CHAPTER 6

Supporting Hard Drives

In this chapter, you will learn:

- About the technologies used inside a hard drive and how a computer communicates with a hard drive
- How to select and install a hard drive
- About tape drives and floppy drives

The hard drive is the most important permanent 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 the techniques for communication between the computer and hard drive continue to improve.

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. You'll learn how to select and install the different types of hard drives and tape drives, and you'll learn enough about floppy drives so that you can support these really old storage devices.

HARD DRIVE TECHNOLOGIES AND INTERFACE STANDARDS

A+ 220-801 1.5, 1.7, 1.11

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. See Figure 6-1. In addition, a smaller 1.8" size hard drive (about the size of a credit card) is used in some low-end laptops and other equipment such as MP3 players.

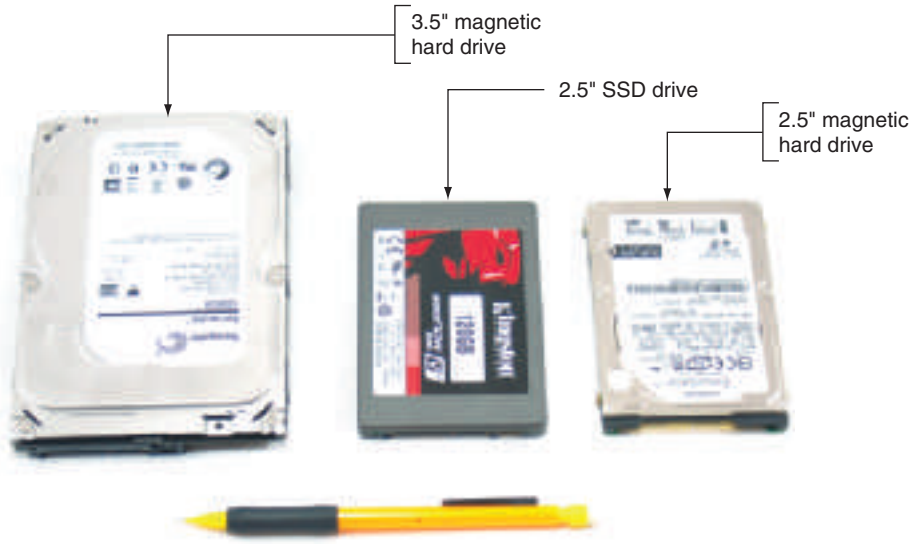


Figure 6-1 A hard drive for a desktop is larger than those used in laptops

In this part of the chapter, you learn about the technologies used inside a hard drive and about the various standards, cables, and connectors a drive might use to interface with the computer.

TECHNOLOGIES USED INSIDE A HARD DRIVE

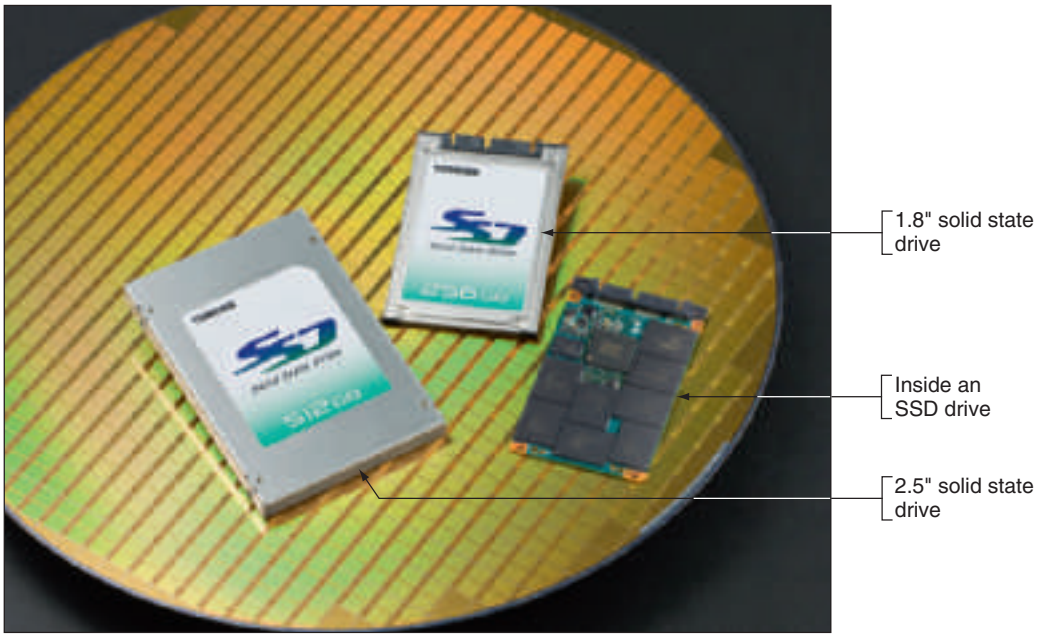
The two types of hardware technologies used inside the drive are solid state and magnetic. In addition, some drives use a combination of both technologies. Here are important details about each:

- ***Solid state drive.*** 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 memory, which is similar to that used for USB flash drives. Recall that this type of memory does not lose its data even after the power is turned off.

  In an SSD drive, flash memory is stored on EEPROM (Electronically Erasable Programmable Read Only Memory) chips inside the drive housing. The chips contain grids of rows and columns with two transistors at each intersection that hold a zero or one bit. One of these transistors is called a floating gate and accepts the zero or one state according to a logic test called NAND (stands for "Not AND"). Therefore, the memory in an SSD is called **NAND flash memory**. EEPROM chips are limited as to the number of times transistors can be reprogrammed. Therefore, the lifespan of an SSD drive is based on the number of write operations to the drive. (The number of read operations does not affect the lifespan.) For normal desktop or laptop computers, an SSD is rated to last for over 200 years. For high-use servers, the lifespan of an SSD is considerably shorter.

A+ 220-801 1.5, 1.7, 1.11

Because flash memory is expensive, solid state drives are much more expensive than magnetic hard drives, but they are faster, more reliable, last longer, and use less power than magnetic drives. Figure 6-2 shows two sizes of solid state drives (2.5" and 1.8") and what the inside of an SSD hard drive looks like.



Courtesy of Toshiba America Electronic Components

Figure 6-2 Solid state drives by Toshiba

- ***Magnetic hard drive.*** 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 (see Figure 6-3). All the

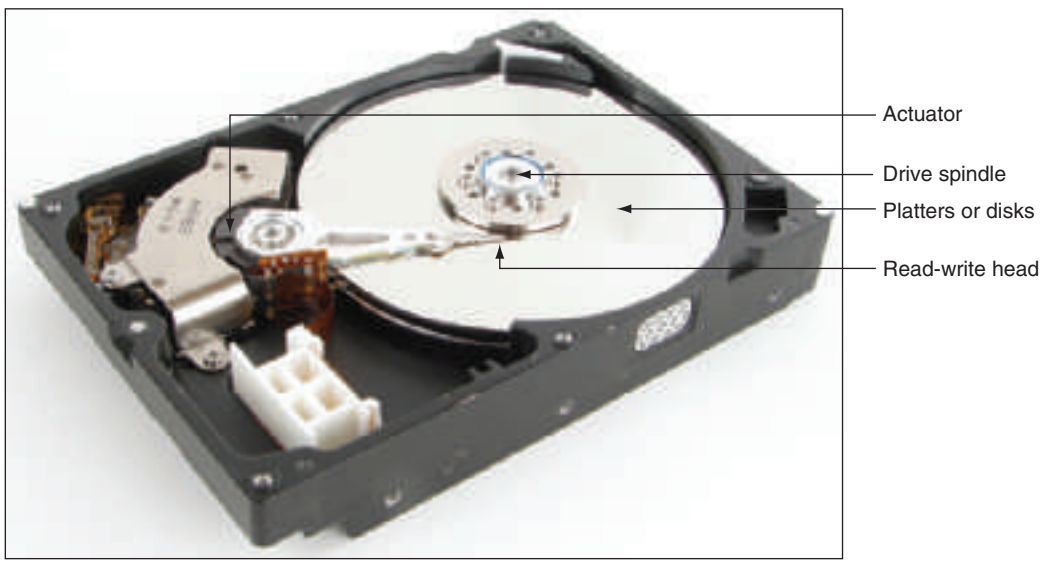


Figure 6-3 Inside a magnetic hard drive

A+ 220-801 1.5, 1.7, 1.11

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. The spindle rotates at 5400, 7200, 10,000, or 15,000 RPM (revolutions per minute). The faster the spindle, the better performing the drive.

Data is organized on a magnetic hard drive in concentric circles, called tracks (see Figure 6-4). Each track is divided into segments called sectors (also called records). Older hard drives used sectors that contained 512 bytes. Most current hard drives use 4096-byte sectors.

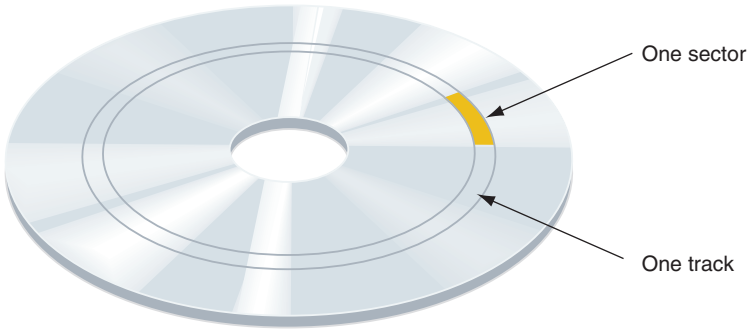


Figure 6-4 A hard drive or floppy disk is divided into tracks and sectors; several sectors make one cluster

- ***Hybrid hard drives.*** Some hard drives are **hybrid hard drives**, using both technologies. The flash component is used as a buffer to improve drive performance. Some hybrid drives perform just as well as an SSD drive. For a hybrid drive to function, the operating system must support it. Windows 7/Vista technology that supports a hybrid drive is called **ReadyDrive**.

Video
Inside a Hard Drive

Before an SSD or magnetic drive leaves the factory, sector markings are written to it in a process called **low-level formatting**. (This formatting is different from the high-level formatting that Windows does after a drive is installed in a computer.) The hard drive firmware, BIOS, and the OS use a simple sequential numbering system called logical block addressing (LBA) to address all the sectors on the drive.

The size of each sector and the total number of sectors on the drive determine the drive capacity. Today's drive capacities are usually measured in GB (gigabytes) or TB (terabytes, each of which is 1024 gigabytes). Magnetic drives are generally much larger in capacity than SSD drives.

You need to be aware of one more technology supported by both SSD and magnetic hard drives called **S.M.A.R.T. (Self-Monitoring Analysis and Reporting Technology)**, which is used to predict when a drive is likely to fail. System BIOS uses S.M.A.R.T. to monitor drive performance, temperature, and other factors. For magnetic drives, it monitors disk spin-up time, distance between the head and the disk, and other mechanical activities of the drive. Many SSD drives report to the BIOS the number of write operations, which is the best measurement of when the drive might 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.

A+ 220-801 1.5, 1.7, 1.11

Notes Malware has been known to give false S.M.A.R.T. alerts.

So now let's look at how the drive's firmware or controller communicates with the motherboard.

INTERFACE STANDARDS USED BY A HARD DRIVE

Video Identifying Drives

The interface standards between the hard drive and the motherboard have evolved over time, and there are competing standards, which can make for a confusing mess of standards. To help keep them all straight, use Figure 6-5 as your guideline for the standards used by internal drives.

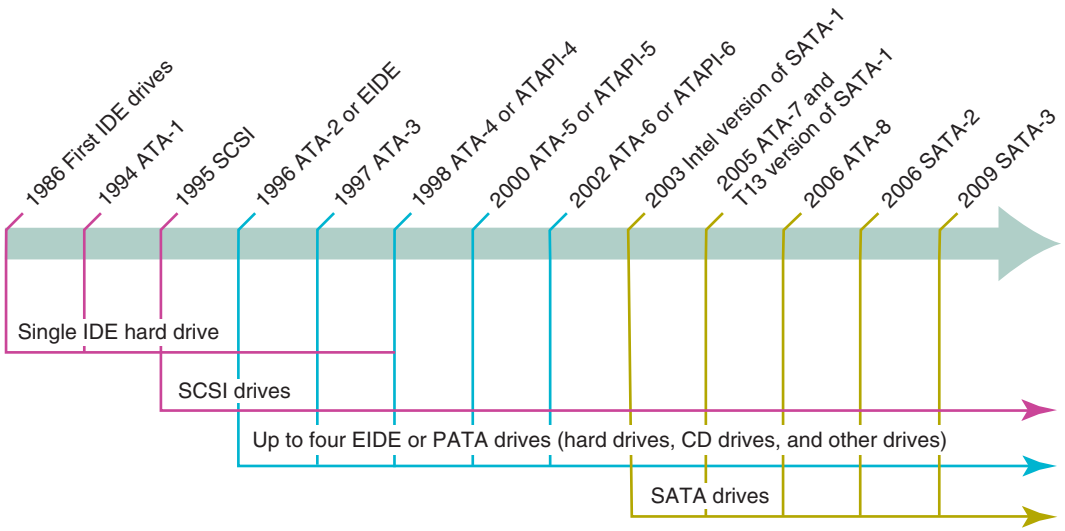
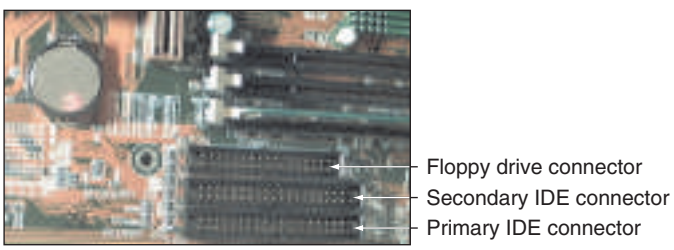


Figure 6-5 Timeline of interface standards used by internal drives

The two most popular internal drive interfaces are Parallel ATA (PATA) and Serial ATA (SATA). **Parallel ATA** or **PATA** (pronounced "pay-ta"), also called the **IDE (Integrated Drive Electronics)** standard, is older and slower than SATA. PATA allows for one or two IDE connectors on a motherboard, each using a 40-pin data cable (see Figure 6-6).



(A)(B)

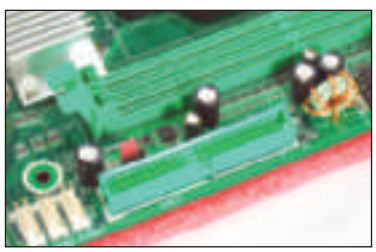


Figure 6-6 (a) A really old motherboard has two IDE connectors and one floppy drive connector
(b) A not-so-old motherboard with one IDE connector

A+ 220-801 1.5, 1.7, 1.11

The **serial ATA or SATA** (pronounced "say-ta") standard uses a serial data path, and a SATA data cable can accommodate only a single SATA drive (see Figure 6-7). New motherboards sold today use only SATA connections, but you still might see many older boards that use a combination of SATA and IDE on the same board or use all IDE connections. A third internal interface standard is SCSI (pronounced "scuzzy").

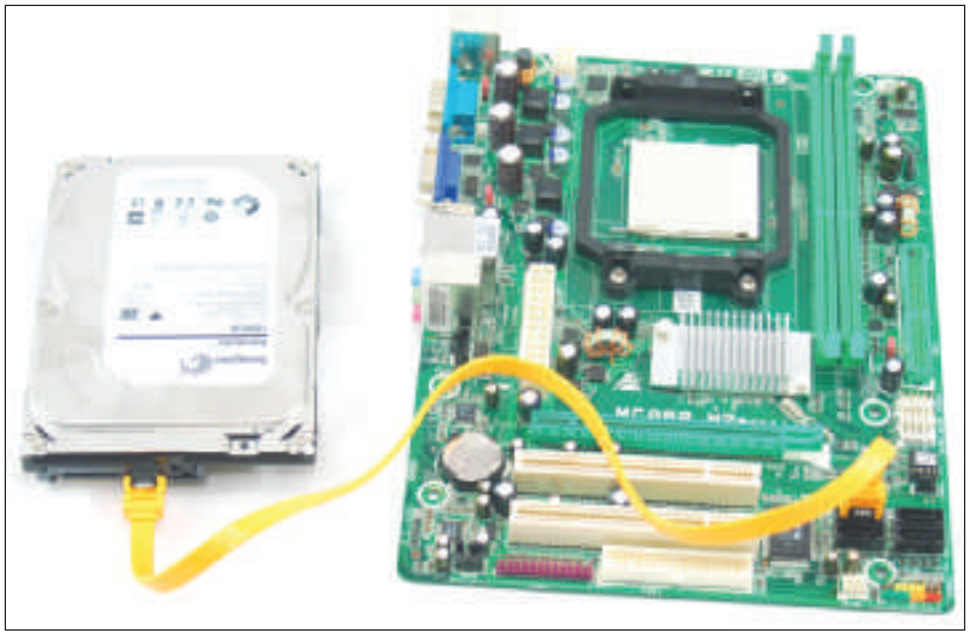


Figure 6-7 A SATA cable connects a single SATA drive to a motherboard SATA connector

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. The external standards are discussed in Chapter 8, and internal interface standards are covered in this chapter.

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

Interface 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 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 have undergone several revisions, which are summarized in Table 6-1.

Notes Remember from Chapter 5 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.

A+ 220-801 1.5, 1.7, 1.11

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, SATA I, SAS STP	Parallel transfer speeds up to 133 MB/sec SATA 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 Tunnelling Protocol).
ATA/ATAPI-8*	N/A	Defined hybrid drives and SATA II. No new revisions of ATA/ATAPI are expected because PATA is retired.

*Name assigned by the T13 Committee

Table 6-1 Summary of ATA interface standards for storage devices

A+ Exam Tip The A+ 220-801 exam expects you to know the speeds used by the IDE interfaces.

Let's now look first at the PATA or IDE standards and then we'll discuss the SATA standards. Finally, you'll learn about SCSI, a less used interface standard.

PARALLEL ATA OR EIDE DRIVE STANDARDS

PATA or IDE drives use ribbon cables that can accommodate one or two drives, as shown in Figure 6-8. A motherboard can have one or two IDE connectors for up to four PATA devices in the system using two data cables. All PATA standards since ATA-2 support this configuration of four IDE devices in a system, which is called the **Enhanced IDE (EIDE)** standard.

An optical 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 or DVD drive, know that the text means the drive connects to the motherboard using an IDE connector or header.

A+ 220-801 1.5, 1.7, 1.11

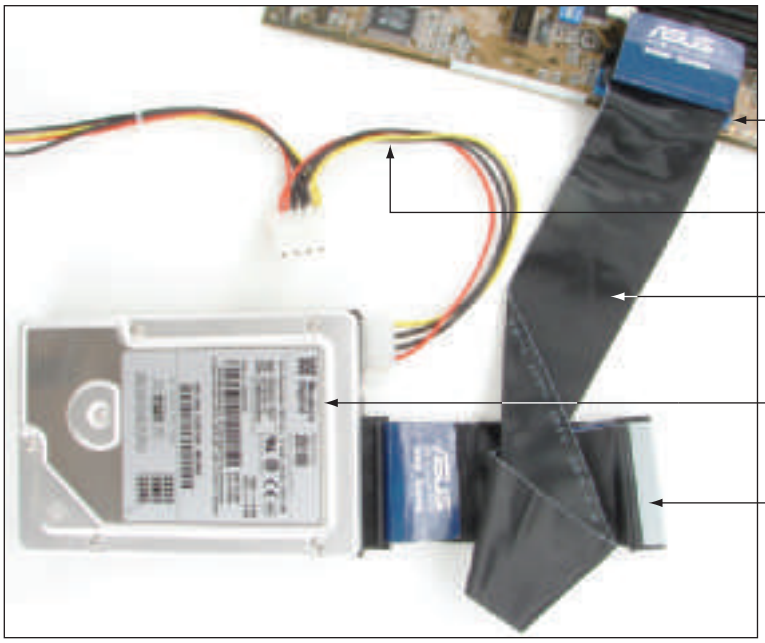


Figure 6-8 A PC's hard drive subsystem using parallel ATA

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**. Also, PATA and IDE are used interchangeably nowadays, although in the past, they had slightly different meanings. Currently, the term IDE is used more often than PATA to describe this interface standard.

Other technologies and changes mentioned in Table 6-1 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 6-9 shows a comparison between the two parallel cables. The 80-conductor cable is 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.

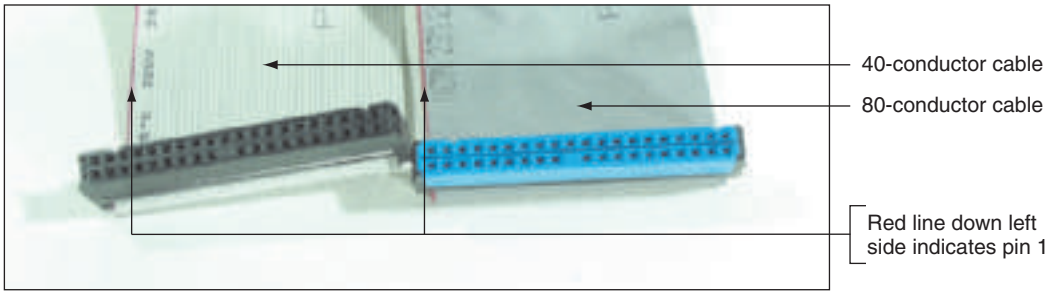


Figure 6-9 In comparing the 80-conductor cable to the 40-conductor cable, note they are about the same width, but the 80-conductor cable has many more and finer wires

A+ 220-801 1.5, 1.7, 1.11

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 an IDE header. 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 (see Figure 6-10).

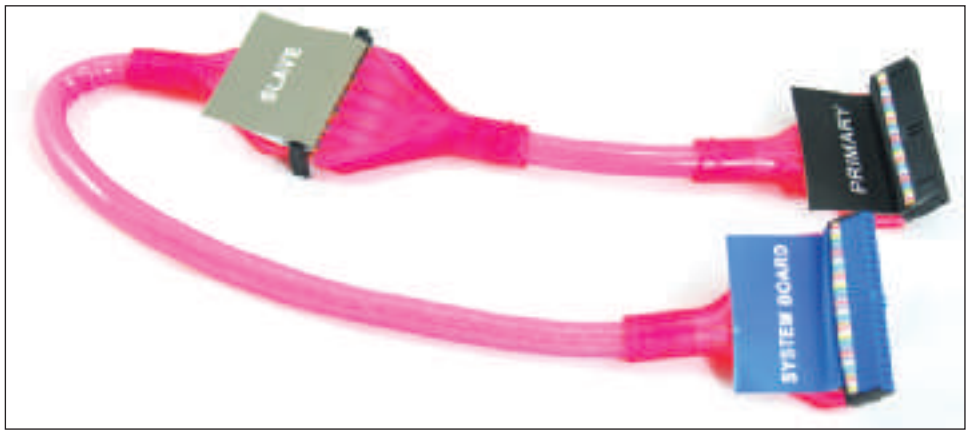
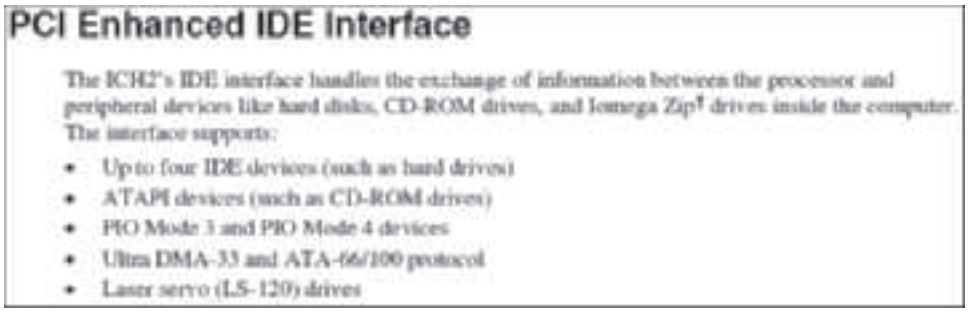


Figure 6-10 Use a smaller round PATA cable so as not to hinder airflow in a system

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 and older than DMA mode.

There are different modes for PIO and DMA because 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 that use IDE today support Ultra DMA, which means that data is transferred twice for each clock beat, at the beginning and again at the end. Figure 6-11 shows a snip from an older Intel motherboard user guide that has two IDE headers. Because ATA-66/100 is mentioned rather than ATA/133, you can conclude the board supports ATA version 6 rather than version 7. (Refer to Table 6-1.)



PCI Enhanced IDE Interface

The ICH2's IDE interface handles the exchange of information between the processor and peripheral devices like hard disks, CD-ROM drives, and Iomega Zip† drives inside the computer. The interface supports:

- Up to four IDE devices (such as hard drives)
- ATAPI devices (such as CD-ROM drives)
- PIO Mode 3 and PIO Mode 4 devices
- Ultra DMA-33 and ATA-66/100 protocol
- Laser servo (LS-120) drives

Source: Intel

Figure 6-11 An older motherboard has two IDE headers using ATA-6 standards

A+ 220-801 1.5, 1.7, 1.11

Most often, when installing an IDE 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 6-1, there are different hard drive standards, each running at different speeds. If two hard drives share the same PATA cable but use different standards, both drives will run at the speed of the slower drive unless the motherboard chipset controlling the IDE 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 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. This fundamental difference is why transfer rates for PATA are expressed in bytes (MB/sec) and transfer rates for SATA are expressed in bits (Gb/sec). The three major revisions to SATA are summarized in Table 6-2.

SATA Standard	Data Transfer Rate	Comments
SATA Revision 1.x* SATA I or SATA1 Serial ATA-150 SATA/150 SATA-150	1.5 Gb/sec	First introduced with ATA/ATAPI-7.
SATA Revision 2.x* SATA II or SATA2 Serial ATA-300 SATA/300 SATA-300	3 Gb/sec	The first SATA II standards were published by the T13 Committee (t13.org) within ATA/ATAPI-8; later revisions of SATA II were published by SATA-IO (sata-io.org). The standard first came out in 2006. Most motherboards used it by 2010.
SATA Revision 3.x* SATA III or SATA3 Serial ATA-600 SATA/600 SATA-600	6 Gb/sec	SATA III was first published by SATA-IO in 2009. Most new motherboards today use this standard.

*Name assigned by the SATA-IO organization

Table 6-2 SATA standards

A+ Exam Tip The A+ 220-801 exam expects you to know the speeds used by SATA1, SATA2, and SATA3, also known as SATA I, SATA II, and SATA III. These speeds apply to internal (SATA) and external (eSATA) devices.

A+ 220-801 1.5, 1.7, 1.11

SATA 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. Whereas PATA drives are not hot-swappable, SATA supports hot-swapping, also called hot-plugging. With **hot-swapping**, you can connect and disconnect a drive while the system is running. Hard drives that can be hot-swapped cost significantly more than regular hard drives.

SATA connections are much easier to configure and use than PATA connections. A SATA drive connects to one internal SATA connector on the motherboard by way of a 7-pin SATA data cable and uses a 15-pin SATA power connector (see Figure 6-12). An internal SATA data cable can be up to 1 meter in length, and is much narrower compared to the 40-pin PATA ribbon cable. The thinner SATA cables don't hinder airflow inside a case as much as the wide ribbon cables do. A motherboard might have two or more SATA connectors; use the connectors in the order recommended in the motherboard user guide. For example, for the four connectors shown in Figure 6-13, you are told to use the red ones before the black ones.

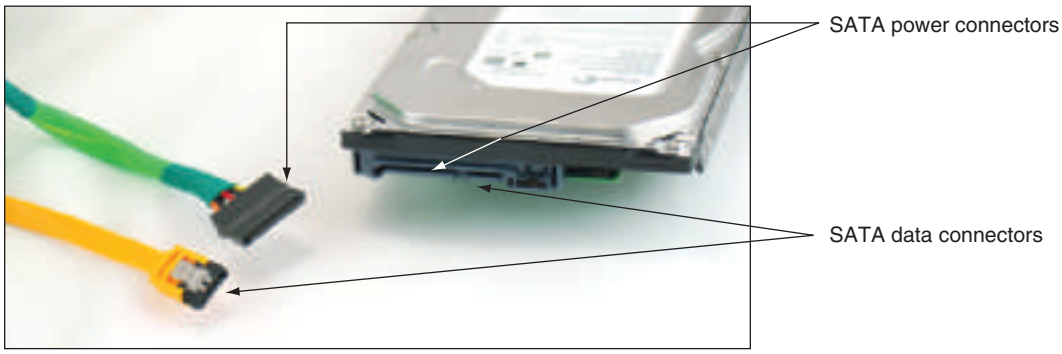


Figure 6-12 A SATA data cable and SATA power cable

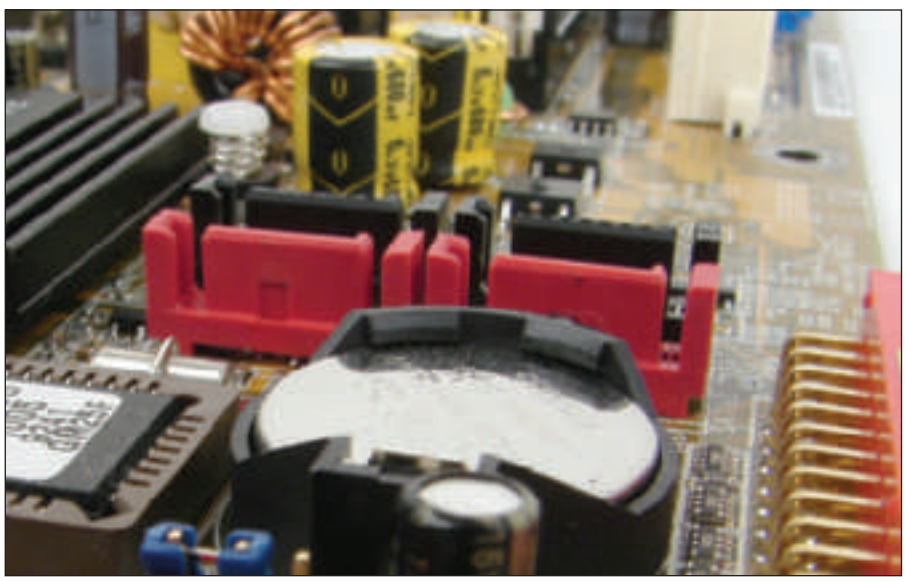


Figure 6-13 This motherboard has two black and two red SATA II ports

A+ 220-801 1.5, 1.7, 1.11

In addition to internal SATA connectors, the motherboard or an expansion card can provide **external SATA (eSATA)** ports for external drives (see Figure 6-14). External SATA drives use a special external shielded SATA cable up to 2 meters long. Seven-pin eSATA ports run at the same speed as the internal ports using SATA I, II, or III standards. The eSATA port is shaped differently from an internal SATA connector so as to prevent people from using the unshielded internal SATA data cables with the eSATA port.

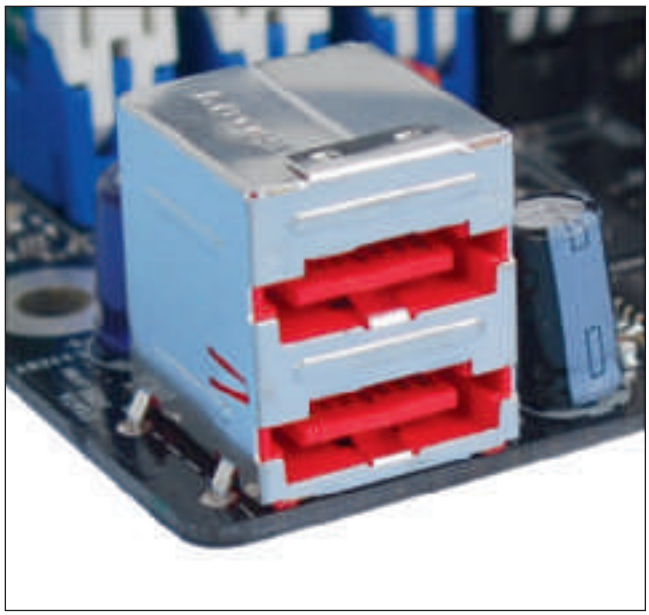


Figure 6-14 Two eSATA ports on a motherboard

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 uses 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.

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, optical 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 6-15).

A+ 220-801 1.5, 1.7, 1.11

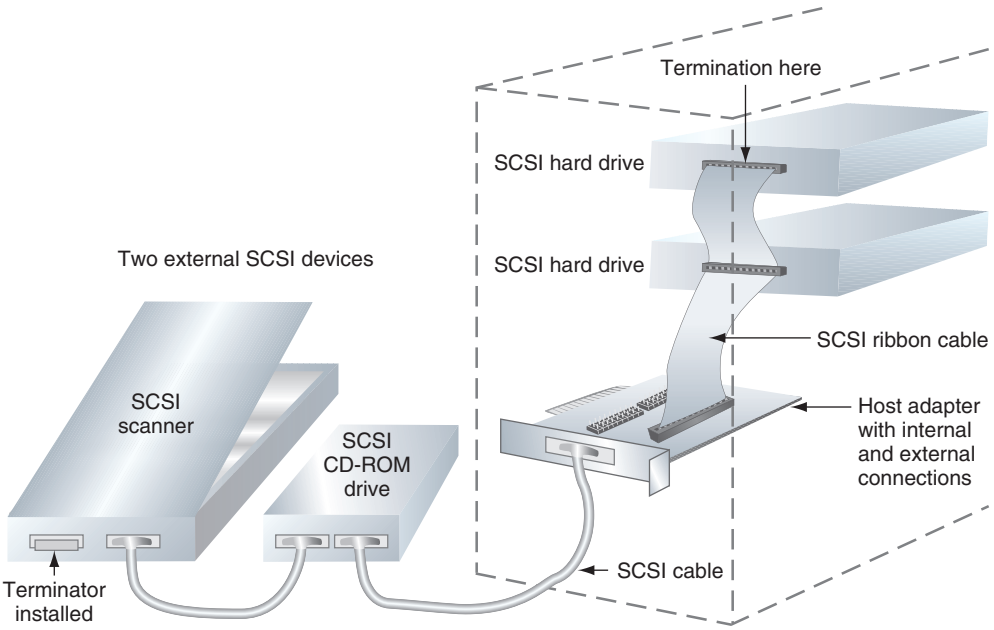


Figure 6-15 Using a SCSI bus, a SCSI host adapter card can support internal and external SCSI devices

All the devices and the host adapter form a single daisy chain. In Figure 6-15, 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 6-16. It fits into a PCIe slot and provides one 68-pin internal SCSI connector and one external 68-pin connector. The host adapter manages all devices as a single SCSI chain and can support up to 15 devices.

A+ Exam Tip The A+ 220-801 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.

Courtesy of PMC-Sierra, Inc.

Figure 6-16 This Adaptec SCSI card uses a PCIe x1 slot and supports up to 15 devices and automatic termination

A+ 220-801 1.5, 1.7, 1.11

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 6-17), or the device can have firmware-controlled termination resistance, which makes installation simpler.

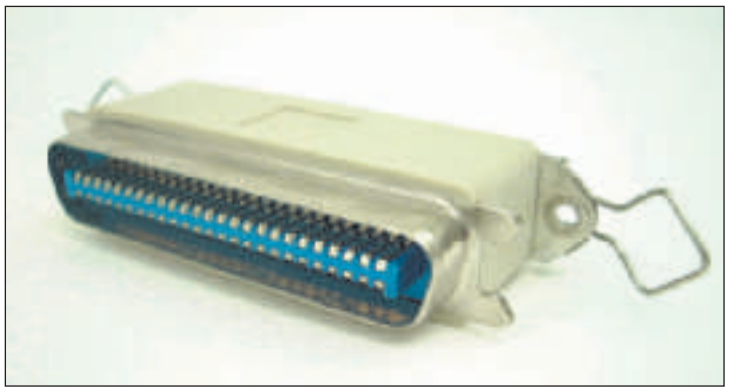


Figure 6-17 External SCSI terminator

Various SCSI Standards and Connectors

The two general categories of all SCSI standards used on PCs have to do with the width in bits of the SCSI data bus, either 8 bits (narrow SCSI) or 16 bits (wide SCSI). In almost every case, if the SCSI standard is 16 bits, the word "wide" is in the name for the standard. For 8-bit SCSI standards, the word "narrow" is usually not mentioned in names for the standard. Narrow SCSI uses a cable with a **50-pin SCSI connector** (also called an A cable), and wide SCSI uses a cable with a **68-pin SCSI connector** (also called a P cable). Narrow SCSI can also use a **25-pin SCSI connector** that looks like a parallel port connector. Figure 6-18 shows five types of SCSI connectors. The 80-pin SCA (Single Connector Attachment) connector can provide power to a SCSI device.

A SCSI bus can support more than one type of connector, and you can use connector adapters to plug a cable with one type of connector into a port using another type of connector. Figure 6-19 shows a SCSI cable. One end of the cable attaches to the host adapter, and, for best results, you should always plug a device into the last connector on the cable.

The three major versions of SCSI are SCSI-1, SCSI-2, and SCSI-3, commonly known as Regular SCSI, Fast SCSI, and Ultra SCSI. A variation of SCSI is serial SCSI, also called

A+ 220-801 1.5, 1.7, 1.11

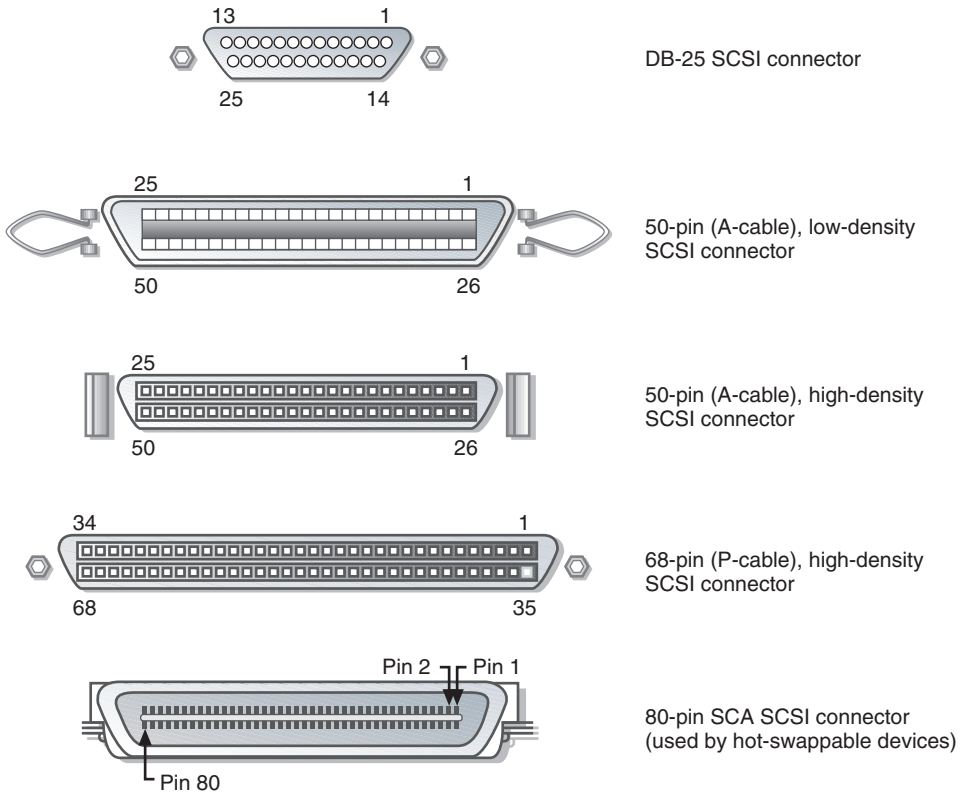


Figure 6-18 The most popular SCSI connectors are 50-pin, A-cable connectors for narrow SCSI and 68-pin, P-cable connectors for wide SCSI

Courtesy of PMC-Sierra, Inc.

Figure 6-19 This 68-pin internal SCSI ribbon cable can connect several SCSI devices

serial attached SCSI (SAS), which 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.

A+ 220-801 1.5, 1.7, 1.11

Hands-on Project 6-1 Examine BIOS Setting for a Hard Drive

Recall that in Chapter 4 you learned how to view and change BIOS settings on your motherboard. Following the directions given in Chapter 4, view the BIOS setup information on your computer, and write down all the BIOS settings that apply to your hard drive. Explain each setting that you can. What is the size of the installed drive? Does your system support S.M.A.R.T.? If so, is it enabled?

A+ 220-801 1.5

Now that you know about the various hard drive technologies and interfaces, let's see how to select and install a hard drive.

HOW TO SELECT AND INSTALL HARD DRIVES

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 SATA drive and an IDE drive in a system. Next, you'll learn how to deal with using removable bays and the problem of installing a hard drive in a bay that is too wide for it. You'll also learn how to set up a RAID system.

SELECTING A HARD DRIVE

When selecting a hard drive, keep in mind that to get the best performance from the system, the system BIOS and the hard drive must support the same standard. If they don't support the same standard, they revert to the 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 providing the drive interface can use. 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.

Notes To learn how to match up and install really old motherboards or drives, see the content "Selecting and Installing Hard Drives using Legacy Motherboards" in the online content at *cengagebrain.com* that accompanies this book. For more information, see the Preface.

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 60 GB for SSD drives to more than 2 TB for magnetic drives. The more gigabytes or terabytes, the higher the price. Magnetic drives have larger capacity for the money than solid state drives.
- ***The spindle speed.*** Magnetic hard drives for desktop systems run at 5400, 7200, 10,000, or 15,000 RPM (revolutions per minute). The most common is 7200 RPM. The higher the RPMs, the faster the drive.

A+ 220-801 1.5

- ***The interface standard.*** Use the standards your motherboard supports. For SATA, most likely that will be SATA II or SATA III. For a PATA IDE drive, most likely that will be Ultra ATA-100/133. For external drives, common standards are eSATA, FireWire 800 or 400, and SuperSpeed or Hi-Speed USB.
- ***The cache or buffer size.*** For magnetic hard drives, buffer memory improves hard drive performance and can range in size from 2 MB to 64 MB. The more the better, though the cost goes up as the size increases. A buffer helps because the hard drive reads ahead of the requested data and stores the extra data in the buffer. If the next read is already in the buffer, the controller does not need to return to the spinning platters for the data. Buffering especially improves performance when managing large files, such as when working with videos or movies.

A hard drive manufacturer might produce both magnetic drives and solid state drives. Some hard drive manufacturers are listed in Table 6-3. Most manufacturers of memory also make solid state drives.

Manufacturer	Web Site
Crucial	*www.crucial.com*
Kingston Technology	*www.kingston.com*
Samsung	*www.samsung.com*
Seagate Technology and Maxtor	*www.seagate.com or www.maxtor.com*
Western Digital	*www.wdc.com*

Table 6-3 Hard drive manufacturers

Video
Installing a Hard Drive

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 SATA connectors might have an IDE header, too. An IDE header can be used for an optical drive or some other EIDE drive, including a hard drive. But SATA drives are faster than PATA drives, so it's best to use the IDE header for other types of drives than the hard drive.

A+ Exam Tip The A+ 220-801 exam expects you to know how to configure IDE and SATA devices in a system. What you learn in this chapter about installing an IDE or SATA hard drive in a system also applies to installing an IDE or SATA optical drive or tape drive. Hard drives, optical drives, and tape drives all use an IDE or SATA data connector and power connector.

In Figure 6-20, you can see the back of two hard drives; one uses a SATA interface and the other uses a PATA interface. Notice the PATA drive has a bank of jumpers. 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 SATA 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 SATA drive, the factory has set them as they should be and advises you not to change them.

Some SATA drives have two power connectors, as does the one in Figure 6-20. Choose between the SATA power connector (which is the preferred connector) or the legacy 5-pin

A+ 220-801 1.5

Figure 6-20 (a) Rear of a SATA drive and (b) rear of a PATA drive

Molex 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 6-21 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.

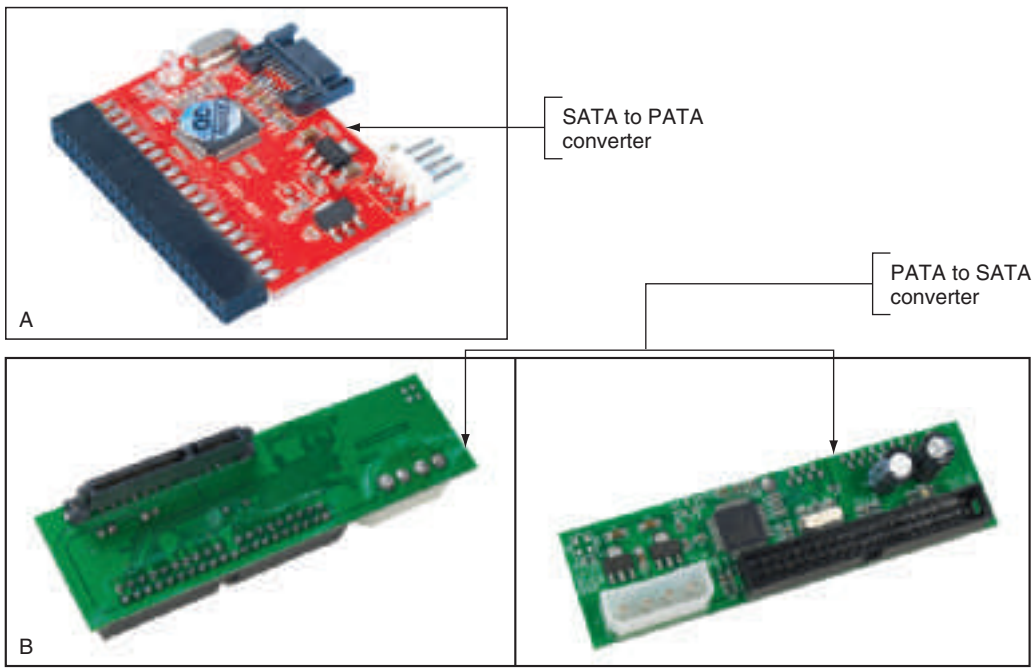


Figure 6-21 (a) SATA to PATA converter and (b) PATA to SATA converter

A+ 220-801 1.5

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 III drive). Figure 6-22 shows a storage controller card that offers one Ultra ATA-133/IDE connection, two internal SATA I connections, and one eSATA port.

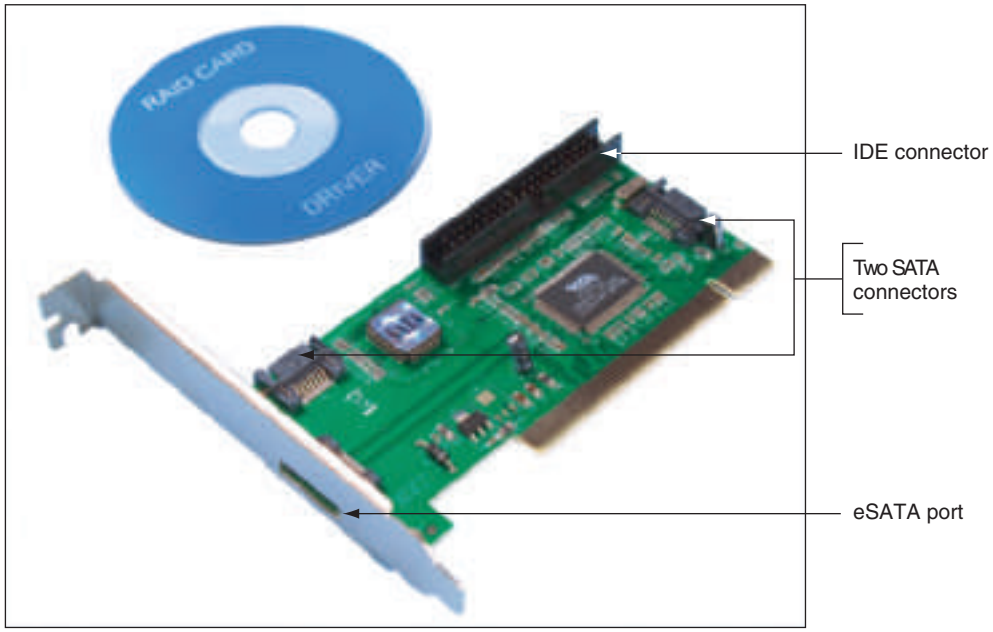


Figure 6-22 EIDE and SATA storage controller card

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

STEP 1: 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 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 computer 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.

STEP 2: READ THE DOCUMENTATION AND PREPARE YOUR WORK AREA

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,

A+ 220-801 1.5

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 with thorough preparation pays off every time!

You're now ready to set out your tools, documentation, new hardware, and notebook. Remember the basic rules concerning static electricity, which you learned in Chapter 1. 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 3: INSTALL THE DRIVE

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

1. Shut down the computer and unplug it. Then press the power button for three seconds to drain residual 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 discs are inserted. Also, some bays are wider than others to accommodate wide drives such as a DVD drive. Will the data cable reach the drives and the motherboard connector? If not, rearrange your plan for locating the drive in a bay, or purchase a custom-length data cable. Some bays are stationary, meaning the drive is installed inside the bay because 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 6-23). 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. Some drive bays provide one or two tabs that you can pull out before you slide the drive in the bay and then push the tabs in to secure the drive. Another option

A+ 220-801 1.5

is a sliding tab (see Figure 6-24) that is used to secure the drive. Pull the tab back; slide in the drive, and push the tab forward to secure the drive.

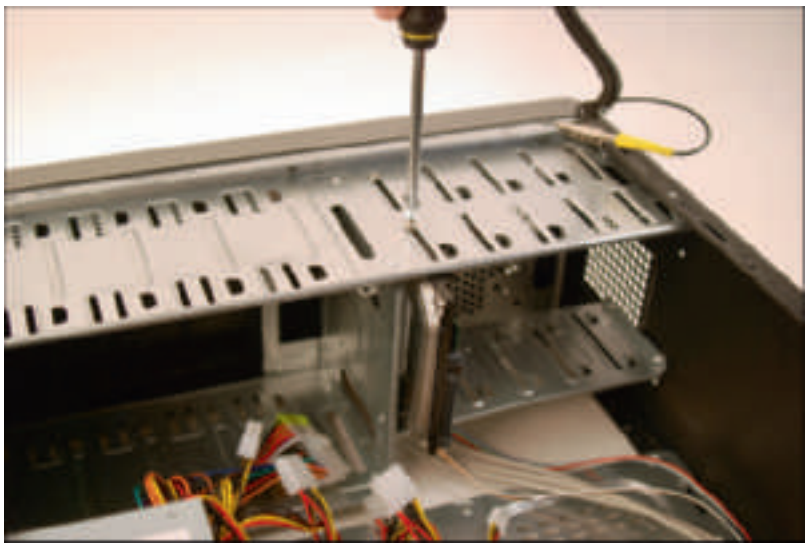


Figure 6-23 Secure one side of the drive with one or two screws

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.

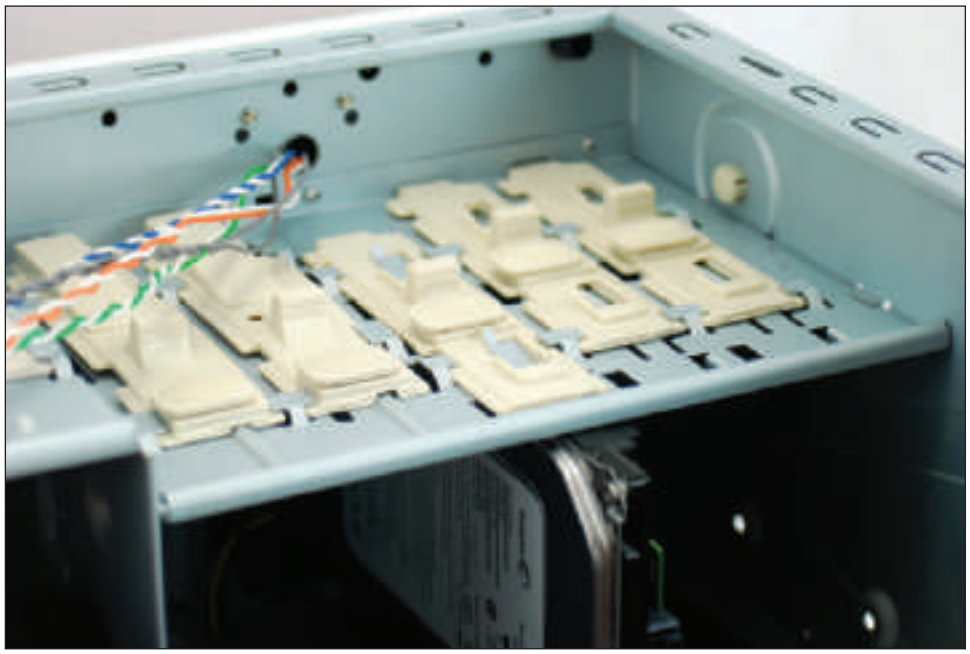


Figure 6-24 This drive bay uses tabs to secure the drive

4. When using screws to secure the drive, carefully, without disturbing the drive, turn the case over and put one or two screws on the other side of the drive (see Figure 6-25). To best secure the drive in the case, use two screws on each side of the drive.

A+ 220-801 1.5

Figure 6-25 Secure the other side of the drive with one or two screws

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 SATA connectors on the board to use first. For example, five SATA connectors are shown in Figure 6-26. The documentation says the two blue SATA connectors support 6.0 Gb/s and slower speeds, and the two black and one red SATA connectors support 3.0 Gb/s and slower speeds. On this board, be sure to connect your fastest hard drive to a blue connector. For both the drive and the motherboard, you can only plug the cable into the connector in one direction. A SATA cable might provide a clip on the connector to secure it (see Figure 6-27).

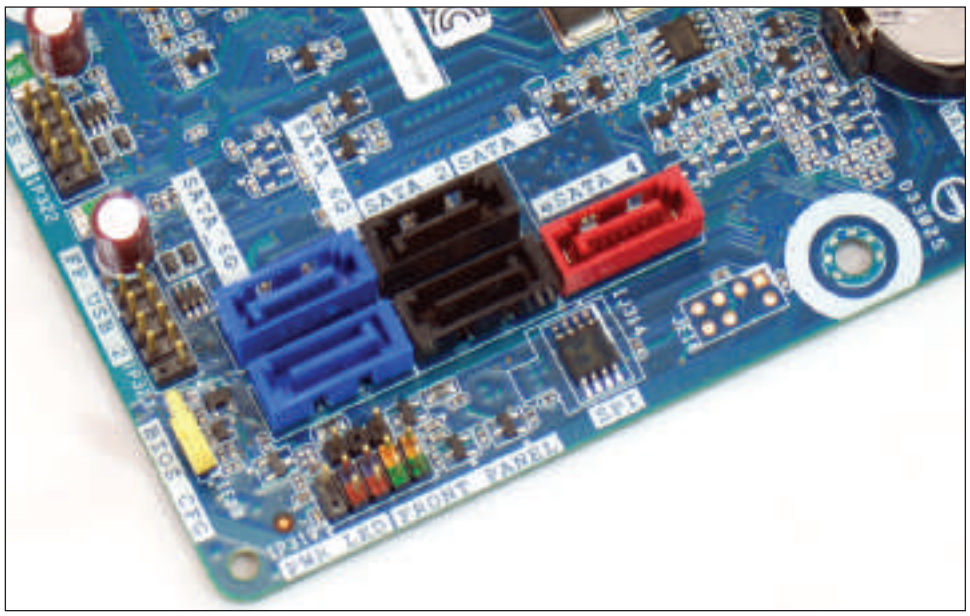


Figure 6-26 Five SATA connectors support different SATA standards

A+
220-801
1.5

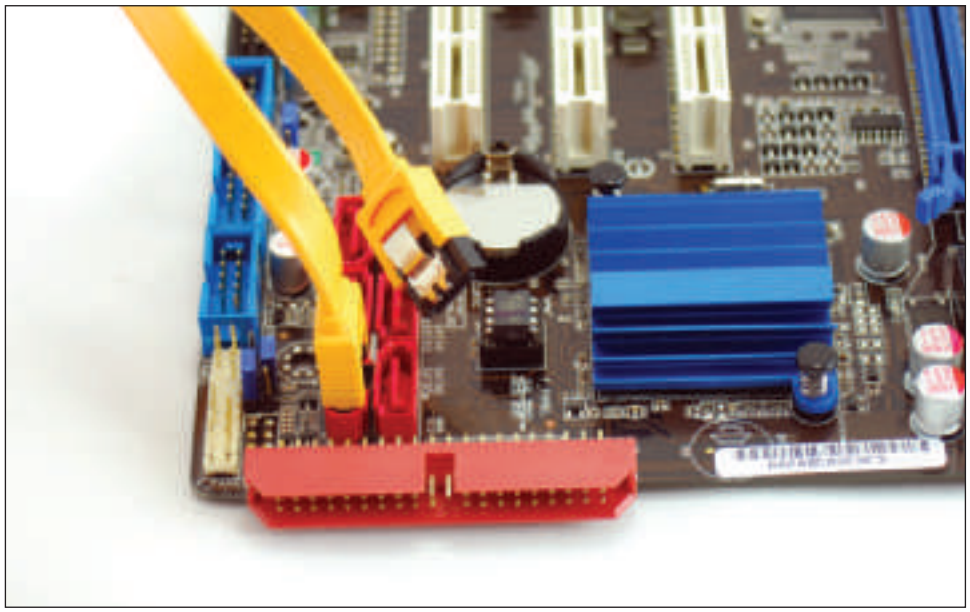


Figure 6-27 A clip on a SATA connector secures the connection

6. Connect a 15-pin SATA power connector or 5-pin Molex power connector from the power supply to the drive (see Figure 6-28).

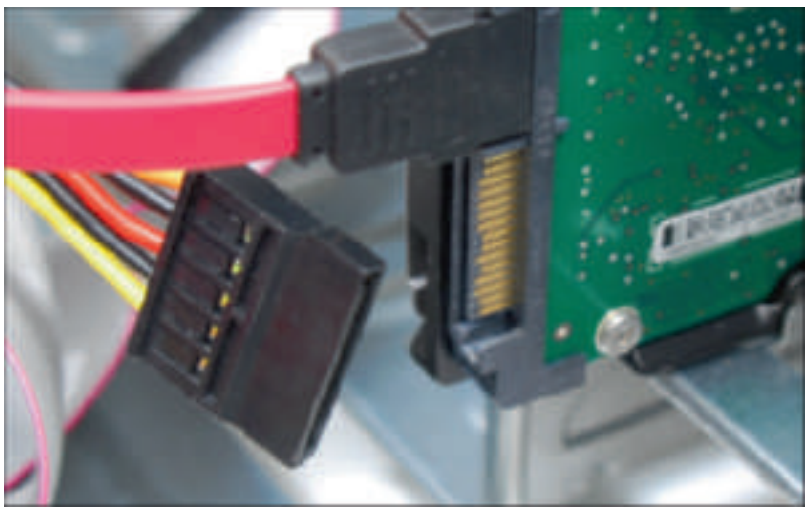
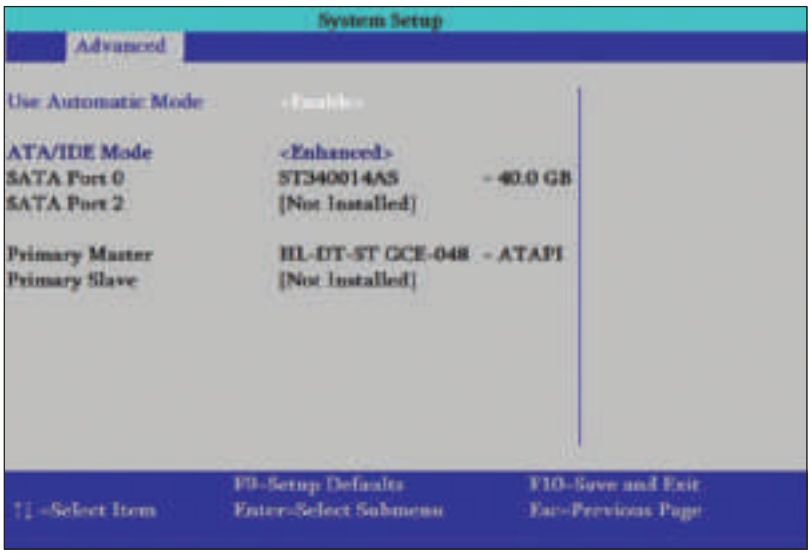


Figure 6-28 Connect the SATA power cord to the drive

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 6-29 shows a BIOS setup screen on one 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.

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.

A+ 220-801 1.5



Source: Intel.com

Figure 6-29 BIOS setup screen showing a SATA hard drive and PATA CD drive installed

You are now ready to prepare the hard drive for first use. If you are installing a new hard drive in a system that is to be used for a new Windows installation, boot from the Windows setup DVD, and follow the directions on the screen to install Windows on the new drive. If you are installing a second hard drive in a system that already has Windows installed on the first hard drive, you use the Disk Management utility in Windows to prepare the drive for first use (called partitioning and formatting the drive). How to install Windows is covered in Chapter 7, and how to use Disk Management is covered in Chapter 10.

INSTALLING A DRIVE IN A REMOVABLE BAY

Now let's see how a drive installation goes when you are dealing with a removable bay. Figure 6-30 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 pins. The third locking pin from the bottom of the case is disconnected in the photo.

Figure 6-30 The removable bay has a fan in front and is anchored to the case with locking pins

A+ 220-801 1.5

Video
Install a Second Hard Drive

Unplug the cage fan from its power source. Turn the handle on each locking pin 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 6-31). Slide the bay back into the case, and reinstall the locking pins. Plug in the cage fan power cord.

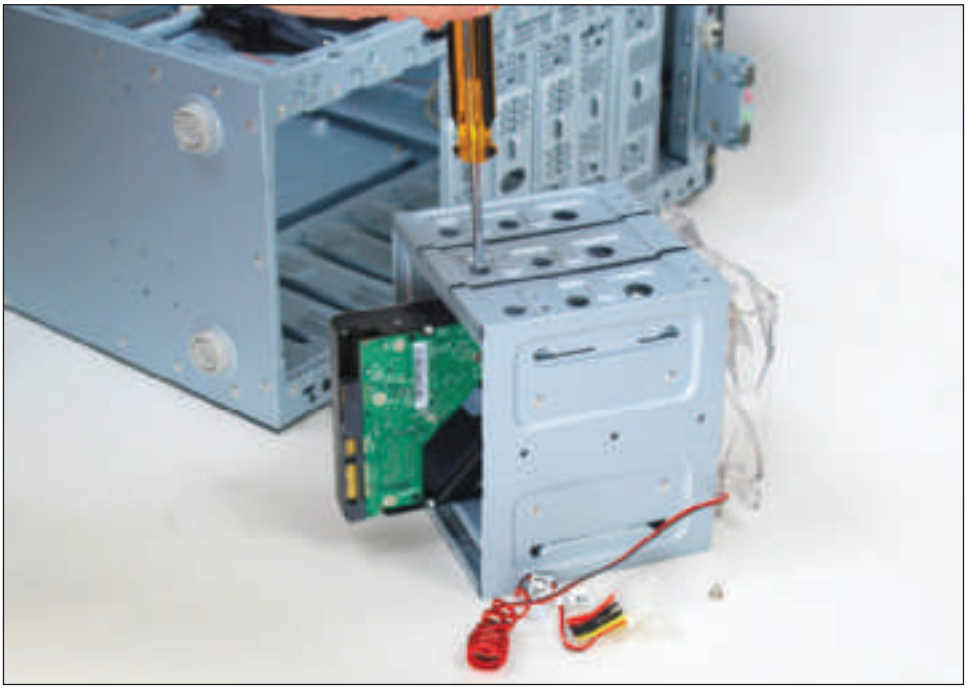


Figure 6-31 Install the hard drive in the bay using two screws on each side of the drive

INSTALLING A SMALL 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 6-32, you can see how the universal bay kit adapter works. The adapter spans the

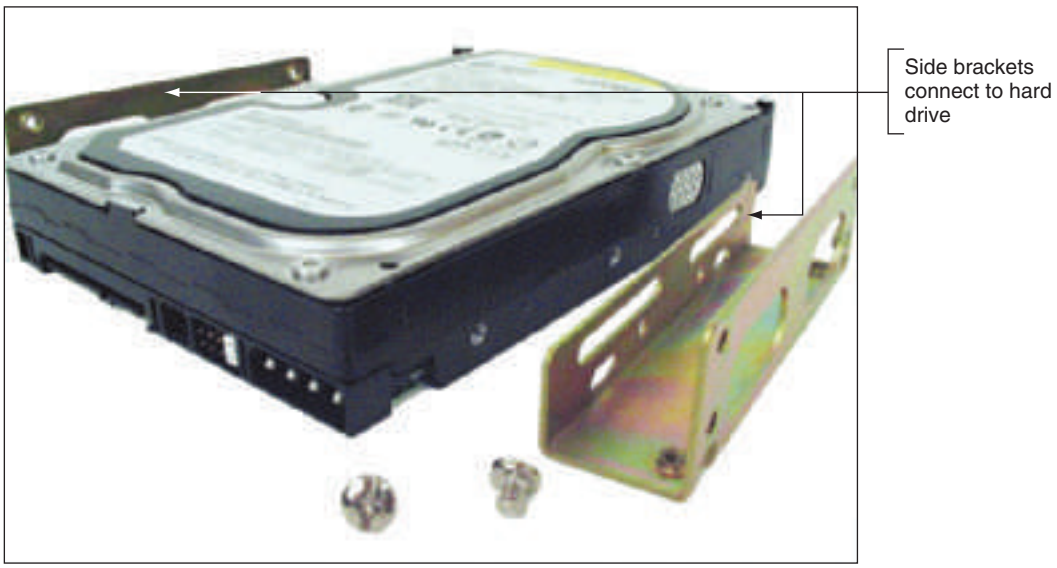


Figure 6-32 Use the universal bay kit to make the drive fit the bay

A+ 220-801 1.5

distance between the sides of the drive and the bay. Figure 6-33 shows a SATA SSD drive with the brackets connected, and Figure 6-34 shows a SATA magnetic drive installed in a wide bay. Because SSD drives are usually smaller than magnetic drives, you're likely to need a bay kit to fit these drives into most computer cases.

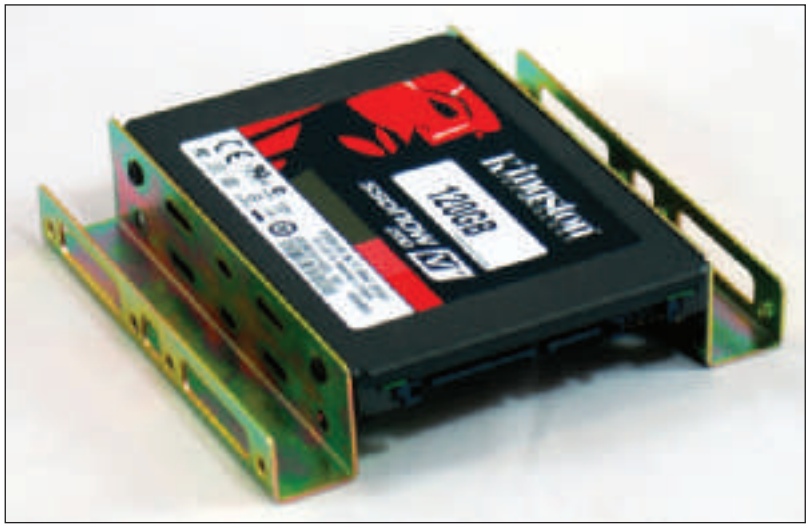


Figure 6-33 SSD drive with bay kit connected

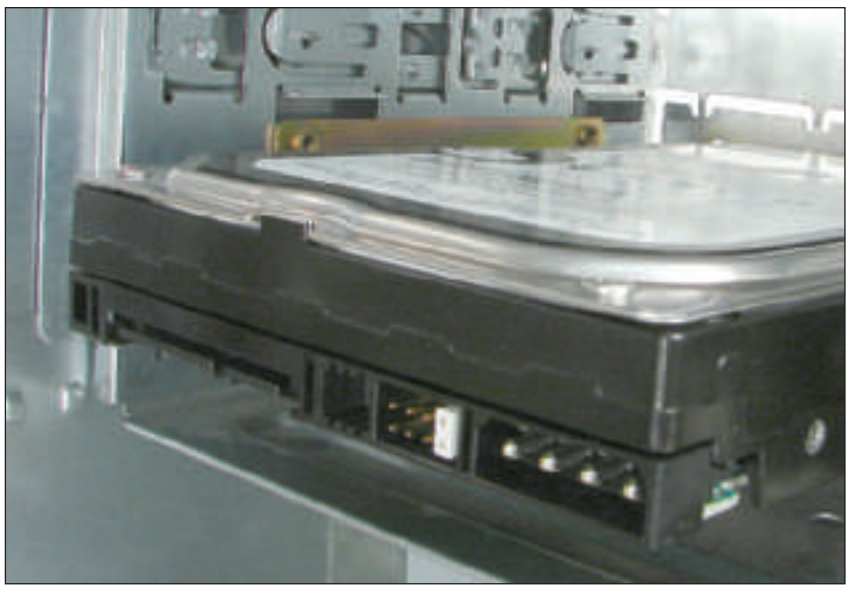


Figure 6-34 Hard drive installed in a wide bay using a universal bay kit adapter

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. A motherboard can have one or two IDE headers (see Figure 6-35). Each header or connector accommodates one IDE channel, and each channel can accommodate one or two IDE devices. One channel is called the primary

A+ 220-801 1.5

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

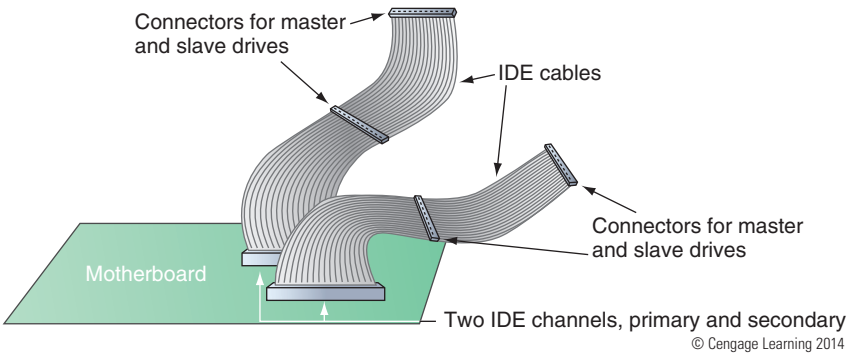


Figure 6-35 A motherboard supporting PATA has two IDE channels; each can support a master and slave drive using a single EIDE cable

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 PATA 80-conductor cable are color-coded (see Figure 6-36). Use the blue end to connect to the motherboard; use the black end to connect to the 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.

Figure 6-36 80-conductor cable connectors are color-coded

A+ 220-801 1.5

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 6-37) 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 6-37 The primary IDE channel connector is often color-coded as blue

A+ Exam Tip The A+ 220-801 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. 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.

A+
220-801
1.5

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 6-38). If they are not, see the documentation, or visit the web site of the drive manufacturer. (Hands-on Project 6-2 gives you practice researching jumper settings.)

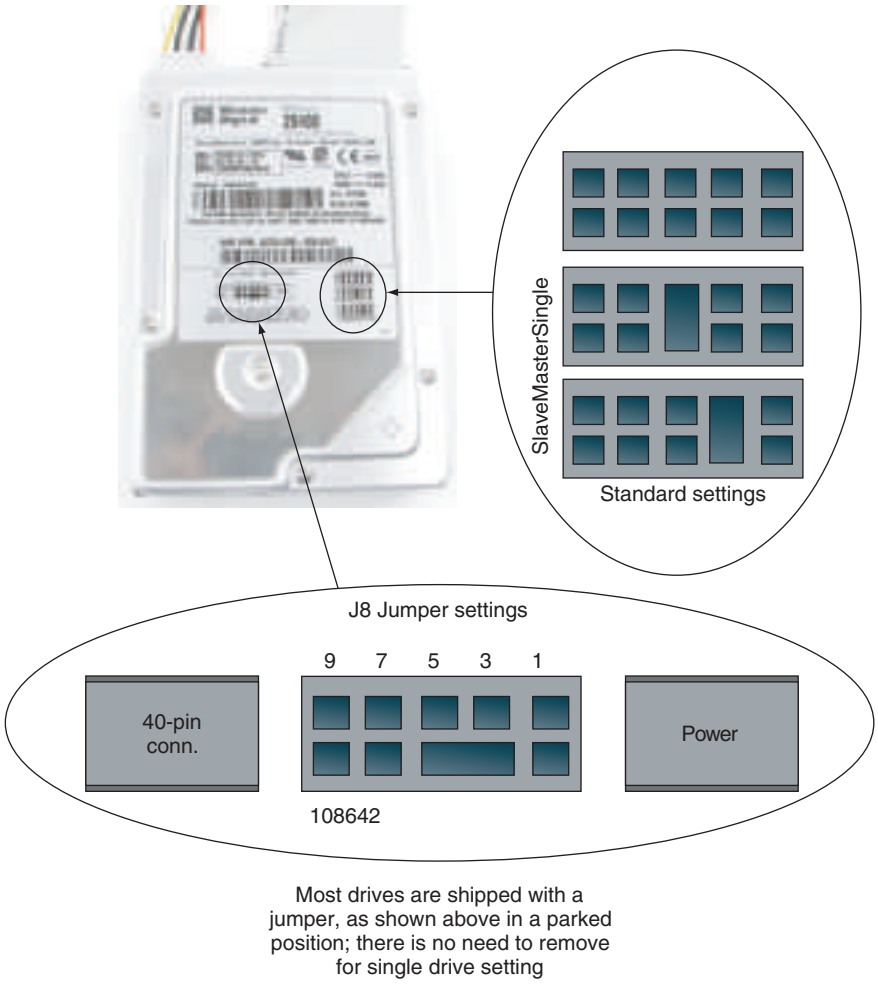


Figure 6-38 A PATA drive most likely will have diagrams of jumper settings for master and slave options printed on the drive housing

Table 6-4 lists the four choices for jumper settings, and Figure 6-39 shows a typical jumper arrangement for a drive that uses three of these settings. In Figures 6-38 and 6-39, 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, 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.

A+ 220-801 1.5

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 6-4 Jumper settings on a PATA hard drive

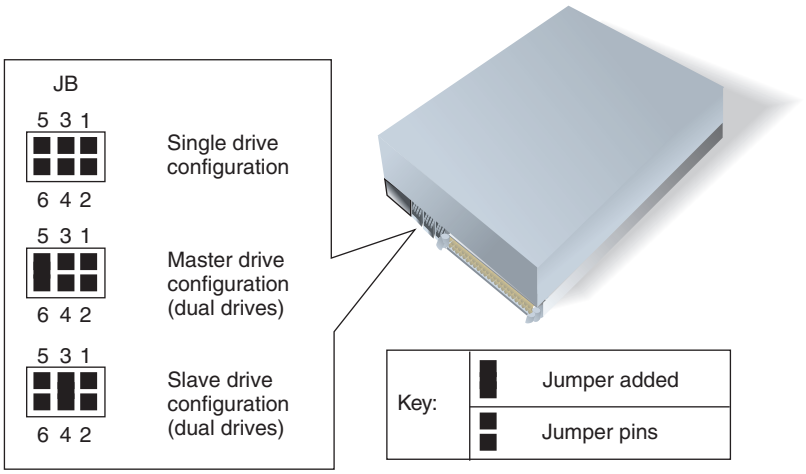


Figure 6-39 Jumper settings on a hard drive and their meanings

Some hard drives have a cable-select configuration option. If you choose this configuration, you must use a cable-select data cable and set both devices on the channel to cable-select. 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. Follow these steps to install the drive:

1. Decide if it's best to connect the ribbon cable to the drive before or after you install the drive in the bay. Then install the drive in the bay and connect the cable in whichever order works best for your situation.
2. Connect the data cable to the IDE connector on the motherboard (see Figure 6-40). 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. Figure 6-41 shows three PATA drives installed in a system with data cables connected to the drives and the motherboard.

A+
220-801
1.5

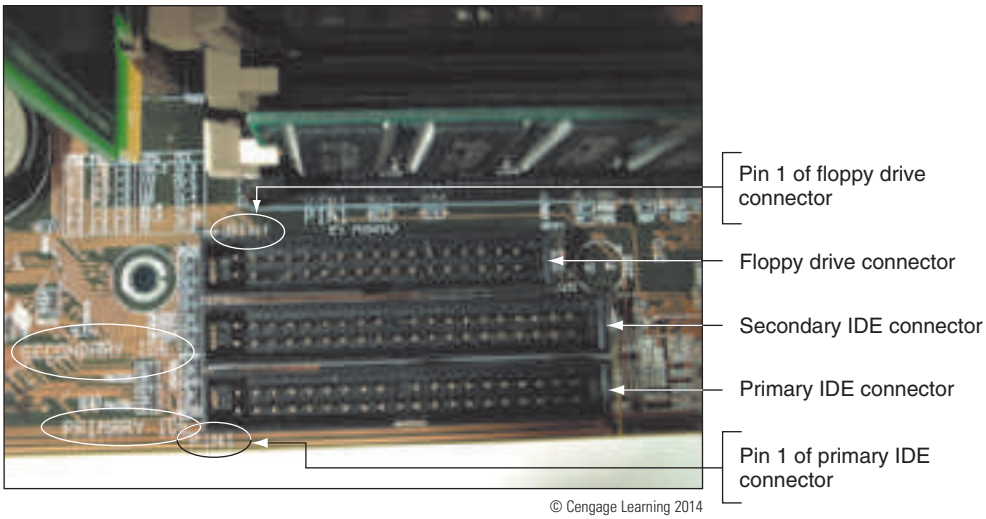


Figure 6-40 Floppy drive and two IDE connectors on the motherboard

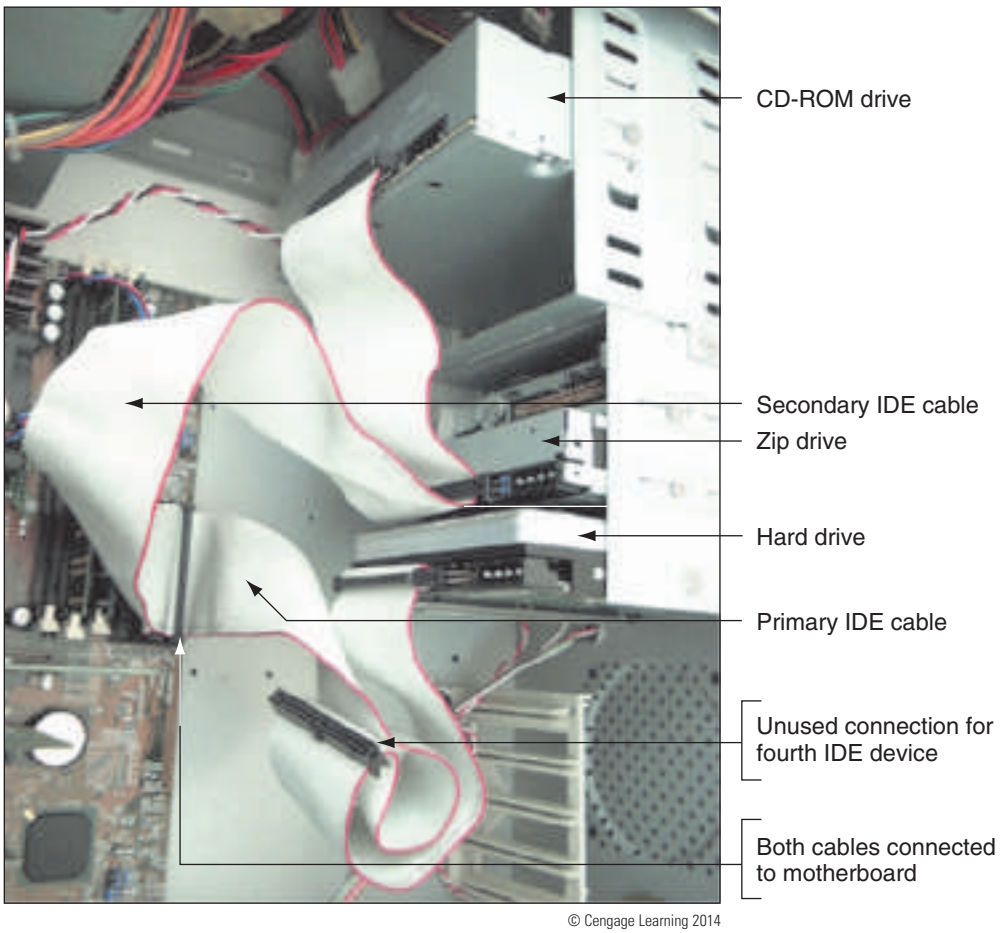
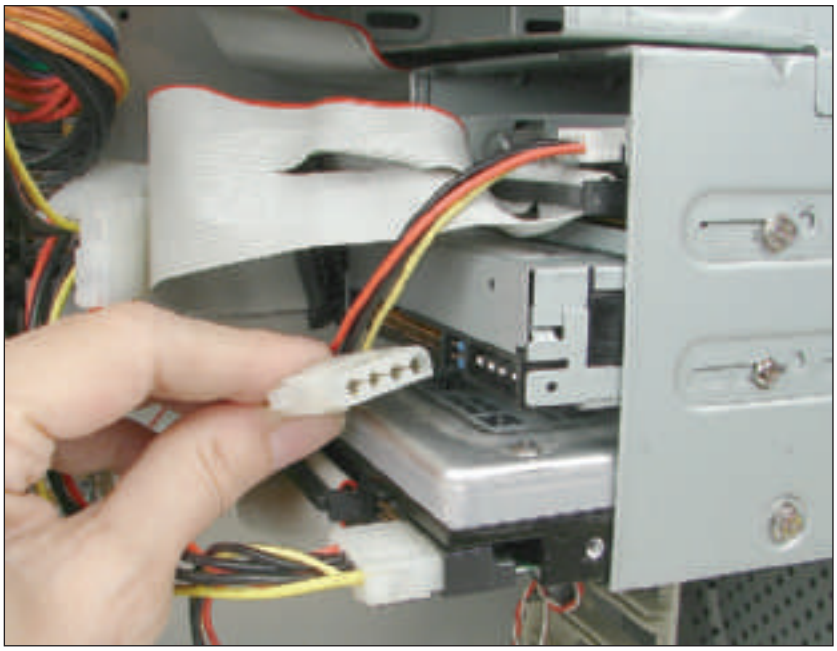


Figure 6-41 This system has a CD-ROM and a Zip drive sharing the secondary IDE cable and a hard drive using the primary IDE cable

3. You can now install a power connection to each drive (Figure 6-42). PATA drives use the Molex 5-pin power connector. The cord only goes into the connection one way.

A+ 220-801 1.5



© Cengage Learning 2014

Figure 6-42 Connect a power cord to each drive

4. 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.) 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, power down the system and replace the case cover. Then the next thing to do is to use an operating system to prepare the drive for first use, which is the topic of the next chapter.

Hands-on Project 6-2 Research Hard Drive Documentation

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.

SETTING UP HARDWARE RAID

For most personal computers, a single hard drive works independently of any other installed drives. 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 writing two

A+ 220-801 1.5

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.

TYPES OF RAID

Several types of RAID exist; the four most commonly used are RAID 0, RAID 1, RAID 5, and RAID 10. Following is a brief description of each, including another method of two disks working together, called spanning. The first four methods are diagrammed in Figure 6-43:

- **Spanning**, sometimes called JBOD (just a bunch of disks), uses two hard drives to hold a single Windows volume, such as drive E:. Data is written to the first drive, and, when it is full, the data continues to be written to the second.
- **RAID 0** also uses 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 0 is preferred to spanning.
- **RAID 1** is a type of mirroring that duplicates data on one drive to another drive and is used for fault tolerance. 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. Windows calls RAID 1 a **mirrored volume**.

Notes In a SCSI implementation of RAID 1, if the two mirrored hard drives are sharing the same host adapter and the adapter fails, both drives go down together. To keep this from happening, each drive has its own host adapter, which is called RAID 1 with duplexing.

- **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 by using the parity information. 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**.

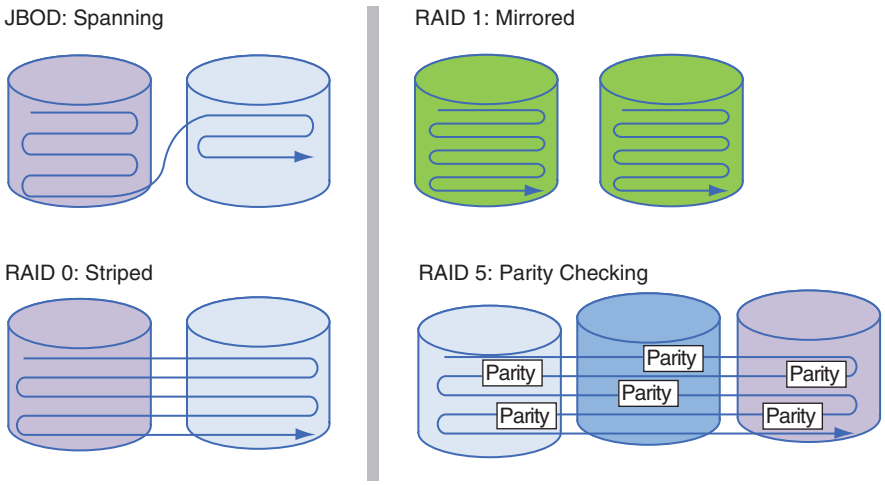


Figure 6-43 Ways that hard drives can work together

A+ 220-801 1.5

- **RAID 10**, also called **RAID 1+0** and pronounced "RAID one zero" (*not* "RAID ten"), is a combination of RAID 1 and RAID 0. It takes at least four disks for RAID 10. Data is mirrored across pairs of disks, as shown at the top of Figure 6-44. In addition, the two pairs of disks are striped, as shown at the bottom of Figure 6-44. To help you better understand RAID 10, in the figure notice the data labeled as A, A, B, B across the first stripe. RAID 10 is the most expensive solution that provides the best redundancy and performance.

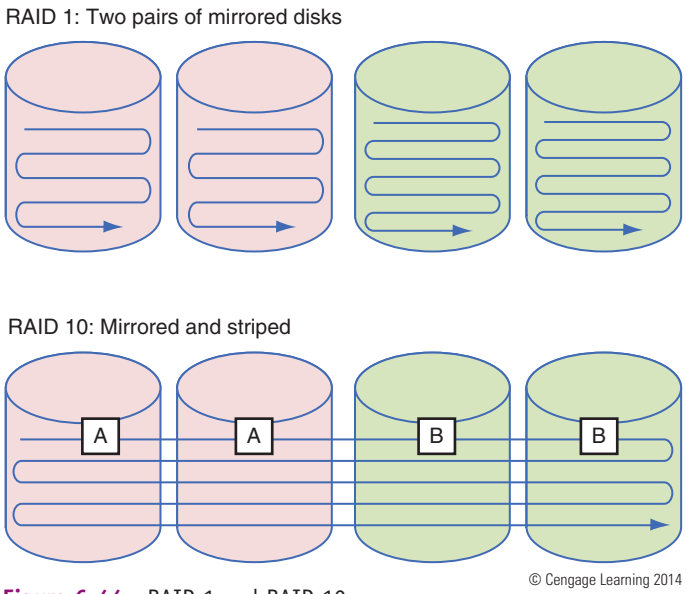


Figure 6-44 RAID 1 and RAID 10

A+ Exam Tip The A+ 220-801 exam expects you to be able to contrast RAID 0, RAID 1, RAID 5, and RAID 10.

All RAID configurations can be accomplished at the hardware level (called hardware RAID) or at the operating system level (called software RAID). Using Windows to implement software RAID, the Disk Management utility is used to configure a group of hard drives in a RAID array. However, software RAID is considered an unstable solution and not recommended by Microsoft. 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 software RAID.

HOW TO IMPLEMENT HARDWARE RAID

Hardware RAID can be set up by using a RAID controller that is part of the motherboard BIOS or by using a RAID controller expansion card. Figure 6-45 shows a RAID controller card by Sabrent that provides four SATA ports.

A+ Exam Tip The A+ 220-801 exam expects you to be able to set up hardware RAID.

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

A+
220-801
1.5

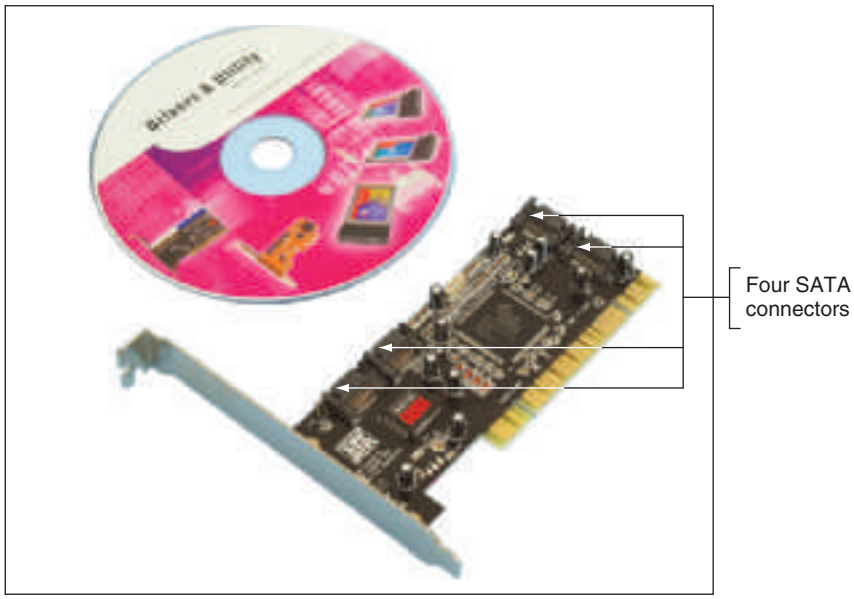


Figure 6-45 RAID controller card provides four SATA internal connectors

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. Make sure you understand which RAID configurations the board supports.

For one motherboard that has six SATA connectors that support RAID 0, 1, 5, and 10, 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 6-46). To help keep the drives cool, the drives are installed with an empty bay between each drive.

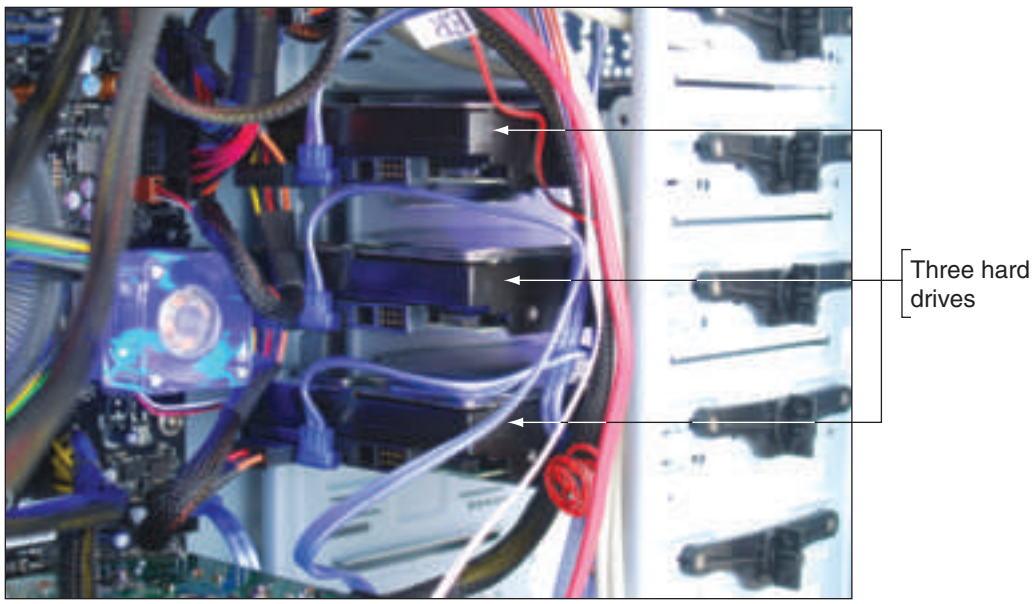
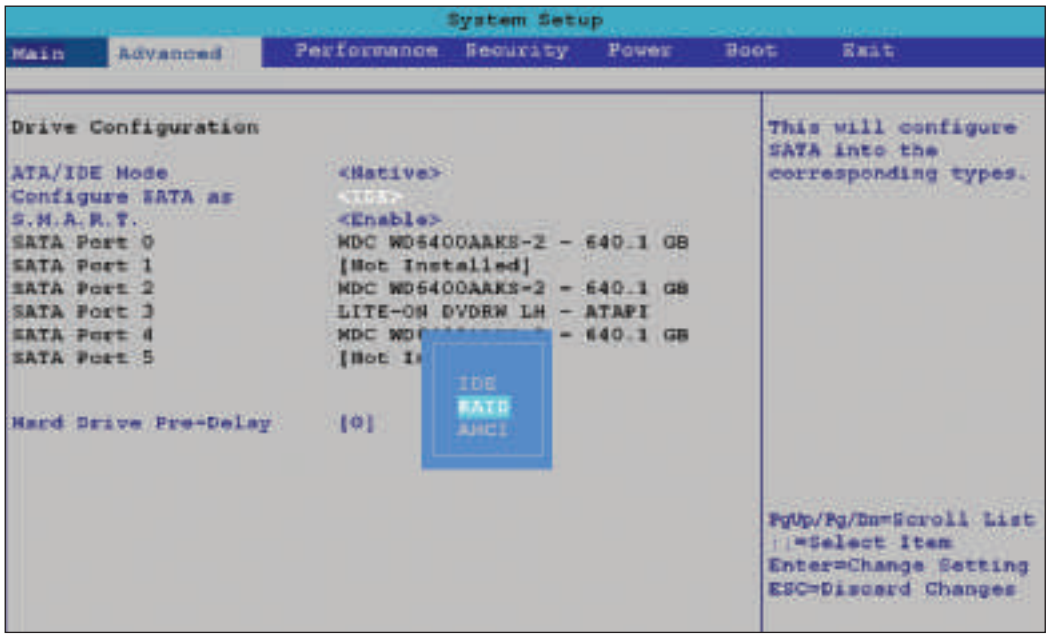


Figure 6-46 Install three matching hard drives in a system

A+ 220-801 1.5

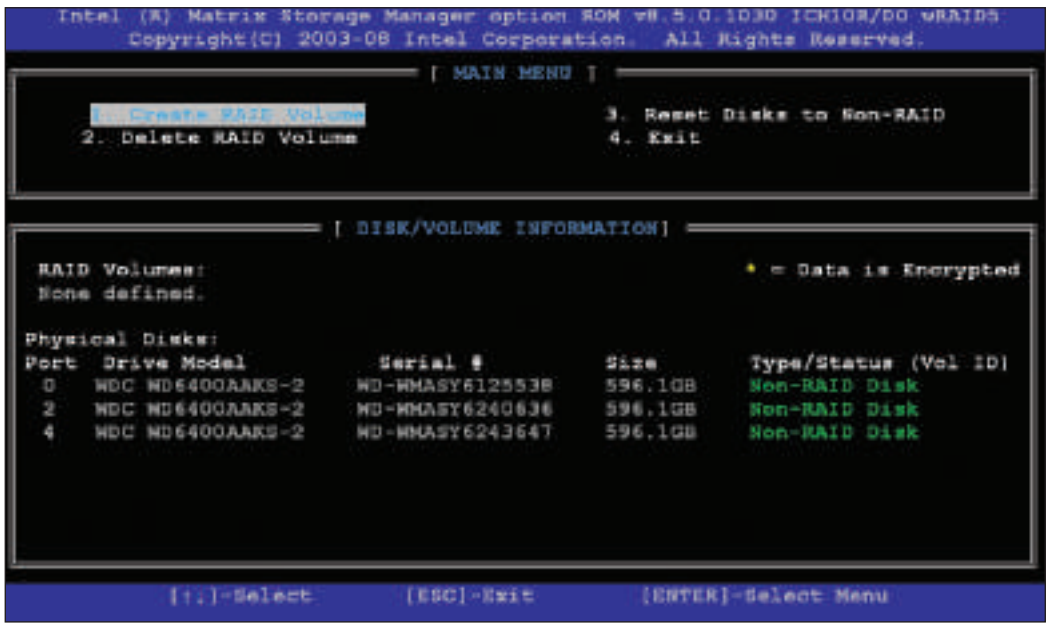
2. Boot the system and enter BIOS setup. On the Advanced setup screen, verify the three drives are recognized. Select the option to configure SATA and then select RAID from the menu (see Figure 6-47).



Source: Intel

Figure 6-47 Configure SATA ports on the motherboard to enable RAID

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 6-48). Notice in the information area that the three drives are recognized and their current status is Non-RAID Disk.

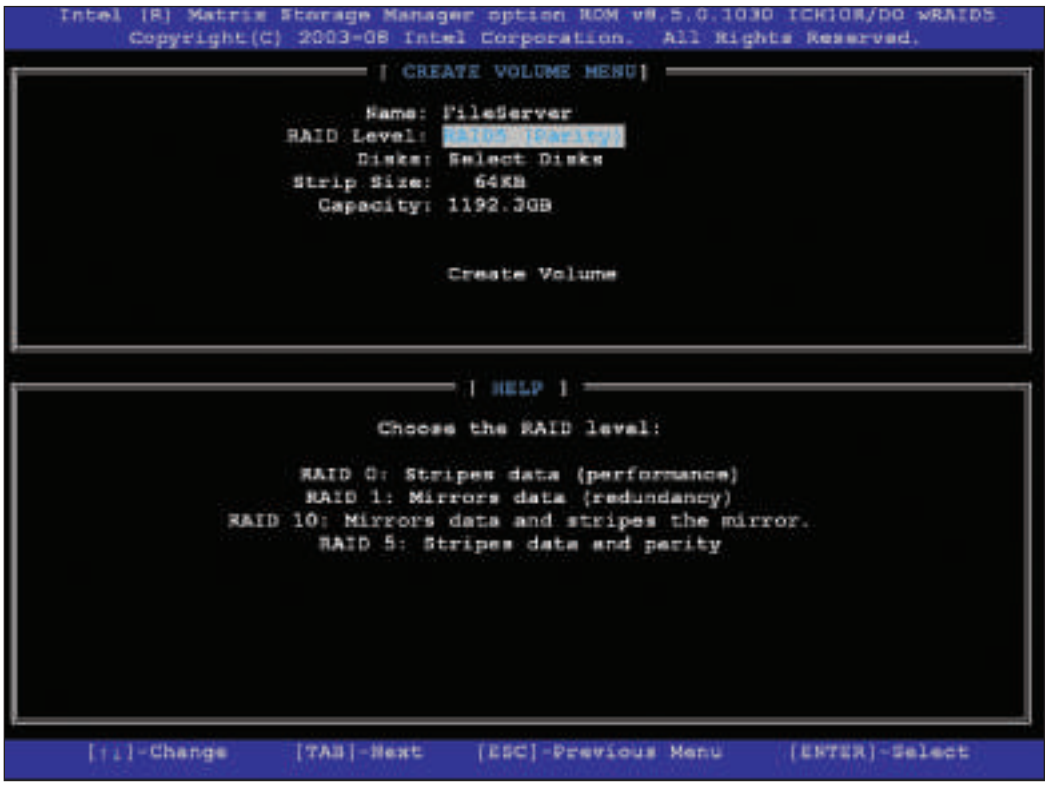


Source: Intel

Figure 6-48 BIOS utility to configure a RAID array

A+ 220-801 1.5

4. Select option 1 to "**Create RAID Volume.**" On the next screen shown in Figure 6-49, enter a volume name (FileServer in our example).



Source: Intel

Figure 6-49 Make your choices for the RAID array

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 6-49 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. Windows 7/Vista automatically "sees" the RAID array as a single 500 GB hard drive because Windows 7/Vista has built-in hardware RAID drivers. For Windows XP, when you begin the XP installation, you must press F6 at the beginning of the installation to install RAID drivers. After Windows is installed on the drive, Windows will call it drive C:.

A+ 220-801 1.5

APPLYING CONCEPTS TROUBLESHOOTING 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.

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 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 DVD 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 some 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 DVD. 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 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?

A+ 220-801 1.5

- 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.

Caution 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!

Hands-on Project 6-3 Select a Replacement Hard Drive

Suppose the 640 GB Western Digital hard drive installed in the RAID array and shown in Figure 6-46 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?

Hands-on Project 6-4 Prepare 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.

Hands-on Project 6-5 Install 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.

ABOUT TAPE DRIVES AND FLOPPY DRIVES

A+ 220-801 1.5, 1.11

Tape drives installed inside a computer case can use a SATA, PATA, or SCSI interface. Occasionally, you might be called on to support a computer with an old floppy drive. Both tape drives and floppy drives are covered in this part of the chapter.

INSTALLING TAPE DRIVES AND SELECTING TAPE MEDIA

Tape drives (see Figure 6-50) are an inexpensive way of backing up an entire hard drive or portions of it. Because tape drives are less expensive for backups than external hard drives, CDs, DVDs, or USB flash drives, they are still used for backups even though other methods are more convenient. Tapes currently have capacities up to 3.0 TB compressed and come in several types and formats. Some tape drives and tape cartridges support WORM (write once and read many). WORM drives and cartridges assure that data written on the tape will not be deleted or overwritten. Most tape drives come bundled with backup software to use them.

Courtesy of Quantum Corporation

Figure 6-50 The LTO-5 HH tape drive by Quantum writes to LTO Ultrium 5 and LTO Ultrium 4 tapes and reads from LTO Ultrium 5, LTO Ultrium 4, and LTO Ultrium 3 tapes. It provides AES 256-bit data encryption security, WORM functionality, and partitioning capability

A+ Exam Tip The A+ 220-801 exam expects you to know how to install a tape drive and how to select the right tapes for the drive.

The biggest disadvantage of using tape drives is that data is stored on tape by **sequential access**; to read data from anywhere on the tape, you must start at the beginning of the tape and read until you come to the sought-after data. Sequential access makes recovering files slow and inconvenient, which is why tapes are not used for general-purpose data storage.

Tape drives accommodate one of two kinds of tapes: full-sized **data cartridges** are $4 \times 6 \times \frac{5}{8}$ inches, and the smaller **minicartridges**, like the one in Figure 6-51, are $3\frac{1}{4} \times 2\frac{1}{2} \times \frac{3}{5}$ inches. Minicartridges are more popular because their drives can fit into a standard 3 inch drive bay of a PC case.

Here is a list of some of the more common types of tape cartridges:

1. DDS-1, DDS-2, DDS-3, DDS-4, and DDS-5 are popular types. DDS-5 holds up to 36 GB native or 72 GB compressed data. DDS-5 is also called DAT72.

A+ 220-801 1.5, 1.11

Figure 6-51 Minicartridge for a tape drive has a write-protect switch

2. LTO Ultrium 2, LTO Ultrium 3, LTO Ultrium 4, and LTO Ultrium 5 are sometimes referred to as LTO cartridges. LTO Ultrium 5 holds up to 1.5 TB native or 3.0 TB compressed data. Figure 6-52 shows an LTO Ultrium 3 tape.
3. DLT IV or DLT-4 holds up to 40 GB native or 80 GB compressed data.
4. Super DLTtape II holds up to 300 GB native or 600 GB compressed data.
5. Travan data types of cartridges vary from TR-1 through TR-7. The TR-7 holds 20 GB native and 40 GB compressed data.
6. AIT types have been around a long time and include AIT Turbo, AIT-1 through AIT-5, and S-AIT. S-AIT holds up to 1.3 TB compressed data.
7. SLR types include SLR1 through SLR140. SLR140 holds 70 GB native or 140 GB compressed data.

Figure 6-52 This Maxell LTO Ultrium 3 data tape cartridge can hold up to 800 GB of compressed data

A+ 220-801 1.5, 1.11

When selecting a tape drive, consider how many and what type of cartridges the drive can use and how it interfaces with the computer. The drive might be able to read from more types of cartridges than it can write to. A tape drive can be external or internal. An external tape drive costs more but can be used by more than one computer. An internal tape drive can interface with a computer using a SCSI, PATA, or SATA connection. An external tape drive can connect to a computer using a USB, FireWire, SCSI, SAS, or eSATA port.

Notes For an interesting photo gallery of tape media, see *www.backupworks.com*.

INSTALLING A FLOPPY DRIVE

Floppy drives: You almost never see them, but they're still covered on the A+ exam, so you need to know about them. We'll try to make this as brief and painless as possible. A 3½" high-density **floppy disk drive (FDD)** holds a mere 1.44 MB of data. When using floppy disks, know that to write to the disk, the write-protect notch must be closed (see Figure 6-53).

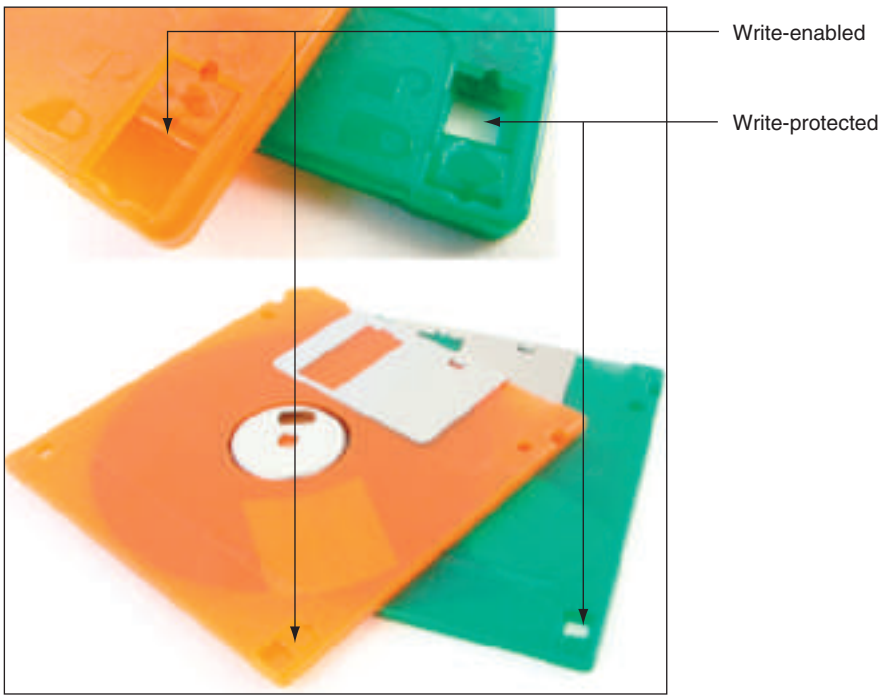


Figure 6-53 For you to write to a disk, the write-protect notch must be closed

Notes One reason you still need to know about floppy disks and floppy disk drives is that Windows Server 2003 relies on floppy disks to recover from a failed installation, and Windows Server 2003 is still a popular server OS.

A floppy drive might be an external or internal device. Figure 6-54 shows a USB floppy drive. Figure 6-55 shows the floppy drive subsystem for an internal device, which consists of the floppy drive, its 34-pin ribbon cable, power cable, and connections. The Berg power connector has a small plastic latch that snaps in place when you connect it to the drive.

A+ 220-801 1.5, 1.11

Figure 6-54 An external floppy drive uses a USB connection

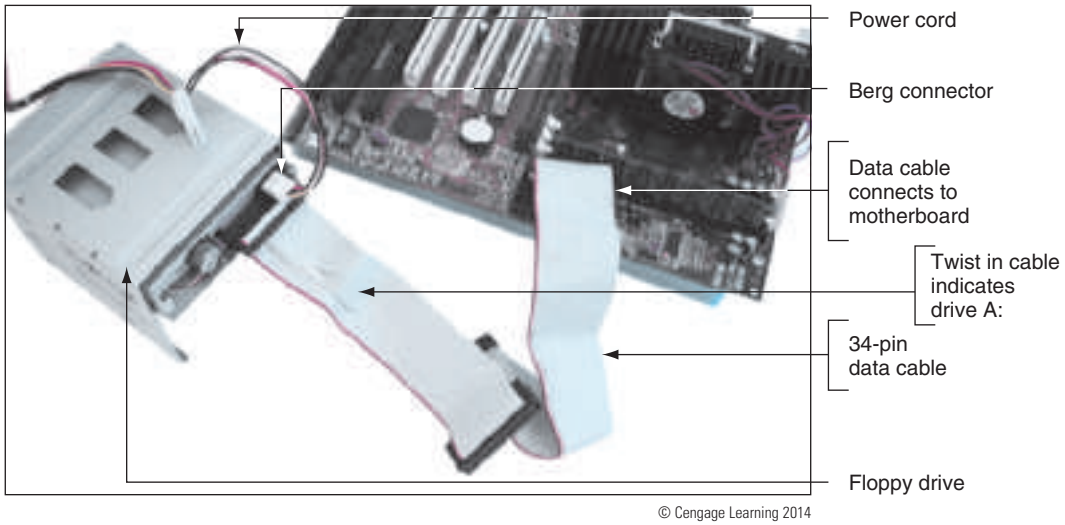


Figure 6-55 Floppy drive subsystem: floppy drive, 34-pin data cable, and power connector

Today's floppy drive cables have a connector at each end and accommodate a single drive, but older cables, like the one in Figure 6-55, 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:. 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.

A+ Exam Tip The A+ 220-801 exam expects you to be able to install and configure a floppy disk drive (FDD).

A+ 220-801 1.5, 1.11

When installing a floppy drive, install the drive in a bay as you would a hard drive and connect the data cable and power cord. When connecting the data cable, align the edge color of the ribbon cable with pin 1 on the motherboard connector. See Figure 6-56. If you connect the cable in the wrong direction, the floppy drive light stays lit continuously and the drive does not work. Some connectors allow you to insert the cable only 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.

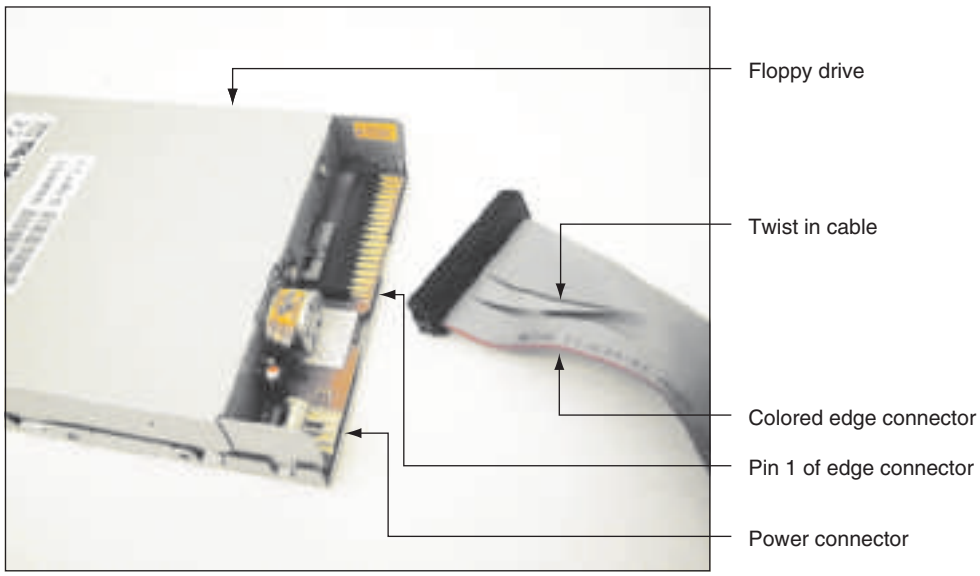


Figure 6-56 Connect colored edge of cable to pin 1

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!

>> CHAPTER SUMMARY

Hard Drive Technologies and Interface Standards

- 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 contains flash memory and is more expensive, faster, more reliable, and uses less power than a magnetic drive.
- 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 (using SATA I), 3.0 Gb/sec (using SATA II), and 6.0 Gb/sec (using SATA III).
- The SCSI interface standards include narrow and wide SCSI, and can use a variety of cables and connectors. Three connectors are a 50-pin, 68-pin, and 25-pin connector. A SCSI chain can contain up to 16 devices including the host adapter. Each device is identified by a SCSI ID, a number from 0 to 15.

How to Select and Install Hard Drives

- When selecting a hard drive, consider the storage capacity, technology (solid state or magnetic), spindle speed, interface standard, and buffer size (for hybrid 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 single drive, master, or slave on a single cable. The PATA cable can accommodate two drives. A PATA motherboard has one or two PATA connectors for up to four PATA drives in the system.
- RAID technology uses an array of hard drives to provide fault tolerance and/or improvement in performance. Choices for RAID are RAID 0 (striping using two drives), RAID 1 (mirroring using two drives), RAID 5 (parity checking using three drives), and RAID 10 (striping and mirroring combined using four drives).
- Hardware RAID is implemented using the motherboard BIOS or a RAID controller card. Software RAID is implemented in Windows. Best practice is to use hardware RAID rather than software RAID.

About Tape Drives and Floppy Drives

- Tape drives are an inexpensive way to back up an entire hard drive or portions of it. Tape drives are more convenient for backups than removable drives. The disadvantage of tape drives is that data can only be accessed sequentially.

- Today's floppy disks are 3½" high-density disks that hold 1.44 MB of data.
- 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.

25-pin SCSI connector
50-pin SCSI connector
68-pin SCSI connector
80-conductor IDE cable
ANSI (American National Standards Institute)
ATAPI (Advanced Technology Attachment Packet Interface)
autodetection
data cartridge
DMA (direct memory access) transfer mode
Enhanced IDE (EIDE)
external SATA (eSATA)
fault tolerance
floppy disk drive (FDD)
hard disk drive (HDD)
hard drive
host adapter
hot-swapping
hybrid hard drive
IDE (Integrated Drive Electronics)
Logical Unit Number (LUN)
low-level formatting
magnetic hard drive
minicartridge
mirrored volume
NAND flash memory
Parallel ATA (PATA)
PIO (Programmed Input/Output) transfer mode
RAID (redundant array of inexpensive disks or redundant array of independent disks)
RAID 0
RAID 1
RAID 1+0
RAID 10
RAID 5
RAID-5 volume
read/write head
ReadyDrive
S.M.A.R.T. (Self-Monitoring Analysis and Reporting Technology)
SCSI (Small Computer System Interface)
SCSI host adapter card
SCSI ID
sequential access
serial ATA (SATA)
solid state device (SSD)
solid state drive (SSD)
spanning
striped volume
terminating resistor

>> REVIEWING THE BASICS

1. What two types of technologies are used inside hard drives?
2. What four speeds in revolutions per minute might the spindle inside a hard drive rotate?
3. What is the name of the Windows technology that supports a memory buffer in a hybrid drive?
4. When the OS addresses the sectors on a hard drive as one long list of sequential sectors, what is this technology called?
5. A CD drive that uses a PATA connection must follow what standard?
6. How many pins does an 80-conductor IDE cable have? What is the maximum recommended length of an IDE cable?
7. What is the transfer speed of an IDE interface using the ATA-7 standard?
8. What is the transfer speed for SATA I? SATA II? SATA III?
9. How many pins does a SATA data cable have? How many pins does a SATA power cable have?

10. What term describes the technology that allows you to exchange a hard drive without powering down the system?
11. What are the four possible configurations for a PATA drive installed in a system?
12. Which SCSI ID is assigned to the SCSI host adapter?
13. Which two SCSI connectors might be used with narrow SCSI?
14. Which version of SCSI is known as Fast SCSI? Which version is known as Ultra SCSI?
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 hard drives does it take to implement RAID 10?
18. How many pins does a floppy drive connector have? What is the storage capacity of a 3½" high-density floppy disk?
19. If a motherboard has one blue IDE connector and one black IDE connector, which do you use to install a single drive?
20. When implementing RAID on a motherboard, where do you enable the feature?

>> THINKING CRITICALLY

1. You install an IDE 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. You want to install an SSD drive in your desktop computer, but the drive is far too narrow to fit snugly into the bays of your computer case. Which of the following do you do?
   a. Install the SSD in a laptop computer.
   b. Buy a bay adapter that will allow you to install the narrow drive in a desktop case bay.
   c. This SSD is designed for a laptop. Flash BIOS so that your system will support a laptop hard drive.
   d. Use a special SATA controller card that will support the narrow hard drive.

3. Mark each statement as true or false:
   a. SATA 1 is about 10 times faster than IDE ATA/133.
   b. SATA 1 is about 100 times faster than IDE ATA/133.
   c. RAID 0 can be implemented using only a single hard drive.
   d. RAID 5 requires five hard drives working together at the same speed and capacity.
   e. You can use an internal SATA data cable with an eSATA port.
   f. A SATA data cable has 7 pins.

>> REAL PROBLEMS, REAL SOLUTIONS

REAL PROBLEM 6-1: Data Recovery Problem

Your friend has a Windows 7 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 6-2: 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.

You check the file server's configuration and discover it has a single hard drive using a SATA connection with Windows Server 2012 installed. There are four empty bays in the computer case and four extra SATA power cords. You also discover an empty PCIe x4 slot on the motherboard. BIOS setup does not offer the option to configure RAID, but you think the slot might accommodate a RAID controller.

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 the RAID controller card support? Which RAID level is best to use? Print any important information in the RAID controller documentation that supports your decisions.
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.