CHAPTER 6

Supporting Hard Drives and Other Storage Devices

After completing this chapter, you will be able to:

- Discuss technologies used inside a hard drive and how a computer communicates with a hard drive
- Install and support a hard drive
- Identify tape drives and tape cartridges
- Support optical drives and flash memory devices
- Troubleshoot hard 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 computer support technician. This chapter introduces the different kinds of hard drive technologies and the ways a computer interfaces with a hard drive. You learn how to select and install the different types of hard drives and how to troubleshoot hard drive problems. You also learn about tape drives and how to select and install optical drives in desktops and laptops. The chapter also covers flash memory cards, including which type of card to buy for a particular need.

HARD DRIVE TECHNOLOGIES AND INTERFACE STANDARDS

A+ 220-901 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.

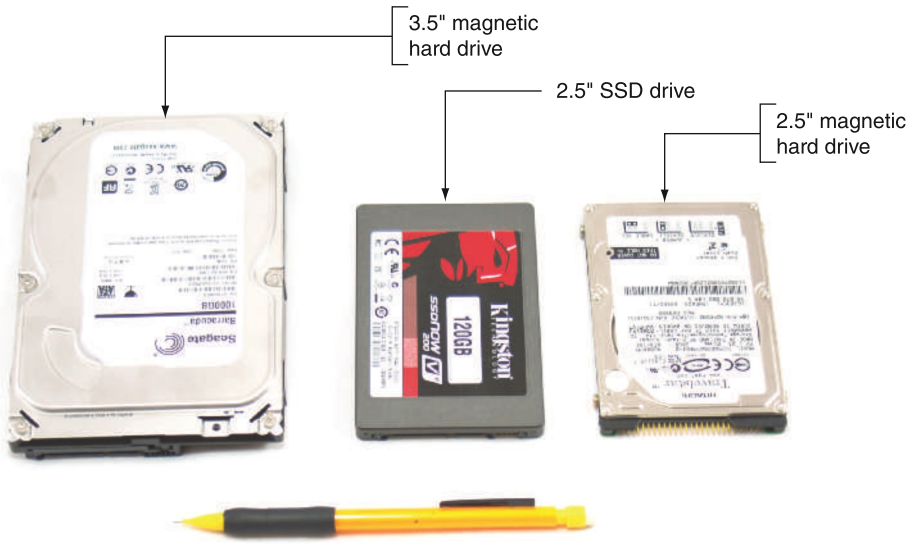


Figure 6-1 A hard drive for a desktop is larger than those used in laptops

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

Now let's look at the technologies used inside a hard drive and then we'll turn to how the drive interfaces with the computer.

TECHNOLOGIES USED INSIDE A HARD DRIVE

A+ 220-901 1.5, 1.7, 1.11

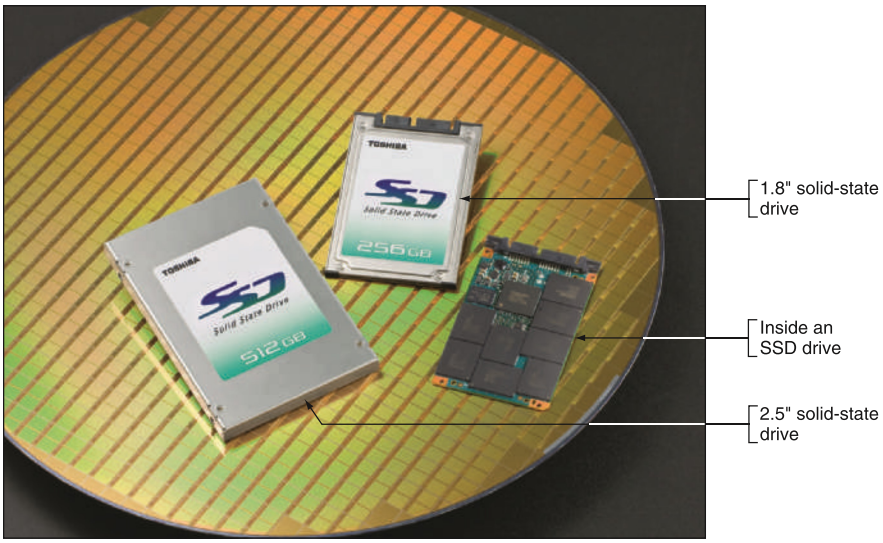
The two types of hardware technologies used inside the drive are solid-state and magnetic. In addition, some drives use a combination of both technologies. Here are important details about each:

- *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 0 or 1 bit. One of these transistors is called a floating gate and accepts the 0 or 1 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 life span of an SSD drive is based on the number of write operations to the drive. (The number of read operations does not affect the life span.) For example, one SSD manufacturer guarantees its SSD drives for 20 GB of write operations per day for three years. For normal use, a drive would not be used that much and would last much longer.

Notes Many solid-state drive manufacturers reserve blocks on the drive that are used when blocks begin to prove they are no longer reliable. Also, a technique called **wear leveling** assures that the logical block addressing does not always address the same physical blocks in order to distribute write operations more evenly across the device.

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. The 1.8" drives are used in some laptops and other small mobile devices.



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 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, or 10,000 RPM (revolutions per minute). The faster the spindle, the better performing the drive.

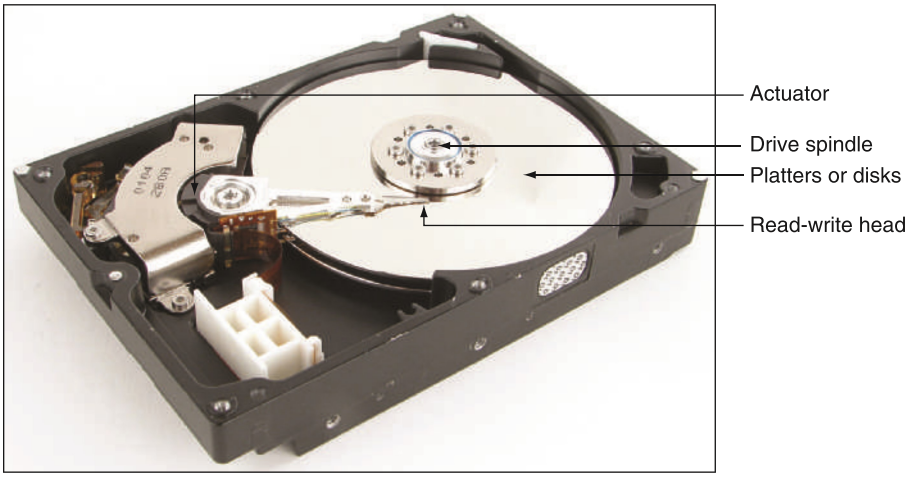


Figure 6-3 Inside a magnetic hard drive

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.

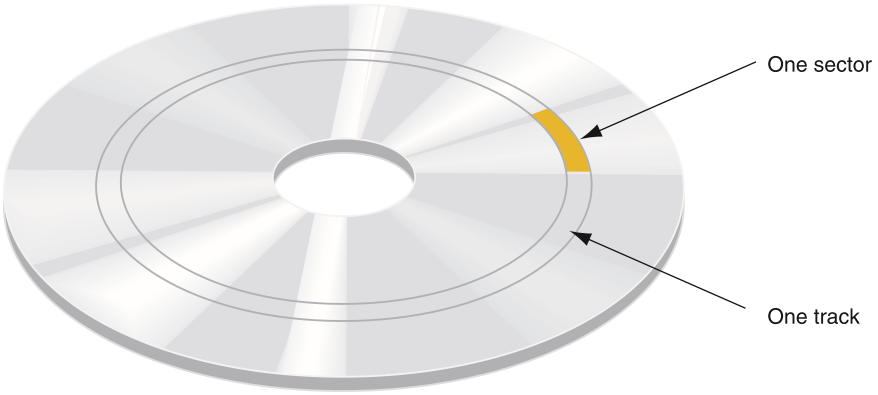


Figure 6-4 A hard drive is divided into tracks and sectors; several sectors make one cluster

- ***Hybrid hard drives.*** A **hybrid hard drive (H-HDD)**, sometimes called a solid-state hybrid drive (SSHD), uses both technologies. The flash component serves 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.

Before a 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, UEFI/BIOS on the motherboard, and the OS use a simple sequential numbering system called logical block addressing (LBA) to address all the sectors on the drive. SSD drives are marked into blocks, which are communicated to the motherboard and OS, which read/write to the drive in blocks just as with magnetic drives.

The size of each block and the total number of blocks 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 UEFI/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 UEFI/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 UEFI/BIOS setup.

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

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

SATA INTERFACE STANDARDS USED BY A HARD DRIVE

A+ 220-901 1.5, 1.7, 1.11

All hard drives in today's personal computers use the SATA interface standards to connect to the motherboard. The serial ATA or SATA (pronounced "*say*-ta") standard uses a serial data path, and a SATA data cable can accommodate a single SATA drive (see Figure 6-5).

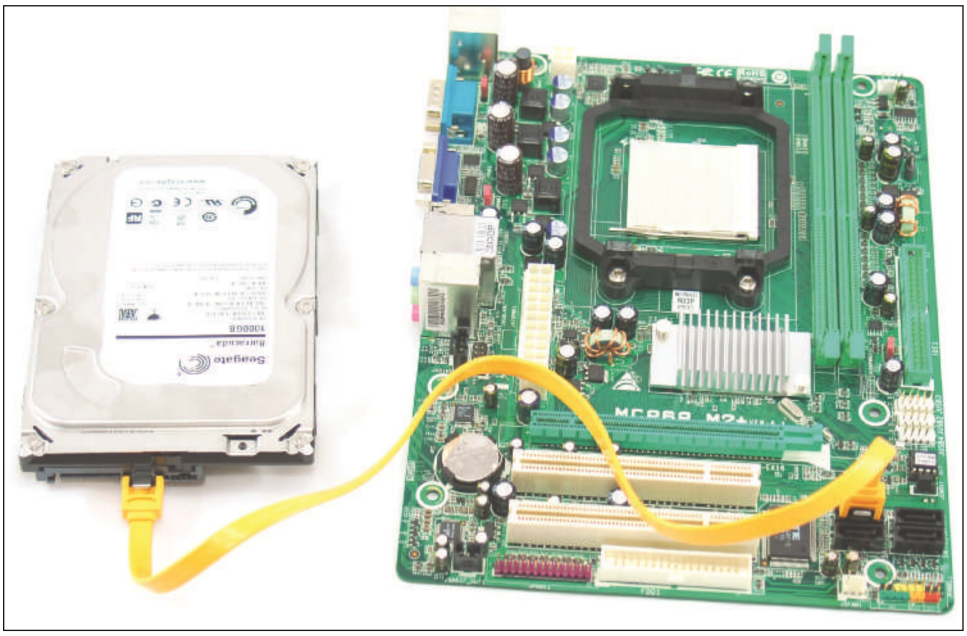


Figure 6-5 A SATA cable connects a single SATA drive to a motherboard SATA connector

Notes Years ago, hard drives used the Parallel ATA (PATA) standards, also called the IDE (Integrated Drive Electronics) standards, to connect to a motherboard. PATA allowed for one or two IDE connectors on a motherboard, each using a 40-pin data cable. Two drives could connect to one cable. In addition, a few personal computer hard drives used the SCSI (pronounced "scuzzy") interface standard.

External hard drives can connect to a computer by way of external SATA (eSATA), FireWire, or USB. Be sure the port provided by the computer uses the same standard that the external drive uses, for example, SuperSpeed USB 3.0 or eSATA III. If the port is not fast enough, you can install an expansion card to provide faster ports.

A consortium of manufacturers, called the Serial ATA International Organization (SATA-IO; see *sata-io.org*) and led by Intel, developed the SATA standards, and the standards also have the oversight of the T13 Committee (*t13.org*). SATA has had three major revisions, which are summarized in Table 6-1.

Notes Interface standards for drives define data speeds and transfer methods between the drive controller, the UEFI/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.

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	SATA, first introduced as an ATA/ATAPI-7 standard, was published as part of a revision to the older PATA standards managed by the T13 Committee (*t13.org*) that governed the PATA standards.
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*), which now manages SATA standards. 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 6-1 SATA standards

A+ Exam Tip The A+ 220-901 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.

SATA interfaces are used by all types of drives, including hard drives, CD, DVD, Blu-ray, and tape drives. 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.

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 6-6). An internal SATA data cable can be up to 1 meter in length. 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 6-7, you are told to use the red ones before the black ones.

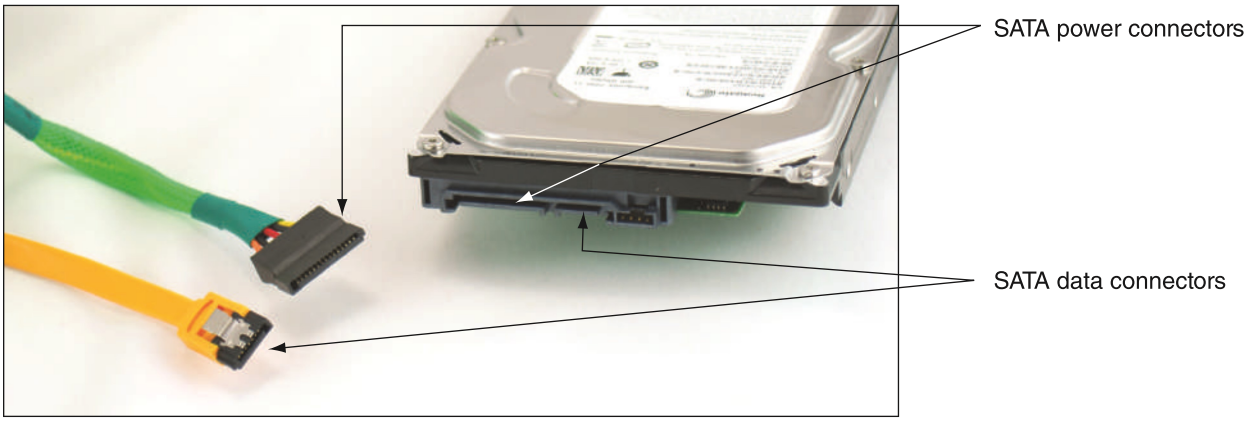


Figure 6-6 A SATA data cable and SATA power cable

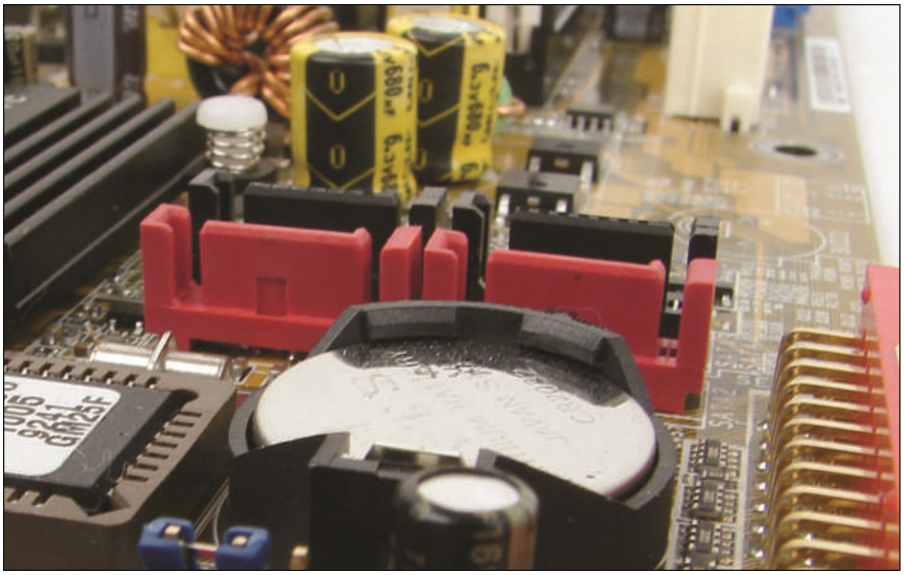


Figure 6-7 This motherboard has two black and two red SATA II ports

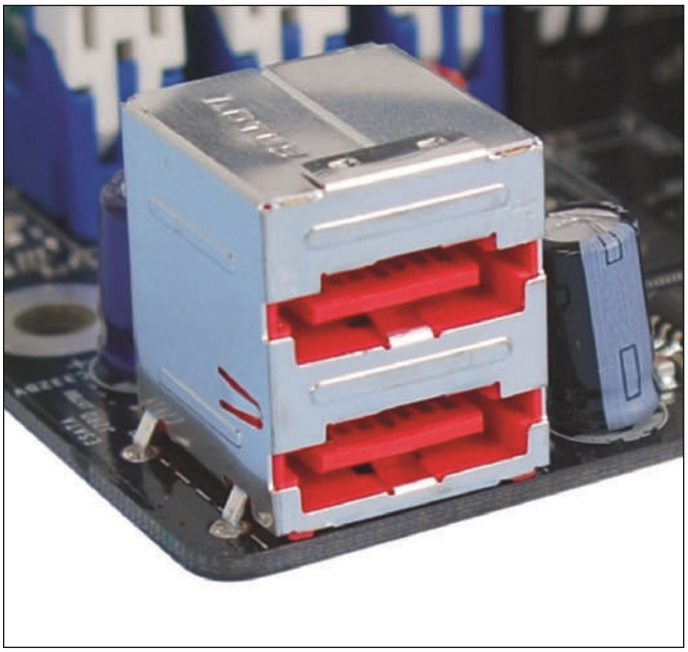


Figure 6-8 Two eSATA ports on a motherboard

In addition to internal SATA connectors, the motherboard or an expansion card can provide **external SATA (eSATA)** ports for external drives (see Figure 6-8). 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.

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.

Hands-On Project 6-1 Examine UEFI/BIOS Settings for a Hard Drive

A+ 220-901 1.5

Following the directions given in the chapter, "All About Motherboards," view the UEFI/BIOS setup information on your computer, and write down all the UEFI/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?

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

A+ 220-901 1.4, 1.5, 1.11, 3.1, 4.2

In this part of the chapter, you learn how to select a hard drive for your system. Then, you learn the details of installing a SATA drive. Next, you learn how to deal with using removable bays, the problem of installing a hard drive in a bay that is too wide for it, and special considerations to install a hard drive in a laptop. You also learn how to set up a RAID system.

SELECTING A HARD DRIVE

A+ 220-901 1.4, 1.5, 1.11

When selecting a hard drive, keep in mind that to get the best performance from the system, the system UEFI/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 UEFI/BIOS setup screens to see which standards are mentioned. However, know that when installing a drive, you don't need to know which SATA standard a hard drive supports because the startup UEFI/BIOS uses autodetection. With autodetection, the UEFI/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 that accompanies this text. 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 1 TB for SSD drives to more than 6 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, or 10,000 RPM (revolutions per minute). The most common is 7200 RPM. The higher the RPMs, the faster the drive.
- ***The interface standard.*** Use the standards your motherboard supports. For SATA, most likely that will be SATA II or SATA III. 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 128 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 6-2. Most manufacturers of memory also make solid-state drives.

Manufacturer	Website
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 6-2 Hard drive manufacturers

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

STEPS TO INSTALL A SATA DRIVE

A+ 220-901 1.4, 1.5, 1.11

In Figure 6-9, you can see the back of a SATA hard drive. 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.

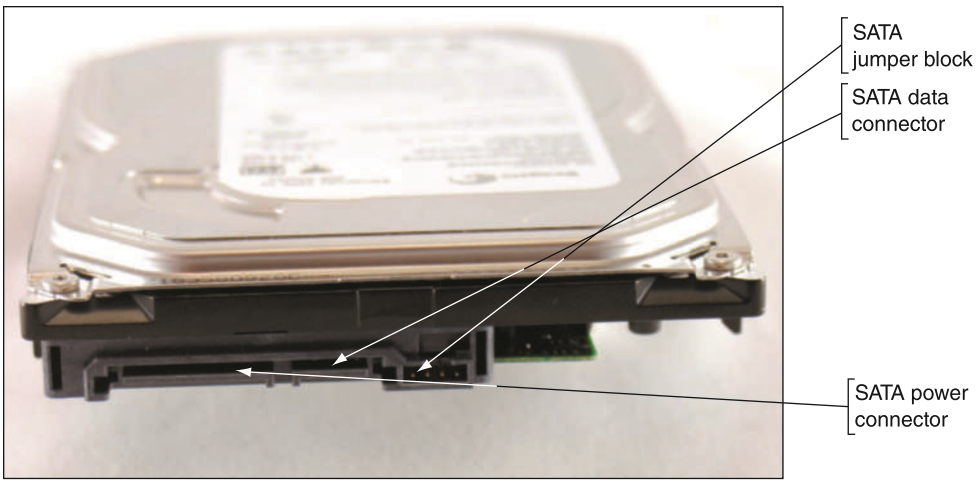


Figure 6-9 Rear of a SATA drive

A+ Exam Tip The A+ 220-901 exam expects you to know how to configure SATA devices in a system. What you learn in this chapter about installing a SATA hard drive in a system also applies to installing a SATA optical drive or tape drive. Hard drives, optical drives, and tape drives use a SATA data connector and a power connector.

Some SATA drives have two power connectors, as does the one in Figure 6-10. Choose between the SATA power connector (which is the preferred connector) or the legacy 4-pin Molex connector, but never install two power cords to the drive at the same time because this could damage the drive.

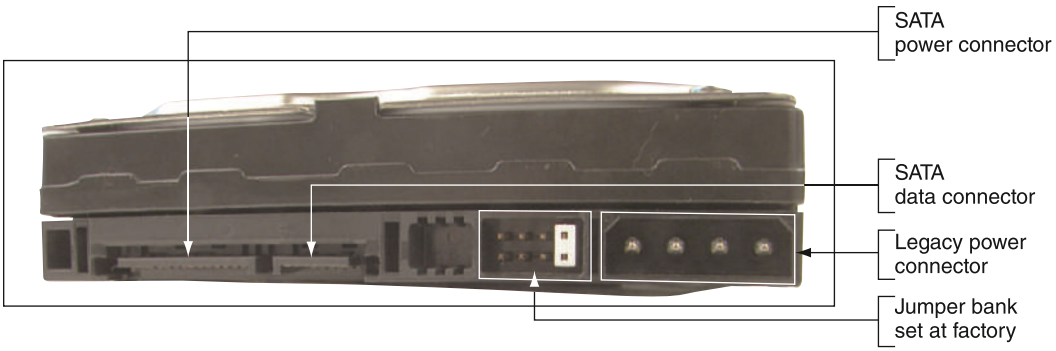


Figure 6-10 Rear of a SATA drive with two power connectors

You can also purchase a SATA controller card that can provide internal 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 a fast SATA standard that your hard drives use. Figure 6-11 shows a PCIe storage controller card that offers two internal SATA III connections and two eSATA III ports.

Source: SYBA at *www.sybausa.com*

Figure 6-11 SATA storage controller card by SYBA has two external and two internal ports and supports 6 Gbps SATA III speeds

Here is the step-by-step process of installing a SATA drive in a desktop system.

STEP 1: KNOW YOUR STARTING POINT

As with installing any other devices, before you begin installing a 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, 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. Be sure to protect against electrostatic discharge (ESD) by wearing an ESD strap 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, in most situations, 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 using a screwdriver, secure one side of the drive with one or two short screws (see Figure 6-12). 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 is a sliding tab (see Figure 6-13) that is used to secure the drive. Pull the tab back, slide in the drive, and push the tab forward to secure the drive.

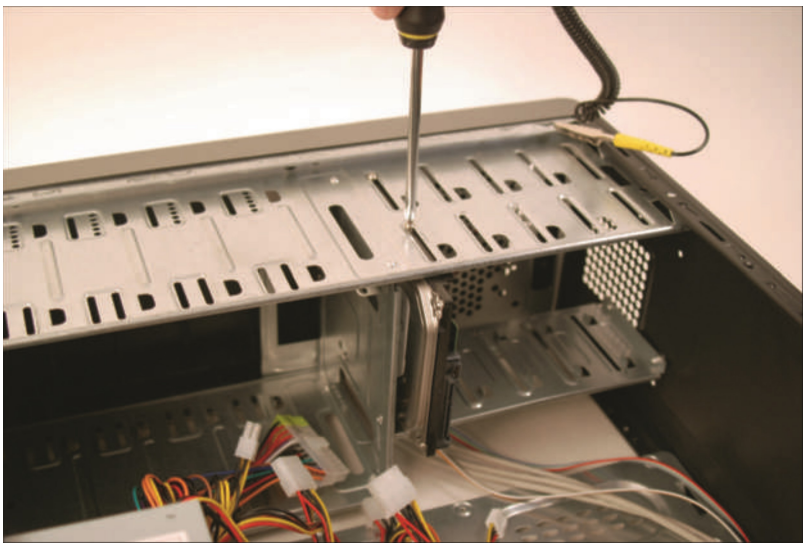


Figure 6-12 Secure one side of the drive with one or two screws

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.

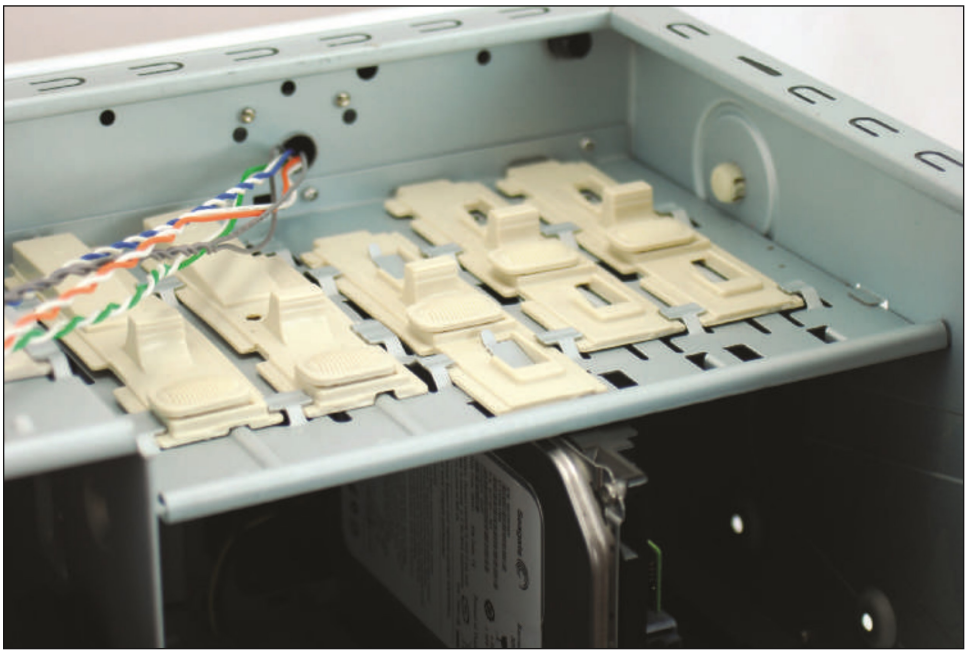


Figure 6-13 This drive bay uses tabs to secure the drive

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 6-14). To best secure the drive in the case, use two screws on each side of the drive.

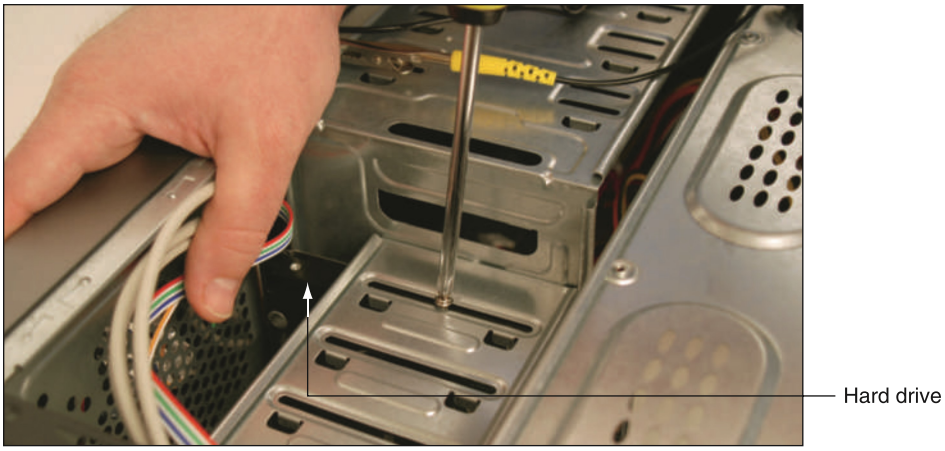


Figure 6-14 Secure the other side of the drive with one or two screws

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 6-15. 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 some boards, the hard drive that has the bootable OS installed must be connected to the first SATA connector, which is usually labeled SATA 0. 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 6-16).

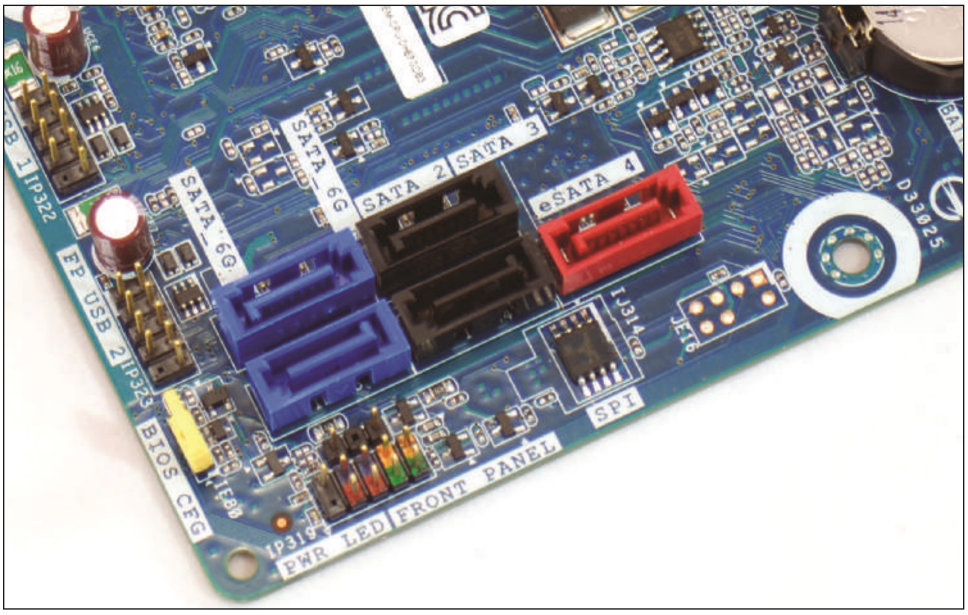


Figure 6-15 Five SATA connectors support different SATA standards

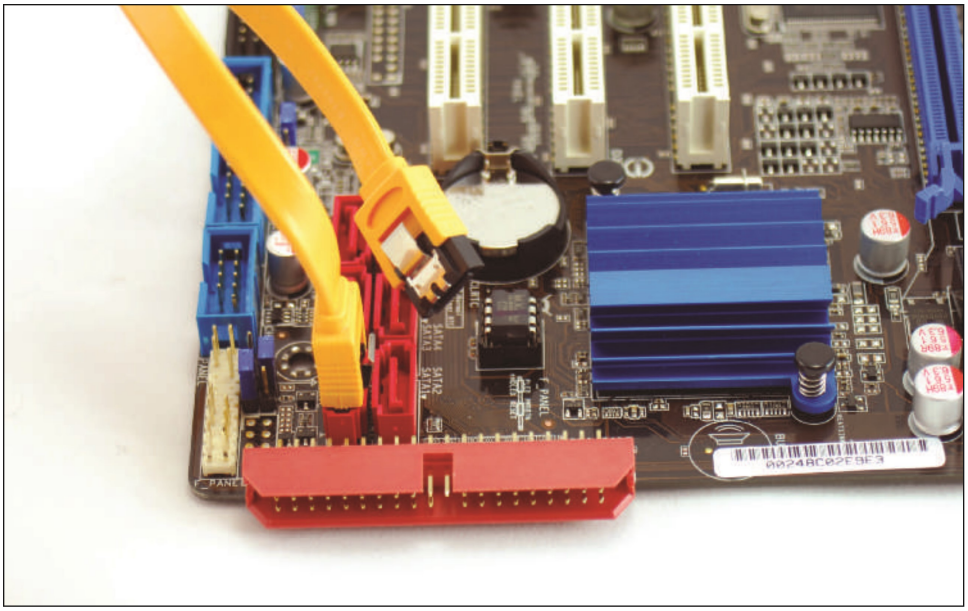


Figure 6-16 A clip on a SATA connector secures the connection

6. Connect a 15-pin SATA power connector or 4-pin Molex power connector from the power supply to the drive (see Figure 6-17).

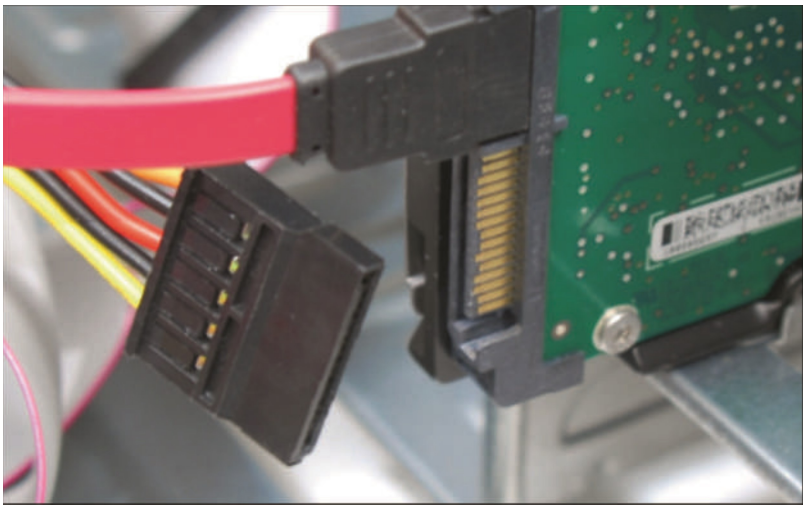
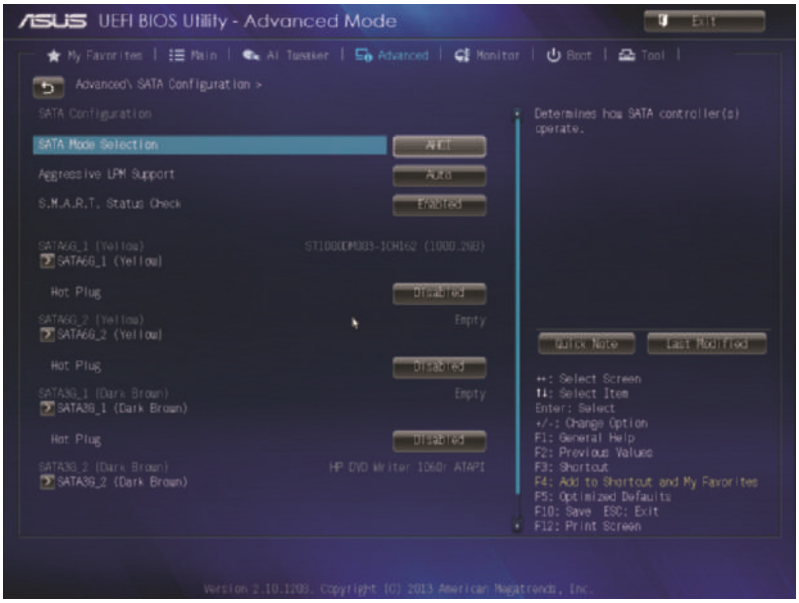


Figure 6-17 Connect the SATA power cord to the drive

7. Check all your connections and power up the system.
8. To verify the drive was recognized correctly, enter UEFI/BIOS setup and look for the drive. Figure 6-18 shows a UEFI setup screen on one system that has four SATA connectors. A hard drive is installed on one of the faster yellow SATA connectors and a DVD drive is installed on one of the slower brown SATA connectors.

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 front panel header on the motherboard.



Source: American Megatrends, Inc.

Figure 6-18 UEFI setup screen showing a SATA hard drive and DVD 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 the "Installing Windows" chapter, and how to use Disk Management is covered in the chapter,"Maintaining Windows."

INSTALLING A DRIVE IN A REMOVABLE BAY

A+ 220-901 1.4, 1.5, 1.11

Now let's see how a drive installation goes when you are dealing with a removable bay. Figure 6-19 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 6-19 The removable bay has a fan in front and is anchored to the case with locking pins

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 6-20). Slide the bay back into the case, and reinstall the locking pins. Plug in the cage fan power cord.

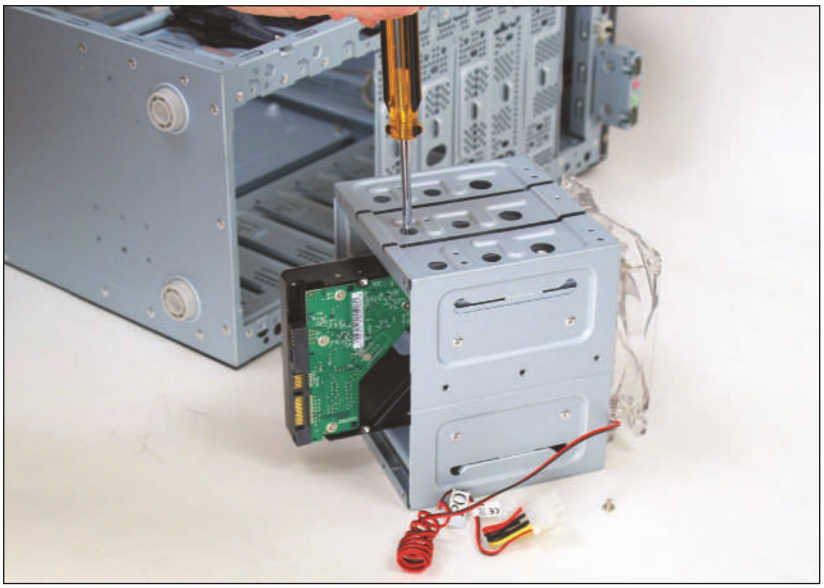


Figure 6-20 Install the hard drive in the bay using two screws on each side of the drive

INSTALLING A SMALL DRIVE IN A WIDE BAY

A+ 220-901 1.4, 1.5, 1.11

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 6-21, you can see how the universal bay kit adapter works. The adapter spans the distance between the sides of the drive and the bay. Figure 6-22 shows a SATA SSD drive with the brackets connected. Because SSD drives are usually smaller than magnetic drives, you're likely to need a bay kit to fit these drives into most desktop computer cases.

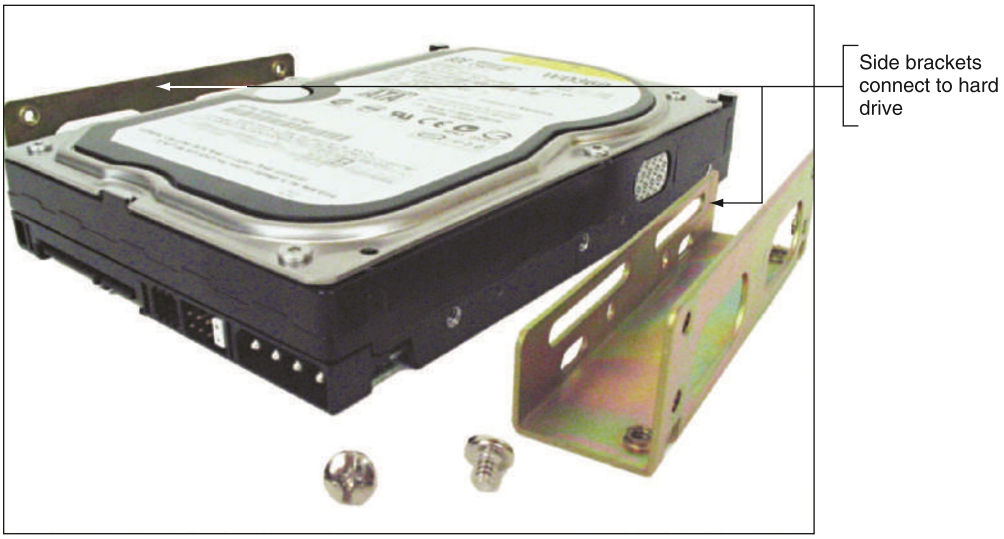


Figure 6-21 Use the universal bay kit to make the drive fit the bay

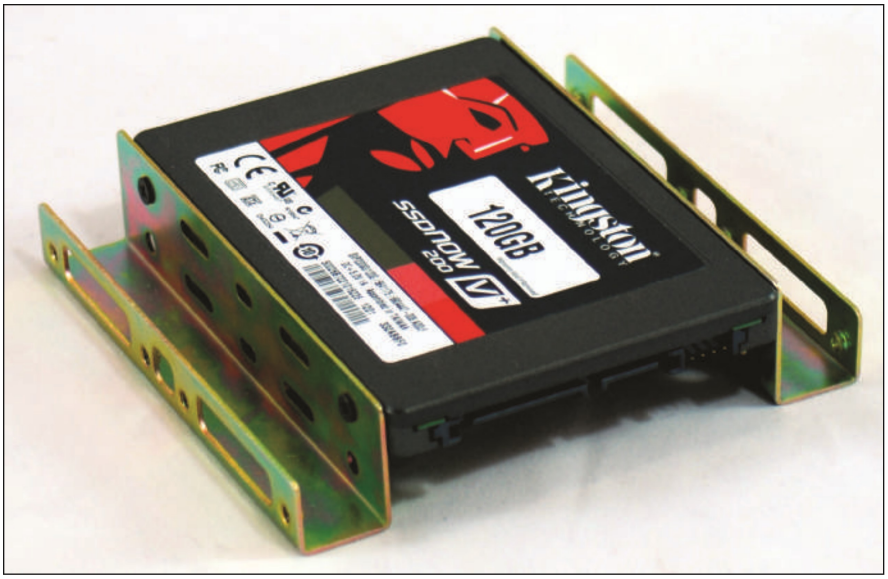


Figure 6-22 SSD drive with bay kit connected

INSTALLING A HARD DRIVE IN A LAPTOP

A+ 220-901 3.1

When purchasing and installing an internal hard drive or optical drive in a laptop, see the laptop manufacturer's documentation about specific sizes and connectors that will fit the laptop. Also be aware of voiding a warranty if you don't follow the laptop manufacturer's directions. Here is what you need to know when shopping for a laptop hard drive:

- A desktop hard drive is 3.5 inches wide and a laptop drive is 2.5 inches or 1.8 inches wide. Because the form factor of a laptop drive is more compact, it costs more than a desktop drive holding the same amount of data. Some laptop hard drives use SSD (solid-state device) technology.
- Today's laptop hard drives use a SATA interface, and older laptops used a PATA interface. Check your laptop manual to know which type of hard drive to buy, or remove the old drive and see which interface it uses. SATA data and power connectors on a laptop hard drive look the same as those in a desktop installation.

Before deciding to replace a hard drive, consider these issues:

- If the old drive has crashed, you'll need the recovery media to reinstall Windows and the drivers. Make sure you have the recovery media before you start.
- If you are upgrading from a low-capacity drive to a higher-capacity drive, you need to consider how you will transfer data from the old drive to the new one. One way to do that is to use a USB-to-SATA converter. Using this converter, both drives can be up and working on the laptop at the same time, so you can copy files.

To replace a hard drive, older laptop computers required that you disassemble the laptop. With newer laptops, you should be able to easily replace a drive. For example, for one laptop, first power down the system, remove peripherals, including the AC adapter, and remove the battery pack. Then remove a screw that holds the drive in place (see Figure 6-23).

Caution To protect sensitive components, never open a laptop case without first unplugging the AC adapter and removing the battery pack.

Figure 6-23 This one screw holds the hard drive in position

Open the lid of the laptop slightly so that the lid doesn't obstruct your removing the drive. Turn the laptop on its side and push the drive out of its bay (see Figure 6-24). Then remove the plastic cover from the drive. Move the cover to the new drive, and insert the new drive in the bay. Next, replace the screw and power up the system.

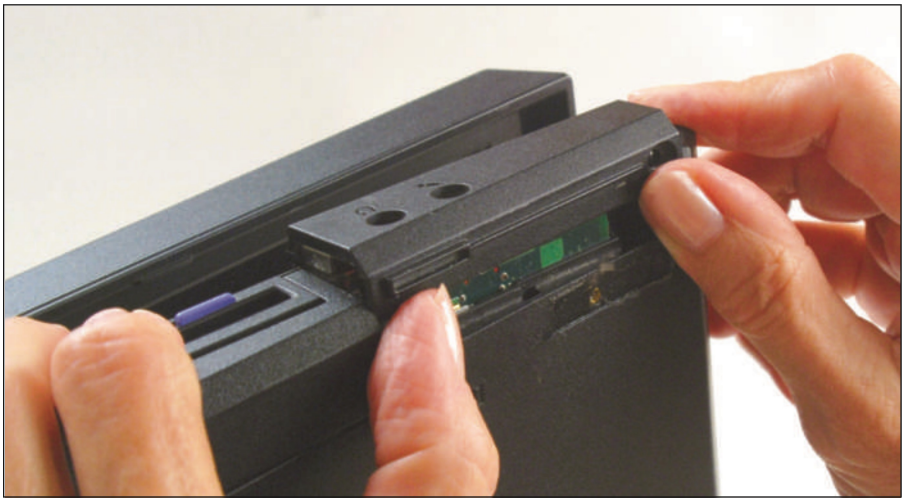


Figure 6-24 Push the drive out of its bay

When the system boots up, if UEFI/BIOS setup is set to autodetect hard drives, UEFI/BIOS recognizes the new drive and searches for an operating system. If the drive is new, boot from the Windows recovery DVD and install the OS.

Notes It is possible to give general directions on desktop computer repair that apply to all kinds of brands, models, and systems. Not so with laptops. Learning to repair laptops involves learning unique ways to assemble, disassemble, and repair laptop components for specific brands and models of laptops.

For some laptops, such as the one shown in Figure 6-25, you remove a cover on the bottom of the computer to expose the hard drive. Then remove one screw that anchors the drive. You can then remove the drive.

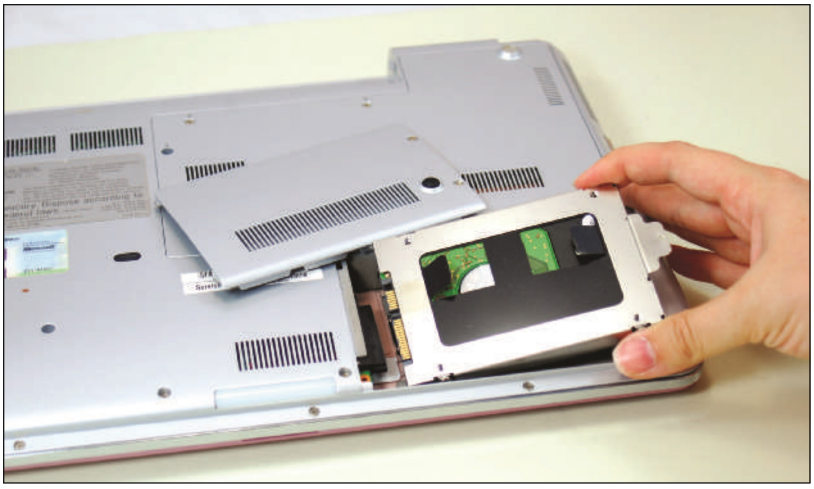


Figure 6-25 Remove a cover on the bottom of the laptop to exchange the hard drive, which is attached to a proprietary bracket

SETTING UP HARDWARE RAID

A+ 220-901 1.5, 1.11

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 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 6-26:

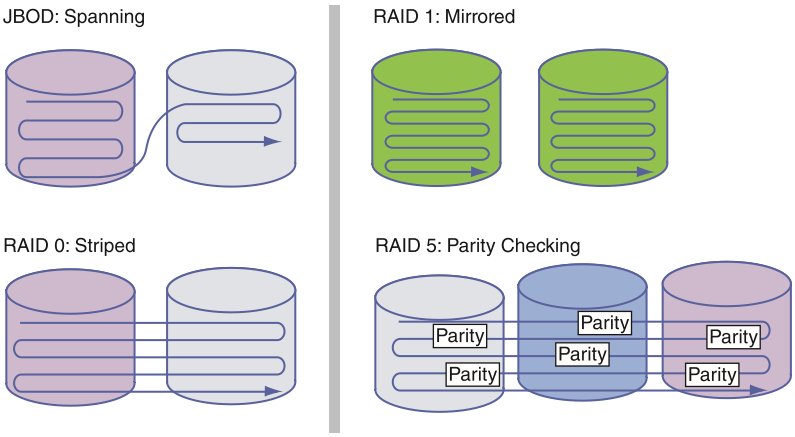


Figure 6-26 Ways that hard drives can work together

- **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**.
- **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**.
- **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 6-27. In addition, the two pairs of disks are striped, as shown at the bottom of Figure 6-27. 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.

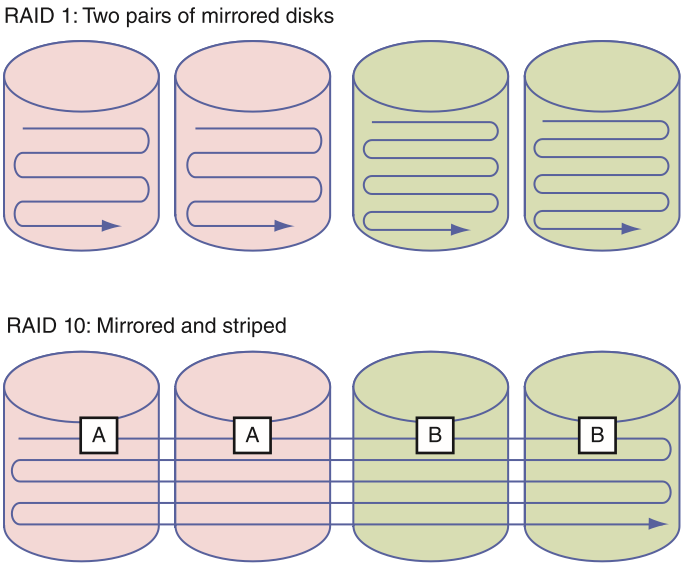


Figure 6-27 RAID 1 and RAID 10

A+ Exam Tip The A+ 220-901 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 7 to implement software RAID, the Disk Management utility is used to configure a group of hard drives in a RAID array. In Windows 8, you can use the Disk Management utility or the new Windows 8 Storage Spaces utility to implement software RAID. However, software RAID is considered an unstable solution and is 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 UEFI/BIOS or by using a RAID controller **storage card**. Figure 6-28 shows a RAID controller card by Sabrent that provides four SATA ports.

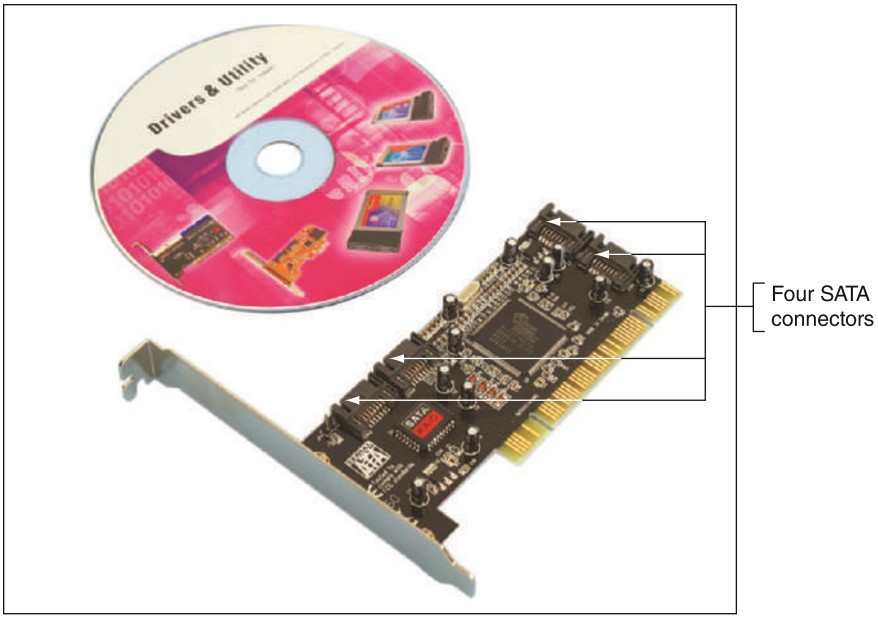


Figure 6-28 RAID controller card provides four SATA internal connectors

A+ Exam Tip The A+ 220-901 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 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 6-29). To help keep the drives cool, the drives are installed with an empty bay between each drive.

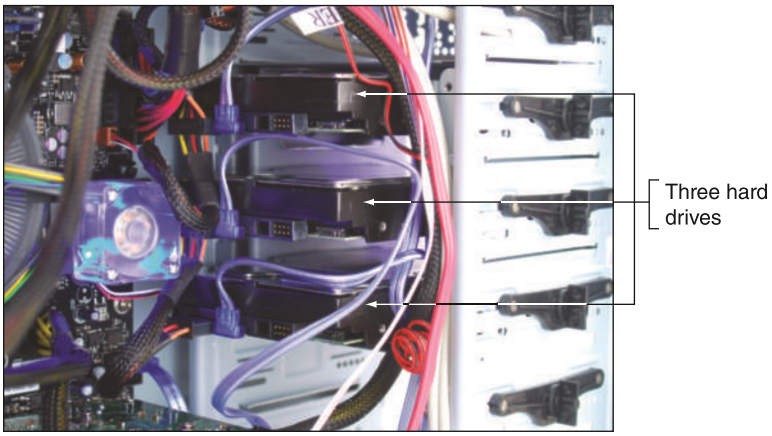
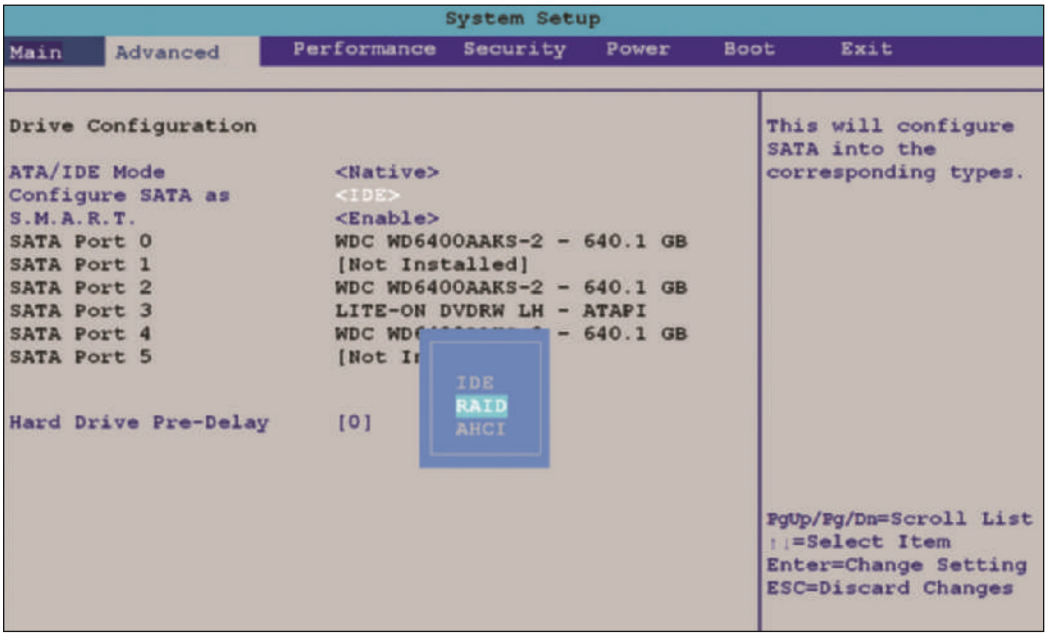


Figure 6-29 Install three matching hard drives in a system

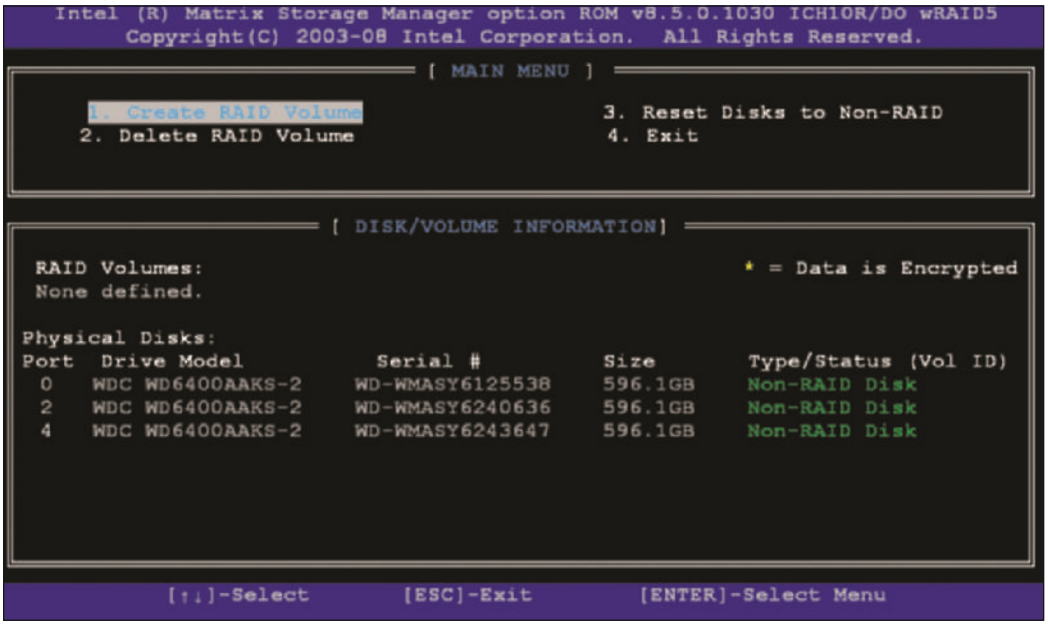
2. Boot the system and enter UEFI/BIOS setup. On the Advanced setup screen, verify the three drives are recognized. Select the option to configure SATA and then select RAID from the menu (see Figure 6-30).



Source: Intel

Figure 6-30 Configure SATA ports on the motherboard to enable RAID

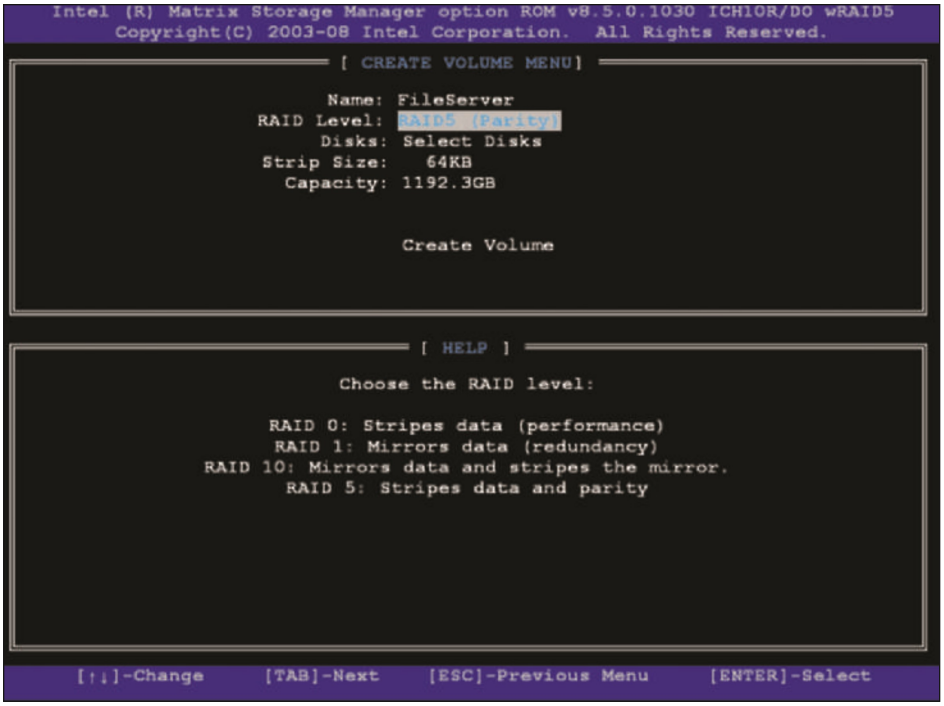
3. Reboot the system and a message is displayed on screen: "Press <Ctrl+I> to enter the RAID Configuration Utility." Press **Ctrl** and **I** to enter the utility (see Figure 6-31). Notice in the information area that the three drives are recognized and their current status is Non-RAID Disk.



Source: Intel

Figure 6-31 BIOS utility to configure a RAID array

4. Select option 1 to **Create RAID Volume**. On the next screen shown in Figure 6-32, enter a volume name (FileServer in our example).



Source: Intel

Figure 6-32 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 6-32 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 8/7/Vista have built-in hardware RAID drivers and, therefore, automatically "see" the RAID array as a single 500-GB hard drive. After Windows is installed on the drive, Windows will call it drive C:.

APPLYING | CONCEPTS TROUBLESHOOT HARD DRIVE INSTALLATIONS

A+ 220-901 4.2

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 extra complexity of installing a RAID array. If a complicated installation is necessary and you have never installed a hard drive, ask for expert help.

(continues)

The following list describes 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 a SATA hard drive. He turned on the machine and accessed UEFI/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 computer, Susan received the following error message: "Hard drive not found." She turned off the machine, checked all cables, and discovered that the data cable from the motherboard to the drive was loose. She 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 computer 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.

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. She plugged the power cord into the drive without turning the computer off. The machine began to smoke and everything went dead. The next thing she learned was how to replace a power supply!

EXTERNAL ENCLOSURES

A+ 220-901 1.5, 1.11

Hard drives are sometimes stored in external enclosures such as the one shown in Figure 6-33. These enclosures make it easy to expand the storage capacity of a single computer or to make available hard drive storage to an entire network. For network attached storage (NAS), the enclosure connects to the network using an Ethernet port. When the storage is used by a single computer, the connection is made using a USB or eSATA port. Regardless of how the enclosure connects to a computer or network, the hard drives inside the enclosure might use a SATA connection.

Courtesy of D-Link Corporation

Figure 6-33 The NAS ShareCenter Pro 1100 by D-Link can hold four hot-swappable SATA hard drives totaling 12 TB of storage, has a dual-core processor and 512 MB of RAM, and supports RAID

Here is what you need to know about supporting these external enclosures:

- An enclosure might contain firmware that supports RAID. For example, a switch on the rear of one enclosure for two hard drives can be set for RAID 0, RAID 1, or stand-alone drives. Read the documentation for the enclosure to find out how to manage the RAID volumes.
- To replace a hard drive in an enclosure, see the documentation for the enclosure to find out how to open the enclosure and replace the drive.
- If a computer case is overheating, one way to solve this problem is to remove the hard drives from the case and install them in an external enclosure. However, it's better to leave the hard drive that contains the Windows installation in the case.

Hands-On Project 6-2 Select a Replacement Hard Drive

A+ 220-901 1.5

Suppose one of the 640-GB Western Digital hard drives installed in the RAID array and shown in Figure 6-29 has failed. Search the Internet and find a replacement drive as close to this drive as possible. Print three webpages showing the sizes, features, and prices of three possible replacements. Which drive would you recommend as the replacement drive and why?

Hands-On Project 6-3 Prepare for Hard Drive Hardware Problems

A+ 220-901 4.2

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 appears.
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 message that appears.
4. Turn off the computer, reconnect the power supply, and reboot the system. Verify the system is working again.

Hands-On Project 6-4 Install a Hard Drive

A+ 220-901 1.5

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 8 File Explorer or Windows 7/Vista Windows Explorer. Then remove the second hard drive, and return it to its original computer. Verify that both computers and drives are working.

Now let's move on to other types of storage devices, including tape drives, optical drives, and flash cards.

Courtesy of Quantum Corporation

Figure 6-34 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.

IDENTIFYING TAPE DRIVES

A+ 220-901 1.5, 1.11

Tape drives (see Figure 6-34) 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 up to 185 TB true tape capacity 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.

A+ Exam Tip The A+ 220-901 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.

Notes Two basic ways computers access data is random access and sequential access. As an analogy, "pick a card, any card" is random access and "take the first card in the stack" is sequential access.

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 shown in Figure 6-35, 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 computer case.

Figure 6-35 Minicartridge for a tape drive has a write-protect switch

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

- *DDS (Digital Data Storage)*. DDS-1, DDS-2, DDS-3, DDS-4, and DDS-5 are popular types. DDS-5 holds up to 36 GB of native or 72 GB of compressed data. DDS-5 is also called DAT72.
- *LTO (Linear Tape-Open)*. 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 of native or 3.0 TB of compressed data. Figure 6-36 shows an LTO Ultrium 3 tape.

Figure 6-36 This Maxell LTO Ultrium 3 data tape cartridge can hold up to 800 GB of compressed data

- *DLT (Digital Linear Tape)*. DLT IV or DLT-4 holds up to 40 GB of native or 80 GB of compressed data.
- *SDLT (Super Digital Linear Tape)*. Super DLT II holds up to 300 GB of native or 600 GB of compressed data.
- *Travan*. Travan cartridges vary from TR-1 through TR-7. The TR-7 holds 20 GB of native and 40 GB of compressed data.
- *AIT (Advanced Intelligent Tape)*. 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 of compressed data.
- *SLR (Scalable Linear Recording)*. SLR types include SLR1 through SLR140. SLR140 holds 70 GB of native or 140 GB of compressed data.

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 SATA, PATA, or SCSI 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 *backupworks.com*.

SUPPORTING OTHER TYPES OF STORAGE DEVICES

A+ 220-901 1.5, 1.11

Before we explore the details of several other types of storage devices, including optical discs, USB flash drives, and memory cards, let's start with the file systems they might use.

FILE SYSTEMS USED BY STORAGE DEVICES

A+ 220-901 1.5, 1.11

A storage device, such as a hard drive, CD, DVD, USB flash drive, or memory card, uses a file system to manage the data stored on the device. A **file system** is the overall structure the OS uses to name, store, and organize files on a drive. In Windows, each storage device is assigned a drive letter. In Windows 8 File Explorer or Windows 7/Vista Windows Explorer, to see what file system a device is using, right-click the device and select **Properties** from the shortcut menu. The device Properties box appears, which shows the file system and storage capacity of the device (see Figure 6-37).

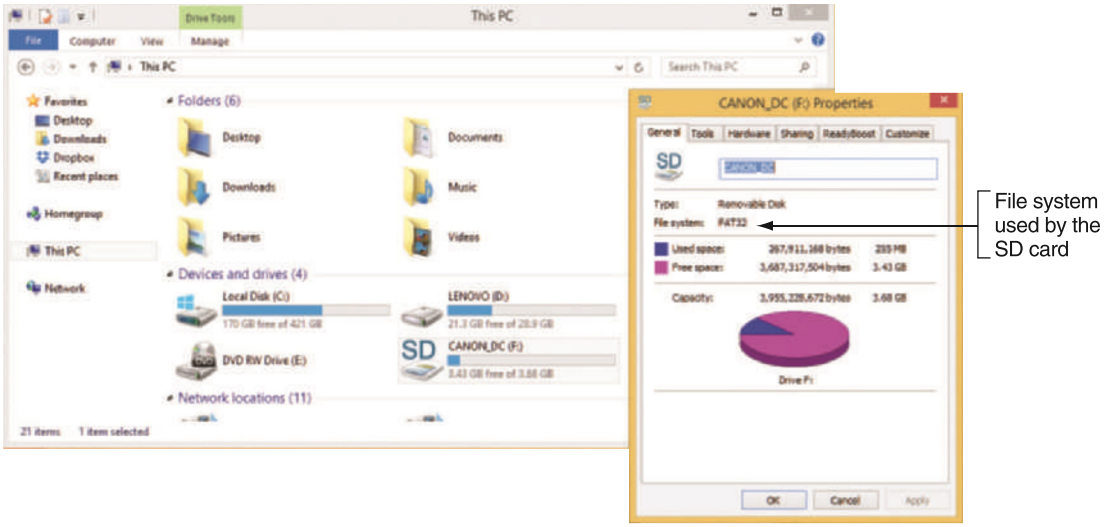


Figure 6-37 This 4-GB SD card is using the FAT32 file system

Installing a new file system on a device is called **formatting** the device, and the process erases all data on the device. One way to format a device is to right-click the device and select **Format** from the shortcut menu. In the box that appears, you can select the file system to use (see Figure 6-38). The New Technology file system (NTFS) is primarily used by hard drives. The exFAT file system is used by large-capacity removable storage devices such as large-capacity USB flash drives, memory cards, and some external hard drives. In addition, the older FAT32 and FAT file systems are used by smaller-capacity devices. If you have problems with a device, make sure it's using a file system appropriate for your situation.

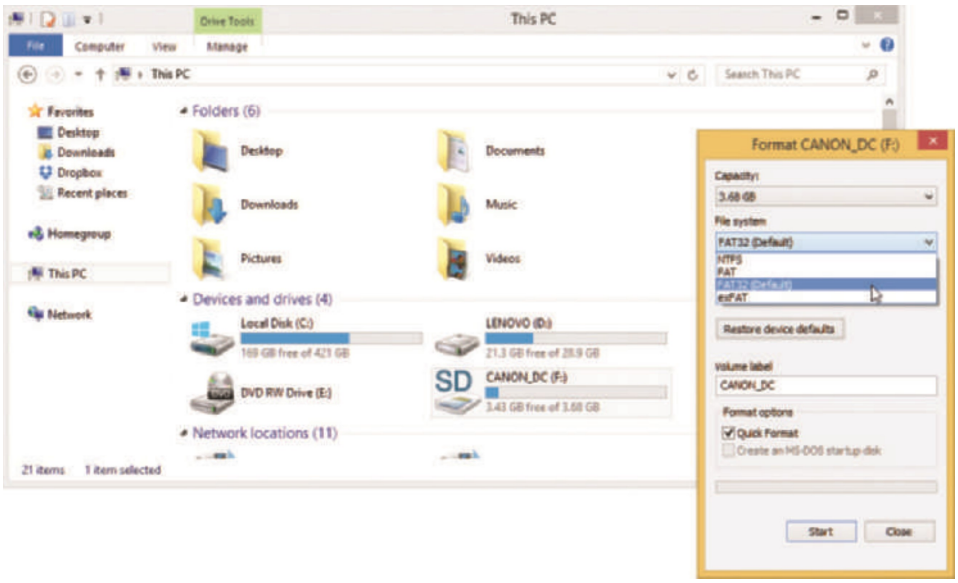


Figure 6-38 A storage device can be formatted using Windows Explorer

Now let's look at the types of optical drives you might be called on to support.

STANDARDS USED BY OPTICAL DRIVES AND DISCS

A+
220-901
1.5, 1.11

CDs, DVDs, and Blu-ray discs use similar laser technologies. Tiny lands and pits on the surface of a disc represent bits, which a laser beam can read. This is why they are called optical storage technologies. **CD (compact disc)** drives use the **CDFS (Compact Disc File System)** or the **UDF (Universal Disk Format) file system**, while **DVD (digital versatile disc** or **digital video disc)** drives and **Blu-ray Disc (BD)** drives use the newer UDF file system.

Blu-ray drives are backward compatible with DVD and CD technologies, and DVD drives are backward compatible with CD technologies. Depending on the drive features, an optical drive might be able to read and write to BDs, DVDs, and CDs. An internal optical drive can interface with the motherboard by way of a SATA connection. An external drive might use an eSATA, FireWire, or USB port. Figure 6-39 shows an internal DVD drive, and Figure 6-40 shows an external DVD drive.

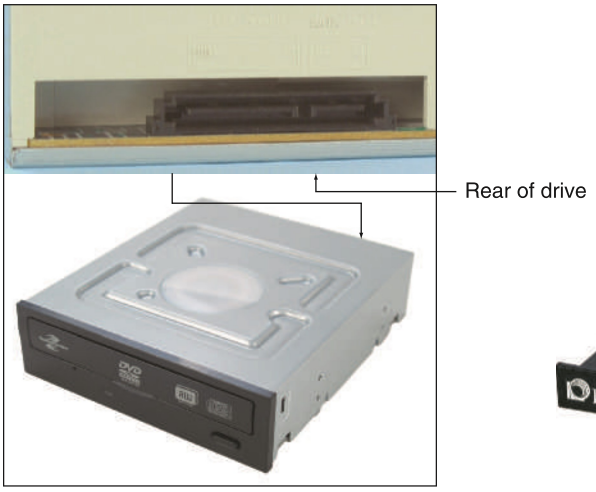


Figure 6-39 This internal DVD drive uses a SATA connection

Courtesy of Plextor

Figure 6-40 The PX-610U external DVD±RW drive by Plextor uses a USB 2.0 port

Data is written to only one side of a CD, but can be written to one or both sides of a DVD or Blu-ray disc. Also, a DVD or Blu-ray disc can hold data in two layers on each side. This means these discs can hold a total of four layers on one disc (see Figure 6-41).

The breakdown of how much data can be held on CDs, DVDs, and BDs is shown in Figure 6-42. The capacities for DVDs and BDs depend on the sides and layers used to hold the data.

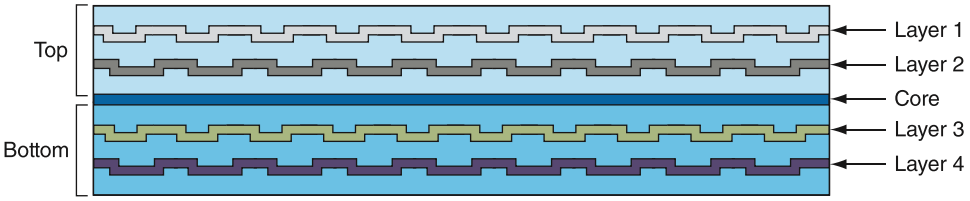


Figure 6-41 A DVD can hold data in double layers on both the top and bottom of the disc, yielding a maximum capacity of 17 GB

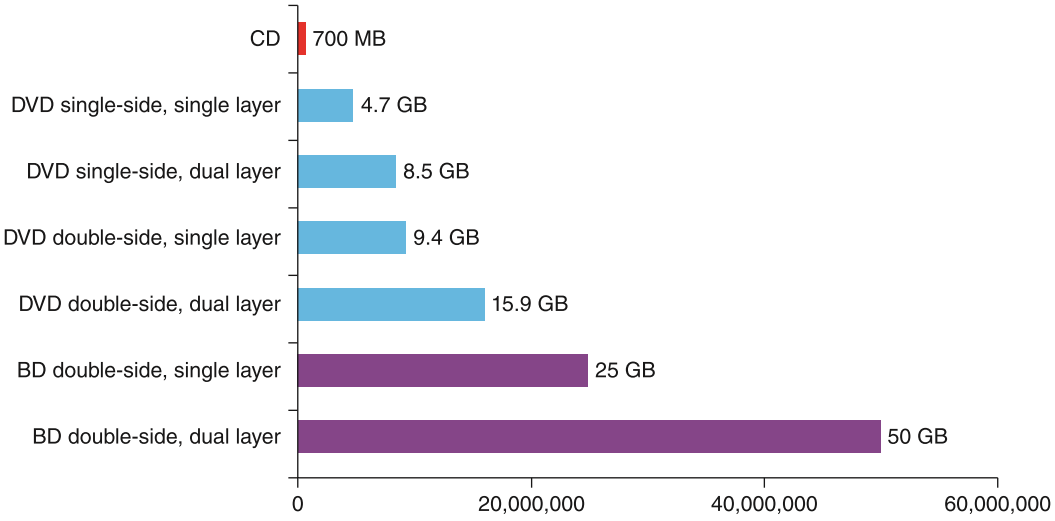


Figure 6-42 Storage capacities for CDs, DVDs, and BD discs

A+ Exam Tip The A+ 220-901 exam expects you to know the capacities of CDs, DVDs, and Blu-ray discs. These capacities are all listed in Figure 6-42.

Notes The discrepancy in the computer industry between one billion bytes (1,000,000,000 bytes) and 1 GB (1,073,741,824 bytes) exists because 1 KB equals 1024 bytes. Even though documentation might say that a DVD holds 17 GB, in fact, it holds 17 billion bytes, which is only 15.90 GB.

When shopping for an optical drive, suppose you see a couple of ads like those shown in Figure 6-43. To sort out the mix of disc standards, Table 6-3 can help. The table lists the popular CD, DVD, and Blu-ray disc standards.

Source: *tigerdirect.com*

Figure 6-43 Ads for internal and external DVD burners

Disc Standard	Description
CD-ROM disc or drive	*CD-read-only memory.* A CD-ROM disc burned at the factory can hold music, software, or other data. The bottom of a CD-ROM disc is silver. A CD-ROM drive can read CDs.
CD-R disc	*CD recordable.* A CD-R disc is a write-once CD.
CD-RW disc or drive	*CD rewriteable.* A CD-RW disc can be written to many times. A CD-RW drive can write to a CD-RW or CD-R disc and also overwrite a CD-RW disc.
DVD-ROM drive	*DVD read-only memory.* A DVD-ROM drive can also read CDs or DVDs.
DVD-R disc	*DVD recordable, single layer.* A DVD-R disc can hold up to 4.7 GB of data and is a write-once disc.
DVD-R DL disc	*DVD recordable in dual layers.* Doubles storage to 8.5 GB of data on one disc surface.
DVD-RW disc or drive	*DVD rewriteable.* A DVD-RW disc is also known as an erasable, recordable drive or a write-many disc. The speeds in an ad for an optical drive indicate the maximum speed supported when burning this type of disc, for example, DVD-RW 6X.
DVD-RW DL disc or drive, aka DL DVD drive	*DVD rewriteable, dual layers.* A DVD-RW DL disc doubles storage capacity to 8.5 GB.
DVD+R disc or drive	*DVD recordable.* Similar to but faster than DVD-R. Discs hold about 4.7 GB of data.
DVD+R DL disc or drive	*DVD recordable, dual layers.* Doubles disc storage to 8.5 GB on one surface.
DVD+RW disc or drive	*DVD rewriteable.* Faster than DVD-RW.
DVD-RAM disc or drive	*DVD Random Access Memory.* Rewriteable and erasable. You can erase or rewrite certain sections of a DVD-RAM disc without disturbing other sections of the disc, and the discs can handle many times over the number of rewrites (around 100,000 rewrites), compared with about a thousand rewrites for DVD-RW and DVD+RW discs. DVD-RAM discs are popular media used in camcorders and set-top boxes.
BD-ROM drive	*BD read-only memory.* A Blu-ray BD-ROM drive can also read DVDs, and some can read CDs.
BD-R disc or drive	*BD recordable.* A BD-R drive might also write to DVDs or CDs.
BD-RE disc or drive	*BD rewriteable.* A BD-RE drive might also write to DVDs or CDs.

Table 6-3 Optical discs and drive standards

A+ Exam Tip The A+ 220-901 exam expects you to know about the combo optical drives and burners, including CD, CD-RW, DVD, DVD-RW, DVD DL, Blu-ray, BD-R, and BD-RE combo drives.

Notes CDs, DVDs, and BDs are expected to hold their data for many years; however, you can prolong the life of a disc by protecting it from exposure to light.

Hands-On Project 6-5 Learn How Optical Drives Work

A+ 220-901 1.5

Optical drives and other removable storage technologies are interesting to study. Check out the animated explanation at the website *howstuffworks.com*. Search on "How Removable Storage Works." List 10 facts you learned about optical drives.

INSTALLING AN OPTICAL DRIVE

A+ 220-901 1.5, 1.11

Internal optical drives on today's computers use a SATA interface. Figure 6-44 shows the rear of a SATA optical drive. An optical drive is usually installed in the drive bay at the top of a desktop case (see Figure 6-45). After the drive is installed in the bay, connect the data and power cables.

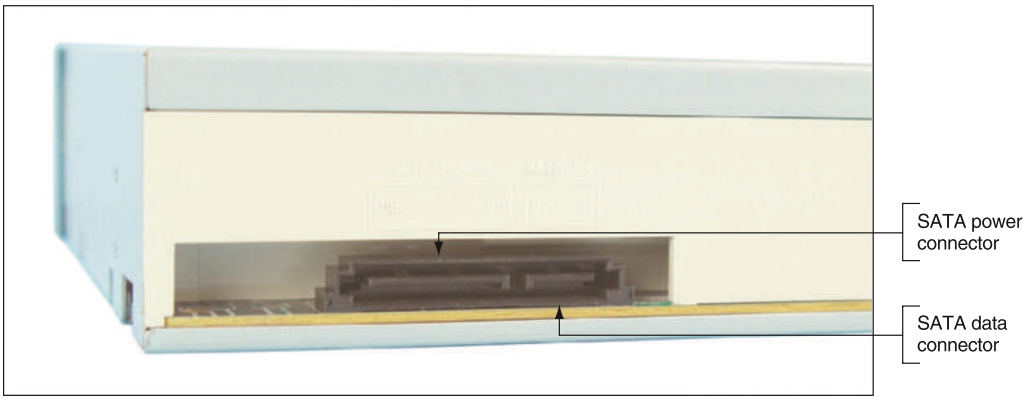


Figure 6-44 Rear of a SATA optical drive

Figure 6-45 Slide the drive into the bay flush with the front panel

A+ Exam Tip The A+ 220-901 exam expects you to know how to install a CD, DVD, or Blu-ray drive.

Windows 8/7/Vista supports optical drives using its own embedded drivers without add-on drivers. Therefore, when Windows first starts up after the drive is installed, it recognizes the drive and installs drivers. Use Device Manager to verify the drive installed with no errors and is ready to use.

REPLACING AN OPTICAL DRIVE ON A LAPTOP

A+ 220-901 1.5, 1.11

Some of the newest laptops do not have an optical drive in order to save on the size and weight of a laptop, but instead use an external optical drive. However, several new laptops still include the optical drive, and if it goes bad on a laptop, it is likely cheaper to replace the optical drive than to replace the laptop. For some systems, you'll need to first remove the keyboard to expose an optical drive. Follow along as we remove the DVD drive from one laptop system:

1. ***Very important:*** Unplug the AC adapter and remove the battery pack.
2. For this laptop, to remove the keyboard, you first remove one screen on the bottom of the case and then turn the case over and pry up the keyboard. You can then move the keyboard to one side. You can leave the ribbon cable from the motherboard to the keyboard connected. When you move the keyboard out of the way, the DVD drive is exposed, as shown in Figure 6-46.

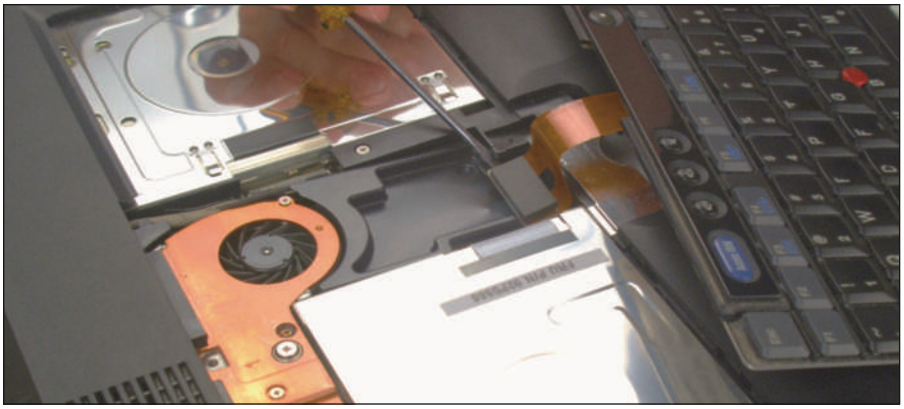


Figure 6-46 Remove the keyboard to expose the optical drive

3. Remove the screw that holds the DVD drive to the laptop (see Figure 6-47).

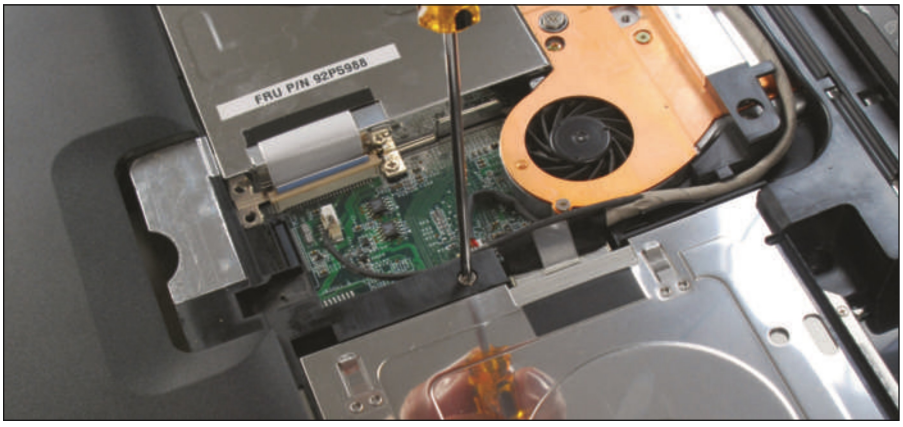


Figure 6-47 Remove the screw that holds the DVD drive

4. Slide the drive out of the bay (see Figure 6-48).
5. When you slide the new drive into the bay, make sure you push it far enough into the bay so that it solidly connects with the drive connector at the back of the bay. Replace the screw.

For other systems, the optical drive can be removed by first removing a cover from the bottom of the laptop. Then you remove one screw that secures the drive. Next, push the optical drive out of the case (see Figure 6-49).

Figure 6-48 Slide the drive out of the bay

Figure 6-49 Push the optical drive out the side of the case

SOLID-STATE STORAGE

A+ 220-901 1.5, 1.11

Types of solid-state storage include SSD hard drives, USB flash drives, and memory cards. USB flash drives currently for sale range in size from 128 MB to 1 TB and go by many names, including a flash pen drive, jump drive, thumb drive, and key drive. Several USB flash drives are shown in Figure 6-50. Flash drives might work at USB 2.0 or USB 3.0 speed and use the FAT (for small-capacity drives) or exFAT file system (for large-capacity drives). Windows 8/7/Vista has embedded drivers to support flash drives. To use one, simply insert the device in a USB port. It then shows in Windows 8 File Explorer or Windows 7/Vista Windows Explorer as a drive with an assigned letter.

Figure 6-50 USB flash drives come in a variety of styles and sizes

To make sure that data written to a flash drive is properly saved before you remove the flash drive from the computer, double-click the **Safely Remove Hardware** icon in the notification area of the Windows taskbar (see Figure 6-51). The Safely Remove Hardware box opens, also shown in Figure 6-51. After you click the device listed, it is then safe to remove it.

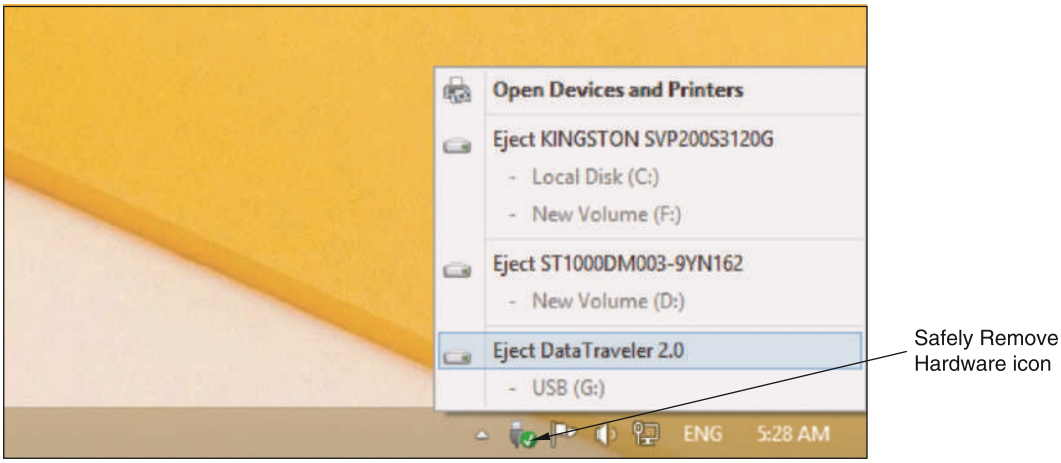


Figure 6-51 Safely Remove Hardware icon and dialog box

Memory cards might be used in digital cameras, tablets, cell phones, MP3 players, digital camcorders, and other portable devices, and most laptops have memory card slots provided by a built-in **smart card reader**. If there is not a memory card slot included in the device, you can add an external smart card reader that uses a USB connection. The most popular memory cards are **Secure Digital (SD) cards**, which follow the standards of the SD Association (*sdcard.org*), and are listed in Table 6-4. The three standards used by SD cards are 1.x (regular SD), 2.x (SD High Capacity or SDHC), and 3.x (SD eXtended Capacity or SDXC). In addition, these cards come in three physical sizes.

	Full-size SD	MiniSD	MicroSD
SD **SD 1.x** **Holds up to 2 GB**	**SD card** 	**MiniSD card** 	**MicroSD card** 
SD High Capacity **SD 2.x** **Holds 2 GB to 32 GB**	**SDHC card** 	**MiniSDHC** 	**MicroSDHC card** 
SD eXtended Capacity **SD 3.x** **Holds 32 GB to 2 TB**	**SDXC card** 	**N/A**	**MicroSDXC card**  Courtesy of SanDisk

Table 6-4 Flash memory cards that follow the SD Association standards

SDHC and SDXC slots are backward compatible with earlier standards for SD cards. However, you cannot use an SDHC card in an SD slot, and you cannot use an SDXC card in an SDHC slot or SD slot. Only use SDXC cards in SDXC slots.

SD and SDHC cards use the FAT file system, and SDXC cards use the exFAT file system. Windows 8/7/Vista support both file systems, so you should be able to install an SD, SDHC, or SDXC card in an SD slot on a Windows 8/7/Vista laptop with no problems (assuming the slot supports the SDHC or SDXC card you are using).

Memory cards other than SD cards are shown in Table 6-5. Some of the cards in Table 6-5 are now obsolete.

Flash Memory Device	Example
The Sony Memory Stick PRO Duo is about half the size of the Memory Stick PRO but is faster and has a higher storage capacity (up to 2 GB). You can use an adapter to insert the Memory Stick PRO Duo in a regular Memory Stick slot.	
Compact Flash (CF) cards come in two types, Type I (CFI) and Type II (CFII). Type II cards are slightly thicker. CFI cards will fit a Type II slot, but CFII cards will not fit a Type I slot. The CF standard allows for sizes up to 137 GB, although current sizes range up to 32 GB. UDMA CompactFlash cards are faster than other CompactFlash cards. UDMA (Ultra Direct Memory Access) transfers data from the device to memory without involving the CPU.	
MultiMediaCard (MMC) looks like an SD card, but the technology is different and they are not interchangeable. Generally, SD cards are faster than MMC cards.	
Embedded MMC (eMMC) is internal storage used instead of using an SSD drive in inexpensive mobile devices such as cell phones, tablets, and laptops.	 Courtesy of SanDisk
The Memory Stick is used in Sony cameras and camcorders. A later version, the Memory Stick PRO, improved on the slower transfer rate of the original Memory Stick.	
The xD-Picture Card has a compact design (about the size of a postage stamp), and currently holds up to 2 GB of data. You can use an adapter to insert this card into a PC Card slot on a laptop computer or a CF slot on a digital camera.	

Table 6-5 Flash memory cards

A+ Exam Tip The A+ 220-901 exam expects you to know about SD, MicroSD, MiniSD, Compact Flash, eMMC, and xD memory cards.

Figure 6-52 shows several flash memory cards together so you can get an idea of their relative sizes. Sometimes a memory card is bundled with one or more adapters so that a smaller card will fit a larger card slot.

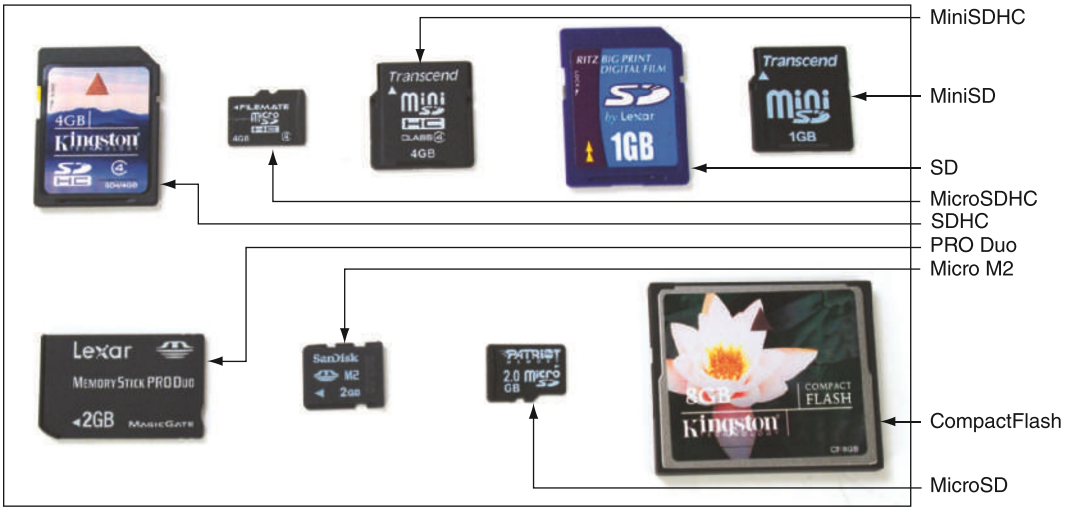


Figure 6-52 Flash memory cards

Hands-On | Project 6-6 Shop for Storage Media

A+ 220-901 1.5

Shop online and print or save webpages showing the following devices. Two online sites you can use are Micro Center (*microcenter.com*) and TigerDirect (*tigerdirect.com*):

1. DVD+R DL discs, which are usually sold in packs. What is the storage capacity of each disc? How many discs are in the pack? What is the price per disc?
2. DVD+RW disc, which is usually sold as a single. What is the price per disc? How many more times expensive is a DVD+RW disc than a DVD+R disc?
3. The largest-capacity USB flash drive you can find. What is its capacity and price?
4. The eight types of SD memory cards in Table 6-4. What is the storage capacity and price of each card? Which type of SD card gives you the most storage per dollar?

TROUBLESHOOTING HARD DRIVES

A+ 220-901 4.2

In this part of the chapter, you learn how to troubleshoot problems with hard drives. Problems caused by the hard drive during the boot can be caused by the hard drive subsystem, by the file system on the drive, or by files required by Windows when it begins to load. When trying to solve a problem with the boot, you need to decide if the problem is caused by hardware or software. All the problems discussed in this section are caused by hardware.

SLOW PERFORMANCE

A+ 220-901 4.2

One of the most common complaints about a computer is that it is running slowly. When files are physically written over a magnetic hard drive in disconnected fragments on the drive, slow performance can result. (SSD drives don't suffer from slow performance when files are fragmented on the drive.) A quick fix for fragmented files is to run the defragmentation tool

on the hard drive. Windows 8/7/Vista automatically defragments a magnetic hard drive once a week, but you can run the defragmentation tool independently of the scheduled maintenance. The Windows defragmentation tool rearranges fragments or parts of files in contiguous clusters so that, when the computer is searching for files, they are easier and faster to find. To run the defragmentation tool, right-click the **Start** button in Windows 8, click **Run**, and enter the **dfrgui** command. In Windows 7, click **Start** and enter the **dfrgui** command in the Search box. Select the drive to defrag (see Figure 6-53 for Windows 8). Windows will tell you if the drive is fragmented and will benefit from defragmentation. Notice in the figure that solid-state drives are not marked as fragmented, but Windows 8 can optimize these drives to release unused space to reduce the number of write operations to the drive. (Windows 7 does not optimize SSD drives.)

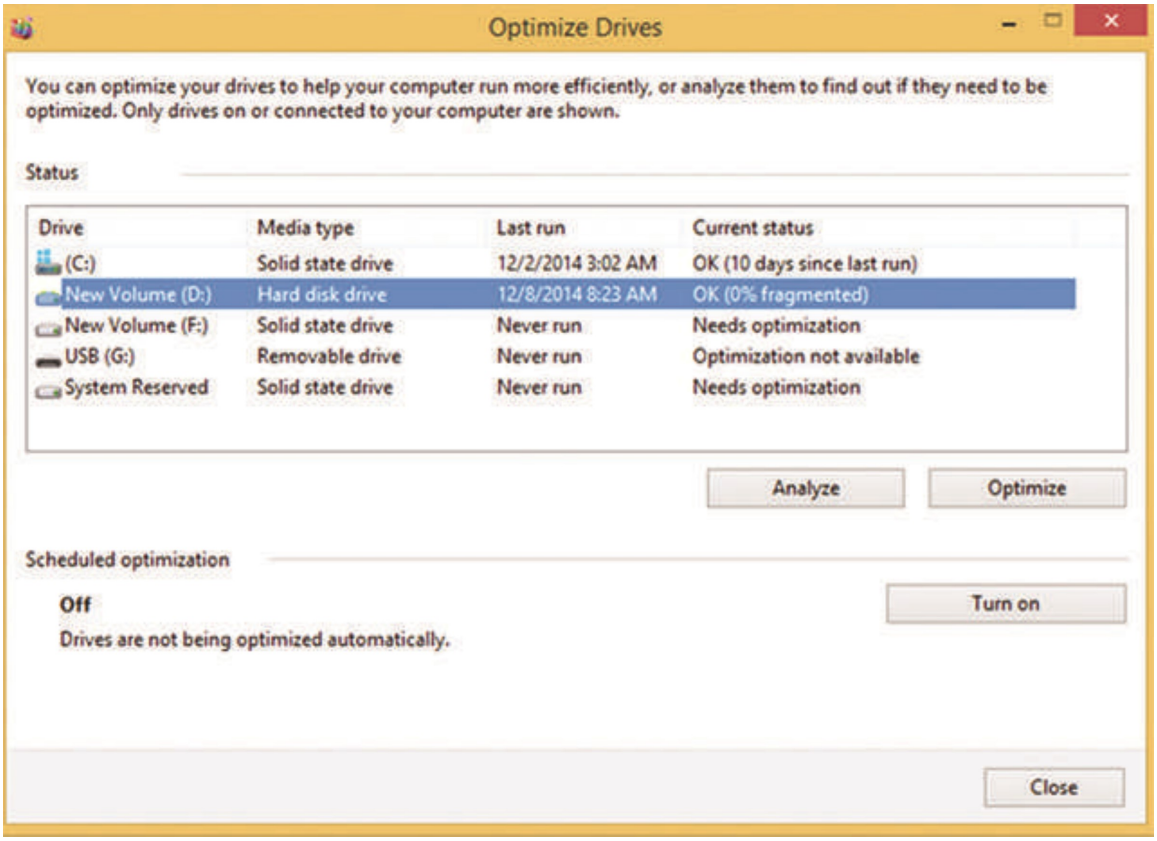


Figure 6-53 Windows reports the selected volume D: is not fragmented

HARD DRIVE PROBLEMS DURING THE BOOT

A+ 220-901 4.2

Hardware problems usually show up at POST, unless there is physical damage to an area of the hard drive that is not accessed during POST. Hardware problems often make the hard drive totally inaccessible. If UEFI/BIOS cannot find a hard drive at POST, it displays an error message similar to these:

```
No boot device available
Hard drive not found
OS not found
Read/write failure
Fixed disk error
Invalid boot disk
Inaccessible boot device
```

```
Drive not recognized
RAID not found
RAID stops working
Numeric error codes in the 1700s or 10400s
S.M.A.R.T. errors during the boot
```

The reasons UEFI/BIOS cannot access the drive can be caused by the drive, the data cable, the electrical system, the motherboard, or a loose connection. Here is a list of things to do and check before you open the case:

1. If UEFI/BIOS displays numeric error codes or cryptic messages during POST, check the website of the UEFI/BIOS manufacturer for explanations of these codes or messages.
2. Check UEFI/BIOS setup for errors in the hard drive configuration. If you suspect an error, set UEFI/BIOS to default settings, make sure autodetection is turned on, and reboot the system.
3. Try booting from another bootable media such as the Windows setup DVD or a USB flash drive or CD with the Linux OS and diagnostics software installed (for example, Hiren's BootCD software at *hirensbootcd.org*). If you can boot using another media, you have proven that the problem is isolated to the hard drive subsystem. You can also use the bootable media to access the hard drive, run diagnostics on the drive, and possibly recover its data.
4. For a RAID array, use the firmware utility to check the status of each disk in the array and to check for errors. Press a key at startup to access the RAID UEFI/BIOS utility. This utility lists each disk in the array and its status. You can search the website of the motherboard or RAID controller manufacturer for an interpretation of the messages on this screen and what to do about them. If one of the disks in the array has gone bad, it might take some time for the array to rebuild using data on the other disks. In this situation, the status for the array is likely to show as Caution.

   After the array has rebuilt, your data should be available. However, if one of the hard drives in the array has gone bad, you need to replace the hard drive. After you have replaced the failed drive, you must add it back to the RAID array. This process is called rebuilding a RAID volume. How to do this depends on the RAID hardware you are using. For some motherboards or RAID controller cards, you use the RAID firmware. For others, you use the RAID management software that came bundled with the motherboard or controller. You install this software in Windows and use the software to rebuild the RAID volume using the new hard drive.

If the problem is still not solved, open the case and check these things. Be sure to protect the system against ESD as you work:

1. Remove and reattach all drive cables.
2. If you're using a RAID or SATA controller card, remove and reseat it or place it in a different slot. Check the documentation for the card, looking for directions for troubleshooting.
3. Inspect the drive for damage, such as bent pins on the connection for the cable.
4. Determine if a magnetic hard drive is spinning by listening to it or lightly touching the metal drive (with the power on).
5. Check the cable for frayed edges or other damage.
6. Check the installation manual for things you might have overlooked. Look for a section about system setup, and carefully follow all directions that apply.
7. S.M.A.R.T. errors that display during the boot result from UEFI/BIOS reporting that the drive has met a threshold point of failure. Back up the data and replace the drive as soon as possible.
8. When Windows installed on a hard drive cannot launch, it might present a BSOD (blue screen of death) screen with error messages or it might hang and you see a never-ending spinning Windows pinwheel or wait icon. Windows includes several tools for checking a hard drive for errors and repairing a corrupted

Windows installation that are covered in the chapter,"Troubleshooting Windows Startup." Without getting into these details of supporting Windows, here are a few simple things you can try:

a. *Use Windows 8/7/Vista Startup Repair.* The Startup Repair utility restores many of the Windows files needed for a successful boot. Following directions given in the chapter,"Supporting the Power System and Troubleshooting Computers," boot from the Windows setup DVD. For Windows 8, on the opening screen, select your language, and click **Repair your computer**. Next choose **Troubleshoot**, then choose **Advanced options**. On Advanced options (see Figure 6-54), click **Startup Repair** and follow the on-screen instructions. In Windows 7, boot from the Windows setup DVD, click **Repair your computer**, and sign in to the Windows system installed on the hard drive. Next, on the System Recovery Options menu (see Figure 6-55), select **Startup Repair**.

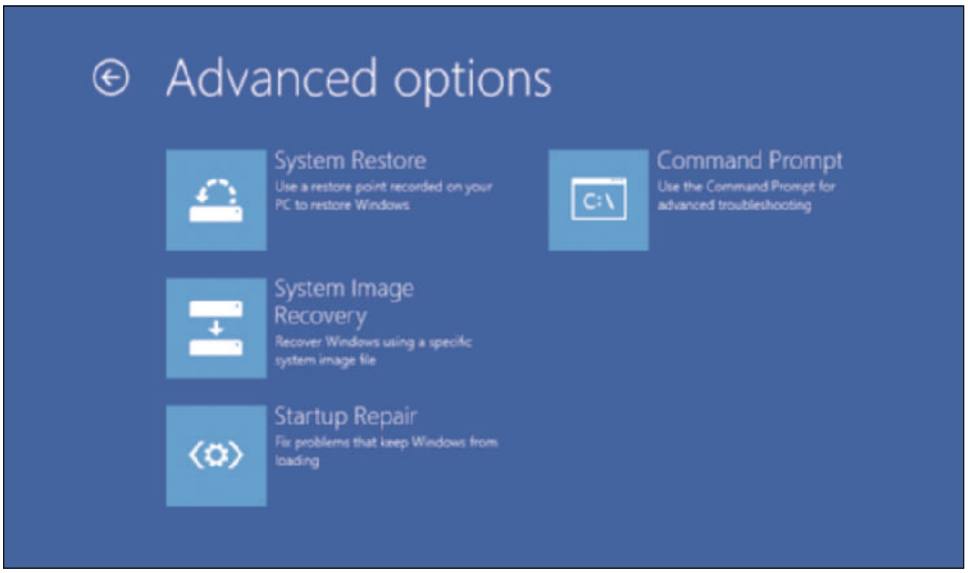


Figure 6-54 Select Startup Repair to fix problems with Windows startup

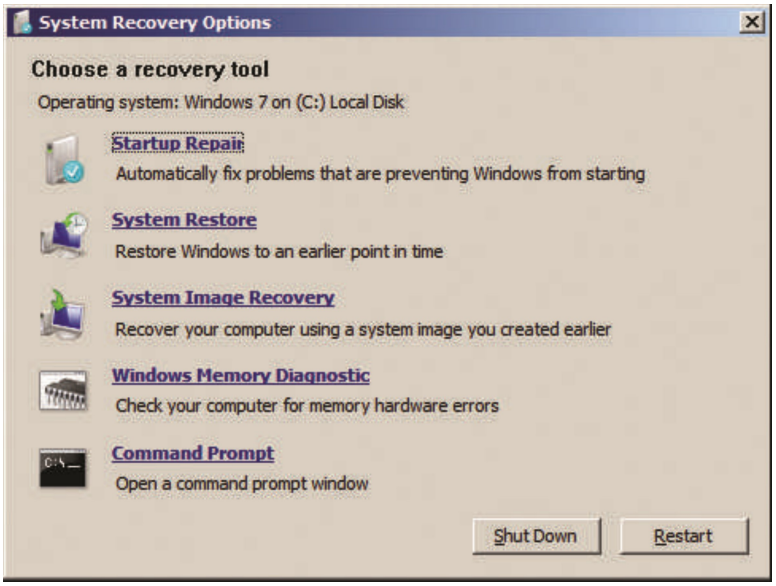


Figure 6-55 Recovery tools in Windows Recovery Environment (Windows RE) for a Windows 7 installation

b. ***Use the chkdsk command.*** To make sure the hard drive does not have bad sectors that can corrupt the file system, you can use the chkdsk command. To use the command in Windows 8, select Command Prompt from the Advanced options menu (refer back to Figure 6-54). In Windows 7, select Command Prompt from the System Recovery Options menu (refer back to Figure 6-55). At the command prompt that appears, use this chkdsk command to search for bad sectors on drive C: and recover data:

```
chkdsk C: /r
```

c. ***Repair the BCD.*** The BCD (Boot Configuration Data) is a small database that holds parameters Windows needs for a successful boot. At a command prompt, use this bootrec command to rebuild the BCD:

```
bootrec /RebuildBCD
```

d. ***Repair the MBR.*** When a hard drive is using the MBR method to manage partitions on the drive, the bootrec command can be used to fix problems with the MBR program that is needed to start Windows. Use this command:

```
bootrec /FixMBR
```

e. ***Repair the boot sector.*** The boot sector holds the MBR partition table. To repair a corrupted boot sector, use this command:

```
bootrec /FixBoot
```

9. Check the drive manufacturer's website for diagnostic software. Sometimes this software can be run from a bootable CD. Run the software to test the drive for errors.

10. If it is not convenient to create a bootable CD with hard drive diagnostic software installed, you can move the drive to a working computer and install it as a second drive in the system. Then you can use the diagnostic software installed on the primary hard drive to test the problem drive. While you have the drive installed in a working computer, be sure to find out if you can copy data from it to the good drive, so that you can recover any data not backed up. Remember that you set the drive on the open computer case (see Figure 6-56) or use a SATA-to-USB converter to connect the drive to a USB port. If you have the case open with the computer turned on, be *very careful* to not touch the drive or touch inside the case.

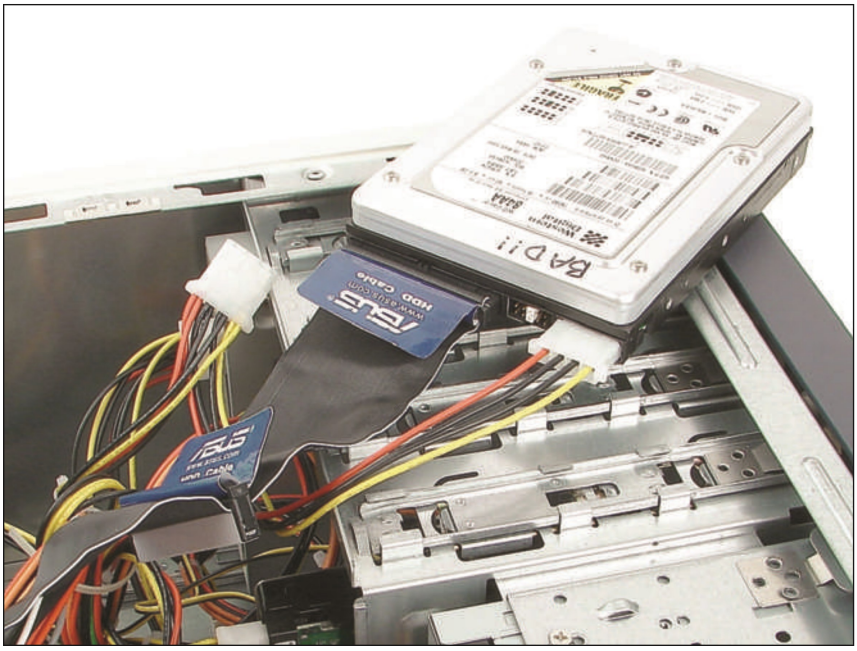


Figure 6-56 Temporarily connect a faulty hard drive to another system to diagnose the problem and try to recover data

11. After you have tried to recover the file system on the drive and before you decide to replace the hard drive, try these things to clean the drive and get a fresh start:

    a. ***Format a hard drive volume.*** If you decide the hard drive volume is corrupted and you want to start over, open a Windows command prompt and use the format command to erase everything on the volume. In this example, D: is the drive letter for the volume:

    ```
    format D:
    ```

    b. ***Use diskpart to start over with a fresh file system.*** If formatting the volume doesn't work, you can erase the hard drive partitions using the diskpart command. When you enter diskpart at a command prompt, the DISKPART> prompt appears. Then use these commands to wipe everything off the hard drive. In the example, you are erasing partition 1 on disk 0.

    ```
    list disk
    select disk 0
    list partition
    select partition 1
    clean
    ```

    Use the **exit** command to exit the diskpart utility. You can then reinstall Windows, which partitions the hard drive again. If Windows cannot recognize the drive, it's probably time to replace hardware in the hard drive subsystem.

12. If the drive still does not boot, exchange the three field replaceable units—the data cable, the storage card (if the drive is connected to one), and the hard drive itself—for a hard drive subsystem. Do the following, in order, and test the hard drive after each step:

    a. Reconnect or swap the drive data cable.

    b. Reseat or exchange the drive controller card, if one is present.

    c. Exchange the hard drive for a known good drive.

13. Sometimes older drives refuse to spin at POST or a failing drive can make a loud clicking noise. Drives that have trouble spinning often whine at startup for several months before they finally refuse to spin altogether. If your drive whines loudly when you first turn on the computer, never turn off the computer and replace the drive as soon as possible. One of the worst things you can do for a drive that is having difficulty starting up is to leave the computer turned off for an extended period of time. Some drives, like old cars, refuse to start if they are unused for a long time. A drive making a loud clicking noise most likely is not accessible and must be replaced.

14. A bad power supply or a bad motherboard also might cause a disk boot failure.

If the problem is solved by exchanging the hard drive, take the extra time to reinstall the old hard drive to verify that the problem was not caused by a bad connection.

>> CHAPTER SUMMARY

Hard Drive Technologies and Interface Standards

- A hard disk drive (HDD) comes in three sizes: 3.5" for desktop computers and 2.5" and 1.8" 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, tape drives, and optical drives use the SATA interface standards. External SATA ports are called eSATA ports.

- Three SATA standards provide data transfer rates of 1.5 Gb/sec (using SATA I), 3.0 Gb/sec (using SATA II), and 16.0 Gb/sec (using SATA III).
- S.M.A.R.T. is a self-monitoring technology whereby the UEFI/BIOS monitors the health of the hard drive and warns of an impending failure.

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.
- Laptop hard drives plug directly into a SATA connection on the system board.
- 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 UEFI/BIOS or a RAID controller card. Software RAID is implemented in Windows. Best practice is to use hardware RAID rather than software RAID.
- Multiple hard drives can be installed in a single external enclosure to expand the storage capacity of a single computer or to make hard drive storage available on a network.

Identifying Tape 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 drives. The disadvantage of tape drives is that data can only be accessed sequentially.

Supporting Other Types of Storage Devices

- File systems a storage device might use in Windows include NTFS, exFAT, FAT32, and FAT.
- CDs, DVDs, and BDs are optical discs with data physically embedded into the surface of the disc. Laser beams are used to read data off the disc by measuring light reflection.
- Optical discs can be recordable (such as a CD-R disc) or rewriteable (such as a DVD-RW disc).
- Flash memory cards are a type of solid-state storage. Types of flash memory card standards by the SD Association include SD, MiniSD, MicroSD, SDHC, MiniSDHC, MicroSDHC, SDXC, and MicroSDXC. Other memory cards include Memory Stick PRO Duo, Memory Stick PRO, Sony Memory Stick Micro M2, CompactFlash I and II, eMMC, and xD-Picture Card.

Troubleshooting Hard Drives

- Defragmenting a magnetic hard drive can sometimes improve slow performance of the drive.
- Problems caused by the hard drive during the boot can be caused by the hard drive subsystem, by the file system on the drive, or by files required by Windows when it begins to load. After the boot, bad sectors on a drive can cause problems with corrupted files.
- To determine if the hard drive is the problem when booting, try to boot from another media, such as the Windows setup DVD.
- For problems with a RAID volume, use the RAID controller firmware (on the motherboard or on the RAID controller card) or RAID management software installed in Windows to report the status of the array and to rebuild the RAID volume.

- To determine if a drive has bad sectors, use the chkdsk command. You can run the command after booting to the System Recovery Options menu using the Windows setup DVD.
- The bootrec command can be used to rebuild the BCD, repair the MBR, or repair the boot sector of a hard drive.
- Use the format command to erase everything on a Windows volume.
- Use commands within the diskpart utility to completely erase a partition on a hard drive.
- Field replaceable units in the hard drive subsystem are the data cable, optional storage card, and hard drive.

>> KEY TERMS

For explanations of key terms, see the Glossary for this text.

autodetection
BCD (Boot Configuration Data)
BD-R
BD-RE
Blu-Ray Disc (BD)
bootrec
CD (compact disc)
CDFS (Compact Disc File System)
CD-ROM
CD-RW
chkdsk
CompactFlash (CF) card
data cartridge
defragmentation tool
diskpart
DVD (digital versatile disc or digital video disc)
DVD-ROM
DVD-RW
DVD-RW DL
embedded MMC (eMMC)
external enclosure
external SATA (eSATA)
fault tolerance
file system
format
formatting
hard disk drive (HDD)
hard drive
hot-swapping
hybrid hard drive (H-HDD)
low-level formatting
magnetic hard drive
minicartridge
mirrored volume
MultiMediaCard (MMC)
NAND flash memory
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
Secure Digital (SD) card
sequential access
serial ATA (SATA)
S.M.A.R.T. (Self-Monitoring Analysis and Reporting Technology)
smart card reader
solid-state device (SSD)
solid-state drive (SSD)
spanning
Startup Repair
storage card
striped volume
UDF (Universal Disk Format) file system
wear leveling
xD-Picture Card

>> REVIEWING THE BASICS

1. What three types of technologies are used inside hard drives?
2. At what three speeds in revolutions per minute might the spindle inside a hard drive rotate?
3. When the OS addresses the sectors on a hard drive as one long list of sequential sectors, what is this technology called?
4. What is the transfer speed for SATA I? SATA II? SATA III?
5. How many pins does a SATA internal data cable have? How many pins does a SATA power cable have?
6. What term describes the technology that allows you to exchange a hard drive without powering down the system?
7. Which RAID level mirrors one hard drive with a second drive so that the same data is written to both drives?
8. Which RAID level stripes data across multiple drives to improve performance and also provides fault tolerance?

9. How many hard drives are necessary to implement RAID 10?
10. When implementing RAID on a motherboard, where do you enable the feature?
11. What type of file system is used by Blu-ray discs?
12. What type of file system is used by SDXC memory cards?
13. How much data can a CD hold?
14. How much data can a double-sided, dual-layer DVD hold?
15. How much data can a double-sided, single-layer BD hold?
16. Which costs more, a CD-R or a CD-RW disc?
17. Which type of flash memory card is currently the smallest type of card?
18. What command-prompt command do you use to determine if a drive has bad sectors?
19. What command can you use to rebuild the BCD?
20. What physical sizes of hard drives are installed in laptops?

>> THINKING CRITICALLY

1. You install a SATA hard drive and then turn on the computer for the first time. You access UEFI/BIOS setup and see that the drive is not recognized. Which of the following do you do next?
   a. Turn off the computer, open the case, and verify that memory modules on the motherboard have not become loose.
   b. Turn off the computer, 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 UEFI/BIOS autodetection is enabled.
   d. Reboot the computer and enter UEFI/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 UEFI/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. PATA hard drives are older and slower than SATA hard drives.
   b. SATA 1 is about 10 times faster than SATA 3.
   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 internal data cable has 7 pins.

>> REAL PROBLEMS, REAL SOLUTIONS

REAL PROBLEM 6-1 Recovering Data

Your friend has a Windows 8 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 an IT support 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. UEFI/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 webpages 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.