

Introduction to the Personal Computer

1.0 Introduction to the Personal Computer System

1.0.1 Introduction

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A computer is an electronic machine that performs calculations based on a set of instructions. The first computers were huge, room-sized machines that took teams of people to build, manage and maintain. The computer systems of today are exponentially faster and only a fraction of the size of those original computers.

A computer system consists of hardware and software components. Hardware is the physical equipment. It includes the case, storage drives, keyboards, monitors, cables, speakers, and printers. Software includes the operating system and programs. The operating system instructs computer operations. These operations can include identifying, accessing, and processing information. Programs or applications perform different functions. Programs vary widely depending on the type of information that is accessed or generated. For example, instructions for balancing a checkbook are different from instructions for simulating a virtual reality world on the Internet.

1.1 Personal Computer Systems

1.1.1 Cases and Power Supplies

1.1.1.1 Cases

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The computer case contains the framework to support the internal components of a computer while providing an enclosure for added protection. Computer cases are typically made of plastic, steel, or aluminum and are available in a variety of styles.

In addition to providing protection and support, cases also provide an environment designed to keep the internal components cool. Case fans move air through the computer case. As the air passes warm components, it absorbs heat and then exits the case. This process keeps the computer components from overheating. Cases also help to prevent damage from static electricity. The computer's internal components are grounded via attachment to the case.

All computers need a power supply to convert alternating-current (AC) power from the wall socket into direct-current (DC) power. Every computer also needs a motherboard. The motherboard is the main circuit board in a computer. The size and shape of the computer case is usually determined by the motherboard, power supply, and other internal components.

The size and layout of a case is called the form factor. The basic form factors for computer cases include desktop and tower, as shown in Figure 1. Desktop cases can be slimline or full-sized. Tower cases can be mini or full-sized.

You can select a larger computer case to accommodate additional components that may be

required in the future. Or you might select a smaller case that requires minimal space. In general, the computer case should be durable, easy to service, and have enough room for expansion.

Computer cases are referred to in a number of ways:

- Computer chassis
- Cabinet
- Tower
- Box
- Housing

Several factors must be considered when choosing a case:

- Size of the motherboard
- Number of external or internal drive locations, called bays
- Available space

See Figure 2 for a list of computer case features.

Note Select a case that matches the physical dimensions of the power supply and motherboard.

1.1.1.2 Power Supplies

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The power supply must provide enough power for the components that are currently installed and allow for other components that may be added at a later time. If you choose a power supply that powers only the current components, you might need to replace the power supply when other components are upgraded.

The power supply, shown in Figure 1, converts Alternating Current (AC) power coming from a wall outlet into Direct Current (DC) power, which is a lower voltage. DC power is required for all components inside the computer. There are 3 main form factors for power supplies, Advanced Technology (AT), AT Extended (ATX), and ATX12V. The ATX12V is the most common form factor used in computers today.

A computer can tolerate slight fluctuations in power, but a significant deviation can cause the power supply to fail. An uninterruptible power supply (UPS) can protect a computer from problems caused by changes in power. A UPS uses a power inverter. A power inverter provides AC power to the computer from a built-in battery by converting the DC current of the UPS battery into AC power. This built-in battery is continually charged via DC current that is converted from the AC supply.

Connectors

Most connectors today are keyed. A keyed connector is designed to be inserted in only one direction. Each power supply connector uses a different voltage, as shown in Figure 2. Different connectors are used to connect specific components to various ports on the motherboard.

- A Molex keyed connector connects to optical drives, hard drives, or other devices that use older technology.
- A Berg keyed connector connects to a floppy drive. A Berg connector is smaller than a Molex connector.
- A SATA keyed connector connects to an optical drive or a hard drive. The SATA connector is wider and thinner than a Molex connector.
- A 20-pin or 24-pin slotted connector connects to the motherboard. The 24-pin connector has two rows of 12 pins each, and the 20-pin connector has two rows of 10 pins each.
- A 4-pin to 8-pin auxiliary power connector has two rows of two to four pins and supplies power to all areas of the motherboard. The auxiliary power connector is the same shape as the main power connector but smaller. It can also power other devices within the computer.
- A 6/8-pin PCIe power connector has two rows of three to four pins and supplies power to other internal components.
- Older standard power supplies used two connectors called P8 and P9 to connect to the motherboard. P8 and P9 were unkeyed connectors. They could be installed backwards, potentially damaging the motherboard or power supply. The installation required that the connectors be lined up with the black wires together in the middle.

Note If you have a difficult time inserting a connector, try repositioning it, or check to make sure that no bent pins or foreign objects are in the way. If it is difficult to plug in a cable or other part, something is wrong. Cables, connectors, and components are designed to fit together snugly. Never force a connector or component. If a connector is plugged in incorrectly, it can damage the plug and the connector. Take your time and make sure that you are handling the hardware correctly.

1.1.1.3 Electricity and Ohm's Law

These are the four basic units of electricity:

- Voltage (V)
- Current (I)
- Power (P)
- Resistance (R)

Voltage, current, power, and resistance are electronic terms that a computer technician must know.

- Voltage is a measure of the force required to push electrons through a circuit. Voltage is measured in volts (V). A computer power supply usually produces several different voltages.
- Current is a measure of the amount of electrons going through a circuit. Current is measured in amperes, or amps (A). Computer power supplies deliver different amperages for each output voltage.

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- Power is a measure of the pressure required to push electrons through a circuit (voltage), multiplied by the number of electrons going through that circuit (current). The measurement is called watts (W). Computer power supplies are rated in watts.
- Resistance is the opposition to the flow of current in a circuit, measured in ohms. Lower resistance allows more current, and therefore more power, to flow through a circuit. A good fuse has low resistance or almost 0 ohms.

A basic equation, known as Ohm's Law, expresses how three of the terms relate to each other. It states that voltage is equal to the current multiplied by the resistance: $V = IR$.

In an electrical system, power is equal to the voltage multiplied by the current: $P = VI$.

In an electrical circuit, increasing the current or the voltage results in higher power.

For example, imagine a simple circuit that has a 9V light bulb hooked up to a 9V battery. The power output of the light bulb is 100W. Using the $P = VI$ equation, you can calculate how much current in amps is required to get 100W out of this 9V bulb.

To solve this equation, we know that $P = 100W$ and $V = 9V$.

$$I = P/V = 100W / 9V = 11.11A$$

What happens if a 12V battery and a 12V light bulb are used to get 100W of power?

$$I = P/V = 100W / 12V = 8.33A$$

This system produces the same power but with less current.

You can use Ohm's Triangle, shown in Figure 1, to calculate voltage, current, or resistance when two of the variables are known. To see the correct formula, cover up the variable that is not known and perform the resulting calculation. For example, if voltage and current are known, cover the R to reveal the formula V / I . Calculate V / I to find R. You can use the Ohm's Law chart shown in Figure 2 to calculate any of the four basic units of electricity using any two known units.

Computers normally use power supplies ranging from 250W to 800W output capacity. However, some computers need 1200W and higher capacity power supplies. When building a computer, select a power supply with sufficient wattage to power all components. Each component inside the computer uses a certain amount of power. Obtain the wattage information from the manufacturer's documentation. When deciding on a power supply, make sure to choose one that has more than enough power for the current components. A power supply with a higher wattage rating has more capacity, therefore, it can handle more devices.

On the back of most power supplies is a small switch called the voltage selector switch. This switch sets the input voltage to the power supply to either 110V / 115V or 220V / 230V. A power supply with this switch is called a dual voltage power supply. The correct voltage setting is determined by the country where the power supply is used. Setting the voltage switch to the incorrect input voltage could damage the power supply and other parts of your computer. If a power supply does not have this switch, it automatically detects and sets the correct voltage.

Caution Do not open a power supply. Electronic capacitors located inside of a power supply, shown in Figure 3, can hold a charge for extended periods of time.

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1.1.1.4 Worksheet - Ohm's Law

1.1.2 Internal PC Components

1.1.2.1 Motherboards

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The motherboard is the main printed circuit board and contains the buses, or electrical pathways, found in a computer. These buses allow data to travel between the various components that comprise a computer. Figure 1 shows a variety of motherboards. A motherboard is also known as the system board or the main board.

The motherboard accommodates the central processing unit (CPU), random access memory (RAM), expansion slots, heat sink and fan assembly, basic input/output system (BIOS) chip, chipset, and the circuitry that interconnects the motherboard components. Sockets, internal and external connectors, and various ports are also placed on the motherboard.

The form factor of motherboards pertains to the size and shape of the board. It also describes the physical layout of the different components and devices on the motherboard. The form factor determines how individual components attach to the motherboard and the shape of the computer case. Various form factors exist for motherboards, as shown in Figure 2.

The most common form factor in desktop computers was the AT, based on the IBM AT motherboard. The AT motherboard can be up to approximately 1 foot wide. This cumbersome size led to the development of smaller form factors. The placement of heat sinks and fans often interferes with the use of expansion slots in smaller form factors.

A newer motherboard form factor, ATX, improved on the AT design. The ATX case accommodates the integrated I/O ports on the ATX motherboard. The ATX power supply connects to the motherboard via a single 20-pin connector, instead of the confusing P8 and P9 connectors used with some earlier form factors. Instead of using a physical toggle switch, the ATX power supply can be powered on and off with signaling from the motherboard.

A smaller form factor designed to be backward-compatible with ATX is the Micro-ATX. Because the mounting points of a Micro-ATX motherboard are a subset of those used on an ATX board, and the I/O panel is identical, you can use the Micro-ATX motherboard in a full-size ATX case.

Because Micro-ATX boards often use the same chipsets (Northbridges and Southbridges) and power connectors as full-size ATX boards, they can use many of the same components. However, Micro-ATX cases are typically much smaller than ATX cases and have fewer expansion slots.

Some manufacturers have proprietary form factors based on the ATX design. This causes some motherboards, power supplies, and other components to be incompatible with standard ATX cases.

The ITX form factor has gained in popularity because of its very small size. There are many types of ITX motherboards. Mini-ITX is one of the most popular. The Mini-ITX form factor uses very little power, so fans are not needed to keep it cool. A Mini-ITX motherboard has only one PCI slot for expansion cards. A computer based on a Mini-ITX form factor can be used in places where it is inconvenient to have a large or noisy computer.

An important set of components on the motherboard is the chipset. The chipset is composed of various integrated circuits attached to the motherboard. They control how system hardware interacts with the CPU and motherboard. The CPU is installed into a slot or socket on the motherboard. The socket on the motherboard determines the type of CPU that can be installed.

The chipset allows the CPU to communicate and interact with the other components of the computer, and to exchange data with system memory, or RAM, hard disk drives, video cards, and other output devices. The chipset establishes how much memory can be added to a motherboard. The chipset also determines the type of connectors on the motherboard.

Most chipsets are divided into two distinct components, Northbridge and Southbridge. What each component does varies from manufacturer to manufacturer. In general, the Northbridge controls access to the RAM, video card, and the speeds at which the CPU can communicate with them. The video card is sometimes integrated into the Northbridge. AMD and Intel have chips that integrate the memory controller onto the CPU die, which improves performance and power consumption. The Southbridge, in most cases, allows the CPU to communicate with the hard drive, sound card, USB ports, and other I/O ports.

1.1.2.2 CPUs

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The central processing unit (CPU) is considered the brain of the computer. It is sometimes referred to as the processor. Most calculations take place in the CPU. In terms of computing power, the CPU is the most important element of a computer system. CPUs come in different form factors, each style requiring a particular slot or socket on the motherboard. Common CPU manufacturers include Intel and AMD.

The CPU socket or slot is the connection between the motherboard and the processor. Most CPU sockets and processors in use today are built around the architectures of the pin grid array (PGA), shown in Figure 1, and land grid array (LGA), shown in Figure 2. In a PGA architecture, pins on the underside of the processor are inserted into the socket, usually with zero insertion force (ZIF). ZIF refers to the amount of force needed to install a CPU into the motherboard socket or slot. In an LGA architecture, the pins are in the socket instead of on the processor. Slot-based processors, shown in Figure 3, are cartridge-shaped and fit into a slot that looks similar to an expansion slot, shown at the bottom left of Figure 4.

The CPU executes a program, which is a sequence of stored instructions. Each model of processor has an instruction set, which it executes. The CPU executes the program by processing each piece of data as directed by the program and the instruction set. While the CPU is executing one step of the program, the remaining instructions and the data are stored nearby in a special memory called cache. Two major CPU architectures are related to instruction sets:

- Reduced Instruction Set Computer (RISC) - Architectures use a relatively small set of instructions. RISC chips are designed to execute these instructions very rapidly.
- Complex Instruction Set Computer (CISC) - Architectures use a broad set of instructions, resulting in fewer steps per operation.

Some Intel CPUs incorporate hyperthreading to enhance the performance of the CPU. With hyperthreading, multiple pieces of code (threads) are executed simultaneously in the

CPU. To an operating system, a single CPU with hyperthreading performs as though there are two CPUs when multiple threads are being processed.

Some AMD processors use hypertransport to enhance CPU performance. Hypertransport is a high-speed, low-latency connection between the CPU and the Northbridge chip.

The power of a CPU is measured by the speed and the amount of data that it can process. The speed of a CPU is rated in cycles per second, such as millions of cycles per second, called megahertz (MHz), or billions of cycles per second, called gigahertz (GHz). The amount of data that a CPU can process at one time depends on the size of the front side bus (FSB). This is also called the CPU bus or the processor data bus. Higher performance can be achieved when the width of the FSB increases. The width of the FSB is measured in bits. A bit is the smallest unit of data in a computer and is the binary format in which data is processed. Current processors use a 32-bit or 64-bit FSB.

Overclocking is a technique used to make a processor work at a faster speed than its original specification. Overclocking is not a recommended way to improve computer performance and can result in damage to the CPU. The opposite of overclocking is CPU throttling. CPU throttling is a technique used when the processor runs at less than the rated speed to conserve power or produce less heat. Throttling is commonly used on laptops and other mobile devices.

The latest processor technology has resulted in CPU manufacturers finding ways to incorporate more than one CPU core onto a single chip. These CPUs are capable of processing multiple instructions concurrently:

- Single Core CPU - One core inside a single CPU that handles all the processing. A motherboard manufacturer might provide sockets for more than one single processor, providing the ability to build a powerful, multiprocessor computer.
- Dual Core CPU - Two cores inside a single CPU in which both cores can process information at the same time.
- Triple Core CPU - Three cores inside a single CPU that is actually a quad-core processor with one of the cores disabled.
- Quad Core CPU - Four cores inside a single CPU
- Hexa-Core CPU - Six cores inside a single CPU
- Octa-Core CPU - Eight cores inside a single CPU

1.1.2.3 Cooling Systems

The flow of current between the electronic components generates heat. Computer components perform better when kept cool. If the heat is not removed, the computer may run slower. If too much heat builds up, computer components can be damaged.

Increasing the air flow in the computer case allows more heat to be removed. A case fan installed in the computer case, as shown in Figure 1, makes the cooling process more efficient. In addition to a case fan, a heat sink draws heat away from the CPU core. A fan on top of the heat sink, as shown in Figure 2, moves the heat away from the CPU.

Other components are also susceptible to heat damage and are sometimes equipped with fans. Video adapter cards also produce a lot of heat. Fans are dedicated to cool the graphics-processing unit (GPU), as shown in Figure 3.

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Computers with extremely fast CPUs and GPUs might use a water-cooling system. A metal plate is placed over the processor, and water is pumped over the top to collect the heat that the processor generates. The water is pumped to a radiator to release the heat into the air and is then recirculated.

1.1.2.4 ROM

Memory chips store data in the form of bytes. Bytes represent information such as letters, numbers, and symbols. A byte is a grouping of 8 bits. Each bit is stored as either 0 or 1 in the memory chip.

Read-only memory (ROM) chips are located on the motherboard and other circuit boards. ROM chips contain instructions that can be directly accessed by a CPU. Basic instructions for operation, such as booting the computer and loading the operating system, are stored in ROM. ROM chips retain their contents even when the computer is powered down. The contents cannot be erased or changed by normal means.

Note ROM is sometimes called firmware. This is misleading, because firmware is actually the software that is stored in a ROM chip.

1.1.2.5 RAM

RAM is the temporary storage for data and programs that are being accessed by the CPU. RAM is volatile memory, which means that the contents are erased when the computer is powered off. The more RAM in a computer, the more capacity the computer has to hold and process large programs and files. More RAM also enhances system performance. The maximum amount of RAM that can be installed is limited by the motherboard and the operating system.

1.1.2.6 Memory Modules

Early computers had RAM installed on the motherboard as individual chips. The individual memory chips, called dual inline package (DIP) chips, were difficult to install and often became loose. To solve this problem, designers soldered the memory chips on a special circuit board to create a memory module. The different types of memory modules are described in Figure 1.

Note Memory modules can be single-sided or double-sided. Single-sided memory modules contain RAM only on one side of the module. Double-sided memory modules contain RAM on both sides.

The speed of memory has a direct impact on how much data a processor can process, because faster memory improves the performance of the processor. As processor speed increases, memory speed must also increase. For example, single-channel memory is capable of transferring data at 64 bits per clock cycle. Dual-channel memory increases the speed by using a second channel of memory, creating a data transfer rate of 128 bits.

Double Data Rate (DDR) technology doubles the maximum bandwidth of Synchronous Dynamic RAM (SDRAM). DDR2 offers faster performance and uses less energy. DDR3 operates at even higher speeds than DDR2. However, none of these DDR technologies are

backward- or forward-compatible. Many common memory types and speeds are shown in Figure 2.

Cache

Static RAM (SRAM) is used as cache memory to store the most recently used data and instructions. SRAM provides the processor with faster access to the data than retrieving it from the slower dynamic RAM (DRAM), or main memory. The three most common types of cache memory are described in Figure 3.

Error Checking

Memory errors occur when the data is not stored correctly in the RAM chips. The computer uses different methods to detect and correct data errors in memory. Different types of error checking are described in Figure 4.

1.1.2.7 Adapter Cards and Expansion Slots

Adapter cards increase the functionality of a computer by adding controllers for specific devices or by replacing malfunctioning ports. Figure 1 shows several types of adapter cards, many of which can be integrated into the motherboard. These are some common adapter cards that are used to expand and customize the capability of a computer:

- Network Interface Card (NIC) - Connects a computer to a network using a network cable.
- Wireless NIC - Connects a computer to a network using radio frequencies.
- Sound adapter - Provides audio capability.
- Video adapter - Provides graphic capability.
- Capture card - Sends a video signal to a computer so that the signal can be recorded to the computer hard drive with Video Capture software.
- TV tuner card - Provides the ability to watch and record television signals on a PC by connecting a cable television, satellite, or antenna to the installed tuner card.
- Modem adapter - Connects a computer to the Internet using a phone line.
- Small Computer System Interface (SCSI) adapter - Connects SCSI devices, such as hard drives or tape drives, to a computer.
- Redundant Array of Independent Disks (RAID) adapter - Connects multiple hard drives to a computer to provide redundancy and to improve performance.
- Universal Serial Bus (USB) port - Connects a computer to peripheral devices.
- Parallel port - Connects a computer to peripheral devices.
- Serial port - Connects a computer to peripheral devices.

Computers have expansion slots on the motherboard to install adapter cards. The type of adapter card connector must match the expansion slot. The different types of expansion slots are shown in Figure 2.

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1.1.2.8 Storage Devices and RAID

Storage drives, as shown in Figure 1, read or write information to magnetic, optical, or semiconductor storage media. The drive can be used to store data permanently or to retrieve information from a media disk. Storage drives can be installed inside the computer case, such as a hard drive. For portability, some storage drives can connect to the computer using a USB port, a FireWire port, eSATA, or a SCSI port. These portable storage drives are sometimes referred to as removable drives and can be used on multiple computers. Here are some common types of storage drives:

- Floppy drive
- Hard drive
- Optical drive
- Flash drive

Floppy Drive

A floppy drive, or floppy disk drive, is a storage device that uses removable 3.5-inch floppy disks. These magnetic floppy disks can store 720 KB or 1.44 MB of data. In a computer, the floppy drive is usually configured as the A: drive. The floppy drive can be used to boot the computer if it contains a bootable floppy disk. A 5.25-inch floppy drive is older technology and is seldom used.

Hard Drive

A hard drive, or hard disk drive, is a magnetic device used to store data. In a Windows computer, the hard drive is usually configured as the C: drive and contains the operating system and applications. The storage capacity of a hard drive ranges from gigabytes (GB) to terabytes (TB). The speed of a hard drive is measured in revolutions per minute (RPM). This is how fast the spindle turns the platters that hold data. The faster the spindle speed, the faster a hard drive can retrieve data from the platters. Common hard drive spindle speeds include 5400, 7200, 10,000, and up to 15,000 RPM in high-end server hard drives. Multiple hard drives can be added to increase storage capacity.

Traditional hard drives use magnetic-based storage. Magnetic hard drives have drive motors that are designed to spin the magnetic platters and move the drive heads. In contrast, the newer solid state drives (SSDs) do not have moving parts and use semiconductors to store data. Because an SSD has no drive motors and moving parts, it uses much less energy than a magnetic hard drive. Nonvolatile flash memory chips manage all storage on an SSD, which results in faster access to data, higher reliability, and reduced power usage. SSDs have the same form factor as magnetic hard drives and use ATA or SATA interfaces. You can replace a magnetic drive with an SSD.

Tape Drive

Magnetic tapes are most often used for backups or archiving data. The tape uses a magnetic read/write head. Although data retrieval using a tape drive can be fast, locating specific data is slow because the tape must be wound on a reel until the data is found. Common tape capacities vary between a few gigabytes to many terabytes.

Optical Drive

An optical drive uses lasers to read data on the optical media. There are three types of optical drives:

- Compact disc (CD)
- Digital versatile disc (DVD)
- Blu-ray disc (BD)

CD, DVD, and BD media can be pre-recorded (read only), recordable (write once), or re-recordable (read and write multiple times). CDs have a data storage capacity of approximately 700 MB. DVDs have a data storage capacity of approximately 4.7 GB on a single-layer disc, and approximately 8.5 GB on a dual-layer disc. BDs have a storage capacity of 25 GB on a single-layer disc, and 50 GB on a dual-layer disc.

There are several types of optical media:

- CD-ROM - CD read-only memory media that is pre-recorded
- CD-R - CD recordable media that can be recorded one time
- CD-RW - CD rewritable media that can be recorded, erased, and re-recorded
- DVD-ROM - DVD read-only memory media that is pre-recorded
- DVD-RAM - DVD RAM media that can be recorded, erased, and re-recorded
- DVD+/-R - DVD recordable media that can be recorded one time
- DVD+/-RW - DVD rewritable media that can be recorded, erased, and re-recorded
- BD-ROM - Blu-ray read-only media that is pre-recorded with movies, games, or software
- BD-R - Blu-ray recordable media that can record high-definition (HD) video and PC data storage one time
- BD-RE - Blu-ray rewritable format for HD video recording and PC data storage

External Flash Drive

An external flash drive, also known as a thumb drive, is a removable storage device that connects to a USB port. An external flash drive uses the same type of nonvolatile memory chips as SSDs and does not require power to maintain the data. These drives can be accessed by the operating system in the same way that other types of drives are accessed.

Types of Drive Interfaces

Hard drives and optical drives are manufactured with different interfaces that are used to connect the drive to the computer. To install a storage drive in a computer, the connection interface on the drive must be the same as the controller on the motherboard. Here are some common drive interfaces:

- IDE - Integrated Drive Electronics, also called Advanced Technology Attachment (ATA), is an early drive controller interface that connects computers and hard disk drives. An IDE interface uses a 40-pin connector.

- EIDE - Enhanced Integrated Drive Electronics, also called ATA-2, is an updated version of the IDE drive controller interface. EIDE supports hard drives larger than 512 MB, enables Direct Memory Access (DMA) for speed, and uses the AT Attachment Packet Interface (ATAPI) to accommodate optical drives and tape drives on the EIDE bus. An EIDE interface uses a 40-pin connector.
- PATA - Parallel ATA refers to the parallel version of the ATA drive controller interface.
- SATA - Serial ATA refers to the serial version of the ATA drive controller interface. A SATA interface uses a 7-pin data connector.
- eSATA - External Serial ATA provides a hot-swappable, external interface for SATA drives. Hot-swapping is the ability to connect and disconnect a device while a computer is powered on. The eSATA interface connects an external SATA drive using a 7-pin connector. The cable can be up to 6.56 ft (2 m) in length.
- SCSI - Small Computer System Interface is a drive controller interface that can connect up to 15 drives. SCSI can connect both internal and external drives. An SCSI interface uses a 25-pin, 50-pin, or 68-pin connector.

RAID provides a way to store data across multiple hard disks for redundancy. To the operating system, RAID appears as one logical disk. Figure 2 shows a comparison of the different RAID levels. The following terms describe how RAID stores data on the various disks:

- Parity - Detects data errors.
- Striping - Writes data across multiple drives.
- Mirroring - Stores duplicate data on a second drive.

1.1.2.9 Internal Cables

Drives require both a power cable and a data cable. A power supply might have SATA power connectors for SATA drives, Molex power connectors for PATA drives, and Berg connectors for floppy drives. The buttons and the LED lights on the front of the case connect to the motherboard with the front panel cables.

Data cables connect drives to the drive controller, which is located on an adapter card or on the motherboard. Here are some common types of data cables:

- Floppy disk drive (FDD) data cable - Has up to two 34-pin drive connectors and one 34-pin connector for the drive controller.
- PATA (IDE/EIDE) 40-conductor data cable - Originally, the IDE interface supported two devices on a single controller. With the introduction of Extended IDE, two controllers capable of supporting two devices each were introduced. The 40-conductor ribbon cable uses 40-pin connectors. The cable has two connectors for the drives and one connector for the controller.
- PATA (EIDE) 80-conductor data cable - As the data rates available over the EIDE interface increased, the chance of data corruption during transmission increased. An 80-conductor cable was introduced for devices transmitting at 33.3 MB/s and over, allowing for a more reliable balanced data transmission. The 80-conductor cable uses 40-pin connectors.

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- SATA data cable - This cable has seven conductors, one keyed connector for the drive, and one keyed connector for the drive controller.
- SCSI data cable - There are three types of SCSI data cables. A narrow SCSI data cable has 50 conductors, up to seven 50-pin connectors for drives, and one 50-pin connector for the drive controller, also called the host adapter. A wide SCSI data cable has 68 conductors, up to 15 68-pin connectors for drives, and one 68-pin connector for the host adapter. An Alt-4 SCSI data cable has 80 conductors, up to 15 80-pin connectors for drives, and one 80-pin connector for the host adapter.

Note A colored stripe on a floppy or PATA cable identifies Pin 1 on the cable. When installing a data cable, always ensure that Pin 1 on the cable aligns with Pin 1 on the drive or drive controller. Keyed cables can be connected only one way to the drive and drive controller.

1.1.3 External Ports and Cables

1.1.3.1 Video Ports and Cables

A video port connects a monitor cable to a computer. There are several video ports and connector types:

- Digital Visual Interface (DVI), as shown in Figure 1, has 24 pins for digital signals and 4 pins for analog signals. DVI-I is used for both analog and digital signals. DVI-D handles digital signals only, while DVI-A handles only analog signals.
- Displayport, as shown in Figure 2, has 20 pins and can be used for audio, video, or both audio and video transmission.
- RCA connectors, as shown in Figure 3, have a central plug with a ring around it and can be used to carry audio or video. It is common to find RCA connectors in groups of three, where a yellow connector carries video and a pair of red and white connectors carry left and right channel audio.
- DB-15, as shown in Figure 4, has 3 rows and 15 pins and is commonly used for analog video.
- BNC connectors, as shown in Figure 5, connect coaxial cable to devices using a quarter-turn connection scheme. BNC is used with digital or analog audio or video.
- RJ-45, as shown in Figure 6, has 8 pins and can be used with digital or analog audio or video.
- MiniHDMI, also called Type C, as shown in Figure 7, has 19 pins, is much smaller than an HDMI connector, and carries the same signals as an HDMI connector.
- Din-6, has 6 pins and is commonly used for analog audio, video, and power in security camera applications.

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Display cables transfer video signals from the computer to display devices. There are several display cable types:

- High-Definition Multimedia Interface (HDMI) - Carries digital video and digital audio signals. Digital signals provide high-quality video and high resolutions (Figure 8).
- DVI - Carries analog, digital, or both analog and digital video signals (Figure 8).
- Video Graphics Array (VGA) - Carries analog video signals. Analog video is low quality and can be interfered with by electrical and radio signals (Figure 8).
- Component/RGB - Carries analog video signals over three shielded cables (red, green, blue) (Figure 8).
- Composite - Carries analog audio or video signals (Figure 9).
- S-Video - Carries analog video signals (Figure 9).
- Coaxial - Carries analog, digital, or both analog and digital video or audio signals (Figure 9).
- Ethernet - Carries analog, digital, or both analog and digital video or audio signals (Figure 9). Ethernet can also carry power.

1.1.3.2 Other Ports and Cables

Input/output (I/O) ports on a computer connect peripheral devices, such as printers, scanners, and portable drives. The following ports and cables are commonly used:

- Serial
- USB
- FireWire
- Parallel
- SCSI
- Network
- PS/2
- Audio

Refer to
Online Course
for Illustration

Serial Ports and Cables

A serial port can be either a DB-9, as shown in Figure 1, or a DB-25 male connector. Serial ports transmit one bit of data at a time. To connect a serial device, such as a modem or printer, you must use a serial cable. A serial cable has a maximum length of 50 ft (15.2 m).

Modem Ports and Cables

In addition to the serial cable used to connect an external modem to a computer, a telephone cable connects the modem to a telephone outlet. This cable uses an RJ-11 connector, as shown in Figure 2. A traditional setup of an external modem using a serial cable and a telephone cable is shown in Figure 3.

USB Ports and Cables

The Universal Serial Bus (USB) is a standard interface that connects peripheral devices to a computer. It was originally designed to replace serial and parallel connections. USB devices are hot-swappable, which means that users can connect and disconnect the devices while the computer is powered on. USB connections can be found on computers, cameras, printers, scanners, storage devices, and many other electronic devices. A USB hub connects multiple USB devices. A single USB port in a computer can support up to 127 separate devices with the use of multiple USB hubs. Some devices can also be powered through the USB port, eliminating the need for an external power source. Figure 4 shows USB cables with connectors.

USB 1.1 allowed transmission rates of up to 12 Mb/s in full-speed mode and 1.5 Mb/s in low-speed mode. A USB 1.1 cable has a maximum length of 9.8 ft (3 m). USB 2.0 allows transmission speeds up to 480 Mb/s. A USB 2.0 cable has a maximum length of 16.4 ft (5 m). USB devices can only transfer data up to the maximum speed allowed by the specific port. USB 3.0 allows transmission speeds up to 5 Gb/s. USB 3.0 is backward-compatible with previous versions of USB. A USB 3.0 cable does not have a maximum defined length, although a maximum length of 9.8 ft (3 m) is generally accepted.

FireWire Ports and Cables

FireWire is a high-speed, hot-swappable interface that connects peripheral devices to a computer. A single FireWire port in a computer can support up to 63 devices. Some devices can also be powered through the FireWire port, eliminating the need for an external power source. FireWire uses the Institute of Electrical and Electronics Engineers (IEEE) 1394 standard and is also known as i.Link. The IEEE creates publications and standards for technology. Figure 5 shows FireWire cables with connectors.

The IEEE 1394a standard supports data rates up to 400 Mb/s for cable lengths of 15 ft (4.5 m) or less. This standard uses a 4-pin or 6-pin connector. The IEEE 1394b and IEEE 1394c standards allow for a greater range of connections, including CAT5 UTP and optical fiber. Depending on the media used, data rates are supported up to 3.2 Gb/s for distances of 328 ft (100 m) or less.

Parallel Ports and Cables

A parallel port on a computer is a standard Type A DB-25 female connector. The parallel connector on a printer is a standard Type B 36-pin Centronics connector. Some newer printers may use a Type C high-density 36-pin connector. Parallel ports can transmit 8 bits of data at one time and use the IEEE 1284 standard. To connect a parallel device, such as a printer, you must use a parallel cable. A parallel cable, as shown in Figure 6, has a maximum length of 15 ft (4.5 m).

eSATA Data Cables

The eSATA cable connects SATA devices to the eSATA interface using a 7-pin data cable. This cable does not supply any power to the SATA external disk. A separate power cable provides power to the disk.

SCSI Ports and Cables

A SCSI port can transmit parallel data at rates in excess of 320 Mb/s and can support up to 15 devices. If a single SCSI device is connected to a SCSI port, the cable can be up to 80 ft long (24.4 m). If multiple SCSI devices are connected to a SCSI port, the cable can be up to 40 ft (12.2 m). A SCSI port on a computer can be a 25-pin, 50-pin, or 80-pin connector, as shown in Figure 7.

Note A SCSI device must terminate at the endpoint of the SCSI chain. Check the device manual for termination procedures.

Caution Some SCSI connectors resemble parallel connectors. Be careful not to connect the cable to the wrong port. The voltage used in the SCSI format may damage the parallel interface. SCSI connectors should be clearly labeled.

Network Ports and Cables

A network port, also known as an RJ-45 port, has 8 pins and connects a computer to a network. The connection speed depends on the type of network port. Standard Ethernet can transmit up to 10 Mb/s, Fast Ethernet can transmit up to 100 Mb/s, and Gigabit Ethernet can transmit up to 1000 Mb/s. The maximum length of network cable is 328 ft (100 m). A network connector is shown in Figure 8.

PS/2 Ports

A PS/2 port connects a keyboard or a mouse to a computer. The PS/2 port is a 6-pin mini-DIN female connector. The connectors for the keyboard and mouse are often colored differently, as shown in Figure 9. If the ports are not color-coded, look for a small figure of a mouse or keyboard next to each port.

Audio Ports

An audio port connects audio devices to the computer. Some of the following audio ports are commonly used, as shown in Figure 10:

- Line in - Connects to an external source, such as a stereo system
- Microphone - Connects to a microphone
- Line out - Connects to speakers or headphones
- Sony/Philips Digital Interface Format (S/PDIF) - Connects to coaxial cable using RCA connectors or fiber-optic cable using TosLink connectors to support digital audio
- Gameport/MIDI - Connects to a joystick or MIDI-interfaced device

1.1.4 Input and Output Devices

1.1.4.1 Input Devices

An input device enters data or instructions into a computer. Here are some examples of input devices:

- Mouse and keyboard
- Gamepad and joystick
- Digital camera and digital video camera
- Biometric authentication device
- Touch screen
- Digitizer
- Scanner

Refer to
Online Course
for Illustration

Mice and Keyboards

The mouse and keyboard are the two most commonly used input devices. The mouse is used to navigate the graphical user interface (GUI). The keyboard is used to enter text commands that control the computer.

A keyboard, video, mouse (KVM) switch is a hardware device that can be used to control more than one computer while using a single keyboard, monitor, and mouse. For businesses, KVM switches provide cost-efficient access to multiple servers. Home users can save space using a KVM switch, as seen in Figure 1, to connect multiple computers to one keyboard, monitor, and mouse.

Newer KVM switches have added the capability to share USB devices and speakers with multiple computers. Typically, by pressing a button on the KVM switch, the user can change the control from one connected computer to another connected computer. Some models of the switch transfer control from one computer to another using a specific key sequence on a keyboard, such as Ctrl > Ctrl > A > Enter to control the first computer connected to the switch, and then Ctrl > Ctrl > B > Enter to transfer control to the next computer.

Gamepads and Joysticks

Input devices for playing games include gamepads and joysticks, as shown in Figure 2. Gamepads allow the player to control movement and views with small sticks moved by the player's thumbs. Multiple buttons are pressed to achieve specific results within a game, such as jumping or shooting. Many gamepads even have triggers that register the amount of pressure the player puts on them. For example, applying more pressure exerted on the trigger accelerates the player faster in a driving game.

Joysticks are also used to play games and run simulations. Joysticks are best when simulating flight where actions such as pulling the joystick toward you allow the simulated plane to climb.

Digital Cameras and Digital Video Cameras

Digital cameras and digital video cameras, shown in Figure 3, create images that can be stored on magnetic media. The image is stored as a file that can be displayed, printed, or altered. Webcams can be built into monitors or laptops, or stand alone to capture images in real time. Webcams are often used to create video for posting on the Internet or performing video chat sessions with others. They can also take still images that can be saved to the computer. A microphone allows the user to communicate audibly with others during a video chat session or record voice while creating a video.

Biometric Identification Devices

Biometric identification makes use of features that are unique to an individual user, such as fingerprints, voice recognition, or a retinal scan. When combined with ordinary usernames, biometrics guarantees that the authorized person is accessing the data. Figure 4 shows a laptop that has a built-in fingerprint scanner. By measuring the physical characteristics of the fingerprint of the user, the user is granted access if the fingerprint characteristics match the database and the correct login information is supplied.

Touch Screens

A touch screen has a pressure-sensitive transparent panel. The computer receives instructions specific to the place on the screen that the user touches.

Digitizers

A digitizer, shown in Figure 5, allows a designer or artist to create blueprints, images, or other artwork by using a pen-like tool called a stylus against a surface that senses where the stylus is located. Some digitizers have more than one surface or sensor and allow the user to create 3D models by performing actions with the stylus in mid-air.

Scanners

A scanner digitizes an image or document. The digitization of the image is stored as a file that can be displayed, printed, or altered. A bar code reader is a type of scanner that reads universal product code (UPC) bar codes. It is widely used for pricing and inventory information.

1.1.4.2 Output Devices

Refer to
Online Course
for Illustration

An output device presents information to the user from a computer. Here are some examples of output devices:

- Monitors and projectors
- Printers, scanners, and fax machines
- Speakers and headphones

Monitors and Projectors

Monitors and projectors are primary output devices for a computer. There are different types of monitors, as shown in Figure 1. The most important difference between these monitor types is the technology used to create an image:

- **CRT** - The cathode-ray tube (CRT) has three electron beams. Each beam is directed at colored phosphor dots on the screen that glow red, blue, or green when struck by the beam. Areas not struck by an electron beam do not glow. The combination of glowing and non-glowing areas creates the image on the screen. Some televisions use this technology. CRTs usually have a degauss button on the front that the user can press to remove discoloration caused by magnetic interference.
- **LCD** - Liquid crystal display (LCD) is commonly used in flat panel monitors, laptops, and some projectors. It consists of two polarizing filters with a liquid crystal solution between them. An electronic current aligns the crystals so that light can either pass through or not pass through. The effect of light passing through in certain areas and not in others is what creates the image. LCD comes in two forms, active matrix and passive matrix. Active matrix is sometimes called thin film transistor (TFT). TFT allows each pixel to be controlled, which creates very sharp color images. Passive matrix is less expensive than active matrix but does not provide the same level of image control. Passive matrix is not commonly used in laptops.
- **LED** - A light-emitting diode (LED) display is an LCD display that uses LED backlighting to light the display. LED has lower power consumption than standard LCD backlighting, allows the panel to be thinner, lighter, brighter, and display better contrast.
- **OLED** - An organic LED display uses a layer of organic material that responds to electrical stimulus to emit light. This process allows each pixel to light individually, resulting in much deeper black levels than LED. OLED displays are also thinner and lighter than LED displays.

- Plasma - Plasma displays are another type of flat panel monitor that can achieve high levels of brightness, deep black levels, and a very wide range of colors. Plasma displays can be created in sizes of up to 150 in (381 cm) or more. Plasma displays get their name from the use of tiny cells of ionized gas that light up when stimulated by electricity. Plasma displays are often used in home theater applications because of their accurate representation of video.
- DLP - Digital Light Processing (DLP) is another technology used in projectors. DLP projectors use a spinning color wheel with a microprocessor-controlled array of mirrors called a digital micromirror device (DMD). Each mirror corresponds to a specific pixel. Each mirror reflects light toward or away from the projector optics. This creates a monochromatic image of up to 1024 shades of gray in between white and black. The color wheel then adds the color data to complete the projected color image.

All-in-One Printers

Printers are output devices that create hard copies of computer files. Some printers specialize in particular applications, such as printing color photographs. All-in-one printers, like the one shown in Figure 2, are designed to provide multiple services, such as printing, scanning, faxing, and copying.

Speakers and Headphones

Speakers and headphones are output devices for audio signals. Most computers have audio support either integrated into the motherboard or on an adapter card. Audio support includes ports that allow input and output of audio signals. The audio card has an amplifier to power headphones and external speakers, as shown in Figure 3.

1.1.4.3 Monitor Characteristics

Monitor resolution refers to the level of image detail that can be reproduced. Figure 1 is a chart of common monitor resolutions. Higher resolution settings produce better image quality. Several factors are involved in monitor resolution:

- Pixel - The term pixel is an abbreviation for picture element. Pixels are the tiny dots that comprise a screen. Each pixel consists of red, green, and blue.
- Dot pitch - Dot pitch is the distance between pixels on the screen. A lower dot pitch number produces a better image.
- Contrast ratio - The contrast ratio is a measurement of the difference in intensity of light between the brightest point (white) and the darkest point (black). A 10,000:1 contrast ratio shows dimmer whites and lighter blacks than a monitor with a contrast ratio of 1,000,000:1.
- Refresh rate - The refresh rate is how often per second the image is rebuilt. A higher refresh rate produces a better image and reduces the level of flicker.
- Interlace/Non-Interlace - Interlaced monitors create the image by scanning the screen two times. The first scan covers the odd lines, top to bottom, and the second scan covers the even lines. Non-interlaced monitors create the image by scanning the screen, one line at a time from top to bottom. Most CRT monitors today are non-interlaced.
- Horizontal, vertical, and color resolution - The number of pixels in a line is the horizontal resolution. The number of lines in a screen is the vertical resolution. The number of colors that can be reproduced is the color resolution.

- Aspect ratio - Aspect ratio is the horizontal to vertical measurement of the viewing area of a monitor. For example, a 4:3 aspect ratio applies to a viewing area that is 16 inches wide by 12 inches high. A 4:3 aspect ratio also applies to a viewing area that is 24 inches wide by 18 inches high. A viewing area that is 22 inches wide by 12 inches high has an aspect ratio of 11:6.
- Native resolution - Native resolution is the number of pixels that a monitor has. A monitor with a resolution of 1280x1024 has 1280 horizontal pixels and 1024 vertical pixels. Native mode is when the image sent to the monitor matches the native resolution of the monitor.

Monitors have controls for adjusting the quality of the image. Here are some common monitor settings:

- Brightness - Intensity of the image
- Contrast - Ratio of light to dark
- Position - Vertical and horizontal location of the image on the screen
- Reset - Returns the monitor settings to factory settings

Adding additional monitors can increase work efficiency. The added monitors allow you to expand the size of the desktop so you can view more open windows. Many computers have built-in support for multiple monitors. See Figure 2 for more information about configuring multiple monitors.

1.2 Selecting Replacement Computer Components

1.2.1 Selecting PC Components

1.2.1.1 Case and Power Supply

Refer to
Online Course
for Illustration

Before making any purchases or performing upgrades, first determine the customer's needs. Ask the customer which devices will be connected to the computer both internally and externally. The computer case must be able to accommodate the size and shape of the power supply.

The computer case holds the power supply, motherboard, memory, and other components. If you are purchasing a computer case and power supply separately, ensure that all components fit into the new case and that the power supply is powerful enough to operate all the components. Many times a case comes with a power supply preinstalled. In this situation, you still need to verify that the power supply provides enough power to operate all the components that will be installed in the case.

Power supplies convert AC input to DC output voltages. Power supplies typically provide voltages of 3.3, 5, and 12, and are measured in wattage. It is recommended that the power supply has approximately 25 percent more wattage than all the attached components require. To determine the total wattage required, add the wattage for each component. If the wattage is not listed on a component, calculate it by multiplying its voltage and amperage. If the component requires different levels of wattage, use the higher requirement. After determining the necessary wattage, ensure that the power supply has the required connectors for all the components.

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for Illustration

1.2.1.2 Selecting Motherboards

New motherboards often have new features or standards that may be incompatible with older components. When you select a replacement motherboard, make sure that it supports the CPU, RAM, video adapter, and other adapter cards. The socket and chipset on the motherboard must be compatible with the CPU. The motherboard must also accommodate the existing heat sink and fan assembly when reusing the CPU. Pay particular attention to the number and type of expansion slots. Make sure that they match the existing adapter cards and allow for new cards that will be used. The existing power supply must have connections that fit the new motherboard. Finally, the new motherboard must physically fit into the current computer case.

Different motherboards use different chipsets. A chipset consists of integrated circuits that control the communication between the CPU and the other components. The chipset establishes how much memory can be added to a motherboard and the type of connectors on the motherboard. When building a computer, choose a chipset that provides the capabilities that you need. For example, you can purchase a motherboard with a chipset that enables multiple USB ports, eSATA connections, surround sound, and video.

Motherboards have different types of CPU sockets and CPU slots. This socket or slot provides the connection point and the electrical interface for the CPU. The CPU package must match the motherboard socket type or CPU slot type. A CPU package contains the CPU, connection points, and materials that surround the CPU and dissipate heat.

Data travels from one part of a computer to another through a collection of wires known as the bus. The bus has two parts. The data portion of the bus, known as the data bus, carries data between the computer components. The address portion, known as the address bus, carries the memory addresses of the locations where data is read or written by the CPU.

The bus size determines how much data can be transmitted at one time. A 32-bit bus transmits 32 bits of data at one time from the processor to RAM or to other motherboard components, while a 64-bit bus transmits 64 bits of data at one time. The speed at which data travels through the bus is determined by the clock speed, measured in MHz or GHz.

PCI expansion slots connect to a parallel bus, which sends multiple bits over multiple wires simultaneously. PCI expansion slots are being replaced with PCIe expansion slots that connect to a serial bus, which sends one bit at a time at a faster rate. When building a computer, choose a motherboard that has slots to meet your current and future needs. For example, if you are building a computer for advanced gaming that needs dual graphics cards, you might choose a motherboard with dual PCIe x16 slots.

1.2.1.3 Selecting the CPU and Heat Sink and Fan Assembly

Before you buy a CPU, make sure that it is compatible with the existing motherboard. Manufacturers' websites are a good resource to investigate the compatibility between CPUs and other devices. When upgrading the CPU, make sure the correct voltage is maintained. A Voltage Regulator Module (VRM) is integrated into the motherboard. You can configure the CPU voltage setting with jumpers, switches located on the motherboard, or settings in the BIOS.

Multicore processors have two or more processors on the same integrated circuit. Integrating the processors on the same chip creates a very fast connection between them. Multicore processors execute instructions more quickly than single-core processors and have increased data throughput. Instructions can be distributed to all the processors at the

same time. RAM is shared between the processors because the cores reside on the same chip. A multicore processor is recommended for applications such as video editing, gaming, and photo manipulation.

High-power consumption creates more heat in the computer case. Multicore processors conserve power and produce less heat than multiple single-core processors, thus increasing performance and efficiency.

The speed of a modern processor is measured in GHz. A maximum speed rating refers to the maximum speed at which a processor can function without errors. Two primary factors can limit the speed of a processor:

- The processor chip is a collection of transistors interconnected by wires. Transmitting data through the transistors and wires creates delays.
- As the transistors change state from on to off or off to on, a small amount of heat is generated. The amount of heat generated increases as the speed of the processor increases. When the processor becomes too hot, it begins to produce errors.

The front-side bus (FSB) is the path between the CPU and the Northbridge. It is used to connect various components, such as the chipset and expansion cards, and RAM. Data can travel in both directions across the FSB. The frequency of the bus is measured in MHz. The frequency at which a CPU operates is determined by applying a clock multiplier to the FSB speed. For example, a processor running at 3200 MHz might be using a 400 MHz FSB. 3200 MHz divided by 400 MHz is 8, so the CPU is eight times faster than the FSB.

Processors are further classified as 32-bit and 64-bit. The primary difference is the number of instructions that can be handled by the processor at one time. A 64-bit processor processes more instructions per clock cycle than a 32-bit processor. A 64-bit processor can also support more memory. To utilize the 64-bit processor capabilities, ensure that the operating system and applications installed support a 64-bit processor.

One of the most expensive and sensitive components in the computer case is the CPU. The CPU can become very hot. Many CPUs require a heat sink, combined with a fan for cooling. A heat sink is a piece of copper or aluminum that sits between the processor and the CPU fan. The heat sink absorbs the heat from the processor and then the fan disperses the heat. When choosing a heat sink or fan, there are several factors to consider.

- Socket type - The heat sink or fan type must match the socket type of the motherboard.
- Motherboard physical specifications - The heat sink or fan must not interfere with any components attached to the motherboard.
- Case size - The heat sink or fan must fit within the case.
- Physical environment - The heat sink or fan must be able to disperse enough heat to keep the CPU cool in warm environments.

The CPU is not the only component in a computer case that can be adversely affected by heat. A computer has many internal components that generate heat while the computer is running. Case fans should be installed to move cooler air into the computer case while moving heat out of the case. When choosing case fans, there are several factors to consider:

- Case size - Larger cases often require larger fans because smaller fans cannot create enough air flow.

- Fan speed - Larger fans spin more slowly than smaller fans, which reduces fan noise.
- Number of components in the case - Multiple components in a computer create additional heat, which requires more fans, larger fans, or faster fans.
- Physical environment - The case fans must be able to disperse enough heat to keep the interior of the case cool.
- Number of mounting places available - Different cases have different numbers of mounting places for fans.
- Location of mounting places available - Different cases have different locations for mounting fans.
- Electrical connections - Some case fans are connected directly to the motherboard, while others are connected directly to the power supply.

Note The direction of air flow created by all the fans in the case must work together to bring the cooler air in while moving the hotter air out. Installing a fan backwards or using fans with the incorrect size or speed for the case can cause the air flows to work against each other.

1.2.1.4 Selecting RAM

Refer to
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for Illustration

New RAM may be needed when an application locks up or the computer displays frequent error messages. To determine if the problem is the RAM, replace the old RAM module as shown in the figure. Restart the computer to see if the computer runs without error messages.

When selecting new RAM, you must ensure that it is compatible with the current motherboard. It must also be the same type of RAM that is currently installed in the computer. The speed of the new RAM must be supported by the chipset. It may help to take the original memory module with you when you shop for the replacement RAM.

1.2.1.5 Selecting Adapter Cards

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Adapter cards, also called expansion cards, are designed for a specific task and add extra functionality to a computer. The figure shows some of the adapter cards available. Before you purchase an adapter card, answer the following questions.

- Is there an open expansion slot?
- Is the adapter card compatible with the open slot?
- What are the customer's current and future needs?
- What are the possible configuration options?
- What are the reasons for the best choice?

If the motherboard does not have a compatible expansion slot, an external device may be an option. Other factors that affect the selection process include cost, warranty, brand name, availability, and form factor.

Graphics Cards

The type of graphics card installed affects the overall performance of a computer. The programs and tasks that the graphics card may need to support could be RAM intensive, CPU intensive, or both. There are several factors to consider when purchasing a new graphics card:

- Slot type
- Port type
- Amount and speed of video RAM (VRAM)
- Graphics processor unit (GPU)
- Maximum resolution

A computer system must have the slots, RAM, and CPU to support the full functionality of an upgraded graphics card to receive all the benefits of the card. Choose the correct graphics card based on your customer's current and future needs. For example, if a customer wants to play 3D games, the graphics card must meet or exceed the minimum requirements for any game they want to play.

Some GPUs are integrated into the CPU. When the GPU is integrated into the CPU, there is no need to purchase a graphics card unless advanced video features such as 3D graphics or very high resolution are required. To use the built-in graphics capability of a CPU, purchase a motherboard that supports this feature.

Sound Cards

The type of sound card installed determines the sound quality of your computer. There are several factors to consider when purchasing a new sound card:

- Slot type
- Digital signal processor (DSP)
- Sample rate
- Port and connection types
- Hardware decoder
- Signal-to-noise ratio

A computer system must have quality speakers and a subwoofer to support the full functionality of an upgraded sound card. Choose the correct sound card based on your customer's current and future needs. For example, if a customer wants to hear a specific type of surround sound, the sound card must have the correct hardware decoder to reproduce it. In addition, the customer can get improved sound accuracy with a sound card that has a higher sample rate.

Storage Controllers

A storage controller is a chip that can be integrated into the motherboard or on an expansion card. Storage controllers allow for the expansion of internal and external drives for

a computer system. Storage controllers, such as RAID controllers, can also provide fault tolerance or increased speed. There are several factors to consider when purchasing a new storage controller card:

- Slot type
- Drive type
- Connector quantity
- Connector location
- Card size
- Controller card RAM
- Controller card processor
- RAID type

The amount of data and the level of data protection needed for the customer influences the type of storage controller required. Choose the correct storage controller based on your customer's current and future needs. For example, if a customer wants to implement RAID 5, a RAID storage controller with at least three drives is needed.

I/O Cards

Installing an I/O card in a computer is a fast and easy way to add I/O ports. There are several factors to consider when purchasing an I/O card:

- Slot type
- I/O port type
- I/O port quantity
- Additional power requirements

FireWire, USB, parallel, and serial ports are some of the most common ports to install on a computer. Choose the correct I/O card based on your customer's current and future needs. For example, if a customer wants to add an internal card reader, and the motherboard has no internal USB connection, a USB I/O card with an internal USB connection is needed.

NICs

Customers upgrade a network interface card (NIC) to get faster speeds, more bandwidth, and better access. There are several factors to consider when purchasing a NIC:

- Slot type
- Speed
- Connector type
- Connection type
- Standards compatibility

Capture Cards

A capture card imports video into a computer and records it on a hard drive. The addition of a capture card with a television tuner allows you to view and record television programming. There are several factors to consider when purchasing a capture card:

- Slot type
- Resolution and frame rate
- I/O port
- Format standards

The computer system must have enough CPU power, adequate RAM, and a high-speed storage system to support the capture, recording, and editing demands of the customer. Choose the correct capture card based on your customer's current and future needs. For example, if a customer wants to record one program while watching another, either multiple capture cards or a capture card with dual TV tuners must be installed.

1.2.1.6 Selecting Hard Drives and Floppy Drives

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You may need to replace a storage device when it no longer meets your customer's needs or it fails. The signs that a storage device is failing might include:

- Unusual noises
- Unusual vibrations
- Error messages
- Corrupt data or applications

Floppy Disk Drive

While Floppy Disk Drives (FDDs) still have some limited uses, they have been largely superseded by USB flash drives, external hard drives, CDs, DVDs, and memory cards. If an existing FDD fails, replace it with one of the newer storage devices.

Hard Drives

A hard drive stores data on magnetic platters. There are several different types and sizes of hard drives. Hard drives use different connection types. Figure 1 shows PATA, SATA, eSATA, and SCSI connectors. There are several factors to consider when purchasing a new hard drive:

- Adding or replacing
- Internal or external
- Case location
- System compatibility
- Heat generation
- Noise generation
- Power requirements

PATA hard drives use a 40-pin / 80-conductor cable or a 40-pin / 40-conductor cable. Choose the PATA hard drive if your customer's system is a legacy system or does not support SATA.

SATA and eSATA hard drives use a 7-pin / 4-conductor cable. Although SATA and eSATA cables are similar, they are not interchangeable. SATA drives are internal. eSATA drives are external. Choose a SATA or eSATA hard drive if your customer needs a much higher data-transfer rate than PATA and the system supports SATA or eSATA.

SCSI hard drives use a 50-pin, 68-pin, or 80-pin connector. Up to 15 SCSI drives can be connected to a SCSI drive controller. A typical use for SCSI drives is to run a server or to implement RAID. SCSI devices are typically connected in a series, forming a chain that is commonly called a daisy chain, as shown in Figure 2. Figure 3 shows the different types of SCSI.

Each device in the SCSI chain must have a unique ID for the computer to communicate with the right device. This includes the SCSI adapter. Typically, the SCSI adapter is given the highest number. For narrow SCSI, the IDs 0-7 are available. For wide SCSI, the IDs 0-15 are available. The controller is 7 or 15, and the other devices in the chain use the remaining IDs. In early SCSI installations, jumpers were used to assign SCSI IDs to adapters and devices. Modern adapters most often assign IDs using a program installed on the adapter or in the operating system.

Some drives may be capable of hot-swapping. Hot-swappable drives can be connected and disconnected to the computer without turning the computer off. Normally, to install an eSATA hard disk, you shut down the computer, connect the drive, and turn the computer back on. A hot-swappable eSATA drive can be plugged in to the computer at any time. External USB hard drives are also capable of hot-swapping. Check the documentation of your motherboard to determine if you can use hot-swappable drives.

1.2.1.7 Selecting Solid State Drives and Media Readers

Solid State Drives

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An SSD uses static RAM instead of magnetic platters to store data, as shown in Figure 1. SSDs are considered to be highly reliable because they have no moving parts.

Choose an SSD if your customer needs to do any of the following:

- Operate in extreme environments
- Use less power
- Produce less heat
- Reduce startup time

Media Readers

A media reader is a device that reads and writes to different types of media cards, for example, those found in a digital camera, smart phone, or MP3 player. When replacing a media reader, ensure that it supports the type of cards used and the storage capacity of the cards to be read. There are several factors to consider when purchasing a new media reader:

- Internal or external
- Type of connector used
- Type of media cards supported

Choose the correct media reader based on your customer's current and future needs. For example, if a customer needs to use multiple types of media cards, a multiple format media reader is needed. These are some common media cards, as shown in Figure 2:

- Secure digital (SD) - SD cards were designed for use in portable devices such as cameras, MP3 players, and tablets. SD cards can hold as much as 4 GB. SD High Capacity (SDHC) cards can hold as much as 32 GB, while SD Extended Capacity (SDXC) cards can hold as much as 2 TB of data.
- microSD - A much smaller version of SD, commonly used in cellular phones.
- CompactFlash - CompactFlash is an older format, but still in wide use because of its high capacity (up to 128 GB is common) and high speed. CompactFlash is often used as storage for video cameras.
- Memory Stick - A proprietary flash memory created by Sony Corporation. Memory Stick is used in cameras, MP3 players, hand-held video game systems, mobile phones, cameras, and other portable electronics.

1.2.1.8 Selecting Optical Drives

Refer to
Online Course
for Illustration

An optical drive uses a laser to read and write data to and from optical media. There are several factors to consider when purchasing an optical drive:

- Interface type
- Reading capability
- Writing capability
- Format

A CD-ROM drive can only read CDs. A CD-RW can read and write to CDs. Choose a CD-RW if your customer needs to read and write to CDs.

A DVD-ROM drive can only read DVDs and CDs. A DVD-RW can read and write to DVDs and CDs. DVDs hold significantly more data than CDs. Choose a DVD-RW if your customer needs to read and write to DVDs and CDs.

A Blu-ray reader (BD-R) can only read Blu-ray Discs, DVDs, and CDs. A Blu-ray writer (BD-RE) can read and write to Blu-ray Discs and DVDs. Blu-ray Discs hold significantly more data than DVDs. Choose a BD-RE drive if your customer needs to read and write to Blu-ray Discs.

1.2.1.9 Selecting External Storage

Refer to
Online Course
for Illustration

External storage connects to an external port, such as a USB, IEEE 1394, SCSI, or eSATA. External flash drives, sometimes called thumb drives, that connect to a USB port are a type of removable storage. There are several factors to consider when purchasing external storage:

- Port type
- Storage capacity
- Speed

- Portability
- Power requirements

External storage offers portability and convenience when working with multiple computers. Choose the correct type of external storage for your customer's needs. For example, if your customer needs to transfer a small amount of data, such as a single presentation, an external flash drive is a good choice. If your customer needs to back up or transfer large amounts of data, choose an external hard drive.

1.2.1.10 Selecting Input and Output Devices

Refer to
Online Course
for Illustration

To select input and output devices, first find out what the customer wants. Next, select the hardware and software by researching the Internet for possible solutions. After you determine which input or output device the customer needs, you must determine how to connect it to the computer. Figure 1 shows common input and output connectors.

Technicians should have a good understanding of several types of interfaces:

- FireWire (IEEE 1394) - Transfers data at 100, 200, or 400 Mb/s and IEEE 1394b at 800 Mb/s.
- Parallel (IEEE 1284) - Transfers data at a maximum speed of 3 MB/s.
- Serial (RS-232) - Early versions were limited to 20 Kb/s, but newer versions can reach transfer rates of 1.5 Mb/s.
- SCSI (Ultra-320 SCSI) - Connects as many as 15 devices with a transfer rate of 320 MB/s.

The USB interface is widespread and used with many different devices. Figure 2 shows the common USB 1.1 and 2.0 plugs and connectors. Figure 3 shows common USB 3.0 plugs and connectors.

The SATA interface has become common in recent years. SATA is replacing IDE and EIDE as the standard interface for hard drives and SSDs. SATA cables are easier to connect because they only have two ends, drives do not need to be jumpered, and eSATA drives can be hot-plugged if the motherboard supports hot-plugging. Figure 4 compares PATA and SATA speeds.

Refer to
Worksheet
for this chapter

1.2.1.11 Worksheet - Research Computer Components

1.3 Configurations for Specialized Computer Systems

1.3.1 Specialized Computer Systems

1.3.1.1 CAx Workstations

Refer to
Online Course
for Illustration

You may need to design, build, and install computers for a customer that can accomplish a specific task. All computers can run programs, store data, and use I/O devices. A special-

ized computer must support hardware and software that allows a user to perform tasks that an off-the-shelf system cannot perform. One example of a specialized computer is a workstation used to run computer-aided design (CAD) or computer-aided manufacturing (CAM) software.

A CAD or CAM (CAx) workstation, as shown in the figure, is used to design products and control the manufacturing process. CAx workstations are used to create blueprints, design homes, cars, airplanes, and many of the parts in the products that you use every day. CAx is even used to develop the computer parts used in CAx workstations. A computer used to run CAx software must support the needs of the software and the I/O devices that the user needs to design and manufacture products. CAx software is often complex and requires robust hardware. Consider the following hardware when you need to run CAx software:

- **Powerful processor** - CAx software must make enormous amounts of calculations very quickly. You must meet the needs of the software when choosing a CPU.
- **High-end video card** - Some CAx software is used to create 3D models. Realistic shading and texturing add to the complexity of the models, and a video card that can handle high resolutions and high detail is needed. Often, multiple monitors are desired or even required so that the user can work with code, 2D renderings, and 3D models all at the same time. Choose a video card that supports multiple monitors.
- **RAM** - Because of the high amount of data processed by a CAx workstation, RAM is very important. The more RAM that is installed, the more data the processor can calculate before needing to read from slower storage, such as hard drives. Install as much memory as is supported by the motherboard and the operating system. The quantity and speed of the memory should exceed the minimums recommended by the CAx application.

1.3.1.2 Audio and Video Editing Workstations

Refer to
Online Course
for Illustration

An audio and video editing workstation is used during many stages of development when creating audio and video material. An audio editing workstation is used to record music, create music CDs, and CD labels. A video editing workstation can be used to create television commercials, prime-time programming, and movies for the theater or home movies.

Specialized hardware and software are combined to build a computer to perform audio and video editing. Audio software on an audio editing workstation, shown in the figure, is used to record audio, manipulate how the audio sounds through mixing and special effects, and finalize recordings for publication. Video software is used to cut, copy, combine, and change video clips. Special effects are also added to video using video software. Consider the following hardware when you need to run audio and video editing software:

- **Specialized audio card** - When recording music to a computer in a studio, multiple inputs from microphones and many outputs to effects equipment may be needed. An audio card capable of handling all these inputs and outputs is needed. Research different audio card manufacturers and understand the needs of your customer to install an audio card that will meet all the needs of a modern recording or mastering studio.
- **Specialized video card** - A video card that can handle high resolutions and multiple displays is necessary to combine and edit different video feeds and special effects in real time. You must understand the needs of the customer and research video cards to install a card that can handle the high amounts of information that comes from modern cameras and effects equipment.

- Large, fast hard drive - Modern video cameras record in high resolution at fast frame rates. This translates into a high amount of data. Small hard drives will fill up very quickly, and slow hard drives will not be able to keep up with demands, even dropping frames at times. A large, fast hard drive is necessary to record high-end video without errors or missed frames. RAID levels such as 0 or 5, where striping is used, can help to increase storage speed.
- Dual monitors - When working with audio and video, two, three, or even more monitors can be very helpful to keep track of everything that is going on with multiple tracks, scenes, equipment, and software. Find out how your customer likes to work to decide how many monitors is most beneficial. If multiple monitors are required, specialized video cards are necessary when building an audio or video workstation.

1.3.1.3 Virtualization Workstations

Refer to
Online Course
for Illustration

You may need to build a computer for a client that uses virtualization technologies. Simultaneously running two or more operating systems on one computer is called virtualization. Often, an operating system is installed, and virtualization software is used to install and manage additional installations of other operating systems. Different operating systems from multiple software companies may be used.

There is also another type of virtualization. Virtual Desktop Infrastructure (VDI) allows users to log in to a server to access their own virtual computers. Input from the mouse and keyboard is sent to the server to manipulate the virtual computer. Output such as sound and video is sent back to the speakers and display of the computer accessing the virtual computer. Low-powered devices, such as old laptops, can perform difficult calculations quickly because they are being performed on a server that is much more powerful. Laptops, smart phones, and tablets can also access the VDI to use the virtual computers. These are some other functions of virtual computing:

- Test software or software upgrades in an environment that does not hurt your current operating system environment
- Use other operating systems on one computer, such as Linux or Ubuntu
- Browse the Internet without harmful software hurting your main installation
- Run old applications that are not compatible with modern operating systems

Virtual computing requires more powerful hardware configurations because each installation needs its own resources. One or two virtual environments can be run on a modern computer with modest hardware, but a complete VDI installation may require fast, expensive hardware to support multiple users in many different environments. This is some of the hardware required to run virtual computers:

- Maximum RAM - You need enough RAM to meet the requirements of each virtual environment and the host computer. A standard installation using only a few virtual machines might require as little as 64 MB of RAM to support a modern operating system such as Windows XP. With multiple users, supporting many virtual computers for each user, you might need to install as much as 64 GB of RAM or more.
- CPU cores - Although a single core CPU can perform virtual computing, a CPU with additional cores increases speed and responsiveness when hosting multiple users and virtual machines. Some VDI installations use computers that have multiple CPUs that have multiple cores.

Refer to
Online Course
for Illustration

1.3.1.4 Gaming PCs

Many people enjoy playing computer games. Each year, games become more advanced and require more powerful hardware, new hardware types, and additional resources to ensure a smooth and enjoyable gaming experience.

You may be required to build a computer for a customer designed specifically for playing games. This is some of the hardware required when building a gaming computer:

- **Powerful processor** - Games require all the components in the computer to work together seamlessly. A powerful processor helps ensure that all the software and hardware data can be addressed in a timely fashion. Multiple core processors can help increase the responsiveness of hardware and software.
- **High-end video card** - Modern games use high resolutions and intricate detail. A video card that has a fast, specialized GPU and high amounts of fast video memory is necessary to ensure that the images displayed on the monitor are high quality, clear, and smooth. Some gaming machines use multiple video cards to produce high frame rates or use multiple monitors.
- **High-end sound card** - Video games use multiple channels of high-quality sound to immerse the player in games. A high-quality sound card increases the quality of sound above that of built-in sound on a computer. A dedicated sound card also helps improve overall performance by taking some of the demand off of the processor.
- **High-end cooling** - High-end components often produce more heat than standard components. More robust cooling hardware is often needed to make sure that the computer stays cool under heavy loads while playing advanced games. Oversized fans, heat sinks, and water cooling devices are often used to keep CPUs, GPUs, and RAM cool.
- **Large amounts of fast RAM** - Computer games require large amounts of memory to function. Video data, sound data, and all the information needed to play the game are constantly being accessed. The more RAM that the computer has, the less often the computer needs to read from slower storage, such as hard drives or SSDs. Faster RAM helps the processor keep all the data in sync, because the data that it needs to calculate can be retrieved when it is needed.
- **Fast storage** - 7200 RPM and 10000 RPM drives can retrieve data at a much faster rate than 5400 RPM hard drives. SSD drives are more expensive, but they improve the performance of games dramatically.
- **Gaming-specific hardware** - Some games involve communicating with other players. A microphone is required to talk to them, and speakers or headphones are required to hear them. Find out what type of games your customer plays to determine if a microphone or headset is needed. Some games can be played in 3D. Special glasses and specific video cards may be required to use this feature. Also, some games might benefit from the use of more than one monitor. Flight simulators, for example, can be configured to display cockpit images across two, three, or even more monitors at the same time.

Refer to
Online Course
for Illustration

1.3.1.5 Home Theater PCs

Building a Home Theater Personal Computer (HTPC) requires specialized hardware to deliver a high-quality viewing experience for the customer. Each piece of equipment must connect and properly provide the necessary services and resources to support the different demands required from an HTPC system.

A useful feature of an HTPC is the ability to record a video program to watch at a later time. HTPC systems can be designed to display live television, stream movies and Internet content, display family photos and videos, and even surf the Internet on a television. Consider the following hardware when building an HTPC:

- Specialized cases and power supplies - Smaller motherboards can be used when building an HTPC so that the components can fit into a more compact form factor case. This small form factor looks like a component usually found in a home theater. Usually an HTPC case contains large fans that move more slowly and create less noise than those found in an average workstation. Power supplies that do not have fans can be used (depending on power requirements) to further reduce the amount of noise created by the HTPC. Some HTPC designs contain high-efficient components and require no fans for cooling.
- Surround sound audio - Surround sound helps to bring the viewer into the video program. An HTPC can use surround sound from the motherboard when the chipset supports it, or a dedicated sound card can be installed to output high-quality surround sound to speakers or an additional amplifier for even better sound.
- HDMI output - The HDMI standard allows for transmission of high-definition video, surround sound, and data to televisions, media receivers, and projectors.
- TV tuners and cable cards - A tuner must be used for the HTPC to display television signals. A TV tuner converts analog and digital television signals into audio and video signals that the computer can use and store. Cable cards can be used to receive television signals from a cable company. A cable card is required for access to premium cable channels. Some cable cards can receive as many as six channels simultaneously.
- Specialized hard drive - Hard drives, that have low noise levels and have reduced power consumption are commonly known as audio/video drives (A/V).

Refer to
Worksheet
for this chapter

1.3.1.6 Worksheet - Build a Specialized Computer System

1.4 Introduction to the Personal Computer

1.4.1 Summary

Refer to
Online Course
for Illustration

This chapter introduced the components that comprise a personal computer system and how to consider upgrade components. Much of the content in this chapter will help you throughout this course.

- Information technology encompasses the use of computers, network hardware, and software to process, store, transmit, and retrieve information.
- A personal computer system consists of hardware components and software applications.
- The computer case and power supply must be chosen carefully to support the hardware inside the case and allow for the addition of components.
- The internal components of a computer are selected for specific features and functions. All internal components must be compatible with the motherboard.
- Use the correct type of ports and cables when connecting devices.

- Typical input devices include the keyboard, mouse, touch screen, and digital cameras.
- Typical output devices include monitors, printers, and speakers.
- Cases, power supplies, the CPU and cooling system, RAM, hard drives, and adapter cards, must be upgraded when devices fail or no longer meet customer needs.
- Specialized computers require hardware specific to their function. The type of hardware used in specialized computers is determined by how a customer works and what a customer wants to accomplish.

Go to the online course to take the quiz and exam

Chapter 1 Quiz

This quiz is designed to provide an additional opportunity to practice the skills and knowledge presented in the chapter and to prepare for the chapter exam. You will be allowed multiple attempts and the grade does not appear in the gradebook.

Chapter 1 Exam

The chapter exam assesses your knowledge of the chapter content.

Your Chapter Notes

