CompTIA A+ 220-901

PART I

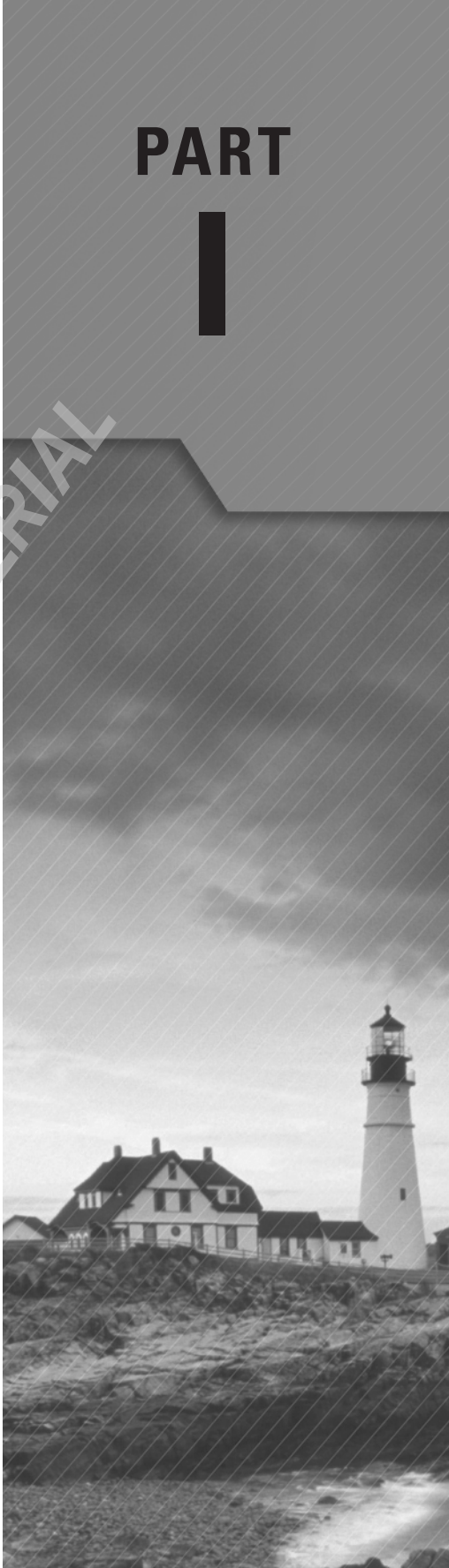
Chapter 1: Hardware

Chapter 2: Networking

Chapter 3: Mobile Devices

Chapter 4: Hardware and Network Troubleshooting

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Chapter

1

Hardware



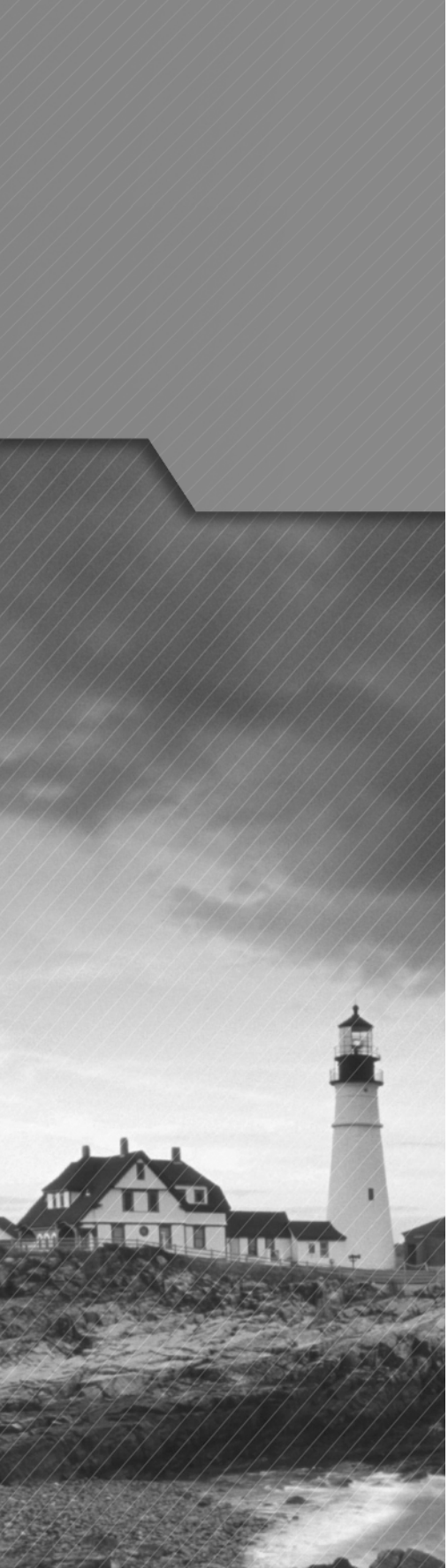
COMPTIA A+ ESSENTIALS EXAM OBJECTIVES COVERED IN THIS CHAPTER:

✓ **1.1 Given a scenario, configure settings and use BIOS/UEFI tools on a PC.**

- Firmware upgrades – flash BIOS
- BIOS component information (RAM, hard drive, optical drive, CPU)
- BIOS configurations (boot sequence, enabling and disabling devices, date/time, clock speeds, virtualization support, BIOS security [passwords, drive encryption: TPM, LoJack, secure boot])
- Built-in diagnostics
- Monitoring (temperature monitoring, fan speeds, intrusion detection/notification, voltage, clock, bus speed)

✓ **1.2 Explain the importance of motherboard components, their purpose, and properties.**

- Sizes (ATX, micro-ATX, mini-ATX, ITX)
- Expansion slots (PCI, PCI-X, PCIe, miniPCI)
- RAM slots
- CPU sockets
- Chipsets (north bridge, south bridge)
- CMOS battery
- Power connections and types
- Fan connectors
- Front/top-panel connectors (USB, audio, power button, power light, drive activity lights, reset button)
- Bus speeds



✓ 1.3 Compare and contrast various RAM types and their features.

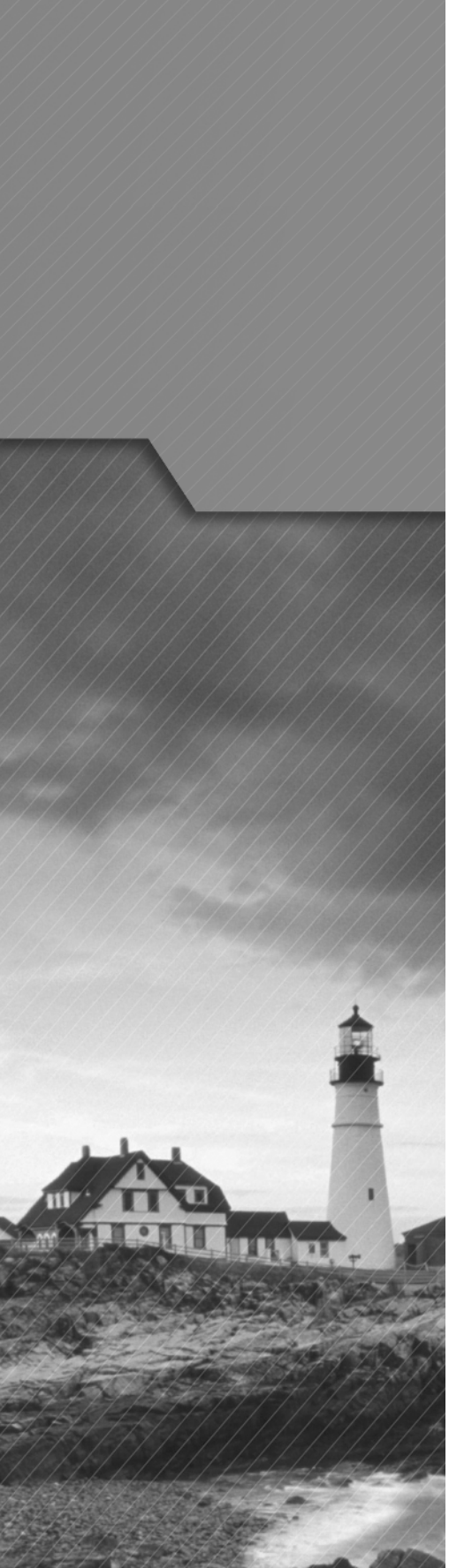
- Types (DDR, DDR2, DDR3, SODIMM, DIMM, parity vs. non-parity, ECC vs. non-ECC)
- RAM configurations (single channel vs. dual channel vs. triple channel)
- Single-sided vs. double-sided
- Buffered vs. unbuffered
- RAM compatibility

✓ 1.4 Install and configure PC expansion cards.

- Sound cards
- Video cards
- Network cards
- USB cards
- FireWire cards
- Thunderbolt cards
- Storage cards
- Modem cards
- Wireless/cellular cards
- TV tuner cards
- Video capture cards
- Riser cards

✓ 1.5 Install and configure storage devices and use appropriate media.

- Optical drives (CD-ROM/CD-RW, DVD-ROM/DVD-RW/DVD-RW DL, Blu-ray, BD-R, BD-RE)
- Magnetic hard drive drives (5,400 rpm, 7,200 rpm, 10,000 rpm, 15,000 rpm)
- Hot-swappable drives
- Solid-state/flash drives (Compact Flash, SD, micro-SD, mini-SD, xD, SSD, hybrid, eMMC)
- RAID types (0, 1, 5, 10)
- Tape drive
- Media capacity (CD, CD-RW, DVD-RW, DVD, Blu-ray, tape, DVD DL)



✓ 1.6 Install various types of CPUs and apply the appropriate cooling methods.

- Socket types (Intel: 775, 1155, 1156, 1366, 1150, 2011, AMD: AM3, AM3+, FM1, FM2, FM2+)
- Characteristics (speeds, cores, cache size/type, hyperthreading, virtualization support, architecture [32-bit vs. 64-bit])
- Integrated GPU
- Disable execute bit
- Cooling (heat sink, fans, thermal paste, liquid-based, fanless/passive)

✓ 1.7 Compare and contrast various PC connection interfaces, their characteristics, and purpose.

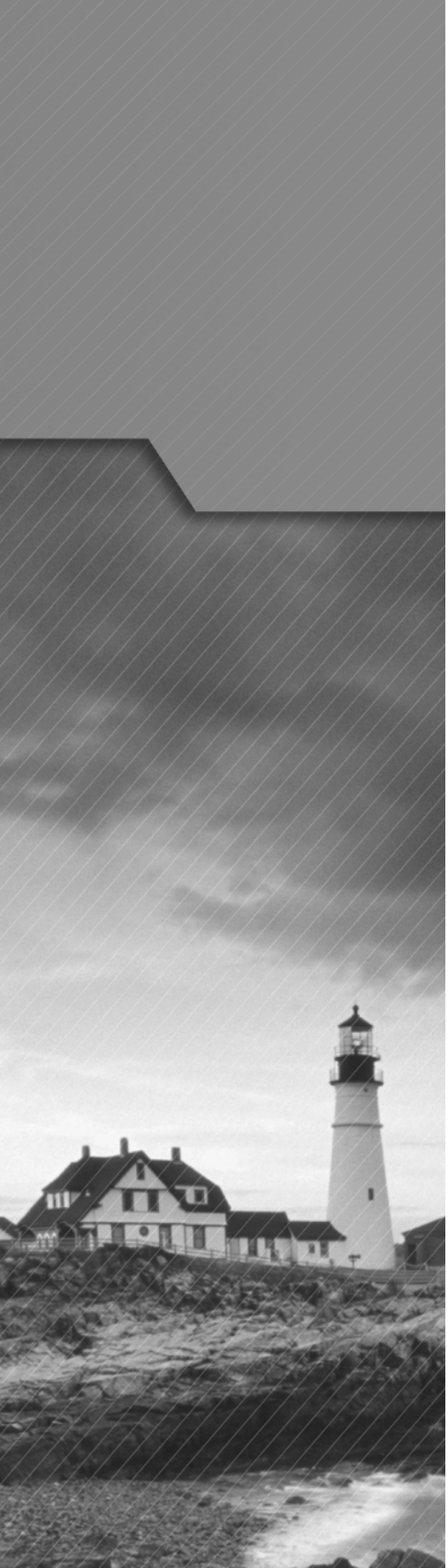
- Physical connections (USB 1.1 vs. 2.0 vs. 3.0, connector types [A, B, mini, micro])
- Firewire 400 vs. Firewire 800
- SATA1 vs. SATA2 vs. SATA3, eSATA
- Other connector types (serial, parallel, VGA, HDMI, DVI, audio [analog, digital/optical connector], RJ-45, RJ-11, Thunderbolt)
- Wireless connections (Bluetooth, RF, IR, NFC)
- Characteristics (analog, digital, distance limitations, data transfer speeds, quality, DRM, frequencies)

✓ 1.8 Install a power supply based on given specifications.

- Connector types and their voltages (SATA, Molex, 4/8-pin 12v, PCIe 6/8-pin, 20-pin, 24-pin)
- Specifications (wattage, dual rail, size, number of connectors, ATX, micro-ATX, dual voltage options)

✓ 1.9 Given a scenario, select the appropriate components for a custom PC configuration to meet customer specifications or needs.

- Graphic/CAD/CAM design workstation (multicore processor, high-end video, maximum RAM)
- Audio/video-editing workstation (specialized audio and video card, large fast hard drive, dual monitors)



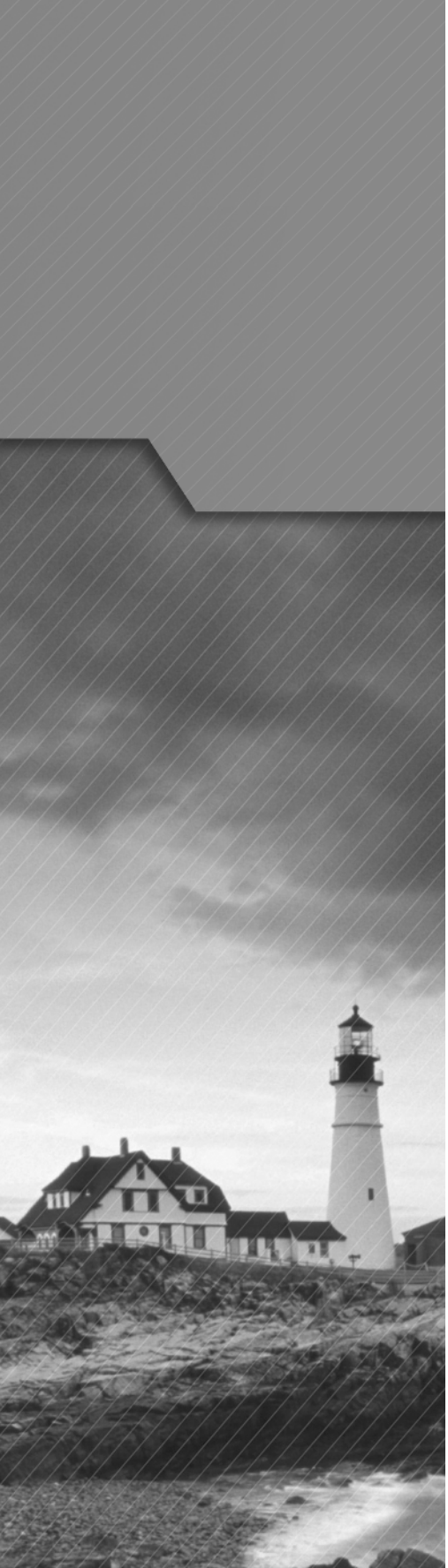
- Virtualization workstation (maximum RAM and CPU cores)
- Gaming PC (multicore processor, high-end video/specialized GPU, high-definition sound card, high-end cooling)
- Home theater PC (surround sound audio, HDMI, output, HTPC compact form factor, TV tuner)
- Standard thick client (desktop applications, meets recommended requirements for selected OS)
- Thin client (basic applications, meets minimum requirements for selected OS, network connectivity)
- Home server PC (media streaming, file sharing, print sharing, Gigabit NIC, RAID array)

✓ 1.10 Compare and contrast types of display devices and their features.

- Types (LCD [TN vs. IPS, fluorescent vs. LED backlighting], plasma, projector, OLED)
- Refresh/frame rates
- Resolution
- Native resolution
- Brightness/lumens
- Analog vs. digital
- Privacy/antiglare filters
- Multiple displays
- Aspect ratios (16:9, 16:10, 4:3)

✓ 1.11 Identify common PC connector types and associated cables.

- Display connector types (DVI-D, DVI-I, DVI-A, DisplayPort, RCA, HD-15 [i.e., DE-15 or DB-15], BNC, miniHDMI, miniDIN-6)
- Display cable types (HDMI, DVI, VGA, component, composite, coaxial)
- Device cables and connectors (SATA, eSATA, USB, FireWire [IEEE 1394], PS/2, audio)
- Adaptors and convertors (DVI to HDMI, USB A to USB B, USB to Ethernet, DVI to VGA, Thunderbolt to DVI, PS/2 to USB, HDMI to VGA)



✓ **1.12 Install and configure common peripheral devices.**

- Input devices (mouse, keyboard, scanner, barcode reader, biometric devices, game pads, joysticks, digitizer, motion sensor, touch pads, smart card readers, digital cameras, microphone, webcam, camcorder, MIDI-enabled devices)
- Output devices (printers, speakers, display devices)
- Input and output devices (touchscreen, KVM, smart TV, set-top box)

✓ **1.13 Install SOHO multifunction devices/printers and configure appropriate settings.**

- Using appropriate drivers for a given operating system
- Configuration settings (duplex, collate, orientation, quality)
- Device sharing (wired [USB, serial, Ethernet], wireless [Bluetooth, 802.11, infrastructure vs. ad hoc])
- Integrated print server (hardware)
- Cloud printing/remote printing
- Public/shared devices (sharing local/networked device via operating system settings [TCP/Bonjour/AirPrint], data privacy, user authentication on the device, hard drive caching)

✓ **1.14 Compare and contrast differences between the various print technologies and the associated imaging process.**

- Laser (imaging drum, fuser assembly, transfer belt, transfer roller, pickup rollers, separate pads, duplexing assembly)
- Inkjet (ink cartridge, print head, roller, feeder, duplexing assembly, carriage and belt, calibration)
- Thermal (feed assembly, heating element, special thermal paper)
- Impact (print head, ribbon, tractor feed, impact paper)
- Virtual (print to file, print to PDF, print to XPS, print to image)

✓ **1.15 Given a scenario, perform appropriate printer maintenance.**

- Laser (replacing toner, applying maintenance kit, calibration, cleaning)
- Thermal (replace paper, clean heating element, remove debris)
- Impact (replace ribbon, replace print head, replace paper)
- Inkjet (clean heads, replace cartridges, calibration, clear jams)



This chapter will focus on the exam topics related to PC hardware. It will follow the structure of the CompTIA A+ 220-901 exam blueprint, objective 1, and it will explore the 15 subobjectives that you will need to master before taking the exam.

1.1 Given a Scenario, Configure Settings and Use BIOS/UEFI Tools on a PC

PCs and other devices that use an operating system usually also contain firmware that provides low-level instructions to the device even in the absence of an operating system. This firmware, called either the Basic Input/Output System (BIOS) or the Unified Extensible Firmware Interface (UEFI), contains settings that can be manipulated as well as diagnostic utilities that can be used to monitor the device. This section discusses those settings and utilities. The topics addressed in objective 1.1 include the following:

- Firmware upgrades—flash BIOS
- BIOS component information
- BIOS configurations
- Built-in diagnostics
- Monitoring

Firmware Upgrades—Flash BIOS

Computer BIOSs don't go bad; they just become out of date or contain bugs. In the case of a bug, an upgrade will correct the problem. An upgrade may also be necessary when the BIOS doesn't support some component that you would like to install—a larger hard drive or a different type of processor, for instance.

Most of today's BIOSs are written to an electrically erasable programmable read-only memory (EEPROM) chip and can be updated through the use of software. Each manufacturer has its own method for accomplishing this. Check out the documentation for complete details. Regardless of the exact procedure, the process is referred to as *flashing*

the BIOS. It means the old instructions are erased from the EEPROM chip and the new instructions are written to the chip.

UEFI is a standard firmware interface for PCs, designed to replace BIOS. Some advantages of UEFI include the following:

- Better security, which protects the pre-boot process
- Faster startup times and resuming from hibernation
- Support for drives larger than 2.2 TB
- Support for 64-bit firmware device drivers
- Capability to use BIOS with UEFI hardware

UEFI can also be updated by using an update utility from the motherboard vendor. In many cases, the steps are as follows:

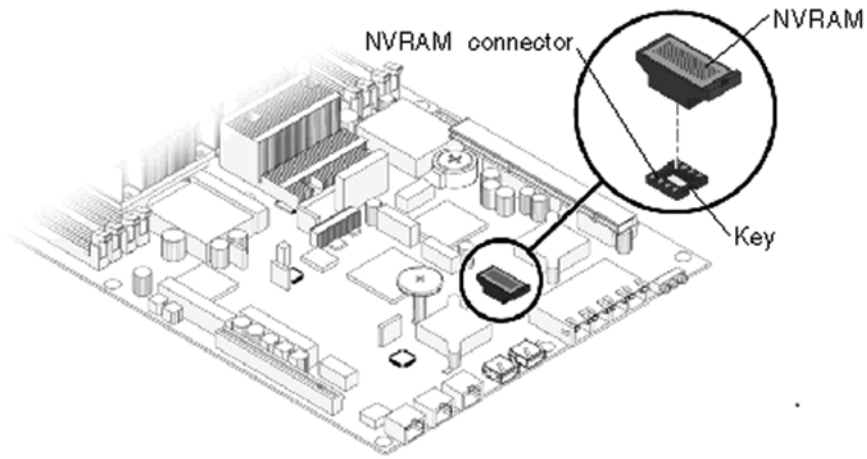
1. Download the update file to a flash drive.
2. Insert the flash drive and reboot the machine.
3. Use the specified key sequence to enter the BIOS settings.
4. If necessary, disable secure boot.
5. Save the changes and reboot.
6. Reenter the BIOS settings.
7. Choose boot options, and boot from the flash drive.
8. Follow the specific directions with the update to locate the upgrade file on the flash drive.
9. Execute the file (usually by typing **flash**).
10. While the update is completing, ensure you maintain power to the device.

BIOS Component

At startup, the BIOS will attempt to detect the devices and components at its disposal. The information that it gathers, along with the current state of the components, will be available for review in the BIOS settings. Some of the components and the types of information available with respect to these devices and components are covered in this section.

You can view and adjust a computer's base-level settings through the CMOS Setup program, which you access by pressing a certain key at startup, such as F1 or Delete (depending on the system). The most common settings to adjust in CMOS include port settings (parallel, serial, USB), drive types, boot sequence, date and time, and virus/security protections. The variable settings that are made through the CMOS Setup program are stored in nonvolatile random access memory (NVRAM), while the base instructions that cannot be changed (the BIOS) are stored on an EEPROM chip. NVRAM is memory that does not lose its content when power is lost to the machine. Figure 1.1 shows an example of NVRAM on a motherboard.

FIGURE 1.1 NVRAM



RAM

Most systems today detect the random access memory (RAM) amount and speed automatically. Some motherboards can use different types of RAM, such as parity and nonparity, or different speeds, and the CMOS Setup program may provide the opportunity to change those settings. Increasingly, however, RAM settings are becoming a read-only part of CMOS Setup programs because the system will detect additional memory added or a change in memory type. This does not preclude you from ensuring you are installing the correct type of memory for the system.

Hard Drive

Some CMOS Setup programs have a feature that polls the IDE channels and provides information about the IDE devices attached to them. You can use this feature to gather the settings for a hard disk. However, most hard disks these days are fully Plug and Play, so they automatically report themselves to the CMOS Setup.

Hard drives can be autodetected by most systems if the IDE setting is set to Auto. The settings detected may include the drive's capacity; its geometry, meaning cylinders, heads, and sectors (CHS); and its preferred programmed input/output (PIO), direct memory access (DMA), or UltraDMA operating mode. You can also configure a hard drive by entering its CHS values manually, but doing so is almost never necessary anymore.



CHS is also called the *drive geometry* because together these three numbers determine how much data the disk can hold. Most CMOS Setup programs are able to automatically detect the CHS values.

Optical Drive

Optical drives, such as CD, CD-R, CD-RW, and DVD players, are also detected and reported by the BIOS. You can even set the computer to boot from one of these drives if desired (see the section "Boot Sequence" later in this chapter). When you do that, in most cases the drives will be listed as CD-ROM or CD-ROM/DVD.

CPU

In most modern systems, the BIOS detects the CPU type and speed automatically, so any CPU settings in CMOS Setup are likely to be read-only. Most operating systems provide utilities for gathering information about the CPU in the computer, but if the computer will not boot or there is no operating system, then viewing the CPU information in the BIOS can be a valuable option.

BIOS Configurations

When any of the changes listed in the following section are made to any of the BIOS configurations, it is important that the program be exited properly to save the changes. The CMOS Setup program includes an Exit command, with options that include Save Changes and Discard Changes. In most programs, Esc is a shortcut for exiting and discarding changes, and F10 is a common shortcut for exiting and saving changes.

Boot Sequence

Each system has a default boot order, which is the order in which it checks the drives for a valid operating system to which it can boot. Usually, this order is set for the hard disk and then CD-ROM, but these components can be placed in any boot order. For example, you might set CD-ROM first to boot from a Windows 7 Setup disk on a system that already contains an operating system. If you receive an error message when booting, always check the CD-ROM, and if a nonsystem disk is present, remove it and reboot.

Enabling and Disabling Devices

In CMOS Setup, you can enable or disable integrated components, such as built-in video cards, sound cards, or network cards. You may disable them in order to replace them with different models on expansion boards, for example.

You can also disable the onboard I/O ports for the motherboard, including parallel, serial, and USB. Depending on the utility, there may also be settings that enable or disable USB keyboard usage, Wake on LAN, or other special features.

In addition to enabling or disabling legacy parallel ports, you can assign an operational mode to the port. Table 1.1 lists the common modes for a parallel port. When you're troubleshooting parallel port problems, sometimes trying a different mode will help. Some legacy systems do not allow onboard devices to be disabled. If this is the case, if an onboard device fails, the entire motherboard may need to be replaced.

TABLE 1.1 Parallel port settings

Setting	Description	Use
Enhanced parallel port (EPP)	Supports bidirectional communication and transfer rates up to 2 Mbps	Newer inkjet and laser printers that can utilize bidirectional communication and scanners
Enhanced capabilities port (ECP)	Supports bidirectional communication (specified in the IEEE 1284 standard) and achieves transfer rates of 2.5 Mbps using direct memory access	Newer inkjet and laser printers that can utilize bidirectional communication, connectivity devices, and scanners
Standard parallel port (SPP, also called Centronics)	Supports bidirectional communication using unidirectional data lines	Older inkjet and laser printers and slower scanners

Date/Time

One of the most basic things you can change in CMOS Setup is the system date and time. You can also change this from within the operating system. When the PC is not keeping correct time or date when turned off, it is usually a CMOS battery issue and may include a warning that the battery is soon going to die. In the absence of the PC receiving time and date updates from a time server such as a Network Time Protocol (NTP) server, the time kept in the CMOS is the time source for the computer.

Clock Speeds

Clock speed is a measurement of the rate at which the clock signal oscillates; it is expressed in millions of cycles per second or megahertz. The motherboard must be set to utilize the proper clock settings for the CPU installed in the computer. The BIOS usually detects the type of CPU and automatically sets the proper timings. In some older systems, you may have to use jumpers to set the correct clock speed and CPU.

External Speed (Clock Speed) The *clock speed*, or *external speed*, which is usually expressed in megahertz or gigahertz, is the speed at which the motherboard communicates with the CPU. It's determined by the motherboard, and its cadence is set by a quartz crystal (the system crystal) that generates regular electrical pulses.

Internal Speed The *internal speed* is the maximum speed at which the CPU can perform its internal operations. This may be the same as the motherboard's speed (the external speed), but it's more likely to be a multiple of it. For example, a CPU may have an internal speed of 1.3 GHz but an external speed of 133 MHz. That means for every tick of the system crystal's clock, the CPU has 10 internal ticks of its own clock.

When the proper CPU speed is known, you must make sure the relationship between the speed of the CPU and that of the motherboard bus is correct. This is done with a value called the *multiplier*. Although the bus speed can also be manipulated, usually it is set to accommodate the required speed of the memory to be used, and so it is more likely you will be using the multiplier to achieve the proper relationship between the CPU speed and the bus speed.

For example, if you have a processor that has a CPU speed of 1.82 GHz, the proper settings for the BIOS would be a bus speed of 166 MHz and a multiplier of 11 (166 MHz × 11 = 1.826 GHz). So if the bus needed to be 166 MHz, you would set the multiplier for 11. On the other hand, if you changed the bus speed to 332 MHz (just a random example), the closest multiplier would be 5.5 to maintain 1.826 GHz (332 MHz × 5.5 = 1.826 GHz). When setting the speed of either is required, refer to the documentation from the CPU and motherboard.

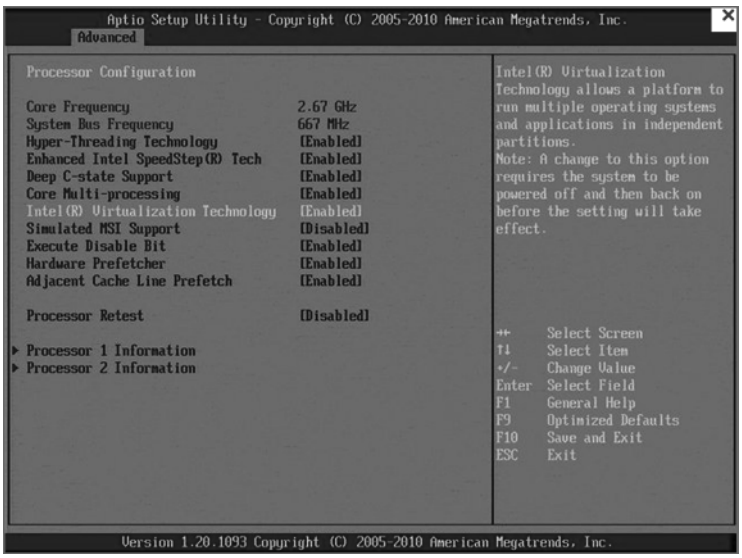
Virtualization Support

Many computers, especially servers, host virtual machines (VMs). These are fully functional operating systems running in their own environment. In many cases, the motherboard and associated BIOS settings need no alteration to provide services to these VMs.

However, some of the newer virtualization products, for example, Microsoft Hyper-V, require that the motherboard support *hardware-assisted virtualization*. This is because in these cases the virtualization product is not installed on top of a regular operating system but is installed directly on bare metal—that is, as an integral part of the operating system, as in Windows Server 2012 R2.

The benefit derived from the virtualization product (also called a *hypervisor*) using hardware-assisted virtualization is it allows the hypervisor to dynamically allocate memory and CPU to the VMs as required. When the motherboard and the BIOS support this technology, you must ensure that it is enabled. Figure 1.2 shows an example of the settings.

FIGURE 1.2 BIOS virtualization



BIOS Security

A number of security features are built into most BIOSs. They include BIOS passwords, drive encryption, Trusted Platform Module (TPM), and LoJack. These items are discussed in this section.

BIOS Passwords In most CMOS Setup programs, you can set a supervisor password. Doing so requires a password to be entered in order to use the CMOS Setup program, effectively locking out users from making changes to it. You may also be able to set a user password, which restricts the PC from booting unless the password is entered.

To reset a forgotten password, you can remove the CMOS battery to reset everything. There also may be a Reset jumper on the motherboard.

Drive Encryption Many operating systems provide the ability to encrypt an entire volume or drive, protecting a mobile device's data in the event of theft. A good example of this is BitLocker, which is available in Windows Vista and Windows 7. The drives are encrypted with encryption keys, and the proper keys are required to boot the device and access the data.

BitLocker can be used with a TPM chip (discussed in the next section), but it is not required. When this feature is in effect with no TPM chip, the keys are stored on a USB drive that must be presented during startup to allow access to the drives. Without the USB drive holding the key, the device will not boot.

TPM Chips When the device has a TPM chip present on the motherboard, additional security and options become available. First the chip contains the keys that unlock the drives. When the computer boots, the TPM chip unlocks the drive only after it compares hashes of the drive to snapshots of the drive taken earlier. If any changes have been made or tampering has been done to the Windows installation, the TPM chip will not unlock the drives.

Moreover, you can (and should) combine this with a PIN entered at startup or a key located in a USB drive. In this scenario, the computer will not start unless the hashes pass the test and the PIN or key is provided.

LoJack LoJack is a product made by Absolute Software that allows you to remotely locate, lock, and delete the data on a mobile device when it is stolen. It is a small piece of software that embeds itself on the computer and is difficult to detect. Once activated, it stays in contact with a monitoring center, allowing you to send the commands to lock and delete data via the center. Not only can you protect the data in this fashion, but also it will gather forensic data that can help to locate the device and aid in its recovery.

Secure Boot Secure Boot is a standard adopted by many venders that requires the operating system to check the integrity of all system files before allowing the boot process to proceed. By doing so, it protects against the alteration or corruption of these system files. As with any emerging technology, issues have already been discovered that can enable a hacker to not only bypass Secure Boot but to also change a key value in the settings that will "brick" the device (render it useless).

Built-in Diagnostics

Although you may not realize it, every time you start the computer, built-in diagnostics are at work. Every computer has a diagnostic program built into its BIOS called the *power-on self-test* (POST). When you turn on the computer, it executes this set of diagnostics. Many steps are involved in the POST, but they happen quickly, they're invisible to the user, and they vary among BIOS versions. The steps include checking the CPU, checking the RAM, checking for the presence of a video card, and so on. The main reason to be aware of the POST's existence is that if it encounters a problem, the boot process stops. Being able to determine at what point the problem occurred can help you troubleshoot.

One way to determine the source of a problem is to listen for a *beep code*. This is a series of beeps from the computer's speaker. The number, duration, and pattern of the beeps can sometimes tell you what component is causing the problem. However, the beeps differ depending on the BIOS manufacturer and version, so you must look up the beep code in a chart for your particular BIOS. Different BIOS manufacturers use the beeping differently. AMI BIOS, for example, relies on a raw number of beeps and uses patterns of short and long beeps.

Another way to determine a problem during the POST routine is to use a *POST card*. This is a circuit board that fits into an Industry Standard Architecture (ISA) or Peripheral Component Interconnect (PCI) expansion slot in the motherboard and reports numeric codes as the boot process progresses. Each of those codes corresponds to a particular component being checked. If the POST card stops at a certain number, you can look up that number in the manual that came with the card to determine the problem.



BIOS Central is a website containing charts detailing the beep codes and POST error codes for many different BIOS manufacturers.

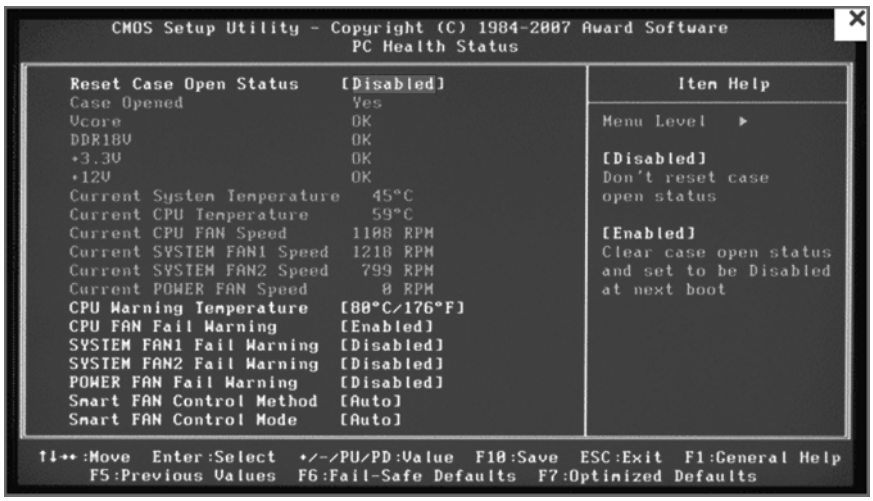
Monitoring

By viewing the information provided in the BIOS, basic monitoring of the many items can be done with varying degrees of certainty. It is simply a matter of navigating the menu-based BIOS program and locating the proper screen that provides the information. Examples are provided in the following sections.

Temperature Monitoring

Temperature is probably the most important item to monitor. When components like the CPU overheat, bad things start to occur, such as repeated reboots. Figure 1.3 shows an example of the values for the CPU. Technicians should retain baseline temperatures for these items. Baseline temperatures should include idle temperature and load temperature baselines. Intel processors run at a cooler temperature than AMD.

FIGURE 1.3 Temperature monitoring



Fan Speeds

The speed at which various fans are operating can also be displayed in the BIOS. There can be a CPU fan, as well as one or more system fans. (See Figure 1.3.) Programs are available that monitor this for you and can send alerts. This is particularly important for servers in a data center.

Intrusion Detection/Notification

It is also possible to enable intrusion detection, which will indicate to you whether the chassis has been opened. This may be referred to as the chassis intrusion detection or possibly the case open status, as shown in Figure 1.3, where this function has been disabled.

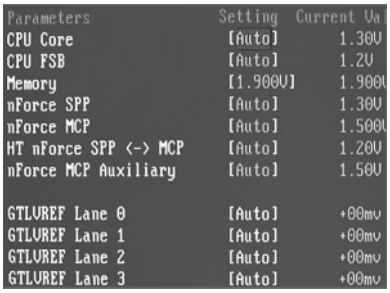
Voltage

You can also monitor and change the voltage settings in the BIOS. Be cautious in changing these settings because improper settings can damage the system or shorten the life of the CPU. Possible settings include the following:

- CPU voltage
- Memory voltage, which will typically be 1.5 volts
- Motherboard voltage
- Voltage of the graphics card

These are just a few examples. Figure 1.4 shows an example of these and many more voltage settings.

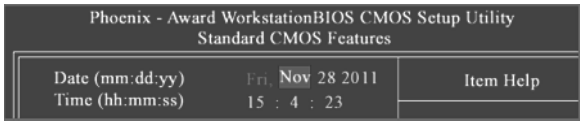
FIGURE 1.4 Voltage settings



Clock

The CMOS clock is located on the computer's motherboard and keeps time when the computer is off. The operating system gets its time from the BIOS clock at boot time. This clock can be set using the BIOS if it is not correct. Figure 1.5 shows the time setting.

FIGURE 1.5 Clock



Bus Speed

The processor's ability to communicate with the rest of the system's components relies on the supporting circuitry. Part of the system board's underlying circuitry is called the *bus*. The computer's bus moves information into and out of the processor and other devices. A bus allows all devices to communicate with one another. The motherboard has several buses. The *external data bus* carries information to and from the CPU and is the fastest bus on the system. The *address bus* typically runs at the same speed as the external data bus and carries data to and from RAM. The address bus gives the address to which the data should go. The data bus uses the address supplied by the address bus and carries the data to the specified location. The PCI, AGP, and ISA interfaces also have their own buses with their own widths and speeds. With newer architectures, the system or front-side bus (FSB) connects the CPU to the north bridge (or memory) hub. The back-side bus (BSB) connects the CPU with the Level 2 (L2) cache, also called the *secondary* or *external* cache. The memory bus connects the north bridge (or memory) hub to RAM.

The bus speed, like the CPU speed, can also be set. (See the section on the relationship between the bus speed, the CPU speed, and the multiplier in the section "Clock Speeds.") Usually, this should be left alone because it is normally set to a setting proper for the memory, but it can be changed. In many systems, this must be done with jumpers on the motherboard.

Exam Essentials

Flash the BIOS or UEFI. Understand the process for upgrading the BIOS or UEFI as the case may be. This usually involves running a program from the BIOS vendor that erases the instructions from the EEPROM chip and writes the new instructions to the same chip.

Identify components reported in the BIOS. These include RAM, hard drives, optical drives, and the CPU. Information is listed for each, and changes can be made to selected settings for each component.

Describe available BIOS configurations. The settings that can be made using the BIOS include the boot sequence, the enabling and disabling of devices, setting the date and time, adjusting clock speeds, enabling and disabling virtualization features if supported, and setting BIOS passwords.

Identify built-in diagnostic tools in the BIOS. The power-on self-test is the most important diagnostic testing that occurs. It runs every time the PC is started and will report—either with a displayed error message or with beep tones—any problem components.

Monitor with the BIOS. Utilize the BIOS display to monitor temperature, fan speeds, intrusion detection messages, voltage settings, the system clock, and bus speed settings.

1.2 Explain the Importance of Motherboard Components, Their Purpose, and Properties

The motherboard is the platform through which all the connected components communicate. The motherboard provides basic services needed for the machine to operate and provides communication channels through which connected devices such as the processor, memory, disk drives, and expansion devices communicate.

This section discusses those components. The topics addressed in objective 1.2 include the following:

- Sizes
- Expansion slots
- RAM slots
- CPU sockets
- Chipsets
- CMOS battery
- Power connections and types
- Fan connectors

- Front-panel connectors
- Bus speeds



The figures in this section are representative of what can be expected. It all depends on the motherboard manufacturer. Consult the documentation for your motherboard.

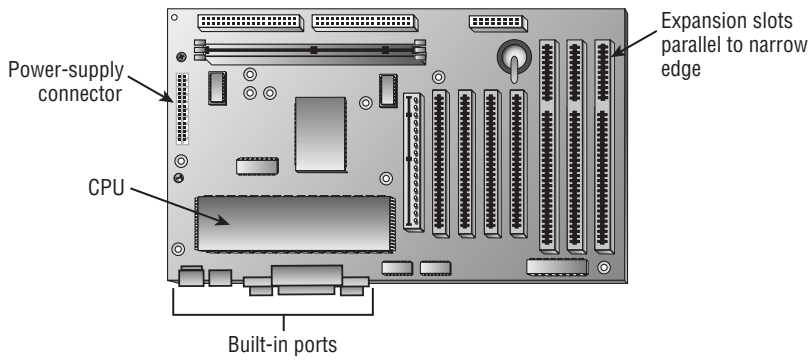
Sizes

The spine of the computer is the *system board*, or *motherboard*. This component is made of green or brown fiberglass and is placed in the bottom or side of the case. It's the most important component in the computer because it connects all the other components of a PC together. On the system board you'll find the central processing unit (CPU), underlying circuitry, expansion slots, video components, RAM slots, and a variety of other chips. There are a number of different sizes or *form factors* of motherboards, which will be discussed in this section.

ATX

An older but still used form factor, Advanced Technology Extended (ATX), provided many design improvements over the previous version, the AT. These improvements include I/O ports built directly into the side of the motherboard, the CPU positioned so that the power-supply fan helps cool it, and the ability for the PC to be turned on and off via software. It uses a PS/2-style connector for the keyboard and mouse, which is rarely used today because USB keyboards are used. Newer ATX models have removed PS/2 connectors. The expansion slots are parallel to the narrow edge of the board. See Figure 1.6.

FIGURE 1.6 An ATX-style motherboard



Micro-ATX

The micro-ATX was released in 1997 for smaller—and typically cheaper—systems. It became popular in later years in low-cost PCs. The maximum size of a micro-ATX

motherboard is 244 mm square, compared to 305 mm×244 mm for a standard ATX motherboard. The micro-ATX is backward compatible with the ATX. Micro-ATX motherboards have a maximum of four expansion slots and four DIMM slots.

Mini-ATX

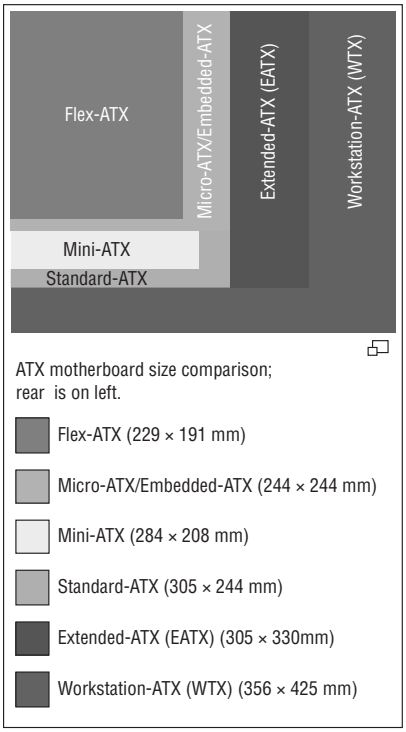
The mini-ATX has dimensions of 15×15 cm (5.9×5.9 in) and is slightly smaller than the mini-ITX (discussed in the next section). It was originally part of the ATX specification but was removed after the introduction of micro-ATX. It uses less power, generates less heat, and fits into a single DIN space.

ITX

The Information Technology eXtended (ITX) motherboards—the mini-ITX, nano-ITX, and pico-ITX—were proposed by VIA Technologies. The mini-ITX fits in the same case as the micro-ATX; uses low power, which means it can be passively cooled (no fan); and has one expansion slot. The nano-ITX is even smaller; it is used for set-top boxes, media centers, and car computers. The pico-ITX is even smaller again, half the size of the nano-ITX. It uses daughter cards (extensions of the motherboard) to supply additional functionality.

Figure 1.7 compares common motherboard types and their sizes.

FIGURE 1.7 Motherboard sizes



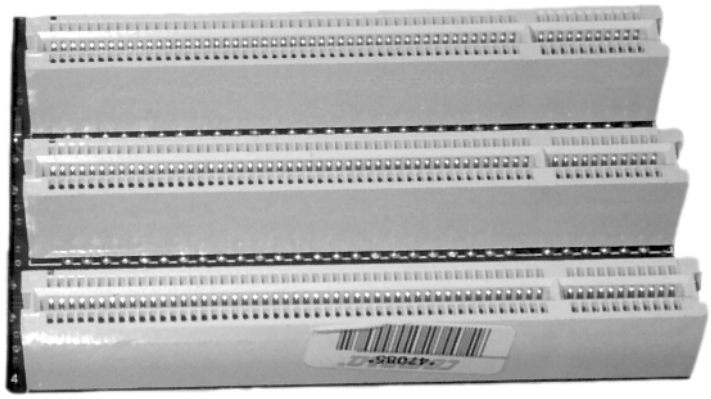
Expansion Slots

Expansion slots exist on a motherboard to allow for the addition of new interfaces to new technologies without replacing the motherboard. If expansion slots did not exist, you would have to buy a new motherboard every time you wanted to add a new device that uses an interface to the board that does not currently exist on the board. This section reviews various types of expansion slots.

PCI

The Peripheral Component Interconnect (PCI) bus is a fast (33 MHz), wide (32-bit or 64-bit) expansion bus that was a modern standard in motherboards for general-purpose expansion devices. Its slots are typically white. PCI devices can share interrupt requests (IRQs) and other system resources with one another in some cases. You may see two PCI slots, but most motherboards have gone to newer standards. Figure 1.8 shows some PCI slots.

FIGURE 1.8 PCI bus connectors



PCI cards that are 32-bit with 33 MHz operate up to 133 MBps, whereas 32-bit cards with 64 MHz operate up to 264 MBps. PCI cards that are 64-bit with 33 MHz operate up to 266 MBps whereas 64-bit cards with 66 MHz operate up to 538 MBps.

PCI-X

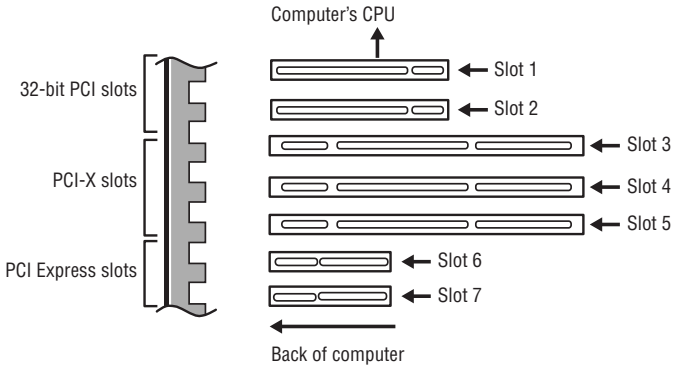
PCI-eXtended (PCI-X) is a double-wide version of the 32-bit PCI local bus. It runs at up to four times the clock speed, achieving higher bandwidth, but otherwise uses the same protocol and a similar electrical implementation. It has been replaced by the PCI Express (see the next section), which uses a different connector and a different logical design. There is also a 64-bit PCI specification electrically different but with the same connector as PCI-X.

There are two versions of PCI-X. Version 1 gets up to 1.06 GBps, and version 2 gets up to 4.26 GBps.

PCIe

PCI Express (PCIE, PCI-E, or PCIe) uses a network of serial interconnects that operate at high speed. It's based on the PCI system; you can convert a PCIe slot to PCI using an adaptor plug-in card, but you cannot convert a PCI slot to PCIe. Intended as a replacement for AGP and PCI, PCIe has the capability of being faster than AGP while maintaining the flexibility of PCI. There are four versions of PCIe: version 1 is up to 8 GBps, version 2 is up to 16 GBps, version 3 is up to 32 GBps, and final specifications for version 4 are still being developed. Figure 1.9 shows the slots discussed so far in this section.

FIGURE 1.9 PCI slots



miniPCI

Laptops and other portable devices utilize an expansion card called the miniPCI. It has the same functionality as the PCI but has a much smaller form factor. Unlike portable PCMCIA cards, which are inserted externally into a slot, these are installed inside the case. Figure 1.10 shows a miniPCI card alongside a miniPCI Express card. Table 1.2 lists the specifications of all the slot types discussed in this section.

FIGURE 1.10 miniPCI

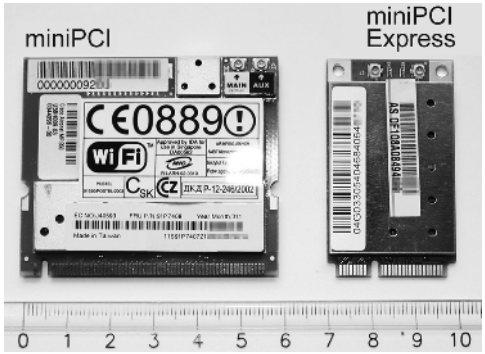


TABLE 1.2 PCI comparison

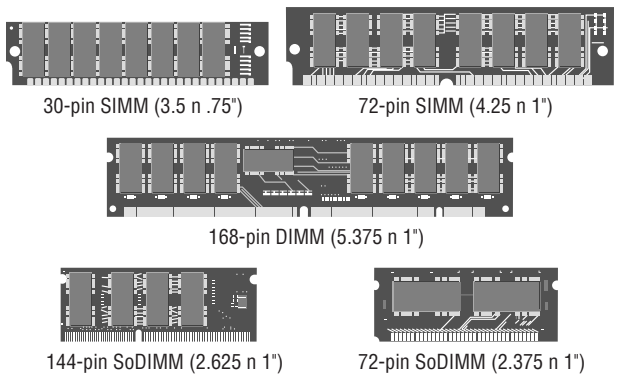
Type	Speeds
PCI 33 MHz 32-bit	133 MBps
PCI 33 MHz 64-bit	266 MBps
PCI 66 MHz 32-bit	264 MBps
PCI 66 MHz 64-bit	538 MBps
PCI-X version 1	1.06 GBps
PCI-X version 2	4.26 GBps

RAM Slots

RAM slots contain the memory chips. There are many and varied types of memory for PCs today. I'll discuss memory later in this chapter. PCs use memory chips arranged on a small circuit board. These circuit boards are called *single inline memory modules* (SIMMs) or *dual inline memory modules* (DIMMs). DIMMs utilize connectors on both sides of the board, whereas SIMMS utilize single connectors that are mirrored on both sides. DIMM is 64-bit and SIMM is 32-bit. There is also a high-speed type of RAM called *rambus dynamic RAM* (RDRAM), which comes on circuit boards called *rambus inline memory modules* (RIMMs).

Along with chip placement, memory modules also differ in the number of conductors, or pins, that the particular module uses. The number of pins used directly affects the overall size of the memory slot. Slot sizes include 30-pin, 72-pin, 168-pin, and 184-pin. Laptop memory comes in smaller form factors known as *small outline DIMMs* (SODIMMs). Figure 1.11 shows the form factors for the most popular memory chips. Notice that they basically look the same, but the memory module sizes are different.

FIGURE 1.11 Various memory module form factors



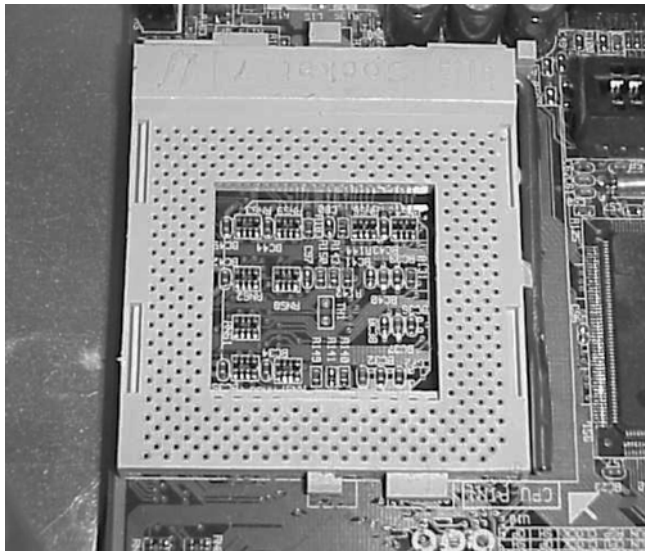
Memory slots are easy to identify on a motherboard. They're usually white and placed close together. The number of memory slots varies from motherboard to motherboard, but the appearance of the different slots is similar. Metal pins in the bottom make contact with the soldered tabs on each memory module. Small metal or plastic tabs on each side of the slot keep the memory module securely in its slot.

CPU Sockets

The CPU slot permits the attachment of the CPU to the motherboard, allowing the CPU to use the other components of the system. There are many different types of processors, meaning there are many types of CPU connectors.

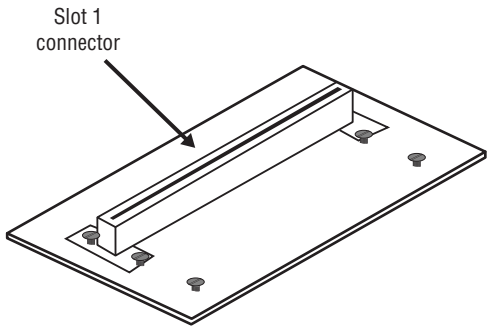
The CPU slot can take on several different forms. In the past, the CPU slot was a rectangular box called a *pin grid array* (PGA) socket, with many small holes to accommodate the pins on the bottom of the chip. With the release of new and more powerful chips, additional holes were added, changing the configuration of the slot and its designator or number. Figure 1.12 shows a typical PGA-type CPU socket.

FIGURE 1.12 A PGA CPU socket



With the release of the Pentium II, the architecture of the slot went from a rectangle to more of an expansion-slot style of interface called a *single-edge contact cartridge* (SECC). This style of CPU slot includes Slot 1 and Slot 2 for Intel CPUs and Slot A for Athlon (AMD) CPUs. This type of slot looks much like an expansion slot, but it's located in a different place on the motherboard from the other expansion slots. Figure 1.13 shows an SECC.

FIGURE 1.13 SECC



To see which socket type is used for which processors, examine Table 1.3. This list is not exhaustive. Some of the slots may fit processors that are not specifically listed.

TABLE 1.3 Socket types and the processors they support

Connector Type	Processor
Socket 1	486 SX/SX2, 486 DX/DX2, 486 DX4 Overdrive
Socket 2	486 SX/SX2, 486 DX/DX2, 486 DX4 Overdrive, 486 Pentium Overdrive
Socket 3	486 SX/SX2, 486 DX/DX2, 486 DX4 486 Pentium Overdrive
Socket 4	Pentium 60/66, Pentium 60/66 Overdrive
Socket 5	Pentium 75-133, Pentium 75+ Overdrive
Socket 6	DX4, 486 Pentium Overdrive
Socket 7	Pentium 75-200, Pentium 75+ Overdrive
Socket 8	Pentium Pro
Socket 370	Pentium III
Socket 423	Pentium 4
Socket 478	Pentium 4 and Celeron 4
SECC (Type I), Slot 1	Pentium II
SECC2 (Type II), Slot 2	Pentium III
Slot A	Athlon

TABLE 1.3 Socket types and the processors they support *(continued)*

Connector Type	Processor
Socket 603	Xeon
Socket 754	AMD Athlon 64
Socket 939	Some versions of Athlon 64
Socket 940	Some versions of Athlon 64 and Opteron
Socket LGA 775	Core 2 Duo/Quad
Socket AM2	Athlon 64 family (replacing earlier socket usage)
Socket F	OpteronShould be AMD Athlon 64 FX and AMD Opteron
Socket AM2+	AMD Athlon64, X2, Phenom, and Phenom II
Socket P	Intel Core2
Socket 441	Intel Atom
Socket LGA 1366/B	Intel Core i7, Xeon (35xx, 36xx, 55xx, 56xx series)
G1/G2/rPGA 988A/B	Intel Core i7, i5, i3, P6000, P4000
Socket AM3	AMD Phenom, Athlon II, Sempron
Socket H/LGA 1156	Intel Core i7, i5, Xeon, Penitium G5000, G1000
Socket G34	AMD Opteron 6000 series
Socket C32	AMD Opteron 4000 series
LGA 1150	Intel Haswell, Haswell Refresh, and Broadwell
Socket AM3+	AMD FX Vishera, AMD FX Zambezi, AMD Phenom II, AMD Athlon II, AMD Sempron
Socket FM2	AMD Trinity Processors
Socket FM2+	AMD Kaveri
LGA 1248	Intel Titanium 9300 series
LGA 1567	Intel Xeon 6500/7500 series
Socket H2/LGA 1155	Intel Sandy Bridge-DT
Socket R/LGA 2011	Intel Sandy Bridge B2 (also referred to as Xeon E5)
Socket FM1	AMD Llano (also referred to as A-series)

Chipsets

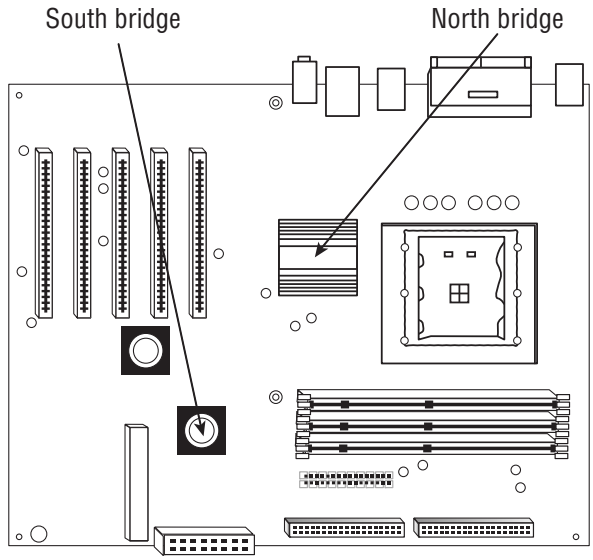
The *chipset* is the set of controller chips that monitors and directs the traffic on the motherboard between the buses. It usually consists of two or more chips. Motherboards use two basic chipset designs: the *north/south bridge chipset* and the *hub chipset*.

The hub chipset, a 2008 innovation, includes a memory controller hub (equivalent to the north bridge), an I/O controller hub (equivalent to the south bridge), and a SuperI/O chip.

North Bridge

The north bridge connects the system bus to the other relatively fast buses (AGP and PCIe). The north bridge typically handles communications between the CPU, RAM, and PCIe (or AGP) video cards and the south bridge. Figure 1.14 shows the location of the north and south bridges.

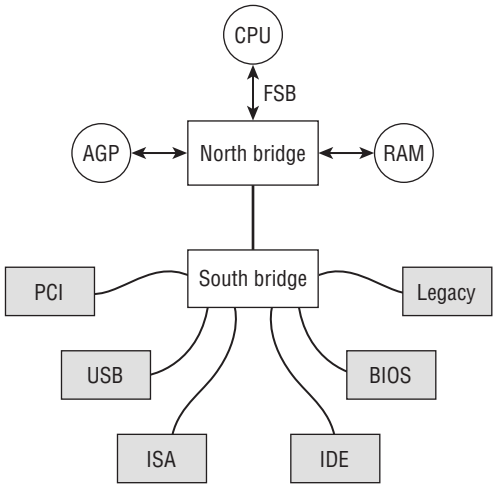
FIGURE 1.14 Location of bridges



South Bridge

The south bridge connects ISA, IDE, USB, audio, serial, the BIOS, the ISA bus, the IDE channels, and the interrupt controller. It handles all the computer's I/O functions. Figure 1.15 shows the relationship between the chipsets.

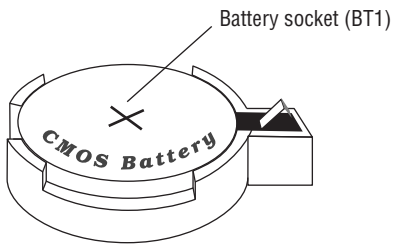
FIGURE 1.15 Chipsets



CMOS Battery

The CMOS chip must have a constant source of power to keep its settings. To prevent the loss of data, motherboard manufacturers include a small battery to power the CMOS memory. On modern systems, this is a coin-style battery, about the diameter of a U.S. dime and about as thick. Figure 1.16 shows the location of the CMOS battery.

FIGURE 1.16 CMOS battery

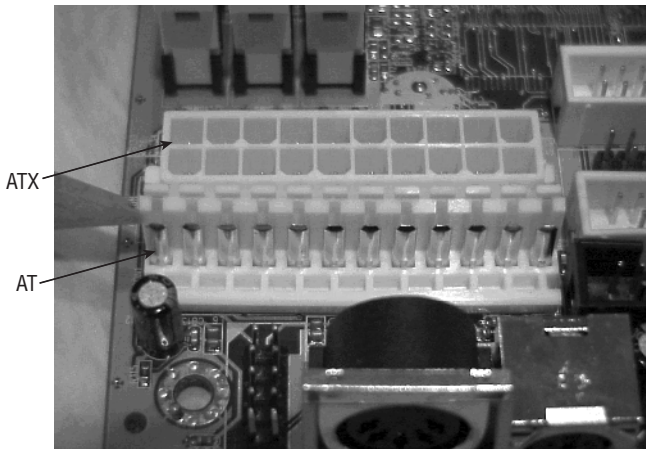


Power Connections and Types

A power connector allows the motherboard to be connected to the power supply. On an ATX, there is a single power connector consisting of a block of 20 holes (in two rows). On an AT, there is a block consisting of 12 pins sticking up; these pins are covered by two connectors with six holes each.

Figure 1.17 shows a versatile motherboard that has both kinds so you can compare them. The upper connector is for ATX, and the lower one is for AT.

FIGURE 1.17 Power connectors on a motherboard



When using the AT power connector, the power cable coming from the power supply will have two separate connectors, labeled P8 and P9. When you are attaching the two parts to the motherboard, the black wires on one should be next to the black wires on the other for proper function.

The 20-pin main connector from the power supply to the motherboard is standard for all ATX power supplies. In addition to this connector, many will include an auxiliary power connector of either four or six pins to provide additional power.

In 2004, the ATX 12V 2.0 (now 2.03) standard was passed, changing the main connector from 20 pins to 24. The additional pins provide +3.3V, +5V, and +12V (the fourth pin is a ground) for use by PCIe cards. When a 24-pin connector is used, there is no need for the optional four- or six-pin auxiliary power connectors.

Most power supplies have a recessed, two-position slider switch (often a red one) on the rear that is exposed through the case. Selections read 110 and 220, 115 and 230, or 120 and 240. This voltage selector switch is used to select the voltage level used in the country where the computer is in service. For example, in the United States, the power grid supplies anywhere from 110 VAC to 120 VAC. However, in Europe, for instance, the voltage supplied is double, ranging from 220 VAC to 240 VAC.

Fan Connectors

Connectors usually used for computer fans are called Molex connectors, and there can be several types. The following are some examples:

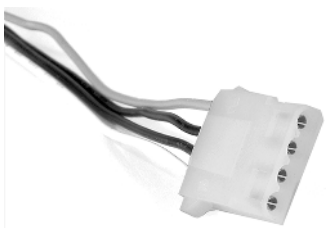
- A three-pin Molex connector is used when connecting a fan to the motherboard or other circuit board. Figure 1.18 shows the three-pin Molex.

FIGURE 1.18 Three-pin Molex



- A four-pin Molex connector includes an additional pin used for a pulse-width modulation signal to provide variable speed control. These connectors can be plugged into three-pin headers but will lose their fan speed control. Figure 1.19 shows the four-pin Molex connector.

FIGURE 1.19 Four-pin Molex



Front/Top-Panel Connectors

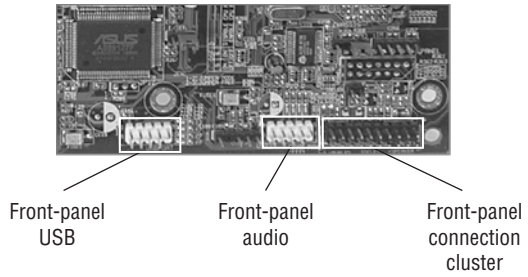
There are a number of interfaces, buttons, lights, and audio jacks in the front panel of the computer that must be connected to the board for power and functionality. This section discusses each of these and their respective methods of connection to the motherboard.

USB

When USB ports exist on the front panel (as they almost always do these days), they must be connected to the motherboard so that the connected USB device can communicate with

the computer. This is done with a 10-pin connector located on the board, as shown in Figure 1.20.

FIGURE 1.20 Front-panel power connectors



Audio

When audio plugs or jacks exist in the front panel, as they do in most computers now, they must be connected to the motherboard if you are using the integrated sound card. (Otherwise, they may connect directly to the sound card.) Figure 1.20 shows an example of the audio plug on the board.

Power Button

The power button located in the front panel must also be connected to the motherboard to communicate on and off to the computer. This connector is located along with the remaining connectors discussed in this section, clustered in a group on the motherboard in the section labeled "Front-panel connection cluster" in Figure 1.20.

Power Light

The power indicator light must also be provided with power and a connection to the board. It is also located in the section labeled "Front-panel connection cluster" in Figure 1.20.

Drive Activity Lights

The drive activity light, which indicates when a hard drive is being either read or written to, must have a connection to the motherboard both for power and to transmit the drive activity information. It is also located in the section labeled "Front-panel connection cluster" in Figure 1.20.

Reset Button

The reset button like all the other front-panel components, has a connection to the motherboard and is located in the section labeled "Front-panel connection cluster" in Figure 1.20.

Bus Speeds

Bus speeds were covered earlier in this chapter in the section "Monitoring" for subobjective 1.1.

Exam Essentials

Differentiate the motherboard form factors. The ATX is the oldest and largest of the motherboard sizes still being manufactured. The micro-ATX is for smaller and cheaper systems. The smaller ITX motherboards come in three sizes: the mini-ITX, the nano-ITX, and the pico-ITX.

Identify expansion slot types. PCI slots are the standard for general-purpose cards. The PCI-X provides higher bandwidth for servers. PCIe is a newer high-speed slot based on the PCI system. MiniPCI slots are used in laptops.

Describe RAM slots. Memory slots accept either single inline memory modules (SIMMs) or dual inline memory modules (DIMMs). DIMMs utilize connectors on both sides of the board, whereas SIMMs utilize single connectors that are mirrored on both sides. DIMM is 64-bit and SIMM is 32-bit. There is also a high-speed type of RAM called rambus dynamic RAM (RDRAM), which comes on circuit boards called rambus inline memory modules (RIMMs).

Locate the CPU socket on the motherboard. The CPU socket can take on several different forms. In the past, the CPU socket was a rectangular box called a PGA socket, with many small holes to accommodate the pins on the bottom of the chip. With the release of the Pentium II, the architecture of the socket went from a rectangle to more of an expansion-slot style of interface called an SECC.

Understand the function of the chipsets. The north bridge connects the system bus to the other relatively fast buses (AGP and PCIe). The south bridge connects ISA, IDE, USB, audio, serial, the BIOS, the IDA bus, the IDE channels, and the interrupt controller. It handles all the computer's I/O functions.

Utilize fan and power connections. A 20- or 24-pin main connector from the power supply to the motherboard is standard for all ATX power supplies. Fans connect with either three- or four-pin Molex connections.

Identify front connections. While the USB and audio jacks will be connected with 10-pin connectors, the remaining front-panel components will connect with much smaller plugs in a cluster in one area on the board.

1.3 Compare and Contrast Various RAM Types and Their Features

Physically, RAM is a collection of integrated circuits that store data and program information as patterns of 1s and 0s (on and off states) in the chip. Most memory chips require constant power (also called a *constant refresh*) to maintain those patterns of 1s and 0s. If power is lost, all those tiny switches revert to the off position, effectively erasing the data from memory. Some memory types, however, don't require a refresh.

This section discusses those RAM types and features. The topics addressed in objective 1.3 include the following:

- Types
- RAM configurations
- Single-sided vs. double-sided
- Buffered vs. unbuffered
- RAM compatibility

Types

There are many types of RAM. They differ in their speed, form factor, their ability to identify errors, and their bandwidth. Let's examine each type in detail.

SDRAM

Synchronous DRAM (SDRAM) is synchronized to the speed of the motherboard's system bus and works at half the speed of DDR. Synchronizing the speed of the systems prevents the address bus from having to wait for the memory because of different clock speeds. A 100 MHz clock signal produces 800 Mbps, and such memory modules are referred to as PC100. PC133, which replaced PC100, uses a 133 MHz clock to produce 1,067 Mbps of throughput.

The relationship between clock speed and throughput is always roughly 1:8. Thus, PC2700 modules are designed specifically for a motherboard with a speed of 333 MHz, and PC3200 modules are designed for a motherboard with a speed of 400 MHz.

SDRAM typically comes in the form of 168-pin DIMMs.

DDR

Double Data Rate (DDR) is clock-doubled SDRAM (covered in the previous section). The memory chip can perform reads and writes on both sides of any clock cycle (the up, or start, and the down, or ending), thus doubling the effective memory executions per second. So, if you're using DDR SDRAM with a 100 MHz memory bus, the memory will execute reads and writes at 200 MHz and transfer the data to the processor at 100 MHz. The advantage of DDR over regular SDRAM is increased throughput and thus increased overall system speed.

DDR2

The next generation of DDR SDRAM is Double Data Rate 2 (DDR2). This allows for two memory accesses for each rising and falling clock and effectively doubles the speed of DDR. DDR2-667 chips work with speeds at 667 MHz and are also referred to as PC2-5300 modules.

DDR3

The primary benefit of DDR3 over DDR2 is that it transfers data at twice the rate of DDR2 (eight times the speed of its internal memory arrays), enabling higher bandwidth or peak data rates. By performing two transfers per cycle of a quadrupled clock, a

64-bit-wide DDR3 module may achieve a transfer rate of up to 64 times the memory clock speed in megabytes per second. In addition, the DDR3 standard permits chip capacities of up to 8 GB. Table 1.4 lists the selected memory standards, speeds, and formats.

TABLE 1.4 Selected memory details

Module Standard	Speed	Format
DDR500	4,000 MBps	PC4000
DDR533	4,266 MBps	PC4200
DDR2-667	5,333 MBps	PC2-5300
DDR2-750	6,000 MBps	PC2-6000
DDR2-800	6,400 MBps	PC2-6400
DDR3-800	6,400 MBps	PC3-6400
DDR3-1600	12,800 MBps	PC3-12800

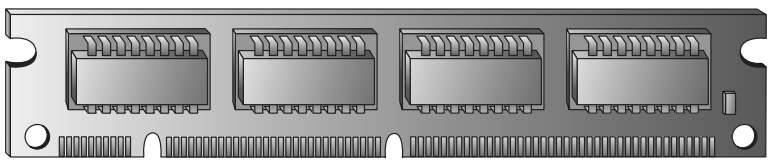
SODIMM

Portable computers (notebooks and subnotebooks) require smaller sticks of RAM because of their smaller size. One of the two types is small outline DIMM (SODIMM), which can have 72, 144, or 200 pins. A SODIMM was shown earlier in the chapter in Figure 1.11.

DIMM

Dual inline memory modules (DIMMs) are double-sided. DIMMs have separate connectors on both sides of the chip. They typically have 168 pins and are 64 bits in width. Figure 1.21 shows a DIMM. For comparison purposes, a DIMM and SODIMM were shown earlier in the chapter in Figure 1.11.

FIGURE 1.21 Dual inline memory module



Parity vs. Nonparity

RAM is supplied with no parity (8 data bits per byte) or with parity (8 data bits and 1 parity bit per byte, for a total of 9 bits per byte). If present, parity bits are used to determine whether data moving to and from memory has been corrupted or damaged (thus changed) in the transmission. You can identify parity SIMMs by counting the number of chips on the stick. If there are nine, it's parity RAM. If there are eight, it's nonparity.

When do you choose parity RAM? Usually, the motherboard requires either parity or nonparity RAM; a few motherboards will accept either. Nowadays, parity RAM is needed only in highly critical computing tasks because advances in RAM technology have created reliable RAM that seldom makes errors.

ECC vs. Non-ECC

Another type of RAM error correction is Error Correction Code (ECC). RAM with ECC can detect and correct errors. Like with parity RAM, additional information needs to be stored, and more processing needs to be done, making ECC RAM more expensive and a little slower than nonparity and parity RAM. Both ECC and parity memory work in ECC mode. However, ECC memory does not work in plain parity checking mode, meaning the extra bits cannot be individually accessed when ECC memory is used. This type of parity RAM is now obsolete. Most RAM today is non-ECC.

RAM Configurations

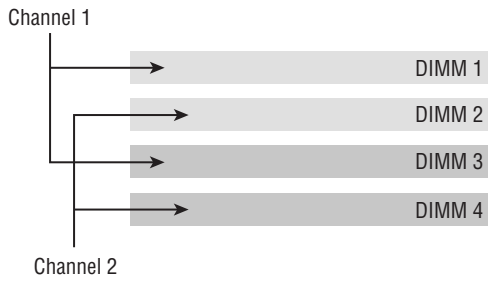
As I discussed earlier in this section, RAM can be either single-sided or double-sided. It can also use single, dual, or triple channels. In this section, I'll discuss the use of channels in RAM.

Single Channel vs. Dual Channel vs. Triple Channel

Utilizing multiple channels between the RAM and the memory controller increases the transfer speed between these two components. Single-channel RAM does not take advantage of this concept, but dual-channel memory does and creates two 64-bit data channels. Do *not* confuse this with DDR or double data rate. DDR doubles the rate by accessing the memory module twice per clock cycle.

This requires a motherboard that supports this and two or more memory modules. The modules go in separate color-coded banks, as shown in Figure 1.22.

FIGURE 1.22 Dual-channel memory slots



Triple-channel architecture adds a third memory module and reduces memory latency by interleaving or accessing each module sequentially with smaller bits of data rather than completely filling up one module before accessing the next one. Data is spread among the modules alternatingly with the potential to triple bandwidth as opposed to storing the data all on one module.

Single-Sided vs. Double-Sided

Earlier we discussed the difference between SIMMs and DIMMs. In review, SIMMs have connectors on one side, whereas DIMMs have connectors on both sides of the chip. DIMMs have twice the pins, meaning twice the contact with the motherboard, creating a larger interface with it and resulting in a wider data path.

Buffered vs. Unbuffered

Buffered memory or registered memory is memory that has a register between it and the memory controller. The register stores bits of information in such a way that systems can write to or read out all the bits simultaneously. This reduces the load on the controller and allows the device to support much more memory than would be possible otherwise. The other possible effect is an introduction of latency and a drop in performance, so you might think of this trade-off as gaining bandwidth (amount of memory) at a small cost of performance (transfer speed).

RAM Compatibility

RAM speed used to be expressed in nanoseconds but is also sometimes expressed in megahertz, like with CPUs. Faster memory can be added to a PC with slower memory installed, but the system will operate only at the speed of the slowest module present.

While you can mix speeds, you cannot mix memory types. For example, you cannot use SDRAM with DDR, and DDR cannot be mixed with DDR2. When looking at the name of the memory, the larger the number, the faster the speed. For example, DDR2-800 is faster than DDR2-533.

Exam Essentials

Identify the types of memory. Types of memory include single data rate (SDRAM), double data rate (DDR), DDR2, and DDR3. These types differ in their data rate. Memory can also differ in packaging. There are SIMMS (single module) and DIMMs (double modules). They also can use either parity or ECC for error checking and can be single, dual, or triple channel, with multiple channels widening the path between the memory and the memory controller.

Follow RAM speed and compatibility guidelines. Faster memory can be added to a PC with slower memory installed, but the system will operate only at the speed of the slowest module present. RAM types cannot be mixed.

1.4 Install and Configure PC Expansion Cards

Expansion cards allow you to add functionality to the PC. In the section "Expansion Slots," I covered the types of expansion slots that can be found on the motherboard. In this section, I'll discuss the types of cards and the functionality they provide. I'll also talk about installing them and configuring them properly.

Newer cards will install in the PCI or PCIe slots and will probably be detected by the operating system. If the operating system already contains the driver for the device in its preinstalled driver library, the process will be done as soon as you restart the PC. If it is not present in the driver cache, you will have to install the driver that came with it. These guidelines apply to all the expansion cards discussed in this section. The topics addressed in objective 1.4 include the following:

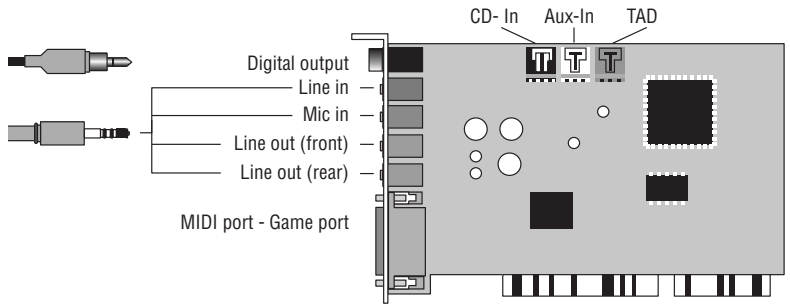
- Sound cards
- Video cards
- Network cards
- USB cards
- FireWire cards
- Thunderbolt cards
- Storage cards
- Modem cards
- Wireless/cellular cards
- TV tuner cards
- Video capture cards
- Riser cards

Sound Cards

Most computers these days come with an integrated sound card, but for more robust sound or advanced features, you may need to install a sound card. Sound cards can be either internal or external. Internal cards require opening the case and installing the card in a slot. External cards plug into the USB socket.

In some cases, an audio cable will be connected from the card to the CD-ROM. This is rarely required these days. Figure 1.23 shows the connectors present on most sound cards today.

FIGURE 1.23 Sound card connectors



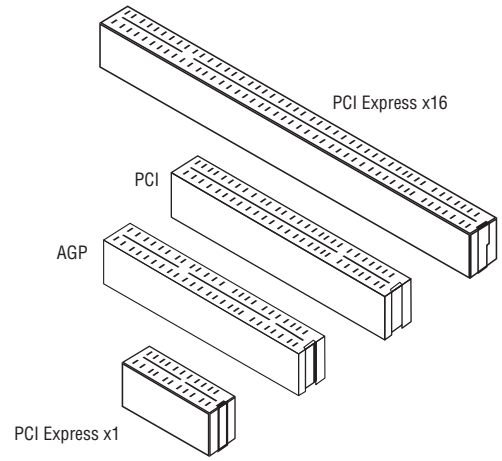
Video Cards

PCs today also contain internal video cards, but like with sound cards, you can achieve better video quality with more expensive video cards. This is especially true when the video card has its own dedicated memory. In earlier times, most internal cards were vastly inferior to the cards you could buy, but that is much less the case today when users have learned to expect better video quality.

Newer operating systems, like Windows Vista and Windows 7, have helped raise the bar for internal cards as well in that they require a card with a minimum set of features and a minimum amount of dedicated RAM to appreciate the visual capabilities of the operating system.

Video cards can be installed in the AGP, PCI, and PCIe slots. At one point, the best choice was clear, and that was the AGP slot. However, the newer PCIe slots provide more bandwidth. AGP provides a wider data path because it's parallel, whereas PCIe is serial. But PCIe now goes up to 16,000 MBps as compared to AGP, which is 2,000 MBps. Figure 1.24 shows the AGP slot next to some slots you have already learned about.

FIGURE 1.24 AGP and PCI slots



Some of the special functions you may get with a more expensive video card are 3D imaging, MPEG decoding, and TV output (discussed later in this section). The ability to use multiple monitors is also built into many cards.

Network Cards

Network cards do exactly what you would think; they provide a connection for the PC to a network. In general, network interface cards (NICs) are added to a PC via an expansion slot or they are integrated into the motherboard, but they may also be added through a USB or PCMCIA slot (also known as PC card). The most common issue that prevents network connectivity is a bad or unplugged patch cable.

Network cards are made for Ethernet, fiber-optic, token ring (rarely used now), and 802.11 (wireless) connections. The Ethernet, token ring, and fiber-optic cards accept the appropriate cable, and the wireless cards have radio transmitters and antennas.

The most obvious difference in network cards is the speed of which they are capable. Most networks today operate at 100 MBps or 1 GBps. Regardless of other components, the PC will operate at the speed of the slowest component, so if the card is capable of 1 GBps but the cable is capable of only 100 MBps, the PC will transmit only at 100 MBps.

Another significant feature to be aware of is the card's ability to perform autosensing. This feature allows the card to sense whether the connection is capable of full duplex and to operate in that manner with no action required.

There is another type of autosensing, in which the card is capable of detecting what type of device is on the other end and changing the use of the wire pairs accordingly. For example, normally a PC connected to another PC requires a crossover cable, but if both ends can perform this sensing, that is not required. These types of cards are called auto-MDIX.

Serial and Parallel Cards



The "Serial and Parallel Cards" section isn't part of the official objectives, but it is helpful to understand these additional concepts.

As discussed in the section "Video Cards," expansion cards and the slots they live in can be either serial or parallel. The difference is in how the bits are sent to and from the card. In standard parallel, these bits are sent eight at time using eight wires, one for each bit, whereas in serial the bits are sent one at a time down the same wire.

Serial has the following advantages over parallel:

- A serial link transmits less data per clock cycle but can achieve a higher data rate because it can be clocked considerably faster than parallel links. (Clock skew between different channels is not an issue because it is in parallel.)
- Fewer interconnecting cables occupy less space, allowing for better isolation of the channel from its surroundings.

- Crosstalk (which occurs when wires in the same cable interfere with one another) is less of an issue because there are fewer conductors in proximity.
- It is cheaper to implement. Serial card interfaces have fewer pins and are therefore less expensive.

USB Cards

Universal Serial Bus (USB) expansion cards are used to provide a USB connection (or an additional connection) to a PC that has none (pretty rare today). All modern motherboards today have at least two USB slots. Some of the advantages of USB include hot-plugging and the capability for up to 127 USB devices to share a single set of system resources. USB 1.1 runs at 12 Mbps, and USB 2.0 runs at 480 Mbps. Because USB is a serial interface, its width is 1 bit. USB 3.0 specifies a maximum transmission speed of up to 5 Gbps (625 MBps), which is more than 10 times as fast as USB 2.0 (480 Mbps or 60 MBps), although this speed is typically achieved only by using powerful, professional-grade or developmental equipment.

These cards are made to plug into PCI, PCIe, or PCMCIA slots (Chapter 3, "Mobile Devices," discusses laptops in more detail).

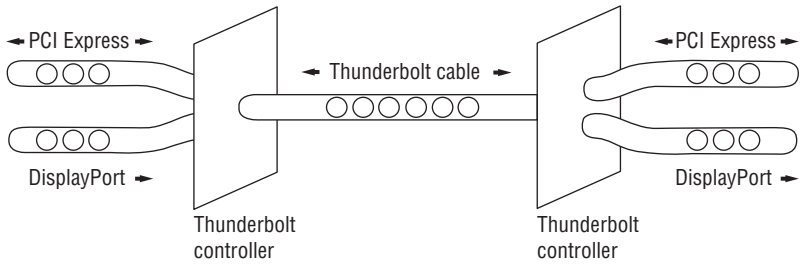
FireWire Cards

FireWire expansion cards, like USB cards, provide this connection when none is present or when more are required. Most new motherboards have a built-in IEEE 1394/FireWire port, although this port can be added with a PCI expansion board. It transfers data at 400 Mbps and supports up to 63 chained devices on a single set of resources. These cards also are made to plug into PCI, PCIe, or PCMCIA slots.

Thunderbolt Cards

Thunderbolt is an expansion card that was originally envisioned to use fiber cabling but was later adapted by Intel and Apple to copper. Thunderbolt controllers multiplex individual data lanes from connected PCIe and DisplayPort devices for transmission via one duplex Thunderbolt lane and then de-multiplex them for use by PCIe and DisplayPort devices on the other end, as depicted in Figure 1.25.

FIGURE 1.25 Thunderbolt cable



Devices can be daisy-chained on the line (up to 6). Thunderbolt devices and non-Thunderbolt devices can be connected, but the controller will treat them differently. It will provide a native DisplayPort signal with four lanes of output data at no more than 5.4 Gbps per Thunderbolt lane. When connected to a Thunderbolt device, the per-lane data rate becomes 10 Gbps, and the four Thunderbolt lanes are configured as two duplex lanes, with each 10 Gbps comprising one lane of input and one lane of output.

Thunderbolt card use has been restricted thus far to Apple devices, but the technology possesses a unique ability to handle audio and video in a way USB cannot. It remains to be seen if you will start seeing these interfaces on PCs in the near future.

Storage Cards

Storage cards plug into a slot (usually PCIe) and have storage devices attached to the card. Increasingly, these are solid-state drives (SSDs). This is like adding an external drive except it is added by placing the card in a slot inside the box.

The following are other ways these cards may be connected to the PC:

- Serial ATA SATA
- Serial-attached SCSI (generally found on servers)
- PCIe
- Fibre Channel (almost exclusively found on servers)
- USB
- Parallel ATA (IDE) interface (mostly replaced by SATA)
- (Parallel) SCSI

Modem Cards

Many PCs already have built-in modems and therefore will have an RJ-11 connector on the back in which to plug a phone line. However, modems can be added with an expansion card. This arrangement makes it possible to connect to your ISP through the phone line, an increasingly rare event that you might use only in an emergency since much faster and simpler connection methods are available. These are usually PCI or PCIe.

Wireless/Cellular Cards

A more likely modem connection you may use is one that connects to your mobile phone provider for wireless connectivity through the same system that your mobile phone uses. These can be either PCMCIA cards or USB devices. Figure 1.26 shows a PCMCIA card. They also are fully wireless versions, meaning there is no physical connection to a device. Your computers and mobile devices connect wirelessly to the card, and the card connects wirelessly to the cellular tower. These are becoming more common because of the ability to connect more than one device to the Internet.

FIGURE 1.26 PCMCIA 3G modem



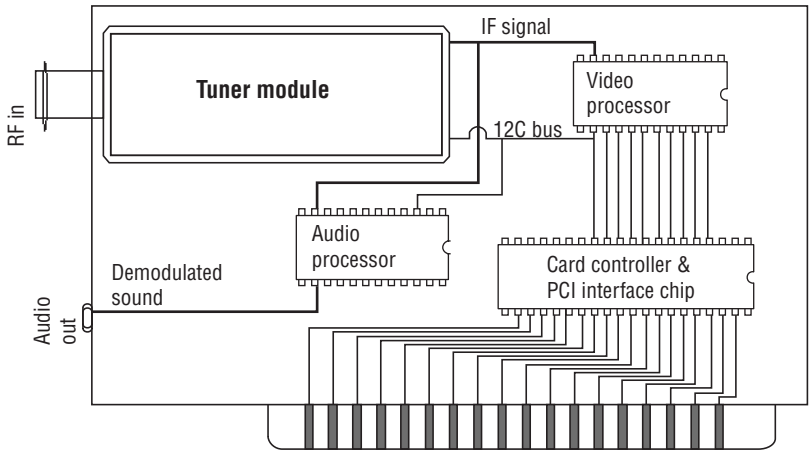
TV Tuner Cards

TV tuner cards are designed to receive TV signals on the computer and usually contain a built-in video capture card (discussed more in the next section). The interfaces are most commonly either PCI or PCIe, but PCMCIA, ExpressCard, and USB devices also exist.

Video Capture Cards

Video capture is the process of converting an analog video signal to digital video. The resulting computer files create a digital video stream. This means that a video capture card takes input—such as that produced by an analog video camera—and converts it to a digital file. These cards usually come in PCI or PCIe format. Figure 1.27 shows an example of a PCI TV tuner card.

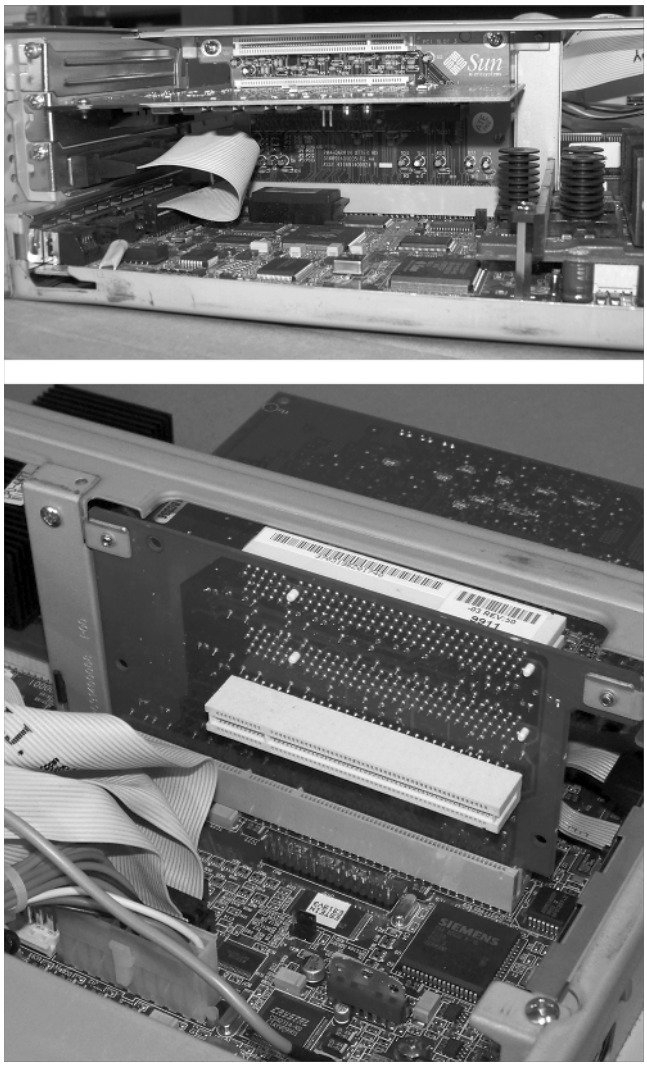
FIGURE 1.27 TV tuner card



Riser Cards

Although it isn't common, you may occasionally encounter a slim-line case, which is a desktop-orientation case that is shorter and thinner than a normal one—so short that normal expansion boards won't fit perpendicular to the motherboard. In such cases a riser card is installed, which sits perpendicular to the motherboard and contains expansion slots. The expansion cards can then be oriented parallel to the motherboard when installed. So, it's a card that hosts other cards. Figure 1.28 shows a riser card from two angles.

FIGURE 1.28 Riser card



Exam Essentials

Describe the installation process as it applies to Plug and Play expansion cards. Newer cards will install in the PCI or PCIe slots and will probably be detected by the operating system. If the operating system already contains the driver for the device in its preinstalled driver library, the process will be done as soon as you restart the PC. If it is not present in the driver library, you will have to install the driver that came with it.

Differentiate each expansion card type. Understand the function of each of the following card types:

- Sound cards
- Video cards
- Network cards
- Serial and parallel cards
- USB cards
- Thunderbolt cards
- FireWire cards
- Storage cards
- Modem cards
- Wireless/cellular cards
- TV tuner cards
- Video capture cards

Explain the purpose of riser cards. Riser cards are used to provide expansions slot types that are not present on the system or that exist in insufficient numbers.

1.5 Install and Configure Storage Devices and Use Appropriate Media

Storage media hold the data being accessed, as well as the files the system needs to operate and the data that needs to be saved. The various types of storage differ in terms of capacity, the access time, and the physical type of media being used. This section covers the installation and configuration of various storage devices. The topics addressed in objective 1.5 include the following:

- Optical drives
- Magnetic hard drives
- Hot-swappable drives

- Solid-state/flash drives
- RAID types
- Tape drive
- Media capacity

Optical Drives

Optical drives work by using a laser rather than magnetism to change the characteristics of the storage medium. This is true for CD-ROM drives, DVD drives, and Blu-ray, all of which are discussed in the following sections.

CD-ROM

CD-ROM stands for Compact Disc Read-Only Memory. The CD-ROM media is used for long-term storage of data. CD-ROM media is read-only, meaning that once information is written to a CD, it can't be erased or changed. Access time for CD-ROM drives is considerably slower than for a hard drive. Standard CDs normally hold 650 MB to 700 MB of data and use the ISO 9660 standard, which allows them to be used in multiple platforms.

DVD-ROM

Because DVD-ROM drives use slightly different technology than CD-ROM drives, they can store up to 4.7 GB of data in a single-layer configuration. This makes DVDs a better choice than CDs for distributing large software bundles. Many software packages today are so huge that they require multiple CDs to hold all the installation and reference files. A single DVD, in a double-sided, double-layered configuration, can hold as much as 17 GB (as much as 26 regular CDs).

Blu-ray

Blu-ray recorders have been available since 2003, and they have the ability to record more information than a standard DVD using similar optical technology. In recent years, Blu-ray has been more synonymous with recording television and movie files than data, but the Blu-ray specification (1.0) includes two data formats: BD-R for write-once and BD-RE for rewritable media (more later in this section). BD-J is capable of more sophisticated bonus features than provided by standard DVD, including network access, picture-in-picture, and access to expanded local storage. With the exception of the Internet access component, these features are called Bonus View. The addition of Internet access is called BD Live.



In the official specification, as noted on the Blu-ray Disc Association website (`http://us.blu-raydisc.com/`), the *r* is lowercase. CompTIA favors the uppercase *R*.

The current capacity of a Blu-ray is 100 GB, with 400 GB on the horizon and an aim for 1 TB by 2015. As a final note, there was a long-running (but finally complete) battle between Blu-ray and HD DVD to be the format of the future, and Blu-ray won.

CD-RW

Compact Disc-ReWritable (CD-RW) media is a rewritable optical disc. A CD-RW drive requires more sensitive laser optics. It can write data to the disc but also has the ability to erase that data and write more data to the disc. It does this by liquefying the layer where the data resides (removing the reflectivity placed there by the writing process used to create the old data) and then creating new reflectivity in the same layer upon writing again that represents the new data. Two states of reflectivity are used to represent the 0s and 1s for the data. CD-RWs cannot be read in some CD-ROM drives built prior to 1997.

DVD-RW

As you might expect, the primary advantage of DVD-RW drives over DVD-R drives is the ability to erase and rewrite to a DVD-RW disc. In these drives, a layer of metal alloy on the disk is manipulated to erase and write the data, rather than burning into the disc itself, similar to the operation of CD-RW.

Dual-Layer DVD-RW

A dual-layer DVD-RW disc employs a second physical layer within the disc itself. The drive with dual-layer capability accesses the second layer by shining the laser through the first semitransparent layer.

BD-R

Blu-ray players have two data formats: BD-R for recording computer data and BD-RE for rewritable media. BD-R can be written to only one time.

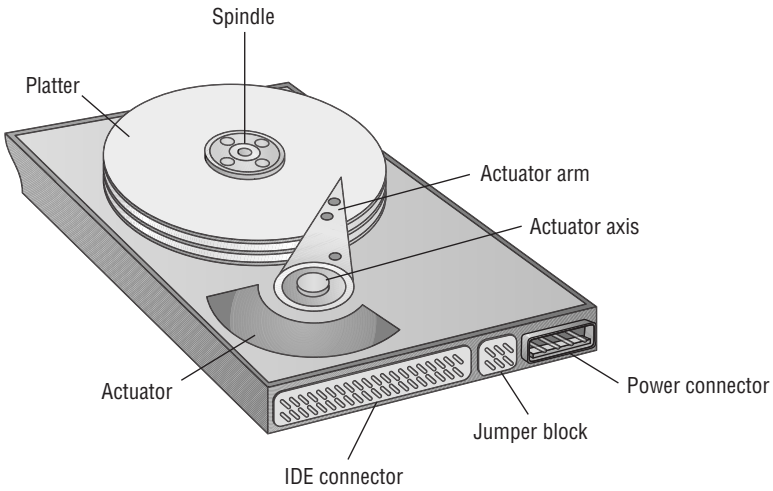
BD-RE

Blu-ray Disc Recordable Erasable (BD-RE) can be erased and written to multiple times. Disc capacities are 25 GB for single-layer discs, 50 GB for double-layer discs, 100 GB for triple-layer discs, and 128 GB for quad-layer discs.

Magnetic Hard Drives

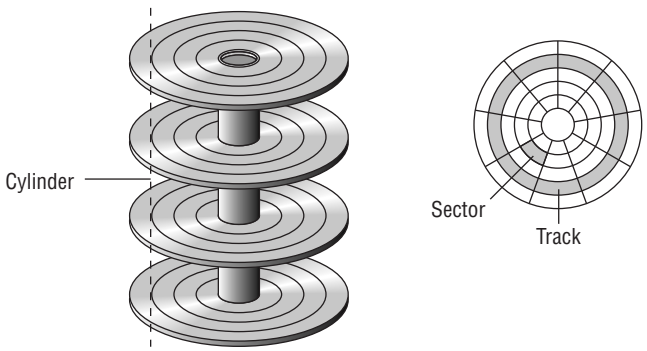
Before the development and use of SSDs, magnetic drives were—and are still as of this writing—the main type of hard drive used. The drive itself is a mechanical device that spins a number of disks or platters and uses a magnetic head to read and write data to the surface of the disks. One of the advantages of SSDs (discussed in the next section) is the absence of mechanical parts that can malfunction. Figure 1.29 shows the parts of a magnetic hard drive.

FIGURE 1.29 Magnetic hard drive



The basic hard disk geometry consists of three components: the number of sectors that each track contains, the number of read/write heads in the disk assembly, and the number of cylinders in the assembly. This set of values is known as CHS (for cylinders/heads/sectors). A *cylinder* is the set of tracks of the same number on all the writeable surfaces of the assembly. It is called a cylinder because the collection of all same-number tracks on all writable surfaces of the hard disk assembly looks like a geometric cylinder when connected vertically. Therefore, cylinder 1, for instance, on an assembly that contains three platters comprises six tracks (one on each side of each platter), each labeled track 1 on its respective surface. Figure 1.30 illustrates the key terms presented in this discussion.

FIGURE 1.30 CHS



5,400 rpm

The rotational speed of the disk or platter has a direct influence on how quickly the drive can locate any specific disk sector on the drive. This locational delay is called *latency* and is measured in milliseconds (ms). The faster the rotation, the smaller the delay will be. A drive operating at 5,400 rpms will experience about 5.5 ms of this delay.

7,200 rpm

Drives that operate at 7,200 rpm will experience about 4.16 ms of latency. As of 2015, a typical 7,200 rpm desktop hard drive has a sustained data transfer rate up to 1,030 Mbps. This rate depends on the track location, so it will be higher for data on the outer tracks and lower toward the inner tracks.

10,000 rpm

At 10,000 rpm, the latency will decrease to about 3 ms. Data transfer rates also generally go up with a higher rotational speed but are influenced by the density of the disk (the number of tracks and sectors present in a given area).

15,000 rpm

Drives that operate at 15,000 rpm are higher-end drives and suffer only 2 ms of latency. These drives also generate more heat, requiring more cooling to the case. They also offer faster data transfer rates for the same areal density.

Hot-Swappable Drives

If a drive can be attached to the PC without shutting down the PC, then it is a hot-swappable drive. Drive types that are hot-swappable include USB, FireWire, SATA, and those that connect through Ethernet. You should always check the documentation to ensure that your drive supports this feature.

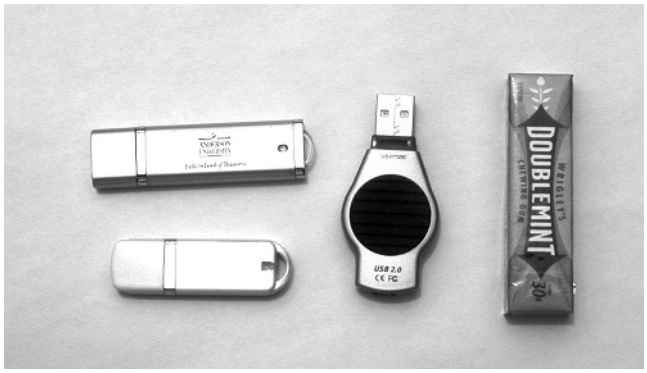
Solid-State/Flash Drives

Solid-state drives (SSDs) retain data in nonvolatile memory chips and contain no moving parts. Compared to electromechanical hard disk drives (HDDs), SSDs are typically less susceptible to physical shock, are silent, have lower access time and latency, but are more expensive per gigabyte.

Thumb drives are USB flash drives that have become extremely popular for transporting files. Figure 1.31 shows three thumb drives (also known as keychain drives) next to a pack of gum for size comparison.

Like with other flash drives, you can find these in a number of different size capacities. Many models include a write-protect switch to keep you from accidentally overwriting files stored on the drive. Most include an LED to show when they're connected to the USB port. Other names for thumb drives include travel drives, flash drives, and jump drives.

FIGURE 1.31 USB flash

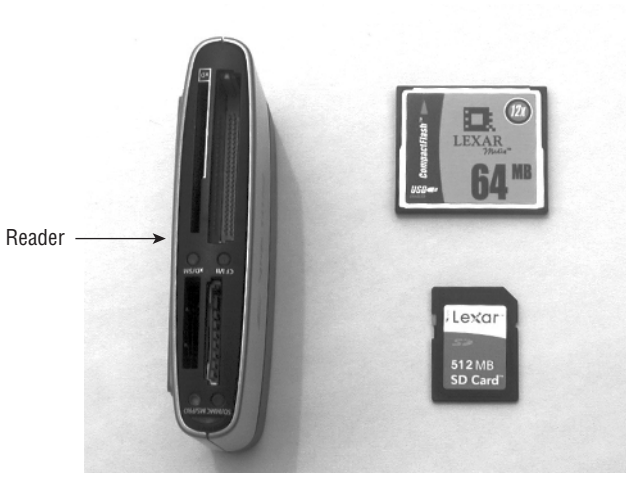


Flash drives (which are solid state) have been growing in popularity for years and replacing floppy disks because of their capacity and small size. Flash technology is ideally suited for use not only with computers but also with many other things—digital cameras, MP3 players, and so on. This section discusses the various forms of these drives.

Compact Flash

Compact Flash (CF) cards are a widely used form of solid-state storage. There are two main subdivisions of CF cards: Type I (3.3-mm thick) and the thicker Type II (CF2) cards (5-mm thick). CF cards can be used directly in a PC card slot with a plug adaptor, used as an ATA (IDE) or PCMCIA storage device with a passive adaptor or with a reader, or attached to other types of ports such as USB or FireWire. Figure 1.32 shows a CF card.

FIGURE 1.32 SD and Compact Flash



SD

Secure Digital (SD) cards are just one type of flash; there are many others. The maximum capacity of a standard SD card is 512 GB, and there are two other standards that go beyond this: SDHC can go to 32 GB and SDXC to 2 TB. Figure 1.32 shows a Compact Flash card (the larger of the two) and an SD card along with an eight-in-one card reader/writer. The reader shown connects to the USB port and then interacts with Compact Flash, Compact Flash II, Memory Stick, Memory Stick PRO, SmartMedia, xD-Picture cards, SD, and MultiMediaCards. The SD card specification defines three physical sizes, discussed in the following sections.

Micro-SD

Micro-SD is the smallest of the three. It is 11 mm × 15 mm × 1 mm.

Mini-SD

Mini-SD is the middle child of the three SD form factors. It is 20 mm × 21.5 mm × 1.4 mm.

xD

xD-Picture card is a flash memory card format, used mainly in older digital cameras. xD stands for Extreme Digital. xD cards are available in capacities of 16 MB up to 2 GB. Pictures are transferred from a digital camera's xD card to a PC by plugging the camera into the USB or IEEE 1394 (FireWire) cable or by removing the card from the camera and inserting it into a card reader.

SSD

A solid-state drive (SSD) is a form of flash drive that takes the place of a magnetic hard drive as the main storage device in the PC. Some SSDs use volatile RAM and external power or batteries to maintain the data after power is removed.

These drives access the data faster because there is no wait for the platters to spin up. Also, with no moving parts, there is less to go wrong with these drives, and they make no noise, like magnetic drives will do. Smartphones are an example of the growing number of devices that use solid-state storage, along with many laptops.

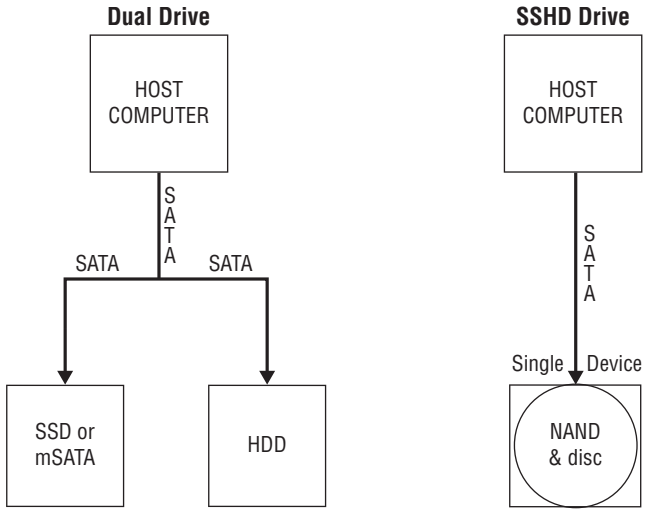
Hybrid

A hybrid drive is one in which both technologies, traditional mechanical and SSDs, are combined. This is done to take advantage of the speed of SSDs while maintaining the cost effectiveness of mechanical drives.

There are main approaches to this: dual-drive hybrid and solid-state hybrid. Dual-drive systems contain both types of drives in the same machine, and performance is optimized by the user placing more frequently used information on the SSD and less frequently accessed data on the mechanical drive. In some cases the operating system can create hybrid volumes using space in both drives.

An SSD, on the other hand, is a single storage device that includes solid-state flash memory in a traditional hard drive. Data that is most related to the performance of the machine is stored in the flash memory, resulting in improved performance. Figure 1.33 shows the two approaches to hybrid drives.

FIGURE 1.33 Hybrid drive approaches



eMMC

An Embedded Multi-Media Controller (eMMC) is a type of flash memory that is slower than solid state but also cheaper. It is often used in less expensive laptops and tablets. It's embedded into the board of the device and has more in common with an SD card than an SSD. Lower performance for lower price is an acceptable trade-off in devices such as cameras that don't demand the type of performance you get from an SSD, but eMMC may not be up to the task in a laptop or desktop machine.

Connection Types

Drives can be installed internally or can be connected externally to the PC. There are various options to connect the drives in both cases. This section discusses those options.



The "Connection Types" section isn't part of the official objectives, but it is helpful to understand these additional concepts.

External

When a PC does not have the type of drive needed and has neither the internal connection type required nor the space inside the box to install the drive internally, external drives are made that can connect to the computer using several types of external interfaces. These connection types are discussed in this section.

USB

USB connections are probably the most widely used because of their inclusion on almost all front or back panels of computers these days. In fact, most have several USB slots, and it is simple to add more with a USB hub. USB drives also have the benefit of being Plug and Play, which makes them user friendly for setup.

FireWire

Although not as widely seen as USB or IEEE 1394, FireWire connections are also present on many computers. It transfers data at 400 Mbps and supports up to 63 chained devices on a single set of resources. It's hot-pluggable, like USB.

eSATA

eSATA provides a form of SATA meant for external connectivity. SATA (discussed more completely in the section "Internal SATA, IDE, and SCSI") is used for drive connections internally on many PCs. eSATA uses a more robust connector, longer shielded cables, and stricter (but backward-compatible) electrical standards. The interface resembles that of USB and IEEE 1394 (FireWire), but the cable cannot be as long, and the cable does not supply power to the device. The advantage it has over the other technologies is speed—it is approximately three times as fast as either FireWire or USB 2.0 (although USB 3.0 is faster).

Ethernet

There are drives that you connect to across the network or through Ethernet. These drives, also sometimes referred to as network-attached storage (NAS) devices, may also allow for wireless access, just as a laptop is capable of both wired and wireless communication. These devices are *not* seen as an attached device to the PC but rather as another device on the network, so they appear as a drive with shared folders as if you were connecting to a server. They only need to be on the same network as the PC.

Internal SATA, IDE, and SCSI

When drives are connected internally, there are several options, and the options available on your PC will be a function of how old it is and, in the case of SCSI, whether it is a computer designed to operate as a server.

IDE drives are the most common type of hard drive found in computers. But IDE is much more than a hard drive interface; it's also a popular interface for many other drive types, including CD-ROM, DVD, and Zip drives. IDE drives are easy to install and configure, and they provide acceptable performance for most applications. Their

ease of use relates to their most identifiable feature—the controller is located on the drive itself.

The design of the IDE is simple: build the controller right on the drive and use a relatively short ribbon cable to connect the drive/controller to the IDE interface. This offers the benefits of decreasing signal loss (thus increasing reliability) and making the drive easier to install. The IDE interface can be an expansion board, or it can be built into the motherboard, as is the case on almost all systems today.

IDE generically refers to any drive that has a built-in controller. The IDE you know today is more properly called AT IDE; two previous types of IDE (MCA IDE and XT IDE) are obsolete and incompatible with it.

There have been many revisions of the IDE standard over the years, and each one is designated with a certain AT attachment (ATA) number—ATA-1 through ATA-8. Drives that support ATA-2 and higher are generically referred to as enhanced IDE (EIDE). Here are some of the highlights: With ATA-3, a technology called ATA Packet Interface (ATAPI) was introduced to help deal with IDE devices other than hard disks. ATAPI enables the BIOS to recognize an IDE CD-ROM drive, for example, or a tape backup or Zip drive. Starting with ATA-4, a new technology was introduced called UltraDMA, supporting transfer modes of up to 33 Mbps. ATA-5 supports UltraDMA/66, with transfer modes of up to 66 Mbps. To achieve this high rate, the drive must have a special 80-wire ribbon cable, and the motherboard or IDE controller card must support ATA-5. ATA-6 supports UltraDMA/100, with transfer modes of up to 100 Mbps.



If an ATA-5 or ATA-6 drive is used with a normal 40-wire cable or is used on a system that doesn't support the higher modes, it reverts to the ATA-4 performance level.

ATA-7 supports UltraDMA/133, with transfer modes of up to 150 Mbps and SATA.

ATA-8 made only minor revisions to ATA-7 and also supports UltraDMA/133, with transfer modes of up to 600 Mbps and SATA.

Table 1.5 lists the ATA standards and their details.

TABLE 1.5 ATA standards

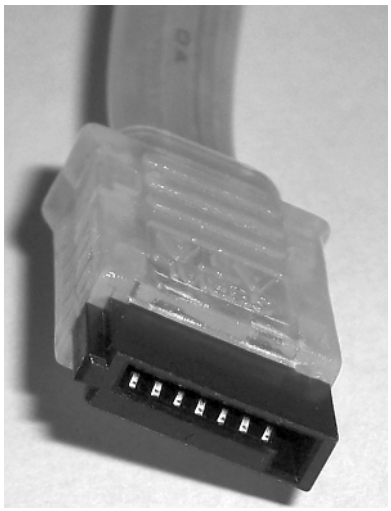
Standard	Speed	Cable Type	New Feature
ATA 1	8.3 Mbps	40 wire	Multiword DMA
ATA 2	16.6 Mbps	40 wire	PIO mode
ATA 3	16.6 Mbps	40 wire	ATAPI
ATA 4	33 Mbps	40 or 80 wire	UltraDMA

TABLE 1.5 ATA standards *(continued)*

Standard	Speed	Cable Type	New Feature
ATA 5	66 Mbps	40 or 80 wire	UltraDMA 66
ATA 6	100 Mbps	40 or 80 wire	UltraDMA 100
ATA 7	150 Mbps	40 or 80 wire	UltraDMA 133
ATA 8	600 Mbps	40 or 80 wire	Hybrid drive capability

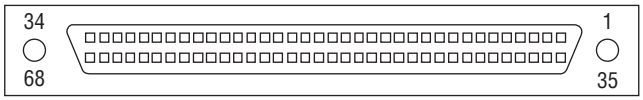
SATA drives are ATA drives that use serial transmission as opposed to parallel. They use a different cable because of this. It is not a ribbon cable but a smaller cable. Figure 1.34 shows the data cable and its connector.

FIGURE 1.34 Serial ATA data cable and connector



Small Computer System Interface (SCSI) is most commonly used for hard disks and tape drives, but it can connect a wide range of other devices, including scanners and CD drives. These devices reside on a single bus, which must be terminated on either end. Eight or sixteen devices can be attached to a single bus, depending on whether the SCSI bus is wide (0–15) or narrow (0–7) bus. There also is a host bus controller, which is usually plugged into a slot in the computer or can be integrated into the motherboard. Figure 1.35 shows an internal SCSI connector.

FIGURE 1.35 Internal SCSI connector



IDE Configuration and Setup (Master, Slave, Cable Select)

The primary benefit of IDE is that it's nearly universally supported. Almost every motherboard has IDE connectors.

A typical motherboard has two IDE connectors, and each connector can support up to two drives on the same cable. That means you're limited to four IDE devices per system unless you add an expansion board containing another IDE interface. In contrast, with SCSI (covered in the next section) you can have up to seven drives per interface (or even more on some types of SCSI).

Performance also may suffer when IDE devices share an interface. When you're burning CDs, for example, if the hard drive you are reading from is on the same cable as the CD drive you are writing to, errors may occur. SCSI drives are much more efficient with this type of transfer.

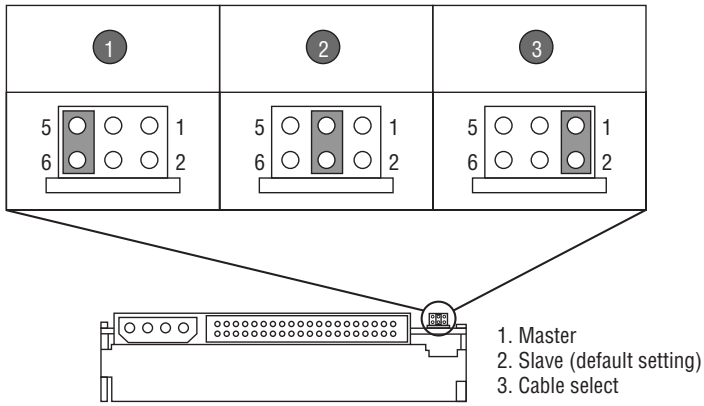
To install an IDE drive, do the following:

1. Set the master/slave jumper on the drive.
2. Install the drive in the drive bay.
3. Connect the power-supply cable.
4. Connect the ribbon cable to the drive and to the motherboard or IDE expansion board. Ensure that the master device is closest to the connection to the motherboard.
5. Configure the drive in BIOS Setup if it isn't automatically detected.
6. Partition and format the drive using the operating system.

Each IDE interface can have only one master drive on it. If there are two drives on a single cable, one of them must be the slave drive. This setting is accomplished via a jumper on the drive. Some drives have a separate setting for Single (that is, master with no slave) and Master (that is, master with a slave); others use the Master setting generically to refer to either case. The cable select setting will assume you have the primary drive first and secondary drive second on the cable. Figure 1.36 shows a typical master/slave jumper scenario, but different drives may have different jumper positions to represent each state. Today, the need for jumper settings has decreased because many drives can autodetect the master/slave relationship.

Most BIOS Setup programs today support Plug and Play, so they detect the new drive automatically at startup. If this doesn't work, the drive may not be installed correctly, the jumper settings may be wrong, or the BIOS Setup may have the IDE interface set to None rather than Auto. Enter BIOS Setup and find out. All you usually have to do is set the IDE interface to Auto and allow the BIOS to detect the drive.

FIGURE 1.36 Master/slave jumpers



In BIOS Setup for the drive, you might have the option of selecting a DMA or PIO setting for the drive. Both are methods for improving drive performance by allowing the drive to write directly to RAM, bypassing the CPU when possible. For modern drives that support UltraDMA, neither of these settings is necessary or desirable.

When the drive is installed, you can proceed to partition and format it for the operating system you've chosen. Then, you can install your operating system of choice.

For a Windows 8 or 8.1 system, allow the Windows Setup program to partition and format the drive (when installing the operating system), or use the Disk Management utility in Windows to perform those tasks. To access Disk Management, from the Control Panel choose Administrative Tools and then Computer Management.

SCSI IDs (0–15)

The devices are identified by a unique SCSI ID. The SCSI ID of a device in a drive enclosure that has a backplane is set either by jumpers or by the slot in the enclosure the device is installed into, depending on the model of the enclosure. In the latter case, each slot on the enclosure's backplane delivers control signals to the drive to select a unique SCSI ID. It is important that all devices have unique IDs. The bootable hard disk should be set with an ID of 0, and the host controller should be set at 7 or 15 in the case of 16-bit SCSI (it will be the highest number possible based on the SCSI width). Each end of the chain must be terminated.

In some cases, a single SCSI *target* (as they are called) may contain multiple drives within the unit. In these cases, the drives are differentiated with a second number called a logical unit number (LUN).

RAID Types

RAID stands for Redundant Array of Independent Disks. It's a way of combining the storage power of more than one hard disk for a special purpose such as increased performance or fault tolerance. RAID is more commonly done with SCSI drives, but it can be done with

IDE or SATA drives. Several types of RAID are covered in the following sections. Because of the methods used to provide fault tolerance, the total amount of usable space in the array will vary, as discussed in each section.

RAID 0

RAID 0 is also known as *disk striping*. This is technically not RAID because it doesn't provide fault tolerance. Data is written across multiple drives, so one drive can be reading or writing while the next drive's read/write head is moving. This makes for faster data access. However, if any one of the drives fails, all content is lost. In RAID 0, since there is no fault tolerance, the usable space in the drive is equal to the total space on all the drives. So if the two drives in an array have 250 GB each of space, 500 GB will be the available drive space.

RAID 1

RAID 1 is also known as *disk mirroring*. This is a method of producing fault tolerance by writing all data simultaneously to two separate drives. If one drive fails, the other drive contains all the data and may also be used as a source of the data. However, disk mirroring doesn't help access speed, and the cost is double that of a single drive. Since RAID 1 repeats the data on two drives, only one half of the total drive space is available for data. So if two 250 GB drives are used in the array, 250 GB will be the available drive space.

RAID 5

RAID 5 combines the benefits of both RAID 0 and RAID 1 and is also known as *striping with parity*. It uses a parity block distributed across all the drives in the array, in addition to striping the data across them. That way, if one drive fails, the parity information can be used to recover what was on the failed drive. A minimum of three drives is required. RAID 5 uses $1/n$ (n = the number of drives in the array) for parity information (for example, one-third of the space in a three-drive array), and only 1 ($1/n$) is available for data. So if three 250 GB drives are used in the array (for a total of 750 GB), 500 GB will be the available drive space.

RAID 10

RAID 10 is also known as RAID 1+0. Striped sets are mirrored (a minimum of four drives, and the number of drives must be even). It provides fault tolerance and improved performance but increases complexity. Since this is effectively a mirrored stripe set and a stripe set gets 100 percent use of the drive without mirroring, this array will provide half of the total drive space in the array as available drive space. For example, if there are four 250 GB drives in a RAID 10 array (for a total of 1,000 GB), the available drive space will be 500 GB.

Tape Drive

Another form of storage device is the tape backup. Tape backup devices can be installed internally or externally and use a magnetic tape medium instead of disks for storage. They

hold much more data than most other media but are also much slower. They're primarily used for archival storage.

Tape drives can be connected with SCSI, Fibre Channel, SATA, USB, FireWire, or other interfaces.

One of the disadvantages of tape drives in the past has been the sequential manner in which data is located on the tape. That issue may become a thing of the past. In 2010, IBM introduced the Linear Tape File System (LTFS), which allows you to access files on tape in the same way as on a disk filesystem.

Media Capacity

One of the common ways that storage options are compared is capacity. The capacity ranges of each option are briefly discussed here:

CD Standard CDs normally hold 650–700 MB of data and use the ISO 9660 standard, which allows them to be used in multiple platforms.

CD-RW Like CDs, CD-RWs normally hold 650–700 MB of data.

DVD-RW The capacity of DVD-RW depends on whether it is single or dual layer. A single-layer DVD-RW holds about 4.7 GB (the same as a DVD-R), and a dual-layer DVD-RW will hold 8.5 GB.

DVD DVDs can have up to four layers, can be either single- or double-sided, and can come in about 10 different types or generations. All affect the capacity. The range of capacities available is from 4.7 GB (DVD-5 single-sided, single-layer) to 17.08 GB (DVD-18, double-sided, double-layer, which results in four layers total).

Blu-ray As mentioned earlier in the section "Optical Drives," the current capacity of a Blu-ray disc is 100 GB, with 400 GB on the horizon, and an aim for 1 TB by 2015.

Tape The current maximum capacity of a standard tape drive is 10 TB. Sony has a new cassette tape that will hold 185 TB of data.

DL DVD As described in the section on DVD capacity, a double-layer (DL) DVD's capacity is influenced by the type or generation of DVD and whether it is single or double sided. Single-sided DL (which results in a total of two layers) in DVD-10 holds up to 9.4 GB, and a double-sided DL (which results in a total of four layers) in DVD-18 holds up to 17.08 GB.

Exam Essentials

Identify and differentiate the optical drive options for the long-term storage of data. Those options include CD-ROM, DVD-ROM, and Blu-Ray. When the ability to erase and rewrite to the disk is required, the options include CD-RW, DVD-RW, dual-layer (DL) DVD-RW, and Blu-ray Disc Recordable Erasable (BD-RE).

Describe the types of interfaces to connect a drive to the system. Drives can be connected externally using USB, FireWire (IEEE 1394), eSATA, and Ethernet. Internally the connection types are SATA, IDE, and SCSI.

Appreciate the importance of the Master/Slave settings for IDE. Each IDE interface can have only one master drive on it. If there are two drives on a single cable, one of them must be the slave drive. This setting is accomplished via a jumper on the drive.

Describe the operations of the SCSI bus. SCSI devices reside on a single bus, which must be terminated on either end. Up to 8 or 16 devices can be attached to a single bus, depending on whether the SCSI bus is wide (0–15) or narrow (0–7). There also is a host bus controller, which is usually plugged into a slot in the computer or integrated into the motherboard.

Identify the advantages and disadvantage to both magnetic and solid-state drive operations. SSDs retain data in nonvolatile memory chips and contain no moving parts. Compared to electromechanical HDDs, SSDs are typically less susceptible to physical shock, are silent, have lower access time and latency, but are more expensive per gigabyte.

List the capacities of various storage systems. These range from 650 MB for a CD-Rom up to 17 GB for a double-sided DL DVD.

Identify the pros and cons of various RAID options. RAID 0 provides only performance enhancement, whereas RAID 1 and RAID 5 provide fault tolerance. RAID 10 provides both performance enhancement and fault tolerance. The cost for these options is the use of multiple hard drives in various arrangements.

1.6 Install Various Types of CPUs and Apply the Appropriate Cooling Methods

The CPU is the brain of the PC and has evolved over the years both in the slots available to connect it to the PC and in its capabilities. With the addition of more processing power came the introduction of more heat in the case and the development of more advanced cooling methods. This section covers these issues as well. The topics addressed in objective 1.6 include the following:

- Socket types
- Characteristics
- Architecture
- Cooling

Socket Types

Sockets are the interface with which CPUs are plugged into the motherboard. These sockets have evolved over the years along with the changes in CPU architecture and design. There are three form factors for CPU chips: pin grid array (PGA), single-edge contact cartridge (SECC), and land grid array (LGA). The PGA style is a flat square or rectangular ceramic chip with an array of pins in the bottom. The actual CPU is a silicon wafer embedded inside that ceramic chip. The SECC style is a circuit board with the silicon wafer mounted on it. The circuit board is then surrounded by a plastic cartridge for protection; the circuit board sticks out of the cartridge along one edge. This edge fits into a slot in the motherboard.

The market leader in chip manufacturing is Intel Corporation, with Advanced Micro Devices (AMD) gaining market share in the home PC market. This section discusses various socket types you may encounter.

Intel: LGA 775, 1155, 1156, 1366, 1150, 2011 Earlier in this chapter, Table 1.3 listed the various Intel CPU slots and sockets you may find in a motherboard and explained which CPUs will fit into them.

AMD: AM3, AM3+, FM1, FM2, FM2+ Table 1.3 also listed the various AMD CPU slots and sockets you may find in a motherboard and explained which CPUs will fit into them. These later-generation AMD sockets were launched as the successor to Socket AM2+. In 2009 AMD3 was released alongside the initial grouping of Phenom II processors designed for it. The principal change from AM2+ to AM3 is support for DDR3 SDRAM. The AM3+ socket has been designed for the AMD FX series Zambezi processors based on the Bulldozer architecture. Socket FM2 is a CPU socket launched in September 2012. Motherboards using the FM2 utilize AMD's new A85X chipset. The FM2+ uses three PCI Express cores: one 2×16 core and two 5×8 cores, for a total of 64 lanes.

Characteristics

CPUs can be compared and contrasted on the basis of a number of characteristics. These characteristics ultimately define the ability of the CPU to perform its main role of processing as well as its ability to provide more advanced features to the PC. These characteristics are discussed in this section.

Speeds

Speeds were discussed earlier in this chapter in the section "1.1 Given a Scenario, Configure Settings and Use BIOS/UEFI Tools on a PC."

Cores

CPUs can have a single-core, dual-core, quad-core, and even dual-quad-core (eight CPUs total). When multiple cores exist, they operate as individual processors, so the more the better. The largest boost in performance will likely be noticed in improved response time

while running CPU-intensive processes, such as virus scans, ripping/burning media (requiring file conversion), or file searching.

The addition of more cores does not have a linear effect on performance. The potential impact of multiple cores also depends on the amount of cache or memory present to serve the CPU. When a computer is designed for the processor, this will have been taken into consideration, but when adding a multicore processor to a PC, it is an issue to consider. Cache or memory is discussed in the next section.

Dual-Core Processors

Dual-core processors, available from Intel as well as AMD, essentially combine two processors into one chip. Instead of adding two processors to a machine (making it a multiprocessor system), you have one chip splitting operations and essentially performing as if it's two processors in order to get better performance. A multicore architecture simply has multiple, completely separate processor dies in the same package, whether it's dual core, triple core, or quad core. The operating system and applications see multicore processors in the same way that they see multiple processors in separate sockets. Both dual-core and quad-core processors are common cases for the multicore technology. Most multicore processors from Intel come in even numbers, whereas AMD's Phenom series can contain odd numbers (such as the triple-core processor).

Cache Size/Type

A *cache* is an area of extremely fast memory used to store data that is waiting to enter or exit the CPU. The *Level 1 cache*, also known as the *L1* or *front-side cache*, holds data that is waiting to enter the CPU. On modern systems, the L1 cache is built into the CPU. The *Level 2 cache*, also known as the *L2* or *back-side cache*, holds data that is exiting the CPU and is waiting to return to RAM. On modern systems, the L2 cache is in the same packaging as the CPU but on a separate chip. On older systems, the L2 cache was on a separate circuit board installed in the motherboard and was sometimes called *cache on a stick* (COAST).

On some CPUs, the L2 cache operates at the same speed as the CPU; on others, the cache speed is only half the CPU speed. Chips with full-speed L2 caches have better performance. Some newer systems also have an *L3 cache*, which is external to the CPU. It sits between the CPU and RAM to optimize data transfer between them.

Hyperthreading

One of the improvements offered since the Pentium 4 is *hyperthreading* technology. This feature enables the computer to multitask more efficiently between CPU-demanding applications. An advantage of hyperthreading is improved support for multithreaded code, allowing multiple threads to run simultaneously and thus improving reaction and response time.

Virtualization Support

When using virtualization technology (discussed in the "BIOS Configurations" section earlier, under "Virtualization Support"), a fuller realization of its benefits can be achieved when the processor supports this concept.

The benefit derived from this support is to allow the virtualization product (also called a *hypervisor*) to use hardware-assisted virtualization. This allows the hypervisor to dynamically allocate CPU to the VMs as required. Both AMD and Intel offer CPUs that support hardware virtualization.

Architecture

CPUs can be either 32-bit or 64-bit. This value describes what is called the *word size* of the processor. Having 64 bits offers two important benefits. Data can be processed in larger chunks, which also means with greater precision. Moreover, the system can point to or address a larger number of locations in physical memory. A key consideration is the operating system. If the operating system is not 64 bit, you cannot take advantage of the 64-bit processor.

Integrated GPU

A graphics processing unit (GPU) is a specialized circuit designed to rapidly manipulate and alter memory to accelerate the building of images in a frame buffer intended for output to a display. It improves the graphic abilities of the PC when this feature is present in the CPU.

Some visual features provided by operating systems such as Windows Vista and Windows 7 are unavailable unless the CPU has dedicated graphics memory or a GPU. For example, the Aero view in Vista and Windows 7 requires a card capable of DirectX, which is a technology that requires the DirectCompute API, which in turn requires a GPU.

Disable Execute Bit

The NX bit (No-eXecute) is a technology used in CPUs to segregate areas of memory for use either for storing processor instructions (code) or for storing data. Execute Disable Bit (EDB) is an implementation of this security feature in some Intel CPUs that helps to reduce vulnerability to malware. In AMD, this feature is called Enhanced Virus Protection. When malware attempts to insert code in the buffer, the processor disables code execution, preventing damage and worm propagation. The operating system must support this feature, and it must be enabled in the system BIOS.

Cooling

CPUs produce heat, and the more powerful the CPU the more heat it produces. Heat is an enemy to the PC in general because it causes problems such as random reboots. Methods of cooling the CPU and in turn the overall interior of the case have evolved with the increasing need to remove this heat. This section covers options that are used.

In methods of cooling, technology that transfers heat away from components uses thermoelectric cooling, and components that perform this function are called Peltier components. Heat sinks, cooling fans, and cooling fins are Peltier components. Liquid cooling, on the other hand, cools not by transferring heat away from components but by circulating a cool liquid around them.

Heat Sink

The cooling can be either active or passive. A *passive heat sink* is a block of heat-conductive material that sits close to the CPU and wicks away the heat into the air. An *active heat sink* contains a fan that pulls the hot air away from the CPU. The heat sink sits atop the CPU, in many cases obscuring it from view entirely.

Fans

Active heat sinks have a fan that sits atop the heat sink. It pulls the heat out of the heat sink and away from it. Then the case fan shunts the heat out the back or side of the case.

Thermal Paste

Most *passive heat sinks* are attached to the CPU using a glue-like thermal compound (called *thermal glue*, *thermal compound*, or *thermal paste*). This makes the connection between the heat sink and the CPU more seamless and direct. Thermal compound can be used on active heat sinks too, but generally it isn't because of the possibility that the fan may stop working and need to be replaced. Thermal compound improves thermal transfer by eliminating tiny air pockets between the heat sink and CPU (or other device like a north bridge or video chipset). Thermal compound provides both improved thermal transfer and adds bonding for heat sinks when there are no mounting holes to clamp the heat sink to the device to be cooled.

Liquid-Based

Liquid-Based Cooling cases are available that use circulating water rather than fans to keep components cool. These cases are typically more expensive than standard ones and may be more difficult for a technician untrained in this technology to work on, but they result in an almost completely silent system.

Issues with Liquid-Based Cooling machines can include problems with hoses or fittings, the pump, or the coolant. A failure of the pump can keep the liquid from flowing and cause the system to overheat. A Liquid-Based Cooling system should also be checked every so often for leaks or corrosion on the hoses and fittings, and the reservoir should be examined to make sure it is full and does not contain contaminants. Liquid-Based Cooling is more expensive, less noisy, and more efficient than Peltier components.

Fanless/Passive

Fanless or passive cooling systems are those that either use a highly efficient heat sink or use some type of Liquid-Based Cooling to keep the CPU cool. Some use a thermal heat pipe

in which liquid is turned to vapor at the hot end, moves as a vapor down the pipe, and then turns back into liquid at the cool end, where it is cycled around to the hot end and the process starts again.

Exam Essentials

Identify the CPU socket types you may encounter. These include but are not limited to Intel LGA, 775, 1155, 1156, and 1366, as well as AMD 940, AM2, AM2+, AM3, AM3+, FM1, and F.

Define the characteristic of CPUs. CPUs can differ based on speed, number of cores, cache size and type, hyperthreading support, virtualization support, architecture (32-bit vs. 64-bit), and integrated GPU support.

Understand the various options available to reduce CPU heat. These options include heat sinks, fans, thermal paste, and liquid cooling.

1.7 Compare and Contrast Various PC Connection Interfaces, Their Characteristics, and Purpose

When using various modes of connection to the PC, you should understand the characteristics of those connections. This includes the types inside the case as well as the ones that appear on the back or front panel and those that are provided as a result of adding an expansion card into a slot that includes a new connector type on the back panel. The topics addressed in objective 1.7 are as follows:

- Physical connections
- Connector types
- Wireless connections
- Characteristics

Physical Connections

Many different types of cables and connectors have been developed over the years to connect devices to the PC. Some have been around almost as long as the PC, whereas many others have made their appearance only in the last few years. This section discusses the physical characteristics of each of these connection methods, along with the operational characteristics, such as the speed and maximum cable length.

USB 1.1 vs. 2.0 vs. 3.0

USB is an expansion bus type that is used almost exclusively for external devices. All motherboards today have at least two USB ports. Some of the advantages of USB include hot-plugging and the capability for up to 127 USB devices to share a single set of system resources. A USB port requires only one IRQ for all USB devices that are connected to it, regardless of the type or number of devices. USB 1.1 runs at 12 Mbps and USB 2.0 runs at 480 Mbps.

USB 3.0 has transmission speeds of up to 5 Gbps, significantly reduces the time required for data transmission, reduces power consumption, and is backward compatible with USB 2.0. Because USB is a serial interface, its width is 1 bit. It is useful to note, however, that a USB 2.0 device will perform at 2.0 speeds even when connected to a 3.0 port.

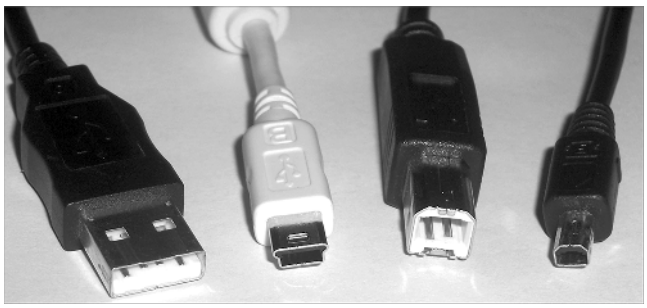
By utilizing USB hubs in conjunction with the USB ports available on the local machine, you can connect up to 127 of these devices to the computer. You can daisy-chain up to four external USB hubs to a USB port. *Daisy chaining* means that hubs are attached to each other in a line. A USB hub will not function if it is more than four hubs away from the root port.

Connector Types: A, B, Mini, Micro

USB connectors come in two types and two form factors or sizes. The type A connector is what is found on USB hubs, on host controllers (cards that are plugged into slots to provide USB connections), and on the front and back panels of computers. Type B is the type of USB connector found on the end of the cable that plugs into the devices.

The connectors also come in a mini version and a micro version. The micro version is used on mobile devices, such as mobile phones, GPS units, PDAs, and digital cameras, whereas the mini is found in applications described in the previous paragraph. The choice between a standard A and B and a mini A and B will be dictated by what is present on the device. The cables used cannot exceed 5 meters in length. Figure 1.37 shows, from left to right, a standard Type A, a mini Type A, a standard Type B, and a mini Type B. Some manufacturers have chosen to implement a mini connector that is proprietary, choosing not to follow the standard.

FIGURE 1.37 USB connectors



FireWire 400 vs. FireWire 800

Some newer motherboards have a built-in IEEE 1394/FireWire socket, although this socket in the past was more commonly provided on a PCI expansion board. It transfers data at 400 Mbps and supports up to 63 chained devices on a single set of resources. It's hot-pluggable, like USB. Figure 1.38 shows the connections on a FireWire card.

FIGURE 1.38 Connections on a FireWire card



FireWire 400 (IEEE 1394a) is the original standard that operates up to 400 Mbps with a maximum cable length of 4.5 meters. Now, however, there are cables that will support 10 meters.

FireWire 800 (IEEE 1394b) uses a different encoding scheme that allows it to go up to 800 Mbps. It also can use a cable up to 10 meters.

SATA1 vs. SATA2 vs. SATA3, eSATA

Connections for storage devices can be either SATA or IDE. IDE was the only option early on, and then SATA came on the scene. SATA came out as a standard and was first adopted in desktops and then laptops. Whereas ATA had always been an interface that sends 16 bits at a time, SATA sends only one bit at a time. The benefit is that the cable used can be much smaller, and faster cycling can actually increase performance. SATA uses a seven-wire cable that can be up to 1 meter in length. eSATA cables can be up to 2 meters. Figure 1.39 shows the SATA and eSATA connectors.

FIGURE 1.39 SATA and eSATA

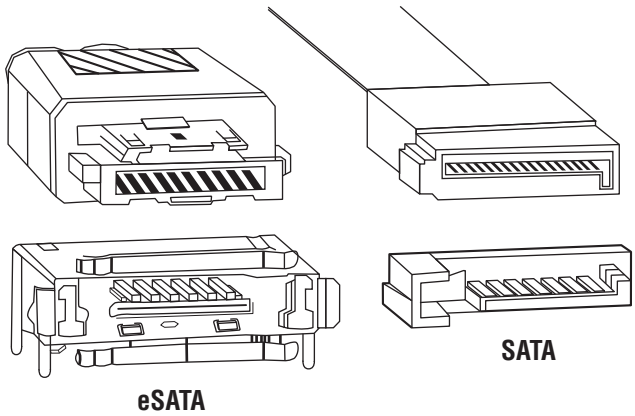


Table 1.6 lists the speeds of the options.

TABLE 1.6 SATA speeds

Standard	Transfer Speed
SATA 1.0	150 MBps
SATA 2.0	300 MBps
SATA 3.0	600 MBps
SATA 3.2	1,969 MBps
eSATA	6 GBps

Other Connector Types

A computer's peripheral ports are the physical connectors outside the computer. Cables of various types are designed to plug into these ports and create a connection between the PC and the external devices that may be attached to it. A successful IT technician should have an in-depth knowledge of ports and cables.

Because the peripheral components need to be upgraded frequently, either to keep pace with technological change or to replace broken devices, a well-rounded familiarity with the ports and their associated cabling is required.

Unless a peripheral device connects directly to the motherboard, it must use a port. Ports can be distinguished from one another by three factors:

- Bits of data simultaneously conveyed
- Data transmission speed
- Type of connector

Serial

A serial cable (and port) uses only one wire to carry data in each direction; all the rest are wires for signaling and traffic control.

Common bit rates include 1,200; 2,400; 4,800; 9,600; 14,400; 19,200; 38,400; 57,600; and 115,200 bits per second. The connector used for serial is a D-shaped connector with a metal ring around a set of pins. These are named for the number of pins/holes used: DB-25, DB-9, HD-15 (also known as DB-15), and so on. Figure 1.40 shows DB-25, DB-15, and DB-9. HD-15 is covered in the section "VGA."

Parallel

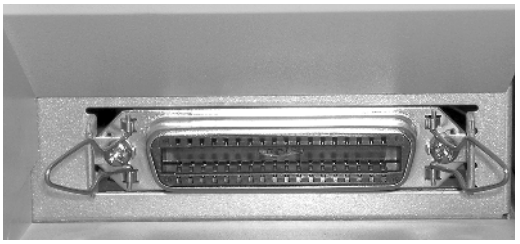
A parallel cable uses eight wires to carry bits of data in each direction, plus extra wires for signaling and traffic control. The most common port of this type before the conversion of most printers to USB was the parallel printer port.

FIGURE 1.40 DB-25, DB-15, and DB-9



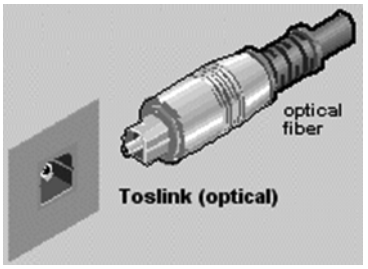
It sends data 8 bits at a time (in parallel) and uses a cable with a male DB-25 connector at the computer and a 36-pin Centronics male connector at the printer. Figure 1.40 shows a DB-25 connector, and Figure 1.41 shows a Centronics. Its main drawback is its cable length. Older-style Centronics parallel cables can sometimes be up to 15 feet long, although 9 feet to 12 feet is more common. Depending on the mode of operation, it can provide up to 2.5 MBps of bandwidth. IEEE-1284, a newer bidirectional standard, can go up to 30 feet.

FIGURE 1.41 Centronics



Optical

Optical ports are beginning to appear on motherboards to accept a Toshiba Link (TOSLINK) cable. This cable is used to connect consumer audio gear that comes with the cable. These cables have several form factors but the most common is the digital connector using a rectangular EIAJ/JEITA RC-5720 connector. This connector and the plug on the computer are shown in the graphic below.



VGA

This is the traditional connector for the display of a computer, and it is shaped like a *D*. It has three rows of five pins each, for a total of 15 pins. This is also often called the HD-15 (also known as DB-15) connector. A VGA cable carries analog signals. The cable length utilized will affect the resolution achieved: 1024×768 would operate more effectively with 30 feet or less of cable length. As the need for resolution increases, the allowable maximum cable length decreases. Figure 1.42 shows a VGA port.

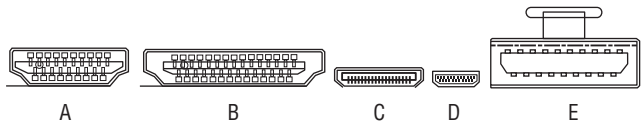
FIGURE 1.42 VGA port



HDMI

High-Definition Multimedia Interface (HDMI) connectors are used to connect compatible digital items (DVD players and conference room projectors, for example). The Type A connector has 19 pins and is backward compatible with DVI. Type B connectors have 29 pins and aren't backward compatible with DVI, but they support greater resolutions. Type C connectors are a smaller version of Type A for portable devices. Type D is an even smaller micro version that resembles a micro-USB connector. Type E is planned for use in automotive applications. HDMI theoretical cable length limit is 25. Figure 1.43 shows all HDMI types.

FIGURE 1.43 HDMI connectors



There are several versions of HDMI, as described in Table 1.7.

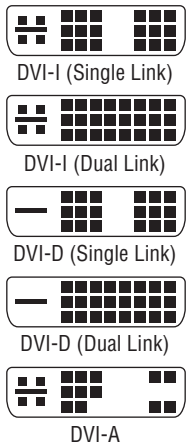
TABLE 1.7 HDMI versions

Version	1.0	1.1	1.2	1.3	1.4	2.0
Maximum throughput (Gbps)	3.96	3.96	3.96	10.2	10.2	6
Maximum color depth (bit/px)	24	24	24	48	48	48
Maximum audio throughput (Mbps)	36.86	36.86	36.86	36.86	36.86	49.152

DVI

There are several types of Digital Video Interface (DVI) pin configurations, but all connectors are D-shaped. The wiring differs based on whether the connector is single-linked or dual-linked (extra pins are used for the dual link). DVI differs from everything else in that it includes both digital and analog signals at the same time, which makes it popular for LCD and plasma TVs. Figure 1.44 shows DVI connectors. Maximum cable length is 16 feet (5 meters). These connectors are covered in more detail in the section "Identify Common PC Connector Types and Associated Cables."

FIGURE 1.44 DVI connectors



Audio

Audio connectors (sound) can be analog or digital. The most common connectors are called a mini-TRS connector. There are usually two of these, one for headphones (or speakers) and the other for a microphone (or line in). Figure 1.45 shows a 3.5-mm plug.

FIGURE 1.45 TRS connector

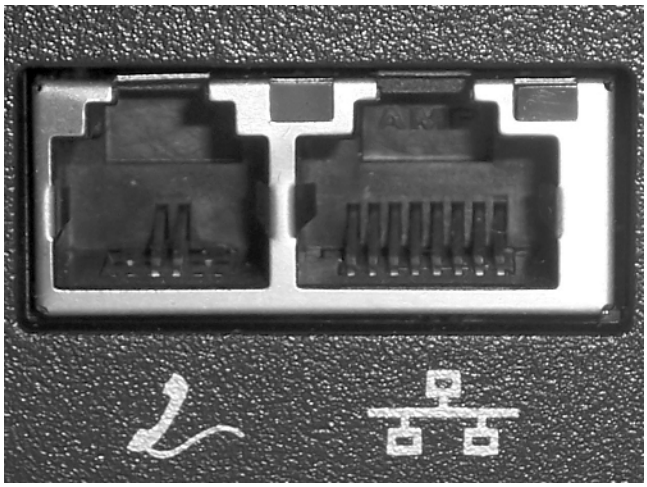


RJ-45

A registered jack (RJ) is a plastic plug with small metal tabs, like a telephone cord plug. Numbering is used in the naming: RJ-11 has two metal tabs, and RJ-14 has four. RJ-45

has eight tabs and is used for Ethernet 10 BaseT/100 BaseT networking. The maximum cable length is 100 meters but can vary slightly based on the category of cabling used. Figure 1.46 shows RJ-11 (left) and RJ-45 (right) connectors.

FIGURE 1.46 RJ-11 and RJ-45



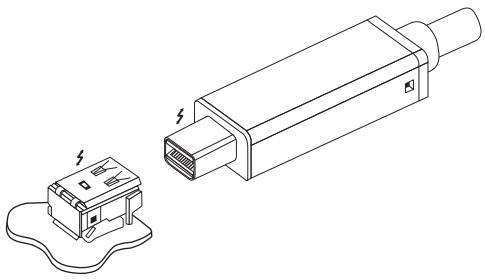
RJ-11

An RJ-11, as described earlier and shown in Figure 1.46, is a standard connector for a telephone line and is used to connect a computer modem to a phone line. It looks much like an RJ-45 but is noticeably smaller.

Thunderbolt

Thunderbolt is a connector type that we introduced earlier in this chapter in the section "Audio." For more information, see that section. Figure 1.47 shows the Thunderbolt cable and connector.

FIGURE 1.47 Thunderbolt connector and cable



Wireless Connections and Their Quality

Wireless connections, once considered a luxury, are now becoming a standard expected by users. There are several forms of wireless communication that serve very different purposes. These connection types differ in their speed, the distance at which they can operate, and the frequencies they use. This section discusses three common types of wireless communication and their applications.

Bluetooth

Bluetooth is a type of wireless that creates what is called a personal area network (PAN). Bluetooth is a radio frequency technology that can connect a device to a computer at a range of about 35 feet. It operates in the 2.4 GHz band, which is the same band as 802.11b/g. Version 2.0 offers 3 Mbps (with actual throughput of 2.1 Mbps).

IR

Infrared technology requires direct line of sight and has been used for printers in the past. It can operate at a distance of 5 meters and can offer up to 4 Mbps. It is being replaced with Bluetooth over time.

RF

Radio frequency (RF) describes any of the technologies, like Bluetooth, that use radio waves. This also includes 802.11 WLAN technologies. These operate in two frequencies: 802.11b/g in the 2.4 GHz range and 802.11a and 802.11ac in the 5.0 GHz range. 802.11n can operate in both. These connections are used for networking. The ranges, speeds, and frequencies of these technologies are covered later in the section "Speed, Distance Limitations, and Frequencies."

NFC

Near field communications (NFC) is a wireless technology that allows smartphones and other equipped devices to communicate when very near one another or when touching. NFC operates at slower speeds than Bluetooth but consumes far less power and doesn't require pairing. It also does not create a PAN like Bluetooth; rather, the connections are point-to-point. NFC can operate up to 20 cm at a transfer rate of 0.424 Mbps.

NFC is also a standard managed by the ISO and uses tags that are embedded in the devices. NFC components include an initiator and a target; the initiator actively generates an RF field that can power a passive target. This enables NFC targets to take simple form factors such as tags, stickers, key fobs, or cards that do not require batteries.

Characteristics

This section will discuss the characteristics of PC connection interfaces.

Analog vs. Digital Transmission

Audio and video can be delivered in either analog or digital form. For video this means that there are two connector types you may find on the PC for connecting the display (or monitor). Both types are discussed next.

VGA vs. HDMI

VGA connections and cables are analog in nature, and I've pretty much said all there is to say about this connector type. HDMI is an interface for transmitting encrypted uncompressed digital data. When these connections are available, they are preferable to using the VGA connector, but they require the use of an HDMI cable between the computer and the display. When compared to HDMI, VGA cannot deliver the high resolutions that HDMI can.

Speed, Distance Limitations, and Frequencies

Table 1.8 compares the speed and distance limitations of the wireless technologies discussed.

TABLE 1.8 Distances, speeds, and frequencies

Technology	Maximum Outdoor Range	Maximum Indoor Range	Maximum Speed	Frequency
Bluetooth	10 m/35 ft	10 m/35 ft	3 Mbps	2.4 GHz
IR	5 m/15 ft	5 m/15 ft	4 Mbps	33-40 GHz or 50-60 GHz
802.11	100 m/330 ft	20 m/66 ft	2 Mbps	2.4 GHz
802.11a	120 m/390 ft	35 m/115 ft	54 Mbps	5.0 GHz
802,11ac	35 m/115 ft	35 m/115 ft	6.933 Gbps	5.0 GHz
80211b	140 m/460 ft	35 m/115 ft	11 Mbps	2.4 GHz
802.11g	140 m/460 ft	38 m/125 ft	54 Mbps	2.4 GHz
802.11n	250 m/820 ft	70m/230 ft	600 Mbps	2.4 and 5.0 GHz

Digital Rights Management

With the rapid increase in wireless usage of all types, the concern for controlling the leakage of data from an organization and the illegal sharing of content wirelessly is rising. The

Open Mobile Alliance (OMA) created a system called OMA digital rights management (DRM) that provides a way for content creators to set enforced limits on the use and duplication of their content by customers. This system has been implemented in more than 500 mobile phone models at the time of this writing.

Exam Essentials

Identify the characteristics of connector types on most PCs. These include but are not limited to USB, SATA, eSATA, FireWire, serial, parallel, VGA, HDMI, DVI, audio, RJ-45, and RJ-11.

Describe the difference in the operation of VGA and HDMI transmission. VGA connections and cables are analog in nature, whereas HDMI is an interface for transmitting digital data.

List the speed, distance, and frequency of wireless connections. For device connections, Bluetooth offers up to 2.1 Mbps at about 35 feet, and infrared transmits at 4 Mbps at 5 meters. For networking, 802.11b operates at 11 Mbps, 802.11g at 54 Mbps, 802.11n at up to 600 Mbps, and 80211ac at up to 6 Gbps. The 802.11a maximum indoor range is 100 meters, or 300 feet, and the maximum outdoor range is 350 meters, or 1,200 feet. The 802.11b maximum indoor range is 150 meters, or 492 feet, and the maximum outdoor range is 500 meters, or 1,640 feet. For 802.11g and 802.11ac, the maximum indoor range is 150 meters, or 492 feet, and the maximum outdoor range is 500 meters, or 1,640 feet.

1.8 Install a Power Supply Based on Given Specifications

The power supply provides a number of connectors for various devices as well as a plug for the motherboard. It is important to understand these connector types and to appreciate the power drawn by various devices. Knowledge of the power needs of the devices can allow the technician to choose a power supply that provides the total power needs of the PC. The topics addressed in objective 1.8 include the following:

- Connector types and their voltages
- Specifications

Connector Types and Their Voltages

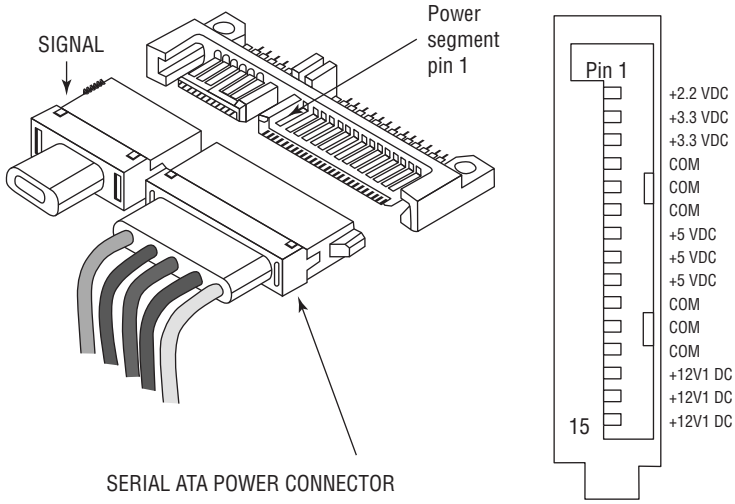
When selecting a power supply, two issues become important. You need to supply the total wattage required by all the devices and the motherboard of the PC, and you must ensure that it has the connector types required by your devices. This section discusses the voltage requirements of various connector types.

To determine the wattage a device draws, multiply voltage by current. For example, if a device uses 5 amps of +3.3 V and 0.7 amps of +12 V, a total of 25 watts is consumed. Do this calculation for every device installed. Most devices have labels that state their power requirements.

SATA

The SATA power connector is 15 pins, with 3 pins designated for 3.3 V, 5 V, and 12 V and with each pin carrying 1.5 amps. This results in a total draw of 4.95 watts + 7.5 watts + 18 watts, or about 30 watts. Figure 1.48 shows the SATA power connector (the data cable was shown earlier in Figure 1.34).

FIGURE 1.48 SATA power connector



Molex

A Molex connector is used to provide power to drives of various types. It has four pins, two of which have power (one 12 V and the other 5 V). These are standard for IDE (PATA) or older SCSI drives. The total power demands are from 5 to 15 watts for IDE and 10 to 40 watts for SCSI. The four-pin Molex connector was shown earlier in Figure 1.19.

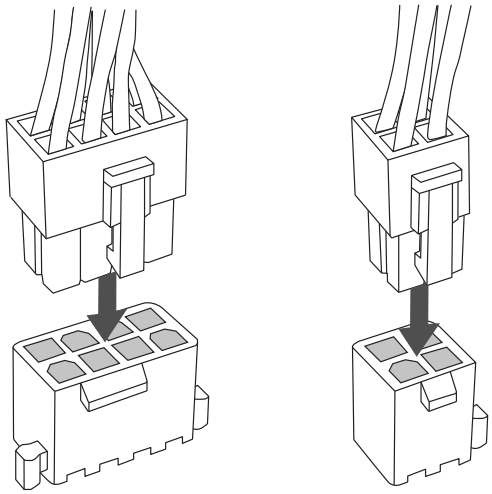
Four/Eight-Pin 12 V

With the introduction of the Pentium 4, the motherboard required more power. Supplemental power connections were provided to the motherboard in 4-, 6- (discussed later in this section), or 8-pin formats. These were in addition to the 20-pin connector (discussed later in this section) that was already provided.

There is a four-pin square mini version of the ATX connector, which supplies two pins with 12 V, and an eight-pin version (two rows) that has four 12 V leads. These connect to

other items, such as the processor, or to other components, such as a network card that may need power that exceeds what can be provided with the ATX connection to the board. Figure 1.49 shows the eight-pin version and the four-pin square mini version.

FIGURE 1.49 Eight-pin and four-pin 12 V



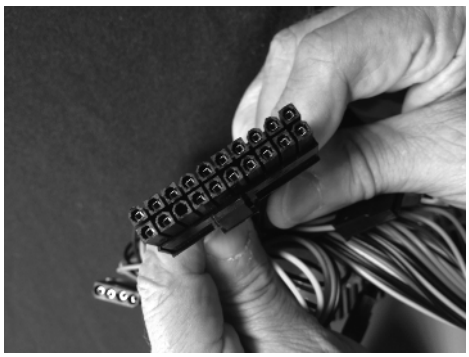
PCIe Six/Eight-Pin

PCIe slots also draw more power and require power in addition to the main 20-pin connector (discussed next). These additional connectors can be six pins and may also contain an additional two-pin connector on the side for cases where the connection required is eight-pin.

20-Pin

The main ATX connector, referenced earlier, is a 20-pin connector. The four pins carrying power are 3.3 V, 3.3 V, 5 V, and 5 V. This allows the motherboard to pull about 20 to 30 watts. Figure 1.50 shows the 20-pin ATX.

FIGURE 1.50 20-pin ATX



24-Pin

The 24-pin ATX connector is simply the 20-pin connector discussed earlier along with the extra 4-pin connector on the side. This provides the four pins carrying power as discussed earlier plus an additional four pins with 5 V standby, 12 V, 12 V, and 3.3. Figure 1.51 shows the 24-pin ATX.

FIGURE 1.51 24-pin ATX



Specifications

When purchasing the power supply, you must take into account issues such as wattage, number of connectors, physical size or form factor, and plug types. This section addresses these considerations.

Wattage

When the wattage needs of each device and of the motherboard and CPU are totaled, you will know the wattage that the power supply must provide. A power supply has a rated output capacity in watts, and when you fill a system with power-hungry devices, you must make sure that maximum capacity isn't exceeded. Otherwise, problems with power can occur, creating lockups or spontaneous reboots. Most power supplies provide between 250 watts and 1,200 watts. It's always a good idea to have more than the minimum required for the devices that are present so that additional devices can be added in the future.

Dual-Rail

Dual-rail power supplies are ones that use multiple wires or "rails" to supply the power rather than a single wire. While some think this will increase the amount of power that can be provided, that is not true. In fact, single rails deliver more power, but you are sending more current over a single wire, which can overheat the wires. Manufacturers typically

group several wires together and apply the current limit to the entire group. Almost all high-power supplies claim to implement separate rails.

Size

The physical dimension of the power supply must also be considered. The slot where the power supply goes in the PC will be the limiting factor. The thin form has been optimized for small and low-profile micro-ATX and FlexATX system layouts. The long, narrow profile of this power supply fits easily into low-profile systems.

Number of Connectors

The power supply can come with any combination of the power connector types discussed earlier in this section. A quick inventory of the connectors that you need will assist you in ensuring that the power supply you purchase has the connectors required.

ATX

If the motherboard is an ATX (the larger motherboard), the power needs of the system will probably be higher than that of a micro-ATX. In that case, ensure that the supply is designed for an ATX system and can provide the higher requirements.

Micro-ATX

Micro-ATX boards are smaller and designed to operate with power supplies of a lower wattage rating. As you add more USB devices or put the board in a larger case with more internal devices, a larger power supply may become necessary.

Dual-Voltage Options

Most power supplies have the ability to accept input of either 110 or 220 volts. Some expensive power supplies can autosense and do not need to be set manually; however, most have to be set manually, and you want to set the switch to the correct voltage setting or you could cause damage. Figure 1.52 shows the typical position of this switch.

FIGURE 1.52 Voltage switch



Exam Essentials

Identify common power connector types and their voltages. These include but are not limited to SATA, Molex, 4- to 8-pin 12 V, PCIe 6- to 8-pin, 20-pin, 24-pin, and floppy connectors.

Understand the specifications of power supplies. Differentiate power supplies by wattage, size, number of connectors, and design (ATX or mini-ATX).

Describe a dual-wattage power supply. This is a supply that can be set to accept either 110 volts or 220 volts.

1.9 Given a Scenario, Select the Appropriate Components for a Custom PC Configuration to Meet Customer Specifications or Needs

In many cases, an off-the-shelf computer does not fill the needs of a customer. In these cases, a unit must be custom built to accommodate their specific needs. This section describes some common custom configurations and options to meet specific needs. The topics addressed in objective 1.9 include the following:

- Graphic/CAD/CAM design workstation
- Audio/video-editing workstation
- Virtualization workstation
- Gaming PC
- Home theater PC
- Standard thick client
- Thin client
- Home server PC

Graphic/CAD/CAM Design Workstation

Computers used for graphic design, computer-aided design (CAD) applications, and computer-aided manufacturing (CAM) require much more horsepower than the standard PC. Specifically, they require multiple or more powerful processors, more robust video cards, and significantly more memory. In this section, these needs are discussed.

Multicore Processor

The resource-intensive applications used with graphics, CAD, and CAM require high-end multicore processors. For example, to run a 64-bit version of Autodesk AutoCAD software, requirements are an AMD Athlon 64 with SSE2 technology, AMD Opteron processor with SSE2 technology, Intel Xeon processor with Intel EM64T support and SSE2 technology, or Intel Pentium 4 with Intel EM64T support and SSE2 technology.

Streaming Single Instruction, Multiple Data Extensions 2 (SSE2) technology is the latest version of a technology that provides additional instructions to the CPU that allows it to perform a single instruction on multiple pieces of data. Moreover, to do 3D modeling (which is graphic intensive), an Intel 4 processor or AMD Athlon 3.0 GHz or greater is required. If a dual-core Intel or AMD dual-core processor is used, then it can be 2.0 GHz.

Keep in mind these are only the minimums. For good performance, these minimums should be exceeded.

High-End Video

As you can imagine, the video demands of graphics such as 3D are much higher than those of common office applications. Continuing with the example of AutoCAD 2012, this requires a 1,280×1,024 true-color video display adaptor with 128 MB of its own memory or greater and Pixel Shader 3.0 or greater, and it should be a Microsoft Direct3D-capable workstation-class graphics card. Note that the graphics card *itself* should have a minimum of 128 MB of RAM for its operations.

Maximum RAM

There can never be enough RAM, and in the case of CAD/CAM and graphics, the minimum (using the same example) is 2 GB of RAM. When the minimum to run the software is 2 GB, you need much more than that for good performance.

Audio/Video-Editing Workstation

As I go over the requirements of these specialty solutions, you may notice a recurring theme: RAM, CPU, and graphics. It's no different with an audio- or video-editing machine. These are the components that are saddled with the workload and will be the ones that require boosting above what would be used on a standard workstation.

With audio and video editing, however, additional components can make the workstation more productive to the user. This section discusses those items.

Specialized Audio and Video Card

Many video- and audio-editing software packages come with a special capture card that works in concert with the accompanying software to provide ease of use. For example, it might be an internal PCI card that captures video from any analog or DV source. You can also output video to a VCR or an analog or DV camcorder from this card. They still require (you guessed it) a high-end audio and video card as well and plenty of memory and a processor that may not have quite the requirements of CAD/CAM but still should be 2.4 GHz or higher.

Large, Fast Hard Drive

Your hard drive should be at least 7,200 RPM. You will also want at least two drives if not three. When doing audio, use one for the operating system and programs and a second drive for audio files. When doing video, consider a third drive used exclusively for video files.

Even better, consider a RAID setup. Many motherboards include a SATA RAID controller built in. Use RAID 0 to enhance performance (see the section "RAID Types").

Dual Monitors

Especially when doing video editing, a second monitor is well worth the money and the desk real estate. You may need to read or refer to something on one screen while using the other for the editing software. The material could be tutorials or source material.

It also may be that you move your tools (for example, Photoshop tools) to one screen so they don't clutter the image you are working on.

Virtualization Workstation

A virtualization workstation is also called a *virtualization host*. The VMs that reside on this operating system are called *guest* operating systems. The host operating system and the guest must all share the total amount of RAM and CPU that the host machine possesses. This section discusses these issues.

Maximum RAM and CPU Cores

The amount of RAM that is required depends on the number of VMs that you anticipate operating at the same time, not how many exist on the desktop. Total the memory requirements of each VM that will be open at the same time, in addition to the requirements of the host operating system. That should be the minimum. Then add more for overhead to ensure performance.

The memory issue is not something you can fudge. If there is not enough memory, the VM will not start, and you will be notified with an error message that there is insufficient memory.

With regard to CPU, it should be dual- if not quad-core, and multiple CPUs would be even better.

Gaming PC

Gaming PCs may place the highest demands on the system of any specialty PC discussed here because the machines are in competition with other machines. The skill of the player is certainly a big factor in success, but at some point the user with the more powerful PC is going to be able to raise the level of the game through hardware.

Multicore Processor

When it comes to the processor, the question becomes "How much do you want to spend?" Just as a comparison (prices change daily!), for more than $600 you can get the Intel Core i7-3930K. (There is also the i7-3960X for $1,000.) Also keep in mind that multiple processors or multicore processors will always improve the gaming experience.

High-End Video/Specialized GPU

When playing a game, it is critical that the action you are seeing (and reacting to) is rendered to the screen as quickly as possible. With gaming machines, dual GPU cards are often used. The higher-end cards also require water cooling of GPUs. In fact, the faster cards all need water cooling (covered later in this section).

High-Definition Sound Card

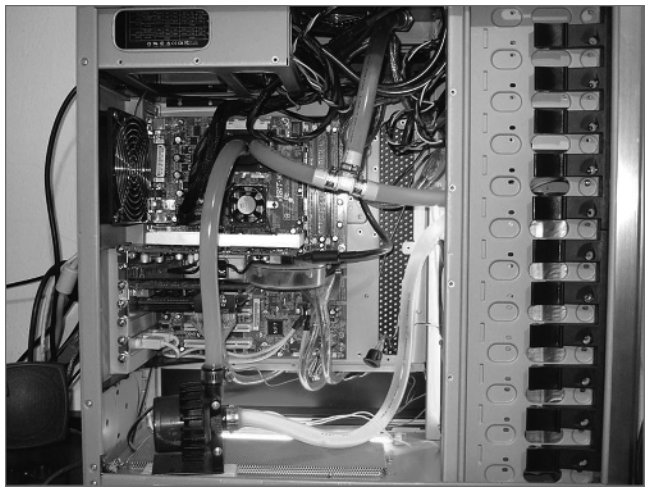
When you're considering the features of a sound card, you want those features to be performed in hardware. Anytime these functions are performed in software, it simply means the main CPU is going to get the workload. Also, you want to go with a high-definition card. The following are things to consider:

- Using the PCI Express slot (better bandwidth) is better than using the PCI slot.
- Make sure the card has its own onboard memory (less work for the main CPU).
- If you are using a Mac, a Thunderbolt card is the way to go.

High-End Cooling

With all the heat being generated by the CPUs and GPUs, fans may not be sufficient to remove the heat. Water-cooling systems will cool the system better and will be quieter as well. Cooling kits circulate water through the case in tubes that enter and exit the box to a unit where the water is cooled again (think of the cooling system in your car). Figure 1.53 shows a cooling system.

FIGURE 1.53 Cooling system



Home Theater PC

A home theater PC (HTPC) is a convergence device. It uses software to bring together video, photo, music playback, television content, and even video recording to a single computer interface. Many operating systems today include this software. To take advantage of its capabilities, however, additional components need to be in place. This section discusses some of the components that will enhance the experience.

Surround Sound Audio

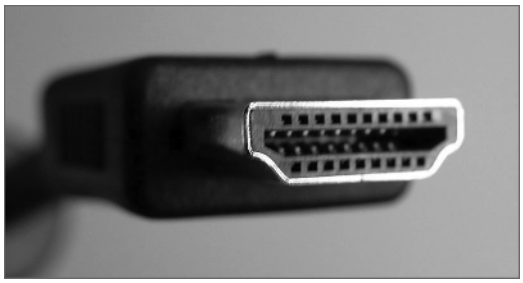
Surround sound speaker systems can add to the experience of the home theater PC. A numbering system has been developed that indicates the number and type of speakers present. The common setups are 2.1, 4.1, 5.1, 6.1, and 7.1. The number on the left is the total number of speakers, and the number on the right is the number of subwoofers (bass).

Don't forget, you will need places to plug these speakers into the system. So, a new card with additional plugs may be called for, or a new-generation external sound processor that can plug into the USB slot may be the solution.

HDMI Output

In some cases, you want to direct the content from your PC to a more suitable viewing device such as your big-screen TV. That is best accomplished with an HDMI plug from the PC to the TV. If the PC does not have multiple outlets for video, you may need to get a graphics card that provides these outlets. If you do that, make sure the card has an HDMI plug. If you are lucky, there will be one of these plugs present on the PC. Figure 1.54 shows an HDMI plug.

FIGURE 1.54 HDMI plug



HTPC Compact Form Factor

An HTPC that appears in the small form factor is one that is smaller in size and shape when compared to a regular PC while still providing the capabilities required. In some cases, they are cubical in shape, and in other cases they resemble a DVR or mini audio receiver. Other changes to the layout include placing all ports in the front. Figure 1.55 shows an example.

FIGURE 1.55 Compact form factor



TV Tuner

If you want to receive TV signals on the HTPC, you will need a TV tuner card. These can be installed internally in a slot, or they can be external units connected with the USB port. They also can be analog, digital, or both (although broadcast analog TV has been discontinued in the United States since 2009). If recording the TV content is required, the card must also be a video capture card.

In cases where it is desired to watch one stream of content while recording another stream, a card that has two tuners in it must be used. These are called *combo tuners*.

Standard Thick Client

When discussing thin and thick clients, you should understand that a thick client is a PC that has all the capabilities of a standard PC. It runs all applications locally from its own hard drive. A thin client (discussed in the next section) is one that has minimal capabilities and runs the applications (and perhaps even the operating system itself) from a remote server.

Desktop Applications

A thick client has the applications installed locally and will need to have sufficient resources to support the applications. Applications state these requirements in the documentation. With a thick client, since all application support will come from the local machine, these requirements must be met to use the software.

Meets Recommended Requirements for Selected Operating System

A standard thick client will need to provide all the hardware requirements of the installed operating system. This is because unlike the thin client (discussed in the next section) none of the processing will be offloaded to a server. It all must be supplied by the thick client. Requirements for various operating systems are covered in Chapter 5, "Windows Operating Systems," and Chapter 6, "Other Operating Systems and Technologies."

Thin Client

A thin client is a PC with minimal resources. Such a system is responsible only for receiving the processed output of an operating system and application running on a server and rendering the output in the screen.

The latest example of this is a computer running the Windows Thin PC (WinTPC) operating system, which is designed to run on older hardware.

Basic Applications

Some applications are created to function in a client-server architecture. When these are used in a thin client, the client side of the application operates on the thin client but requires minimal system resources. The server side of the application performs all the processing, and the client side simply renders the output to the display and transmits keystrokes to the server.

Meets Minimum Requirements for Selected Operating System

Even thin client operating systems have minimum requirements. Follow the documented requirements to ensure good performance. In many cases, older computers that are of no use because thick clients are suitable candidates to be thin clients.

Network Connectivity

Most traditional thin clients come with a NIC built in. They require the same settings that any networked device does, including IP address, subnet mask, and default gateway. These can be static configuration, or the device can receive these through DHCP.

Home Server PC

Many homes and small offices have a network of computers to rival a small enterprise. In these cases, sometimes it makes sense to centralize the location of resources for both ease of use and security of information. There are even home server operating systems made, but that is not required to make a PC a home server. This section discusses some common roles of a home server.

Media Streaming

The home server can act as a streaming media server to other computers in the home network if the operating system provides this capability. An example of such an operating system is Windows Home Server. Once the streaming feature is enabled, other systems can use their Windows Media Players to connect to any shared content and stream that content to the other PC. One of the benefits of this is centralized storage of the content and reduced duplication of the content on other machines in the network. This type of server should have plenty of disk space and memory.

File Sharing

For the same reasons that centralized storage of media content reduces content duplication in the network, so can file sharing from a home server. Another great benefit of this is a central location to perform regular backups of the files so that this does not need to be done on all the other machines in the network. This server should have plenty of disk space.

Print Sharing

Centralized control of printing can also be done with a home server. The machine can be the print server for all home printers. When done this way, printer permissions can be used to control who does what to the printers as well as whose print jobs get priority in a crunch. Print servers needs extra memory.

Gigabit NIC

When a machine is acting as the home server for all these functions, the network card will be busy. For that reason, it is probably a good idea to ensure that it is a Gigabit NIC, which allows it to operate 10 times faster than the standard 100 MB NIC. Make sure that the cabling supports 1 GB, or you will be wasting your time and money.

RAID Array

To speed the access to data or to provide fault tolerance to any data stored on the home server, consider using multiple hard drives and implementing a RAID 0, RAID 1, or RAID 5 hard disk system. See the section “RAID Types.”

Exam Essentials

Describe the specific requirements of specialty workstations. These include but are not limited to graphic, CAD, CAM, audio/video editing, virtualization, gaming, home theater, and home server systems.

Identify the difference between a thick and a thin client. A thick client runs the operating system and applications from the local hard drive, whereas a thin client runs these components from a remote server.

1.10 Compare and Contrast Types of Display Devices and Their Features

The possibilities for displaying the content from a PC used to consist of two options, cathode ray tube (CRT) technology found in television sets or the liquid crystal display (LCD) technology found on all laptop, notebook, and palmtop computers. That is no longer the case. Now this output can be directed to a number of different devices employing several technologies. This section discusses these options. The topics addressed in objective 1.10 include the following:

- Types
- Refresh/frames rate
- Resolution
- Native resolution
- Brightness/lumens
- Analog vs. digital
- Privacy/antiglare filters
- Multiple displays
- Aspect ratios

Types

Today, users need to redirect the content from the PC to other devices besides the regular monitor. Even within the monitor category, various technologies are employed to present content to a user from a computer device. This section discusses devices to which computer content may be directed, along with competing technologies for rendering the content.

LCD

LCDs have almost completely replaced CRTs as the default display type for both laptops and desktops. Two major types of LCDs are used today: active matrix screens and passive matrix screens. Their main differences lie in the quality of the image. Both types use some kind of lighting behind the LCD panel to make the screen easier to view. One or more small fluorescent tubes are used to backlight the screen.

Passive Matrix A passive matrix screen uses a row of transistors across the top of the screen and a column of them down the side. It sends pulses to each pixel at the intersection of each row and column combination, telling it what to display. Passive matrix displays are becoming obsolete because they're less bright and have poorer refresh rates and image quality than active matrix displays. However, they use less power than active matrix displays do.

Active Matrix An active matrix screen uses a separate transistor for each individual pixel in the display, resulting in higher refresh rates and brighter display quality. These screens use more power, however, because of the increased number of transistors that must be powered. Almost all notebook PCs today use active matrix. A variant called thin-film transistor (TFT) uses multiple transistors per pixel, resulting in even better display quality.

TN vs. IPS

There are two major LCD technologies used in LCDs. This section discusses the pros and cons of each.

Twisted Nematic (TN) Twisted nematic (TN) is the older of the two major technologies for flat-panel displays. While it provides the shortest response time, high brightness, and draws less power than competing technologies, it suffers from poor quality when viewed from wide angles. It suffers color distortions when viewed from above or from the sides.

In-Plane Switching (IPS) This is a newer technology that solves the issue of poor quality at angles other than straight on. It also provides better color quality. However, it has much slower response time and is more expensive. Newer versions like Super-IPS (SIPS) make improvements on the response time.

Fluorescent vs. LED Backlighting

LCDs can use two kinds of backlighting: LED-based and fluorescent. Fluorescent is an older technology and consists of a fluorescent tube connected to a voltage inverter board that provides power to the backlight. LED-based is a newer technology and uses a matrix of LEDs for the backlighting. Table 1.9 compares the two technologies.

TABLE 1.9 Fluorescent and LED

Characteristic	Fluorescent	LED
Size	Thicker and heavier	Thinner and lighter
Cost	Cheaper	More expensive
Power	High power consumption and heat generation	Lower power consumption and heat generation
Brightness	Lower	Higher
Lifespan	Shorter	Longer

LED

LED-based monitors are still LCDs (they still use liquid crystals to express images onscreen), but they use a different type of backlight than what is normally used. Several types of backlights are used with LED.

The most common for computers is white LEDs (WLEDs). Using a special diffuser, the light is spread to cover the entire screen. A more expensive type is RGB LED. Instead of using WLEDs on one edge of the screen, with RGB LCD layers, like the previous technology, RGB LEDs are aligned all over the panel matrix. Each LED is capable of red-, green-, or blue-colored light. This gives the display more accurate color than WLEDs. Finally, there is WLED on a flat array, covering the entire screen (like an RGB LED using only WLEDs). Currently, it's used only in LED-backlit HDTVs. As you've seen, however, computer output can be directed to the HDTV screen.

Plasma

Plasma displays utilize small cells containing ionized gases, similar to what is used in fluorescent lamps. They have the advantage of high-quality picture, wider viewing angles, and less motion blur—but they have the disadvantage of screen burn-in and high energy requirements.

They have mainly been used for TV displays but now can be purchased simply as display monitors that accept output from a variety of devices, including PCs.

Projector

In the business world, it is frequently necessary to share the desktop with others in a meeting. This is easily accomplished by directing the output of the PC to a projector. The projector can be plugged into the same connector as the monitor, and in most cases both can be used at the same time. Some projectors require an HDMI connector.

OLED

Organic light-emitting diode (OLED) technology uses a layer of organic compound with emissive electroluminescent qualities to emit light in response to an electric current. This organic layer resides between two electrodes. Although it uses no backlight, it results in a higher-contrast ratio than an LCD in low-light conditions.

This technology is currently expensive, and the materials used have a limited life span. As of this writing, 17-inch models with LED technology run close to $5,000.

Refresh/Frame Rate

A monitor's refresh rate specifies how many times in one second the scanning beam of electrons redraws the screen. The phosphors stay bright for only a fraction of a second, so they must constantly be hit with electrons to stay lit. Given in draws per second, or hertz (Hz), the refresh rate affects how much energy is being put into keeping the screen lit. Most people notice a flicker in the display at refresh rates of 75 Hz or lower because the phosphors begin to decay to black before they're revived; increasing the refresh rate can help reduce eyestrain by reducing the flickering. CRTs experienced a refresh flicker that was often visible to the naked eye. This is no longer a problem with newer LCD monitors.

The frame rate, or frame frequency, is the frequency at which an imaging device produces unique consecutive images called *frames*. It is a description of the number of frames per second that the card writes to the buffer, while the refresh rate refers to how often the screen is drawn from the data coming from the buffer. That means the refresh rate depends on the display, and the frame rate depends on the application writing data to the buffer.

If the application writes data at a rate faster than the display can refresh, then some visual data will be lost because screen buffer updates will be overwritten by the application before the display refresh occurs. This results in what is typically called screen *tearing*.

Resolution

The resolution of a monitor is the number of horizontal and vertical pixels that are displayed. Most monitors allow for two or more resolutions, and you can pick the one to use in the desktop settings of the operating system. On a CRT, the vertical hold (V-hold) setting can be tweaked to make the image appear properly in the monitor.

Display resolutions include the following:

VGA Video graphics array is a 320×200 resolution and uses analog technology.

XGA Extended graphics array has been around since 1990. It's a 1,024×768 resolution that offers fixed-function hardware acceleration for 2D tasks.

SXGA+ Super extended graphics array is a 1,400×1,050 resolution commonly used on 14- or 15-inch laptops. It's typically considered the maximum resolution that video projectors will work with.

UXGA Ultra-extended graphics array is a 1,600×1,200 resolution and is the next step in the monitor-resolution evolution.

WUXGA Widescreen ultra-extended graphics array is a resolution of 1,920×1,200 with a 16:10 screen aspect ratio. It's also a standard for use with television sets, at a slightly different ratio.

Native Resolution

The native resolution of a display refers to its single fixed resolution. An LCD cannot change resolution to match the signal being displayed like a CRT monitor can, meaning that optimal display quality can be reached only when the signal input matches the native resolution. Most LCD monitors are able to inform the PC of their native resolution.

Brightness/Lumens

Contrast ratio is a measurement of the brightness of the LCD panels. A general rule of thumb is the greater the contrast ratio, the brighter the display can be, and thus a rating of 3,000:1 is preferred over 800:1.

You can adjust the brightness by using the controls that are usually found on the front of the monitor, but keep in mind that these adjustments will be less refined than if you use a calibration program. Standard symbols are used to represent brightness; the location

and operation of these controls vary from monitor to monitor. Use the documentation that came with your monitor.

Analog vs. Digital

As described in the section "VGA vs. HDMI," VGA connections and cables are analog in nature, and HDMI and DVI are interfaces for transmitting encrypted uncompressed digital data.

CRT monitors require the signal information in analog. In those cases, the video adaptor converts digital data into analog. DVI and HDMI maintain the information in digital format through the process with no need for conversion. Some DVI connectors will support both analog and digital.

Privacy/Antiglare Filters

Privacy and antiglare filters fit over the front of a display screen and either reduce the glare on the screen or, in the case of privacy filters, make it difficult if not impossible to read the monitor unless you are squarely in front of it, which helps to reduce eavesdropping or shoulder surfing. In situations where high-security information will be displayed on the desktop, a privacy filter may be called for. When the workstation is facing sunlight, an antiglare filter may be beneficial.

Multiple Displays

Most PCs allow you to use multiple monitors as long as there is a display card installed for each. Although this can be useful for running a window for each monitor, one of the most common uses is the Presenter View in Microsoft PowerPoint. When chosen, this allows a different view of the slideshow to be shown on the main monitor (typically a projector) than what is shown on the secondary monitor (such as presenter notes, the next slide that is set to appear, and so forth). Multiple displays can present the same desktop on both displays (mirroring) or can be set up as a large single desktop, which is called extending the desktop. Multiple displays are beneficial in any cases where many windows or documents need to open at the same time, especially if copying and pasting may be called for between the windows.

Aspect Ratios

Aspect ratio describes the proportional relationship between its width and its height and is usually expressed as a ratio such as 16:9, where the first value is the width and the second is the length. Keep in mind the values are not inches or centimeters or any other absolute value, but describe the proportional relationship between the two. Three standard aspect ratios are discussed here:

4:3 At one time most monitors had a 4:3 aspect ratio. This continued until about 2006.

16:10 Starting about 2006, the 16:10 aspect ratio began to replace the 4:3 aspect ratio, as the use of "square" monitors began to decline.

16:9 In about 2008, this ratio, sometimes referred to as *sixteen-nine* began to replace both 16:10 and 4:3. By 2010, virtually all manufacturers had moved to 16:9.

Exam Essentials

Identify the common technologies used on devices that display computer output. These include but are not limited to LCD, LED, plasma, and OLED displays. Projectors are included as well.

Describe the settings and characteristics of various display types. Understand refresh rate, resolution, native resolution, and brightness.

Describe the differences between analog and digital display. The video adaptor converts digital data into analog. DVI and HDMI maintain the information in digital format through the process with no need for conversion.

1.11 Identify Common PC Connector Types and Associated Cables

A wide variety of connector types and cables are used to hook together the parts and pieces of a PC system. This section briefly reviews the connectors and cables that have been covered and discusses others for the first time. The topics addressed in objective 1.11 include the following:

- Display connector types
- Display cable types
- Device cables and connectors
- Adaptors and converters

Display Connector Types

Connecting the monitor to the PC can be accomplished with many different connector types. In this section, for those types that have been covered earlier, I'll provide a reference to the section discussing them.

DVI-D

DVI connectors can come in several forms. You may remember that DVI can sometimes do analog and digital at the same time. DVI-D (the *D* stands for digital) connectors supply digital signals only. These can also come in a single- or dual-link format. A dual-link format allows for a second data link.

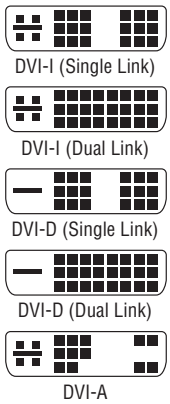
DVI-I

A DVI-I connector (the *I* stands for integrated) has pins that can provide analog and digital. These can also come in a single- or dual-link format.

DVI-A

A DVI-A connector (the *A* stands for analog) has pins that can provide analog and digital. This type comes in a single-link format only. Figure 1.56 shows the various types of DVI plugs discussed in this section.

FIGURE 1.56 DVI connectors



DisplayPort

DisplayPort is a digital interface standard produced by the Video Electronics Standards Association (VESA), used for audio and video. The interface is primarily used to connect a video source to a display device such as a computer monitor or television set. It resembles a USB connector (see Figure 1.57).

FIGURE 1.57 DisplayPort



RCA

RCA plugs are sometimes used for audio and video in the same way that mini-TRS connectors are (see the "Audio" section under "Other Connector Types"). They are nearly the same size but look quite different. Figure 1.58 shows a set of these connectors.

FIGURE 1.58 RCA plugs



HD-15 (Examples: DE-15 or DB-15)

The DB-15 plug is the standard VGA plug that has been around since the earliest displays. It was discussed in the section "Serial" under "Other Connector Types." Figure 1.59 shows an example.

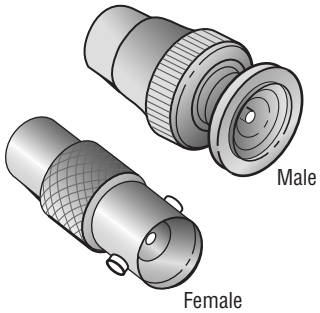
FIGURE 1.59 DB-15



BNC

Bayonet Neill–Concelman (BNC) connectors are sometimes used in the place of RCA connectors for video electronics, so you may encounter these connectors, especially when video equipment connects to a PC. In many cases, you may be required to purchase an adaptor to convert this to another form of connection because it is rare to find one on the PC. Figure 1.60 shows male and female BNC connectors.

FIGURE 1.60 BNC



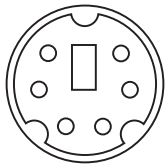
miniHDMI

The miniHDMI is a small form-factor version of HDMI. It is intended for portable devices such as a camcorder. Cables that are made to connect a portable device to a PC will have a miniHDMI connector on one end and a standard HDMI (type A) connector on the other. A miniHDMI connector (type C) was shown in Figure 1.43.

miniDIN-6

MiniDIN connectors come with a number of different pin arrangements and are used in various applications. A six-pin version, miniDIN-6, is used to connect to some projectors and speaker systems. When connecting those devices to the PC, you may encounter this plug. As with the BNC connector, it may require a converter to a connection type that exists on the PC, such as USB. Figure 1.61 shows a six-pin miniDIN.

FIGURE 1.61 Six-pin miniDIN



Display Cable Types

Cables must match the connector. This section provides a quick survey of the cables that go with the various connectors.

HDMI HDMI cables are rated by the resolution they can provide. Category 2 (also called *high speed*) provides better resolution than Category 1. These also differ in acceptable length. Category 1 is best at 5 meters, whereas Category 2 can be up to 15 meters.

DVI When purchasing DVI cables, you should make note of the connector type that exists on the PC. The cable connector must be the same type as the PC. Review the section "Display Connector Types."

VGA VGA cables are quite common and come in lengths up to 50 feet. They have an HD-15 (or DB-15a) female connector on one end and a DB-15 male connector on the other.

Component Component video is a video signal that has been split into two or more component channels. It is transmitted or stored as three separate signals. There will typically be three color-coded plugs on the cable that connect to the same color plug on the PC or the video device.

Composite Composite video combines the signal into one line-level signal, so there is one plug on the connector, usually an RCA plug.

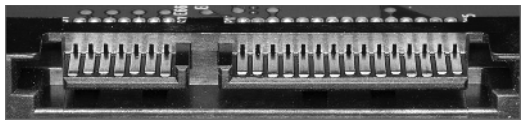
Coaxial When BNC cables are used, the cable type will be coaxial. See the BNC section in "Display Connector Types."

Device Cables and Connectors

As with display connectors, there are a wide variety of connector and cable types for the other devices in the PC. This includes internal devices as well as peripherals. In this section, the most common connectors are discussed along with the pin-outs. In many cases, the number of pins and their arrangement is the only way to differentiate two connector types with common form factors. In cases where the connector has been discussed, a reference is provided to the section where the connector was discussed. Following that section is one on cable types.

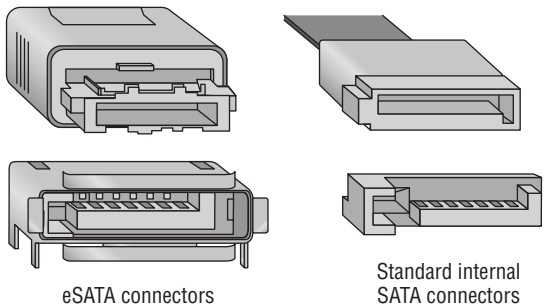
SATA Internal SATA storage devices have a 7-pin data connection and a 15-pin power connection. Those connections sit next to one another on the SATA device, as shown in Figure 1.62.

FIGURE 1.62 SATA connections



eSATA External SATA devices use receptacles rarely found in PCs as of this writing. An eight-pin eSATA connector is shown next to an internal SATA connector in Figure 1.63.

FIGURE 1.63 eSATA connections

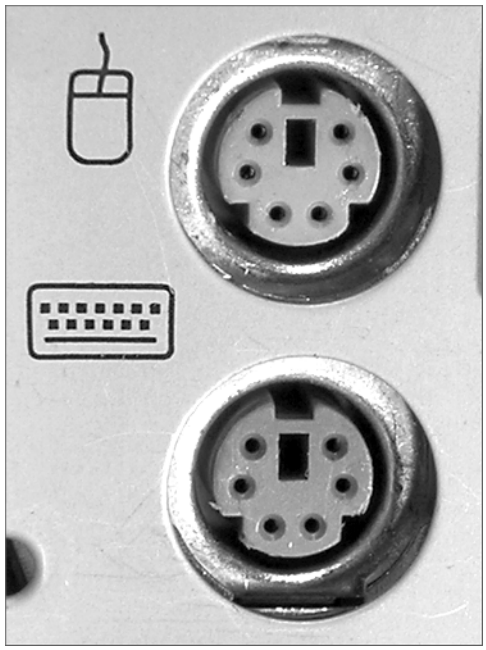


USB USB connectors were discussed in the section "Front-Panel Connectors."

FireWire (IEEE 1394) IEEE 1394 (FireWire) was discussed in the section "FireWire Cards," and the connectors on the PC were shown in Figure 1.38.

PS/2 Though rarely used anymore, some PCs may still have a PS/2 connector for the mouse and the keyboard. These have been replaced for the most part with USB mice and keyboards. Figure 1.64 shows the PS/2 connectors.

FIGURE 1.64 PS/2



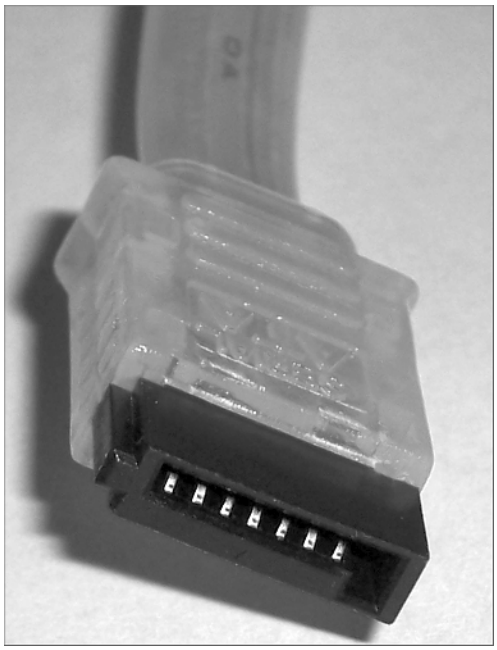
Audio TRS audio connectors were discussed in the section "Audio" and shown in Figure 1.45. RCA connectors were covered in the section "RCA" and shown in Figure 1.58.

Device Cable Types

Cables must match the connector. This section provides a quick survey of the cables that go with the various connectors.

SATA Internal SATA storage devices have 7-pin data cables and a 15-pin power cable. Figure 1.65 shows a SATA data cable.

FIGURE 1.65 SATA data cable



eSATA eSATA cables may be either flat or round and can be only 2 meters in length. An eSATA connector was shown in Figure 1.63.

USB USB cables were discussed in the section "USB 1.1 vs. 2.0 vs. 3.0," and the micro and mini versions were displayed in Figure 1.37.

IEEE 1394 IEEE 1394 (FireWire) was discussed in the section "FireWire 400 vs. FireWire 800." The cables look very much like USB cables.

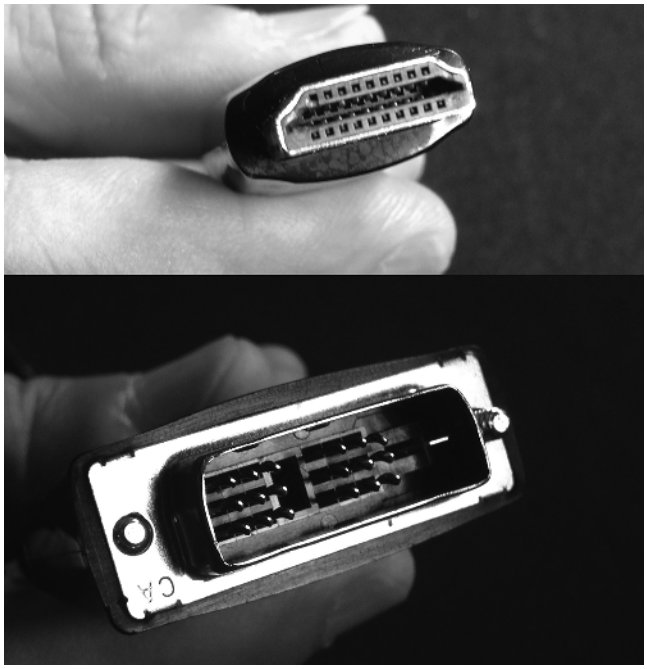
Adaptors and Converters

In many cases, you will need to attach a device to a computer on which the correct connectors is not present. In these cases, there are adaptors (converters) and connectors that can be used to connect the device to a connector type for which it was not designed. In this section, you'll look at some of the more common of these.

DVI to HDMI

These adaptors connect from HDMI to DVI and come in a number of gender combinations (male DVI to female HDMI, male DVI to male HDMI, female DVI to male HDMI, and so on) and as either a cable or simply an inline connector. Figure 1.66 shows an inline connector.

FIGURE 1.66 HDMI to DVI



USB A to USB B

These adaptors will connect the A end of a USB connection to the B end of a USB cable. Figure 1.67 shows an example of one of these inline converters.

FIGURE 1.67 USB A to USB B



USB to Ethernet

These converters allow you to use a USB port as a network interface. They come both as cables and as inline connectors. Figure 1.68 shows an example of a USB to Ethernet adaptor.

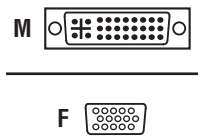
FIGURE 1.68 USB to Ethernet



DVI to VGA

In cases where you need to convert DVI to VGA, you can use a DVI to VGA adaptor. These come as a cable or inline connectors and also come in a variety of gender combinations. Figure 1.69 shows an example of the ends of this adaptor.

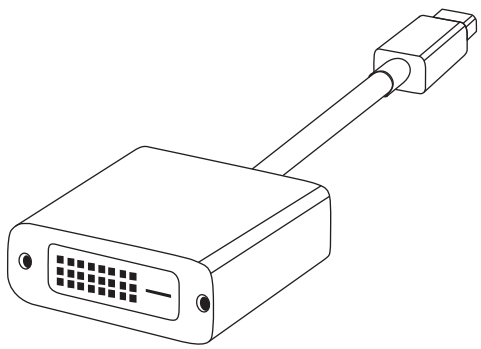
FIGURE 1.69 DVI to VGA



Thunderbolt to DVI

The Thunderbolt connector is typically found only in Apple products, but if you need to connect from a Thunderbolt interface to a DVI, this adaptor is what you need. Figure 1.70 shows an inline connector.

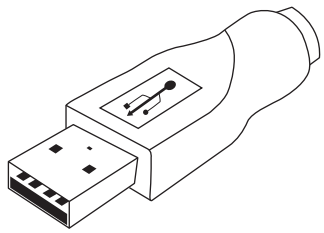
FIGURE 1.70 Thunderbolt to DVI



PS/2 to USB

There aren't too many computers still in use that have a PS/2 connector for the keyboard and mouse, but if the need arises (or if you have an old PS/2 keyboard or mouse that you need to connect to a USB port), these adaptors are what you need. They come in versions that will solve either connectivity issue. Figure 1.71 shows a version that connects a PS/2 keyboard into a USB port.

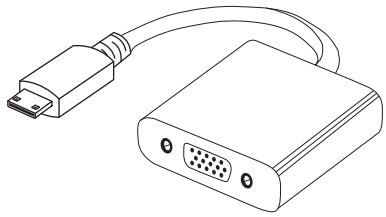
FIGURE 1.71 PS/2 to USB



HDMI to VGA

Another quite common need is to adapt HDMI to VGA. The one pictured in Figure 1.72 connects an HDMI-compatible device to a monitor or projector with a VGA port.

FIGURE 1.72 HDMI to VGA



Exam Essentials

Identify display connectors, their associated cables, and the maximum cable lengths. This includes but is not limited to DVI in all variants, DisplayPort, RCA, HD-15 (or DB-15), BNC, miniHDMI, and miniDIN-6.

Identify other device connectors, their associated cables, and the maximum cable lengths. This includes but is not limited to SATA, eSATA, USB, IEEE 1394, PS/2, and audio.

1.12 Install and Configure Common Peripheral Devices

Installing devices is much easier today than it was at one time. In most cases, the device is detected and set up for you by the operating system as soon as you plug it in. This section discusses any deviations from that along with any special issues related to a particular device type. The topics addressed in objective 1.12 include the following:

- Input devices
- Output devices
- Input and output devices

Input Devices

Input devices allow you to communicate with the PC either by clicking an item or by using the keyboard. This category also includes devices that allow you to import information into the system in other ways. This section discusses the installation of each device.

Mouse

Mice are typically USB devices these days and require you only to plug them in; in moments they are functional. In some rare cases (especially for a mouse with special capabilities), you may need to install a driver for the mouse. These types typically have a CD you can access that will install those drivers for you.

Keyboard

Keyboards can be treated the same as mice. Follow the guidelines in the section on mice.

Scanner

Scanners are used to convert paper documents or photographs to digital files so they can be stored on a PC and transmitted as files across the network. The installation process is much like a print device. Because so many of these now are USB, plugging them in will install the driver. In cases where that does not work (usually when it is a new model and the operating system is older), use the installation disc to install the driver.

Barcode Reader

Barcode readers read and input codes used to identify products. They are used in warehouses and at retail checkouts. Once you plug the device into either the serial or the USB connector, you need to install the software that comes with the reader. Use the installation disc that comes with the reader.

Microphone

Microphones are simple to install. Typically, all you do is plug them into the mini-TRS connector. There are usually two of these: one for headphones (or speakers) and the other for a microphone (or line in). In some systems, you may be prompted to specify the mic or line in when you plug in a headset. A 3.5-mm plug was shown in Figure 1.45.

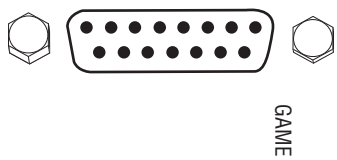
Biometric Devices

Biometric devices allow for inputting information used to authenticate or identify a user to the system. That input may be a retina scan or a fingerprint, for example. Use the installation disc that comes with the device. In most cases, you should install the software before you plug in the device (usually USB). During the installation process of the software, at some point you will be told to connect the device. Follow the instructions.

Game Pads

You may begin to notice a pattern. Game pads are also usually USB and install in the same way as biometric devices and barcode readers. Install the software and connect the device when instructed. One additional thing you may need to do with the game pad is to calibrate it. Once it's installed, locate the device in Control Panel in the correct section (usually Game Controllers), open the properties of the device, and click the option Calibrate. Follow the instructions. This will make it operate correctly. Some game pads require a DB-15 serial port, as shown in Figure 1.73.

FIGURE 1.73 DB-15 game port



Joysticks

Joysticks use the same guidelines and instructions as game pads and usually the same connectors.

Digitizer

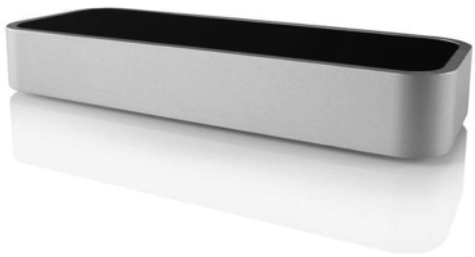
Digitizers are pad-like devices that allow you to write and draw on the pad and input that to a digital file. Treat the installation of these devices in the same way as the other devices in this section. Install the software first and connect the digitizer when instructed to do so.

Motion Sensor

Motion sensors can be used to allow control of the computer using hand gestures. It allows you to control an operating system with your hands and fingers and never touch a mouse or keyboard. It also can be used in PC gaming when developers integrate these controls in

their games as they build them. Figure 1.74 shows a USB-based motion sensor. The device is a small rectangular cube that you plug into your computer via the USB drive. To install these, you simply connect them and if the operating system does not have the drivers, provide these drivers during installation.

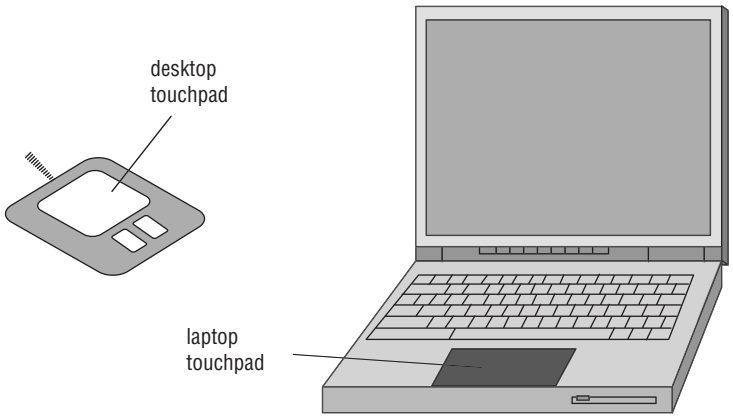
FIGURE 1.74 Motion sensor



Touchpads

While touchpads come on laptops, you can also buy add-on touchpads. These allow you to perform basic mouse functions on the device. In most cases, they use a USB connector. To install them, you simply connect them and if the operating system does not have the drivers, provide these drivers during installation. Figure 1.75 shows an external touchpad and a laptop.

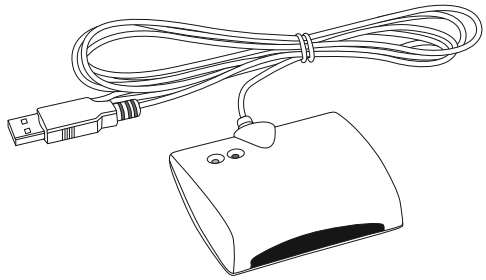
FIGURE 1.75 Touchpads



Smart Card Readers

Smart card readers are used to accept input from a smart card, which is a credit card–sized piece of plastic that can be used to input credentials securely. They are small and usually USB based, as shown in Figure 1.76. To install them, you simply connect them and if the operating system does not have the drivers, provide these drivers during installation.

FIGURE 1.76 Smart card reader



Digital Cameras

Digital cameras usually connect to the PC with a USB cable. In many cases, the operating system comes with software that may detect the camera and assist you in accessing the pictures and moving them to the computer. In other instances, you may want to install software that came with the camera. Doing so will often allow you to take fuller advantage of the features the camera offers. SD cards can be used to transfer images from the camera if a cable is not available.

Microphone

Follow the instructions in the earlier section "Input Devices." In some cases, the connector on the microphone may not be one that is present on the PC. You may be able to purchase a converter to match the input on the PC.

Webcam

First install the software that came with the webcam (sound familiar?) and then connect the webcam to the USB port when instructed. If the webcam has been out for some time and the operating system is new, it may be possible to just plug in the camera and let the operating system set it up.

Camcorder

Treat camcorders like cameras for the purpose of installation. If the camcorder is an older analog model, you will need to install a signal digitizer. If you have a TV tuner card present, it can perform the conversion.

MIDI-Enabled Devices

Musical Instrument Digital Interface (MIDI) is an industry specification for encoding, storing, synchronizing, and transmitting musical performance information, basically allowing you to digitally record a musical instrument.

The MIDI controller (usually an instrumental keyboard) connects to the PC using MIDI cables, which use a five-pin DIN connector. Since most computers don't have these, you may need to buy a MIDI-to-USB converter cable. Some specialized sound cards come with a MIDI port.

To use the controller, you install the software and then connect the MIDI device. The software will install the driver for the device. Once that is taken care of, install the recording software of choice. If the installation of the device went correctly, the recording software should recognize the MIDI controller and allow you to record from it.

Output Devices

Output devices allow you to print, listen to, or view information from the PC. The installation of these devices is remarkably like that of input devices.

Printers

Printers and their installation are covered in the "Compare and Contrast Differences Between the Various Print Technologies and the Associated Imaging Process" section later in this chapter.

Speakers

Installing speakers is more a matter of connecting them properly than installing them. Usually, one of the speakers will connect to a power source and the other will connect to the powered speaker. Once they are connected to a power source, connect the speaker cable to the proper plug in the PC. These plugs will be marked with icons that indicate which is for a microphone and which is for speakers.

Display Devices

Before connecting or disconnecting a monitor, ensure that the power to both the PC and the monitor is off. Then, connect a VGA (DB-15) cable from the monitor to the PC's video card, and connect the monitor's power cord to an AC outlet. If a better connection is available (DVI, for example), use it.

Input and Output Devices

There are also several dual-purpose input/output devices.

Touchscreen

Touchscreen monitors allow you to interact with the screen instead of using the mouse. These monitors may require installing a driver to function. Use the CD that comes with the device to install the driver. Touchscreens also require calibration. Most vendors include calibration software with the installation disc.

KVM

A keyboard, video, and mouse (KVM) device allows you to plug multiple PCs (usually servers) into the device and to switch easily back and forth from system to system using

the same mouse, monitor, and keyboard. The KVM is actually a switch that all the systems plug into. There is usually no software to install. Just turn off all the systems, plug them all into the switch, and turn them back on; then you can switch from one to another using the same keyboard, monitor, and mouse device connected to the KVM switch.

Smart TV

A smart TV is one with integrated Internet and Web 2.0 features. These devices can provide Internet TV (receiving a TV signal from an Internet connection), online interactive media, over-the-top content (content that arrives from a third party), as well as on-demand streaming media and home networking access. "Installing" a smart TV really consists of connecting it to the Internet, which can be done in several ways.

- Some devices have an Ethernet jack on the back of the TV, and you can use that option.
- Other devices have wireless capability, and you need to connect the smart TV to your home wireless network.
- Some will allow you to connect to the Internet though a gaming console.
- Finally, you can connect some to a computer or laptop that in turn has Internet access.

Set-Top Box

Another option for getting content to a TV is to use a set-top box. These are appliances that contain a TV-tuner input and display output to a television set or other display device. Some can accept input from multiple sources (cable, satellite, and so on). They are used in cable television, satellite television, and over-the-air television systems. The exact manner in which they are installed and the specific connectors they require to be on the TV vary, so it is important to determine beforehand if the set-top box can be used with the TV based on the connectors present on both devices.

Exam Essentials

Install input devices. These include the mouse, keyboard, scanner, barcode reader, biometric devices, game pads, joysticks, digitizer, motion sensor, touchpads, smart card readers, digital cameras, microphone, webcam, camcorder, and MIDI-enabled devices.

Install output devices. These include printers, speakers, and display devices. Take appropriate precautions if encountering an LCD.

Install devices that are both input and output. These include but are not limited to touchscreen devices, KVMs, smart TVs, and set-top boxes.

1.13 Install SOHO Multifunction Devices/ Printers and Configure Appropriate Settings

Printers are one of the most common elements in any computing environment, from home to office. The range they cover is phenomenal—everything from a free printer included by a vendor with the purchase of a PC up to a monolith in a large office churning out hundreds of pages a minute. Regardless of where a printer falls in that spectrum, they are all the same in that they must be installed and properly configured to be of use. Moreover, most printing devices today are multifunction devices. They print, scan, and fax in various combinations.

The topics addressed in objective 1.13 include the following:

- Using appropriate drivers for a given operating system
- Configuration settings
- Device sharing
- Integrated print server (hardware)
- Cloud printing/remote printing
- Public/shared devices

Printing Components

Printing components are not a topic of objective 1.13, but they are something that will be helpful for you to understand in the real world. In addition to the physical body of the printer, components and consumables are associated with it. Components include the following:

Memory As a general rule, the more memory a laser printer has, the better. The memory is used to hold the print jobs in the printer queue; the more users and the larger the print jobs, the more memory you'll want. Dot-matrix and inkjet printers contain little memory, the former using only a buffer to hold a few characters.

Drivers These are the software components of the printer—allowing the device to communicate with the operating system. It's important to always have the correct and most current drivers for the greatest efficiency. The printer drivers vary based on the operating system being used on the client computer, and if a printer is attached to more than one operating system, you have to make sure you have the appropriate driver for each operating system in use.

Firmware Although drivers can be updated, firmware rarely is. Firmware is installed on the printer and can be thought of as the operating system for that device.

Consumables for printers are those items you must change as you use the printer—the variable items that get consumed and must be replenished. These include toner (or ink, depending on the type of printer you're using) and paper. Be sure to always order and use the correct grade of consumables that are recommended for your machine. For example, don't use inkjet media in a laser printer or you will run the risk of the laser printer's fuser melting it.

Using Appropriate Drivers for a Given Operating System

Besides understanding the printer's operation, for the exam you need to understand how these devices talk to a computer. The driver software controls how the printer processes the print job. When you install a printer driver for the printer you are using, it allows the computer to print to that printer correctly (assuming you have the correct interface configured between the computer and printer). Also keep in mind that drivers are specific to the operating system, so you need to select the one that is both for the correct printer and for the correct operating system.

An interface is the collection of hardware and software that allows the device to communicate with a computer. Each printer, for example, has at least one interface, but some printers have several to make them more flexible in a multiplatform environment. If a printer has several interfaces, it can usually switch between them on the fly so that several computers can print at the same time.

Configuration Settings

You need to be familiar with the various settings that are available and what these settings do. This section covers the more common settings, features, and characteristics of printers.

Duplex An optional component that can be added to printers (usually laser but also inkjet) is a duplexer. This can be an optional assembly added to the printer, or built into it, but the sole purpose of duplexing is to turn the printed sheet over so it can be run back through the printer and allow printing on both sides.

Collate Collating is the process of arranging the output of a print job so that multiple individual sets of the output are in proper order. A collator is a unit that if present on the printer will allow the printer to collate.

Orientation The orientation of a document refers to how the printed matter is laid out on the page. In the landscape orientation, the printing is written across the paper turned on its long side, while in portrait the paper is turned up vertically and printed top to bottom.

Quality Print quality is a description of the look of the printing, its sharpness, and its color depth. It is impacted by the quality of the paper, the speed of the printing process, and the resolution settings. It can also be affected by the DPI setting. This setting controls the size of objects on the screen and therefore their quality. As you increase the size of an object, its quality will usually decrease a bit.

Device Sharing

Printer sharing covers the hardware technologies involved in getting the information to and from the computer. There are several types, which can be broken into two broad categories: wired and wireless.

Wired

The wired forms of connection this exam test on are USB, parallel, serial, and Ethernet. Each is addressed in the sections that follow.

USB The most popular type of printer interface as this book is being written is USB. It's the most popular interface for just about every peripheral. The benefits for printers are that it has a higher transfer rate than either serial or parallel and it automatically recognizes new devices. USB is also fully Plug and Play, and it allows several printers to be connected at once without adding ports or using up additional system resources.

Serial This is the traditional RS-232 serial port found on most PCs. The original printer interface on the earliest computers, it has fallen out of favor and is seldom used anymore for printing because it's so slow.

Ethernet Most large-environment printers (primarily laser and LED printers) have a special interface that allows them to be hooked directly to a network. These printers have a NIC and ROM-based software that let them communicate with networks, servers, and workstations.

Wireless

The wireless forms of connection included on this exam are Bluetooth, 802.11*x*, and Infrared (IR). Each is addressed in the sections that follow.

Bluetooth Bluetooth is an infrared technology that can connect a printer to a computer at a short range; its absolute maximum range is 100 meters (330 feet), and most devices are specified to work within 10 meters (33 feet). When printing with a Bluetooth-enabled device (like a PDA or mobile phone) and a Bluetooth-enabled printer, all you need to do is get within range of the device (that is, move closer), select the print driver from the device, and choose Print. The information is transmitted wirelessly through the air using radio waves and is received by the device.

802.11 (a, b, g, n, ac) A network-enabled printer that has a wireless adaptor can participate in a wireless Ethernet (IEEE 802.11b, a, g, n, or ac) network, just as it would as a wired network client.

Infrastructure vs. ad hoc The architecture of the wireless network may affect the way you set up a wireless printer. In ad hoc mode, all devices communicate directly in a peer-to-peer fashion. This means that each user who accesses the wireless printer will establish their own connection to the wireless printer, and they need to ensure they are in the same IP network with the printer as well as the same WLAN. In infrastructure mode, the wireless network is using an access point (AP), and all communication goes through the AP. In this case, the printer must be set up to automatically connect to the AP so it is on the same network as the wireless clients that need to use the printer.

Integrated Print Server (Hardware)

A print server is a popular option for adding a printer to the network and not adding a host computer. To be a print server, the NIC in the printer differs from a NIC in a computer in

that it has a processor on it to perform the management of the NIC interface and it is made by the same manufacturer as the printer.

To qualify as a print server, when someone on the network prints, the print job goes directly to the printer and not through any third-party device. This tends to make printing to that printer faster and more efficient—that NIC is dedicated to receiving print jobs and sending printer status to clients.

Cloud Printing/Remote Printing

While printing remotely to a printer over the Internet has been available for a number of years, cloud printing is a new service being offered by cloud vendors. In a cloud arrangement, you connect your printer to the vendor's cloud, and then the printer is available to you anywhere you can get Internet access, just as cloud-based resources are available anywhere you can get Internet access.

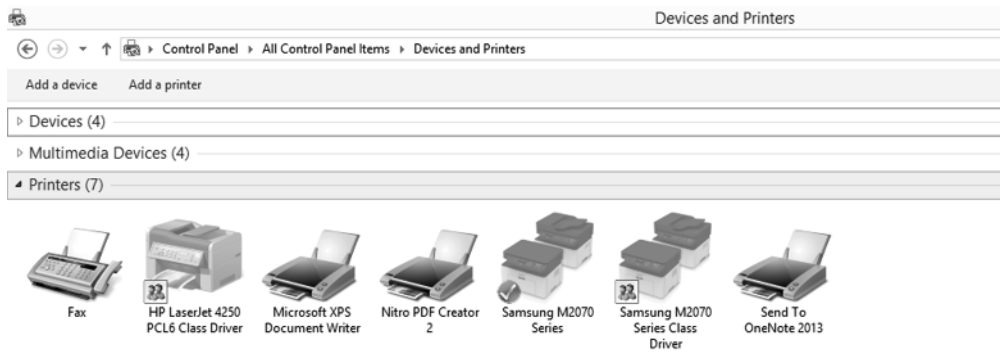
While not required, cloud vendors encourage the use of cloud-ready printers in this arrangement. These are printers that need no PC to connect to the Internet. It makes the process of connecting to the cloud print server much simpler.

Another option is to create a VPN connection to your home network. Once connected to the home network over the VPN, you should be able to connect to and print to the printer as if you were sitting in your home office.

Public/Shared Devices

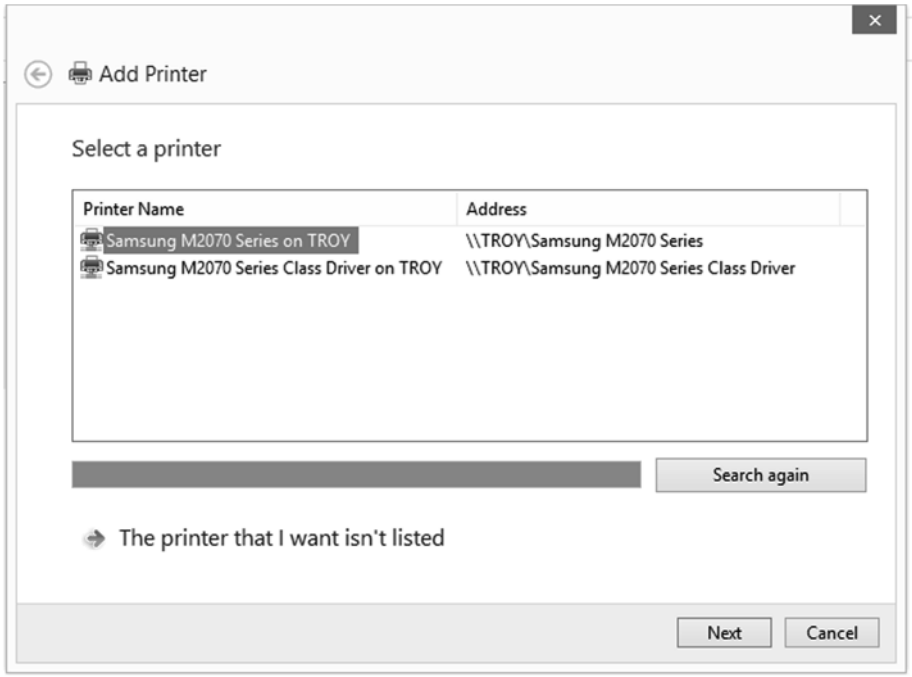
All operating systems allow you to share a local printer or connect over the network to one that has been shared. To connect to a printer in Windows 8.1, choose Start ➢ Control Panel ➢ Devices And Printers, and it will show the currently recognized printers (see Figure 1.77) and allow you to add new ones.

FIGURE 1.77 Devices And Printers



The image of a check box on the first instance of the Samsung M 2070 shows that it is the current default printer, and the image of two people on the second instance of the device means that it is shared. Clicking Add A Printer (at the top of the dialog box) starts the wizard shown in Figure 1.78.

FIGURE 1.78 Adding a printer



Sharing Local/Networked Device via Operating System Settings

To share a local/networked printer via the Windows operating systems, right-click the icon for the printer (beneath Devices And Printers or Printers And Faxes, depending on your operating system) and choose Printer Properties. Next, click the Sharing tab.

Select Share This Printer and provide a name that the printer will be known by on the network. This is the name that will appear when adding a new network printer on a client, and it can also be referenced by the entire qualified name using the syntax \\host\share_name.

TCP A TCP printer is one that is not shared by a computer but one that has its own network card and IP address. To share them, you must create a TCP port on the computer from which you would like to print that points to the IP address of the printer. Then when adding the printer, select the TCP port you created instead of selecting a local port (USB, and so on) like you would do if setting up a printer that is connected locally.

Bonjour Bonjour is an Apple technology that discovers devices on a network. It can also be used to facilitate the sharing of a printer in the network. While it can work with Windows, the steps for using it on a Mac are as follows:

1. Click the System Preferences icon in the Dock to open the System Preferences window.
2. Click Print And Scan in the Hardware section to open the Print And Scan window.
3. Click the + button under the Printers list box to open the Add window.
4. Click the Default tab to display the list of available printers. Choose the name of the network printer from the list of printers. The system automatically searches for and installs the appropriate driver for the printer.
5. If the system cannot find a printer driver, click the Use box and manually select it from the pop-up menu. Click Add to automatically make the printer available in the printer queue.

AirPrint AirPrint is the Apple technology for printing wirelessly to a printer in the network. Many printers come ready to support AirPrint. One important thing to note is that AirPrint does not support printing directly to the wireless printer; it must be done through an AP. This means that you can use this technology only in a WLAN where an AP is present.

Data Privacy

In any scenario where users are sharing a device, data privacy is an issue. There are several things that can be done to protect the privacy of data sent to the printer.

- Ensure that all users are authenticated to the device (discussed in the next section).
- Ensure that users are given only the rights to the device they need to perform their job.
- Consider the use of data loss prevention (DLP). These services can be used to control the printing, emailing, sharing, or deleting of documents.
- Make use of the auditing features to maintain an awareness of who does what and when they do it.

User Authentication on the Device

While nearly all enterprise-grade multifunction devices support user authentication, it may be easier and make more sense in a large network to perform this on the print server and use domain credentials to take advantage of single sign-on. In any case, user authentication forms the bedrock for auditing.

Hard Drive Caching

It is also important to realize that most enterprise-grade multifunction devices have hard drives and cache information on those hard drives. You must take steps to protect that

data; it can be stolen from the hard drive, either by remote access or by extracting the data once the drive has been removed.

Options for securing the data on the device include the following:

Encryption Encodes the data stored on the hard drive so that it cannot be retrieved even if the hard drive is removed from the machine.

Overwriting Changes the values of the bits on the disk that make up a file by overwriting existing data with random characters. By overwriting the disk space that the file occupied, its traces are removed, and the file can't be reconstructed as easily.

Exam Essentials

Be familiar with the possible interfaces that can be used for printing. The types generally fall into two categories: wired (USB, parallel, Ethernet) and wireless (Bluetooth and 802.11x).

Know how to install printers. The manufacturer is the best source of information about installing printers. You should, however, know about the wizards available in Windows as well.

Know how to share printers. This includes how to share in Windows and by using AirPrint and Bonjour.

1.14 Compare and Contrast Differences Between the Various Print Technologies and the Associated Imaging Process

This objective tests your knowledge of five types of printers: laser, inkjet (sometimes called *ink dispersion*), thermal, impact, and virtual. Make certain you understand the imaging process associated with each of these printer types and—in particular—can name the steps in the laser imaging process. The A+ certification exams have traditionally focused heavily on laser printers, but you can expect to also see questions about other printer types. The topics covered in subobjective 1.14 include the following:

- Laser
- Inkjet
- Thermal
- Impact
- Virtual

Printer Introduction

Although it is not a topic for objective 1.14, it is helpful to know that printers may be differentiated from one another in several ways, including the following:

Impact vs. Nonimpact Impact printers physically strike an inked ribbon and therefore can print multipart forms; nonimpact printers deliver ink onto the page without striking it. Dot matrix is impact; all the other printers you need to know for the exam are nonimpact.

Continuous Feed vs. Sheet Fed Continuous-feed paper feeds through the printer using a system of sprockets and tractors. Sheet-fed printers accept plain paper in a paper tray. Dot matrix is continuous feed; everything else is sheet fed.

Line vs. Page Line printers print one line at a time; page printers compose the entire page in memory and then place it all on the paper at once. Dot matrix and inkjet are line printers; laser is a page printer.

Laser

Laser printers are referred to as *page printers* because they receive their print job instructions one page at a time. They're sheet-fed, nonimpact printers. Another name for a laser printer is an *electrophotographic* (EP) printer.



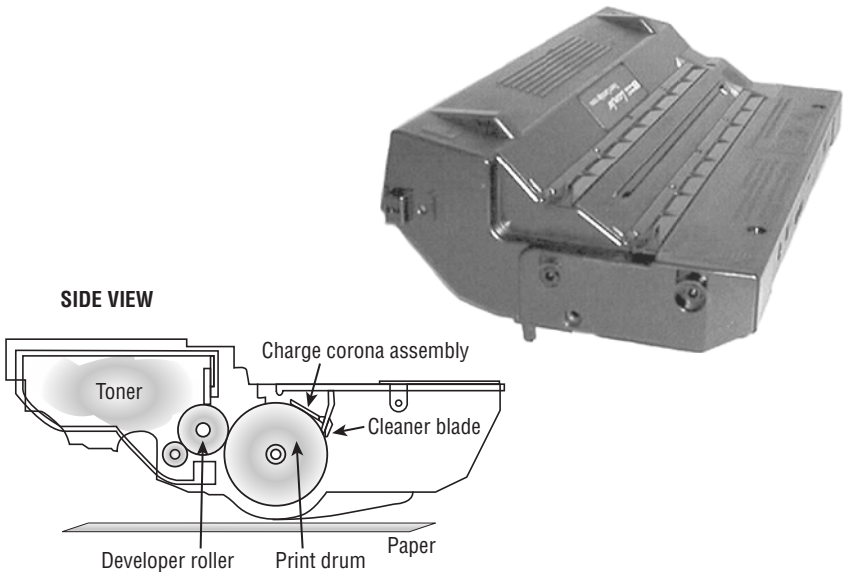
LED printers are much like laser printers except they use light-emitting diodes (LEDs) instead of lasers. Their process is similar to that of laser printers.

An EP (laser) printer consists of the following major components:

Printer Controller This is a large circuit board that acts as the motherboard for the printer. It contains the processor and RAM to convert data coming in from the computer into a picture of a page to be printed.

Imaging Drum The toner cartridge and drum are typically packaged together as a consumable product that contains the toner. Toner is a powdery mixture of plastic resin and iron oxide. The plastic allows it to be melted and fused to the paper, and the iron oxide allows it to be moved around via positive or negative charge. Toner comes in a cartridge, like the one shown in Figure 1.79.

FIGURE 1.79 An EP toner cartridge



The drum is light sensitive; it can be written to with the laser scanning assembly. The toner cartridge in Figure 1.79 contains the print drum, so every time you change the toner cartridge, you get a new drum. In some laser printers, the drum is a separate part that lasts longer, so you don't have to change it every time you change the toner.

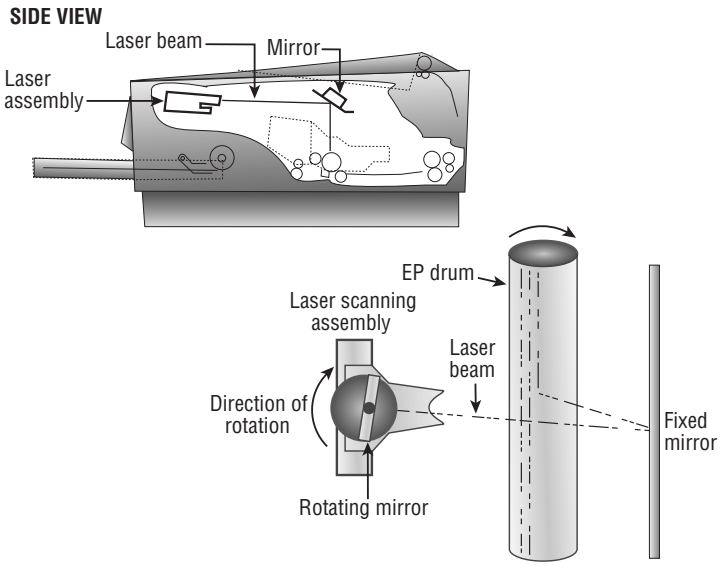


There are quite a few images included with this discussion. You need not memorize the images for the exam; they are included to help make concepts that may seem difficult more easily explainable.

Primary Corona (Charge Corona) This applies a uniform negative charge (around –600V) to the drum at the beginning of the printing cycle.

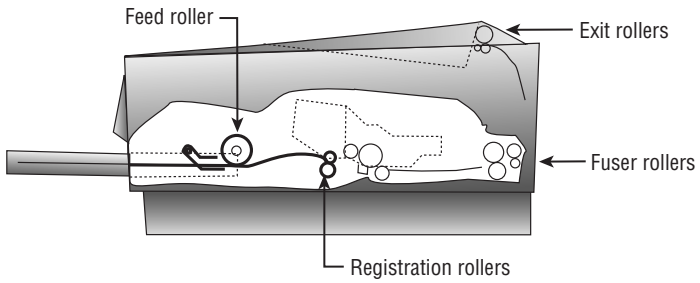
Laser Scanning Assembly This uses a laser beam to neutralize the strong negative charge on the drum in certain areas, so toner will stick to the drum in those areas. The laser scanning assembly uses a set of rotating and fixed mirrors to direct the beam, as shown in Figure 1.80.

FIGURE 1.80 The EP laser scanning assembly (side view and simplified top view)



Paper Transport Assembly (Transfer Belt, Transfer Rollers) This moves the paper through the printer. The paper transport assembly consists of a motor and several rubberized rollers and transfer belts. These rollers are operated by an electronic stepper motor. See Figure 1.81 for an example.

FIGURE 1.81 Paper transport rollers

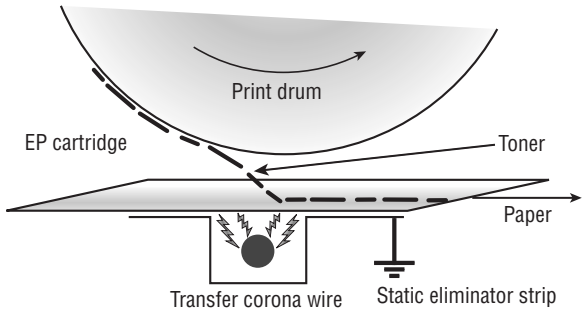


Pickup Rollers Pickup rollers are rubber wheels that grab the paper and feed it in. When these parts get old, they lose their ability to grip the paper, so they should be checked and changed regularly.

Separate Pads These pads are used to separate sheets in a stack of printing paper. It does this as the paper passes over them by creating friction that separates the paper. These pads are usually 2 to 3 inches wide, and when they start to wear out, they lose their ability to create friction, and you start getting two and three sheet at a time pulled through.

Transfer Corona This applies a uniform positive charge (about +600V) to the paper. When the paper rotates past the drum, the toner is pulled off the drum and onto the paper. Then the paper passes through a static eliminator that removes the positive charge from it (see Figure 1.82). Some printers use a transfer corona wire; others use a transfer corona roller.

FIGURE 1.82 The transfer corona assembly

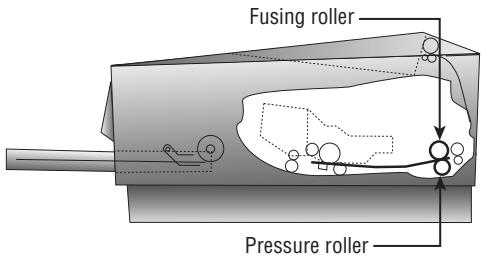


High-Voltage Power Supply (HVPS) This delivers the high voltages needed to make the printing process happen. It converts ordinary 120V household AC current into high-DC voltages used to energize the primary and transfer corona wires (discussed later).

DC Power Supply This delivers lower voltages to components in the printer that need much lower voltages than the corona wires do (such as circuit boards, memory, and motors).

Fusing Assembly This melts the plastic resin in the toner so that it adheres to the paper. The fusing assembly contains a halogen heating lamp, a fusing roller made of Teflon-coated aluminum, and a rubberized pressure roller. The lamp heats the fusing roller, and as the paper passes between the two rollers, the pressure roller pushes the paper against the hot fusing roller, melting the toner into the paper (see Figure 1.83).

FIGURE 1.83 The fusing assembly



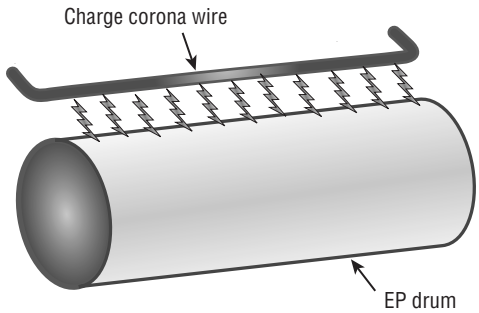
Duplex Assembly Duplex assemblies were discussed in the section "Duplex" earlier in this chapter.

Imaging Process

The laser (EP) print process consists of six steps. Here are the steps in the order you'll see them on the exam:

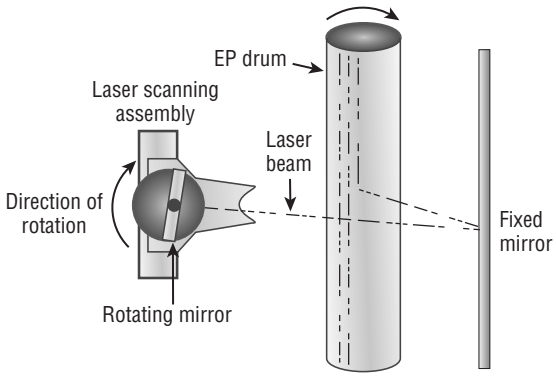
Step 1: Conditioning In the *conditioning* step (Figure 1.84), a special wire (called a *primary corona* or *charge corona*) within the EP toner cartridge (above the photosensitive drum) gets a high voltage from the HVPS. It uses this high voltage to apply a strong, uniform negative charge (around –600VDC) to the surface of the photosensitive drum.

FIGURE 1.84 The conditioning step of the EP process



Step 2: Writing In the *writing* step of the EP process, the laser is turned on and scans the drum from side to side, flashing on and off according to the bits of information the printer controller sends it as it communicates the individual bits of the image. In each area where the laser touches the photosensitive drum, the drum's charge is severely reduced from –600VDC to a slight negative charge (around –100VDC). As the drum rotates, a pattern of exposed areas is formed, representing the image to be printed. Figure 1.85 shows this process.

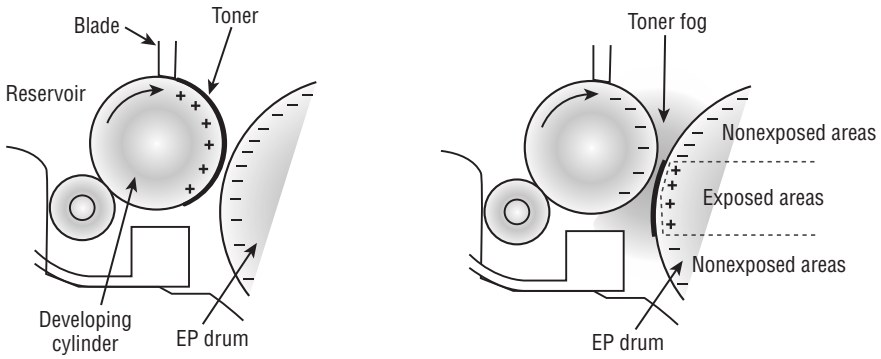
FIGURE 1.85 The writing step of the EP process



At this point, the controller sends a signal to the pickup roller to feed a piece of paper into the printer, where it stops at the registration rollers.

Step 3: Developing Now that the surface of the drum holds an electrical representation of the image being printed, its discrete electrical charges need to be converted into something that can be transferred to a piece of paper. The EP process's *developing* step accomplishes this (Figure 1.86). In this step, toner is transferred to the areas that were exposed in the writing step.

FIGURE 1.86 The developing step of the EP process



A metallic *developing roller* or *cylinder* inside an EP cartridge acquires a –600VDC charge (called a *bias voltage*) from the HVPS. The toner sticks to this roller because there is a magnet located inside the roller and because of the electrostatic charges between the toner and the developing roller. While the developing roller rotates toward the photosensitive drum, the toner acquires the charge of the roller (–600VDC). When the toner comes between the developing roller and the photosensitive drum, the toner is attracted to the areas that have been exposed by the laser (because these areas have a lesser charge of –100VDC). The toner also is repelled from the unexposed areas (because they're at the same –600VDC charge and like charges repel). This toner transfer creates a fog of toner between the EP drum and the developing roller.

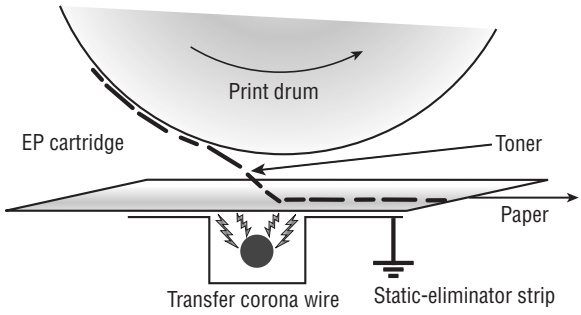
The photosensitive drum now has toner stuck to it where the laser has written. The photosensitive drum continues to rotate until the developed image is ready to be transferred to paper in the next step.

Step 4: Transferring At this point in the EP process, the developed image is rotating into position. The controller notifies the registration rollers that the paper should be fed through. The registration rollers move the paper underneath the photosensitive drum, and the process of transferring the image can begin with the *transferring* step.

The controller sends a signal to the corona wire or corona roller (depending on which one the printer has) and tells it to turn on. The corona wire/roller then acquires a strong *positive* charge (+600VDC) and applies that charge to the paper. The paper, thus

charged, pulls the toner from the photosensitive drum at the line of contact between the roller and the paper because the paper and toner have opposite charges. Once the registration rollers move the paper past the corona wire, the static-eliminator strip removes all charge from that line of the paper. Figure 1.87 details this step. If the strip didn't bleed this charge away, the paper would attract itself to the toner cartridge and cause a paper jam.

FIGURE 1.87 The transferring step of the EP process

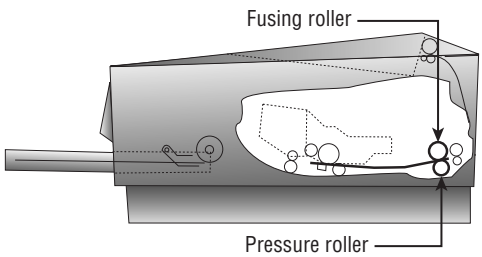


The toner is now held in place by weak electrostatic charges and gravity. It won't stay there, however, unless it's made permanent, which is the reason for the fusing step.

Step 5: Fusing In the next step, the *fusing* step, the toner image is made permanent. The registration rollers push the paper toward the fuser rollers. Once the fuser grabs the paper, the registration rollers push for only a short time more. The fuser is now in control of moving the paper.

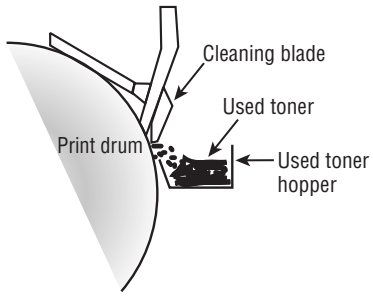
As the paper passes through the fuser, the fuser roller melts the polyester resin of the toner, and the rubberized pressure roller presses it permanently into the paper (Figure 1.88). The paper continues on through the fuser and eventually exits the printer.

FIGURE 1.88 The fusing step of the EP process



Step 6: Cleaning In the last part of the laser print process, a rubber blade inside the EP cartridge scrapes any toner left on the drum into a used-toner receptacle inside the EP cartridge, and a fluorescent lamp discharges any remaining charge on the photosensitive drum (remember that the drum, being photosensitive, loses its charge when exposed to light). See Figure 1.89.

FIGURE 1.89 The cleaning step of the EP process





A color laser is much like a regular laser printer except that multiple passes over the page are made, one for each ink color. Consequently, the printing speed is rather low.

The EP cartridge is constantly cleaning the drum. It may take more than one rotation of the photosensitive drum to make an image on the paper. The cleaning step keeps the drum fresh for each use. If you didn't clean the drum, you would see ghosts of previous pages printed along with your image.



The actual amount of toner removed in the cleaning process is quite small. The cartridge will run out of toner before the used toner receptacle fills up.

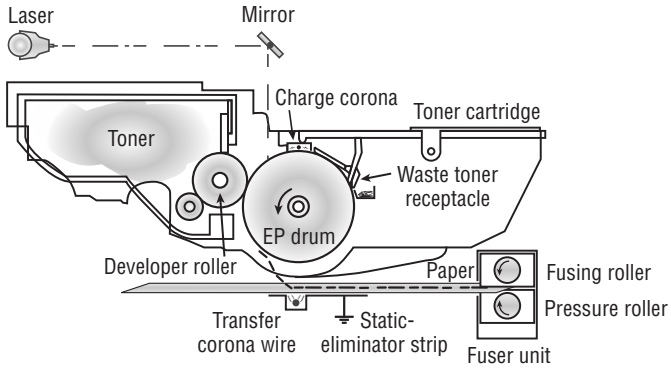
Putting It All Together

Figure 1.90 summarizes all the EP process printing steps. First, the printer uses a rubber scraper to clean the photosensitive drum. Then the printer places a uniform, negative, –600VDC charge on the photosensitive drum by means of a charge corona. The laser paints an image onto the photosensitive drum, discharging the image areas to a much lower voltage (–100VDC). The developing roller in the toner cartridge has charged (–600VDC) toner stuck to it. As it rolls the toner toward the photosensitive drum, the toner is attracted to (and sticks to) the areas of the photosensitive drum that the laser has discharged. The image is then transferred from the drum to the paper at its line of contact by means of the corona wire (or corona roller) with a +600VDC charge. The static-eliminator strip removes the high, positive charge from the paper, and the paper, now holding the image, moves on. The paper then enters the fuser, where the fuser roller and the pressure roller make the image permanent. The paper exits the printer, and the printer starts printing the next page or returns to its ready state.



An optional component that can be added to printers (usually laser but also inkjet) is a duplexer. This can be an optional assembly added to the printer, or built into it, but the sole purpose of *duplexing* is to turn the printed sheet over so it can be run back through the printer and allow printing on both sides.

FIGURE 1.90 The EP print process



Inkjet

Inkjet printers are one of the most popular types in use today. This type of printer sprays ink on the page to print text or graphics. It's a nonimpact, sheet-fed printer. Figure 1.91 shows an ink cartridge.

FIGURE 1.91 A typical ink cartridge



There are two kinds of inkjet printers: *thermal* and *piezoelectric*. These terms refer to the way the ink is sprayed onto the paper. A thermal inkjet printer heats the ink to about 400 degrees Fahrenheit, creating vapor bubbles that force the ink out of the cartridge. Thermal inkjets are also sometimes called *bubble jets*. A piezoelectric printer does the same thing but with electricity instead of heat.

Inkjet printers are popular because they can print in color and are inexpensive. However, their speed isn't quite as good as that of a laser printer, and the per-page cost of ink can be higher than for a laser printer. Therefore, most businesses prefer laser printers for their main printing needs, perhaps keeping one or two inkjet printers around for situations requiring color printing. Components of an inkjet printer are covered in the following sections.

Ink Cartridge

These cartridges contain the ink. Some cartridges contain the print head for that color of ink; you get a new print head each time you replace the cartridge. On other printer models, the ink cartridge is just an ink reservoir, and the heads don't need replacing.

Print Head

The print head has a series of nozzles from which the ink is sprayed onto the paper. They may be attached to the ink cartridge, or those two components may be separate. In cases where they are one piece, you will be getting a new print head each time you get a new ink cartridge.

Roller

Just as on a laser printer, rollers are used to pull the paper in from the tray or feeder and advance the paper when the print head assembly is ready for another pass. As is the case with any rollers, they will need to be replaced when they lose their ability to "grab" the paper.

Feeder

The feeder looks like a tray and is where you load paper. It is from here that it is pulled into the printer when a new sheet is required. These feeders do not usually hold as much paper as a tray in a printer will.

Duplexing Assembly

A duplexing assembly performs the same function on an inkjet printer that it does on a laser printer, which is to flip a sheet over to print on the back side.

Carriage and Belt

The carriage holds the ink cartridges, and it uses a belt to move the entire piece across the paper as it is printing. As it prints, it uses ink from the various cartridges in whatever proportion is necessary to create the desire colors.

Calibration

Calibrating an inkjet printer is the process of ensuring that there is proper alignment of the cartridges to one another and to the paper so that high quality is maintained. When a printer gets out of calibration, the print quality will decline. When a new cartridge is

loaded, the printer will usually perform a calibration, but you may need to do this manually from time to time, especially on printers that are not used often enough to require a cartridge change as often as a calibration may be required.

On an inkjet printer, calibration is more commonly known as *head alignment*. The printer will automatically try to align ink cartridges each time they are replaced (or installed). If you want to make sure they are in the right place, most printers allow you to print an alignment page from the maintenance menu.

If characters are not properly formed or are appearing as straight lines along the margin (usually the left), you can use the maintenance menu settings to align the ink cartridges.

Thermal

Thermal printers can be found in many older fax machines (most newer ones use either inkjet or laser printing) that print on a waxy paper that comes on a roll; the paper turns black when heat passes over it. These are also found on many handheld package tracking and point-of-sale (POS) devices such as credit card terminals. Thermal printers work by using a print head the width of the paper. When it needs to print, the print head heats and cools spots on the print head. The paper below the heated print head turns black in those spots. As the paper moves through the printer, the pattern of blackened spots forms an image on the page of what is being printed.

Another type of thermal printer uses a heat-sensitive ribbon instead of heat-sensitive paper. A thermal print head melts wax-based ink from the ribbon onto the paper. These are called *thermal transfer* or *thermal wax-transfer* printers.

Thermal direct printers typically have long lives because they have few moving parts. However, the paper is somewhat expensive, doesn't last long, and produces poorer-quality images (that tend to fade over time) than most of the other printing technologies.

There are some deviations of thermal printing that exist. They're all high-end color graphics printers designed for specialty professional usage. Here are four popular ones:

Thermal Wax Transfer This is a color, nonimpact printer that uses a solid wax. A heater melts the wax and then sprays it onto the page, somewhat like an inkjet. The quality is very high, but so is the price.

Dye Sublimation This is another color, nonimpact line printer. This one converts a solid ink into a gas that is then applied to the paper. Color is applied in a continuous tone, rather than individual dots, and the colors are applied one at a time. The ink comes on film rolls. The paper is expensive, as is the ink. Print speeds are low. The quality is extremely high.

Feed Assembly Feed assemblies, commonly called *feeders*, are available to allow you to feed in the media you are printing on (paper, cards, and so on). Some feeders allow you to switch between multiple feeds, which is helpful if you need to alternate printing on different types of stock.

Heating Element The heating element for a thermal printer is what generates the heat and does the actual printing. It is often the most expensive component of the printer.

Special Thermal Paper

To print with a thermal printer, you need to use heat-sensitive paper designed for the thermal printer as opposed to paper for any other type of printer. Rolls of thermal paper are available in a variety of sizes and colors.

Impact

A dot-matrix printer is an impact printer; it prints by physically striking an inked ribbon, much like a typewriter. It's an impact, continuous-feed printer.

The print head on a dot-matrix printer consists of a block of metal pins that extend and retract. These pins are triggered to extend in patterns that form letters and numbers as the print head moves across the paper. Early models, known as near letter-quality (NLQ), printed using only nine pins. Later models used 24 pins and produced much better letter-quality (LQ) output.

The main advantage of dot matrix is its impact (physical striking of the paper). Because it strikes the paper, you can use it to print on multipart forms. Nonimpact printers can't do that. Dot-matrix printers aren't commonly found in most offices these days because of their disadvantages, including noise, slow speed, and poor print quality.



Dot-matrix printers are still found in many warehouses, and other businesses, where multipart forms are used or where continuous feed is required.

Key elements of an impact printer are discussed in the sections that follow.

Print Head The pins in the print head are wrapped with coils of wire to create a solenoid and are held in the rest position by a combination of a small magnet and a spring. To trigger a particular pin, the printer controller sends a signal to the print head, which energizes the wires around the appropriate print wire. This turns the print wire into an electromagnet, which repels the print pin, forcing it against the ink ribbon and making a dot on the paper.

Ribbon The ribbon is like that on an old typewriter. Most impact printers have an option to adjust how close the print head rests from the ribbon. So if your printing is too light, you may be able to adjust the print head closer to the ribbon. If it's too dark or you get smeared printing, you may be able to move the print head back.

Tractor Feed The tractor feed unit feeds in the continuous feed paper. This paper has holes running down both edges.

Impact Paper

An impact printer uses continuous feed paper fed to it by the tractor feed unit.

Virtual

There is also virtual printing that is not really printing at all but a way to convert a document to a particular format. There a number of ways this conversion can take place.

Print to File

Print to file is quite an old concept by now but still available as an option when printing. When you do this, the information that would normally be sent to the printer is saved, usually as a `.prn` file. It is a way to avoid the printing process from within an application (which may be time-consuming or inconvenient) and print it (convert it) once and then save the file so that whenever you need a copy, you can simply send that to the printer.

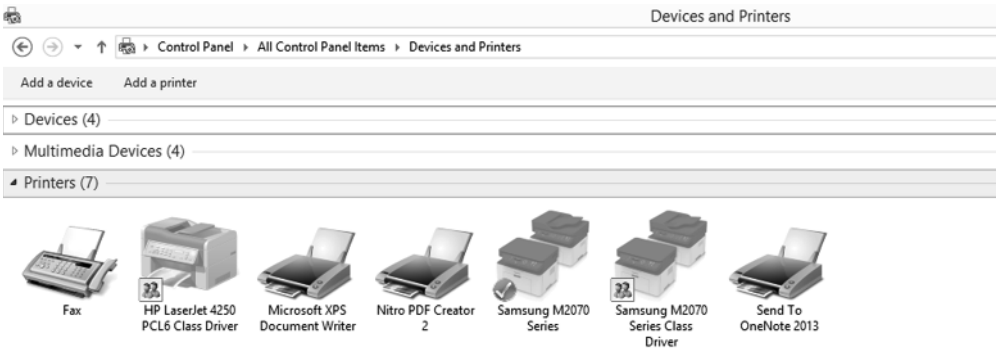
Print to PDF

If you can print to file, you can print to PDF. In applications that support this feature, it will be an option presented when you select to print. When you select this option, it produces an Adobe PDF instead of a printout. It is a convenient format because you can still print them later, search them, and send them, and when you do send them, you can be certain that the way the document appears to you will be the way it does to the recipient, regardless of the device type on which they are viewing it.

Print to XPS

An XPS document is a standardized open format and is Microsoft's answer to the PDF. It is always offered as a printer type in Windows. It will be called a Microsoft XPS Document Writer and will appear with other printers in the printer's folder, as shown in Figure 1.92.

FIGURE 1.92 Microsoft XPS Document Writer



When your file is converted, it will appear with an `.opxs` file extension (Open XPS). While Microsoft encourages the use of these documents and of the default XPS device and offers more support for it then for PDF, the document type is not as widely supported elsewhere as the PDF.

Print to Image

Finally, printing to an image is somewhat like scanning because it creates an image of the document. This typically requires a third-party application. Many of the applications that will create a PDF, such as Nitro PDF Writer, will also allow for you to convert those formats to a `.jpg` file.

Exam Essentials

Identify the components of laser printers. These include the imaging drum, fuser assembly, transfer belt, transfer roller, pickup rollers, separate pads, and duplexing assembly.

Describe the function of the components of an inkjet printer. These include the ink cartridge, print head, roller, feeder, duplexing assembly, carriage, and belt.

Identify examples of using a virtual printer. These include print to file, print to PDF, print to XPS, and print to image.

1.15 Given a Scenario, Perform Appropriate Printer Maintenance

Most printing problems today are because of either improper configuration or actual physical problems that arise from the poor maintenance of the printer. As far as configuration goes, the Windows architecture is such that when a client wants to print to a network printer, a check is first done to see whether the client has the latest printer driver. If it doesn't—as judged by the print server—the new driver is sent from the server to the client, and then the print job is accepted. This is an enormous help to the administrator because when a new driver comes out, all the administrator must do is install it on the server, and the distribution to the clients becomes automatic. The printers covered in subobjective 1.15 include the following:

- Laser
- Thermal
- Impact
- Inkjet



This objective tests your knowledge of some of the basic operations of printers. The emphasis, however, is on detecting and solving problems with them. If you truly want to show your expertise with printers, CompTIA offers another certification, PDI+, which is meant for that purpose.

General Maintenance

Beyond what is covered in subobjective 1.15, it is important to know good principles of general printer maintenance. To keep your printers working efficiently and extend their life as much as possible, you should start by creating a log of scheduled maintenance as outlined by the vendor's guidelines and then make certain this maintenance log is adhered to. For many printers, the scheduled maintenance includes installing maintenance kits. Maintenance kits typically include a fuser, transfer roller, pickup rollers (for the trays), separation rollers, and feed rollers.



After installing the maintenance kit, you need to reset the maintenance counter as explained in the vendor's documentation.

Pay a great deal of attention to the ambient surroundings of the printers as well. High temperature, high humidity, and high levels of dust and debris can negatively affect the life of the printer and the quality of print jobs. Always make certain you use recommended supplies. It may be cheaper to buy off-brand supplies that aren't intended for your equipment, but you're taking a gamble with shortening the life of your printer and decreasing the quality of your output.

Some general preventive maintenance includes the following:

- Never reuse paper in a laser printer that has been through the printer once. Although it may look blank, you're repeating the charging and fusing process on a piece of paper that most likely has *something* already on it.
- Change the toner when needed. You should recycle; most toner manufacturers participate in a recycling program of some type. The toner cartridge should never be exposed to light for longer than a few minutes; it usually comes sealed in a black plastic light-resistant bag.
- Clean any toner that accidentally spills into the printer with a dry, lint-free cloth. Bear in mind that spilled toner in the paper path should clear after you run a few blank pages through. If toner gets on your clothes, wipe them with a dry cloth and wash them with cold water (hot water works like the fusing process to set them into the material).
- Clean any paper shreds, dust, or dander that gets deposited in the printer. Pressurized air is the most effective method of removal.
- Keep the drum in good working order. If it develops lines, replace it.
- Install the maintenance kit when needed and reset the page count. The maintenance kit (sometimes called a *fuser kit*) typically includes a fusing assembly, rollers, and

separation pads. A printer that displays a message similar to "Perform Printer Maintenance" indicates the printer has reached its maintenance interval and a maintenance kit needs to be installed.

- Don't be afraid to cycle the power for an unresponsive printer. Turning it off, leaving it off for one minute to clear, and then turning it back on can solve a great many problems.
- For inkjet and impact printers, you should periodically clean the print head.

While the previous list is a good rule of thumb, for this objective CompTIA wants you to be familiar with maintenance for three types of printers: laser, thermal, and impact. The following sections will look at each of those.

Laser

Just as laser printers are the most complicated of the types (and offer the most capabilities), they also have the most things that can go awry. A thermal fuse is included to keep the system from overheating, and if it becomes faulty, it can prevent the printer from printing. Many high-capacity laser printers also include an ozone filter to prevent the corona's ozone output from reaching too high a level. On these printers, the filter should be changed as part of regular maintenance.

Other common problems and solutions are as follows:

Paper Jams While paper jams can be caused by numerous problems, two common ones are the paper not feeding correctly and moisture. To correct improper feeds, make sure you set the alignment guides for the paper you are using and verify the paper is feeding in straight. Keep paper from getting any moisture before feeding into the printer because moisture often causes pages to stick together and bind. Paper jams can also be caused by using paper that is not approved for the printer—particularly thick cardstock.



One employee routinely had problems with a printer each time he went to print on high-quality paper—a problem experienced by no one else. Upon close examination, it turned out that each time he chose to print to the expensive paper, he counted the number of sheets he loaded into the printer—counting that involved licking his finger and then touching each page. A simple directive to stop doing this solved the problem.

Regardless of the cause of a paper jam, you need to always fully clear the printer of any traces of paper (torn or whole) before attempting to print again.

Error Codes Many laser printers include LCDs for interaction with the printer. When error codes appear, refer to the manufacturer's manuals or website for information on how to interpret the codes and solve the problem causing them.

Out-of-Memory Error While PCs now may need a minimum of 1 GB of RAM to run at a base level, it is not uncommon to find printers that still have only 4 MB or 8 MB of memory. If you are routinely running out of memory on a printer, add more memory if possible, and replace the printer when it is no longer possible to do so.

Lines and Smearing Lines and smearing can be caused by the toner cartridge or the fuser. Try replacing the toner first (and cleaning any that may have spilled). If this does not fix the problem, replace the fuser.

Blank Pages Print Verify that there is toner in the cartridge. If it's an old cartridge, you can often shake it slightly to free up toner once before replacing. If it's a new cartridge, make sure the sealing tape has been removed from the cartridge prior to placing it in the printer.



Be careful when doing this operation. Someone who has asthma or who is sensitive to microfine particles could be adversely affected by the toner.

Dark Spots Print The most likely culprit is too much toner. Run blank pages through the printer to clean it.

Garbled Pages Print Make sure you're using the right printer driver in your application.

Ghosted Images Print Ghosting—repeating text or images on the page—is usually caused by a bad cartridge. There can be damage to the drum or charging roller, and if there is, replacing the cartridge will help with the problem.

No Connectivity If a network printer is not able to receive jobs, it can be an issue with the IP address that it has (or, more correctly, does not have). Often the printer will need to be manually assigned an IP address to make sure that it has the same one each time. Read the manufacturer's documentation for assigning an IP address to the printer and walk through the steps to do so.



Never overlook the obvious. Connectivity problems also occur when the printer is turned off.

Print-Quality Problems See whether your printer has the ability to turn Resolution Enhancement Technology (RET) on and off. This is what allows the printer to use partial-sized dots for images that are rounded. If it's turned off, turn it back on. If there are small marks or defects in the same spot on every page printed, the most likely culprit is a scratch on the drum.

Replacing Toner Toner represents the consumable within the laser printer. Toner cartridges are used by laser printers to store toner. Use toner that is recommended for your printer. Using bad supplies could ruin your printer and void your warranty. Remove the toner before moving or shipping a printer to avoid spills.

Applying a Maintenance Kit Maintenance kits are marketed by the manufacturer. Each kit varies in contents based on the printer in question but typically consists of a fuser, transfer roller, and feed/separation rollers. A counter on the laser printer often identifies when the maintenance kit is needed, and you can reset the counter after applying the new kit.

Calibration With laser printers and inkjets, there is often a need to calibrate. Calibration is the process by which the result produced matches what was created. All the hardware, including the monitor, scanner, and printer, need to match on color, margins, and so forth.

The calibration process is different for each manufacturer but is usually similar to the following:

1. During installation of the software, you are asked (by the installation wizard) if you want to calibrate now (say Yes).
2. The printer prints multiple sets of numbered lines. Each set of lines represents an alignment instance, and you are asked which set looks the best.
3. You enter the set number and click OK. In some cases, the alignment ends here. In other cases, the alignment page is reprinted to verify that the settings are correct, and you are given a chance to change.
4. You exit the alignment routine.

Cleaning It is important to keep the printer and the area around it clean. Each time you replace the toner or perform any maintenance, be sure to clean the debris.

Thermal

The amount of maintenance required on a thermal printer pales in comparison to laser since there are no moving parts to speak of. The following sections look at the key items to be aware of related to thermal printers as you study for the exam.

Replace Paper Replace the thermal paper as it is needed; be sure to keep the feed area clean of paper slivers and other debris.

Clean Heating Element Before even looking at a heating element, always unplug the printer and make certain it is cool. Thermal printer cleaning cards, cleaning pens, and kits are available and recommended for cleaning.

Remove Debris Keep the printer free of dust and debris. Any particulates that get into the printer can interfere with the paper feeding properly or can affect the print quality. Use compressed air or computer vacuum to remove any debris.

Impact

A dot-matrix print head reaches high temperatures, and care must be taken to avoid a user or technician touching it and getting burned. Most dot-matrix printers include a temperature sensor to tell whether the print head is getting too hot. The sensor interrupts printing to let the print head cool down and then allows printing to start again. If this sensor becomes faulty, it can cause the printer to print a few lines, stop for a while, print more, stop, and so on. The following sections look at the key items to be aware of related to impact printers as you study for the exam.

Replace Ribbon A common culprit with poor printing is the ribbon. A tight ribbon, or one that isn't advancing properly, will cause smudges or overly light printout. To solve this problem, replace the ribbon.

Replace Print Head The print head should never be lubricated, but you can clean off debris with a cotton swab and denatured alcohol. Print pins missing from the print head

will cause incomplete images or characters or white lines running through the text. This can be remedied by replacing the print head.

If the print head isn't at fault, make certain it's close enough to the platen to make the right image. The print head can be moved closer and farther from the platen (the surface on which typing occurs) depending on the thickness of the paper and other considerations.

Replace Paper Preventive maintenance includes not only keeping the print head dry and clean but also vacuuming paper shreds from inside the machine. This should be done more often if needed but always when you replace the paper.

Inkjet

While inkjet printers use a different technology to print, they require many of the same maintenance procedures. These are discussed briefly in this section.

Clean Heads Two maintenance task apply to the print heads. If your colors don't look the same or your blacks are getting a bronze look, you need to clean the nozzles. This can be done with the head cleaning cycle, which will clear out the nozzles. The second task is head alignment. If you see white repeating lines or a grid-like pattern in the printing, the head is misaligned. While some newer printers have an automatic alignment and cleaning function, you may need to do this manually using the printer documentation.

Replace Cartridges When ink runs low (and most printers will alert you before you run out), you must remove the old cartridge and replace it with a new one. The procedure is as follows:

1. Open the printer cover and locate the button that is used to place the cartridge in the replacement position.
2. Open the cover that may be over the cartridge.
3. Grasp and remove the empty cartridge.
4. Take the new cartridge out of its packaging.
5. Place the new cartridge in the empty position left by the old cartridge. It should "click" into place.
6. Replace the cartridge cover.
7. Use the same button you used to place the cartridge into the replacement positon to move it back to the home position.

Calibration Calibration is a task usually performed by accessing the properties of the printer and looking for the calibration function either on the General tab or on the Advanced tab. Just select it, and the printer will perform a calibration. It is also useful to know that in most cases a calibration is done whenever you replace one of the cartridges.

Clear Jams While keeping in mind that many paper jams are a result of using poor-quality paper, there will be times you suffer jams with good paper. To clear a jam, do the following:

1. Check the paper tray. If you see a piece protruding from where the paper is picked up, pull it out gently.
2. If there is still a jam, remove the rear access door and look into the printer. If you see any paper stuck inside, pull it out, making sure you get all the pieces out.
3. Check the front door of the printer and see whether any pieces are stuck in that section; if so, gently pull them out.
4. At any point in this process you can select the resume button, and if you have cleared the jam, the print process will resume.

Exam Essentials

Know how to interact with printers. Know that the Properties page for each, available from Windows, allows you to interact with them, but many printers also include advanced utilities that go beyond basic interaction.

Know the common printing problems listed. Understand the most common problems that occur in an environment.

Know the importance of running scheduled maintenance. Scheduled maintenance can prolong the life of your equipment and help ensure that your output continues to live up to the quality you expect.

Understand the importance of a suitable environment. If you want your equipment to last as long as possible and deliver quality, you should pay attention to the environment in which you place it.

Review Questions

You can find the answers in the Appendix.

1. Which if the following is a standard firmware interface for PCs, designed to replace BIOS.
   - **A.** UEFI
   - **B.** NVRAM
   - **C.** CMOS
   - **D.** CHS
2. Which if the following is memory that does not lose its content when power is lost to the machine.
   - **A.** CMOS
   - **B.** NVRAM
   - **C.** CHS
   - **D.** SDRAM
3. Which if the following is also called the drive geometry?
   - **A.** EEPROM
   - **B.** SDRAM
   - **C.** CHS
   - **D.** CMOS
4. Which of the following NOT an example of an optical drive?
   - **A.** CD
   - **B.** CD-R
   - **C.** DVD
   - **D.** ROM
5. Where do you change the boot sequence?
   - **A.** BIOS/UEFI settings
   - **B.** Control Panel
   - **C.** Jumper settings
   - **D.** Command prompt
6. What value represents the relationship between the speed of the CPU and that of the motherboard bus?
   - **A.** divisor
   - **B.** multiplier
   - **C.** gradient
   - **D.** correlation

7. Which of the following is required to take the most advantage of drive encryption technologies?
   - **A.** Lo jack
   - **B.** Secure boot
   - **C.** TPM chip
   - **D.** POST card

8. Which of the following allows you to remotely locate, lock, and delete the data on a mobile device when it is stolen?
   - **A.** Lo jack
   - **B.** TPM chip
   - **C.** POST card
   - **D.** Secure Boot

9. Which of the following is a standard adopted by many venders that requires the operating system to check the integrity of all system files before allowing the boot process to proceed?
   - **A.** PXE boot
   - **B.** Secure Boot
   - **C.** POST boot
   - **D.** Bootcheck

10. What is the name for the set of diagnostic steps the computer undertakes when you first boot it up?
    - **A.** PXE
    - **B.** CHS
    - **C.** POST
    - **D.** PRE