SECTION 2.2

INPUT AND OUTPUT DEVICES

Essential Question

Why is it important for input and output devices to be accessible to people with disabilities?

To enable processing, information must reach the CPU inside the computer system. There are many input devices for entering data, from the common keyboard to a complex voice- or retinal-recognition system. Input tasks require the most work by the user. For users to "see" the results, the information must be output in the form of text, pictures, sounds, or video.

The earliest computers relied on punched cards for input and output on the large machines. Soon thereafter, a freestanding machine similar to a typewriter called a teleprinter, often sold under the trade name Teletype, was used for both input and output. Thanks to teleprinters, for the first time reports on paper were available to let programmers know what the calculations were producing. Users soon identified their growing needs for entering data more easily. Engineers have since designed and implemented a very large variety of input and output devices.

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TERMS

audio-input devices
audio-output device
data projector
image-input devices
keyboard
monitor
mouse
optical-character recognition (OCR)
output device
pointing device
printer
ripping
stylus
text-input devices
touch screen
user interface (UI)
webcam

LEARNING GOALS

After completing this section, you will be able to:

- Discuss input devices and their functions.
- Describe output devices and their functions.

Input Devices and Their Functions

Computing Fundamentals 2.1.1, 3.3.1

An input device makes it possible for the user to provide communication to the computer. The means by which the user enters data and receives feedback is called the **user interface (UI).** The UI is a combination of hardware and software. There are many input devices available to the user, including keyboards, pointing devices, touch screens, image-input devices, text-input devices, audio-input devices, and devices to assist persons with disabilities.

Keyboards

The **keyboard** is a device for inputting textual and numeric data. It is the most basic input device for user interface. The keyboard is used for creating documents and spreadsheets, navigating windows in the operating system, playing games, controlling functions of the computer, and many other purposes.

FYI

Some keyboards, especially on laptop computers, support fingerprint recognition to prevent unlawful use.

Actions of Keyboards

The keys on a keyboard trigger switches inside the device. When a switch is triggered, an electrical signal is sent to the CPU. The CPU then processes the signal and provides the data to whatever software is running. The software in turn acts on the data.

Types of Keyboards

The placement of the alphabetic and numeric characters is fairly standard on keyboards. This is important because people who learn how to touch-type expect the keys to be in the same positions on any keyboard. The most common arrangement of keys on a keyboard in the United States is referred to as the *QWERTY layout*, as shown in Figure 2-8. This name comes from the positions of the first six keys on the left in the top row of letters. The letters in the Latin alphabet are in the middle of the keyboard, and a row of Arabic numerals appears above the letters. The QWERTY layout was designed to avoid the jamming of keys on early mechanical typewriters.

FYI

The ability to use a keyboard without looking at the keys is an important skill to develop.

BonD80/Shutterstock.com

Figure 2-8. The most common keyboard layout in the United States is the QWERTY layout.

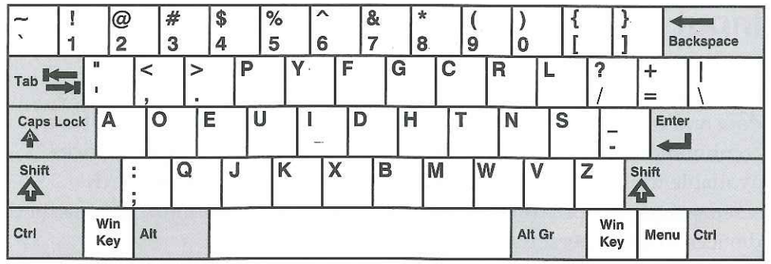

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Figure 2-9. The layout of a Dvorak keyboard.

Other schemes for key placement have been proposed. For example, the *Dvorak keyboard*, shown in Figure 2-9, was invented in the 1930s. In this layout, the characters of the Latin alphabet most commonly used in English are the "home keys" in the middle of the keyboard. The Dvorak keyboard is designed to allow for faster finger movement. However, the traditional QWERTY layout remains the most popular.

Standard QWERTY keyboards have 12 function keys along the top, labeled [F1] through [F12]. These keys are used to immediately execute a function. Windows keyboards also have two alternate keys, labeled [Alt], and two control keys, labeled [Ctrl]. These keys are used in combination with other keys to execute shortcuts and commands. Standard keyboards also have a set of arrows for navigation and sometimes an extra numeric keypad. The numeric keypad allows for faster entry of numeric data than is possible with the row of number keys above the letter keys.

Keyboards on laptop computers are smaller than the keyboards for desktop computers. Additionally, they do not have a separate numeric keypad, but several of the keys have dual functions to make up for this. The secondary purpose is activated with the function key, labeled [Fn].

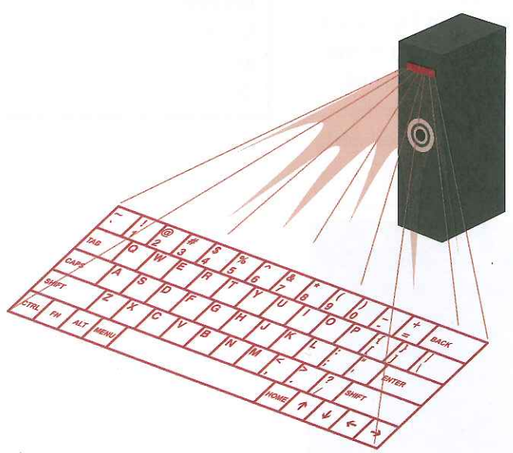

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Figure 2-10. A projection keyboard is a type of virtual keyboard.

Wireless keyboards eliminate the need to have the keyboard close to the system's processing unit. In fact, wireless keyboards can be located from six to 30 feet away from the system, depending on the keyboard. The data are transmitted to the computer via radio signals.

Some keyboards are *virtual keyboards*, which means they do not physically exist. One form of virtual keyboard is projection-based. An image of the keyboard is projected on a flat surface and sensors detect when the user's fingers touch the images of the keys. A sound can be played to provide feedback to the user since there is no physical feedback provided to the fingers. Figure 2-10 depicts a projection keyboard in use. Other virtual keyboards are displayed on-screen.

The user clicks the keys with the pointing device or, in the case of a touch screen, touches the keys with a finger.

Factors in Evaluating Keyboards

Computing Fundamentals 2.3.1

Choose a keyboard that supports the intended use of the computer. If much of the input is numeric, ensure that the numeric keypad is included. If the primary user is left-handed, the numeric keypad should be on the left side of the keyboard.

Consider how far from the computer system the user will sit. If the computer box is across the room, a wireless keyboard may be required. Wireless keyboards are powered by batteries, which may be a concern. A rechargeable unit eliminates the need to replace batteries. However, a wired keyboard may need to be kept as a backup for when the batteries run out.

How your body is positioned when using the keyboard is a concern. Choose a keyboard that will maintain a straight wrist during typing. Several of these are available and are discussed in Chapter 16.

wavebreakmedia/Shutterstock.com

Figure 2-11. This student is using a computer that has not only a mouse, but a graphics tablet.

Pointing Devices

The **pointing device** allows the user to control the movement of the cursor, or pointer, on the screen. There are many types of pointing devices that can be used with a computer, but a mouse is the most common type, as shown in Figure 2-11. Most pointing devices have at least two buttons and many have a wheel. Some pointing devices may have three or more buttons to allow for specialized functions.

Actions of Pointing Devices

The basic actions of a pointing device include:

- pointing;
- clicking;
- dragging; and
- double-clicking.

Pointing is moving the cursor to a particular screen location. *Clicking* is pressing the primary button once, which is done to activate a command button, set the insertion point in a document, or otherwise interact with the system. *Dragging* is clicking and holding down the primary button while moving the pointing device to highlight text or move an object on the screen. *Double-clicking* is quickly pressing the primary button twice, which is usually done to select a word or to initiate an option.

The left button on the pointing device is the primary button and used for most standard operations. Generally, the right button displays a shortcut menu containing commands and options. The functions of the buttons can be reversed for a left-handed setup.

FYI

It is often possible to use associated software to vary the options when using pointing devices.

The wheel on the pointing device allows the user to scroll through a document or web page. Games often make use of the wheel for zooming as well as allowing the user to scroll through an inventory of items.

Types of Pointing Devices

A basic or traditional **mouse** is a device with one or more buttons that can be moved on a flat surface to control the cursor. A *mechanical mouse* has a rollerball on the bottom surface. As it rolls on a flat surface, it sends signals to the system unit. It requires a mouse pad to run smoothly. An *optical mouse* uses a laser instead of a rollerball to track the mouse's movements. It does not require a mouse pad and has fewer moving parts than a mechanical version. This is the most common type of mouse. A *touch mouse* is an optical mouse with a touch-sensitive top surface in place of buttons and a wheel.

A *trackball mouse* is similar to a mechanical mouse, but the rollerball is located on the top or side of the device. When the user wants to move the pointer on the screen, the mouse remains stationary while the user rolls the ball.

Laptop computers contain an integrated pointing device, either a touch pad or a pointing stick, and two buttons below the keyboard. A *touch pad* is a touch-sensitive area, usually below the keyboard, that the user can tap or slide fingers across. A *pointing stick* is a small joystick in the middle of the keyboard. The buttons below the keyboard correspond to the left and right mouse buttons.

A *graphics tablet* is a form of touch pad, but is a separate device that is larger than what is found on a laptop. A graphics tablet is usually connected to a desktop computer. A stylus is used to interact with the graphics tablet. A **stylus** is a pen-like pointer, but without ink. Graphics tablets are most commonly used for applications such as computer-aided design (CAD), photo editing, and other graphics work.

A pointing device may be wired or wireless. The wireless versions send data to the computer via radio signals and are powered by batteries.

STEM

Technology

A battery is an electrical device consisting of electrochemical cells. These cells convert chemical energy into electrical energy. Single-use batteries are discarded after the electrode materials are discharged. Rechargeable batteries, such as electric car batteries and lithium-ion batteries in electronic devices, can be recharged through electrical outlets.

Computing Fundamentals 2.3.1

Factors in Evaluating Pointing Devices

Choose a pointing device that supports the intended use of the computer. If the user is required to do a great deal of Internet browsing or reading of long documents, a pointing device with a wheel will make these tasks easier. If most of the work is text input where the pointing device is not often used, then a basic mouse without a wheel may provide enough function. Also consider where the pointing device will be used. If there is not a flat surface on which to operate a mouse, a trackball mouse may be the best option.

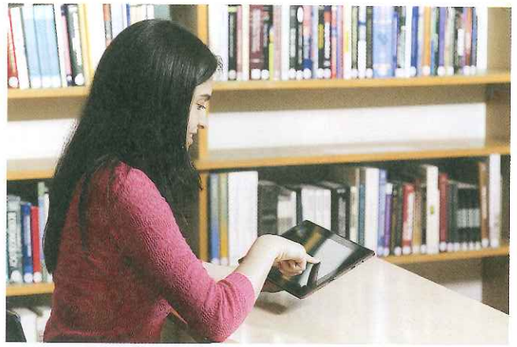
Some applications may be able to take advantage of a pointing device with more than two buttons. Many intensive graphics applications, such as CAD, have options for using multibutton pointing devices.

A wireless pointing device is encouraged for places where the wire will impede the movement of the device. Often, a desktop computer box

is placed on the floor. The wire for the pointing device may not be long enough to provide free movement. A wireless pointing device will not have this issue.

Touch Screens

A **touch screen** is a device that senses applied pressure and sends signals to the CPU. A touch screen makes it easy to input data if a keyboard or traditional pointing device is impractical. Unlike the touch pads found on laptops, touch screens also provide display output. A touch screen provides the functions of a pointing device and the computer monitor, as shown in Figure 2-12.



cristovao/Shutterstock.com

Figure 2-12. A touch screen serves as both output and input.

Actions of Touch Screens

A finger or a stylus is used to apply the pressure to the touch screen. The touch screen provides the four basic functions of a pointing device: pointing, clicking, dragging, and double-clicking.

Types of Touch Screens

The following devices all have touch screens: tablets, smartphones, and portable gaming devices. Many desktop computers have touch-screen monitors. Additionally, many devices with embedded computers have touch screens, such as music players, thermostats, and automotive diagnostic tools.

Interactive kiosks usually have touch screens. A kiosk is a stand-alone computerized device placed in a public space to provide information, sales, or entertainment. The ease of use of a touch screen allows an intuitive interface to be designed for these devices. Many automated teller machines (ATMs) have touch screens for the same reason.

Factors in Evaluating Touch Screens

Computing Fundamentals 2.3.1

A consideration in touch screen use is the accuracy of the pressure response. A touch screen should have a quick and accurate response. Often the size of areas for touching is controlled by software. For devices with small touch screens, a stylus may be required if icons and other interface items are too small and close together for a human finger to individually touch.

Image-Input Devices

Image-input devices are used to digitize images so they can be used by the computer. To *digitize* means to convert from a physical form, such as a photograph, into data the computer can use. These images can be in the form of still pictures or video clips, as shown in Figure 2-13.

Monkey Business Images/Shutterstock.com

Figure 2-13. A cell phone camera is a type of image-input device.

Actions of Image-Input Devices

White light consists of all colors of the visible spectrum: red, orange, yellow, green, blue, indigo, and violet. As light strikes an object, the object absorbs some of the light and reflects some of it. What you see as the color of an object is really the part of light that the object reflects. So, when you see a red apple, you are seeing the red portion of white light reflected off the apple. All other portions of white light are absorbed by the apple.

Image-input devices are digital devices that use electronics to create electrical signals to represent data. Scanners and digital cameras digitize images based on light. In the case of a scanner, a light inside the device it used. In the case of a camera, the light in the environment is used, sometimes with additional light provided by a flash. Both scanners and cameras contain sensors that detect which colors are hitting them. The position of each sensor in the group determines where that color is placed in the final image.

Types of Image-Input Devices

In addition to making phone calls and texting, most cell phones also function as digital cameras. A digital camera is a handheld image-input device that captures still or motion images. The camera digitizes the actual image and stores it in a file of 1s and 0s in the camera. Video cameras, also called camcorders, generally only capture motion video. However, the capture is performed in exactly the same manner as a digital camera.

A **webcam** is an image-input device that can be mounted on top of a monitor or may be built into a laptop computer. The webcam transfers live video over the web. Skype is a popular application that uses a webcam to allow users to see each other from distant locations.

Scanners also create visual images. They can digitize an image and save the data in a graphic file format.

Computing Fundamentals
2.3.1

Factors in Evaluating Image-Input Devices

The greater number of pixels in a digitized image, the better the representation of the real object. Higher pixel density or pixels per inch produce better quality images. Some digital cameras also provide a video capture option.

A webcam is a simple video and still camera that is attached to a computer. Its purpose is to facilitate video communication. Focus is available, but mobility is not its strength. A handheld video camera provides more flexibility in taking video. Not only is it mobile, but it provides the ability to change focus. Some video cameras provide editing

capability on the camera itself. A higher-end cell phone provides video capture, but the capability is limited in quality.

A wide range of scanners is available for purchase. Even the very inexpensive models provide a range of resolutions for the final image. Almost all also provide a cropping feature to limit the portion being scanned. If the primary task is scanning pages, then a page feeder is recommended. If the primary use is scanning business cards or photo slides, buy a specialized small scanner for that task.

FYI

Many printers combine printing, scanning, and photocopying capabilities.

Text-Input Devices

Text-input devices are generally image-input devices used with software to convert the image to text that can be used by the computer, as shown in Figure 2-14.

LoloStock/Shutterstock.com

Figure 2-14. OCR software can be used with a scanner to input text from a hard copy, such as a book.

Actions of Text-Input Devices

The basic feature of a scanner digitizes the original document as an image. An image of a text page is fine for reading; however, the text is pixels, not characters that can be edited. To be able to edit a scanned document, the image must be transformed into a text document. **Optical-character recognition (OCR)** software can be used with image scanners to digitize text so the computer understands it as text characters. Much of the reliability of OCR software depends on the quality of the original printed page. Proofread the document to make sure it has been properly scanned.

Banks use OCR software to scan the numerical information on checks. Businesses scan old typewritten documents to convert them into computer-usable text files. In some cases, handwritten notes can be scanned into text files.

Types of Text-Input Devices

Text can be entered using a scanner if there is a feature for converting the scanned image into text. Many scanners produce a PDF output. There are third-party software packages that will perform the step of converting a PDF file into a text document. The more reliable method is to use OCR software with the scanner.

Many smartphones use a variety of methods to enter text. The most often used is the virtual keyboard that appears on the display. To enter text, use your fingers to tap the keys. This is the basis of texting. The text also can be sent to another phone user or entered into a file to be saved on the smartphone. In addition, voice can be used to speak into the phone and speech recognition software converts the sounds to text.

Some smartphones have an additional hardware component of a physical keyboard that slides out for use.

Computing Fundamentals 2.3.1

Factors in Evaluating Text-Input Devices

Choose a scanning device that supports the intended use. For scanning multiple loose pages, select a scanner with an automatic document feeder. For scanning pages in a bound document, select a scanner that can automatically turn pages as it scans.

Scanner resolution and speed are important considerations. Fast or low-resolution scans are generally not as clear as slow or high-resolution scans. However, there needs to be a balance between how long a job will take and the cleanliness of the resulting text document. Depending on your needs, a high-end scanner may be required to quickly scan at a high resolution.

If considering a smartphone as a scanning device, look at the resolution of the phone's camera and the effectiveness of the autofocus feature. These will impact the quality of the scan. Also, be sure OCR software is available for the smartphone.

An additional aspect to evaluate is the OCR software that will be used. Be sure the capability of the software will meet your needs. For example, if you plan to scan handwritten notes, look for software that supports handwriting recognition. Also be sure the software can save text in a file format that you will be able to use.

Green Tech

Environmentally Friendly Electronics

It is important to purchase environmentally friendly devices. Some manufacturers use recycled materials in the construction of their products. Additionally, some companies offer electronics recycling services. They often partner with recyclers who use best practices to repair, repurpose, or recycle the equipment. These products send the message that the company values preserving the environment.

Audio-Input Devices

Audio-input devices convert sounds into data that can be used by the computer. Digitized sound can be used for audio playback or voice commands. Inputting sound into the computer requires the use of a microphone. Many laptops and mobile devices have embedded microphones.

Voice input allows the user to issue computer commands and enter text without using a keyboard or pointing device. Directory assistance on the telephone and search functions on a smartphone are examples of voice input.

Voice-recognition software must be installed to enable voice input. Early versions of voice-recognition software had to be "taught" to understand the user. Current versions of voice-recognition software understand most voices and accents found in the general public without prior preparation by the user.

Actions of Audio-Input Devices

To capture sound for computer use, it must be digitized. In nature, sound is continuous. The digital world works in individual bits or binary digits. Audio-input devices use a process called sampling. Sampling is capturing data at very small and regular intervals, as shown in Figure 2-15. The input device assigns a number to each sample and saves

these numbers in an audio file. Playback devices use the numbers to replicate the sound. Sampling is discussed in more detail in Chapter 14.

The smaller the interval, or the higher the sampling rate, the better the representation of the original sound will be. Increasing the sampling rate also increases the file size. Fortunately, there are many very good audio compression-decompression schemes (codecs). A typical sampling rate for CD quality audio is 44,100 times per second. This is often enough to fool the human ear into thinking the playback is a continuous sound and not a stream of samples played back-to-back.

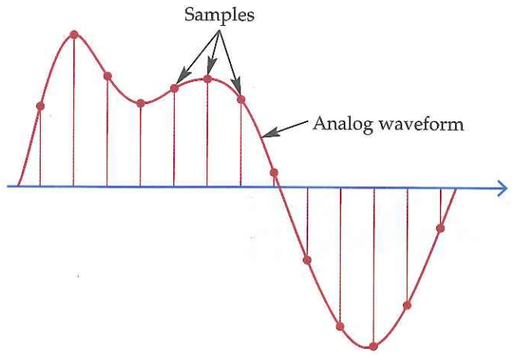


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Figure 2-15. To convert sound into digital form, it must be sampled at regular intervals.

Types of Audio-Input Devices

Many computers have an imbedded microphone. If not, external microphones can be used by way of the microphone jack on the audio card. The better the quality of the microphone, the better the quality of the audio capture will be. Care must be taken using an external microphone because touching it or moving it adds extra noise to the captured file. A headset eliminates this problem.

A headset is a device that sits securely on the user's head and holds a microphone near the user's mouth. This keeps the microphone steady and at the same distance from a user's mouth even if the head turns. Many headsets are a combination of microphone and earphones.

Ripping audio is another method for getting audio into the computer. **Ripping** is the process of extracting audio from a CD, DVD, or video file. The audio in this format is not directly playable using a computer-based media player. Ripping converts it to a computer-based format.

Certain electronic musical devices can be connected to a computer by way of the musical instrument digital interface (MIDI). A MIDI device may be able to stream data to a computer for capture of a real-time performance. MIDI software also can be used to create music using the computer keyboard.

Factors in Evaluating Audio-Input Devices

Computing Fundamentals 2.3.1

Choosing an audio-input device for a system depends on the user's needs. Microphones can sit on the desk, be clipped onto the user's clothing, or be part of a headset or webcam. Smartphones also have microphones. Select the type of microphone that will work best for your needs.

The intended input is also a consideration in selecting an audio-input device. For voice input, a simple microphone is usually fine. However, for conversations online, a headset is recommended so that there is no feedback from the audio output. Feedback occurs when the microphone

picks up the output from the speakers and feeds it back into the computer. This produces, at best, an echo or, at worst, a screeching sound.

For capturing high-quality audio, the tonal qualities of the microphone must be considered. High-quality audio may be needed for a movie or video soundtrack, musical recordings, or other application. The quality of the captured sound will be only as good as the capabilities of the input device.

FYI

The Americans with Disabilities Act provides guidelines for accessible devices. Devices that do not meet these guidelines are considered *noncompliant*.

Input Devices for Users with Disabilities

Just about everybody relies on computers, and people with disabilities are no different. Special input devices make computers accessible to those facing challenges related to mobility, visual impairment, and motor control.

Actions of Accessible Input Devices

Many adaptive devices are available to support people with disabilities. The actual input device for a person with a disability depends on the nature of the disability and the input to be captured. For example, a person unable to control a computer mouse by hand may use a device controlled by the head to point and click at a computer screen. The purpose of an accessible device is the same as a noncompliant device: to enter data that can be digitized.

Belushi/Shutterstock.com

Figure 2-16. This person is using a headset with his computer that allows him to input commands using his voice.

Types of Accessible Input Devices

Many adaptive devices are available to support people with disabilities. The types of accessible input devices include keyboards, pointing devices, touch screens, image-input devices, text-input devices, and audio-input devices. Following are some examples.

Voice-recognition technology has made it possible for disabled people to command wheelchair movement. This technology also allows commands to be entered into the computer, as shown in Figure 2-16. Data can be entered using this technology as well.

Enlarged keyboards and touch-screen devices help visually challenged users input data. The larger size allows for characters on the keys or screen to be easier to see.

Special trackballs and head-mounted pointing devices can be used if arm movement is impaired. One example is a light pen attached to a headset or eyeglasses that directs a laser beam

at the monitor. The monitor uses a reader to interpret where the beam is pointing, which takes the place of mouse input.

Factors in Evaluating Accessible Input Devices

Computing Fundamentals 2.3.1

While there is a wide range of assistive devices available, there are a few key assessments for all of them. Check that the device is simple and intuitive to use for the person who will operate it. See that the input is easy to accomplish. Be sure the device will function within any space constraints where it will be used. Ensure that the effort required to operate the device is within the normal range of the person who will use the device.

Another important consideration is the error rate for input. This is a measure of how accurately the user can achieve the intended result. The error rate should be as low as possible to ensure an efficient computer-operating experience.

Output Devices and Their Functions

Computing Fundamentals 3.3.1

An **output device** makes it possible for the user to receive communication from the computer. To see, hear, save, or send the results of the computer's processor, the information must be transformed by an output device. Information can be output to the user as video (text and images), sound, or in physical form (printed). There are thousands of output devices, the most common ones are discussed here.

Monitors

The most common output device is the monitor. A **monitor** is a device that provides a display output. Most of the output from a computer is provided to the user through the monitor. This is the device where the user can see the graphical interface of the operating system and software applications.

FYI

The pixels in a monitor can be clearly seen by holding a magnifying glass to the screen.

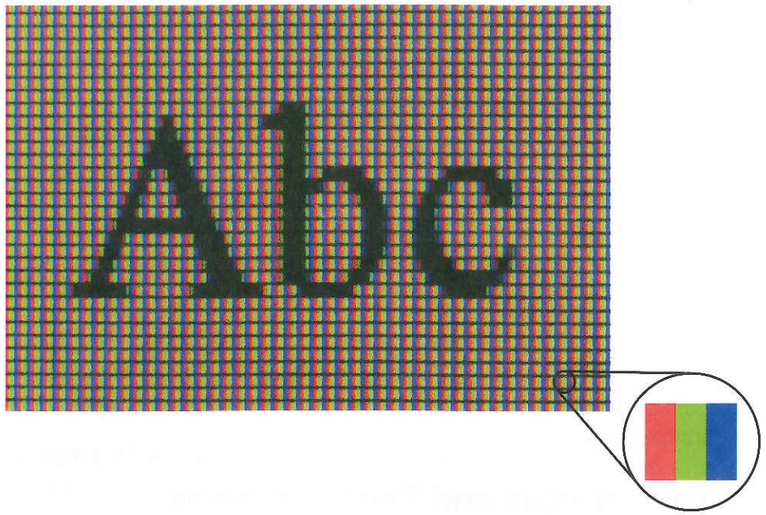
Actions of Monitors

Monitors operate by displaying the video output from the computer as a collection of pixels. One *pixel*, or picture element, is the smallest point a monitor can display. Each pixel is a tiny point of light made of a combination of red, green, and blue, as shown in Figure 2-17. A fluorescent panel is illuminated at the back of the screen. When an electrical current is applied, which comes from CPU via the video card, how much and what color light passes through each pixel is set.

Types of Monitors

The most common type of monitor is a liquid crystal display (LCD). It is also called a *flat-panel monitor*. LCDs are popular because they are light, inexpensive, and energy efficient.

A newer type of flat-panel monitor is the LED monitor. This monitor uses light-emitting diodes (LEDs) to create the light instead of an LCD.



grey_elkin/Shutterstock.com

Figure 2-17. One pixel on the monitor is a combination of red, green, and blue light.

An LED monitor is even more efficient and has better color representation than an LCD monitor.

Older monitors were cathode-ray tubes (CRTs). These are the large monitors that looked like an old-style television. CRT monitors have been almost completely replaced by LCD and LED monitors, but may still be found in applications such as automated teller machines.

Computing Fundamentals 2.3.1

Factors in Evaluating Monitors

The efficiency of monitors is measured by:

- screen size;
- contrast ratio;
- dot pitch;
- resolution; and
- viewing angle.

The *screen size* is a diagonal measurement, in inches, from corner to corner. This is the physical size of the screen in the monitor. Common standard desktop monitors are usually between 17 and 28 inches. Laptop screens are usually between 10 and 15 inches. Smartphone screens are usually between 4.5 inches and 6 inches.

The number of pixels on the screen is referred to as *screen resolution*. The more pixels there are in a given space, the more precise the image that can be displayed. A 21-inch monitor typically can display a maximum of 1680 pixels horizontally and 1050 pixels vertically.

The *contrast ratio* is the difference in light intensity between the brightest white and the darkest black. The higher the ratio, the greater the intensity difference between white and black. A high contrast ratio will make the images on screen easier to see in a well-lighted room.

FYI

The actual displayed screen resolution is a function of the video card, but the monitor screen determines what screen resolutions are supported.

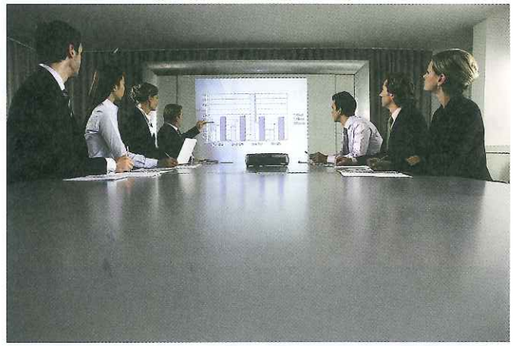
The *dot pitch*, also called the *pixel pitch*, is the distance, in millimeters, between pixels. The smaller the distance between the pixels, the sharper the display appears. A dot pitch between 0.22 and 0.28 mm is typical.

The *resolution* of a monitor is the density of the pixels displayed on the screen. The higher the resolution, the clearer the display is. Resolution is measured in horizontal and vertical pixels. A resolution of 1024 × 768, for example, means 1,024 pixels are displayed in the horizontal direction and 768 are displayed in the vertical direction. The resolution settings are determined by the graphics card and the monitor itself.

The *viewing angle* is how far the user can move to the side before the image can no longer be seen. Most LCD monitors have a viewing angle of 150°. This means the user can move 75° to either side of center and still see the images on screen.

Projectors

A **data projector** is an output device that collects video data from a computer or other media player and projects the images onto a separate screen, as shown in Figure 2-18. Projectors are most commonly used in educational and business settings to show images, lessons, and presentations. It is also common to find these output devices in sports and entertainment venues where large audiences attend and it is difficult to see the performers.



bikeriderlondon/Shutterstock.com

Figure 2-18. A data projector is like a computer monitor, except the graphic output is projected onto a separate screen.

Actions of Projectors

A projector is a light-based device that collects data intended for the monitor and displays it elsewhere. In general, these devices accept a signal from the computer and pass it through a prism or spinning color wheel to break up the signal into the three basic computer colors of red, green, and blue (RGB). Then each of these colors is separately projected into another component within the device, such as another prism. This combines the three colored beams of light into a single beam that is then projected onto a screen.

Types of Projectors

There are several different types of projects, including LCD, DLP, LCoS, and LED. A liquid crystal display (LCD) projector uses a prism to split a white light signal into RBG display. A digital light processing (DLP) projector uses a rotating color wheel to split a white signal into RBG display. A liquid crystal on silicone (LCoS) projector uses a combination of prisms and silicone panels to provide a display that is as easy to see close up as well as far away. A light emitting diode (LED) projector creates the projected image based on light emitted from the diode array. This type eliminates the heat and warm-up time of other

projector types. The result is greater image clarity and less power consumption.

Computing Fundamentals 2.3.1

Factors in Evaluating Projectors

Two factors to consider when selecting a projector are its size and weight. If the device is to be stationary, weight and size are not as important as if the device is to be carried to presentations in other places. For portability, a small size and light weight are best. If portability is important, size and weight may have a greater influence in selection than other factors.

A key feature of quality that increases with the cost is the number of lumens, which is a measure of brightness. If the presentations are to be given in a lighted room, the projector must have a greater lumens rating than if the session is in a darkened room.

Resolution may be a concern. If the projected display needs to show fine details, such as when demonstrating photographic or illustrative work, a high-resolution projector may be needed. However, basic projectors are capable of a resolution suitable for most uses.

The distance the projector will be from the screen should be considered. This distance determines the size of the projected image. Moving the projector closer to the screen will reduce the size of the image. Moving the projector farther from the screen will increase the size of the image.

Chuck Rausin/Shutterstock.com

Figure 2-19. This large-format ink-jet printer is typical of the type of computer printer used in the graphics industry.

Printers

The second most common output device is a printer. The **printer** transforms computer information into a physical form, most commonly an image or text on paper, as shown in Figure 2-19.

Actions of Printers

The true action of a printer occurs in the printer driver. It is this software program that formats the printed page from the printer based on the output from another software program, such as Microsoft Word or Adobe Photoshop. Once the page is formatted, instructions are sent to the printer. The printer then creates the printed page by depositing ink or toner onto the paper based on the instructions from the printer driver.

Types of Printers

Two types of printers are currently widespread: ink-jet and laser. However, other types of printers exist, such as solid-ink and 3D.

Ink-jet printers are common for home use and small businesses. They are affordable and can produce high-quality color printouts quickly and quietly. Ink-jet printers spray tiny drops of ink through a nozzle onto the paper to form the output. This type of printer uses the cyan, magenta, yellow, key (CMYK) color model. Most ink-jet printers have four ink cartridges, one for each color with black being the key color. Some ink-jet printers have two cartridges, one that contains cyan, magenta, and yellow and one for black.

FYI

With the proper paper, the output from an ink-jet printer can look like a traditional continuous tone photograph.

Laser printers use the same principle as photocopiers. A laser beam creates a charge of static electricity on a drum. The toner, which is a fine powder, is attracted to the charge and sticks to the drum. As the drum is rotated, paper moves past it and the toner is transferred to the paper. Heat is then applied to fuse the toner to the paper. Laser printers are popular in offices and schools because they produce high-quality text and are generally faster than ink-jet printers. The majority of laser printers output in black only, but color laser printers are available.

FYI

Impact printers, which create an image by pressing ink into the paper, are no longer common in general use, but still have specialized uses.

Solid-ink printers use wax-like sticks of solid ink to create an image on paper. In function, these printers are similar to ink-jet printers. The solid ink is melted and then sprayed onto the paper. However, the melted ink solidifies very quickly once it is on the paper. The liquid ink in an ink-jet printer must dry for a few seconds before becoming permanent. Solid-ink printers generate less waste because there are no ink or toner cartridges. The per-page operating cost of solid-ink printers is much lower than other printers. Solid-ink printers are not common, usually found only in some businesses and schools.

Ink-jet, laser, and solid-ink printers produce an image on a flat surface. This is a two-dimensional (2D) output. However, 3D printers produce a three-dimensional (3D) output. These printers create 3D output by building up material in very thin layers. Most 3D printers create the output in plastic, but printers that output in metal and other materials have been created.

Factors in Evaluating Printers

Computing Fundamentals 2.3.1

When evaluating an ink-jet or laser printer, consider:

- speed;
- resolution;
- duty cycle; and
- cost.

The speed of ink-jet and laser printers are measured by pages per minute (ppm). Printer speeds are typically in the 8 to 38 ppm range. Color output generally takes longer than black output.

The resolution of a printer is measured in dots per inch (dpi). The greater the dpi, the higher the resolution the printer can output. For most applications, 1,200 dpi is sufficient. For photographic-quality output, the resolution should be at least 2,400 dpi.

The *duty cycle* is the manufacturer's estimate for how long a machine can print before a failure occurs. This is generally expressed in the

FYI

Some printers are capable of duplex printing, which is the ability to print on both sides of the page. This can save paper and the associated cost.

number of pages produced on a monthly basis. A personal laser printer has a duty cycle of about 3,000 pages per month. A good ink-jet printer may be rated at 1,000 pages per month. A printer for business use should be rated much higher.

Printers themselves are very inexpensive compared to the cost of using them. In addition to the initial cost of the printer, ink or toner is used up as pages are printed. It is important to consider the cost of replacing these items. The capacity of these cartridges varies, so be sure to check the output rating when comparing prices. With ink-jet printers, a model having a separate cartridge for each color instead of colors combined in a single cartridge can be more economical. The type of paper required by the printer is also a variable expense. Photo-quality paper is generally more expensive than the paper used for printing text.

Audio-Output Devices

An **audio-output device** converts data in the computer into sounds, as shown in Figure 2-20. The computer uses sounds to alert the user about the status of the system. Additionally, many applications use sounds to communicate with the user. Sound is an integral part of most video games as well.

Actions of Audio-Output Devices

An audio-output device uses the decompression instructions of the codec used to create the file. The device takes the digitized sound file, decompresses it, and uses its hardware to play it. The digitized sound is replicated by the hardware of the device.

Kzenon/Shutterstock.com

Figure 2-20. This audio technician has speakers and earphones as output devices from his computer.

Types of Audio-Output Devices

Almost all personal computers are equipped with internal speakers. These speakers are sufficient for the basic audio communication from the computer. They are sufficient to play basic audio, such as sound clips and videoconferencing.

To play high-quality audio, such as music, movie soundtracks, and game sound effects, external speakers may be required. External speakers are connected to the computer through an audio jack in the sound card. There are many variations in external speakers, from small units that sit on the desk in front of the user, to surround-sound systems with large speakers that sit in the corners of the room and a subwoofer that sits under the desk.

For privacy, headphones or earbuds can be used. These devices generate sound directly at the user's ears, so the sounds cannot be heard by anyone other than the user.

In some cases, the audio-output device is a storage device such as a hard drive or DVD. For example, if the computer is used to compose and mix music, the audio output may be recorded directly on a DVD.

Factors in Evaluating Audio-Output Devices

Computing Fundamentals 2.3.1

The intended use of the audio output will determine the type of device. For music, movie playback, or gaming, high-quality external speakers are needed, but the specific quality and other features of the speakers are largely a personal decision. If the playback is for a performance, then size of the venue and connection to the venue's sound-amplification system are key factors.

Cost is a consideration. Generally, as the physical size and the quality of the speakers increase, so will the price. There is a wide range of prices for audio-output devices.

Hands-On Example 2.2.1

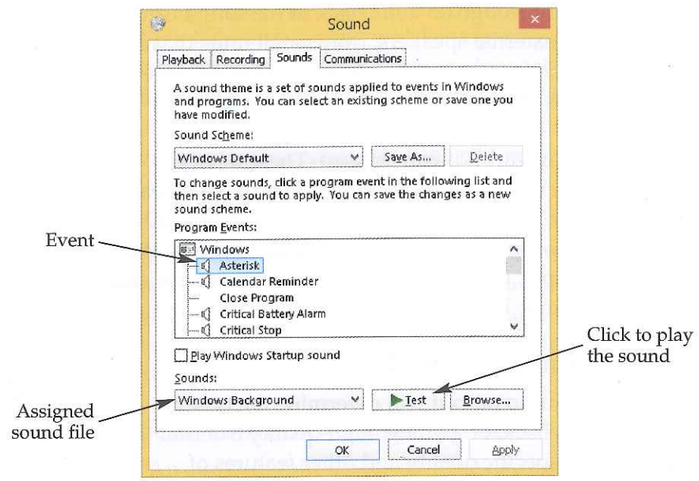
Audio Output

The Windows operating system has several events with which a sound can be associated. It is easy to change these sounds.

1. In Windows 8, click the **Apps** button. In Windows 7, click the **Start** button on the taskbar.
2. Click **Control Panel** in the menu. The Control Panel window is displayed.
3. Click **Hardware and Sound**. Note: if you do not see this option, click the **View by:** link at the top of the dialog box, and click **Category** in the drop-down menu.
4. Under the **Sound** heading, click **Adjust System Volume**. The **Volume Mixer** dialog box is opened, which provides volume control of the unit's sounds. Drag the slider for **System Sounds** upward to increase the volume. To mute, or silence, the system sounds, click the speaker icon below the **System Sounds** slider. This is a toggle, which means clicking it turns it on or off. For this activity, make sure the system sounds are on.

HANDS-ON EXAMPLE 2.2.1 (CONTINUED)

5. Close the **Volume Mixer** dialog box by clicking the standard close button, which is the X in the upper-right corner.
6. Click **Change System Sounds** in the **Hardware and Sound** view of the Control Panel window. The **Sound** dialog box is displayed, as shown. If the **Sounds** tab is not already active, click it.



7. One by one, highlight each of the events in the **Program Events:** window, and click the **Test** button to hear the sound. Only those events with a speaker icon next to it currently have an associated sound.
8. Highlight an event that currently does not have a sound associated with it. Then, click the **Browse...** button. A standard Windows open dialog box is displayed.
9. Navigate to a folder containing WAV files. The Windows\Media folder should contain several. WAV files are sound wave files.
10. Open a WAV file from the folder to associate the sound with the event.
11. Click the **Test** button to play the sound associated with the event.
12. Click the **Save As...** button in the **Sound** dialog box. In the dialog box that is displayed, enter *YourName*_Sounds, and click the **OK** button. The sound scheme is saved under this name and can be restored.
13. Close the **Sound** dialog box by clicking the **OK** button, and close the Control Panel window by clicking the Windows close button (X).

Output Devices for Users with Disabilities

People with disabilities rely on computers as much as those who do not have disabilities. Computers are made accessible to those facing challenges related to mobility, visual impairment, and motor control through special output devices, as shown in Figure 2-21.

Actions of Accessible Output Devices

Many adaptive devices are available to support people with disabilities. The actual output device for a person with a disability depends on the nature of the disability and the output to be created. For example, a person unable to view a computer screen in the default resolutions may use a device that magnifies the content on the screen. The purpose of the device is the same: to output data in a format the person can use.

Goodheart-Willcox Publisher; Denis Tabler/Shutterstock.com

Figure 2-21. A screen magnifier can make a computer accessible for someone with impaired vision.

Types of Accessible Output Devices

Many adaptive devices are available to support people with disabilities. The types of accessible output devices include monitors, projectors, printers, and audio-output devices. Following are some examples. Other output devices are similarly made accessible.

Larger monitors with a lower-resolution setting can assist those with impaired vision. This, in effect, magnifies the screen display. If this is not an adequate accommodation, there are software solutions. A screen-magnification program will enlarge the screen display, often with a scrolling function to pan the view. A screen reader is software that reads text aloud or describes what is displayed on the screen.

For printing, text can be enlarged in software or special Braille printers can be used to make the output accessible to the visually impaired. Braille is a code of raised dots in which English can be written. Braille printers are impact printers that emboss the page so those who are blind can read with their fingertips.

Closed captioning should be provided for video content. This allows the content to be accessed by those with hearing impairments. Closed captioning can be provided through software. Additionally,

FYI

A correctly designed website will contain the information needed by screen readers. Web accessibility is an important aspect of website design.

TITANS OF TECHNOLOGY

Intel Corporation was founded in 1968 by Gordon Moore and Robert Noyce under the name NM Electronics. Intel Corporation is a semiconductor company responsible for the most popular CPUs used in personal computers. Moore's law is based on an observation made by Gordon Moore that the number of transistors incorporated in a chip double about every 24 months. Even though this observation was made over 50 years ago, it holds today. Robert Noyce coinvented the integrated circuit. This device now exists in every digital device. Each integrated circuit is a collection of electronic circuits on a chip made of silicon. Developers have decreased the distance between transistors, making the chips smaller and smaller. This continual miniaturization accounts for part of the increase of processing speed because the signals have to travel shorter and shorter distances. The continued miniaturization of chips is what allows Moore's law to remain current.

many software programs that use sound as a communication feature have settings that allow a visual cue to be used instead of the sound. For example, software that plays a sound when a new e-mail message is received may have an option for the cursor to flash instead of playing a sound.

Computing Fundamentals 2.3.1

Factors in Evaluating Accessible Output Devices

While there is a wide range of assistive devices available, there are a few key assessments for all of them. Check that the device is simple and intuitive to use for the person who will use it. Check that the output will be easy to use. Be sure the device will function within any space constraints where it will be used. Ensure that the device produces an output within the normal range of the person who will use the device.

Cost is a consideration for some assistive output devices. Larger monitors generally cost more than smaller monitors. Braille printers are expensive. The cost is in the range of $2,000 for personal printers to $80,000 for large-scale printing operations. These printers are also noisy to operate and much slower than ink-jet and laser printers.

Hands-On Example 2.2.2

Accessibility Assessment

This checklist covers recommendations from the University of Washington to increase accessibility for all users in a computer lab. Complete this assessment to see if any of these recommendations are provided in your school's computer lab. Be prepared to discuss with the class how to implement any missing accommodations or additional accommodations that could be included.

Accommodation	✓
Printed resources placed so that a wheelchair user can reach them.	
At least one adjustable workstation provided.	
Keyboard guards and wrist rests provided.	
Trackball, joystick, or other mouse alternative available.	
Lab signs printed in high contrast and large print.	
Key documents available in large print or Braille formats.	
Screen-reading software and a speech-output system provided.	
Braille conversion programs and a Braille printer available.	
Large-print key-top labels, screen-enlargement software, and a large monitor (at least 17 inches) available.	
Key documents state the school's commitment to access and provide procedures for requesting disability accommodations.	
Staff is familiar with the adaptive technology and trained in disability issues.	

2.2 Section Review

Check Your Understanding

1. What is the function of the user interface?
2. Which input device senses applied pressure and sends signals to the CPU while providing the function of a computer monitor?
3. How does the purpose of an input device for users with disabilities differ from the purpose of a noncompliant device?
4. What is the most common output device?
5. What are the four factors to consider when evaluating an ink-jet or laser printer?

IC3 Certification Practice

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

1. Which is the most common type of computer monitor in use today?
   A. LCD
   B. CRT
   C. LED
   D. HD

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.

audio-input devices
audio-output device
data projector
image-input devices
keyboard
monitor
mouse
optical-character recognition (OCR)
output device
pointing device
printer
ripping
stylus
text-input devices
touch screen
user interface (UI)
webcam