CHAPTER 8

Supporting Hard Drives

In this chapter, you will learn:

- About the technologies used inside a hard drive and how data is organized on the drive
- How a computer communicates with a hard drive
- How hard drives can work together in a RAID array
- About floppy drives
- How to select and install a hard drive
- How to solve hard drive problems

The hard drive is the most important secondary storage device in a computer, and supporting hard drives is one of the more important tasks of a PC support technician. This chapter introduces the different kinds of hard drive technologies that have accounted for the continual upward increase in hard drive capacities and speeds over the past few years. The ways a computer interfaces with a hard drive have also changed several times over the years as both the computer and hard drives improve the technologies and techniques for communication. In this chapter, you will learn about past and present methods of communication between the computer and drive so that you can support both older and newer drives.

Floppy drives are becoming obsolete, but they have not completely disappeared. In this chapter, you'll learn just enough about them to know how to support this older technology. One benefit to studying floppy drives is that they are similar in design to hard drives and yet much easier to understand. Therefore, they can be a great aid in understanding how hard drives work. Finally, you'll learn how to install the different types of hard drives and what to do if you have problems with a hard drive.

INSIDE A HARD DRIVE

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A **hard disk drive (HDD)**, most often called a **hard drive**, comes in two sizes for personal computers: the 2.5" size is used for laptop computers and the 3.5" size is used for desktops. In addition, a smaller 1.8" size (about the size of a credit card) hard drive is used in some low-end laptops and other equipment such as MP3 players.

All three sizes of hard drives use the same types of hardware technologies inside the drive: solid state or magnetic. In addition, some drives use a combination of both technologies. As a support technician, you need to understand a little about solid state and magnetic technologies, and you also need to know how data is organized inside a hard drive. Both topics are covered in this part of the chapter.

SOLID STATE, MAGNETIC, AND HYBRID DRIVES

Inside the drive housing, two types of technologies can be used: solid state and magnetic. A **solid state drive (SSD)**, also called a **solid state device (SSD)**, is called solid state because it has no moving parts. The drives are built using nonvolatile flash memory, which is similar to that used for USB flash drives. Recall from Chapter 1 that nonvolatile memory does not lose its data even after the power is turned off. Because the technology is expensive, solid state drives are currently 2.5" drives used only in laptop computers. However, by the time this book is in print, it is expected that solid state external hard drives and solid state drives for desktop computers will be available. Figure 8-1 shows two sizes of solid state drives (2.5" and 1.8") and what the inside of an SSD hard drive looks like. Solid state hard drives cost more and are more rugged than magnetic hard drives. Because they have no moving parts, they also last longer, use less power, and are more reliable.

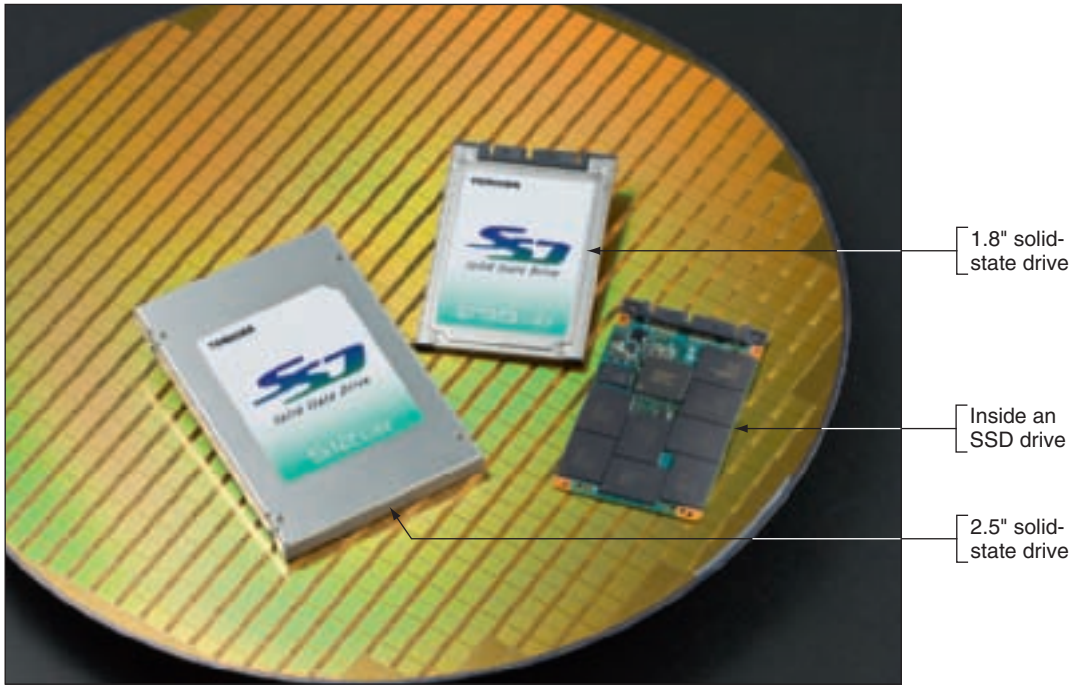

Figure 8-1 Solid state drives by Toshiba
Courtesy of Toshiba America Electronic Components

A **magnetic hard drive** has one, two, or more platters, or disks, that stack together and spin in unison inside a sealed metal housing that contains firmware to control reading and writing data to the drive and to communicate with the motherboard. The top and bottom of each disk have a **read/write head** that moves across the disk surface as all the disks rotate on a spindle

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Video
Inside a Hard Drive

(see Figure 8-2). All the read/write heads are controlled by an actuator, which moves the read/write heads across the disk surfaces in unison. The disk surfaces are covered with a magnetic medium that can hold data as magnetized spots. Almost all hard drives sold today for desktop computers are magnetic hard drives.

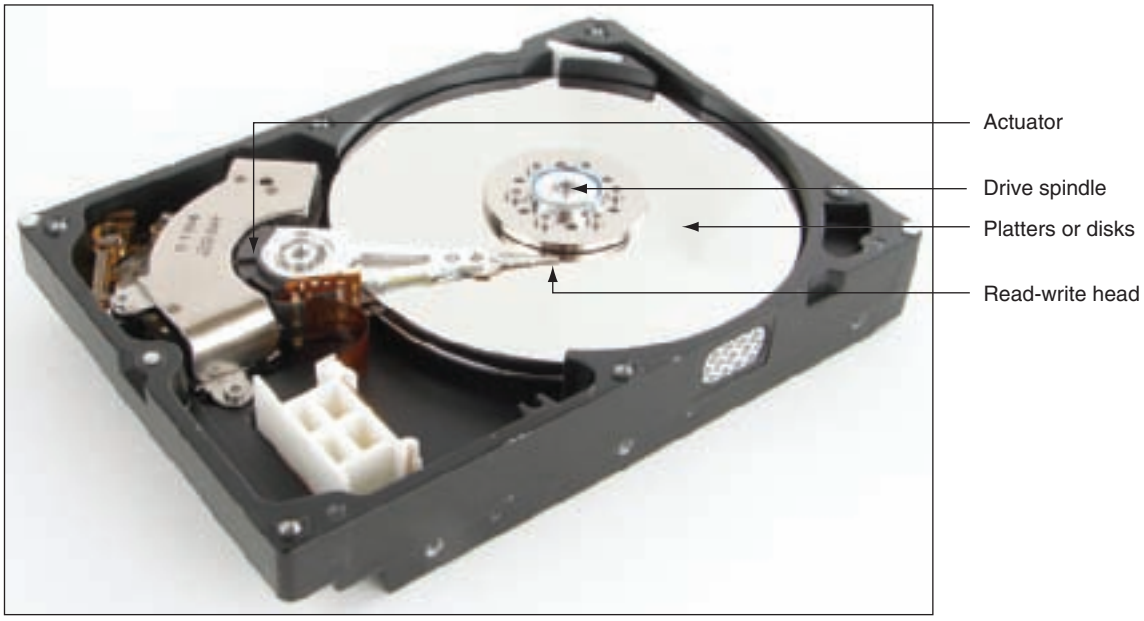

Figure 8-2 Inside a hard drive
Courtesy: Course Technology/Cengage Learning

Figure 8-3 shows a close-up of the hard drive in Figure 8-2. You can see that this drive has two platters. Both sides of each platter are used to store data. Each side, or surface, of one hard drive platter is called a **head**. (Don't confuse this with the read/write mechanism that moves across a platter, which is called a read/write head.) Thus, the drive in Figure 8-3 has four heads because there are two platters, each having two heads.

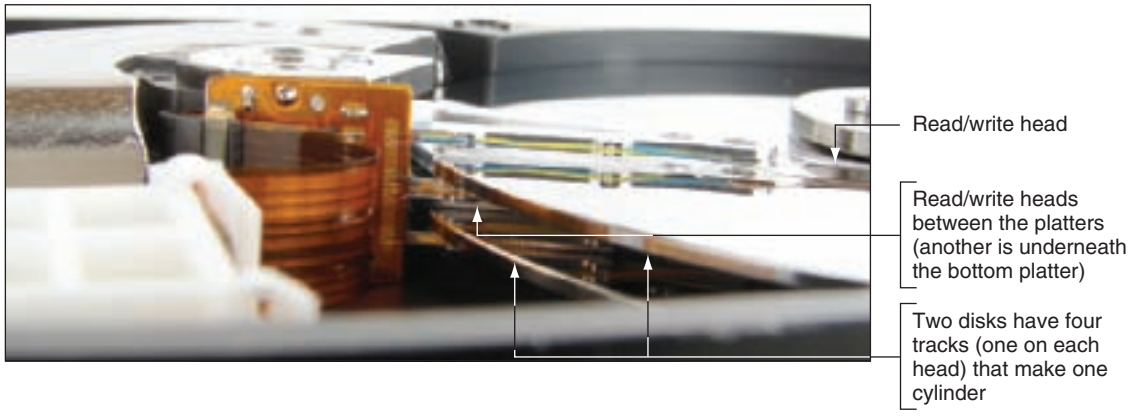

Figure 8-3 A hard drive with two platters
Courtesy: Course Technology/Cengage Learning

Some hard drives are **hybrid hard drives**, using both technologies. For example, the 2.5" Seagate Momentus hybrid hard drive holds 80 GB of data and has a 256 MB flash component. Often-used data is stored on the faster flash component. Also, when data is first written to the drive, the data is written to the faster flash component and later moved to the slower magnetic component. For a hybrid drive to function, the operating system must support it. Windows Vista technology that supports a hybrid drive is called **ReadyDrive**.

HOW DATA IS ORGANIZED ON A HARD DRIVE

Each disk surface on a hard drive is divided into concentric circles, called tracks. Recall from Chapter 5 that each track is further divided into 512-byte segments called sectors (also called records). All the tracks that are the same distance from the center of the platters make up one cylinder. Track and sector markings (see Figure 8-4) are written to a hard drive before it leaves the factory in a process called **low-level formatting**. The total number of sectors on the drive determines the drive capacity. Today's drive capacities are usually measured in GB (gigabytes) or TB (terabytes, each of which is 1,024 gigabytes).

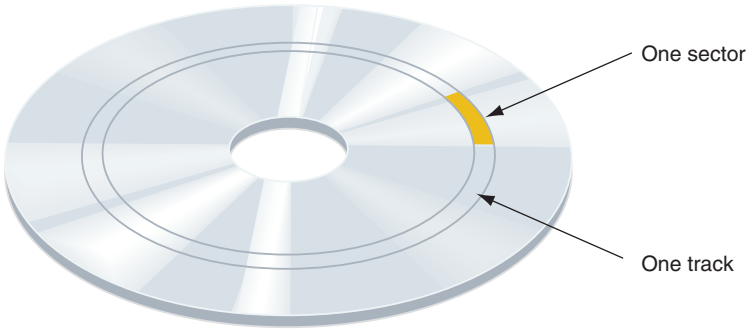

Figure 8-4 A hard drive or floppy disk is divided into tracks and sectors; several sectors make one cluster
Courtesy: Course Technology/Cengage Learning

Firmware on a circuit board inside the drive housing is responsible for writing and reading data to these tracks and sectors and for keeping track of where everything is stored on the drive. Figure 8-5 shows the bottom side of a hard drive, which has this circuit board exposed. Some drives protect the board inside the drive housing. BIOS and the OS use a simple sequential numbering system called logical block addressing (LBA) to address all the sectors on the hard drive without regard to where these sectors are located.

Figure 8-5 The bottom of a hard drive shows the circuit board that contains the firmware that controls the drive
Courtesy: Course Technology/Cengage Learning

When a hard drive is first installed in a system, Windows initializes the drive and identifies it as a basic disk. A **basic disk** is a single hard drive that works independently of other hard drives. The initializing process writes a Master Boot Record (MBR) to the drive. Recall from Chapter 5 that the MBR is the first sector at the beginning of a hard drive (512 bytes). It contains two items:

- The master boot program (446 bytes), which loads the OS boot program stored in the OS boot record. (This program begins the process of loading the OS.)
- The partition table, which contains the description, location, and size of each partition on the drive. For Windows-based systems, the MBR has space for four 16-byte entries that are used to define up to four partitions on the drive. For each partition, the 16 bytes are used to hold the beginning and ending location of the partition, the number of sectors in the partition, and whether or not the partition is bootable. The one bootable partition is called the **active partition**.

The next step is to create a partition on the drive in a process called **high-level formatting** or **operating system formatting**. During this process, you specify the size of the partition and what file system it will use. A partition can be a primary partition or an extended partition. A **primary partition** is also called a **volume** or a **simple volume**. The volume is assigned a drive letter (such as drive C: or drive D:) and is formatted using a file system. A **file system** is the overall structure an OS uses to name, store, and organize files on a drive. In a file system, a **cluster** is the smallest unit of space on a disk for storing a file and is made up of one or more sectors. A file system tracks how these clusters are used for each file stored on the disk. The active partition is always a primary partition.

One of the four partitions on a drive can be an extended partition (see Figure 8-6). An **extended partition** can be divided into one or more **logical drives**. Each logical drive is assigned a drive letter (such as drive G:) and is formatted using its own file system.

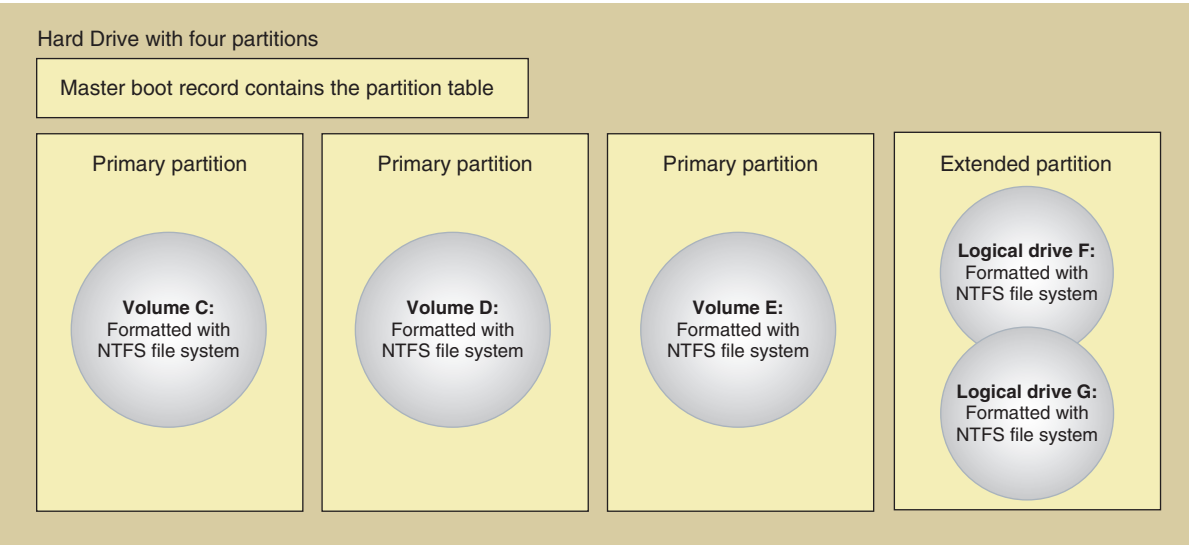

Figure 8-6 A hard drive with four partitions; the fourth partition is an extended partition
Courtesy: Course Technology/Cengage Learning

Primary and extended partitions can be created on a hard drive when the drive is first installed, when an OS is first installed, or after an existing partition becomes corrupted. When an OS is first installed, the installation process partitions and formats the drive, if necessary. After Windows is installed, you can use the Disk Management tool to view and manage partitions on a drive. For example, look at the Disk Management window shown in Figure 8-7. The system has two hard drives installed, labeled Disk 0 and Disk 1. Disk 0 has two primary partitions (drives C: and J:) with some space not yet allocated. Disk 1 has three primary partitions (drives E:, F:, and G:) and one extended partition. The one extended partition has been divided into two logical drives (drives H: and I:) and still has some free space left over. This example is not a very practical way to partition the drives in a system, but is done this way so you can see what is possible. Figure 8-8 shows Windows Explorer and the seven drives. How to use Disk Management is covered later in the chapter.

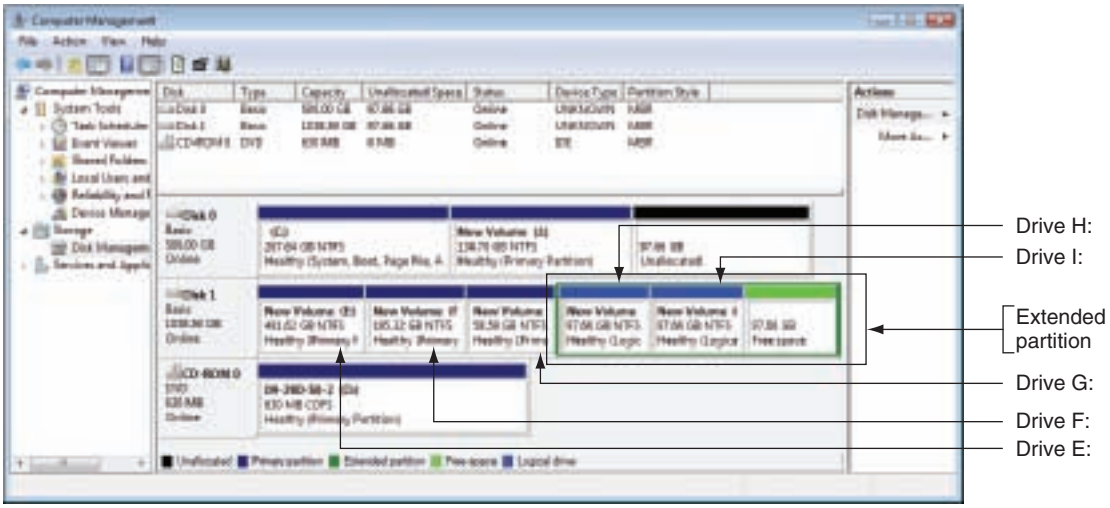

Figure 8-7 The second hard drive has three primary partitions and one extended partition, which contains two logical drives
Courtesy: Course Technology/Cengage Learning

Before a primary partition or volume can be used, it must be formatted using a file system. For the extended partition, each logical drive must be formatted with a file system. Depending on the situation, you can have up to three choices for a file system:

- Windows XP offers the FAT32 or the NTFS file system. The FAT32 file system is named after the **file allocation table (FAT)**, a table on a hard drive or floppy disk that tracks how space on a disk is used to store files. It has storage limitations concerning hard drive size, volume size, and file size. The **New Technology file system (NTFS)** is designed to provide greater security and to support more storage capacity than the FAT32 file system.
- If Vista's Service Pack 1 is not yet installed, Windows Vista offers only the NTFS file system.
- Windows Vista with Service Pack 1 or later service packs installed offers FAT32, NTFS, and exFAT. The exFAT (extended FAT) uses a 64-bit file allocation table. It does not have the storage limitation that FAT32 has, does not offer the security features of NTFS, and does not require as much overhead as NTFS. exFAT is normally used in low-end systems with smaller hard drives where security is not a big concern. In most situations, your best choice is NTFS.
- In addition to FAT32 and NTFS, Windows XP will offer exFAT if Service Packs 2 and 3 are installed and you download and install an additional update from Microsoft.

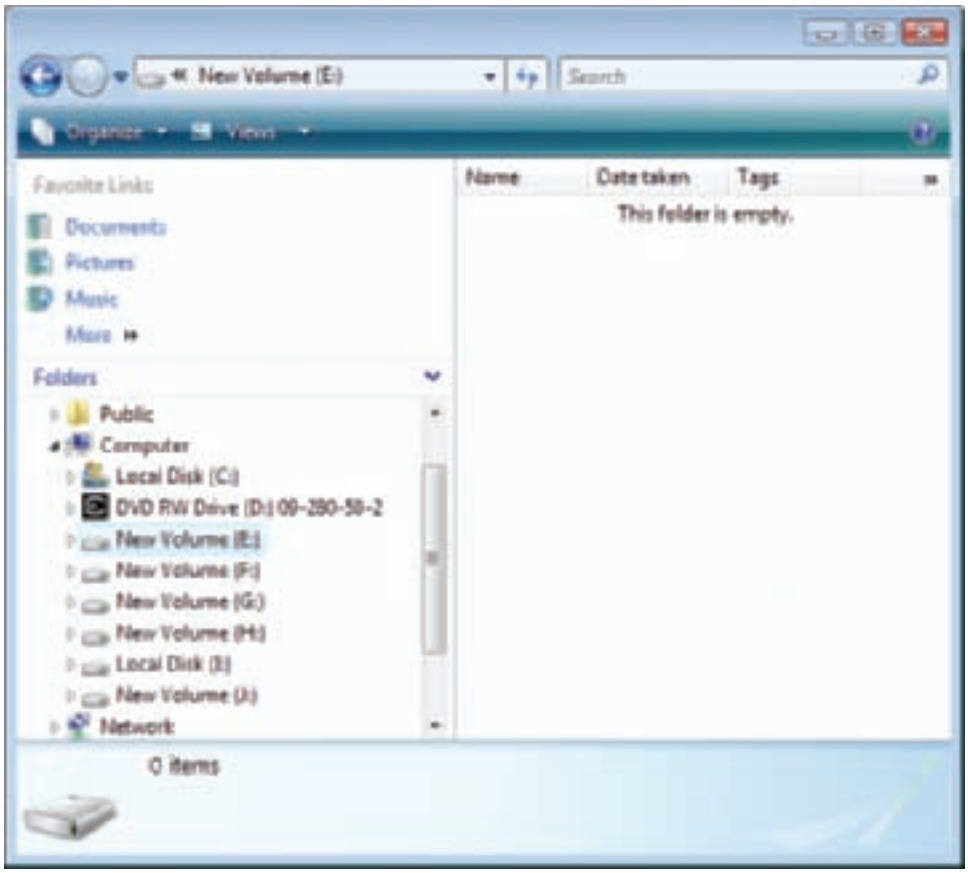

Figure 8-8 Windows Explorer shows five volumes and two logical drives
Courtesy: Course Technology/Cengage Learning

Now that you have a general understanding of how hard drives work and how the OS organizes data on the drive, let's turn our attention to how the drive's firmware communicates with the motherboard.

HARD DRIVE INTERFACE STANDARDS

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Hard drives have different ways to interface with the computer. Some standards compete with others and each type of interface standard has evolved over time, which can make for a confusing mess of standards. To help keep them all straight, use Figure 8-9 as your guideline for the standards used by internal drives.

Video Examining Hard Drives

The three current methods used by internal hard drives are Parallel ATA (PATA), Serial ATA (SATA), and SCSI. External hard drives can connect to a computer by way of external SATA (eSATA), SCSI, FireWire, USB, or a variation of SCSI called Fibre Channel. Currently, the most popular solutions for external hard drives are USB and FireWire, which you will learn about in Chapter 9. All the other interface standards are discussed in this section. By far, the most popular standards for internal drives are the ATA standards, so we begin there.

Notes In technical documentation, you might see a hard drive abbreviated as HDD (hard disk drive). However, this chapter uses the term "hard drive."

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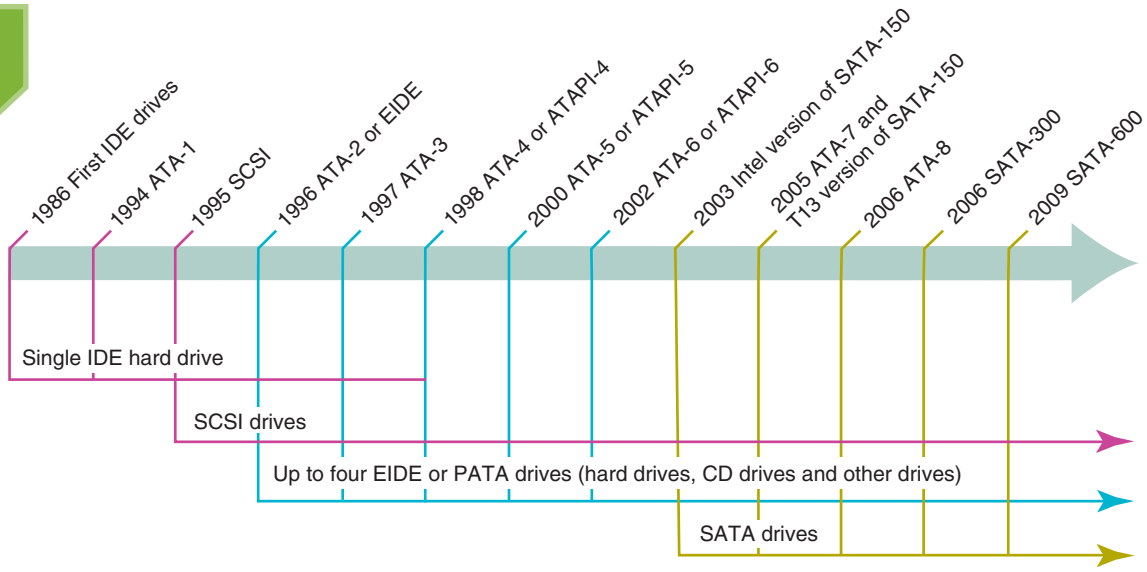

Figure 8-9 Timeline of interface standards used by internal drives
Courtesy: Course Technology/Cengage Learning

THE ATA INTERFACE STANDARDS

The ATA interface standards define how hard drives and other drives such as CD, DVD, tape, and Blu-ray drives interface with a computer system. The standards define data speeds and transfer methods between the drive controller, the BIOS, the chipset on the motherboard, and the OS. The standards also define the type of cables and connectors used by the drive and the motherboard or expansion cards.

The ATA interface standards are developed by Technical Committee T13 (*www.t13.org*) and published by **ANSI (American National Standards Institute**, *www.ansi.org*.) As these standards developed, different drive manufacturers called them different names, which can be confusing when reading documentation or advertisements.

The ATA standards can be categorized into two groups: PATA and SATA. PATA (pronounced "*pay*-ta") is the older and slower standard that has seen many changes. SATA (pronounced "*say*-ta") is the faster and newer standard, which, so far, has had only three revisions. SATA is slowly replacing PATA, but you need to know how to support both. In fact, many motherboards sold today will have a mix of SATA and PATA connectors on the same board.

The ATA standards have undergone several revisions, which are summarized in Table 8-1. All but the last two standards apply only to PATA except for S.M.A.R.T., which is supported by all SATA and PATA drives sold today. **S.M.A.R.T. (Self-Monitoring Analysis and Reporting Technology)** is a system BIOS feature that monitors hard drive performance, disk spin up time, temperature, distance between the head and the disk, and other mechanical activities of the drive in order to predict when the drive is likely to fail. If S.M.A.R.T. suspects a drive failure is about to happen, it displays a warning message. S.M.A.R.T. can be enabled and disabled in BIOS setup.

Notes Remember from Chapter 7 that many memory standards exist because manufacturers and consortiums are always trying to come up with faster and more reliable technologies. The many ATA standards exist for the same reasons. It's unfortunate that you have to deal with so many technologies, but the old ones do stick around for many years after faster and better technologies are introduced.

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Standard (Can Have More Than One Name)	Data Transfer Rate	Description
ATA* IDE/ATA	From 2.1 MB/sec to 8.3 MB/sec	The first T13 and ANSI standard for IDE hard drives. Limited to no more than 528 MB. Supports PIO modes 0-2.
ATA-2* ATAPI, Fast ATA, Parallel ATA (PATA), Enhanced IDE (EIDE)	Up to 16.6 MB/sec	Broke the 528-MB barrier. Allows up to four IDE devices; defines the EIDE standard. Supports PIO modes 3-4 and DMA modes 1-2.
ATA-3*	Up to 16.6 MB/sec (little speed increase)	Improved version of ATA-2 and introduced S.M.A.R.T.
ATA/ATAPI-4* Ultra ATA, Fast ATA-2, Ultra DMA Modes 0-2, DMA/33	Up to 33.3 MB/sec	Defined Ultra DMA modes 0-2 and an 80-conductor cable to improve signal integrity.
ATA/ATAPI-5* Ultra ATA/66, Ultra DMA/66	Up to 66.6 MB/sec	Defined Ultra DMA modes 3-4. To use these modes, an 80-conductor cable is required.
ATA/ATAPI-6* Ultra ATA/100, Ultra DMA/100	Up to 100 MB/sec	Requires the 80-conductor cable. Defined Ultra DMA mode 5 and supports drives larger than 137 GB.
ATA/ATAPI-7* Ultra ATA/133, Serial ATA (SATA), SAS STP	Parallel transfer speeds up to 133 MB/sec Serial transfer speeds up to 1.5 GB/sec	Can use the 80-conductor cable or serial ATA cable. Defines Ultra DMA mode 6, serial ATA (SATA), and Serial Attached SCSI (SAS) coexisting with SATA by using STP (SATA Tunneling Protocol).
ATA/ATAPI-8*	N/A	Defined hybrid drives and improvements to SATA.

*Name assigned by the T13 Committee

Table 8-1 Summary of ATA interface standards for storage devices

Let's now look first at the PATA standards and then we'll discuss the SATA standards.

PARALLEL ATA OR EIDE DRIVE STANDARDS

Parallel ATA, also called the **EIDE (Enhanced IDE)** standard or, more loosely, the IDE (Integrated Drive Electronics) standard, allows for one or two IDE connectors on a motherboard, each using a 40-pin data cable. These ribbon cables can accommodate one or two drives, as shown in Figure 8-10. All PATA standards since ATA-2 support this configuration. Using this standard, up to four parallel ATA devices can connect to a motherboard using two data cables.

Parallel ATA or EIDE applies to other drives besides hard drives, including CD drives, DVD drives, tape drives, and so forth. An EIDE drive such as a CD or DVD drive must follow the **ATAPI (Advanced Technology Attachment Packet Interface)** standard in order to connect to a system using an IDE connector. Therefore, if you see ATAPI mentioned in an ad for a CD drive, know that the text means the drive connects to the motherboard using an IDE connector.

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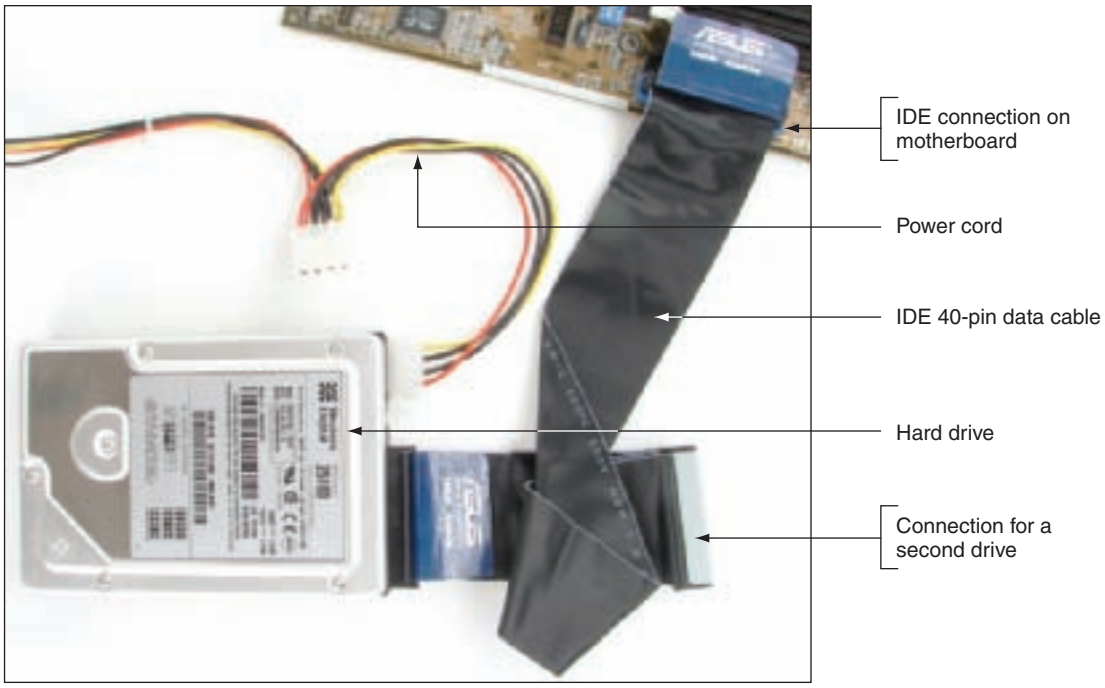

Figure 8-10 A PC's hard drive subsystem using parallel ATA
Courtesy: Course Technology/Cengage Learning

Notes Acronyms sometimes change over time. Years ago, technicians knew *IDE* to mean *Integrated Drive Electronics*. As the term began to apply to other devices than hard drives, we renamed the acronym to become **Integrated Device Electronics**.

Other technologies and changes mentioned in Table 8-1 that you need to be aware of are the two types of PATA data cables, DMA and PIO modes used by PATA, and Independent Device Timing. All these concerns are discussed next.

Two Types of PATA Ribbon Cables

Under parallel ATA, two types of ribbon cables are used. The older cable has 40 pins and 40 wires. The **80-conductor IDE cable** has 40 pins and 80 wires. Forty wires are used for communication and data, and an additional 40 ground wires reduce crosstalk on the cable. For maximum performance, an 80-conductor IDE cable is required by ATA/66 and above. Figure 8-11 shows a comparison between the two parallel cables. The 80-conductor cable is

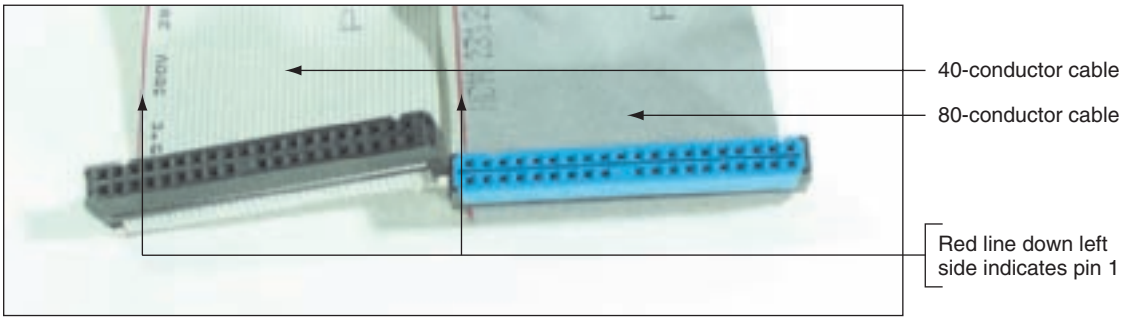

Figure 8-11 In comparing the 80-conductor cable to the 40-conductor cable, note they are about the same width, but the 80-conductor cable has many more and finer wires
Courtesy: Course Technology/Cengage Learning

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color-coded with the blue connector always connected to the motherboard. The connectors on each cable otherwise look the same, and you can use an 80-conductor cable in place of a 40-conductor cable in a system.

The maximum recommended length of both cables is 18", although it is possible to purchase 24" cables. A ribbon cable usually comes bundled with a motherboard that has a PATA connector. Because ribbon cables can obstruct airflow inside a computer case, you can purchase a smaller round PATA cable that is less obstructive to the airflow inside the case.

DMA or PIO Transfer Modes

A hard drive uses one of two methods to transfer data between the hard drive and memory: **DMA (direct memory access) transfer mode** or **PIO (Programmed Input/Output) transfer mode**. DMA transfers data directly from the drive to memory without involving the CPU. PIO mode involves the CPU and is slower than DMA mode.

There are different modes for PIO and DMA, due to the fact that both standards have evolved over the years. There are five PIO modes used by hard drives, from the slowest (PIO mode 0) to the fastest (PIO mode 4), and seven DMA modes from the slowest (DMA mode 0) to the fastest (DMA mode 6). All motherboards today support Ultra DMA, which means that data is transferred twice for each clock beat, at the beginning and again at the end.

Most often, when installing a drive, the startup BIOS autodetects the drive and selects the fastest mode that the drive and the BIOS support. After installation, you can go into BIOS setup and see which DMA mode is being used.

Independent Device Timing

As you saw in Table 8-1, there are different hard drive standards, each running at different speeds. If two hard drives share the same parallel ATA cable but use different standards, both drives will run at the speed of the slower drive unless the motherboard chipset controlling the ATA connections supports a feature called Independent Device Timing. Most chipsets today support this feature and with it, the two drives can run at different speeds as long as the motherboard supports those speeds.

SERIAL ATA STANDARDS

A consortium of manufacturers, called the Serial ATA International Organization (SATA-IO; see *www.sata-io.org*) and led by Intel, developed the **serial ATA (SATA)** standards. These standards also have the oversight of the T13 Committee. SATA uses a serial data path rather than the traditional parallel data path. (Essentially, the difference between the two is that data is placed on a serial cable one bit following the next, but with parallel cabling, all data in a byte is placed on the cable at one time.) The three major revisions to SATA are summarized in Table 8-2.

Serial ATA interfaces are much faster than PATA interfaces and are used by all types of drives, including hard drives, CD, DVD, Blu-ray, and tape drives. A motherboard can have two, four, six, or more SATA connectors, which are much easier to configure and use than PATA connectors. SATA supports **hot-swapping**, also called **hot-plugging**. With hot-swapping, you can connect and disconnect a drive while the system is running.

A SATA drive connects to one internal SATA connector on the motherboard by way of a SATA data cable. An internal SATA data cable can be up to 1 meter in length, has 7 pins, and is much narrower compared to the 40-pin parallel IDE cable (see Figure 8-12). The thin cables don't hinder airflow inside a case as much as the wide parallel ATA cables do.

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SATA Standard	Data Transfer Rate	Comments
SATA Revision 1.x* SATA 1 Serial ATA-150 SATA/150 SATA-150	1.5 Gb/sec	First introduced with ATA/ATAPI-7
SATA Revision 2.x* SATA 2 Serial ATA-300 SATA/300 SATA-300	3 Gb/sec	Currently, the most popular SATA standard
SATA Revision 3.x* SATA 3 Serial ATA-600 SATA/600 SATA-600	6 Gb/sec	Currently used only by SSD hard drives for laptops

*Name assigned by the SATA-IO organization

Table 8-2 SATA Standards

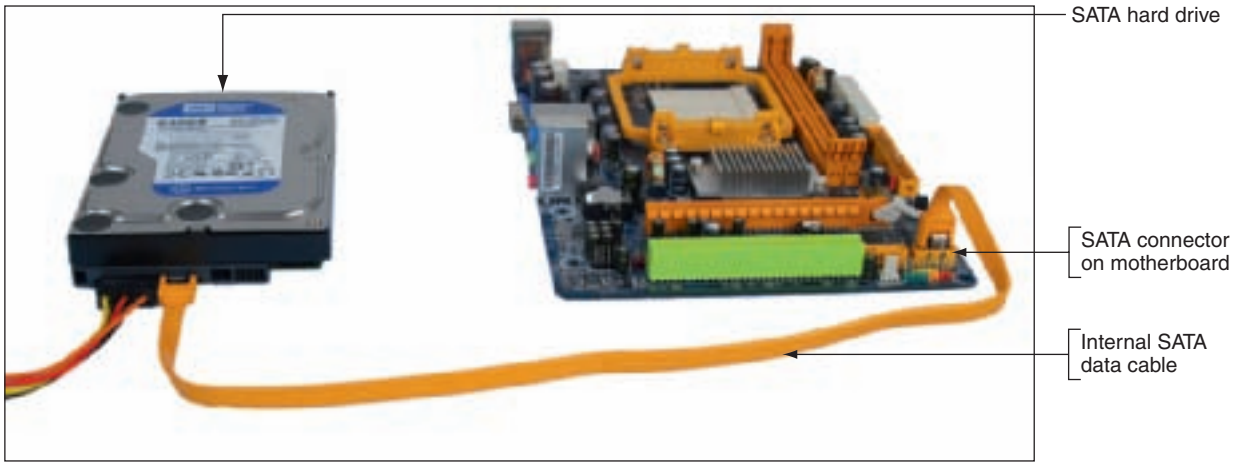

Figure 8-12 A SATA hard drive subsystem uses an internal SATA data cable
Courtesy: Course Technology/Cengage Learning

In addition to internal SATA connectors, the motherboard or an expansion card can provide external SATA (eSATA) ports for external drives (see Figure 8-13). **External SATA (eSATA)** is up to six times faster than USB or FireWire. External SATA drives use a special external shielded **serial ATA cable** up to 2 meters long.

When purchasing a SATA hard drive, keep in mind that the SATA standards for the drive and the motherboard need to match. If either the drive or the motherboard use a slower SATA standard than the other device, the system will run at the slower speed. Other hard drive characteristics to consider when selecting a drive are covered later in the chapter.

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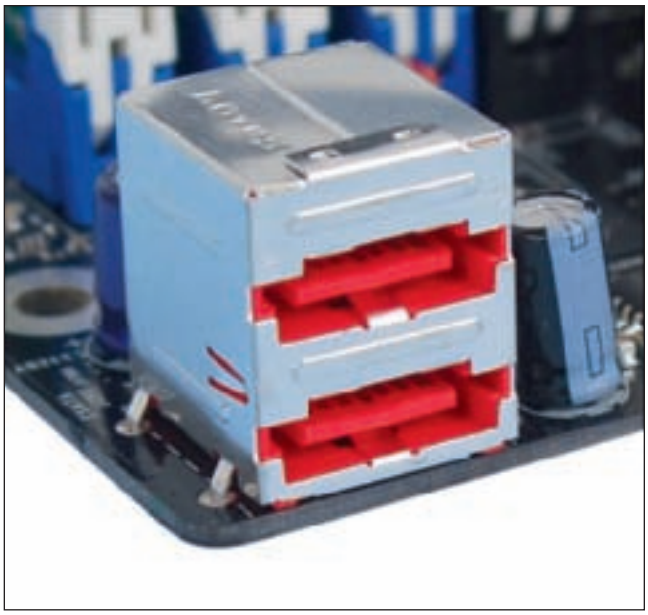

Figure 8-13 Two eSATA ports on a motherboard
Courtesy: Course Technology/Cengage Learning

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SCSI TECHNOLOGY

Other than ATA, another interface standard for drives and other devices is SCSI, which is primarily used in servers. SCSI standards can be used by many internal and external devices, including hard drives, CD-ROM drives, DVD drives, printers, and scanners. **SCSI** (pronounced "scuzzy") stands for **Small Computer System Interface**, and is a standard for communication between a subsystem of peripheral devices and the system bus. The SCSI bus can support up to 7 or 15 devices, depending on the SCSI standard. SCSI devices tend to be faster, more expensive, and more difficult to install than similar ATA devices. Because they are more expensive and more difficult to install, they are mostly used in corporate settings and are seldom seen in the small office or used on home PCs.

THE SCSI SUBSYSTEM

If a motherboard does not have an embedded SCSI controller, the gateway from the SCSI bus to the system bus is the **SCSI host adapter card**, commonly called the **host adapter**. The host adapter is inserted into an expansion slot on the motherboard and is responsible for managing all devices on the SCSI bus. A host adapter can support both internal and external SCSI devices, using one connector on the card for a ribbon cable or round cable to connect to internal devices, and an external port that supports external devices (see Figure 8-14).

All the devices and the host adapter form a single daisy chain. In Figure 8-14, this daisy chain has two internal devices and two external devices, with the SCSI host adapter in the middle of the chain. An example of a host adapter card is shown in Figure 8-15. It fits into a PCI slot and provides two internal SCSI connectors and one external connector. Even though there are three connectors and all can be used at the same time, logically the host adapter manages all devices as a single SCSI chain and can support up to 15 devices.

A+ Exam Tip The A+ 220-701 Essentials exam expects you to know that a motherboard might provide a SCSI controller and connector or that the SCSI host adapter can be a card installed in an expansion slot.

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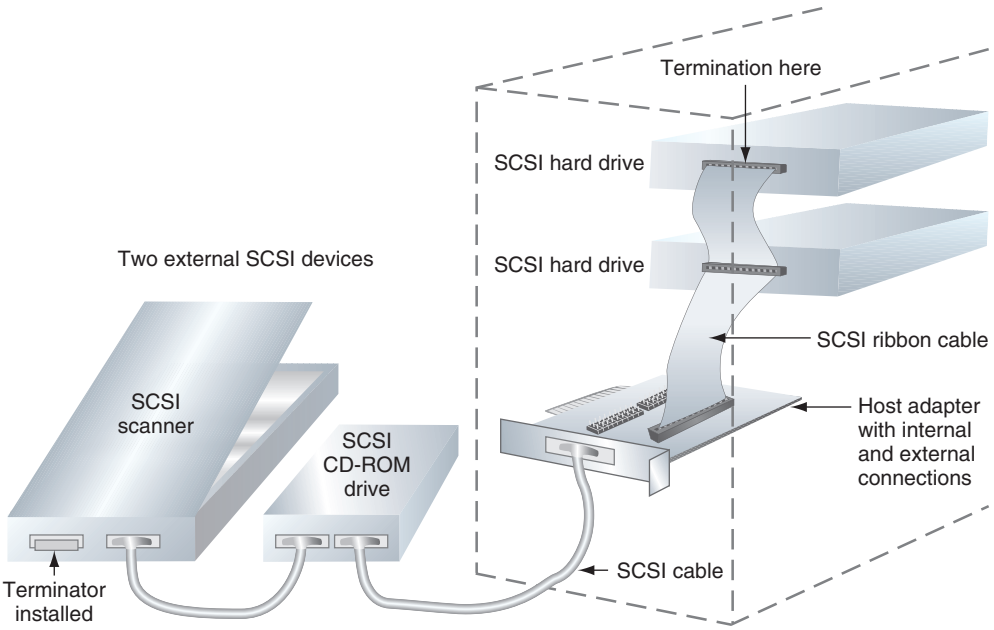

Figure 8-14 Using a SCSI bus, a SCSI host adapter card can support internal and external SCSI devices
Courtesy: Course Technology/Cengage Learning

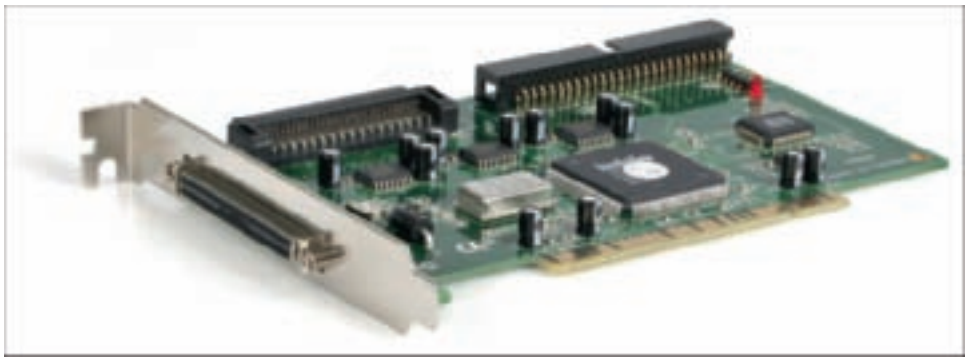

Figure 8-15 PCI SCSI host adapter card by StarTech
Courtesy of StarTech.com

All devices go through the host adapter to communicate with the CPU or directly with each other without involving the CPU. Each device on the bus is assigned a number from 0 to 15 called the **SCSI ID**, by means of DIP switches, dials on the device, or software settings. The host adapter is assigned SCSI ID 7, which has the highest priority over all other devices. The priority order is 7, 6, 5, 4, 3, 2, 1, 0, 15, 14, 13, 12, 11, 10, 9, and 8. Cables connect the devices physically in a daisy chain, sometimes called a straight chain. The devices can be either internal or external, and the host adapter can be at either end of the chain or somewhere in the middle. The SCSI ID identifies the physical device, which can have several logical devices embedded in it. For example, a CD-ROM jukebox—a CD-ROM changer with trays for multiple CDs—might have seven trays. Each tray is considered a logical device and is assigned a **Logical Unit Number (LUN)** to identify it, such as 1 through 7 or 0 through 6. The ID and LUN are written as two numbers separated by a colon. For instance, if the SCSI ID is 5, the fourth tray in the jukebox is device 5:4.

To reduce the amount of electrical "noise," or interference, on a SCSI cable, each end of the SCSI chain has a **terminating resistor**. The terminating resistor can be a hardware device plugged into the last device on each end of the chain (see Figure 8-16), or the device can have firmware-controlled termination resistance, which makes installation simpler.

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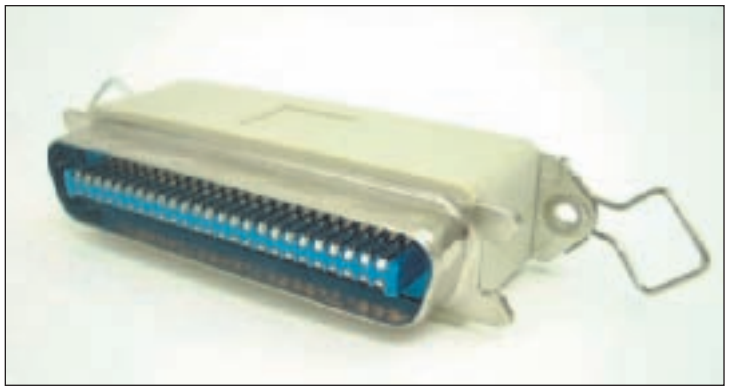

Figure 8-16 External SCSI terminator
Courtesy: Course Technology/Cengage Learning

VARIOUS SCSI STANDARDS

Just as with IDE/ATA standards, SCSI standards have improved over the years and use different names. SCSI standards are developed by the SCSI T10 Technical Committee (*www.t10.org*) and sent to ANSI, which publishes and maintains the official versions of the standards. The SCSI Trade Association (*www.scsita.org*) promotes SCSI devices and standards, and the T10 Technical Committee (*www.t10.org*) publishes information about SCSI. In addition to varying standards, SCSI also uses different types of cabling, connectors, and bus widths. Because there are so many variations with SCSI, when setting up a SCSI subsystem, it's important to pay careful attention to compatibility and make sure all devices, the host adapter, cables, and connectors can work together.

The three major versions of SCSI are SCSI-1, SCSI-2, and SCSI-3, commonly known as Regular SCSI, Fast SCSI, and Ultra SCSI. The latest SCSI standard, serial SCSI, also called **serial attached SCSI (SAS)**, allows for more than 15 devices on a single SCSI chain, uses smaller, longer, round cables, and uses smaller hard drive form factors that can support larger capacities than earlier versions of SCSI. SAS can be compatible with SATA drives in the same system, and claims to be more reliable and better performing than SATA. For more information on SCSI, see the content "All About SCSI" on the CD that accompanies this book.

FIBRE CHANNEL

Fibre Channel is a type of SCSI technology, but in the industry, it is sometimes considered a rival of SCSI for high-end server solutions. Using Fibre Channel, you can connect up to 126 devices together on a single Fibre Channel bus. Fibre Channel is faster than other SCSI implementations, when more than five hard drives are strung together to provide massive secondary storage. However, Fibre Channel is too expensive and has too much overhead, except when used in high-end server solutions.

Now let's look at how multiple hard drives can work together in various RAID configurations.

RAID: HARD DRIVES WORKING TOGETHER

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A technology that configures two or more hard drives to work together as an array of drives is called **RAID (redundant array of inexpensive disks or redundant array of independent disks)**. Two reasons you might consider using RAID are:

- To improve **fault tolerance**, which is a computer's ability to respond to a fault or catastrophe, such as a hardware failure or power outage, so that data is not lost. If data is important enough to justify the cost, you can protect the data by continuously

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writing two copies of it, each to a different hard drive. This method is most often used on high-end, expensive file servers, but it is occasionally appropriate for a single-user workstation.
- To improve performance by writing data to two or more hard drives so that a single drive is not excessively used.

Several levels of RAID exist, but the three most commonly used are RAID 0, RAID 1, and RAID 5. Here is a brief description of each:

- **RAID 0** uses space from two or more physical disks to increase the disk space available for a single volume. RAID 0 writes to the physical disks evenly across all disks so that no one disk receives all the activity, and therefore improves performance. Windows calls RAID 0 a **striped volume**. To understand that term, think of data striped—or written across—several hard drives.
- **RAID 1** is a type of drive imaging. It duplicates data on one drive to another drive and is used for fault tolerance. (A **drive image** is a duplication of everything written to a hard drive.) Each drive has its own volume, and the two volumes are called mirrors. If one drive fails, the other continues to operate and data is not lost. A variation of mirroring is disk duplexing, which uses two hard drive controllers, one for each drive. If one controller fails, the other controller keeps on working, providing more assurance of fault tolerance than mirroring. Windows calls RAID 1 a **mirrored volume**.
- **RAID 5** stripes data across three or more drives and uses parity checking, so that if one drive fails, the other drives can re-create the data stored on the failed drive. Data is not duplicated, and, therefore, RAID 5 makes better use of volume capacity. RAID 5 drives increase performance and provide fault tolerance. Windows calls these drives **RAID-5 volumes**.

A+ Exam Tip The A+ 220-701 Essentials exam expects you to be able to contrast RAID 0, RAID 1, and RAID 5.

Besides the three levels of RAID listed, another practice of tying two drives together in an array is called spanning. With **spanning**, two hard drives are configured as a single volume. Data is written to the first drive, and when it is full, the data continues to be written to the second drive. The advantage of spanning is that you can have a very large file that is larger than either drive. The disadvantages of spanning are that it does not provide fault tolerance, and that it does not improve performance. Sometimes spanning is called JBOD (Just a Bunch of Disks).

All RAID configurations can be accomplished at the hardware level or the operating system level. Configuring RAID at the hardware level is considered best practice because, if Windows gets corrupted, the hardware might still be able to protect the data. Also, hardware RAID is generally faster than operating system RAID. You will learn how to implement hardware RAID later in the chapter. Windows RAID is covered in Chapter 13.

ABOUT FLOPPY DRIVES

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Even though a **floppy disk drive (FDD)** holds only 1.44 MB of data, these drives are still used in some computers today, and you need to know how to support them. Floppy drives can be especially useful when recovering from a failed BIOS update. Also, floppy disks are inexpensive and easy for transferring small amounts of data. In this part of the chapter, you'll learn about the hardware and file system used by floppy drives.

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FLOPPY DRIVE HARDWARE

Years ago, floppy drives came in two sizes to accommodate either a 5¼" or 3½" floppy disk. The 3½" disks were formatted as high density (1.44 MB), extra-high density (2.88 MB), and double density (720 K). The only floppy drives you see in use today are the 3½" high-density drives that hold 1.44 MB of data.

Figure 8-17 shows the floppy drive subsystem, which consists of the floppy drive, its ribbon cable, power cable, and connections. The ribbon data cable connects to a 34-pin floppy drive connector on the motherboard. Recall that most hard drives use the larger Molex connector as a power connector, but floppy drives use the smaller Berg connector. The Berg power connector has a small plastic latch that snaps in place when you connect it to the drive.

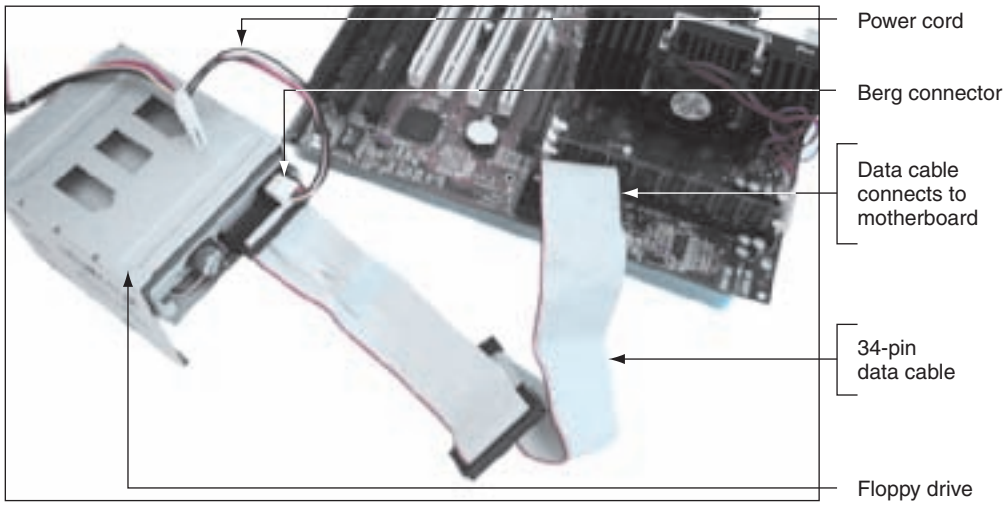

Figure 8-17 Floppy drive subsystem: floppy drive, 34-pin data cable, and power connector
Courtesy: Course Technology/Cengage Learning

Today's floppy drive cables have a connector at each end and accommodate a single drive, but older cables, like the one in Figure 8-17, have an extra connector or two in the middle of the cable for a second floppy drive. For these systems, you can install two floppy drives on the same cable, and the drives will be identified by BIOS as drive A and drive B. Figure 8-18 shows an older floppy drive cable. Notice in the figure the twist in the cable. The drive that has the twist between it and the controller is drive A. The drive that does not have the twist between it and the controller is drive B. Also notice in the figure the edge color down one side of the cable, which identifies the pin-1 side of the 34-pin connector.

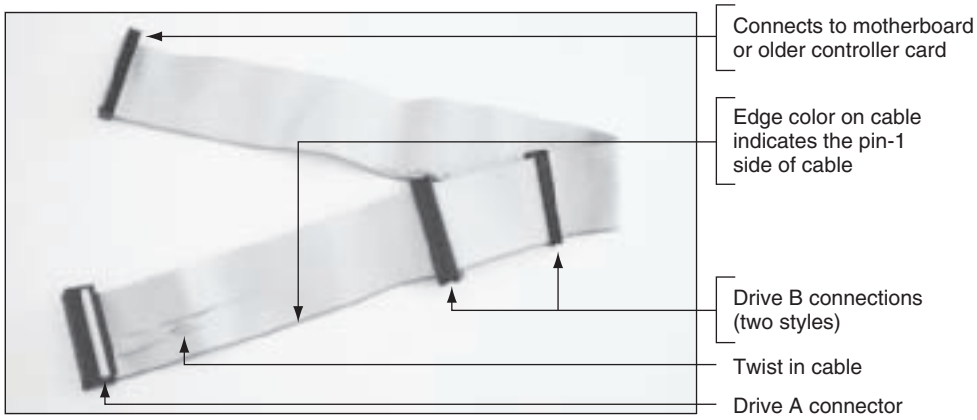

Figure 8-18 Twist in cable determines which drive is drive A
Courtesy: Course Technology/Cengage Learning

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A+ Exam Tip The A+ 220-701 Essentials exam expects you to be familiar with a floppy disk drive (FDD).

FLOPPY DRIVE FILE SYSTEM

Learning about the details of a floppy drive file system can help you understand how a hard drive is organized. The floppy drive file system is similar to that of a hard drive file system, yet it is simpler and easier to understand.

When floppy disks are first manufactured, the disks have nothing on them; they are blank sheets of magnetically coated plastic. During the **formatting** process, tracks and sectors to hold the data are written to the blank surface (see Figure 8-19).

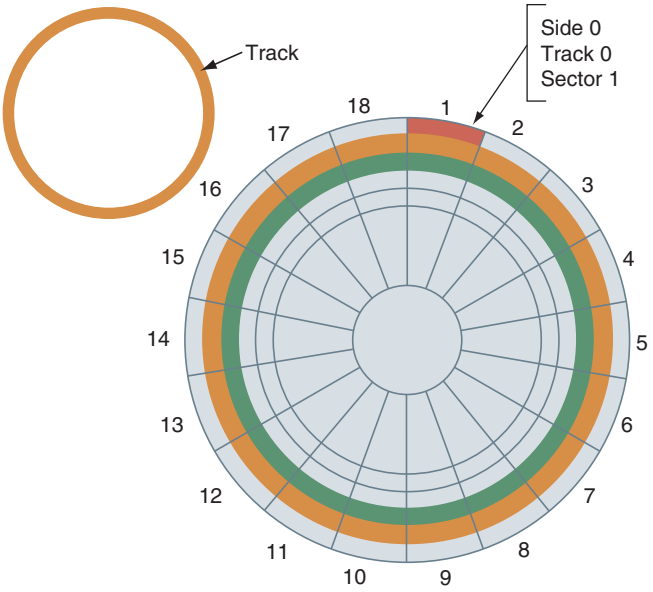

Figure 8-19 3½", high-density floppy disk showing tracks and sectors
Courtesy: Course Technology/Cengage Learning

There are 80 tracks, or circles, on the top side of the disk and 80 more tracks on the bottom. The tracks are numbered 0 through 79. Each track has 18 sectors, numbered 1 through 18 for a total of 1440 sectors on each side. Because each sector holds 512 bytes of data, a 3½", high-density floppy disk has 2880 x 512 = 1,474,560 bytes of data. Divide this number by 1024 to convert bytes to kilobytes and you will find out that the storage capacity of this disk is 1440 kilobytes. You can then divide 1440 by 1000 to convert kilobytes to megabytes, and the storage is 1.44 MB.

Notes There is a discrepancy in the way the computer industry defines a megabyte. Sometimes 1 megabyte = 1,000 kilobytes; at other times, we use the relationship 1 megabyte = 1,024 kilobytes. Computers calculate in powers of 2, and 1,024 is 2 raised to the 10th power.

Most floppy disks come already formatted, but occasionally you will need to format one. Whether you use the format command at a command prompt or Windows Explorer to format a floppy disk, the following are created:

- *Tracks and sectors*. These tracks and sectors provide the structure to hold data on the disk.
- *The boot record*. The first sector on the disk, called the **boot sector** or **boot record**, contains the information about how the disk is organized and the file system used.

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- *Two copies of the file allocation table (FAT)*. Under Windows, a hard drive can use either the NTFS or FAT32 file system, but a floppy drive is always formatted using the FAT12 file system. Using **FAT12**, each entry in the file allocation table (FAT) is 12 bits. Each FAT entry lists how each cluster (or **file allocation unit**) on the disk is currently used. Using FAT12, one sector equals one cluster, so every sector or cluster on the disk is accounted for in the FAT. A file is stored in one or more clusters that do not have to be contiguous on the disk.
- *The root directory*. The root directory contains a fixed number of rows to accommodate a predetermined number of files and subdirectories. A 3½", high-density floppy disk has 224 entries in the root directory. Some important items in a directory are a list of filenames and their extensions, the time and date of creation or last update of each file, and the file attributes. Attributes are on/off switches indicating the archive, system file, hidden file, and read-only file status of the file or directory.

The root directory and all subdirectories contain the same information about each file. Only the root directory has a limitation on the number of entries because it has a fixed length that it uses to store all filenames and folder names created in the root directory. Subdirectories can have as many entries as disk space allows. Because long filenames require more room in a directory than short filenames, assigning long filenames reduces the number of files that can be stored in the root directory.

Notes For tech-hungry readers, you can use the DEBUG command to view the contents of the boot record or FAT. How to do that is covered in the "Behind the Scenes with DEBUG" content that you can find on the CD that accompanies this book. Also, to see a group of tables showing the contents of the floppy disk boot record, the root directory, and the meaning of each bit in the attribute byte, see the content on the CD titled "FAT Details."

Let's now turn our attention back to hard drives and focus on what you need to know when selecting one.

A+ Exam Tip The content on the A+ 220-701 Essentials exam ends here and the content on the A+ 220-702 Practical Application exam begins.

HOW TO SELECT AND INSTALL HARD DRIVES AND FLOPPY DRIVES

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In this part of the chapter, you'll learn how to select a hard drive for your system. Then, you'll learn the details of installing a serial ATA drive and a parallel ATA drive in a system. Next, you'll learn how to deal with the problem of installing a hard drive in a bay that is too wide for it and also how to set up a RAID system. Lastly, you'll see how to install a floppy drive.

SELECTING A HARD DRIVE

When selecting a hard drive, keep in mind that there are many hard drive standards. To get the best performance from the system, the system BIOS on the motherboard or the firmware on the hard drive controller card must use the same standards used by the drive. If the motherboard

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or controller card does not use the same standards as the hard drive, they will probably revert to a slower standard that both can use, or the drive will not work at all. There's no point in buying an expensive hard drive with features that your system cannot support.

Therefore, when making purchasing decisions, you need to know what standards the motherboard or controller card uses. To find out, see the documentation for the board or the card. For the motherboard, you can look at BIOS setup screens to see which standards are mentioned. However, know that when installing a drive, you don't need to know which ATA standard a hard drive supports, because the startup BIOS uses autodetection. With **autodetection**, the BIOS detects the new drive and automatically selects the correct drive capacity and configuration, including the best possible standard supported by both the hard drive and the motherboard.

One more point is important to know: Legacy motherboards or hard drives might present complex situations. If you install a new drive that the startup BIOS of a legacy motherboard is not designed to support, the BIOS will either not recognize the drive at all or will detect the drive and report in BIOS setup that the drive has a smaller capacity than it actually does. The solution is to flash BIOS, replace the controller card, or replace the motherboard. For a full discussion of how to deal with legacy motherboards or drives, see the content "Selecting and Installing Hard Drives using Legacy Motherboards" on the CD that accompanies this book.

When purchasing a hard drive, consider the following factors that affect performance, use, and price:

- *The capacity of the drive*. Today's hard drives for desktop systems are in the range of 80 GB to more than 1.5 TB. The more gigabytes or terabytes, the higher the price.
- *The spindle speed*. Hard drives for desktop systems run at 5400, 7200, or 10,000 RPM (revolutions per minute). The most common is 7200 RPM. The higher the RPMs, the faster the drive.
- *The interface standard*. Use the standards your motherboard supports. For SATA, most likely that will be SATA-300. For a PATA IDE drive, most likely that will be Ultra ATA-100. For external drives, common standards are eSATA, FireWire 800 or 400, and Hi-Speed USB.
- *The cache or buffer size*. Buffers improve hard drive performance and can range in size from 2 MB to 32 MB. The more the better, though the cost goes up as the size increases.
- *The average seek time (time to fetch data)*. Look for 13 to 8.5 ms (milliseconds). The lower the number, the higher the drive performance and cost.
- *Hybrid drive*. A hybrid drive costs more, but performs better than other comparable desktop drives. Solid state drives are currently only available for laptops.

When selecting a drive, consider the manufacturer warranty and be sure to match the drive to what your motherboard supports. Also, be sure to keep the receipt with the warranty statement. After you know what drive your system can support, you then can select a drive that is appropriate for the price range and intended use of your system. For example, Seagate has two lines of IDE hard drives: The Barracuda is less expensive and intended for the desktop market, and the Cheetah is more expensive and targets the server market. When purchasing a drive, you can compare price and features by searching retail sites or the Web sites of the drive manufacturers. Some of the more popular ones are listed in Table 8-3. The same manufacturers usually produce ATA drives and SCSI drives.

Now let's turn our attention to the step-by-step process of installing a Serial ATA drive.

STEPS TO INSTALL A SERIAL ATA DRIVE

A motherboard that has serial ATA connectors most likely has one or more PATA connectors, too. A PATA connector can be used for an optical drive or some other EIDE drive

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Manufacturer	Web Site
Hitachi	*www.hitachigst.com*
Maxtor Corporation (currently owned by Seagate Technology)	*www.maxtor.com*
Samsung	*www.samsung.com*
Seagate Technology	*www.seagate.com*
Western Digital	*www.wdc.com*

Table 8-3 Hard drive manufacturers

including a hard drive. But SATA drives are faster than PATA drives, so it's best to use the PATA connector for other type drives than the hard drive.

A+ Exam Tip The A+ 220-702 Practical Application exam expects you to know how to configure PATA and SATA devices in a system.

In Figure 8-20, you can see the back of two hard drives; one uses a serial ATA interface and the other uses a parallel ATA interface. Notice the parallel ATA drive has a bank of jumpers and a 4-pin power connector. These jumpers are used to determine master or slave settings on the IDE channel. Because a serial data cable accommodates only a single drive, there is no need for jumpers on the drive for master or slave settings. However, a serial ATA drive might have jumpers used to set features such as the ability to power up from standby mode. Most likely, if jumpers are present on a serial ATA drive, the factory has set them as they should be, and advises you not to change them.

Figure 8-20 Rear of a serial ATA drive and a parallel ATA drive
Courtesy: Course Technology/Cengage Learning

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Some serial ATA drives have two power connectors, as does the one in Figure 8-20. Choose between the serial ATA power connector (which is the preferred connector) or the legacy 4-pin connector, but never install two power cords to the drive at the same time, because this could damage the drive.

If you have a PATA drive and a SATA connector on the motherboard, or you have a SATA drive and a PATA connector on the motherboard, you can purchase an adapter to make the hard drive connector fit your motherboard connector. Figure 8-21 shows two converters: one converts SATA drives to PATA motherboards and the other converts PATA drives to SATA motherboards. When you use a converter, know that the drive will run at the slower PATA speed.

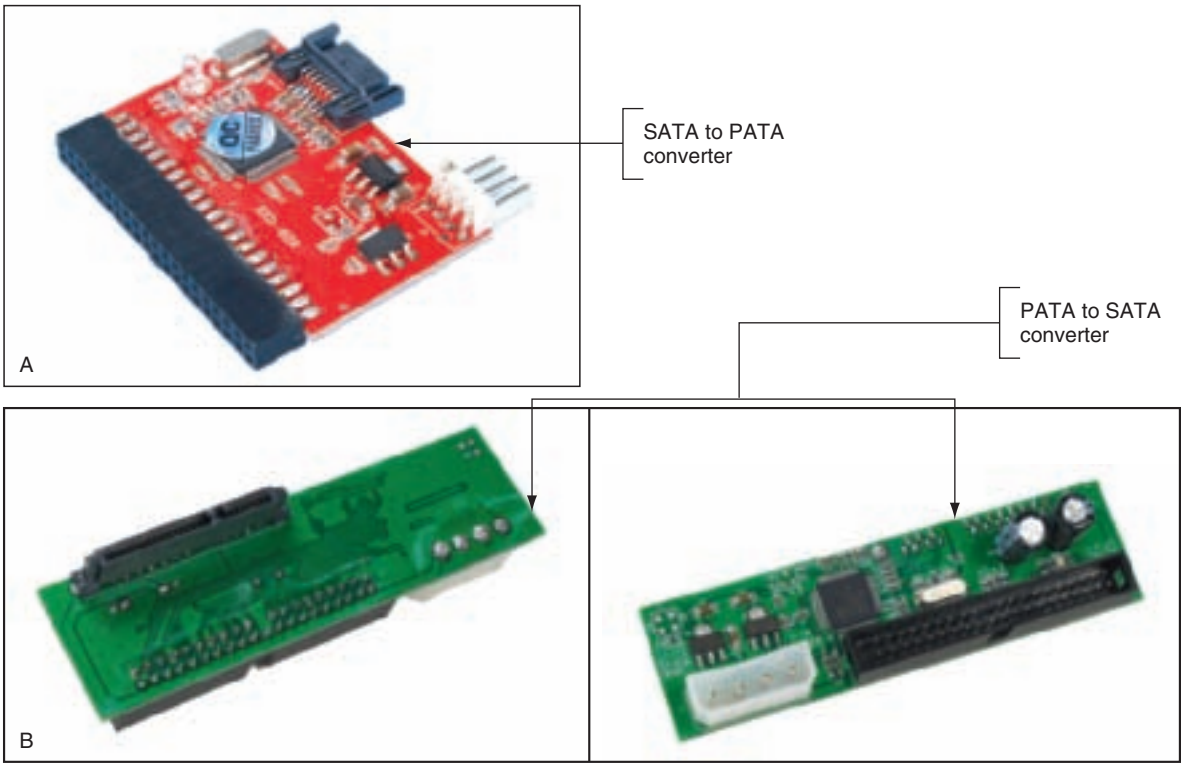

Figure 8-21 SATA to PATA and PATA to SATA converters
Courtesy: Course Technology/Cengage Learning

You can also purchase a SATA and/or PATA controller card that can provide internal PATA or SATA connectors and external eSATA connectors. You might want to use a controller card when (1) the motherboard drive connectors are not functioning; or (2) the motherboard does not support an ATA standard you want to implement (such as a SATA II drive). Figure 8-22 shows a storage controller card that offers one Ultra ATA-133/IDE connection, two internal SATA I connections, and one eSATA port.

Now let's look at the step-by-step process of installing a SATA drive.

STEP 1: PREPARE FOR THE INSTALLATION

Prepare for the installation by knowing your starting point, reading the documentation, and preparing your work area.

Know Your Starting Point

As with installing any other devices, before you begin installing your hard drive, make sure you know where your starting point is. Do this by answering these questions: How is your

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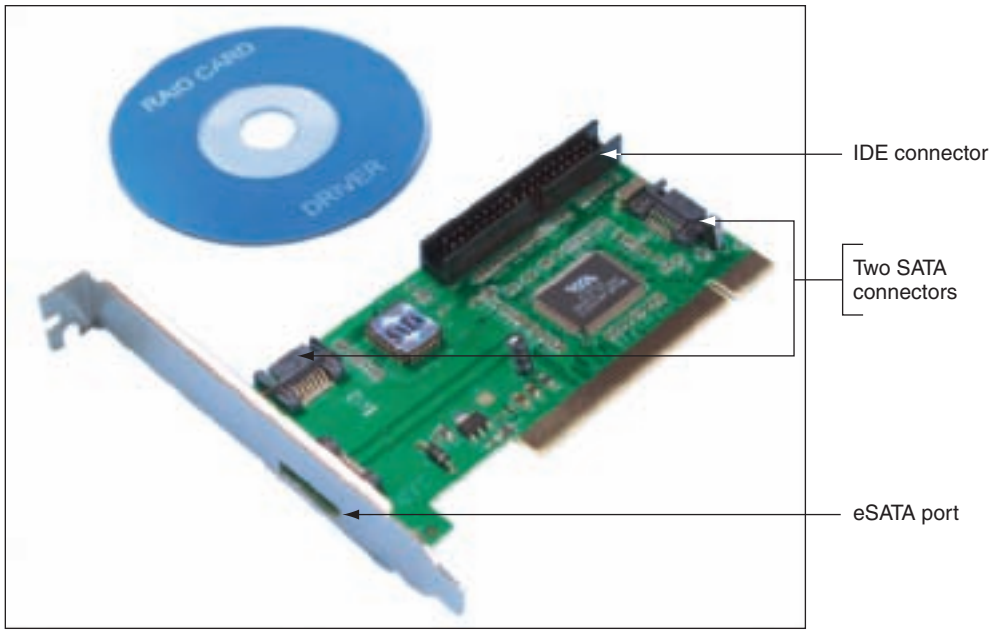

Figure 8-22 EIDE and SATA storage controller card
Courtesy: Course Technology/Cengage Learning

system configured? Is everything working properly? Verify which of your system's devices are working before installing a new one. Later, if a device does not work, the information will help you isolate the problem. Keeping notes is a good idea whenever you install new hardware or software or make any other changes to your PC system. Write down what you know about the system that might be important later.

Notes When installing hardware and software, don't install too many things at once. If something goes wrong, you won't know what's causing the problem. Install one device, start the system, and confirm that the new device is working before installing another.

As always, just in case you lose BIOS setup information in the process, write down any variations in setup from the default settings. Two good places to record BIOS settings are the notebook you keep about this computer and the manual for the motherboard.

Read Documentation

Before you take anything apart, carefully read all the documentation for the drive and controller card, as well as the part of your motherboard documentation that covers hard drive installation. Make sure that you can visualize all the steps in the installation. If you have any questions, keep researching until you locate the answer. You can also call technical support, or ask a knowledgeable friend for help. As you get your questions answered, you might discover that what you are installing will not work on your computer, but that is better than coping with hours of frustration and a disabled computer. You cannot always anticipate every problem, but at least you can know that you made your best effort to understand everything in advance. What you learn in thorough preparation pays off every time!

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Prepare Your Work Area and Take Precautions

The next step is to prepare a large, well-lit place to work. Set out your tools, documentation, new hardware, and notebook. Remember the basic rules concerning static electricity, which you learned in Chapter 4. Be sure to protect against ESD by wearing a ground bracelet during the installation. You need to also avoid working on carpet in the winter when there's a lot of static electricity.

Some added precautions for working with a hard drive are as follows:

- Handle the drive carefully.
- Do not touch any exposed circuitry or chips.
- Prevent other people from touching exposed microchips on the drive.
- When you first take the drive out of the static-protective package, touch the package containing the drive to a screw holding an expansion card or cover, or to a metal part of the computer case, for at least two seconds. This drains the static electricity from the package and from your body.
- If you must set down the drive outside the static-protective package, place it component-side-up on a flat surface.
- Do not place the drive on the computer case cover or on a metal table.

If you're assembling a new system, it's best to install drives before you install the motherboard so that you will not accidentally bump sensitive motherboard components with the drives.

STEP 2: INSTALL THE DRIVE

So now you're ready to get started. Follow these steps to install the drive in the case:

1. Turn off the computer and unplug it. Press the power button to drain the power. Remove the computer case cover. Check that you have an available power cord from the power supply for the drive.

Notes If there are not enough power cords from a power supply, you can purchase a Y connector that can add an additional power cord.

2. Decide which bay will hold the drive. To do that, examine the locations of the drive bays and the length of the data cables and power cords. Bays designed for hard drives do not have access to the outside of the case, unlike bays for optical drives and other drives in which disks are inserted. Also, some bays are wider than others to accommodate wide drives such as CD drives and DVD drives. Will the data cable reach the drives and the motherboard connector? If not, rearrange your plan for locating the drives in the bays, or purchase a custom-length data cable. Some bays are stationary, meaning the drive is installed inside the bay as it stays in the case. Other bays are removable; you remove the bay and install the drive in the bay, and then return the bay to the case.
3. For a stationary bay, slide the drive in the bay, and secure one side of the drive with one or two short screws (see Figure 8-23). It's best to use two screws so the drive will not move in the bay, but sometimes a bay only provides a place for a single screw on each side.

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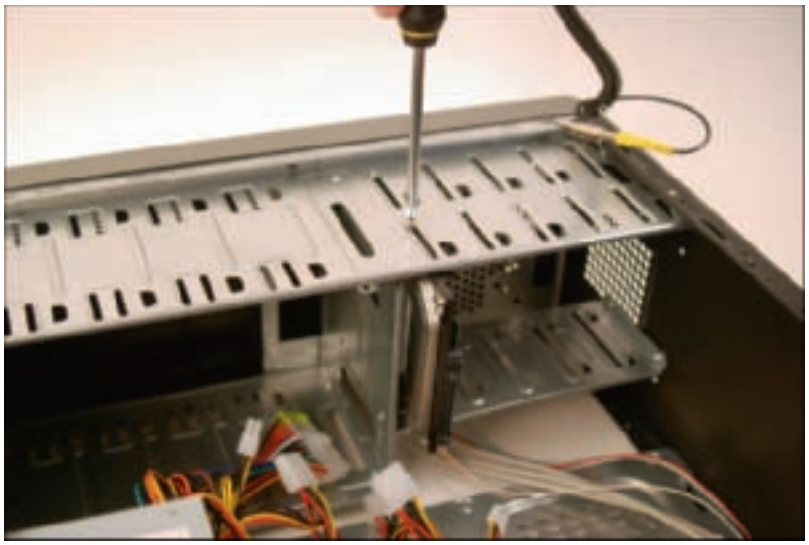

Figure 8-23 Secure one side of the drive with one or two screws
Courtesy: Course Technology/Cengage Learning

Caution Be sure the screws are not too long. If they are, you can screw too far into the drive housing, which will damage the drive itself.

4. Carefully, without disturbing the drive, turn the case over and put one or two screws on the other side of the drive (see Figure 8-24).

Figure 8-24 Secure the other side of the drive with one or two screws
Courtesy: Course Technology/Cengage Learning

Notes Do not allow torque to stress the drive. In other words, don't force a drive into a space that is too small for it. Also, placing two screws in diagonal positions across the drive can place pressure diagonally on the drive.

5. Check the motherboard documentation to find out which serial ATA connectors on the board to use first. For example, four serial ATA connectors are shown in Figure 8-25. The documentation says to use the two red connectors (labeled SATA1 and SATA2 on the board) before you use the black connectors (labeled SATA3 and SATA4). Connect

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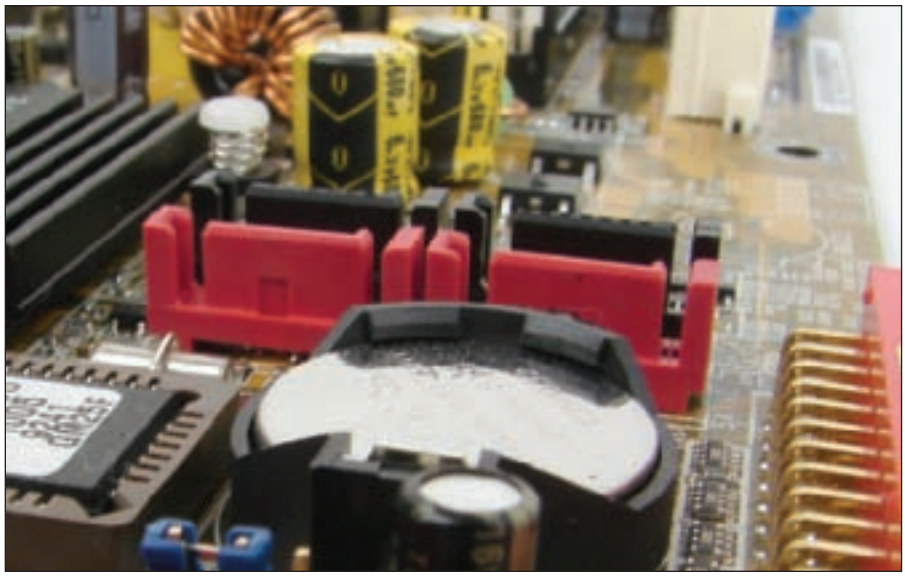

Figure 8-25 This motherboard has four serial ATA connectors
Courtesy: Course Technology/Cengage Learning

the serial ATA data cable to the hard drive and to the red SATA1 connector. For both the drive and the motherboard, you can only plug the cable into the connector in one direction.

6. Connect a SATA or 4-pin power connector from the power supply to the drive (see Figure 8-26).

Figure 8-26 Connect the SATA power cord to the drive
Courtesy: Course Technology/Cengage Learning

7. Check all your connections and power up the system.
8. To verify the drive was recognized correctly, enter BIOS setup and look for the drive. Figure 8-27 shows a BIOS setup screen on a system that has two SATA connectors and one PATA connector. A hard drive is installed on one SATA connector and a CD drive is installed on the PATA connector.

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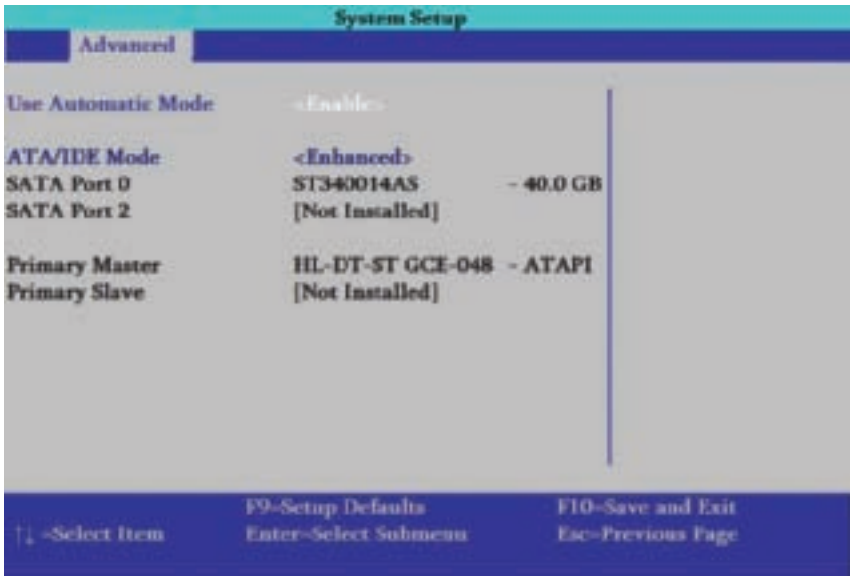

Figure 8-27 BIOS setup screen showing a SATA hard drive and PATA CD drive installed
Courtesy: Course Technology/Cengage Learning

Notes If the drive light on the front panel of the computer case does not work after you install a new drive, try reversing the LED wire on the motherboard pins.

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STEP 3: USE WINDOWS TO PARTITION AND FORMAT THE NEW DRIVE

If you are installing a new hard drive in a system that is to be used for a new Windows installation, after you have physically installed the drive, boot from the Windows setup CD or DVD, and follow the directions on the screen to install Windows on the new drive. The setup process partitions and formats the new drive before it begins the Windows installation. How to install Windows is covered in Chapter 12.

If you are installing a second hard drive in a system that already has Windows installed on the first hard drive, use Windows to partition and format the second drive. Follow these steps:

1. Boot the system to the Windows Vista desktop.
2. Click **Start**, right-click **Computer** (for Windows XP, right-click **My Computer**), and select **Manage** from the shortcut menu. Respond to the UAC box. In the Computer Management window, click **Disk Management**. The Disk Management window opens (see Figure 8-28).
3. In Figure 8-28, the new hard drive shows as Disk 1. Right-click **Disk 1** and select **Initialize Disk** from the shortcut menu, as shown in the figure.
4. On the next screen (see Figure 8-29), select **MBR (Master Boot Record)** and click **OK**. The drive will be initialized as a Basic Disk.
5. To format the drive, right-click the unallocated space on the drive and select **New Simple Volume** from the shortcut menu (see Figure 8-30). The New Simple Volume

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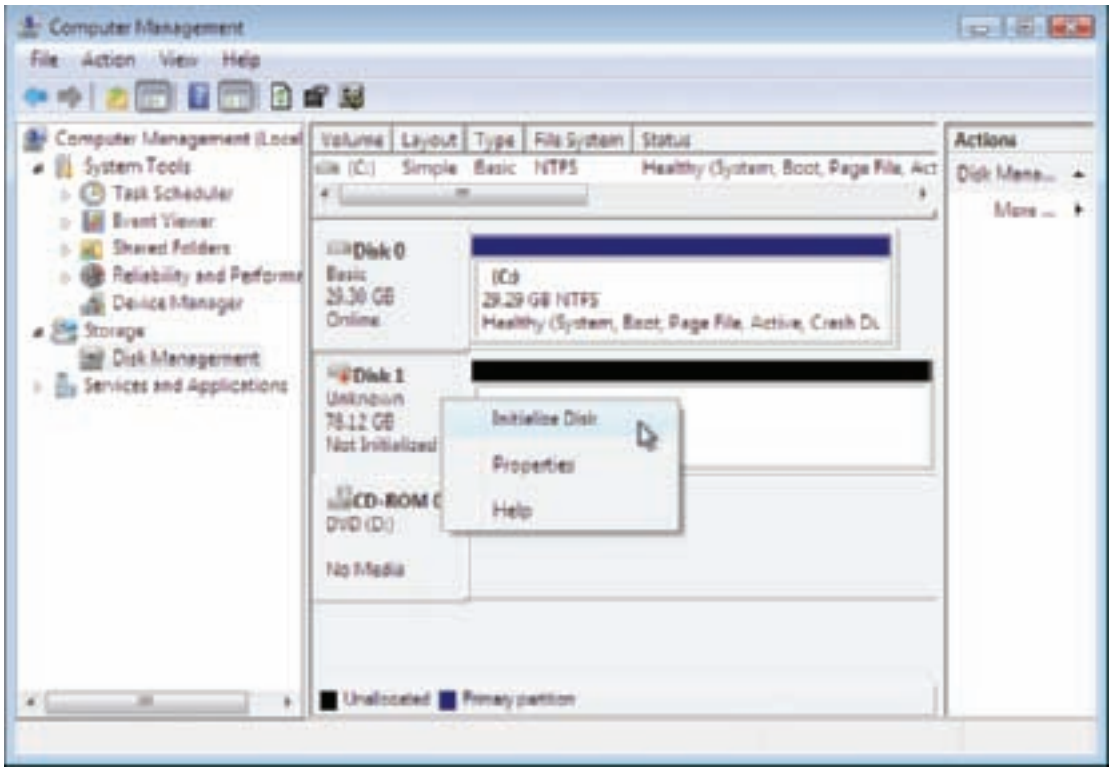

Figure 8-28 Use Disk Management to partition the new drive
Courtesy: Course Technology/Cengage Learning

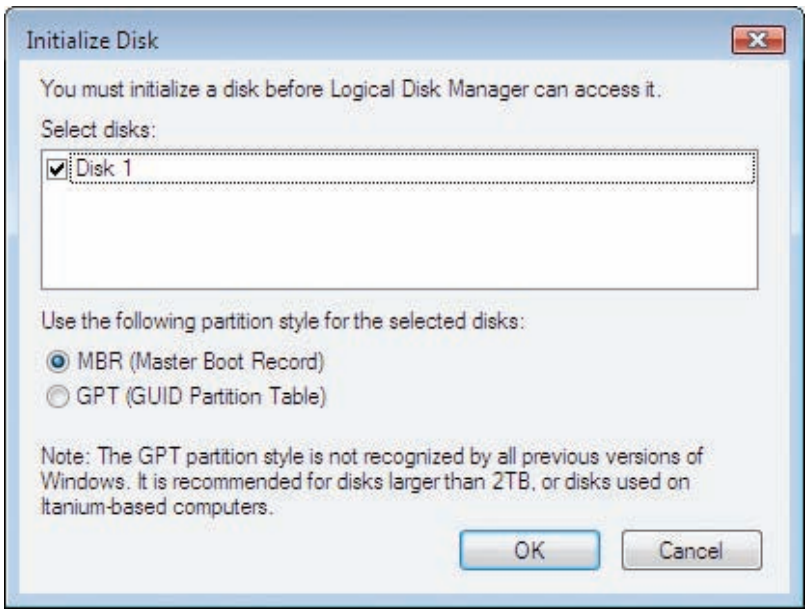

Figure 8-29 Select MBR as the partition style for the new drive
Courtesy: Course Technology/Cengage Learning

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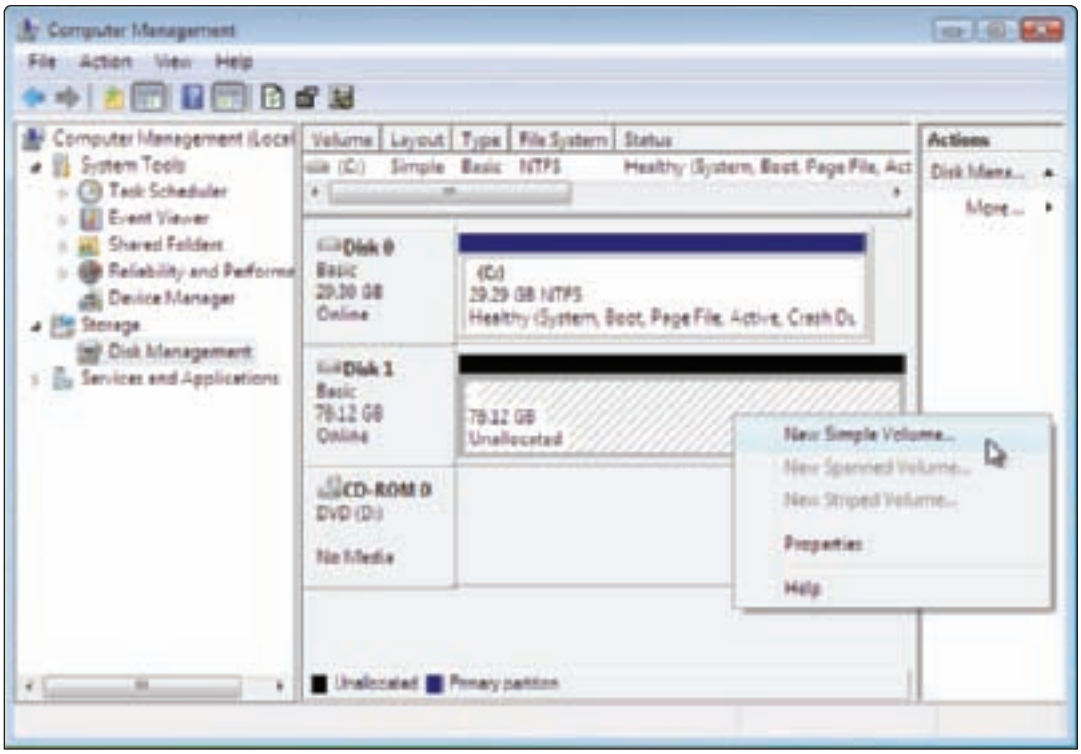

Figure 8-30 Simple volumes are created on basic disks
Courtesy: Course Technology/Cengage Learning

Wizard appears. Follow the wizard to choose a volume size, assign a drive letter to the volume, assign a volume name, and select the type of file system. Depending on which Windows OS you are using and the service packs installed, your choices for a file system will be NTFS, FAT32, or FAT (which is exFAT). For most situations, select NTFS, which is always available as a choice. The drive will format and then be ready to use. When you use Vista to create partitions, the first three partitions will be primary partitions and the fourth partition will be an extended partition. Windows XP allows you to decide which partition will be the extended partition.

Notes Solid state drives are currently only used on laptops. However, by the time this book is in print, it is expected that SSD drives will be available for desktop computers. Some SSD drives come preformatted from the manufacturer using the NTFS file system. Other SSD drives require you to partition and format them the same way you format magnetic drives. SSD drives can use either a SATA or PATA connection in laptops. The installation of an SSD drive in a computer case works the same way as does a magnetic drive installation.

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INSTALLING A SATA DRIVE IN A REMOVABLE BAY

Now let's see how a drive installation goes when you are dealing with a removable bay. Figure 8-31 shows a computer case with a removable bay that has a fan at the front of the bay to help keep the drives cool. (The case manufacturer calls the bay a fan cage.) The bay is anchored to the case with three black locking devices. The third locking device from the bottom of the case is disconnected in the photo.

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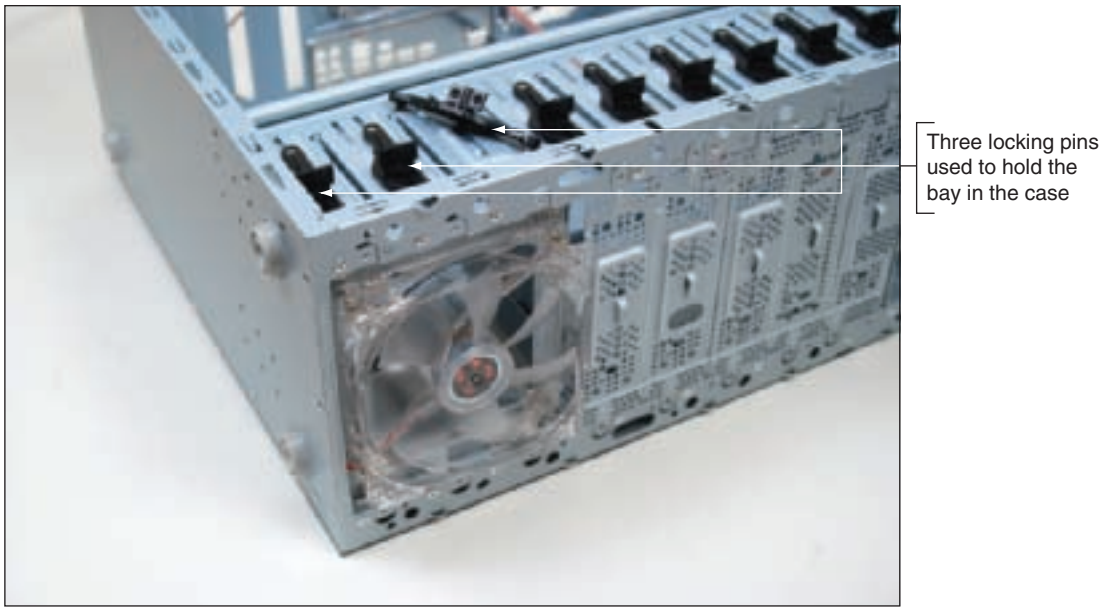

Figure 8-31 The removable bay has a fan in front and is anchored to the case with locking pins
Courtesy: Course Technology/Cengage Learning

Turn the handle on each locking device counterclockwise to remove it. Then slide the bay to the front and out of the case. Insert the hard drive in the bay, and use two screws on each side to anchor the drive in the bay (see Figure 8-32). Slide the bay back into the case, and reinstall the locking pins. The installation now goes the same way as when you are using a stationary bay.

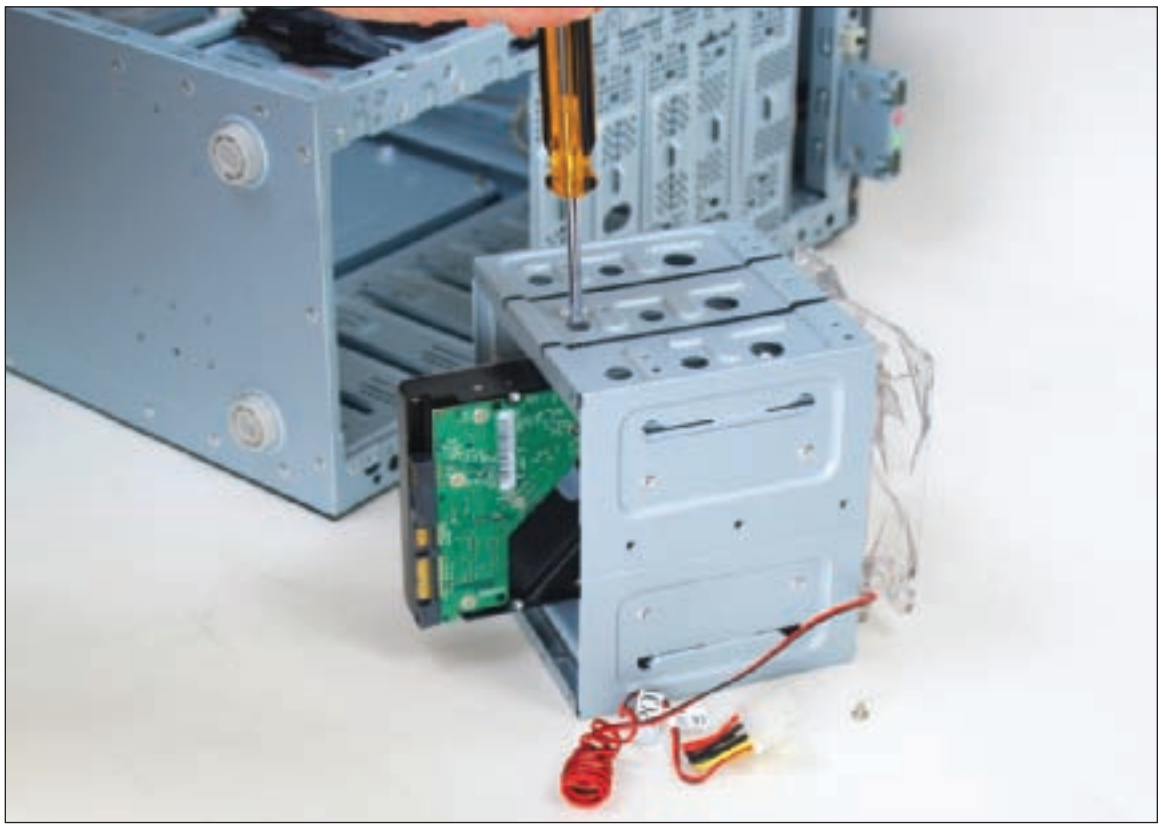

Figure 8-32 Install the hard drive in the bay using two screws on each side of the drive
Courtesy: Course Technology/Cengage Learning

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STEPS TO CONFIGURE AND INSTALL A PARALLEL ATA DRIVE

Following the PATA or EIDE standard, a motherboard can support up to four EIDE devices using either 80-conductor or 40-conductor cables. The motherboard offers two IDE connectors (see Figure 8-33). Each connector accommodates one IDE channel, and each channel can accommodate one or two IDE devices. One channel is called the primary channel, while the other channel is called the secondary channel. Each IDE connector uses one 40-pin cable. The cable has two connectors on it: one connector in the middle of the cable and one at the far end. An EIDE device can be a hard drive, DVD drive, CD drive, tape drive, or another type of drive. One device is configured to act as the master controlling the channel, and the other device on the channel is the slave. There are, therefore, four possible configurations for four EIDE devices in a system:

- Primary IDE channel, master device
- Primary IDE channel, slave device
- Secondary IDE channel, master device
- Secondary IDE channel, slave device

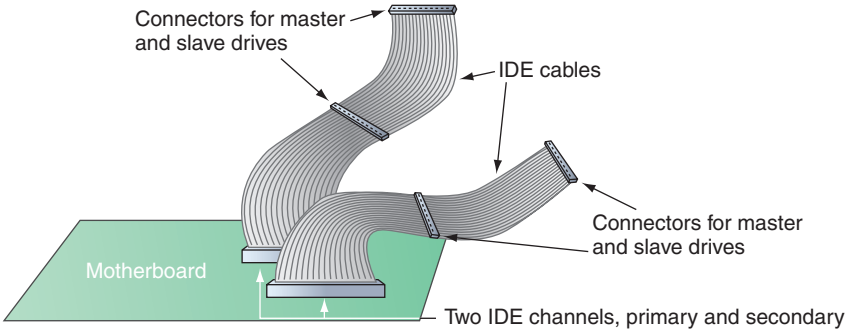

Figure 8-33 A motherboard supporting PATA has two IDE channels; each can support a master and slave drive using a single EIDE cable
Courtesy: Course Technology/Cengage Learning

The master or slave designations are made by setting jumpers or DIP switches on the devices, or by using a special cable-select data cable. Documentation can be tricky. Some hard drive documentation labels the master drive setting as the Drive 0 setting and the slave drive setting as the Drive 1 setting rather than using the terms master and slave. The connectors on a parallel ATA 80-conductor cable are color-coded (see Figure 8-34). Use the blue end to connect to the motherboard; use the black end to connect to the drive.

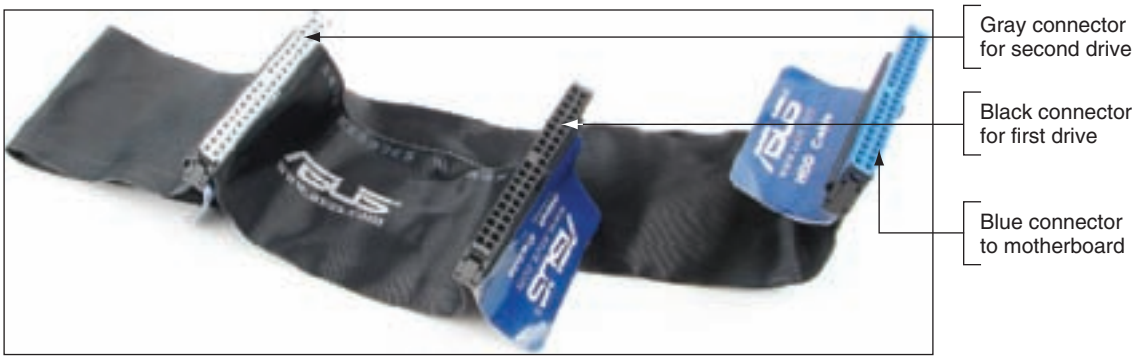

Figure 8-34 80-conductor cable connectors are color-coded
Courtesy: Course Technology/Cengage Learning

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Video
Installing a Hard drive

If you only have one drive connected to the cable, put it on the black connector at the end of the cable, not the gray connector in the middle.

Notes When installing a hard drive on the same channel with an ATAPI drive such as a CD drive, always make the hard drive the master and make the ATAPI drive the slave. An even better solution is to install the hard drive on the primary channel and the CD drive and any other drive on the secondary channel.

The motherboard might also be color-coded so that the primary channel connector is blue (see Figure 8-35) and the secondary channel connector is black. This color-coding is intended to ensure that the ATA/66/100/133 hard drive is installed on the primary IDE channel.

Figure 8-35 The primary IDE channel connector is often color-coded as blue
Courtesy: Course Technology/Cengage Learning

A+ Exam Tip The A+ 220-702 Practical Application exam expects you to know how to install a device such as a hard drive. Given a list of steps for the installation, you should be able to order the steps correctly or identify an error in a step.

As with installing SATA drives, know your starting point, read the documentation for the drive and the motherboard, prepare your work area, and be careful when handling the drive to protect it against ESD. Wear a ground bracelet as you work. Now let's look at the steps for installing a PATA drive.

STEP 1: OPEN THE CASE AND DECIDE HOW TO CONFIGURE THE DRIVES

Turn off the computer and unplug it. Press the power button to drain the power. Remove the computer case cover. Check that you have an available power cord from the power supply for the drive.

You must decide which IDE connector to use, and if another drive will share the same IDE data cable with your new drive. When possible, leave the hard drive as the single drive on one channel, so that it does not compete with another drive for access to the channel and possibly slow down performance. Use the primary channel before you use the secondary channel. Place the fastest devices on the primary channel, and the slower devices on the secondary channel. This pairing helps keep a slow device from pulling down a faster device.

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As an example of this type of pairing, suppose you have a tape drive, CD drive, and two hard drives. Because the two hard drives are faster than the tape drive and CD drive, put the two hard drives on one channel and the tape drive and CD drive on the other.

Notes If you have three or fewer devices, allow the fastest hard drive to be your boot device and the only device on the primary channel.

STEP 2: SET THE JUMPERS ON THE DRIVE

Often, diagrams of the jumper settings are printed on the top of the hard drive housing (see Figure 8-36). If they are not, see the documentation, or visit the Web site of the drive manufacturer. (Hands-On Project 8-4 gives you practice researching jumper settings.)

Table 8-4 lists the four choices for jumper settings, and Figure 8-37 shows a typical jumper arrangement for a drive that uses three of these settings. In Figures 8-36 and 8-37, note that a black square represents an empty pin and a black rectangle represents a pair of pins with a jumper in place. Know that your hard drive might not have the first configuration as an option, but it should have a way of indicating if the drive will be the master device. The factory default setting is usually correct for the drive to be the single drive on a system. Before you change any settings, write down the original ones. If things go wrong,

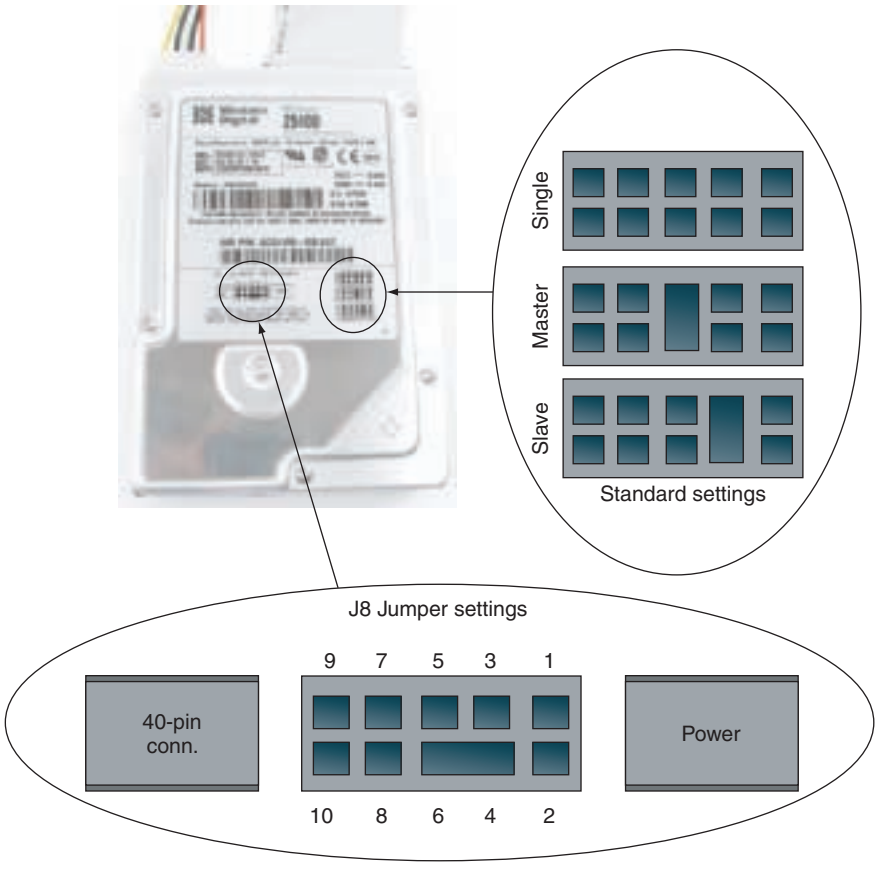

Figure 8-36 A PATA drive most likely will have diagrams of jumper settings for master and slave options printed on the drive housing
Courtesy: Course Technology/Cengage Learning

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Configuration	Description
Single-drive configuration	This is the only hard drive on this EIDE channel. (This is the standard setting.)
Master-drive configuration	This is the first of two drives; it most likely is the boot device.
Slave-drive configuration	This is the second drive using this channel or data cable.
Cable-select configuration	The cable-select (CS or CSEL) data cable determines which of the two drives is the master and which is the slave.

Table 8-4 Jumper settings on a parallel ATA hard drive

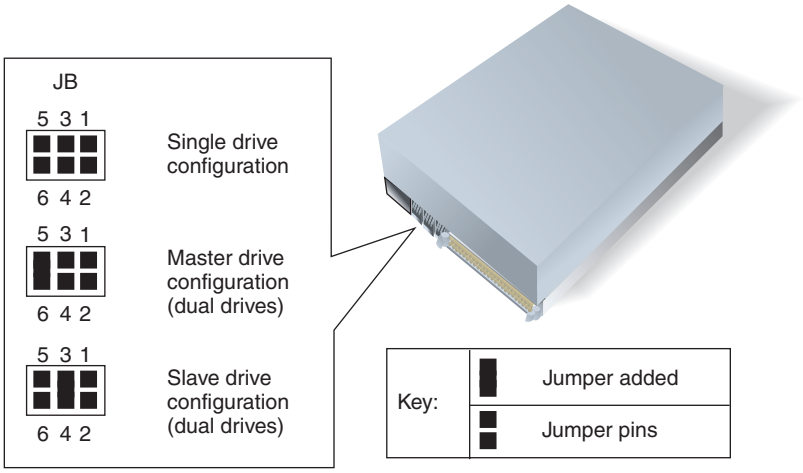

Figure 8-37 Jumper settings on a hard drive and their meanings
Courtesy: Course Technology/Cengage Learning

you can revert to the original settings and begin again. If a drive is the only drive on a channel, set it to single. For two drives on a controller, set one to master and the other to slave.

Some hard drives have a cable-select configuration option. If you choose this configuration, you must use a cable-select data cable. When using an 80-conductor cable-select cable, the drive nearest the motherboard is the master, and the drive farthest from the motherboard is the slave. You can recognize a cable-select cable by a small hole somewhere in the data cable or by labels (master or slave) on the connectors.

STEP 3: MOUNT THE DRIVE IN THE BAY

Now that you've set the jumpers, your next step is to look at the drive bay that you will use for the drive. The bay can be stationary or removable. You saw both types of bays earlier in the chapter. In the following steps, you will see how the hard drive is installed in a computer case that has three other drives: a DVD drive, a Zip drive, and a floppy drive. All three drives install in a removable bay. Do the following to install the hard drive in the bay:

1. Remove the bay from the case and insert the hard drive in the bay. You can line up the drive in the bay with the front of the computer case (see Figure 8-38) to see how drives will line up in the bay. Put the hard drive in the bay flush with the front of the bay so it will butt up against the computer case once the bay is in position (see Figure 8-39). Line up other drives in the bay so they are flush with the front of the computer case. In Figure 8-39, a floppy drive and Zip drive are already in the bay.

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Figure 8-38 Line up the floppy drive in the removable bay so it's flush with the front of the case
Courtesy: Course Technology/Cengage Learning

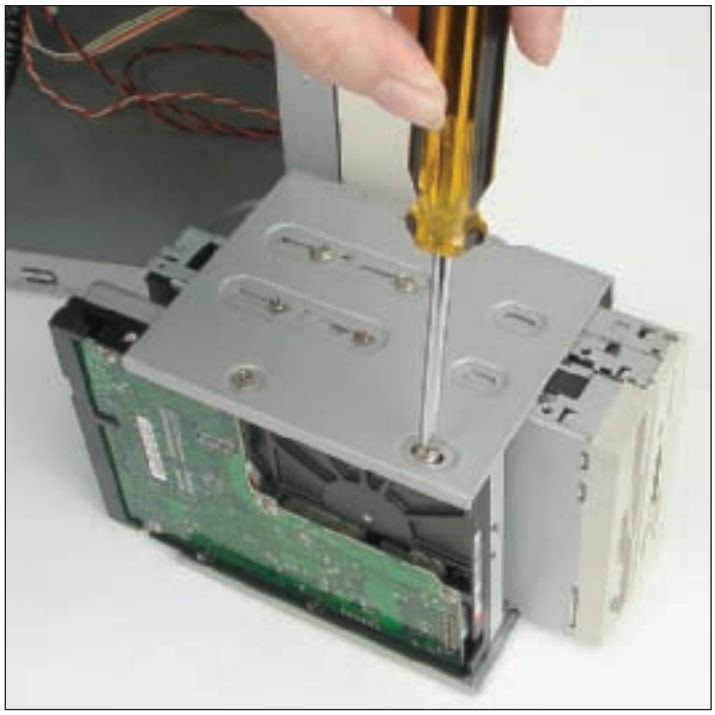

Figure 8-39 Position the hard drive flush with the end of the bay
Courtesy: Course Technology/Cengage Learning

2. You must be able to securely mount the drive in the bay; the drive should not move when it is screwed down. Line up the drive and bay screw holes, and make sure everything will fit. After checking the position of the drive and determining how screws are placed, install four screws (two on each side) to mount the drive in the bay.
3. Decide whether to connect the data cable to the drive before or after you insert the bay inside the computer case, depending on how accessible the connections are. In this

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example, the data cables are connected to the drives first and then the bay is installed inside the computer case. In Figure 8-40, the data cables for all the drives in the bay are connected to the drives.

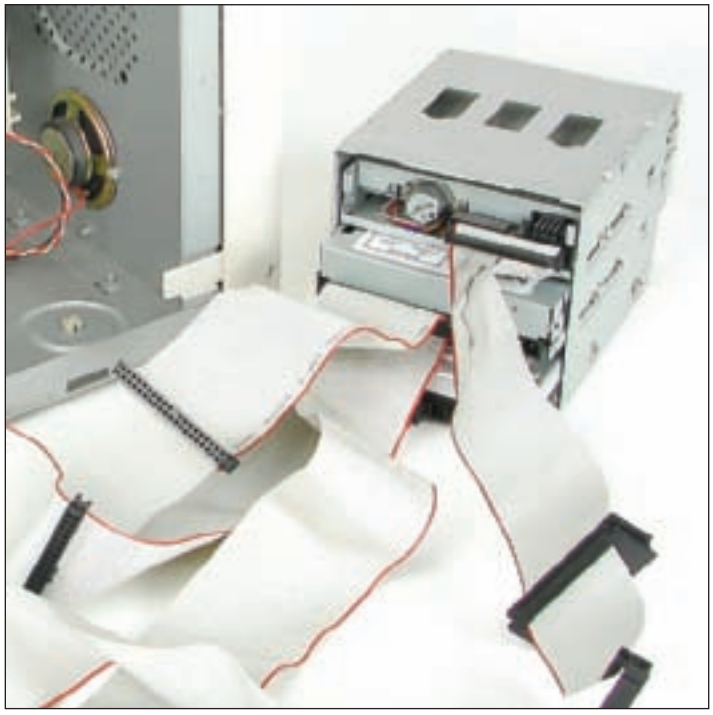

Figure 8-40 Connect the cables to all three drives
Courtesy: Course Technology/Cengage Learning

4. The next step is to place the bay back into position and secure the bay with the bay screw or screws (see Figure 8-41). Note that some bays are secured with clips. For example, for the bay shown in Figure 8-42, when you slide the bay into the case, you will hear the clipping mechanism pop into place when the bay is all the way in.

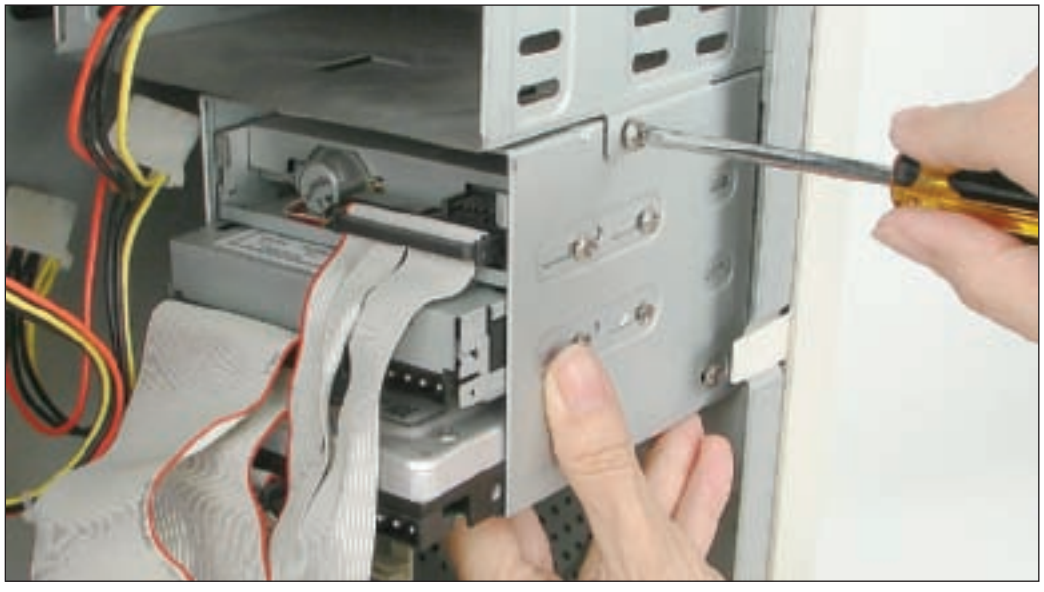

Figure 8-41 Secure the bay with the bay screw
Courtesy: Course Technology/Cengage Learning

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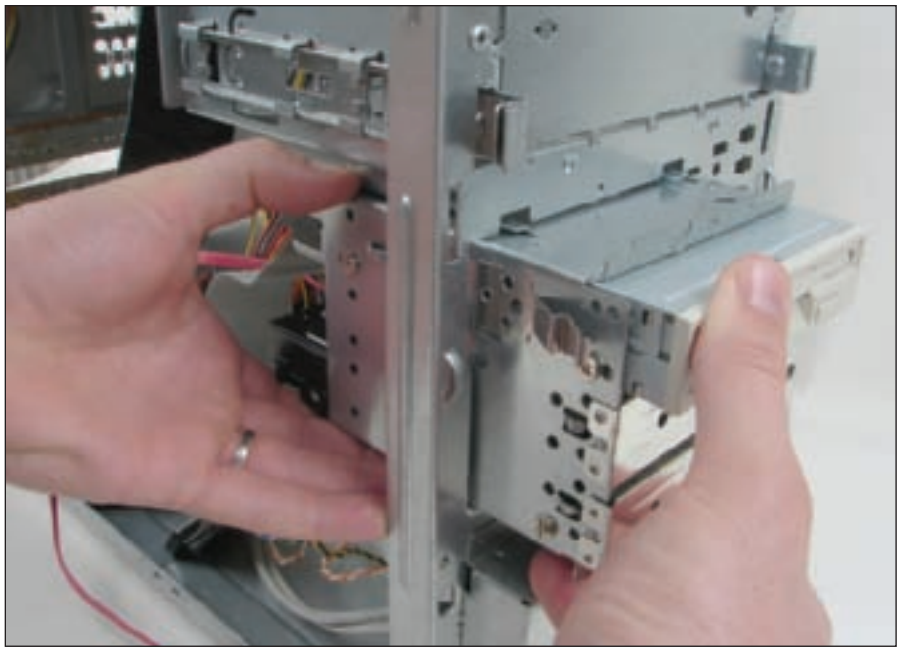

Figure 8-42 Slide the bay into the case as far as it will go
Courtesy: Course Technology/Cengage Learning

5. You can now install a power connection to each drive (Figure 8-43). In Figure 8-43, the floppy drive uses the small Berg power connection, and the other drives use the large Molex ones. It doesn't matter which of the power cords you use, because they all produce the same voltage. Also, the cord only goes into the connection one way.

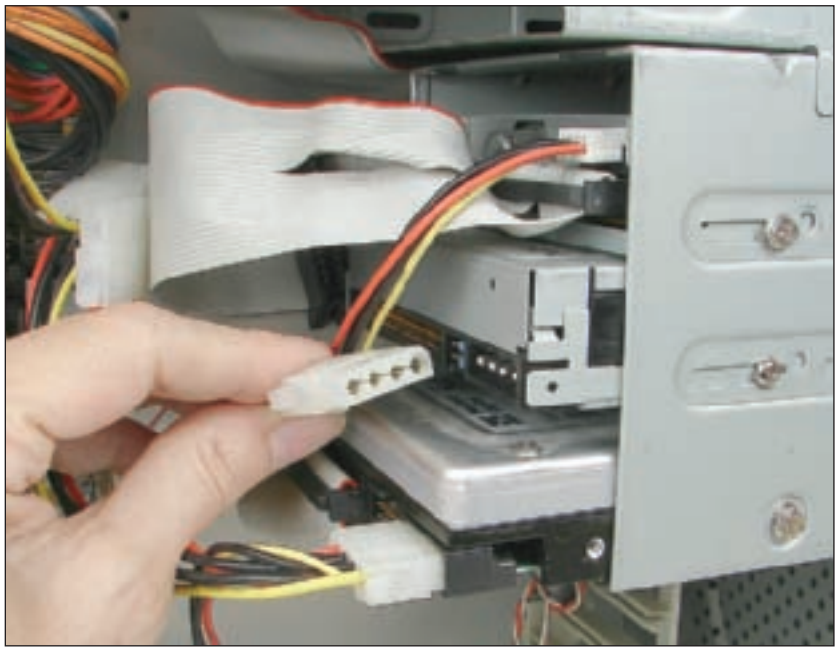

Figure 8-43 Connect a power cord to each drive
Courtesy: Course Technology/Cengage Learning

6. Next, connect the data cable to the IDE connector on the motherboard (see Figure 8-44). Make certain pin 1 and the edge color on the cable align correctly at both ends of the cable. Normally, pin 1 is closest to the power connection on the drive.

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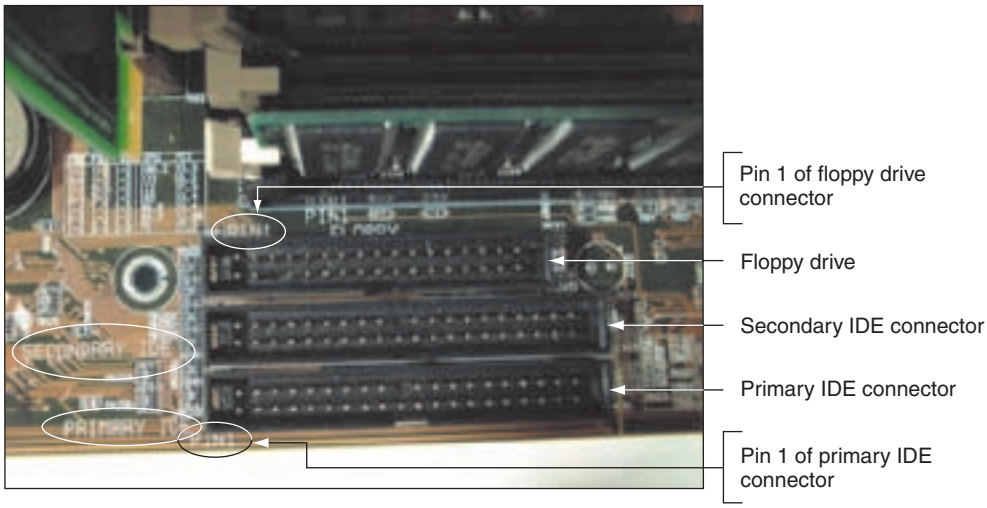

Figure 8-44 Floppy drive and two IDE connectors on the motherboard
Courtesy: Course Technology/Cengage Learning

7. When using a motherboard connection, if the wire connecting the motherboard to the hard drive light on the front of the case was not connected when the motherboard was installed, connect it now. If you reverse the polarity of the LED wire, the light will not work. Your motherboard manual should tell you the location of the LED wires on the motherboard.
8. Before you replace the case cover, plug in the monitor and turn on the computer. (On the other hand, some systems won't power up until the front panel is installed.) Verify that your system BIOS can find the drive before you replace the cover and that it recognizes the correct size of the drive. If you have problems, refer to the troubleshooting section at the end of this chapter.

After you confirm that your drive is recognized, the size of the drive is detected correctly, and supported features are set to be automatically detected, reboot the system. Then the next thing to do is to use an operating system to prepare the drive for first use.

INSTALLING A HARD DRIVE IN A WIDE BAY

If you are mounting a hard drive into a bay that is too large, a universal bay kit can help you securely fit the drive into the bay. These inexpensive kits should create a tailor-made fit. In Figure 8-45, you can see how the universal bay kit adapter works. The adapter spans the distance between the sides of the drive and the bay. Figure 8-46 shows the drive installed in a wide bay.

HOW TO IMPLEMENT HARDWARE RAID

RAID can be implemented by hardware (using a RAID controller on the motherboard or on a RAID controller card) or by the operating system. When RAID is implemented at the hardware level, the motherboard does the work and Windows is not aware of a hardware RAID implementation. If the motherboard does not have RAID connectors on the board, you can purchase a RAID adapter card (also called a RAID controller card) to provide the RAID hard drive connectors and to manage the RAID array. Some SCSI host adapter cards support RAID or you can use a RAID controller card

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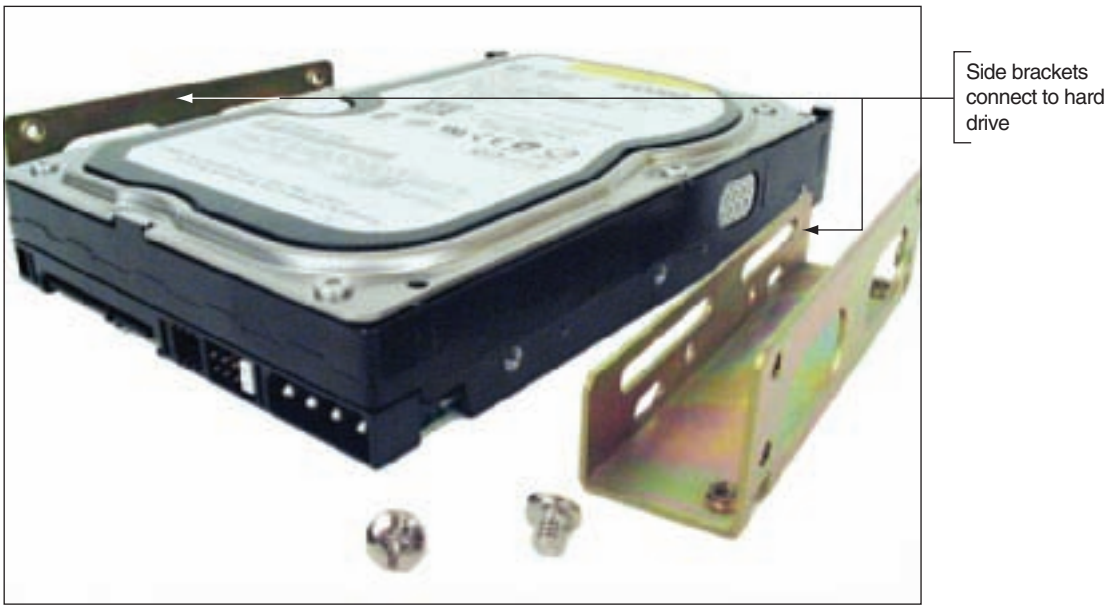

Figure 8-45 Use the universal bay kit to make the drive fit the bay
Courtesy: Course Technology/Cengage Learning

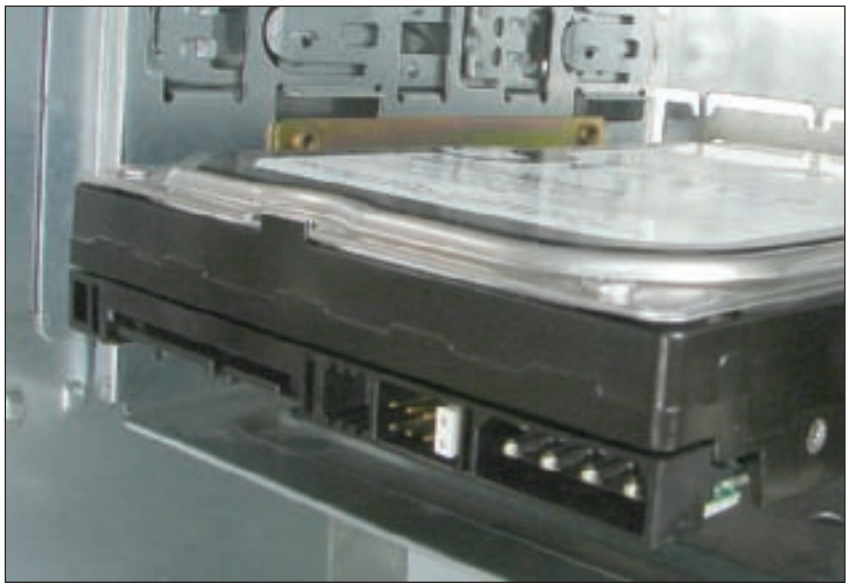

Figure 8-46 Hard drive installed in a wide bay using a universal bay kit adapter
Courtesy: Course Technology/Cengage Learning

that provides IDE or serial ATA connectors. Figure 8-47 shows a RAID controller card by Sabrent that provides four SATA ports.

A+ Exam Tip The A+ 220-702 Practical Application exam expects you to be able to detect problems, troubleshoot, and replace a RAID controller card.

Figure 8-48 shows a motherboard that has two regular IDE connectors, two serial ATA connectors that can be configured for RAID, and two IDE RAID connectors. This board supports spanning, RAID 0, RAID 1, and a combination of RAID 0 and RAID 1 (called RAID 0+1). For another motherboard, six SATA connectors on the motherboard can be used as RAID connectors if RAID is enabled in BIOS setup.

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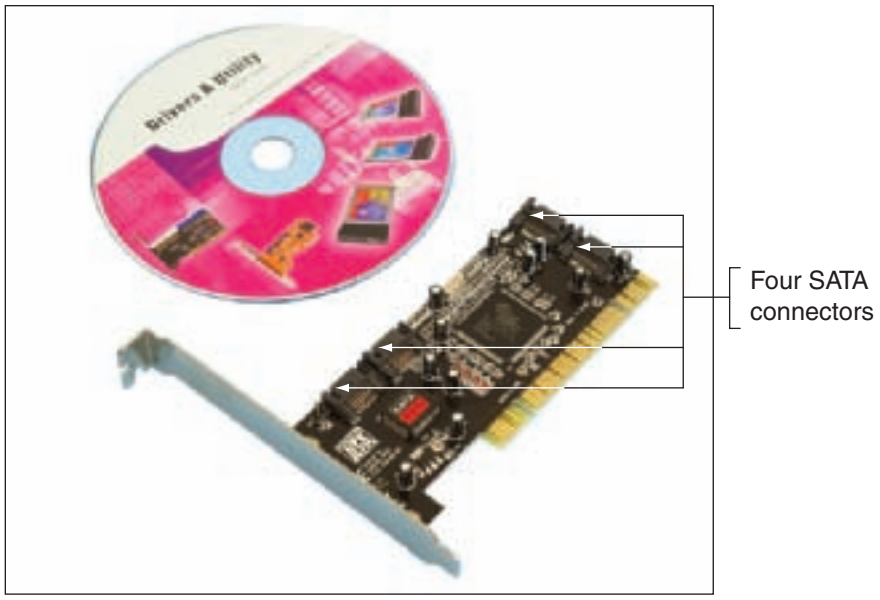

Figure 8-47 RAID controller card provides four SATA internal connectors
Courtesy: Course Technology/Cengage Learning

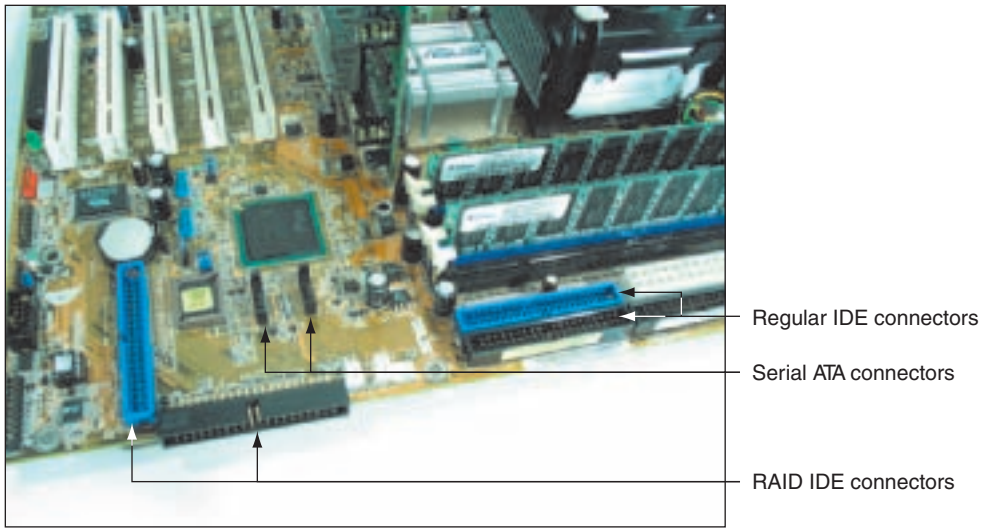

Figure 8-48 This motherboard supports RAID 0 and RAID 1
Courtesy: Course Technology/Cengage Learning

When installing a hardware RAID system, for best performance, all hard drives in an array should be identical in brand, size, speed, and other features. Also, if Windows is to be installed on a hard drive that is part of a RAID array, RAID must be implemented before Windows is installed. As with installing any hardware, first read the documentation that comes with the motherboard or RAID controller and follow those specific directions rather than the general guidelines given here. For one motherboard that has six SATA connectors that support RAID, here are the general directions to install the RAID array using three matching hard drives in a RAID 5 array:

1. Install the three SATA drives in the computer case and connect each drive to a SATA connector on the motherboard (see Figure 8-49). To help keep the drives cool, the drives are installed with an empty bay between each drive.

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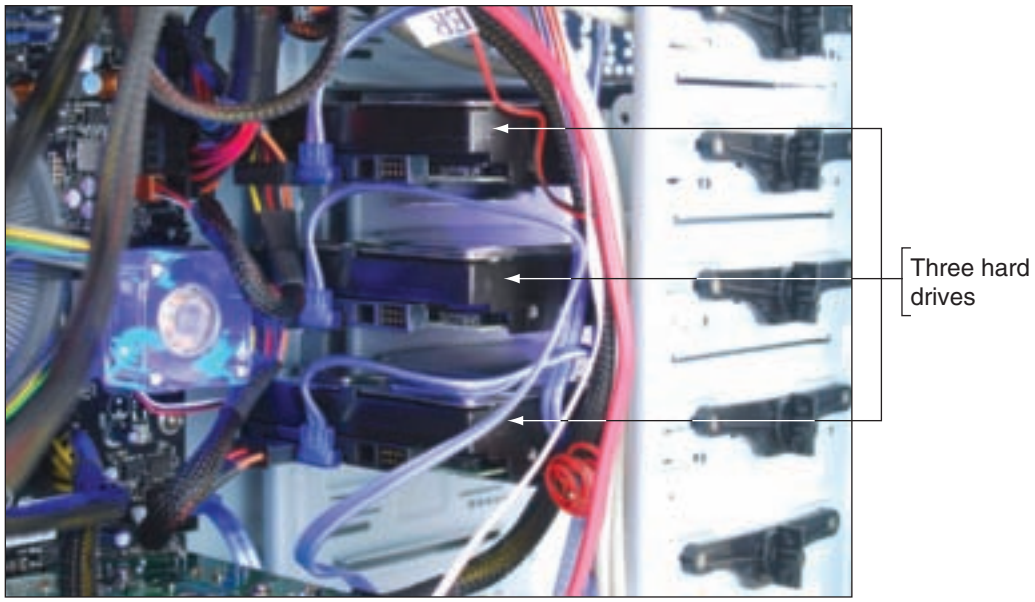

Figure 8-49 Install three matching hard drives in a system
Courtesy: Course Technology/Cengage Learning

2. Boot the system and enter BIOS setup. On the Advanced setup screen, verify the three drives are recognized. Select the option to configure SATA and then select RAID from the menu (see Figure 8-50).
3. Reboot the system and a message is displayed on-screen: "Press <**Ctrl-I**> to enter the RAID Configuration Utility." Press **Ctrl** and **I** to enter the utility (see Figure 8-51).

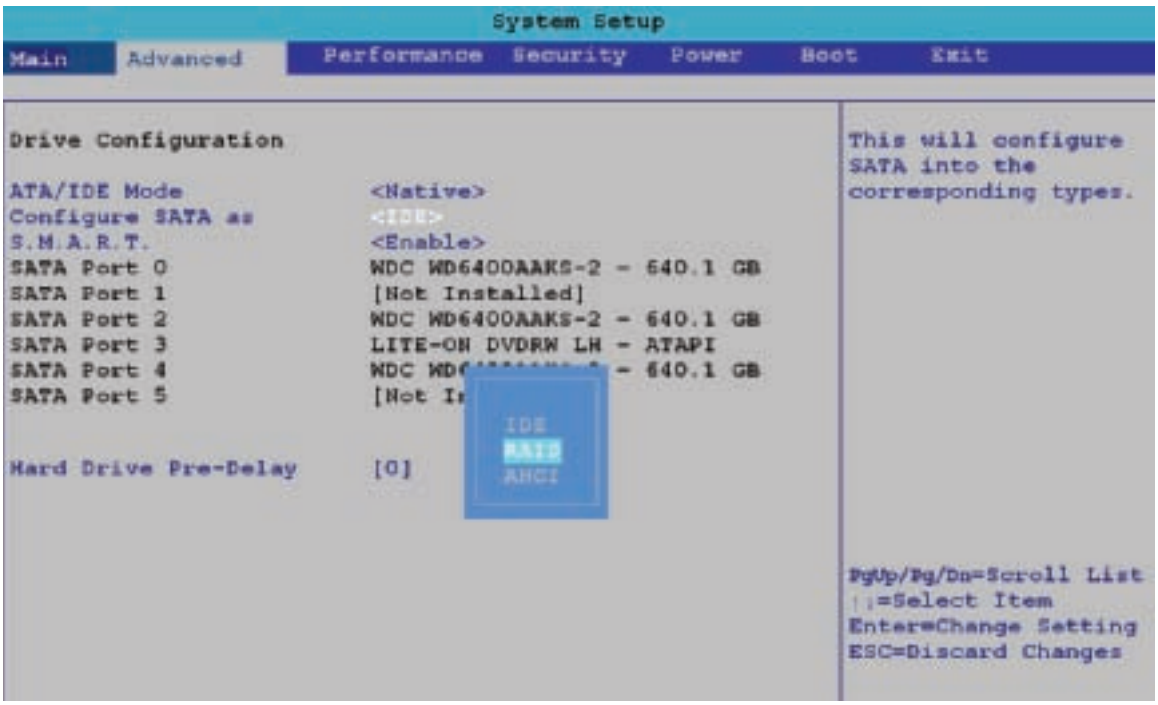

Figure 8-50 Configure SATA ports on the motherboard to enable RAID
Courtesy: Course Technology/Cengage Learning

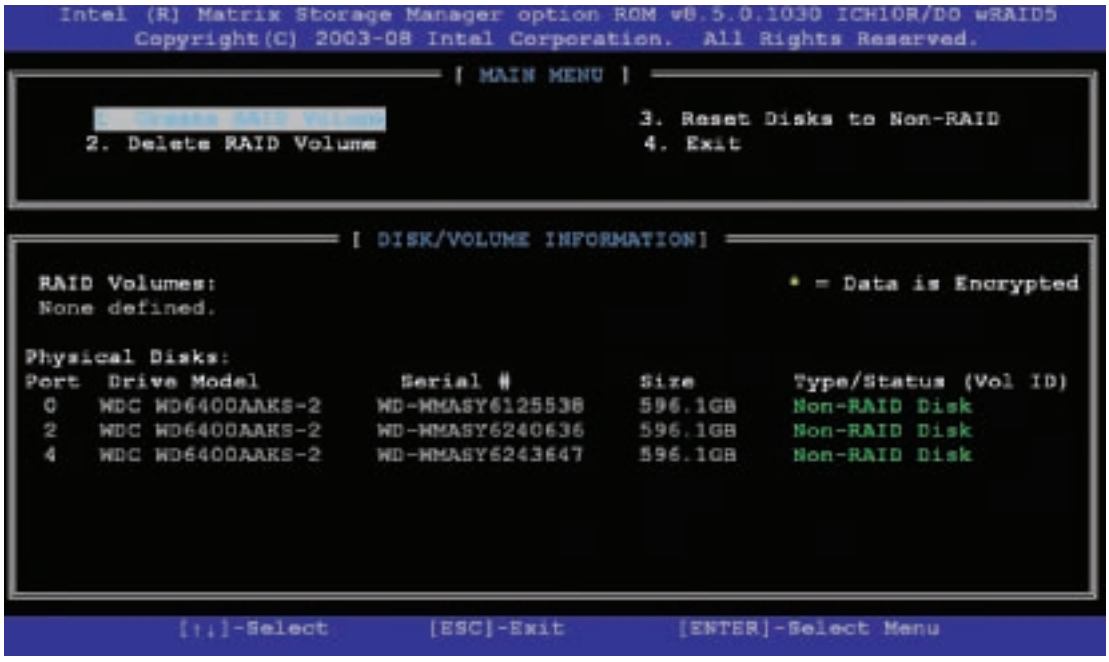

Figure 8-51 BIOS utility to configure a RAID array
Courtesy: Course Technology/Cengage Learning

Notice in the information area that the three drives are recognized and their current status is Non-RAID Disk.

4. Select option 1 to "**Create RAID Volume.**" On the next screen shown in Figure 8-52, enter a volume name (FileServer in our example).

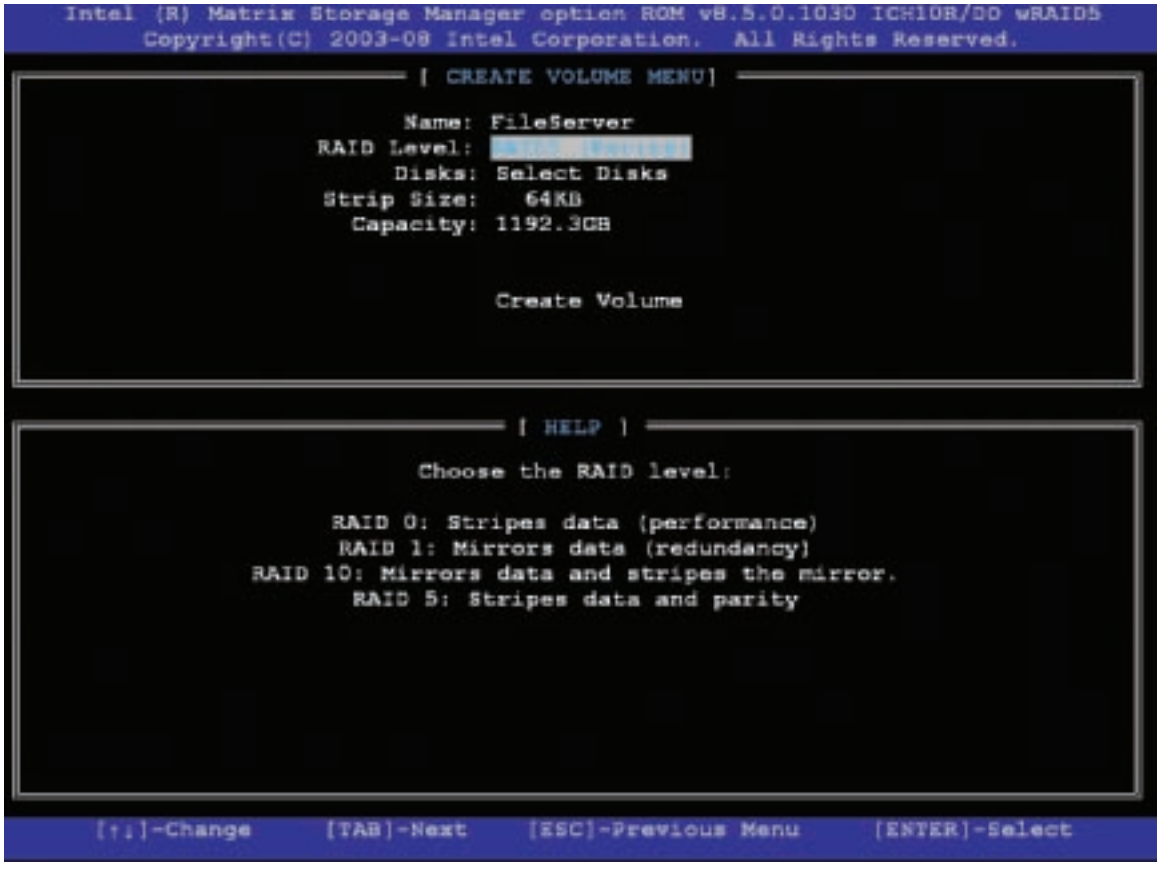

Figure 8-52 Make your choices for the RAID array
Courtesy: Course Technology/Cengage Learning

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5. Under RAID Level, select **RAID5 (Parity)**. Because we are using RAID 5, which requires three hard drives, the option to select the disks for the array is not available. All three disks will be used in the array.
6. Select the value for the Strip Size. (This is the amount of space devoted to one strip across the striped array. Choices are 32 KB, 64 KB, or 128 KB.)
7. Enter the size of the volume. The available size is shown in Figure 8-52 as 1192 GB, but you don't have to use all the available space. The space you don't use can later be configured as another array. (In this example, I entered 500 GB.)
8. Select **Create Volume** to complete the RAID configuration. A message appears warning you, that if you proceed, all data on all three hard drives will be lost. Type **Y** to continue. The array is created and the system reboots.

You are now ready to install Windows. Do the following:

1. Boot from the Windows setup CD or DVD.
2. For Windows XP, at the beginning of Windows setup, you are given the opportunity to press F6 to install a RAID or SCSI driver. Press **F6** and insert the RAID driver CD that came bundled with the motherboard. Windows Vista does not require the RAID drivers and the installation proceeds as normal. (The details of installing Windows XP and Vista are covered in Chapter 12.)

Figure 8-53 shows the Disk Management window for this system immediately after Vista was installed. Notice Vista recognizes one hard drive, which it partitioned and formatted during the installation process as drive C:. The drive C: size is 500 GB, which is the amount of space that was dedicated to the RAID array. As far as Vista knows, there is a single 500 GB hard drive. BIOS is managing the RAID array without Vista's awareness. If we install the RAID drivers that are found on the motherboard driver CD, then we can manage the RAID array from within Windows. Alternately, the RAID array can be managed from the BIOS utility by pressing Ctrl-I during the boot.

For file servers using RAID 5 that must work continuously and hold important data, it might be practical to use hardware that allows for hard drive hot-swapping, which means you can remove one hard drive and insert another without powering down the computer. However, hard drives that can be hot-swapped cost significantly more than regular hard drives. RAID hard drive arrays are sometimes used as part of a storage area network (SAN). A SAN is a network that has the primary purpose of providing large amounts of data storage.

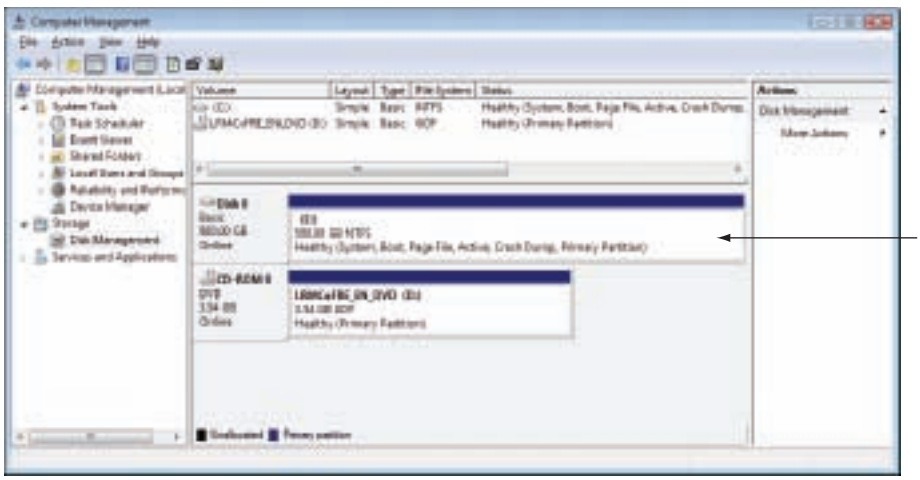

Figure 8-53 Vista Disk Management sees the RAID array as a single 500 GB hard drive
Courtesy: Course Technology/Cengage Learning

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STEPS TO INSTALL A FLOPPY DRIVE

Many computers today come with a hard drive and CD or DVD drive, but don't include a floppy drive, although the motherboard most likely has a 34-pin floppy drive connector. Most computer cases also have one or more empty bays for a 3½" floppy drive.

If you have no extra bay and want to add a floppy drive, you can attach an external drive that comes in its own case and has its own power supply. Most external drives today connect to the main system using a USB port, such as the one in Figure 8-54.

Figure 8-54 An external floppy drive uses a USB connection
Courtesy: Course Technology/Cengage Learning

Here are the steps to add or replace a floppy drive. Be sure to protect the computer against ESD as you work.

1. Turn off the computer, unplug the power cord, press the power button, and remove the cover.
2. Unplug the power cable to the old floppy drive. Steady the drive with one hand while you dislodge the power cable with the other hand. Unplug the data cable from the old drive.
3. Unscrew and dismount the drive. Some drives have one or two screws on each side that attach the drive to the drive bay. After you remove the screws, the drive usually slides to the front and out of the case. Sometimes, you must lift a catch underneath the drive as you slide the drive forward. Sometimes, the drive is installed into a removable bay. For this type of case, first unscrew the screws securing the bay (most likely these screws are on the front of the case) and remove the bay. Then unscrew and remove the drive from the bay.
4. Slide the new drive into the bay. Screw the drive down with the same screws used on the old drive. Make sure the drive is anchored so that it cannot slide forward or backward, or up or down, even if a user turns the case on its side.
5. If you are adding (not replacing) a floppy drive, connect the floppy drive data cable to the motherboard. Align the edge color of the ribbon cable with pin 1 on the motherboard connectors. Some connectors only allow you to insert the cable in one direction. Be sure the end of the cable with the twist connects to the drive and the other end to the motherboard.

Notes If your power supply doesn't have the smaller Berg connector for the floppy drive, you can buy a Molex-to-Berg converter to accommodate the floppy drive power connector.

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6. Connect the data cable and power cord to the drive. Make sure that the data cable's colored edge is connected to the pin-1 side of the connection, as shown in Figure 8-55. With some newer floppy drives, pin 1 is marked as an arrow on the drive housing (see Figure 8-56).

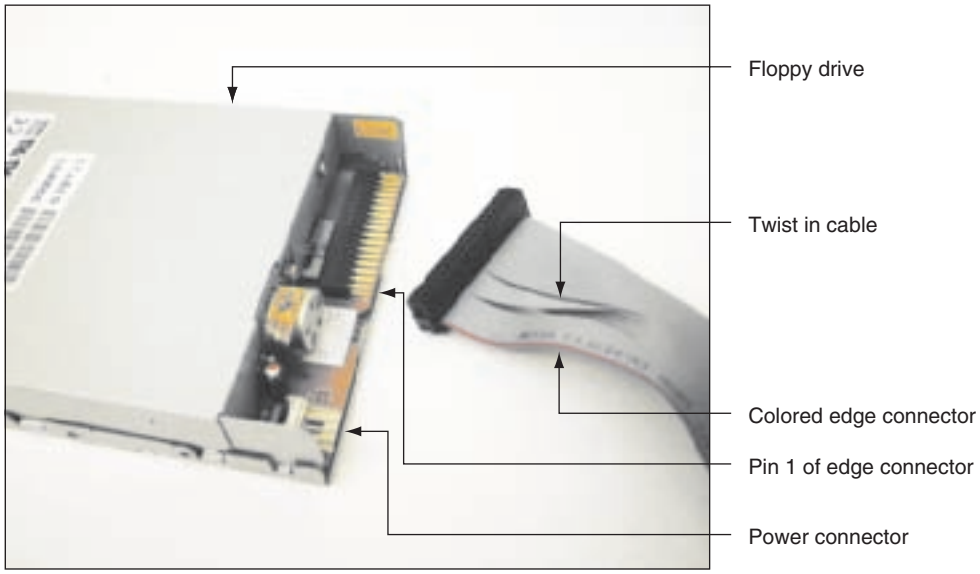

Figure 8-55 Connect colored edge of cable to pin 1
Courtesy: Course Technology/Cengage Learning

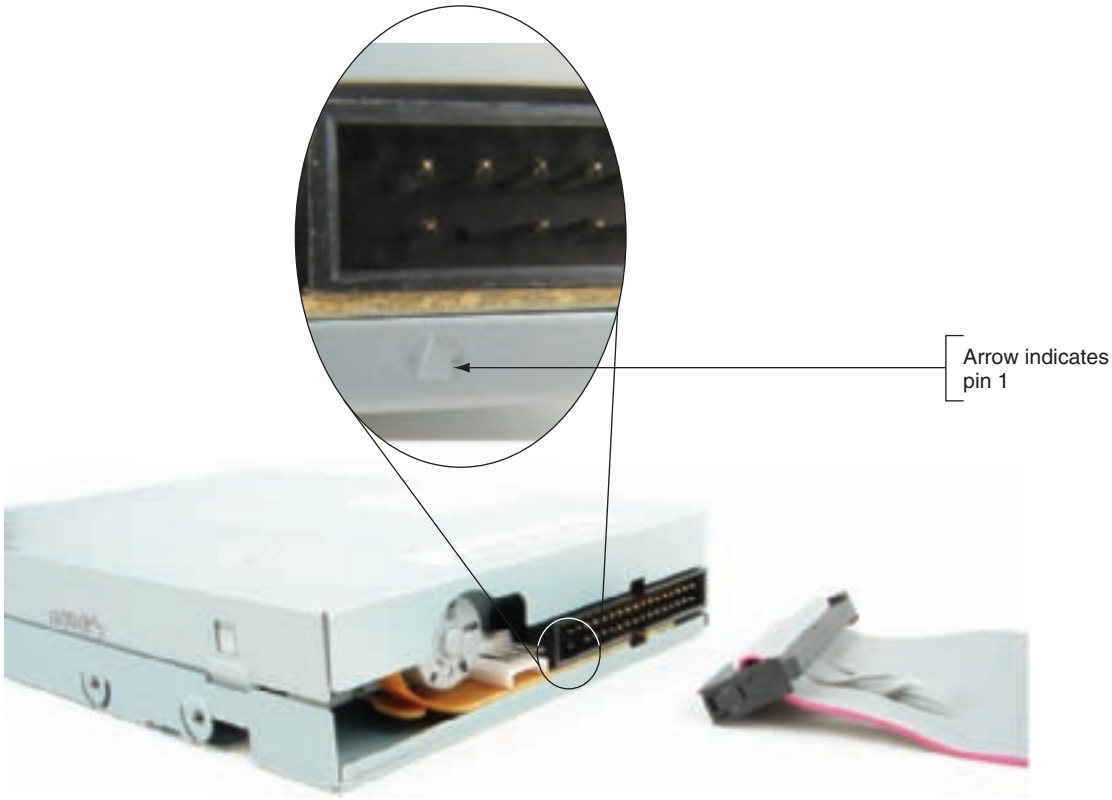

Figure 8-56 Pin 1 is marked on this floppy drive with an arrow on the drive housing
Courtesy: Course Technology/Cengage Learning

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Most connections on floppy drives are oriented the same way, so this one probably has the same orientation as the old drive. The power cable goes into the power connection in only one direction. Be careful not to offset the connection by one pin.

7. Replace the cover, turn on the computer, and enter BIOS setup to verify the drive is recognized with no errors. If you are adding (not replacing) a floppy drive, you must inform BIOS setup by accessing setup and changing the drive type. Boot to the Windows desktop and test the drive by formatting a disk or copying data to a disk.

Notes Note that you can turn on the PC and test the drive before you replace the computer case cover. If the drive doesn't work, having the cover off makes it easier to turn off the computer, check connections, and try again. Just make certain that you don't touch anything inside the case while the computer is on. Leaving the computer on while you disconnect and reconnect a cable is very dangerous for the PC and will probably damage something—including you!

TROUBLESHOOTING HARD DRIVES

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In this part of the chapter, you'll learn how to troubleshoot problems with hard drives and floppy drives. The following sections cover problems with hard drive installations, and problems that occur after the installation with hard drives and floppy drives. Problems with booting the PC caused by hard drive hardware are also covered. How to deal with problems caused by a corrupted Windows installation is covered in Chapters 15 and 16.

PROBLEMS WITH HARD DRIVE INSTALLATIONS

Sometimes, trouble crops up during an installation. Keeping a cool head, thinking things through carefully a second, third, and fourth time, and using all available resources will most likely get you out of any mess.

Installing a hard drive is not difficult, unless you have an unusually complex situation. For example, your first hard drive installation should not involve the intricacies of installing a second SCSI drive in a system that has two SCSI host adapters. Nor should you install a second drive in a system that uses an IDE connection for one drive on the motherboard and an adapter card in an expansion slot for the other drive. If a complicated installation is necessary and you have never installed a hard drive, ask for expert help.

Video Installing a Second Hard Drive

The following list describes the errors that cropped up during a few hard drive installations; the list also includes the causes of the errors, and what was done about them. Everyone learns something new when making mistakes, and you probably will, too. You can then add your own experiences to this list.

- Shawn physically installed an IDE hard drive. He turned on the machine and accessed BIOS setup. The hard drive was not listed as an installed device. He checked and discovered that autodetection was not enabled. He enabled it and rebooted. Setup recognized the drive.
- When first turning on a previously working PC, John received the following error message: "Hard drive not found." He turned off the machine, checked all cables, and

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discovered that the data cable from the motherboard to the drive was loose. He reseated the cable and rebooted. POST found the drive.

- Lucia physically installed a new hard drive, replaced the cover on the computer case, and booted the PC with a Windows setup CD in the drive. POST beeped three times and stopped. Recall that diagnostics during POST are often communicated by beeps if the tests take place before POST has checked video and made it available to display the messages. Three beeps on most computers signal a memory error. Lucia turned off the computer and checked the memory modules on the motherboard. A module positioned at the edge of the motherboard next to the cover had been bumped as she replaced the cover. She reseated the module and booted again, this time with the cover still off. The error disappeared.
- Jason physically installed a new hard drive and turned on the computer. He received the following error: "No boot device available." He forgot to insert a Windows setup CD. He put the disc in the drive and rebooted the machine successfully.
- The hard drive did not physically fit into the bay. The screw holes did not line up. Juan got a bay kit, but it just didn't seem to work. He took a break, went to lunch, and came back to make a fresh start. Juan asked others to help view the brackets, holes, and screws from a fresh perspective. It didn't take long to discover that he had overlooked the correct position for the brackets in the bay.
- Maria set the jumpers on a PATA hard drive and physically installed the drive. She booted and received the following error message: "Hard drive not present." She rechecked all physical connections and found everything okay. After checking the jumper settings, she realized that she had set them as if this were the second drive of a two-drive system, when it was the only drive. She restored the jumpers to their original state. In this case, as in most cases, the jumpers were set at the factory to be correct when the drive is the only drive.

If BIOS setup does not recognize a newly installed hard drive, check the following:

- Has BIOS setup been correctly configured for autodetection?
- Are the jumpers on the drive set correctly?
- Have the power cord and data cable been properly connected? Verify that each is solidly connected at both ends.
- Check the Web site of the drive manufacturer for suggestions, if the above steps don't solve your problem. Look for diagnostic software that can be downloaded from the Web site and used to check the drive.

A+ Exam Tip The A+ 220-702 Practical Application exam might give you a symptom and expect you to select a probable source of a problem from a list of sources. These examples of what can go wrong can help you connect problem sources to symptoms.

Caution One last warning: When things are not going well, you can tense up and make mistakes more easily. Be certain to turn off the machine before doing anything inside! Not doing so can be a costly error. For example, a friend had been trying and retrying to boot for some time, and got frustrated and careless. He plugged the power cord into the drive without turning the PC off. The machine began to smoke and everything went dead. The next thing he learned was how to replace a power supply!

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HOW TO APPROACH A HARD DRIVE PROBLEM AFTER THE INSTALLATION

After the hard drive is working, problems can arise later, such as corrupted data files, a corrupted Windows installation, or a hardware problem that causes the system to refuse to boot. In this section, you'll learn about some tools you can use to solve hard drive problems and how to approach the problem and prioritize what to do first. Then, in later sections, we'll look at some specific error messages and symptoms and how to deal with them.

START WITH THE END USER

When an end user brings a problem to you, begin the troubleshooting process by interviewing the user. When you interview the user, you might want to include these questions:

- Can you describe the problem and describe when it occurs?
- Was the computer recently moved?
- Was any new hardware or software recently installed?
- Was any software recently reconfigured or upgraded?
- Did someone else use your computer recently?
- Does the computer have a history of similar problems?
- Is there important data on the drive that is not backed up?
- Can you show me how to reproduce the problem?

After you gather this basic information, you can prioritize what to do and begin diagnosing and addressing the hard drive problems.

PRIORITIZE WHAT YOU HAVE LEARNED

If a hard drive is not functioning and data is not accessible, setting priorities helps focus your work. For most users, data is the first priority unless they have a recent backup. Software can also be a priority if it is not backed up. Reloading software from the original installation disks or CD can be time consuming, especially if the configuration is complex or software macros or scripts are on the drive and not backed up.

If a system won't boot from the hard drive, your first priority might be to recover data on the drive. Therefore, before you try to solve the hardware or Windows problem that prevents booting, consider removing the drive and installing it as a second drive in a working system. If the partition table on the problem drive is intact, you might be able to copy data from the drive to the primary drive in the working system. Then turn your attention to solving the original problem.

If you have good backups of both data and software, hardware might be your priority. It could be expensive to replace, but downtime can be costly, too. The point is, when trouble arises, determine your main priority and start by focusing on that.

BE AWARE OF AVAILABLE RESOURCES

Be aware of the resources available to help you resolve a problem:

- *User manuals* often list error messages and their meanings.
- *Installation manuals* most likely will have a troubleshooting section and list any diagnostic tools available.

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- *The Internet* can also help you diagnose hardware and software problems. Go to the Web site of the product manufacturer, and search for the FAQs (frequently asked questions) list or a support forum. It's likely that others have encountered the same problem and posted the question and answer. If you search and cannot find your answer, you can post a new question. Use a search engine such as *www.google.com* to search for the error, the hardware device, the problem, the technology used, and other keywords that can help you find useful information. Many technicians enjoy sharing what they know online, and the Internet can be a rich source of all kinds of technical information and advice. Be careful, however. Not all technical advice is correct or well intentioned.
- *Training materials* can offer insights, explain concepts and tools, and give you a general direction as to how to approach a problem.
- *Telephone, chat, or e-mail technical support* from the hardware and software manufacturers can help you interpret an error message, or it can provide general support in diagnosing a problem. Most technical support is available during working hours by telephone. Check your documentation for telephone numbers. An experienced computer troubleshooter once said, "The people who solve computer problems do it by trying something and making phone calls, trying something else and making more phone calls, and so on, until the problem is solved."
- *PartitionMagic* by Symantec (*www.symantec.com*) lets you manage partitions on a hard drive for Windows XP. You can change the size of partitions and move partitions without losing data while you work. You can switch file systems without disturbing your data, and you can hide and show partitions to secure your data. For Vista, Disk Management performs many of the same functions.
- *SpinRite* by Gibson Research (*www.grc.com*) is hard drive utility software that has been around for years. Still a DOS application without a sophisticated GUI interface, SpinRite has been updated to adjust to new drive technologies. It supports NTFS, FAT32, and SCSI drives. It can be installed and run from any bootable device, including a CD, USB drive, or floppy disk, which means that it doesn't require much system overhead. Because it is written in a language closer to the binary code that the computer understands, it is more likely to detect underlying hard drive problems than software that uses Windows, which can stand as a masking layer between the software and the hard drive. SpinRite analyzes the entire hard drive surface, performing data recovery of corrupted files and file system information. Sometimes, SpinRite can recover data from a failing hard drive when other software fails.
- *GetDataBack* by Runtime Software (*www.runtime.org*) can recover data and program files even when Windows cannot recognize the drive. It can read NTFS and FAT32 file systems and can solve problems with a corrupted partition table, boot record, or root directory.
- *Hard drive manufacturer's diagnostic software* is available for download from the Web sites of many hard drive manufacturers. For example, you can download Data Lifeguard Diagnostic for DOS from the Western Digital Web site (*www.wdc.com*), burn the software to CD, and boot from the CD (see Figure 8-57). Using the software, you can do a quick test to check Western Digital drives for physical problems or an extended test to repair any correctable problems. You can also write zeros to every sector on the drive to get a fresh start with the drive. There's also a Windows version that can be used to test a second hard drive in your system. Another similar program is SeaTools by Seagate

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Figure 8-57 Download hard drive diagnostic software from the drive manufacturer's Web site
Courtesy: Course Technology/Cengage Learning

(see Figure 8-58) that can be downloaded and used to create a bootable CD or floppy that can be used to test and analyze most ATA and SCSI drives by Seagate and other manufacturers.

Notes Always check compatibility between utility software and the operating system with which you plan to use it. One place you can check for compatibility is the service and support section of the software manufacturer's Web site.

Notes Remember one last thing: After making a reasonable and diligent effort to resolve a problem, getting the problem fixed could become more important than resolving it yourself. There comes a time when you might need to turn the problem over to a more experienced technician.

A+ Exam Tip The A+ 220-702 Practical Application exam expects you to know how to troubleshoot problems with SATA, PATA, and solid state hard drives and with floppy disk drives.

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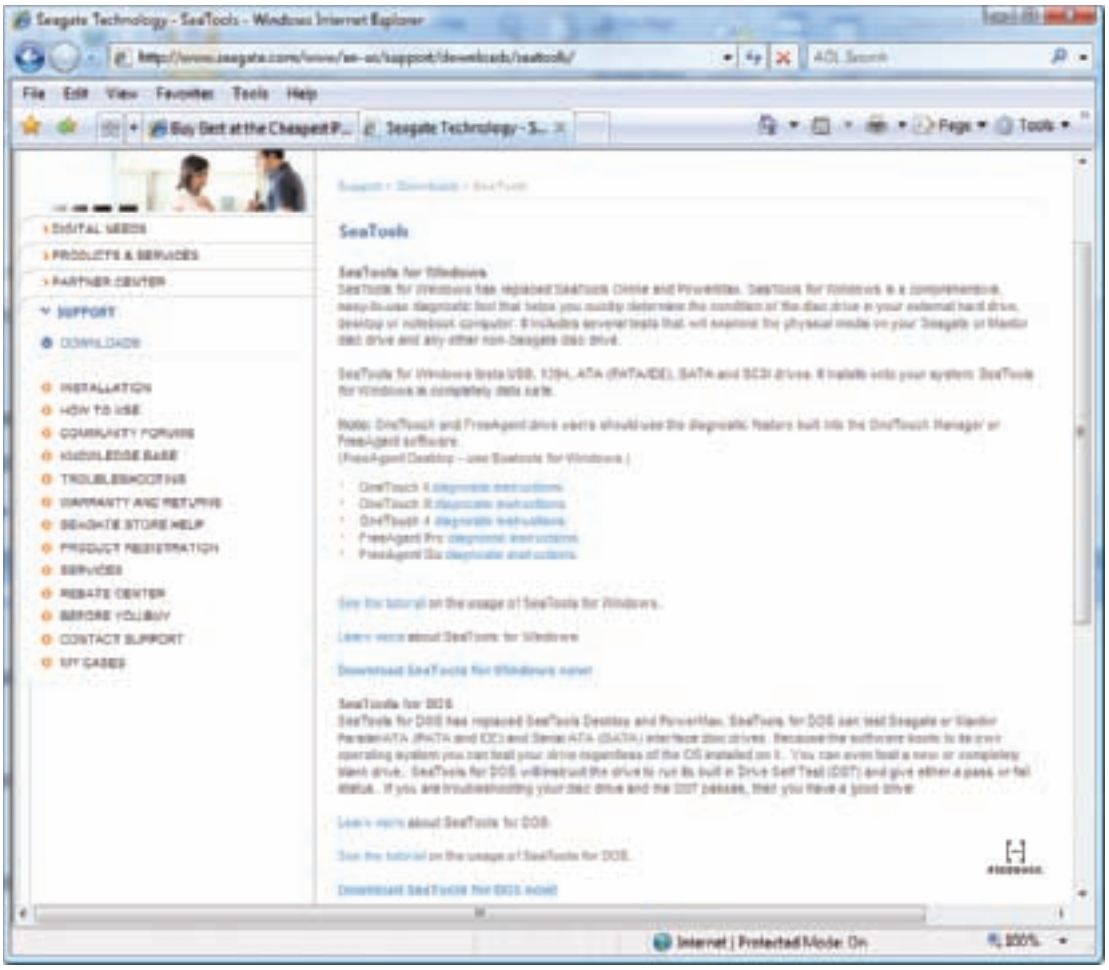

Figure 8-58 Use SeaTools by Seagate to create a diagnostic CD or floppy to test and analyze hard drives
Courtesy: Course Technology/Cengage Learning

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BOOT PROBLEMS CAUSED BY HARD DRIVE HARDWARE

In this section, we look at different problems with the hard drive that present themselves during the boot. These problems can be caused by the hard drive subsystem, by the partition table or file system on the drive, or by files required for the OS to boot. When trying to solve a problem with the boot, you need to decide if the problem is caused by hardware or software. All the problems discussed in this section are caused by hardware. In Chapters 15 and 16, you'll learn how to deal with problems that cause errors when loading the operating system and problems with missing or corrupted data files. All these type errors are caused by software.

PROBLEMS AT POST

Recall from Chapter 5 that the BIOS performs the POST at the beginning of the boot to verify that essential hardware devices are working. Hardware problems usually show up at POST, unless there is physical damage to an area of the hard drive that is not accessed during POST. Hardware problems often make the hard

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drive totally inaccessible. If BIOS cannot find a hard drive at POST, it displays an error message similar to this:

```
Hard drive not found

Fixed disk error

Invalid boot disk

Inaccessible boot device

Inaccessible boot drive

Numeric error codes in the 1700s or 10400s
```

The reasons BIOS cannot access the drive can be caused by the drive, the data cable, the electrical system, the motherboard, the controller card (if one is present), or a loose connection. Here is a list of things to do and check:

1. If BIOS displays numeric error codes or cryptic messages during POST, check the Web site of the BIOS manufacturer for explanations of these codes or messages.
2. For a RAID array, use the BIOS utility to check the status of each disk in the array and to check for errors.
3. In BIOS setup, look for the ability to disable block mode. **Block mode** speeds up access time by allowing blocks of data to be read from the drive at one time. Disabling it will slow down drive performance but might solve the problem.
4. Remove and reattach all drive cables. Check for correct pin-1 orientation.
5. If you're using a RAID, eSATA, SATA, PATA, or SCSI controller card, remove and reseat it or place it in a different slot. Check the documentation for the card, looking for directions for troubleshooting.
6. Check the jumper settings on the drive.
7. Inspect the drive for damage, such as bent pins on the connection for the cable.
8. Determine if the hard drive is spinning by listening to it or lightly touching the metal drive (with power on).
9. Check the cable for frayed edges or other damage.
10. Check the installation manual for things you might have overlooked. Look for a section about system setup, and carefully follow all directions that apply.
11. Be sure the power cable and drive data cable connections are good.
12. Check BIOS setup for errors in the hard drive configuration. If you suspect an error, set CMOS to default settings, make sure autodetection is turned on, and reboot the system.
13. Try booting from another media such as the Windows setup CD. If you can boot using another media, you have proven that the problem is isolated to the hard drive subsystem. Windows recovery tools to use from the setup CD are covered in Chapters 15 and 16.
14. Check the drive manufacturer Web site for diagnostic software. Run the software to test the drive for errors.
15. If it is not convenient to create a boot CD with hard drive diagnostic software installed, you can move the drive to a working computer and install it as a second

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drive in the system. Then you can use the diagnostic software installed on the primary hard drive to test the problem drive. While you have the drive installed in a working computer, be sure to find out if you can copy data from it to the good drive, so that you can recover any data not backed up. Note that for these temporary tests, you don't have to physically install the drive in the working system. Open the computer case. Carefully lay the drive on the case and connect a power cord and data cable (see Figure 8-59). Then turn on the PC. While you have the PC turned on, be *very careful* to not touch the drive or touch inside the case. Also, while a tower case is lying on its side like the one in Figure 8-59, don't use the CD or DVD drive.

Figure 8-59 Temporarily connect a faulty hard drive to another system to diagnose the problem and try to recover data
Courtesy: Course Technology/Cengage Learning

16. If the drive still does not boot, exchange the three field replaceable units—the data cable, the adapter card (optional), and the hard drive itself—for a hard drive subsystem. Do the following, in order:
    - Reconnect or swap the drive data cable.
    - Reseat or exchange the drive controller card, if one is present.
    - Exchange the hard drive for a known good unit.
17. If the hard drive refuses to work but its light stays on even after the system has fully booted, the problem might be a faulty controller on the hard drive or motherboard. Try replacing the hard drive. Next, try an ATA controller card to substitute for the ATA connectors on the motherboard or replace the motherboard.
18. Sometimes older drives refuse to spin at POST. Drives that have trouble spinning often whine at startup for several months before they finally refuse to spin altogether. If your drive whines loudly when you first turn on the computer, never turn off the computer. One of the worst things you can do for a drive that is having difficulty starting up is to leave the computer turned off for an extended period of time. Some drives, like old cars, refuse to start if they are unused for a long time.

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Notes You can purchase an inexpensive converter such as the one in Figure 8-60 to connect a failing PATA hard drive to a working computer using a USB port. The kit also comes with a converter for a notebook hard drive. (A PATA connector on a laptop is shorter than a desktop PATA connector.) Figure 8-61 shows a SATA to USB converter kit. The SATA connector can be used for desktop or laptop hard drives because a SATA connector is the same for both. These ATA to USB converters are really handy when troubleshooting problems with hard drives that refuse to boot.

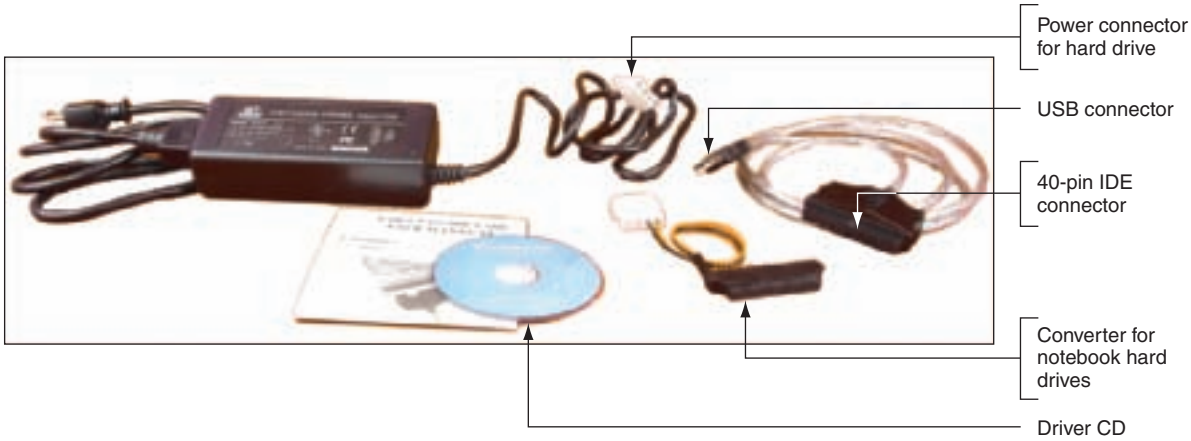

Figure 8-60 Use an IDE to USB converter for diagnostic testing and to recover data from a failing PATA hard drive
Courtesy: Course Technology/Cengage Learning

Figure 8-61 Use a SATA to USB converter to recover data from a drive using a SATA connector
Courtesy: Course Technology/Cengage Learning

A bad power supply or a bad motherboard also might cause a disk boot failure. If the problem is solved by exchanging one of the field replaceable units listed, you still must reinstall the old unit to verify that the problem was not caused by a bad connection.

BUMPS ARE BAD!

The read/write heads at the ends of the read/write arms on a hard drive get extremely close to the platters, but do not actually touch them. This minute clearance between the heads

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and platters makes hard drives susceptible to destruction. Should a computer be bumped or moved while the hard drive is operating, a head can easily bump against the platter and scratch the surface. Such an accident causes a "hard drive crash," often making the hard drive unusable.

If the head mechanism is damaged, the drive and its data are probably total losses. If the first tracks that contain the partition table, boot record, MFT (for the NTFS file system), or root directory are damaged, the drive could be inaccessible, although the data might be unharmed.

Here's a trick that might work for a hard drive whose head mechanism is intact but whose first few tracks are damaged. First, find a working hard drive that has the same partition table information as the bad drive. Take the computer case off, place the good drive on top of the bad drive housing, and connect a spare power cord and the ATA data cable to the good drive. Leave a power cord connected to the bad drive. Boot from a bootable CD or floppy disk. No error message should show at POST. Access the good drive by entering C: at the command prompt. The C prompt should show on the monitor screen.

Without turning off the power, gently remove the data cable from the good drive and place it on the bad drive. Do not disturb the power cords on either drive or touch chips on the drive logic boards. Immediately copy the data you need from the bad drive to another media, using the Copy command. If the area of the drive where the data is stored, the FAT or MFT, and the directory are not damaged, this method should work.

Here's another trick for an older hard drive having trouble spinning when first turned on. Remove the drive from the case, hold it firmly in both hands, and give the drive a quick and sudden twist that forces the platters to turn inside the drive housing. Reinstall the drive. It might take several tries to get the drive spinning. After the drive is working, immediately make a backup and plan to replace the drive soon.

INVALID DRIVE OR DRIVE SPECIFICATION

If you get the error message "Invalid drive or drive specification," the system BIOS cannot read the partition table information. You'll need to boot from the Windows setup CD or DVD and check the partition table. How to do that is covered in Chapters 15 and 16.

BAD SECTOR ERRORS

Track and sector markings on a drive sometimes "fade" off the hard drive over time, which causes "bad sector" errors to crop up. These errors can also occur if an area of the drive has become damaged. Do not trust valuable data to a drive that has this kind of trouble. Plan to replace the drive soon. In the meantime, make frequent backups and leave the power on. You'll learn more about this and other software errors in later chapters.

SOLID STATE DRIVES

Recall that solid state drives have no moving parts, so you don't have to be concerned with bumping the drive while it is in use. They might come from the factory already partitioned and formatted using the NTFS file system, or you might have to format them yourself. If the drive gives errors, try using diagnostic software specific for this drive if it is available from the drive manufacturer. Also check the support section of the Web site for troubleshooting tips. SATA and PATA connections and BIOS settings for solid state drives look and work the same as for other drives.

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TROUBLESHOOTING FLOPPY DRIVES AND DISKS

Table 8-5 lists errors that occur during and after the boot with the floppy drive or disks.

Problem or Error Message	What to Do About It
During the boot, numeric error messages in the 600 range or text error messages about the floppy drive appear on-screen.	◢ The floppy drive did not pass POST, which can be caused by problems with the drive, data cable, or motherboard. Check power and data cable connections. ◢ Try a different power cord. ◢ Check BIOS setup and reboot. ◢ Replace the drive.
Cannot read from a floppy disk	◢ The disk is not formatted. Try a different disk or try formatting this disk. ◢ The shuttle window on the floppy disk cannot open fully. ◢ The disk is inserted incorrectly. ◢ Something is lodged inside the disk's plastic housing. Check the shuttle window. ◢ Does the drive light come on? BIOS setup might be wrong, or the command you're using is wrong.
Non-system disk or disk error. Replace and strike any key when ready. No operating system found Missing NTLDR Invalid system disk Invalid boot disk	◢ You are trying to boot from a disk that is not bootable. Try a different disk or remove the disk and boot from the hard drive.
Not ready reading drive A:, Abort, Retry, Fail?	◢ The disk in drive A is not readable. Try formatting the disk.
General failure reading drive A:, Abort, Retry, Fail?	◢ The disk is badly corrupted or not yet formatted.
Track 0 bad, disk not usable	◢ The disk is bad or you are trying to format it using the wrong parameters on the Format command.
Write-protect error writing drive A:	◢ The disk is write-protected and the application is trying to write to it. Close the switch shown in Figure 8-62.
Bad sector or sector not found reading drive A, Abort, Retry, Ignore, Fail?	◢ Sector markings are corrupted or fading. Press I to ignore that sector and move on. Don't trust this disk with important data.

Table 8-5 Floppy drive and floppy disk errors that can occur during and after the boot

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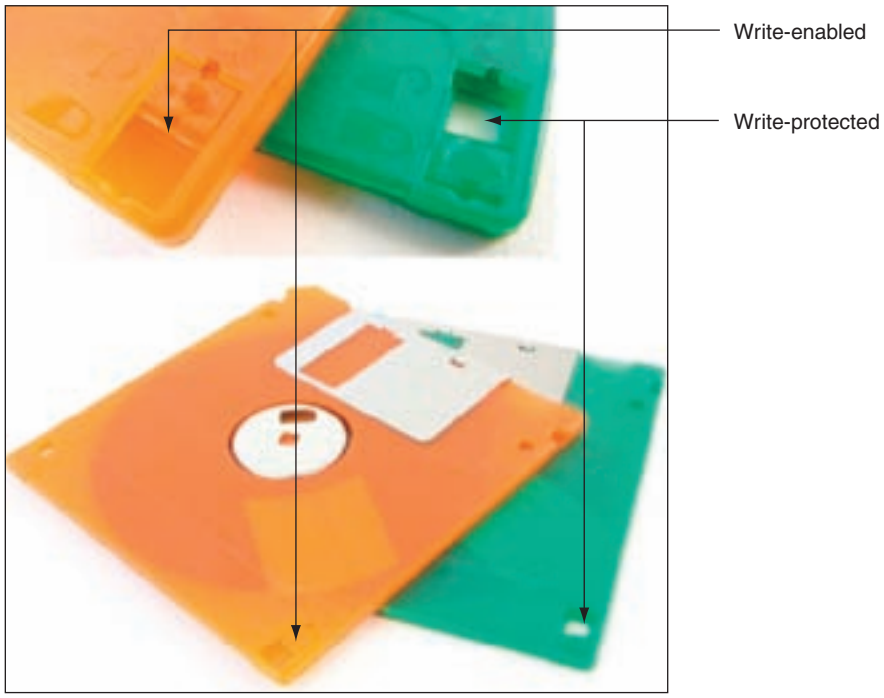

Figure 8-62 For you to write to a disk, the write-protect notch must be closed
Courtesy: Course Technology/Cengage Learning

>> CHAPTER SUMMARY

- A hard disk drive (HDD) comes in two sizes: 3.5" for desktop computers, and 2.5" for laptops.
- A hard drive can be a magnetic drive, a solid state drive, or a hybrid drive. A solid state drive is more expensive, faster, more reliable, and uses less power than a magnetic drive.
- A hard drive is low-level formatted at the factory where track and sector markings are written to the drive. Drive capacity is measured in GB or TB.
- When Windows prepares a drive as a basic disk, it installs a Master Boot Record (MBR) which contains a partition table and a master boot program.
- A primary partition is also called a volume, simple volume, or basic volume. An extended partition can have more than one logical drive.
- Two file systems used for hard drives are FAT32 (the older system) and NTFS (the newer system).
- Most hard drives use the ATA interface standards. The two main categories of ATA are parallel ATA and serial ATA. Serial ATA is easier to configure and better performing than PATA. External SATA ports are called eSATA ports.
- S.M.A.R.T. is a self-monitoring technology whereby the BIOS monitors the health of the hard drive and warns of an impending failure.
- ATAPI standards are used by optical drives and other drives that use the ATA interface on a motherboard or controller card.
- Several PATA standards are Fast ATA, Ultra ATA, Ultra ATA/66, Ultra ATA/100, and Ultra ATA/133.

- Three SATA standards provide data transfer rates of 1.5 Gb/sec, 3.0 Gb/sec, and 6.0 Gb/sec. Currently, the second standard is the most popular and is sometimes called SATA-300.
- SCSI is an interface standard for high-end hard drives used in servers.
- RAID technology uses an array of hard drives used to provide fault tolerance and/or improvement in performance.
- Today's floppy disks are 3½", high-density disks that hold 1.44 MB of data.
- When selecting a hard drive, consider the capacity of the drive, the spindle speed (for magnetic drives), the interface standard used, the cache or buffer size, and the average seek time. Also, solid state or hybrid drives are faster than magnetic drives.
- SATA drives require no configuration and are installed using a power cord and a single SATA data cable.
- PATA drives require you to set a jumper to determine if the drive will be the master or slave on a single cable. The PATA cable can accommodate two drives. A PATA motherboard has two PATA connectors for a total of four PATA drives in the system.
- After a hard drive is installed, verify it is recognized by BIOS and then use Windows to partition and format the drive. Solid state drives might be preformatted using the NTFS file system.
- Hardware RAID can be implemented by the motherboard or a RAID controller card. Software RAID is implemented by Vista or Windows XP. Best practice is to use hardware RAID rather than software RAID.
- After a floppy disk drive is installed, you must configure the drive in BIOS setup.

>> KEY TERMS

For explanations of key terms, see the Glossary near the end of the book.

80-conductor IDE cable
active partition
ANSI (American National Standards Institute)
ATAPI (Advanced Technology Attachment Packet Interface)
autodetection
basic disk
block mode
boot record
boot sector
cluster
DMA (direct memory access) transfer mode
drive image
EIDE (Enhanced IDE)
extended partition
external SATA (eSATA)
FAT12
fault tolerance
file allocation table (FAT)
file allocation unit
file system
floppy disk drive (FDD)
formatting
hard disk drive (HDD)
hard drive
head
high-level formatting
host adapter
hot-plugging
hot-swapping
hybrid hard drives
Integrated Device Electronics
Logical Unit Number (LUN)
logical drives
low-level formatting
magnetic hard drive
mirrored volume
New Technology file system (NTFS)
operating system formatting
parallel ATA
PIO (Programmed Input/Output) transfer mode
primary partition
RAID (redundant array of inexpensive disks or redundant array of independent disks)
RAID 0
RAID 1
RAID 5
RAID-5 volumes
read/write head
ReadyDrive
SCSI ID
SCSI host adapter card
serial ATA (SATA)
serial ATA cable
serial attached SCSI (SAS)
simple volume
S.M.A.R.T. (Self-Monitoring Analysis and Reporting Technology)
solid state device (SSD)
solid state drive (SSD)
spanning
striped volume
terminating resistor
volume

>> REVIEWING THE BASICS

1. What are the two common sizes for hard drives?
2. Why is a solid state drive referred to as solid state?
3. If a magnetic drive has four platters, how many heads does it have?
4. What is the name of the Vista technology that supports a hybrid drive?
5. When the OS addresses the sectors on a hard drive as one long list of sequential sectors, what is this technology called?
6. What are the main two components of the Master Boot Record on a hard drive?
7. What is the smallest unit of space on a hard drive that can be used to store a file?
8. What two file systems can Windows use to format a hard drive? Which system supports the most storage capacity?
9. Which ATA standard for hard drives first introduced S.M.A.R.T.?
10. Which ATA standard is the latest standard that made improvements to PATA?
11. A CD drive that uses a PATA connection must follow what standard?
12. How many pins does a PATA cable have? What is the maximum recommended length of a PATA cable?
13. What transfer mode can transmit data from a device to memory without involving the CPU?
14. What term describes the technology that allows you to exchange a hard drive without powering down the system?
15. Which RAID level mirrors one hard drive with a second drive so that the same data is written to both drives?
16. Which RAID level stripes data across multiple drives to improve performance and also provides fault tolerance?
17. How many pins does a floppy drive cable have?
18. Which file system does a floppy disk use?
19. What are three current ratings for spindle speed for a magnetic hard drive?
20. What Windows utility can be used to partition and format a hard drive?
21. What are the four possible configurations for a PATA drive installed in a system?
22. If a motherboard has one blue IDE connector and one black IDE connection, which do you use to install a single drive?
23. When implementing RAID on a motherboard, where do you enable the feature?
24. To write to a floppy disk, is it necessary for the write-protect notch to be open or closed?
25. What is the name of the Seagate utility that can be used to test a hard drive and diagnose a hard drive problem?

>> THINKING CRITICALLY

1. You install a hard drive and then turn on the PC for the first time. You access BIOS setup and see that the drive is not recognized. Which of the following do you do next?
   a. Turn off the PC, open the case, and verify that memory modules on the motherboard have not become loose.
   b. Turn off the PC, open the case, and verify that the data cable and power cable are connected correctly and jumpers on the drive are set correctly.
   c. Verify that BIOS autodetection is enabled.
   d. Reboot the PC and enter BIOS setup again to see if it now recognizes the drive.
2. Most motherboards that use SATA connectors have at least one PATA connector on the board. What is the most important reason this PATA connector is present?
   a. The hard drive used for booting the OS must use a PATA connector.
   b. The IDE controller will not work without at least one PATA connector.
   c. The board can accommodate older hard drives using the PATA connector.
   d. The PATA connector can be used for EIDE drives such as a CD or DVD drive.
3. You want to set up your desktop system to use a solid state drive, but the only solid state drives you can find are 2.5" drives intended for laptops. Which of the following do you do?
   a. Buy a laptop computer with a solid state drive.
   b. Buy a bay adapter that will allow you to install a 2.5" drive in a desktop case bay.
   c. Flash BIOS so that your system will support a laptop hard drive.
   d. Use a special SATA controller card that will support a laptop hard drive.

>> HANDS-ON PROJECTS

PROJECT 8-1: Examining the BIOS Setting for a Hard Drive

From the BIOS setup information on your computer, write down or print all the BIOS settings that apply to your hard drive. Explain each setting that you can. What is the size of the installed drive?

PROJECT 8-2: Selecting a Replacement Hard Drive

Suppose the 640-GB Western Digital hard drive installed in the RAID array and shown in Figure 8-49 has failed. Search the Internet and find a replacement drive as close to this drive as possible. Print three Web pages showing the sizes, features, and prices of three possible replacements. Which drive would you recommend as the replacement drive and why?

PROJECT 8-3: Preparing for Hard Drive Hardware Problems

1. Boot your PC and make certain that it works properly. Turn off your computer, remove the computer case, and disconnect the data cable to your hard drive. Turn on the computer again. Write down the message that you get.

2. Turn off the computer and reconnect the data cable. Reboot and make sure the system is working again.
3. Turn off the computer and disconnect the power supply cord to the hard drive. Turn on the computer. Write down the error that you get.
4. Turn off the computer, reconnect the power supply, and reboot the system. Verify the system is working again.

PROJECT 8-4: Researching with the Internet

Suppose a friend has asked you to install an old hard drive in his computer. The drive is the Maxtor Quantum Fireball Plus AS 20.5-GB hard drive. You want the drive to be the slave drive, and you know that you must change the current jumper settings. The four jumpers on the drive are labeled *DS, CS, PK*, and *Rsvd*. The description of the jumpers doesn't tell you how to set the jumpers so the drive is the slave. The documentation is not available. What do you do?

The best solution is to use the Internet to access the drive manufacturer's Web site for this information. In this case, the site is *www.maxtor.com*. Use this example or some other example given by your instructor to determine the correct settings for the jumpers.

PROJECT 8-5: Researching Floppy Drives on the Internet

Use the Internet to answer the following questions:

- What is the price of an internal floppy drive?
- What kind of connections do external floppy disk drives use? What is the price of an external drive?
- Why do you think external drives cost more than internal drives? What are the advantages of external drives? Internal drives?

PROJECT 8-6: Installing a Hard Drive

In a lab that has one hard drive per computer, you can practice installing a hard drive by removing a drive from one computer and installing it as a second drive in another computer. When you boot up the computer with two drives, verify that both drives are accessible in Windows Explorer. Then remove the second hard drive, and return it to its original computer. Verify that both computers and drives are working.

>> REAL PROBLEMS, REAL SOLUTIONS

REAL PROBLEM 8-1: Data Recovery Problem

Your friend has a Windows XP desktop system that contains important data. He frantically calls you to say that when he turns on the computer, the lights on the front panel light up and he can hear the fan spin for a moment and then all goes dead. His most urgent problem is the data on his hard drive, which is not backed up. The data is located in several folders on the drive. What is the quickest and easiest way to solve the most urgent problem, recovering the data? List the major steps in that process.

REAL PROBLEM 8-2: Salvaging Valuable Data on a Floppy Disk

On the job as a PC repair technician at a local university, a distraught student comes to you in a panic. Susan shows you the plastic housing of her floppy disk has been chipped and cracked so she can't insert it into a floppy disk drive. The problem is it holds her only copy of her term paper that is due tomorrow! She desperately needs your help.

You examine the floppy disk and confirm that, yes, the housing is completely destroyed. You ask her how that happened and she begins to turn red as she describes a very vindictive little brother. You begin to feel sorry for her and decide to take the time to help. You notice the disk inside the housing appears to be in good shape. Can you remove the disk from the floppy disk housing and carefully place it in a new housing so she can insert it in a floppy disk drive? Test your theory by removing a floppy disk that has data written to it from one housing, putting it into another housing, and then reading the data on the disk.

REAL PROBLEM 8-3: Using Hardware RAID

You work as a PC technician for a boss who believes you are really bright and can solve just about any problem he throws at you. Folks in the company have complained one time too many that the file server downtime is just killing them, so he asks you to solve this problem. He wants you to figure out what hardware is needed to implement hardware RAID for fault tolerance. Here are the first steps you take:

1. You check the file server's configuration and discover it has a single hard drive using a serial ATA connection with Windows Server 2003 installed. There are four empty bays in the computer case and four extra 4-pin power cords.
2. You discover the server's motherboard has an empty PCIe x4 slot. You think the slot might accommodate a RAID controller.
3. After doing a little searching on the Web, you find the Intel RAID Controller SASMF8I (*http://www.intel.com/products/server/raid-controllers/sasmf8i/sasmf8i-overview.htm*). You think it might work.
4. The next steps are to read the documentation about this controller, and then decide on which RAID configuration you should use and how many and what kind of hard drives you should buy.

Complete the investigation and do the following:

1. Decide what hardware you must purchase and print Web pages showing the products and their cost.
2. What levels of RAID does this controller support? Which RAID level is best to use? Print any important information in the RAID controller documentation that supports your decisions. If you prefer, you can recommend a different RAID controller.
3. What is the total hardware cost of implementing RAID? Estimate how much time you think it will take for you to install the devices and test the setup.