2-6. Quantities of bytes and approximate storage capacity.

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Figure 2-7. A CPU being inserted into a socket on the motherboard.

installed on top of it to cool the circuits. A heat sink looks like a bunch of metal fins.

The CPU controls all jobs performed by the computer's other parts. When the user runs a program, the program's instructions set the CPU's list of jobs. The CPU has two primary components: the arithmetic/logic unit and the control unit.

The **arithmetic/logic unit (ALU)** temporarily holds data that are being processed and handles all arithmetic operations such as addition and subtraction. It also performs logic tasks, such as comparing values to see which is greater or where bits do not match up. Because it can combine these types of operations, the ALU can perform complex tasks that make it possible to run programs requiring fast action, such as video games.

The **control unit** fetches each instruction from the list directed by the program being run. It then decodes the instruction and executes it. Finally, the control unit places the result in the ALU.

Fetching, decoding, and running one instruction is one cycle. CPU speeds are measured in how many cycles can be performed in one second. The speed rating of a CPU is also called **clock speed**. Currently, clock speeds are in the range of gigacycles, or gigahertz (GHz). The prefix *giga* means billions. Hz is the symbol for hertz, which is a unit of measure for frequency. One hertz is one cycle per second. Therefore, 1GHz is one billion cycles per second. A 1GHz processor can fetch, decode, and run one billion instructions every second. Most current CPUs can perform 3.5 billion tasks per second without error.

Motherboard

The CPU and memory are both mounted on a larger printed circuit board called the motherboard or the *system board*. The **motherboard** connects all of the hardware in the computer. It provides the electrical connections through which all data are transferred between hardware devices. In addition to connecting the on-board hardware, such as the CPU and memory, the motherboard also contains expansion ports or slots to connect external devices, such as hard drives and video cards. The three main components on the motherboard are the processor, memory, and expansion ports/slots.

For data to travel to and from the motherboard, the motherboard must be connected to the input and output devices. The most common connection is the USB port. A **port** is a point of interface between the motherboard and external devices. **Universal serial bus (USB)** is an industry standard for communication between devices and the computer. Many keyboards, printers, and pointing devices are USB-connected devices.

FYI

Many stand-alone monitors contain USB ports on the side so peripherals can be attached without needing to reach to the computer box.

A computer may have many other types of ports. These ports are usually connected to the motherboard by device-interface cards contained in expansion slots on the motherboard. The best example is the graphics or video card. This device-interface card is used to process data from the CPU and send it to the monitor. The sound card contains ports for speakers, a microphone, and a headset. A network card contains ports for making network connections.

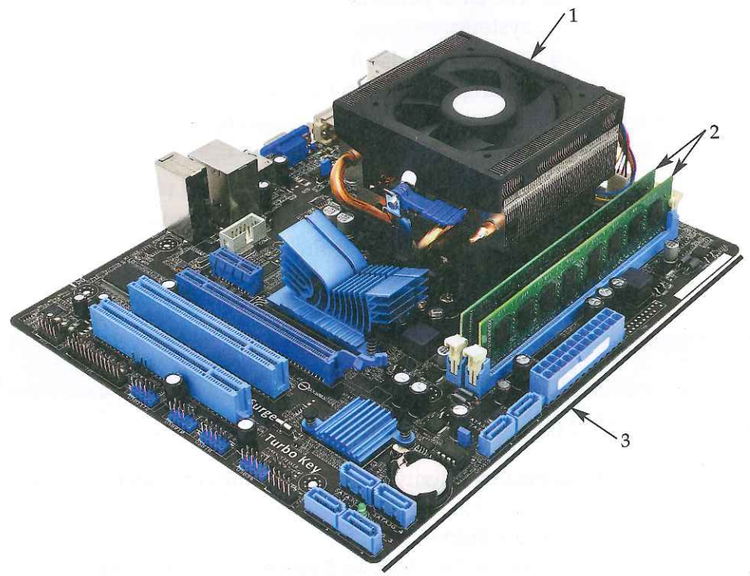
Output

Output is data provided to the user. An output device produces an action based on the instructions from the CPU. The most common output device is a computer monitor. This device formats the 1s and 0s the CPU uses into human-readable material. Speakers output audio based on the 1s and 0s generated by the CPU. Data can also be output to a printer; an internal or external storage device such as a hard drive, flash drive, CD, or DVD; another computer; a mechanical system such as a relay or switch; or a number of other devices.

HANDS-ON EXAMPLE 2.1.1

COMPONENT IDENTIFICATION

Using the image shown, identify the computer hardware components labeled by number.



vetkit/Shutterstock.com

1. Object number 1 is called a(n) _____.
2. Objects number 2 are _____.
3. Assembly number 3 is called a(n) _____.

FYI

When people wore big, heavy boots, they had trouble pulling them on. Shoe manufacturers included a small strap across the heel so the wearer could pull on the boot without any help. This is the origin of the computer term *booting*.

Computing Fundamentals
4.2.1

Operating System

The **operating system (OS)** is software that manages all of the devices, as well as locates and provides instructions to the CPU. It is specific to the type of the computer. The various versions of Windows, Mac OS, and GNU/Linux are all examples of computer operating systems.

General-use computers, such as a PC or tablet, must have an OS to work. Single-use computers, such as those in satellites and space probes, do not require an operating system. Operating systems are discussed in detail in Chapter 3.

Before the operating system can run, the computer must go through boot procedures to get the basic functions started and the OS loaded. **Booting** or *bootstrapping* describes using a small program to get the computer running and the OS loaded. This program is stored in ROM on the motherboard. It contains circuitry and software, sometimes referred to as **firmware**, that hold instructions for initializing the hardware and loading the main OS. In PCs, firmware is generally used to remember how to boot the computer. On smartphones, the entire OS and bundled application suites are stored in firmware.

Six events take place when a computer running the Windows operating systems boots up, starting with the power being turned on:

1. The power light comes on, the fan starts up, and electricity is sent throughout the hardware components.
2. The CPU follows the instructions set up in ROM.
3. The CPU performs tests on the computer's critical internal systems.
4. The CPU finds all connected peripheral devices, checks their settings, and alerts the user if there is a problem.
5. The CPU loads the OS from the hard drive into RAM.
6. The OS reads a file that contains configuration data to tell it what windows to open, icons to display, or programs to run.

When the main screen appears on the computer monitor, the system is ready to follow the user's directions.

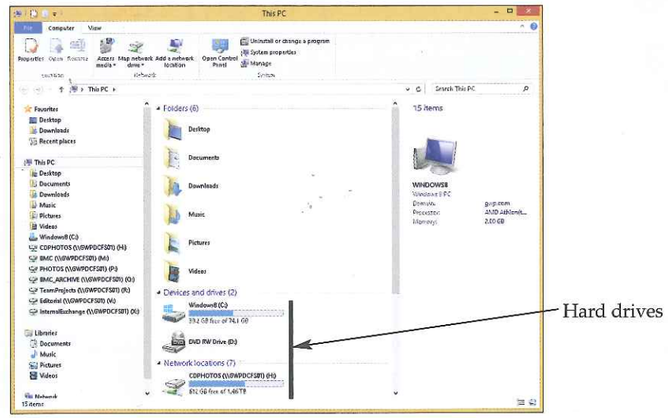
HANDS-ON EXAMPLE 2.1.2

BASIC COMPUTER COMPONENTS

Locate a computer to use for this activity. Do not open the computer box unless directed to do so by your instructor.

1. Click the **Apps** button or the **Start** button.
2. In Windows 8, click **This PC** in the **Windows System** group of the **Apps** menu. In Windows 7, click **Computer** in the right-hand column of the **Start** menu. A list of hard drives and devices with removable storage is displayed, as shown. Name them.

HANDS-ON EXAMPLE 2.1.2 (CONTINUED)



3. Click **System Properties** at the top of the window.
4. List the Windows version that the computer is using.
5. Identify the type of processor.
6. Identify the amount of installed memory (RAM).

2.1 SECTION REVIEW

CHECK YOUR UNDERSTANDING

1. What are four main categories of computers?
2. What are the four functions of a computer?
3. What does an input device provide to the computer?
4. Why are device drivers needed when attaching peripherals to a computer?
5. What is the purpose of the operating system?

IC3 CERTIFICATION PRACTICE

The following question is a sample of the types of questions presented on the IC3 exam.

1. The processing speed of a computer is measured in:
   A. bytes
   B. gigabytes
   C. hertz
   D. gigaseconds

BUILD YOUR VOCABULARY

As you progress through this course, develop a personal IT glossary. This will help you build your vocabulary and prepare you for a career. Write a definition for each of the following terms and add it to your IT glossary.

arithmetic/logic unit (ALU)
booting
central processing unit (CPU)
clock speed
computer system
control unit
firmware
floating point operations per second (FLOPS)
hardware
input
input device
mainframe computers
memory
millions of instructions per second (MIPS)
motherboard
operating system (OS)
output
peripheral devices
personal computer
port
processing
random-access memory (RAM)
read-only memory (ROM)
server
storage
supercomputers
universal serial bus (USB)