Chapter Six

Storage

Objectives

After completing this chapter, you will be able to:

1 Describe the characteristics of an internal hard disk including capacity, platters, read/write heads, cylinders, sectors and tracks, and revolutions per minute

2 Discuss the purpose of network attached storage devices, external and removable hard disks, and hard disk controllers

3 Describe the various types of flash memory storage: solid state drives, memory cards, USB flash drives, and ExpressCard modules

4 Describe cloud storage and explain its advantages

5 Describe the characteristics of optical discs

6 Differentiate among various types of optical discs: CDs, archive discs and Picture CDs, DVDs, and Blu-ray Discs

7 Identify the uses of tape, magnetic stripe cards, smart cards, microfilm and microfiche, and enterprise storage

Storage

Storage holds data, instructions, and information for future use. For example, all types of users store digital photos; appointments, schedules, and contact/address information; correspondence, such as letters, e-mail messages; tax records; and Web pages. A home user also might store budgets, bank statements, a household inventory, records of stock purchases, tax information, homework assignments, recipes, music, and videos. In addition or instead, a business user stores reports, financial records, travel records, customer orders and invoices, vendor payments, payroll records, inventory records, presentations, quotations, and contracts. Other users store diagrams, drawings, blueprints,

internal hard disk

external
hard disks

network attached
storage device

microfilm

magnetic stripe card

Storage

smart card

optical disc

Figure 6-1   A variety of storage options.

designs, marketing literature, corporate newsletters, and product catalogs. All computers also store system and application software.

Storage requirements among users vary greatly. Home users typically have much smaller storage requirements than enterprise users. For example, a home user may need 320 GB (billion bytes) of storage, while enterprises may require 50 PB (quadrillion bytes) of storage.

A **storage medium** (media is the plural), also called **secondary storage**, is the physical material on which a computer keeps data, instructions, and information. Examples of storage media are hard disks, solid state drives, memory cards, USB flash drives, ExpressCard modules, optical discs, smart cards, magnetic stripe cards, and microfilm. Cloud storage is another storage option, in which the actual storage media used is transparent to the user. Figure 6-1 shows a variety of storage options.

miniature hard disk

solid state drive

memory cards

USB flash drive

cloud storage

ExpressCard module

Capacity is the number of bytes (characters) a storage medium can hold. Figure 6-2 identifies the terms manufacturers use to define the capacity of storage media. For example, a reasonably priced USB flash drive can store up to 4 GB of data (approximately four billion bytes) and a typical hard disk has 320 GB (approximately 320 billion bytes) of storage capacity.

A **storage device** is the computer hardware that records and/or retrieves items to and from storage media. **Writing** is the process of transferring data, instructions, and information from memory to a storage medium. **Reading** is the process of transferring these items from a storage medium into memory. When storage devices write data on storage media, they are creating output. Similarly, when storage devices read from storage media, they function as a source of input. Nevertheless, they are categorized as storage devices, not as input or output devices.

The speed of storage devices is defined by access time. **Access time** measures the amount of time it takes a storage device to locate an item on a storage medium. The access time of storage devices is slow, compared with the access time of memory. Memory (chips) accesses items in billionths of a second (nanoseconds). Storage devices, by contrast, access items in thousandths of a second (milliseconds) or millionths of a second (microseconds).

Storage Terms

Storage Term	Approximate Number of Bytes	Exact Number of Bytes
Kilobyte (KB)	1 thousand	2^{10} or 1,024
Megabyte (MB)	1 million	2^{20} or 1,048,576
Gigabyte (GB)	1 billion	2^{30} or 1,073,741,824
Terabyte (TB)	1 trillion	2^{40} or 1,099,511,627,776
Petabyte (PB)	1 quadrillion	2^{50} or 1,125,899,906,842,624
Exabyte (EB)	1 quintillion	2^{60} or 1,152,921,504,606,846,976
Zettabyte (ZB)	1 sextillion	2^{70} or 1,180,591,620,717,411,303,424
Yottabyte (YB)	1 septillion	2^{80} or 1,208,925,819,614,629,174,706,176

Figure 6-2   The capacity of a storage medium is measured by the number of bytes it can hold.

Hard Disks

A **hard disk** is a storage device that contains one or more inflexible, circular platters that use magnetic particles to store data, instructions, and information. The system unit on most desktop and notebook computers contains at least one hard disk. The entire device is enclosed in an airtight, sealed case to protect it from contamination. A hard disk that is mounted inside the system unit sometimes is called a fixed disk because it is not portable (Figure 6-3). With respect to a storage medium, the term portable means you can remove the medium from one computer and carry it to another computer.

Current personal computer hard disks have storage capacities from 160 GB to 2 TB and more. Home users store documents, spreadsheets, presentations, databases, e-mail messages, Web pages, digital photos, music, videos, and software on hard disks. Businesses use hard disks to store correspondence, reports, financial records, e-mail messages, customer orders and invoices, payroll records, inventory records, presentations, contracts, marketing literature, schedules, and Web sites.
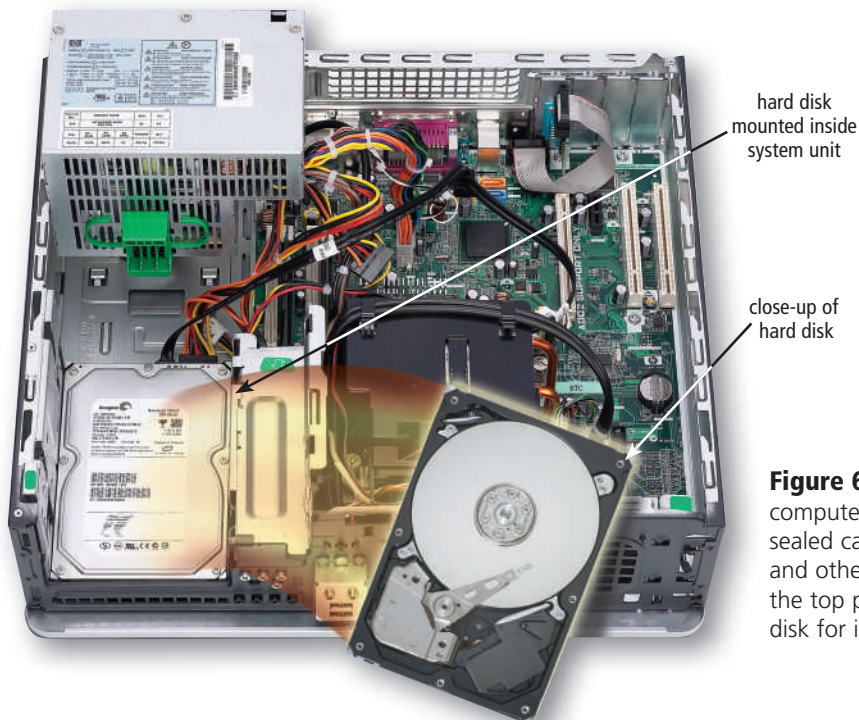
Traditionally, hard disks stored data using **longitudinal recording**, which aligned the magnetic particles horizontally around the surface of the disk. With **perpendicular recording**, by contrast, hard disks align the magnetic particles vertically, or perpendicular to the disk's surface, making much greater storage capacities possible. Experts estimate that hard disks using perpendicular recording provide storage capacities about 10 times greater than disks that use longitudinal recording.

Hard disks are read/write storage media. That is, you can read from and write on a hard disk any number of times. Read Ethics & Issues 6-1 for a related discussion.

Perpendicular Recording

For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Web Link resource for this book, and then click Perpendicular Recording.
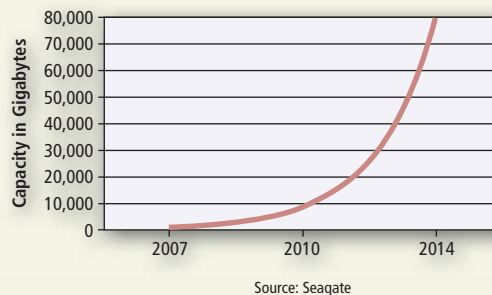
Figure 6-3   The hard disk in a desktop computer is enclosed inside an airtight, sealed case inside the system unit. (In this and other hard disk photos in the book, the top plate is removed from the hard disk for illustration purposes.)

? **FAQ 6-1**

To what degree are hard disk capacities increasing?

Hard disk capacities have increased at an exponential rate. Advancements in technology, such as perpendicular recording and enhanced read/write heads that can read and write denser areas on the platter, have resulted in a hard disk's capability of storing increasing amounts of data and information in a fixed amount of space. The chart to the right illustrates that the maximum hard disk size is growing.

Source: Seagate

For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 FAQ resource for this book, and then click Hard Disk Capacity.

Ethics & Issues

For the complete text of the Ethics & Issues boxes found in this chapter, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com and then navigate to the Chapter 6 Ethics & Issues resource for this book.

ETHICS & ISSUES 6-1

Should the Government Require Hard Disks to Be Cleaned?

An IT professional recently purchased a hard disk on an auction Web site only to find private banking records of several million people. Fortunately, the purchaser notified authorities, rather than use the data for nefarious purposes. In other incidents, taxpayer data and secret police tactics appeared on hard disks purchased on auction Web sites, donated to charitable organizations, or recovered from discarded computers. Most people do not realize that deleting files from a computer does not render the data permanently inaccessible. Deleted files can be recovered easily by a smart criminal or digital forensics examiner.

Experts recommend that special utility software, known as a wiping utility,

be used to clean the contents of a hard disk before it leaves possession of the owner. The government sets various disk wiping standards. For example, one standard requires that the software wipe the drive seven times, while a more stringent standard requires fourteen. Experts also recommend the use of full disk encryption, which is the process of encoding data and information into an unreadable form. Others recommend that any hard disk that at any time contained sensitive information be destroyed by a service company that specializes in hard disk destruction. Some companies now offer a service that allows you to keep a hard disk if it fails while covered by a warranty. Typically, companies

require that you return the damaged hard disk when you receive the replacement. Some people are not comfortable with this service, for fear of confidential information on the damaged hard disk falling into the wrong hands.

Should the government require that hard disks on sold, donated, or discarded computers be cleaned, encrypted, or destroyed? Why or why not? Would you make an extra effort to clean or encrypt the contents of hard disks on sold, donated, or discarded computers? Why or why not?
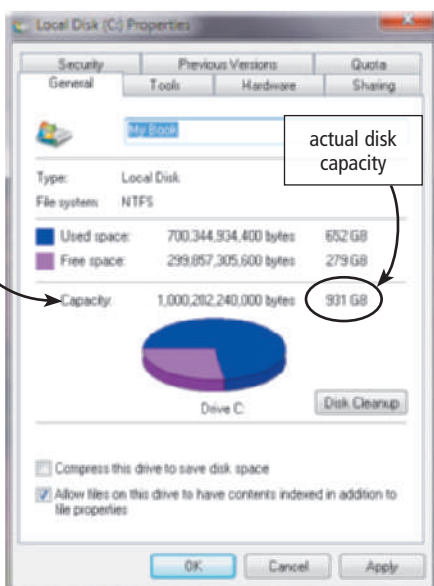
Characteristics of a Hard Disk

Characteristics of a hard disk include capacity, platters, read/write heads, cylinders, sectors and tracks, revolutions per minute, transfer rate, and access time. Figure 6-4 shows sample characteristics of a 1 TB hard disk. The following paragraphs discuss each of these characteristics.

1 TB disk can store any of the following:
- 500,000,000 pages of text
- 285,000 digital photos
- 250,000 songs
- 120 hours of digital video

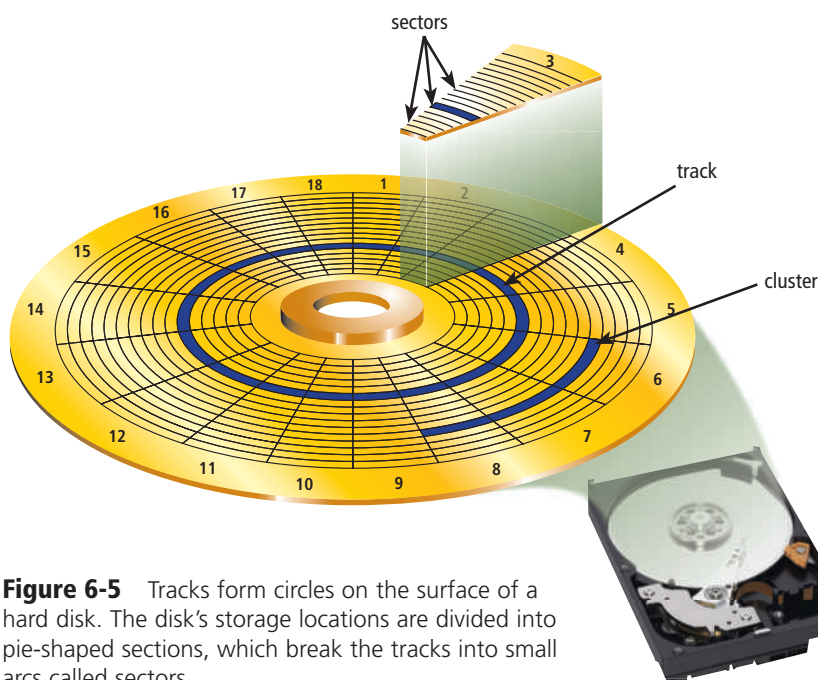| Sample Hard Disk Characteristics	
Advertised capacity	1 TB
Platters	4
Read/write heads	8
Cylinders	16,383
Bytes per sector	512
Sectors per track	63
Sectors per drive	1,953,525,168
Revolutions per minute	7,200
Transfer rate	300 MBps
Access time	8.5 ms

Figure 6-4 Characteristics of a sample 1 TB hard disk. The actual disk's capacity sometimes is different from the advertised capacity because of bad sectors on the disk.

actual disk capacity

Figure 6-5 Tracks form circles on the surface of a hard disk. The disk's storage locations are divided into pie-shaped sections, which break the tracks into small arcs called sectors.

The capacity of a hard disk is determined from whether it uses longitudinal or perpendicular recording, the number of platters it contains, and the composition of the magnetic coating on the platters. A platter is made of aluminum, glass, or ceramic and is coated with an alloy material that allows items to be recorded magnetically on its surface. The coating usually is three millionths of an inch thick.

Magnetic disks store data and instructions in tracks and sectors (Figure 6-5). A track is a narrow recording band that forms a full circle on the surface of the disk. The disk's storage locations consist of pie-shaped sections, which break the tracks into small arcs called sectors. On a hard disk, a sector typically stores up to 512 bytes of data.

On desktop computers, platters most often have a size of approximately 3.5 inches in diameter. On notebook computers, mobile devices, and some servers, the diameter is 2.5 inches or less. A typical hard disk has multiple platters stacked on top of one another. Each platter has two read/write heads, one for each side. The hard disk has arms that move the read/write heads to the proper location on the platter (Figure 6-6).
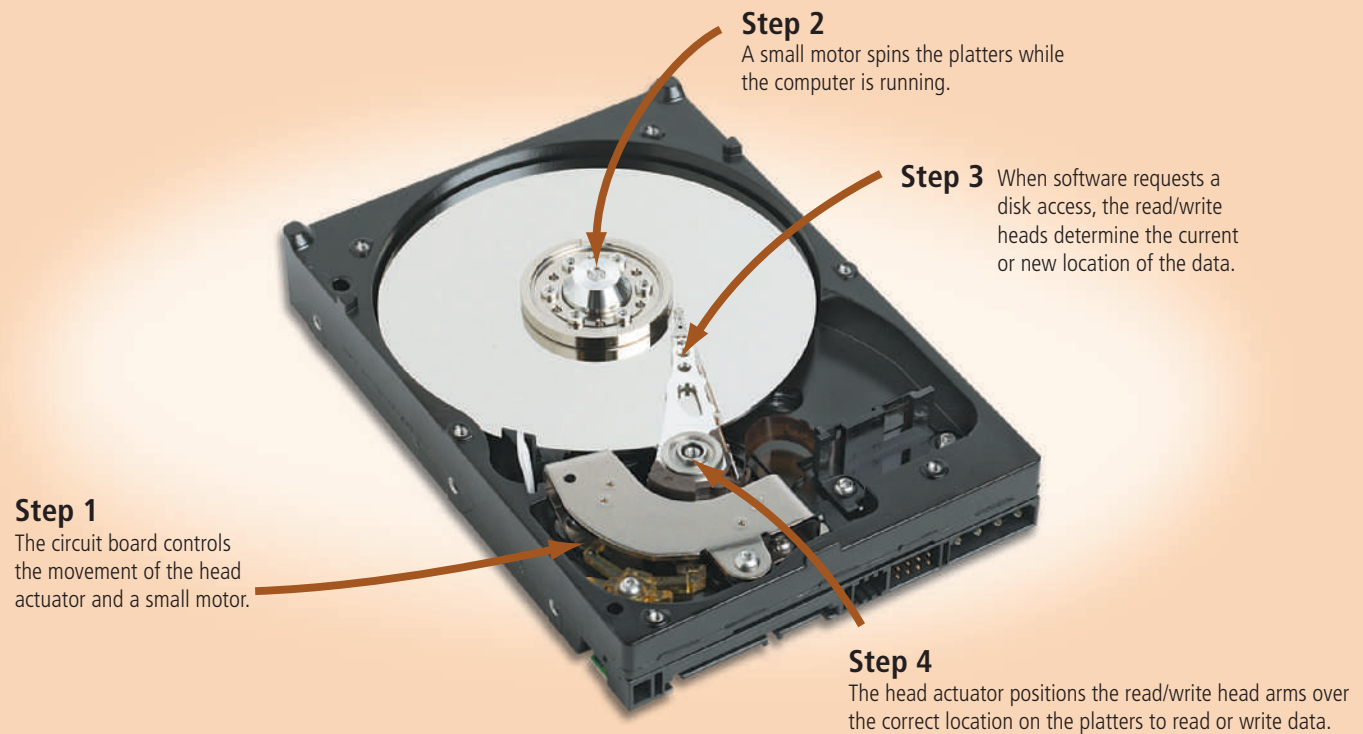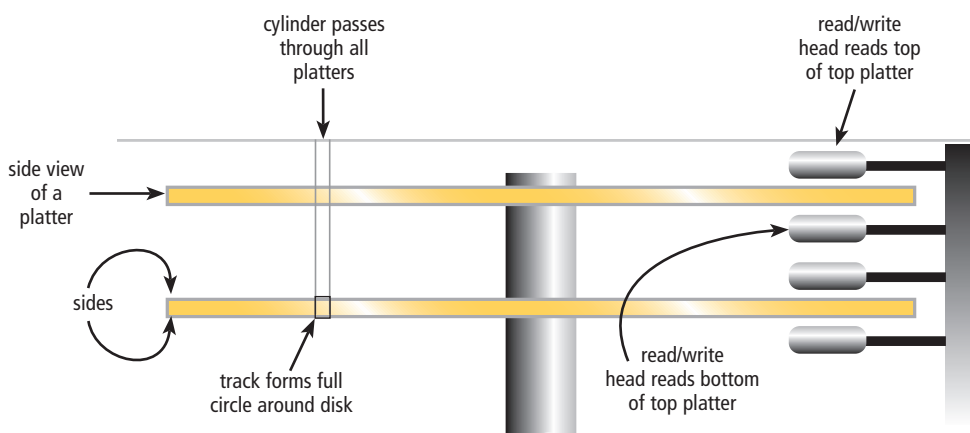
The location of the read/write heads often is referred to by its cylinder. A cylinder is the vertical section of a track that passes through all platters (Figure 6-7). A single movement of the read/write head arms accesses all the platters in a cylinder. If a hard disk has two platters (four sides), each with 1,000 tracks, then it will have 1,000 cylinders with each cylinder consisting of 4 tracks (2 tracks for each platter).

While the computer is running, the platters in the hard disk rotate at a high rate of speed. This spinning, which usually is 5,400 to 15,000 revolutions per minute (rpm), allows nearly instant access to all tracks and sectors on the platters. The platters may continue to spin until power is removed from the computer, or more commonly today, they stop spinning or slow down after a specified time to save power. The spinning motion creates a cushion of air between the platter and its read/write head. This cushion ensures that the read/write head floats above the platter instead of making direct contact with the platter surface. The distance between the read/write head and the platter is about two millionths of one inch.
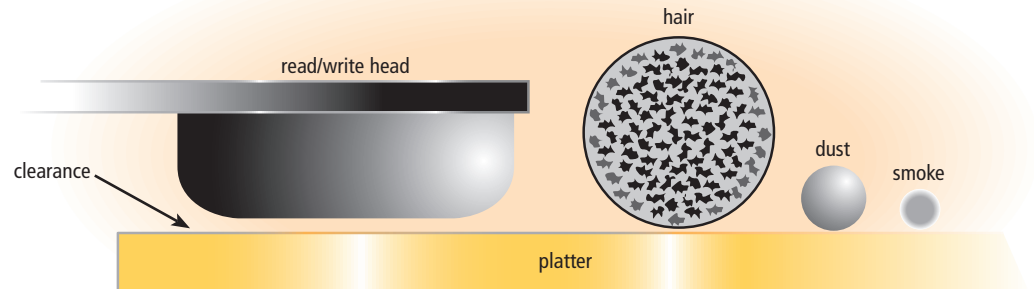
How a Hard Disk Works

Step 2
A small motor spins the platters while the computer is running.

Step 3 When software requests a disk access, the read/write heads determine the current or new location of the data.

Step 1
The circuit board controls the movement of the head actuator and a small motor.

Step 4
The head actuator positions the read/write head arms over the correct location on the platters to read or write data.

Figure 6-6   This figure shows how a hard disk works.

cylinder passes through all platters

read/write head reads top of top platter

side view of a platter

sides

track forms full circle around disk

read/write head reads bottom of top platter

Figure 6-7   A cylinder is the vertical section of track through all platters on a hard disk.

As shown in Figure 6-8, this close clearance leaves no room for any type of contamination. Dirt, hair, dust, smoke, and other particles could cause the hard disk to have a head crash. A head crash occurs when a read/write head touches the surface of a platter, usually resulting in a loss of data or sometimes loss of the entire disk. Thus, it is crucial that you back up your hard disk regularly. A **backup** is a duplicate of a file, program, or disk placed on a separate storage medium that you can use in case the original is lost, damaged, or destroyed. Chapter 7 discusses backup techniques. Access time for today's hard disks ranges from approximately 3 to 12 ms (milliseconds).

Figure 6-8 The clearance between a disk read/write head and the platter is about two millionths of an inch. A smoke particle, dust particle, human hair, or other contaminant could render the disk unusable.

RAID

Some personal computer manufacturers provide a hard disk configuration that connects multiple smaller disks into a single unit that acts like a single large hard disk. A group of two or more integrated hard disks is called a **RAID** (redundant array of independent disks). RAID is an ideal storage solution for users who must have the data available when they attempt to access it.

NAS

A **network attached storage** (NAS) device is a server connected to a network with the sole purpose of providing storage (shown in Figure 6-1 on page 238). Any user or device connected to the network can access files on the NAS device. These devices often use a RAID configuration. In the past, enterprises were the primary users of NAS. With the introduction of smaller, less expensive NAS devices, however, some home and small business users opt to add up to 6 TB or more of hard disk storage space to their network with a NAS device.

External and Removable Hard Disks

An **external hard disk**, shown in the left picture in Figure 6-9, is a separate freestanding hard disk that connects with a cable to a USB port or FireWire port on the system unit or communicates wirelessly. As with the internal hard disk, the entire hard disk is enclosed in an airtight, sealed case. External hard disks have storage capacities of up to 4 TB and more. Some external hard disk units include multiple hard disks that you can use for different purposes, if desired.

A **removable hard disk** is a hard disk that you insert and remove from a drive. A removable hard disk drive, shown in the right picture in Figure 6-9, reads from and writes on the removable hard disk. Removable hard disks have storage capacities up to 1 TB or more.

External and removable hard disks offer the following advantages over internal hard disks (fixed disks):
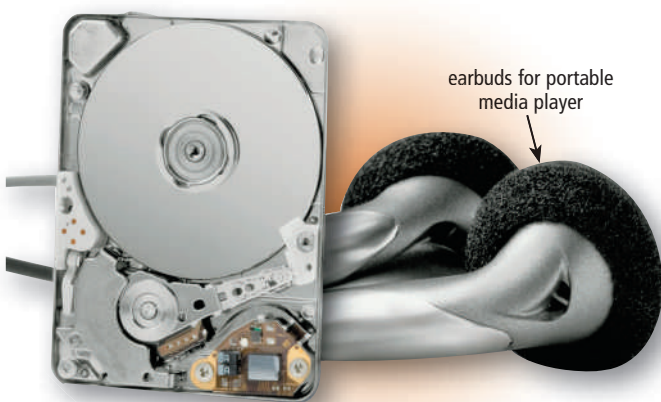
- Transport a large number of files
- Back up important files or an entire internal hard disk (several external hard disk models allow you to back up simply by pushing a button on the disk)
- Easily store large audio and video files
- Secure your data; for example, at the end of a work session, remove the hard disk and lock it up, leaving no data in the computer
- Add storage space to a notebook computer, including netbooks and Tablet PCs
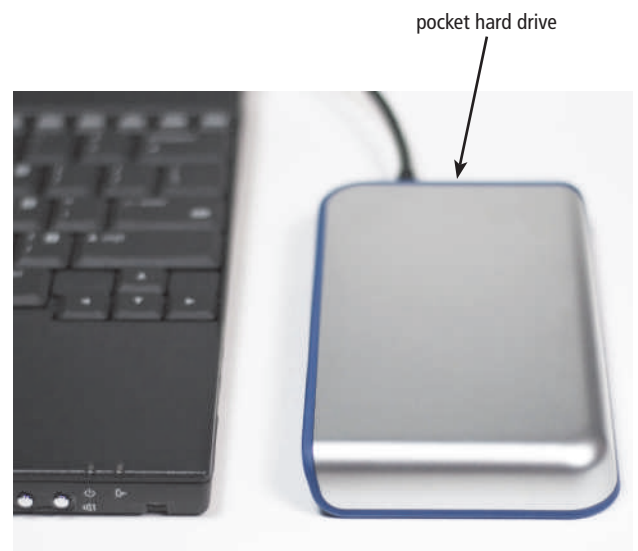- Add storage space to a desktop computer without having to open the system unit or connect to a network

Figure 6-9   Examples of external and removable hard disks.

Miniature Hard Disks

Both internal and external hard disks are available in miniature sizes. These tiny hard disks have form factors of 1.8 inch, 1 inch, and 0.85 inch. Devices such as portable media players, digital cameras, and smart phones often have internal miniature hard disks, which provide greater storage capacities than flash memory (Figure 6-10). External hard disks that are smaller in size and capacity, which also contain miniature hard disks, are sometimes called a **pocket hard drive** because they enable mobile users easily to transport photos and other files from one computer to another (Figure 6-11). Miniature hard disks have storage capacities that range from 4 GB to 250 GB.

Figure 6-10   This miniature hard disk is used in portable media players and other small devices, enabling users to store music, videos, movies, and any other type of files on the disk.

Figure 6-11   Users easily can transport data from one computer to another with a pocket hard drive.

Hard Disk Controllers

A **disk controller** consists of a special-purpose chip and electronic circuits that control the transfer of data, instructions, and information from a disk to and from the system bus and other components in the computer. That is, it controls the interface between the hard disk and the system bus. A disk controller for a hard disk, called the hard disk controller, may be part of a hard disk or the motherboard, or it may be a separate adapter card inside the system unit.

In their personal computer advertisements, vendors usually state the type of hard disk interface supported by the hard disk controller. Thus, you should understand the types of available hard disk interfaces. In addition to USB and FireWire, which can function as external hard disk interfaces, four other types of hard disk interfaces for use in personal computers are SATA, EIDE, SCSI, and SAS.

- SATA (Serial Advanced Technology Attachment) uses serial signals to transfer data, instructions, and information. The primary advantage of SATA interfaces is their cables are thinner, longer, more flexible, and less susceptible to interference than cables used by hard disks that use parallel signals. SATA interfaces also support connections to optical disc drives. External disks use the eSATA (external SATA) interface, which is much faster than USB and FireWire.
- EIDE (Enhanced Integrated Drive Electronics) is a hard disk interface that uses parallel signals to transfer data, instructions, and information. EIDE interfaces can support up to four hard disks at 137 GB per disk. EIDE interfaces also provide connections for optical disc drives and tape drives.
- SCSI interfaces, which also use parallel signals, can support up to eight or fifteen peripheral devices. Supported devices include hard disks, optical disc drives, tape drives, printers, scanners, network cards, and much more. Some computers have a built-in SCSI interface, while others use an adapter card to add a SCSI interface.
- SAS (serial-attached SCSI) is a newer type of SCSI that uses serial signals to transfer data, instructions, and information. Advantages of SAS over parallel SCSI include thinner, longer cables; reduced interference; less expensive; support for many more connected devices at once; and faster speeds. In addition to hard disks, SAS interfaces support connections to optical disc drives, printers, scanners, digital cameras, and other devices. Experts predict that SAS eventually will replace parallel SCSI.

Maintaining Data Stored on a Hard Disk

Most manufacturers guarantee their hard disks to last approximately three to five years. Many last much longer with proper care. To prevent the loss of items stored on a hard disk, you regularly should perform preventive maintenance such as defragmenting or scanning the disk for errors. To learn more about how to maintain a hard disk, complete the Learn How To 1 activity on pages 266 and 267. Chapter 7 discusses these and other utilities in depth.

✔ **QUIZ YOURSELF 6-1**

Instructions: Find the true statement below. Then, rewrite the remaining false statements so that they are true.

1. Hard disks contain one or more inflexible, circular platters that magnetically store data, instructions, and information.
2. SATA is a hard disk interface that uses parallel signals to transfer data, instructions, and information.
3. Storage media is the computer hardware that records and/or retrieves items to and from a storage device.
4. Users can move an internal hard disk from computer to computer as needed by connecting the disk to a USB port or FireWire port on the system unit.

Quiz Yourself Online: To further check your knowledge of pages 238 through 246, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Quiz Yourself resource for this book, and then click Objectives 1 – 2.

Flash Memory Storage

As discussed in Chapter 4, flash memory is a type of nonvolatile memory that can be erased electronically and rewritten. Flash memory chips are a type of **solid state media**, which means they consist entirely of electronic components, such as integrated circuits, and contain no moving parts. The lack of moving parts makes flash memory storage more durable and shock resistant than other types of media such as magnetic hard disks or optical discs.

Types of flash memory storage include solid state drives, memory cards, USB flash drives, and ExpressCard modules.

Solid State Drives

A **solid state drive** (**SSD**) is a storage device that typically uses flash memory to store data, instructions, and information (Figure 6-12). With available sizes of 3.5 inches, 2.5 inches, and 1.8 inches, SSDs are used in all types of computers including servers, desktop computers, and mobile computers and devices such as portable media players and digital video cameras. Storage capacities of current SSDs range from 16 GB to 256 GB and more.

SSDs have several advantages over magnetic hard disks.
- Access times of SSDs are about 0.1 ms, which is more than 80 times faster than a hard disk.
- Transfer rates of SSDs are faster than comparable hard disks.
- SSDs generate less heat and consume less power than hard disks.
- Manufacturers claim that SSDs will last more than 50 years, which is much greater than the 3 to 5 year hard disk stated lifespan.

The disadvantages of SSDs are they currently have a higher failure rate than hard disks, and their cost is much higher per gigabyte. As the price of SSDs drops, experts estimate that increasingly more users will purchase computers and devices that use this media.

Solid State Drives

For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Web Link resource for this book, and then click Solid State Drives.

Figure 6-12   As the price of SSDs drops, experts estimate that increasingly more users will purchase computers and devices that use this media.

Memory Cards

Memory cards enable mobile users easily to transport digital photos, music, or files to and from mobile devices and computers or other devices. As mentioned in Chapter 4, a **memory card** is a removable flash memory device, usually no bigger than 1.5 inches in height or width, that you insert and remove from a slot in a computer, mobile device, or card reader/writer (Figure 6-13).

Common types of memory cards include **CompactFlash** (**CF**), **Secure Digital** (**SD**), **Secure Digital High Capacity** (**SDHC**), **microSD**, **microSDHC**, **xD Picture Card**, **Memory Stick**, and **Memory Stick Micro** (**M2**). The table in Figure 6-14 compares storage capacities and uses of

Figure 6-13   Many types of computers and devices have slots for memory cards.

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USB Flash Drives

A **USB flash drive**, sometimes called a thumb drive, is a flash memory storage device that plugs in a USB port on a computer or mobile device (Figure 6-15). USB flash drives are convenient for mobile users because they are small and lightweight enough to be transported on a keychain or in a pocket. Current USB flash drives have storage capacities ranging from 512 MB to 64 GB, with the latter being extremely expensive.

Figure 6-15   A close-up of the flash memory and circuitry inside a USB flash drive.
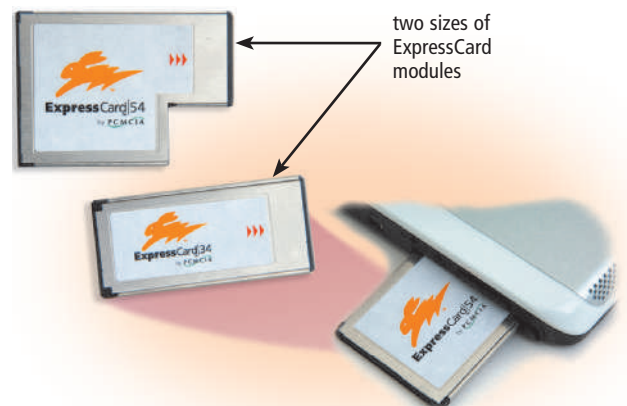

? | **FAQ 6-2**

Can airport security screening equipment damage or erase the data on my mobile media or hard disk?

The Transportation Security Administration's Web site states that their screening (X-ray) equipment will not damage or erase the data stored on flash memory mobile media, optical discs, or hard disks. Although your media is equally safe whether you carry it onto the airplane or leave it in checked baggage, packing it with your carry-on items is a better safeguard against physical damage. If you are uneasy about your media passing through the airport screening equipment, you may be able to request that the items be manually (hand) searched. It is important to note that the equipment used to screen checked baggage will not harm electronic media, but it may damage undeveloped film. As a safeguard, you should carry all film onto the airplane and request a manual search.

For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 FAQ resource for this book, and then click Airport Screening Equipment.

ExpressCard Modules

An **ExpressCard module** is a removable device, about 75 mm long and 34 mm wide or L-shaped with a width of 54 mm, that fits in an ExpressCard slot (Figure 6-16). ExpressCard modules can be used to add memory, storage, communications, multimedia, and security capabilities to a computer. ExpressCard modules commonly are used in notebook computers.
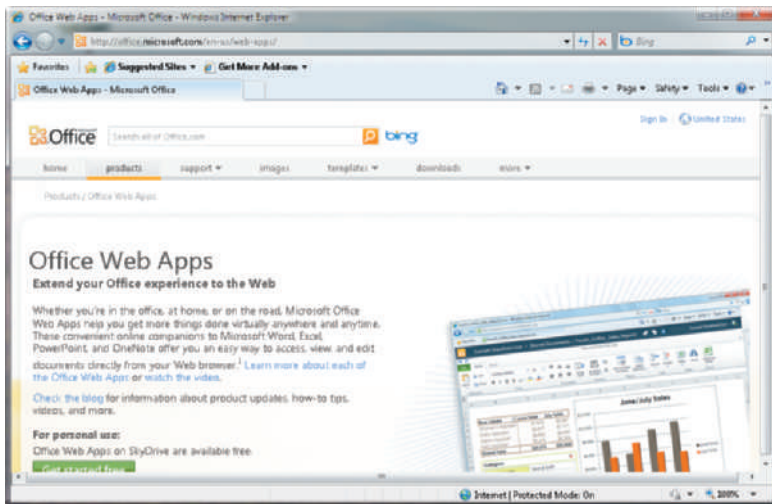

two sizes of ExpressCard modules

Figure 6-16   ExpressCard modules are available in two sizes.

Cloud Storage

Some users choose cloud storage instead of storing data locally on a hard disk or other media. **Cloud storage** is an Internet service that provides hard disk storage to computer users (Figure 6-17).

Types of services offered by cloud storage providers vary. Figure 6-18 identifies a variety of cloud storage providers. Read Innovative Computing 6-1 to find out about another type of cloud storage.

Fee arrangements vary. For example, one cloud storage service provides 25 GB of storage free to registered users; another charges $5 per month for 150 GB of storage. For enterprises, cloud storage services typically charge for storage on a per gigabyte basis, such as 15 cents per gigabyte.

Figure 6-17   An example of one Web site that provides cloud storage.

INNOVATIVE COMPUTING 6-1

Digital Books Are a Good Read

It is time to dust off your library card, because thousands of libraries are stocking their digital shelves with electronic books that you can download from anywhere you have computer access. Just locate a participating library's Web site, download the desired book files to your personal computer, and then transfer the files to your portable media player or smart phone. For patrons who do not want to download files, some libraries are lending a Playaway, which is a small device that stores 80 hours of digitized audio books.

Another set of books is available for reading at the British Library's Online Gallery. Software called Turning the Pages allows readers to browse some of the rarest books in the world and magnify details on the pages. The books include the *Gutenberg Bible*, Lewis Carroll's original *Alice in Wonderland*, and *The Diamond Sutra*, the oldest book in existence, printed in China in 868 A.D.

For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Innovative Computing resource for this book, and then click Online Libraries.

Cloud Storage Providers		
Web Site Names	**Type of Storage Provided**	**Other Services**
Box.net, IDrive, Windows Live SkyDrive	Backup or additional storage for any type of file	
Flickr, Picasa	Digital photos	Photo editing and photo management
YouTube	Digital videos	
Facebook, MySpace	Digital photos, digital videos, messages, and personal information	Social networking
Google Docs, Office Web Apps	Documents, spreadsheets, presentations	Productivity suite
Gmail, Windows Live Hotmail, Yahoo! Mail	E-mail messages	
Amazon EC2, Amazon S3, Nirvanix	Enterprise-level storage	Web services, data center services

Figure 6-18   Some of the more widely used cloud storage providers.

Users subscribe to a cloud storage service for a variety of reasons:
- To access files on the Internet from any computer or device that has Internet access
- To allow others to access their files on the Internet so that others can listen to an audio file, watch a video clip, or view a photo — instead of e-mailing the file to them
- To view time-critical data and images immediately while away from the main office or location; for example, doctors can view X-ray images from another hospital, home, or office
- To store offsite backups of data
- To provide data center functions, relieving enterprises of this task

Read Ethics & Issues 6-2 for a related discussion.

ETHICS & ISSUES 6-2

Is Data Stored in the Cloud Free from Prying Eyes?

At an ever increasing rate, companies and individuals store Web sites and data in the cloud. For example, those who utilize Web-based e-mail store their sent and received e-mail messages in the e-mail provider's cloud environment. Those who use corporate or private e-mail servers do not store their communications in the cloud. Important legal rulings highlight the differences between the two approaches for storing e-mail. Law enforcement agencies consider e-mail stored in the cloud to belong to the company that owns the cloud service, often an Internet access provider. E-mail stored on a private e-mail server, however, is the property of the company or individual who owns the server. When the law enforcement officials need to read someone's e-mail on a private e-mail server, they must obtain a warrant that outlines exactly the information being sought. In the cloud, however, law enforcement officials simply may need to request the information from the company that owns the cloud service. The user might not be notified of the search until up to 90 days later; further, the search may occur without limitations and may include continuous monitoring of an individual's e-mail. While the government takes a liberal approach to viewing one's e-mail in the cloud, individuals who secretly read others' e-mail messages may be subject to felony computer crimes.

Should data kept in the cloud be treated the same way legally as items that are kept in one's home? Why? Should the government be able to access your data in the cloud without your knowledge or permission? Why or why not? What types and amount of personal data are you comfortable storing in the cloud? Why?

QUIZ YOURSELF 6-2

Instructions: Find the true statement below. Then, rewrite the remaining false statements so that they are true.

1. A USB flash drive is a flash memory storage device that plugs in a parallel port on a computer or mobile device.
2. CompactFlash and Memory Sticks are two types of flash memory cards.
3. Cloud storage is a storage device that typically uses flash memory to store data, instructions, and information.
4. An ExpressCard module is a removable RAID device that fits in an ExpressCard slot.

Quiz Yourself Online: To further check your knowledge of pages 247 through 252, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Quiz Yourself resource for this book, and then click Objectives 3 – 4.

Optical Discs

Figure 6-19 A slot-loaded optical disc drive.

An **optical disc** is a type of optical storage media that consists of a flat, round, portable disc made of metal, plastic, and lacquer. These discs usually are 4.75 inches in diameter and less than one-twentieth of an inch thick.

Optical discs primarily store software, data, digital photos, movies, and music. Some optical disc formats are read only, meaning users cannot write (save) on the media. Others are read/write, which allows users to save on the disc just as they save on a hard disk.
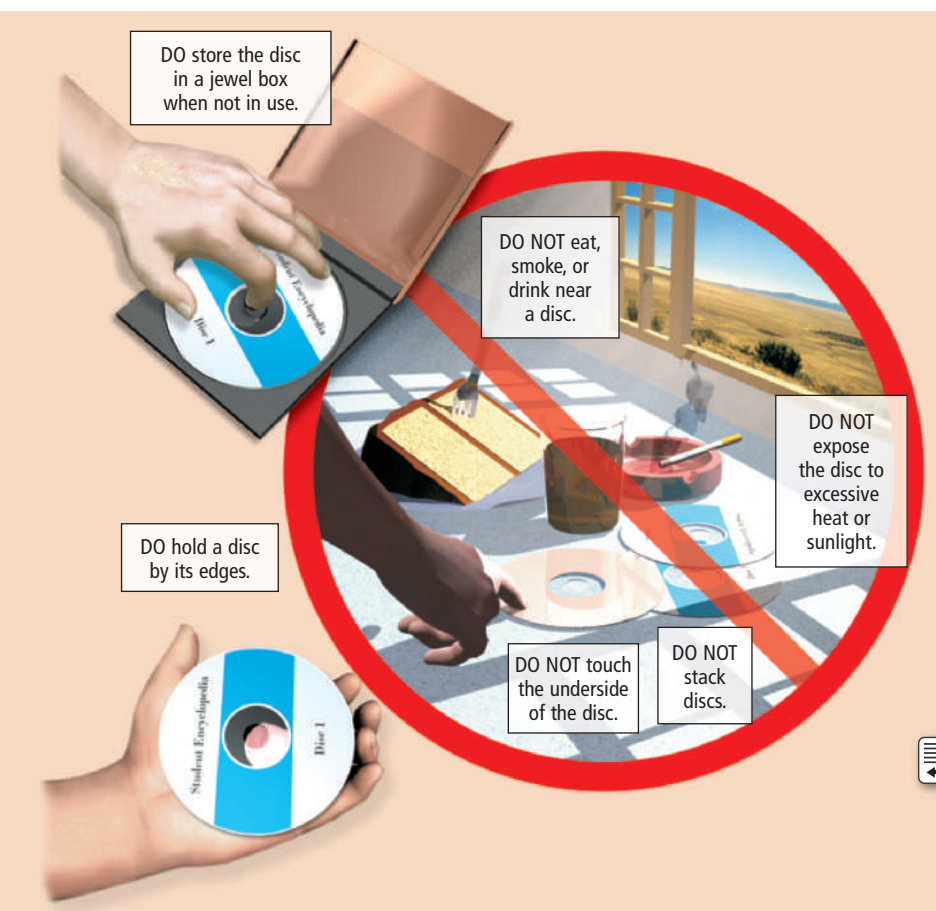
Nearly every personal computer today includes some type of optical disc drive installed in a drive bay. On some, you push a button to slide out a tray, insert the disc, and then push the same button to close the tray; others are slot loaded, which means you insert the disc in a narrow opening on the drive (Figure 6-19).

With some discs, you can read and/or write on one side only. Manufacturers usually place a silk-screened label on the top layer of these single-sided discs. You insert a single-sided disc in the drive with the label side up. Other discs are double-sided. Simply remove the disc from the drive, flip it over, and reinsert it in the drive to use the other side of the disc. Double-sided discs often have no label; instead, each side of the disc is identified with small writing around the center of the disc. Some drives use **LightScribe technology**, which works with specially coated optical discs, to etch labels directly on the disc (as opposed to placing an adhesive label on the disc).

Optical discs store items by using microscopic pits (indentations) and lands (flat areas) that are in the middle layer of the disc. A high-powered laser light creates the pits. A lower-powered laser light reads items from the disc by reflecting light through the bottom of the disc. The reflected light is converted into a series of bits the computer can process.

Manufacturers claim that a properly cared for high-quality optical disc will last 5 years but could last up to 100 years. Figure 6-20 offers some guidelines for the proper care of optical discs.

Many different formats of optical discs exist today. Figure 6-21 identifies a variety of optical disc formats and specifies whether a user can read from the disc, write to the disc, and/or erase the disc. The following sections describe characteristics unique to each of these disc formats.

Optical Disc Formats

Optical Disc	Read	Write	Erase
CD-ROM	Y	N	N
CD-R	Y	Y	N
CD-RW	Y	Y	Y
DVD-ROM BD-ROM	Y	N	N
DVD-R DVD+R BD-R	Y	Y	N
DVD-RW DVD+RW DVD-RAM BD-RE	Y	Y	Y

Figure 6-21 Manufacturers sell CD-ROM, DVD-ROM, and BD-ROM media prerecorded (written) with audio, video, and software. Users cannot change the contents of these discs. Users, however, can purchase the other formats of optical discs as blank media and record (write) their own data, instructions, and information on these discs.

DO store the disc in a jewel box when not in use.

DO NOT eat, smoke, or drink near a disc.

DO NOT expose the disc to excessive heat or sunlight.

DO hold a disc by its edges.

DO NOT touch the underside of the disc.

DO NOT stack discs.

Figure 6-20 Some guidelines for the proper care of optical discs.

Can I clean a disc?

Yes, you can remove dust, dirt, smudges, and fingerprints from the surface of an optical disc. Moisten a nonabrasive cloth with warm water or rubbing alcohol (do not use ammonia-based solutions) and then wipe the disc in straight lines from the center outward. You also can repair scratches on the bottom surface with a specialized disc repair kit.
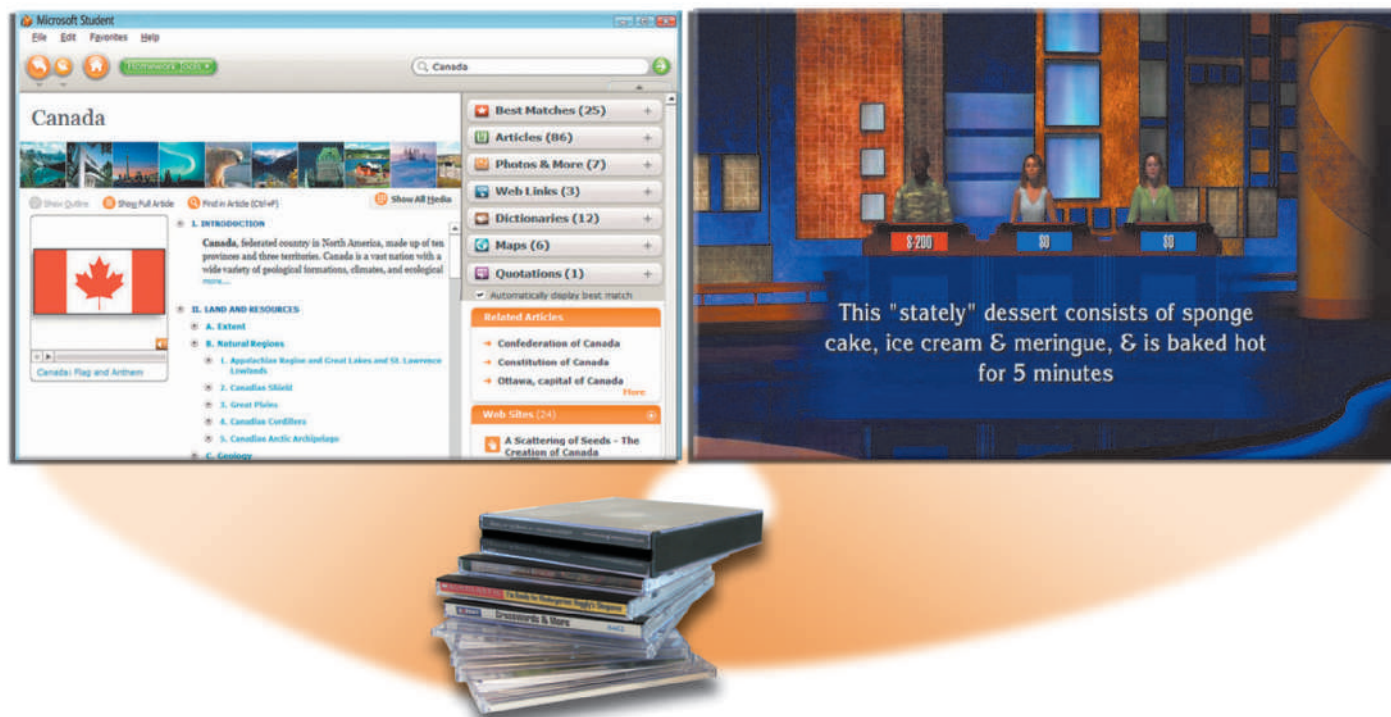
For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 FAQ resource for this book, and then click Cleaning and Repairing Discs.

CDs

A **CD-ROM**, or compact disc read-only memory, is a type of optical disc that users can read but not write (record) or erase — hence, the name read-only. Manufacturers write the contents of standard CD-ROMs. A standard CD-ROM is called a single-session disc because manufacturers write all items on the disc at one time. Software manufacturers often distribute programs using CD-ROMs (Figure 6-22).

A typical CD-ROM holds from 650 MB to 1 GB of data, instructions, and information. To read a CD-ROM, insert the disc in a **CD-ROM drive** or a CD-ROM player. Because audio CDs and CD-ROMs use the same laser technology, you may be able to use a CD-ROM drive to listen to an audio CD while using the computer.

Figure 6-22 Encyclopedias, games, simulations, and many other programs are distributed on CD-ROM.

CD-Rs and CD-RWs Many personal computers today include either a CD-R or CD-RW drive, or a combination drive that includes CD-R or CD-RW capabilities, as a standard feature. Unlike standard CD-ROM drives, users record, or write, their own data on a disc with a CD-R or CD-RW drive. The process of writing on an optical disc is called **burning**.

A **CD-R** (compact disc-recordable) is a multisession optical disc on which users can write, but not erase, their own items such as text, graphics, and audio. Multisession means you can write on part of the disc at one time and another part at a later time. Each part of a CD-R can be written on only one time, and the disc's contents cannot be erased.

A **CD-RW** (compact disc-rewritable) is an erasable multisession disc you can write on multiple times. To write on a CD-RW disc, you must have CD-RW software and a **CD-RW drive**. A popular use of CD-RW and CD-R discs is to create audio CDs. For example, users can record their own music and save it on a CD, purchase and download songs from the Web, or rearrange tracks on a purchased music CD. The process of copying audio and/or video data from a purchased disc and saving it on digital media is called **ripping**.

Archive Discs and Picture CDs

Many people use archive discs or Picture CDs to preserve their photos. When you post and share photos online on a photo sharing community, you can choose to save your collection of online photos on an **archive disc**, which stores photos in the jpg file format (Figure 6-23). The cost of archive discs is determined by the number of photos being stored. One service, for example, charges $9.99 for the first hundred pictures.
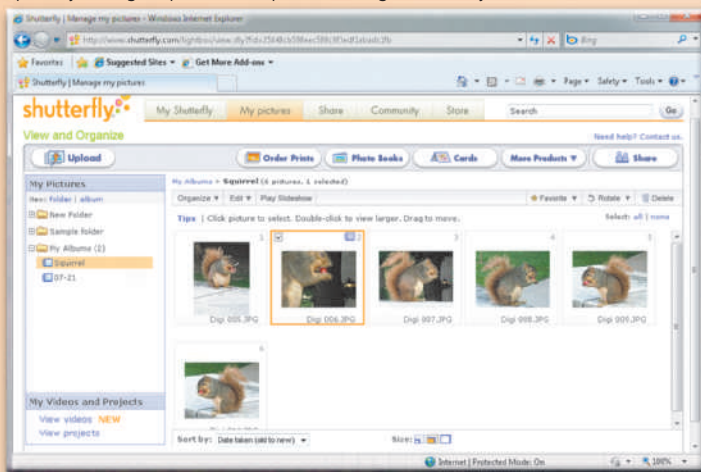
A Kodak **Picture CD** stores digital versions of film using a jpg file format. Many photo centers offer Picture CD service for consumers when they drop off film to be developed. The additional cost for a Picture CD is about $3 per roll of film.

Most optical disc drives can read an archive disc and a Picture CD. You can print copies of the photos from the disc on paper with an ink-jet printer. If you do not have a printer to print the images, many stores have kiosks at which you can print pictures from an archive disc, a Picture CD, or other media.
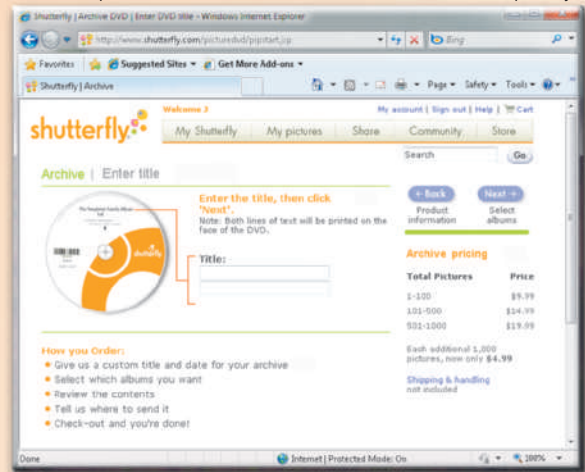
How an Archive Disc Works

Step 1
Upload your digital photos to a photo sharing community for others to view.

Step 2
Select the photos to be stored on the archive disc and then place your order.

Step 3
Pick up your archive disc at a designated store or receive it in the mail. At home, edit and/or print images from the archive disc on your ink-jet or photo printer, or view the images on a monitor or television screen. At a store, edit and/or print images from the archive disc at a kiosk.

archive disc →

Figure 6-23   This figure shows how an archive disc works.

DVDs and Blu-ray Discs

Although the size and shape of a CD and DVD are similar, a DVD stores data, instructions, and information in a slightly different manner and thus achieves a higher storage capacity. DVD quality also far surpasses that of CDs because images are stored at higher resolution.

A **DVD-ROM** (digital versatile disc-read-only memory or digital video disc-read-only memory) is a high-capacity optical disc on which users can read but not write or erase. Manufacturers write the contents of DVD-ROMs and distribute them to consumers. DVD-ROMs store movies, music, huge databases, and complex software (Figure 6-24).

To read a DVD-ROM, you need a **DVD-ROM drive** or DVD player. Most DVD-ROM drives also can read audio CDs, CD-ROMs, CD-Rs, and CD-RWs. Some drives, called DVD/CD-RW drives, are combination drives that read and write DVD and CD media. Many of today's computers include these combination drives.

A DVD-ROM uses one of three storage techniques. The first involves making the disc denser by packing the pits closer together. The second involves using two layers of pits. For this technique to work, the lower layer of pits is semitransparent so that the laser can read through it to the upper layer. This technique doubles the capacity of the disc. Finally, some DVD-ROMs are double-sided.

A newer, more expensive DVD format is Blu-ray, which is a higher capacity and better quality than standard DVDs, especially for high-definition audio and video. A **Blu-ray Disc** (BD) has storage capacities of 100 GB, with expectations of exceeding 200 GB in the future. Blu-ray Disc drives and players are backward compatible with DVD and CD formats. Figure 6-25 compares the current storage capacities of DVD and Blu-ray media. Another high density format, called **HD VMD** (Versatile Multilayer Disc) potentially will contain up to 20 layers, each with a capacity of 5 GB. Current HD VMDs have capacities of 40 GB and more.

A mini-DVD that has grown in popularity is the UMD, which works specifically with the PlayStation Portable (PSP) handheld game console. The **UMD** (Universal Media Disc), which has a diameter of about 2.4 inches, can store up to 1.8 GB of games, movies, or music. Similarly, the mini Blu-ray Disc, which is used primarily in digital video recorders, stores approximately 7.5 GB.

Figure 6-24   A DVD-ROM is a high-capacity optical disc.

DVD and Blu-ray Storage Capacities

Sides	Layers	DVD	Blu-ray
1	1	4.7 GB	25 GB
1	2	8.5 GB	50 GB
2	1	9.4 GB	50 GB
2	2	17 GB	100 GB

Figure 6-25   Storage capacities of DVDs and Blu-ray Discs.

Recordable and Rewritable DVDs   Many types of recordable and rewritable DVD formats are available. DVD-R, DVD+R and BD-R allow users to write on the disc once and read (play) it many times. **DVD-RW, DVD+RW**, and **DVD+RAM** are three competing rewritable DVD formats. Similarly, **BD-RE** is a high-capacity rewritable DVD format. To write on these discs, you must have a compatible drive or recorder.

Rewritable DVD drives usually can read a variety of DVD and CD media. Before investing in equipment, check to be sure it is compatible with the media on which you intend to record.

Other Types of Storage

In addition to the previously discussed types of storage, other options are available for specific uses and applications. These include tape, magnetic stripe cards and smart cards, microfilm and microfiche, and enterprise storage.

Tape

One of the first storage media used with mainframe computers was tape. **Tape** is a magnetically coated ribbon of plastic capable of storing large amounts of data and information at a low cost. Tape no longer is used as a primary method of storage. Instead, business users utilize tape most often for long-term storage and backup.

A **tape drive** reads and writes data and information on a tape. Although older computers used reel-to-reel tape drives, today's tape drives use tape cartridges. A tape cartridge is a small, rectangular, plastic housing for tape (Figure 6-26). Tape cartridges that contain quarter-inch-wide tape are slightly larger than audiocassette tapes.

Business users sometimes back up personal computer hard disks to tape, often using an external tape drive. On larger computers, tape cartridges are mounted in a separate cabinet called a tape library.

Tape storage requires sequential access, which refers to reading or writing data consecutively. As with a music tape, you must forward or rewind the tape to a specific point to access a specific piece of data.

Hard disks, flash memory storage, and optical discs all use direct access. Direct access means that the device can locate a particular data item or file immediately, without having to move consecutively through items stored in front of the desired data item or file. When writing or reading specific data, direct access is much faster than sequential access.
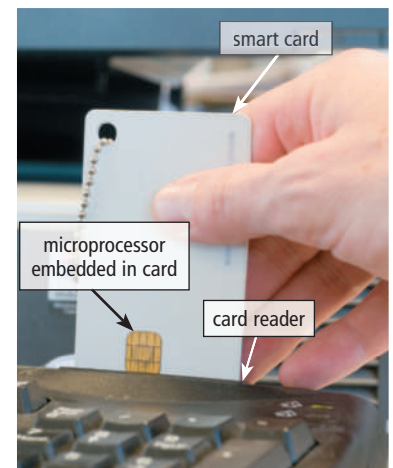
Figure 6-26   A tape drive and a tape cartridge.

Magnetic Stripe Cards and Smart Cards

A **magnetic stripe card** is a credit card, entertainment card, bank card, or other similar card, with a stripe that contains information identifying you and the card (shown in Figure 6-1 on page 238). Information stored in the stripe includes your name, account number, and the card's expiration date. A magnetic stripe card reader reads information stored on the stripe.

A **smart card**, which is similar in size to a credit card or ATM card (Figure 6-27), stores data on a thin microprocessor embedded in the card. Smart cards contain a processor and have input, process, output, and storage capabilities. When you insert the smart card in a specialized card reader, the information on the smart card is read and, if necessary, updated. Uses of smart cards include storing medical records, vaccination data, and other health care or identification information; tracking information, such as customer purchases or employee attendance; storing a prepaid amount of money, such as for student purchases on campus; and authenticating users, such as for Internet purchases or building access. In addition, a smart card can double as an ID card. Read Ethics & Issues 6-3 for a related discussion.

Figure 6-27   This user inserts the smart card to access the computer.

Should the World Become a Cashless Society?

Do you toss your loose change in a jar with the hopes of making a special purchase with the savings someday? This habit may become futile if the world goes cashless. One form of payment that could end the need for cash is the smart card, which can store a dollar amount on a thin microprocessor and update the amount whenever a transaction is made. Advocates claim that smart cards would eliminate muggings and robberies, make it difficult to purchase illegal goods, and reduce taxes by identifying tax cheats. Also, payment using biometrics, such as fingerprints, is becoming more common. Several high-profile security breaches at credit reporting and credit card companies, however, have heightened concerns over privacy. In a recent survey, most Americans said that they would not use a smart card even if privacy was guaranteed. Another survey shows that most Americans believe that fingerprints are a trustworthy form of identification. A cash purchase usually is anonymous. Yet, a smart card purchase preserves a record of the transaction that could become available to other merchants, advertisers, government agencies, or hackers.

Should the world become a cashless society? Why or why not? Would you be comfortable using a smart card or fingerprint instead of cash for all transactions? Why?

Figure 6-28 Images on microfilm can be read only with a microfilm reader.

Media Life Expectancies*
(when using high-quality media)

Media Type	Guaranteed Life Expectancy	Potential Life Expectancy
Magnetic disks	3 to 5 years	20 to 30 years
Optical discs	5 to 10 years	50 to 100 years
Solid state drives	50 years	140 years
Microfilm	100 years	500 years

*according to manufacturers of the media

Figure 6-29 Microfilm is the medium with the longest life.

Microfilm and Microfiche

Microfilm and microfiche store microscopic images of documents on roll or sheet film. **Microfilm** is a 100- to 215-foot roll of film. **Microfiche** is a small sheet of film, usually about 4 × 6 inches. A computer output microfilm recorder is the device that records the images on the film. The stored images are so small that you can read them only with a microfilm or microfiche reader (Figure 6-28).

Microfilm and microfiche use is widespread, with many companies allowing you to search through and view microfilm images online. Libraries use these media to store back issues of newspapers, magazines, and genealogy records. Some large organizations use microfilm and microfiche to archive inactive files. Some banks use them to store transactions and canceled checks. The U.S. Army uses them to store personnel records.

The use of microfilm and microfiche provides a number of advantages. They greatly reduce the amount of paper firms must handle. They are inexpensive and have the longest life of any storage media (Figure 6-29). Read Looking Ahead 6-1 for a look at long-term storage.

↗ LOOKING AHEAD 6-1

Rosetta Project a Storage Solution

The Rosetta Stone unlocked the secret of understanding Egyptian hieroglyphics. Created in 186 B.C., the carved stone contains translations of one hieroglyphic passage into three languages. Today, more than 2,500 human languages exist, but 50 to 90 percent of them are expected to become extinct by the end of this century. In an effort to preserve these languages using long-term storage technology, thousands of people collaborated on the Rosetta Project to create the Rosetta Disk.

Measuring only 3 inches wide, the nickel Rosetta Disk contains 15,000 etched pages documenting more than 1,000 known languages in the world. Each page is .019 inches wide, approximately the width of 5 human hairs. The pages are readable when the Disk is magnified 1,000 times. For protection, the Disk is housed in a 4-inch spherical container.

Five prototype Disks were created. The original Disk is attached to the European Space Agency's Rosetta Space Probe that was launched in 2004 and is expected to land on a comet in 2014. The Probe will measure the comet's molecular composition and then orbit the sun for millions of years.

For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Looking Ahead resource for this book, and then click Long-Term Storage.

Enterprise Storage

A large business, commonly referred to as an enterprise, has hundreds or thousands of employees in offices across the country or around the world. Enterprises use computers and computer networks to manage and store huge volumes of data and information about customers, suppliers, and employees.

To meet their large-scale needs, enterprises use special hardware geared for heavy use, maximum availability, and maximum efficiency. One or more servers on the network have the sole purpose of providing storage to connected users. For high-speed storage access, entire networks are dedicated exclusively to connecting devices that provide storage to other servers. In an enterprise, some storage systems can provide more than 185 TB of storage capacity. Optical disc servers hold hundreds of optical discs.

An enterprise's storage needs usually grow daily. Thus, the storage solutions an enterprise chooses must be able to store its data and information requirements today and tomorrow. Read Ethics & Issues 6-4 for a related discussion.

ETHICS & ISSUES 6-4

Who Should Be Looking at Your Medical Records?

A medical transcriber based in a foreign country and hired by a U.S. medical center threatened to post private medical records to the Internet if she was not paid more. With the widespread use of computers and an explosion in data storage capacity around the world, private information, such as medical records, requires increased diligence by companies, governments, and individuals to maintain this privacy. The government would like most Americans' health care records available in privacy-protected electronic format by 2014. Although these records will be stored by a corporation or the government, individuals probably will have complete control, or ownership, of these electronic records.
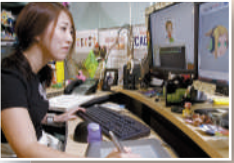
The Health Insurance Portability and Accountability Act (HIPAA) sets rigorous standards for medical record privacy. The law does not cover financial records, education records, or employment records — each of which may contain medical information about you. Your medical information also may be examined by insurance companies, government agencies, the Medical Information Bureau (MIB), employers, and the courts. You also inadvertently may pass on medical information to direct marketers when you participate in informal health screenings or surveys. Some people have found that discussing medical conditions via Internet chat rooms or newsgroups has resulted in unwanted attention, and they later regret the disclosures. Proponents of greater electronic access to medical records claim that more access means that physicians can be better prepared when they see patients, physicians will make fewer errors, and insurance companies can better root out fraud.

Should more limits be placed on what other people can do with your medical information? Why or why not? What are the advantages of increased access to medical records? What are the disadvantages?

Putting It All Together

Many factors influence the type of storage devices you should use: the amount of data, instructions, and information to be stored; the hardware and software in use; and the desired cost. The table in Figure 6-30 outlines several suggested storage devices for various types of computer users.

Categories of Users

User	Typical Storage Devices	User	Typical Storage Devices
Home	• 500 GB hard disk • Cloud storage • Optical disc drive • Card reader/writer • USB flash drive	**Power**	• 2.5 TB hard disk • Cloud storage • Optical disc drive • Portable hard disk for backup • USB flash drive

Small Office/ Home Office	• 1 TB hard disk
	• Cloud storage
	• Optical disc drive
	• External hard disk for backup
	• USB flash drive
		Enterprise	• Desktop Computer
			  - 1 TB hard disk
			  - Optical disc drive
			  - Smart card reader
			  - Tape drive
			  - USB flash drive
			• Server or Mainframe
			  - Network storage server
			  - 40 TB hard disk system
			  - Optical disc server
			  - Microfilm or microfiche

Mobile	• 250 GB hard disk • Cloud storage • Optical disc drive • Card reader/writer • Portable hard disk for backup • USB flash drive		

Figure 6-30 Recommended storage devices for various users.

Instructions: Find the true statement below. Then, rewrite the remaining false statements so that they are true.

1. A CD-RW is a type of optical disc on which users can read but not write (record) or erase.
2. A DVD-RAM is a single-session disc that stores digital versions of film using a jpg file format.
3. DVDs have the same storage capacities as CDs.
4. Optical discs are written and read by mirrors.
5. Microfilm and microfiche have the shortest life of any media.

Quiz Yourself Online: To further check your knowledge of pages 252 through 259 visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Quiz Yourself resource for this book, and then click Objectives 5 – 7.

Chapter Summary

Storage holds data, instructions, and information, which includes pictures, music, and videos, for future use. Users depend on storage devices to provide access to their storage media for years and decades to come.

This chapter identified and discussed various storage media and storage devices. Storage media covered included internal hard disks; external and removable hard disks; solid state drives; memory cards; USB flash drives; ExpressCard modules; cloud storage; CDs, DVDs, and Blu-ray Discs; tape; smart cards; and microfilm and microfiche.

Computer Usage @ Work

Meteorology

With the television tuned to the local weather station, you anxiously are awaiting to see the projected path of a hurricane in the tropics. Having experienced hurricanes in the past, you rely heavily on the accuracy of weather forecasts so that you can adequately prepare if a storm travels through the area. Computers allow meteorologists to better estimate the severity and path of storms, enabling people to make potentially life-saving preparations.

The National Hurricane Center uses multiple computer models to determine a storm's path. These models consider factors such as the storm's current strength, the effects of nearby weather systems, the storm's central pressure, and whether the storm may travel over land. These models also may consider previous storms that traveled a similar path. Historical weather and storm data are stored on large storage devices by the National Weather Service. While these models are not 100 percent accurate, they do ensure that everyone who may be affected by the storm has enough time to prepare.

Violent, rotating thunderstorms potentially can spawn tornadoes, which sometimes cause catastrophic damage. For this reason, it is important for everyone to closely watch or listen to the weather during the storm. Meteorologists can monitor weather systems on multiple radars and send additional severe weather warnings automatically to weather radios. Computer technology enables these messages to be broadcast automatically only to weather radios in areas that may be affected.

In addition to computers helping us stay safe during severe storms, they also assist with day-to-day weather forecasting. Several years ago, meteorologists could predict the weather for only a few days into the future. Beyond that point, the forecast was very uncertain. Meteorologists presently are able to predict the weather, including temperature and chance of precipitation, one week or more into the future with much greater accuracy because computers create models using historical weather data and behavior to predict the future path of various weather systems.

News and weather stations also post their weather forecasts online. In fact, several Web sites have interactive radars that allow visitors to zoom in and view how weather is affecting their immediate neighborhood.

The meteorology field has made significant advancements because of computer technologies. Weather forecasts are more meaningful, which not only helps us prepare on land but also helps to protect those traveling by air or by sea.

For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Computer Usage @ Work resource for this book, and then click Meteorology.

Companies on the Cutting Edge

SEAGATE TECHNOLOGY Storage Solutions Supplier

The average household with a broadband Internet connection will need nearly 1 TB of storage for its personal media collections, and Seagate has the storage solutions for practically every digital need. The company offers more than 40 products for the personal computing, consumer electronics, and enterprise computing fields.

Seagate has been at the forefront of the digital storage world since it developed the first 5.25-inch hard disk for the personal computer in 1980. In 2008 it shipped its one billionth hard disk, making the company's

production for the past 30 years a total of 79 million terabytes. Seagate expects to ship its two billionth hard disk by 2013.

Seagate recently introduced the FreeAgent DockStar network adapter. This device allows users to access their digital media from anywhere in the world and share these files with anyone. The FreeAgent DockStar network adapter also enables users to link their digital content to online social networks such as Facebook, Twitter, and MySpace.

SANDISK CORPORATION Flash Memory Storage Supplier

The number of flash memory card formats is growing, and only one company has the rights to design, develop, manufacture, and market every one of them: SanDisk. The company is the world's largest supplier of flash memory storage products and also has lines of portable media players.

The company was founded in 1988, and one of its earliest flash drives was used on a U.S. space shuttle three years later. Today SanDisk is developing rewritable 3-D memory products that will store data vertically, and

company executives believe this technology will replace flash products in the next decade.

SanDisk recently introduced the world's fastest 32 GB SDHC card. The 32 GB SanDisk Extreme SDHC card boasts read and write speeds of 30 megabytes per second. The increased speeds enable photographers to take pictures quickly without having to wait long for the card to record the images. In addition, computer users also are able to transfer data to and from the card quickly.

For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com and then navigate to the Chapter 6 Companies on the Cutting Edge resource for this book.

Technology Trailblazers

AL SHUGART Storage Expert

Al Shugart said that his real goal in life was to have fun, and he spent his life doing the things that gave him the most pleasure. The day after receiving his bachelor's degree in engineering physics in 1951, he landed a job at IBM doing what he loved to do: fixing broken items and developing new technology. He was promoted to supervisor of the product development team that developed the first removable hard disk drive.

Shugart then left IBM, became vice president of Memorex, and then started Shugart Associates and

began developing floppy disks. In 1979 he founded Seagate Technology with a friend. As his company grew to become the world's largest hard disk manufacturer, he had fun placing his dog, Ernest, on the ballot for a Congressional seat.

Shugart served as president and CEO of Al Shugart International, a venture capital firm in California, until his death in 2006.

MARK DEAN IBM Inventor

Web 2.0 applications demand large, inexpensive storage, and Mark Dean is hard at work helping to meet this need. As vice president of IBM's Almaden Research Center lab in California, Dean is responsible for developing innovative products.

Dean joined IBM after graduating from Stanford University with a degree in electrical engineering. He led a team that developed the first CMOS microprocessor to operate at one gigahertz and has more than

40 patents or patents pending that are used in more than 40 million personal computers manufactured each year. Three of his patents are among the nine registered for the architecture of the original personal computer.

Dean is the first African-American to be appointed to IBM Fellow, the company's highest level of technical merit. He also was inducted in the National Inventors Hall of Fame.

For more information, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com and then navigate to the Chapter 6 Technology Trailblazers resource for this book.

Chapter Review

The Chapter Review section reinforces the main concepts presented in this chapter.

To listen to an audio version of this Chapter Review, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com and then navigate to the Chapter 6 Chapter Review resource for this book.

1. What Are the Characteristics of an Internal Hard Disk?   A **hard disk** is a storage device that contains one or more inflexible, circular platters that use magnetic particles to store data, instructions, and information. The system unit in most desktop and notebook computers contains at least one hard disk. **Capacity** is the number of bytes (characters) a storage medium can hold. Hard disk capacity is determined from whether it uses **longitudinal recording** or **perpendicular recording**, the number of platters it contains, and the composition of the magnetic coating on the platters. A platter is made of aluminum, glass, or ceramic and is coated with a material that allows items to be recorded magnetically on its surface. Each platter has two read/write heads, one for each side. The location of a read/write head often is referred to by its cylinder, which is the vertical section of a track that passes through all platters. Magnetic disks store data and instructions in tracks and sectors. A track is a narrow recording band that forms a full circle on the surface of the disk. The disk's storage locations consist of pie-shaped sections, which break the tracks into small arcs called sectors. While the computer is running, the platters rotate at 5,400 to 15,000 revolutions per minute (rpm), which allows nearly instant access to all tracks and sectors on the platters.

2. What Is the Purpose of Network Attached Storage Devices, External and Removable Hard Disks, and Hard Disk Controllers?   A **network attached storage** (NAS) device is a server connected to a network with the sole purpose of providing storage. Any user or device connected to the network can access files on the NAS device. These devices often use a **RAID** (redundant array of independent disks) configuration. A group of two or more integrated hard disks is called a RAID. An **external hard disk** is a separate freestanding hard disk that connects with a cable to a USB or FireWire port on the system unit or communicates wirelessly. External hard disks have storage capacities up to 4 TB or more. A **removable hard disk** can be inserted or removed from a drive. Removable hard disks have storage capacities up to 1 TB. A **disk controller** consists of a special-purpose chip and electronic circuits that control the transfer of data, instructions, and information from a disk to and from the system bus and other components in the computer. A hard disk controller may be part of a hard disk on the motherboard, or it may be a separate adapter card inside the system unit. In addition to USB and FireWire, which can function as hard disk interfaces, four other types of hard disk interfaces for use in personal computers are SATA (Serial Advanced Technology Attachment), EIDE (Enhanced Integrated Drive Electronics), SCSI, and SAS (serial-attached SCSI).

Visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Quiz Yourself resource for this book, and then click Objectives 1 – 2.

3. What Are the Various Types of Flash Memory Storage?   Flash memory chips are a type of **solid state media,** which means they consist entirely of electronic components and contain no moving parts. A **solid state drive** (**SSD**) is a storage device that uses flash memory to store data, instructions, and information. Although SSDs currently have a higher failure rate than hard disks and are more expensive, experts estimate that as the price of SSDs drops, increasingly more users will purchase computers and devices that contain this media. A **memory card** is a removable flash memory device that you insert and remove from a slot in a computer, mobile device, or card reader/writer. Common types of memory cards include **CompactFlash (CF), Secure Digital (SD), Secure Digital High Capacity (SDHC), microSD, microSDHC, xD Picture Card, Memory Stick,** and **Memory Stick Micro (M2)**. A **USB flash drive** is a flash memory storage device that plugs in a USB port on a computer or mobile device. An **ExpressCard module** is a removable device that fits in an ExpressCard slot. ExpressCard modules add storage or other capabilities to a computer and commonly are used in notebook computers.

4. What Is Cloud Storage, and What Are Its Advantages?   **Cloud storage** is an Internet service that provides storage for computer users. Types of services offered by cloud storage providers vary. Available for all sizes of users, with various degrees of storage services available for home and business users, cloud storage fees vary, depending on the user's storage requirements. Advantages include accessing files on the Internet from any computer or device with Internet access; storing large audio, video, and graphics files on the Internet instantaneously; allowing others to access their files on the Internet; viewing time-critical data and images immediately; storing off-site backups of data; and providing data center functions.

Visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Quiz Yourself resource for this book, and then click Objectives 3 – 4.

Chapter Review

5. **What Are the Characteristics of Optical Discs?**   An **optical disc** is a type of storage media that consists of a flat, round, portable disc made of metal, plastic, and lacquer. These discs usually are 4.75 inches in diameter and less than one-twentieth of an inch thick. Optical discs primarily store software, data, digital photos, movies, and music. Some are read only, which means users cannot write (save) on them; others are read/write, which allows users to save on the disc just as they save on a hard disk. Optical discs store items by using microscopic pits (indentations) and lands (flat areas). A high-powered laser light creates the pits, and a lower-powered laser light reads items by reflecting light through the bottom of the disc. The reflected light is converted into a series of bits the computer can process.

6. **What Are the Various Types of Optical Discs?**   A **CD-ROM** is an optical disc that users can read but not write (record) or erase. A **CD-R** is a multisession disc on which users can write, but not erase. A **CD-RW** (compact disc-rewritable) is erasable and can be written on multiple times. An **archive disc** is used to store photos from a photo sharing community in the jpg file format. A **Picture CD** stores digital versions of film using a jpg file format. A **DVD-ROM** is a high-capacity disc which users can read but not write on or erase. A **Blu-ray Disc** (BD) currently has storage capacities of 100 GB. The **HD VMD** (Versatile Multilayer Disc) is a high-density format with a capacity of 40 GB or more. A mini-DVD that has grown in popularity is the UMD (Universal Media Disc), which works specifically with the PlayStation Portable handheld game console. Similarly, the mini Blu-ray Disc is used primarily in digital video recorders. DVD-R, DVD+R, BD-R formats can be written on once. **DVD-RW**, **DVD+RW**, and **DVD+RAM** are three competing high-capacity rewritable DVD formats. **BD-RE** is a high-capacity rewritable DVD format.

7. **How Are Tape, Magnetic Stripe Cards, Smart Cards, Microfilm and Microfiche, and Enterprise Storage Used?**   **Tape** is a magnetically coated ribbon of plastic capable of storing large amounts of data and information at a low cost. A **tape drive** reads and writes data and information on tape. Business users utilize tape most often for long-term storage and backup. A **magnetic stripe card** is a credit card, entertainment card, bank card, or other similar card with a stripe that contains information identifying you and the card. A magnetic stripe card reader reads information stored on the stripe. A **smart card**, which is similar in size to a credit or ATM card, stores data on a thin microprocessor embedded in the card. Smart cards contain a processor and have input, process, output, and storage capabilities. **Microfilm** is a 100- to 215-foot roll of film. **Microfiche** is a small sheet of film, usually about 4 × 6 inches. Microfilm and microfiche greatly reduce the amount of paper firms must handle, are inexpensive, and have the longest life of any storage media. Enterprises use special hardware to meet their large-scale needs, including servers, entire networks, and optical disc servers. In an enterprise, some storage systems can provide more than 185 TB of storage capacity.

Visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 Quiz Yourself resource for this book, and then click Objectives 5 – 7.

Key Terms

You should know each key term. The list below helps focus your study.

To see an example of and a definition for each term, and to access current and additional information from the Web, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com and then navigate to the Chapter 6 Key Terms resource for this book.

access time (240)	DVD+RAM (256)	microfiche (258)	Secure Digital (SD) (248)
archive disc (255)	DVD-ROM (256)	microfilm (258)	Secure Digital High Capacity
backup (244)	DVD-ROM drive (256)	microSD (248)	(SDHC) (248)
BD-RE (256)	DVD+RW (256)	microSDHC (248)	smart card (257)
Blu-ray Disc (256)	DVD-RW (256)	network attached storage	solid state drive (SSD) (247)
burning (254)	ExpressCard module (250)	(244)	solid state media (247)
capacity (240)	external hard disk (244)	optical disc (252)	storage device (240)
card reader/writer (249)	hard disk (240)	perpendicular recording	storage medium (239)
CD-R (254)	HD VMD (256)	(240)	tape (257)
CD-ROM (254)	LightScribe technology (253)	Picture CD (255)	tape drive (257)
CD-ROM drive (254)	longitudinal recording (240)	pocket hard drive (245)	UMD (256)
CD-RW (255)	magnetic stripe card (257)	RAID (244)	USB flash drive (250)
CD-RW drive (255)	memory card (248)	reading (240)	writing (240)
cloud storage (251)	Memory Stick (248)	removable hard disk (244)	xD Picture Card (248)
CompactFlash (CF) (248)	Memory Stick Micro (M2)	ripping (255)	
disk controller (246)	(248)	secondary storage (239)	

Checkpoint

The Checkpoint exercises test your knowledge of the chapter concepts. The page number containing the answer appears in parentheses after each exercise.

To complete the Checkpoint exercises interactively, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com and then navigate to the Chapter 6 Checkpoint resource for this book.

Multiple Choice   Select the best answer.

1. _____ measures the amount of time it takes a storage device to locate an item on a storage medium. (240)
   a. Capacity
   b. Access time
   c. A storage medium
   d. Reading

2. A group of two or more integrated hard disks is called a _____. (244)
   a. backup
   b. platter
   c. RAID
   d. portable hard disk

3. A _____ consists of a special-purpose chip and electronic circuits that control the transfer of data, instructions, and information from a disk to and from the system bus and other components in the computer. (246)
   a. pocket hard drive
   b. removable hard disk
   c. magnetic disk
   d. disk controller

4. A _____ is a memory storage device that plugs in a USB port on a computer or mobile device. (250)
   a. smart card
   b. USB flash drive
   c. UMD
   d. Memory Stick

5. Users subscribe to a cloud storage service to _____. (252)
   a. access files from any computer that has Internet access
   b. allow others to access their files
   c. store offsite backups of data
   d. all of the above

6. _____ technology works with specially coated optical discs to etch labels directly on the disc. (253)
   a. LightScribe
   b. SATA
   c. LightSaber
   d. SCSI

7. _____ storage requires sequential access. (257)
   a. Hard disk
   b. Tape
   c. Memory card
   d. DVD

8. A(n) _____ card is a credit card, entertainment card, bank card, or other similar card, with a stripe that contains information identifying you and the card. (257)
   a. Secure Digital High Capacity
   b. magnetic stripe
   c. Secure Digital
   d. microSDHC

Matching   Match the terms with their definitions.

_____ 1. backup (244)
_____ 2. external hard disk (244)
_____ 3. solid state media (247)
_____ 4. solid state drive (247)
_____ 5. card reader/writer (249)

a. media which consist entirely of electronic components, such as integrated circuits, and contain no moving parts
b. device that reads and writes data, instructions, and information stored on memory cards
c. portable, large-capacity magnetic medium that can store from 100 MB to 750 MB of data
d. duplicate of a file, program, or disk placed on a separate storage medium that you can use in case the original is lost, damaged, or destroyed
e. a storage device that typically uses flash memory to store data, instructions, and information
f. a separate freestanding hard disk that connects with a cable to a USB port or FireWire port on the system unit or communicates wirelessly

Short Answer   Write a brief answer to each of the following questions.

1. What is longitudinal recording? _____ What is the benefit of perpendicular recording over longitudinal recording? _____

2. What is network attached storage? _____ How much hard disk storage can home and small business users add to their network with a NAS device? _____

3. How is a single-session disc different from a multisession disc? _____ What is a CD-RW? _____

4. Why do users use memory cards? _____ Name five types of memory cards and describe some of the characteristics of each card. _____

5. What is one difference between microfilm and microfiche? _____ What are some uses of microfilm and microfiche? _____

Problem Solving

The Problem Solving exercises extend your knowledge of the chapter concepts by seeking solutions to practical computer problems that you may encounter at home, school, or work. The Collaboration exercise should be completed with a team.

In the real world, practical problems often can be solved in multiple ways. Provide one solution to each of the following problems using available resources, such as articles on the Web or in print, blogs, podcasts, videos, television, user guides, other individuals, and electronics and computer stores. You may need to use multiple resources to obtain an answer. Present your solutions in the form requested by your instructor (brief report, presentation, discussion, or other means).

@ Home

1. **Old Movies**   During the past two decades, you have been recording home movies on VHS tapes. It is becoming more difficult to locate blank VHS tapes, and you are worried that if your current VCR breaks, it will be hard to find a store that sells them new. A friend suggests that you copy these movies to an optical disc. What steps will you take to convert these movies?

2. **Possible Head Crash**   When you turn on your computer, you hear a clicking sound coming from inside the computer. Furthermore, you realize that Windows is not starting automatically. You talk to a friend who said that your hard disk might have experienced a head crash. What might have caused this?

3. **Missing Cable**   You are attempting to install a new 1 TB hard disk in your computer. You have found the empty bay for the new hard disk, but you cannot locate the cable that connects it to the computer. What are your next steps?

4. **Memory Card Problems**   For the past two years, you have been using the same Secure Digital (SD) memory card to take pictures with your digital camera. When you insert the SD memory card in your computer's card reader to transfer the pictures, your computer does not display the contents of the card. When you put the card back into your digital camera, you can see that the pictures still are stored on the card. What might be wrong?

@ Work

5. **Disk Not Recognized**   The information technology manager at your company has purchased external hard disks for employees to use to back up their files. When you connect the external hard disk to the USB port on your computer, the computer displays a message stating that it cannot recognize the device. What might you do to correct this problem?

6. **File Will Not Open**   Your computer is unable to open a file on an optical disc that you just inserted into the optical disc drive. You have been able to access other files on the same disc, but one file in particular is not opening. What might be causing this?

7. **Backing Up Data**   It has been several years since your office computer was upgraded, and you just received an e-mail message stating that you finally will receive a new computer next week. The e-mail message also stated that all employees will be responsible for backing up their data. What files will you back up?

8. **Optical Disc Problem**   Your colleague gives you an optical disc containing some video files. When you insert the disc in your computer, the disc burning software asks if you would like to finalize the disc. How will you respond?

Collaboration

9. **Computers in Meteorology**   Your environmental sciences instructor is teaching a lesson about how computers have advanced the meteorology field. Form a team of three people to prepare a brief report about how computers and meteorology are connected. One team member should research how meteorologists predicted weather patterns before computer use became mainstream. Another team member should create a timeline illustrating when and how computers were introduced to the meteorology field, and the third team member should research the types of computer hardware and software required for a typical news station to forecast and present the weather.

Learn How To

The Learn How To activities step you through fundamental technology skills when using a computer. The Learn How To exercises enable you to become more proficient with these skills.

> Premium Activity: To relate this Learn How To activity to your everyday life, see a visual demonstration of the activity, and complete a short assessment, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com and then navigate to the Chapter 6 Learn How To resource for this book.

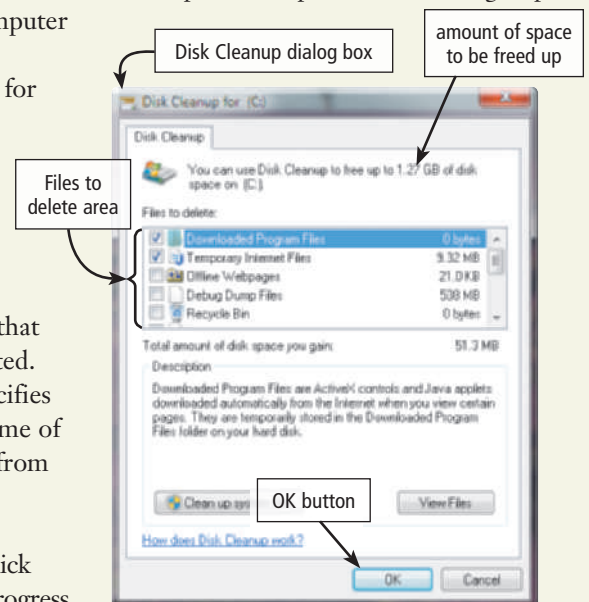## Learn How To 1: Maintain a Hard Disk

A computer's hard disk is used for the majority of storage requirements. It is important, therefore, to ensure that each hard disk on a computer is operating at peak efficiency, both to use the available storage space effectively and to make disk operations as fast as possible.

Two tasks that maximize disk operations are removing unused or unnecessary files and folders by using the Disk Cleanup utility program and consolidating files and folders into contiguous storage areas using the Disk Defragmenter utility program. Defragmenting allows your system to access stored files and folders more efficiently.

A. Cleanup Disk

To clean up the disk by removing any programs and data that are not required for the computer, complete the following steps:

1. Click the Start button on the Windows taskbar and then click Computer on the Start menu.
2. When the Computer window opens, right-click the hard disk icon for drive C (or any other hard disk you want to select) and then click Properties on the shortcut menu.
3. If necessary, click the General tab in the disk drive Properties dialog box to display the General sheet.
4. Click the Disk Cleanup button in the General sheet to display the Disk Cleanup Options dialog box.
5. The Disk Cleanup dialog box is displayed and contains a message that indicates the amount of space that can be freed up is being calculated.
6. After the calculation is complete, the Disk Cleanup dialog box specifies the amount of space that can be freed up and the files to delete, some of which are selected automatically (Figure 6-31). Select those items from which you wish to delete files.
7. Click the OK button in the Disk Cleanup dialog box.
8. A dialog box asks if you are sure you want to perform these actions. Click the Delete Files button. The Disk Cleanup dialog box illustrates the progress of the cleanup. When the cleanup is complete, the dialog box closes.

Disk Cleanup dialog box

amount of space to be freed up

Files to delete area

OK button

Figure 6-31

B. Defragment Disk

After removing all the unnecessary files from the hard disk, the next step in disk maintenance is to defragment all the files on the disk. When a file is stored on disk, the data in the file sometimes is stored contiguously, and other times is stored in a noncontiguous manner. The greater the amount of data on a disk, the more likely files will be stored noncontiguously. When a file is stored in a noncontiguous manner, it can take significantly longer to find and retrieve data from the file. One of the more useful utilities to speed up disk operations, therefore, is the defragmentation program, which combines all files so that no files are stored in a noncontiguous manner. To use the defragmentation program, complete the following steps:

1. If necessary, click the Tools tab in the Properties dialog box for the hard disk to be defragmented.
2. Click the Defragment now button in the Tools sheet to open the Disk Defragmenter window (Figure 6-32). This window displays the Disk Defragmenter schedule, when Disk Defragmenter was run last, and when Disk Defragmenter is scheduled to run next.
3. Click the Defragment disk button. The defragmentation process begins. During the defragmentation process, the Stop operation button replaces the Defragment disk button. The defragmentation process can consume more than one hour in some cases, depending on the size of the hard disk and the amount of processing that must occur. You can cancel the operation at any time by clicking the Stop operation button in the Disk Defragmenter window.
4. When the process is complete, the Defragment disk button will replace the Stop operation button.
5. Click the Close button to close the Disk Defragmenter window.

Proper disk maintenance is critically important so that disk operation is as efficient as possible.

Learn How To

Exercises

Caution: The exercises for this chapter that require actual disk maintenance are optional. If you are performing these exercises on a computer that is not your own, obtain explicit permission to complete these exercises. Keep in mind that these exercises can require significant computer time and the computer may be unusable during this time.

1. Display the Properties dialog box for a hard disk found on the computer. Display the General sheet. What is the capacity of the hard disk? How much space is used? How much free space is available? Click the Disk Cleanup button. How much space can be freed up if you use the Disk Cleanup program? Click the OK button to clean up the disk. How long did it take to perform the disk cleanup? Submit your answers to your instructor.

Disk Defragmenter window

Defragment disk button

Close button

Figure 6-32

2. Display the Properties dialog box for a hard disk found on the computer. Display the Tools sheet. Click the Defragment now button. In the Disk Defragmenter window, click the Defragment disk button. How could you tell when the defragmentation process was completed? How long did defragmentation require? Submit your answers to your instructor.
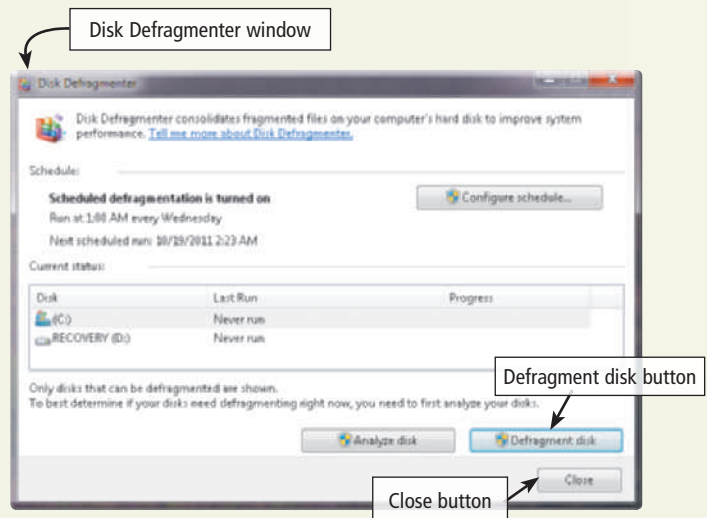
Learn It Online

The Learn It Online exercises are interactive Web exercises designed to reinforce and expand your understanding of the chapter concepts. The descriptions below briefly summarize each exercise.

To complete the Learn It Online exercises, visit the Computer Concepts CourseMate Web site at www.cengagebrain.com, navigate to the Chapter 6 resources for this book, click the link for the exercise you want to complete, and then read the instructions.

1 At the Movies — Thumb-drive (USB Flash Drive) Encryption
Watch a movie to learn how people who store personal and confidential information on USB flash drives can use third-party programs to password-protect the files so that others cannot access them and then answer questions about the movie.

2 Student Edition Labs — Maintaining a Hard Drive (Hard Disk) and Managing Files and Folders
Enhance your understanding and knowledge about maintaining a hard disk and managing files and folders by completing the Maintaining a Hard Drive and Managing Files and Folders Labs.

3 Practice Test
Take a multiple choice test that checks your knowledge of the chapter concepts and review the resulting study guide.

4 Who Wants To Be a Computer Genius²?
Play the Shelly Cashman Series version of this popular game by answering questions to find out if you are a computer genius. Panic buttons are available to provide assistance during game play.

5 Crossword Puzzle Challenge
Complete an interactive crossword puzzle to reinforce concepts presented in this chapter.
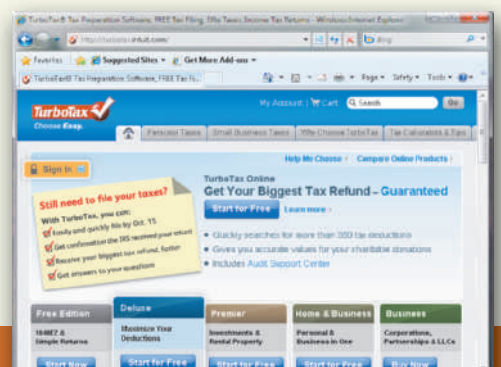
6 Windows Exercises
Step through the Windows 7 exercises to learn about the Recycle Bin, working with files, the hard disk, and Disk Cleanup.

7 Exploring Computer Careers
Read about a career as a computer technician, search for related employment advertisements, and then answer related questions.

8 Web Apps — TurboTax Online
Learn how to use TurboTax Online to create an account, start a new tax return from scratch, review your tax return, and then print and file your tax return.

Web Research

The Web Research exercises broaden your understanding of chapter concepts by presenting questions that require you to search the Web for answers.

1 Search Sleuth

Use one of the search engines listed in Figure 2-8 in Chapter 2 on page 65 or your own favorite search engine to find the answers to the following questions. Copy and paste the Web address from the Web page where you found the answer. Some questions may have more than one answer. If required, submit your answers to your instructor. (1) What album did Hillsong United release in 2008 on a flash drive embedded in a rubber wristband? (2) What country uses the MyKad smart card for national identification? (3) What product did HP develop in 2004 based on the efforts of engineer Daryl Anderson? (4) What products are available for sale at the SanDisk Plaza? (5) For what storage medium are phase change alloys used? (6) What company introduced using a hard disk for accounting projects in 1956?

2 Green Computing

Data storage is doubling every 18 months according to some computer industry experts, and consumers and businesses are turning to environmentally sound methods of backing up and storing files. Accessing hard disks consumes 80 percent of a storage system's electrical consumption, so companies have developed products that reduce a system's energy usage. Businesses invest in cooling systems that dissipate the heat generated when servers and storage hardware operate. Locate Web sites that describe these products and how they operate efficiently to conserve energy. How much energy savings do they claim to make in one year? To what extent are carbon dioxide and other greenhouse gases reduced? How do they maximize the use of power and cooling resources? Review your search results and then write a 50-word summary of your findings.

3 Social Networking

Privacy on social networking Web sites such as MySpace and Facebook is an international concern, and the Electronic Privacy Information Center (epic.org/privacy/socialnet) features news, policies, and resources discussing safeguarding and controlling personal information. At least one-fourth of hiring managers admit to researching job applicants' "digital dirt" by searching social networks and blogs, and some employers search social networking Web sites for profiles of current employees. Visit the Reputation Defender (reputationdefender.com) and Defend My Name (defendmyname.com) Web sites and read about the services offered. Then view the standards posted on the MySpace and Facebook Web sites regarding privacy and allowable content. Summarize the information you read and viewed.

4 Blogs

Exercise and nutrition advice is available from experts who post firsthand experiences in their blogs. These authorities may be people who share a particular experience, such as losing weight or training for a marathon, or who have specialized training in the fitness field. For example, noted author Lou Schuler discusses nutrition, weight training, and issues of particular interest to men (malepatternfitness.com). Other popular fitness blogs are featured by The Families .com (fitness.families.com/blog) and Diet-Blog (diet-blog.com). Athlete Blog Central (yardbarker.com/athletes) lists blogs that professional and amateur athletes and their fans write. Visit these sites and read the posts. Which stories received more than 25 comments? Which food, exercises, and programs are featured?

5 Ethics in Action

The United States Federal Bureau of Investigation used a controversial program until January 2005 to monitor and store the e-mail and Internet activity of suspected criminals. Originally called Carnivore, the surveillance program was renamed DCS1000. The program was designed to track the activities of potential terrorists, spies, drug traffickers, and organized crime ring members. FBI agents needed to obtain a court order to monitor an individual, but privacy advocates claim the software tracked people not covered under the court order. View online sites that provide information about DCS1000 or Carnivore, including HowStuffWorks (howstuffworks.com/carnivore.htm). What commercial software has replaced Carnivore? Write a report summarizing your findings, and include a table of links to Web sites that provide additional details.