31 Days Before Your CompTIA A+ Exams

Ben Conry

A day-by-day review guide for the Cisco Networking Academy IT Essentials student

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Mind Wide Open

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Introduction

31 Days Before Your CompTIA A+ Exams is a bridge between the Cisco IT Essentials: PC Hardware and Software v4.0 course and the CompTIA A+ exams. You stand ready to make your knowledge official, provable, to become a professional computer technician. Every day for the next 31 days, you will cover a small area of the exams. The divide-and-conquer strategy allows you to focus on the topics at hand and not be overwhelmed with the massive amount of tested material.

Professional certifications have been an important part of the computing industry for many years and will continue to become more important. Many reasons exist for these certifications, but the most popularly cited reason is that of credibility. All other considerations held equal, the certified employee/consultant/job candidate is considered more valuable than one who is not.

Goals and Methods

The goal of this book is to provide you with a step-by-step method of study and preparation for the CompTIA A+ exam that is mapped directly to the Cisco Networking Academy course IT Essentials: PC Hardware and Software. In this book, you will find the following:

- Short summaries of topics, definitions, and diagrams of important concepts
- Numbers that map topics in this book to pages in the IT Essentials: PC Hardware and Software v4.0 course
- Tables, figures, and examples of devices, directions, and commands you might find on the CompTIA A+ exams
- References for further study and exploration
- Occasional attempts at nerd humor

This book can also serve as guide for instructors to review the IT Essentials: PC Hardware and Software v4.0 course and prepare an entire class for the A+ exams. You can use this book to fit certification exam preparation into a busy schedule, because it is a little bit of study each day.

Who Should Read This Book?

This book is for students who are about to take the CompTIA A+ exams and are either currently enrolled or a recent graduate of Cisco Networking Academy IT Essentials: PC Hardware and Software v4.0 course.

Strategies for Exam Preparation

Find a distraction-free area: no kids, no siblings, no pets, no headphones, no radio or TV. (A cup of coffee and a fireplace are recommended, however.) Dedicate about an hour every day to study in this refuge. It can be difficult at first to find the time and place, but it is time and effort well spent. To that retreat, bring this book, your attention, and preferably access to the Cisco IT Essentials PC Hardware and Software v4.0 online course. A set of A+ flash cards are a great resource, too. InformIT offers a great set that you can find at http://www.informit.com/title/0789739208.

How This Book Is Organized

This book is organized differently than most. The A+ exam has three paths to completion. Everyone takes the A+ Essentials exam. Then you choose one of three specialization exams to take. Sucessful completion of either the 220-602 Field Technician, 220-603 Remote Technician, or 220-604 Bench Technician exam will earn your A+ certification.

This book begins with the Essentials exam coverage in Day 31 to Day 15. After that, you choose which exam to take based on your scores in the eight domains covered on the Essentials exam. (Refer to the CompTIA website, http://www.comptia.org, for more information about the eight domains.) You will then continue on to the part of the book that covers that exam and work through Day 14 to Day 1 of that specific part.

To aid in your exam preparation, use the calendars printed on the tearout card to map out each day of study. Also, before you take the Essentials and specialized exams, use the checklists printed on the inside front and back covers of this book to ensure you have a firm grasp of the exam topics.

Day 31

Hardware Concepts: Part 1 of 2

A+ Essentials Exam Objective

Objective 1.1: Identify the fundamental principles of using personal computers

Key Points

Today you will cover topics from Chapters 1 and 3 in the IT Essentials v4.0 course. Specifically, you will review the names, purposes, and characteristics of storage devices, adapter cards, motherboards, central processing units (CPU), and power supplies. Today is the first half of two challenging days. It does get easier. The internal devices have many details, all of which are fair game on the CompTIA A+ exam. Today you will cover the devices, and tomorrow you will review some of the technologies and installation procedures. Remember that 21% of the CompTIA A+ Essentials exam comes from these first two days. Faced with entering a cold swimming pool, a running-start, closed-eye, tucked-knee cannonball is a great way to get in the water (and impress your friends). So take a big breath and hold your nose.

Storage Devices

1.4.6: Storage devices include hard drives, floppy drives, nonvolatile random-access memory (NVRAM), tape drives, optical drives (CD and DVD drives), and network drives.

Hard Drives

The hard disk drive (HDD) has been a mainstay of PCs for a long time. Because of its widespread use, it is a big part of the A+ exam. Traditionally, the HDD stores the operating system and the bulk of data in the PC. It is mounted in a 3.5-inch bay, and connects internally through a parallel advanced technology attachment (PATA) channel. PATA interfaces are sometimes referred to as advanced technology attachment (ATA) or integrated drive electronics (IDE). Jumpers are used to determine the HDD's designation either as master or slave.

Most new PCs use a controller called serial ATA (SATA) for HDD and optical drives. SATA does not use jumpers or designations. Instead, SATA uses one header and one cable per drive.

All HDDs work the same way. Arms move read/write (R/W) heads over the surface of spinning magnetic platters. These R/W heads either align molecules to create a positive charge (a 1) or leave it neutral charge (a 0), thus making the binary code. When reading, the heads float above the disks and feel the positive charges or no pull from the neutral.

Floppy Drives

In many ways, a floppy disk drive (FDD) is like a HDD. It spins a disk, moves R/W heads across the surface, and stores data magnetically. There are two important differences: Capacity is limited to 1.44 MB, and the disk is removable by the end user. A classic A+ question involves an FDD status light that stays lit all the time. The cable is oriented backward. Turn off the PC, unplug the FDD cable from the drive, flip it over, and plug it back in. Normally, the colored wire on the ribbon cable (pin 1) is closest to the Berg power connector. On the motherboard end, it should be oriented based on the numbers printed around the FDD cable header. Because there are 34 wires in an FDD cable, it is narrower than a PATA ribbon.

Solid-State HDD and NVRAM

Ranging from small external universal serial bus (USB) devices to larger-capacity HDDs, solid-state drives are in reality NVRAM storage devices. NVRAM, often referred to as flash memory or flash RAM, is slower than RAM but still faster than traditional magnetic storage media. Unlike RAM, NVRAM can maintain its data when not powered. Solid-state drives are especially good for laptops where portability, performance, durability, and low power consumption are valued over price and drive capacity.

Tape Drives

A magnetic tape is drawn across stationary R/W heads, but the same magnetic process takes place. The tape is removable by the user, but the drive remains mounted and connected to the PC. Tape capacity is large, comparable to HDDs, but access time is slow because of the sequential nature of tape media. These are primarily used as server backups.

CD and DVD Drives

The basic optical drive is a compact disc read-only memory (CD-ROM). This CD-ROM drive reads premade discs and cannot write (burn) CDs. The CD can hold 650 MB or 700 MB of data. The CD-ROM drive mounts in a 5.25-inch bay and connects to the motherboard via a PATA or SATA interface.

Digital versatile disc (DVD) has many more variations. The basic read and write letters still apply, but there are two formats: + and –. For our purposes, they are the same. Just note that they are not compatible with each other. Plus drives only read/write plus CDs. Newer +/– hybrid drives can read and write both. Generally speaking, DVD drives are backward compatible and can use CDs. A typical DVD holds 4.7 GB of data or 8.5 GB for double layered (on the same side).

Table 31-1 compares CD and DVD drives.

Table 31-1 Optical Drives

CD Family	DVD Family	Need to Know
CD-ROM	DVD-ROM	Can only read premade discs.
CD-R	DVD+/-R	(Recordable) Write a disc once, and it is read-only after that.
CD-RW	DVD+/-RW	(Rewritable) Read and write a disc repeatedly.
CDRAM (not an optical drive)	DVD-RAM	("Endlessly" rewritable) Used primarily as surveillance-camera footage.

Network Drives

These drives are often referred to as remote, shared, or mapped drives. This means that the storage device resides on another computer, server, printer, or other network device, not on the end user's (local) PC.

Interfaces and Cables

1.4.7: All storage devices in the computer are connected to the motherboard through cables. For your A+ exam, you just need to know a few basics about each cable. The term *hot swappable* means the drive can be connected and unplugged while the PC is running. Pin 1 is always the pin with the blue, red, or pink stripe. Both the device and the motherboard will specify (usually with inhumanly small numbers) which side is pin 1. If there is no indication how to orient the cable, put pin 1 closest to the Molex power plug.

Table 31-2 compares the features of different drive interfaces.

Table 31-2 Drive Interfaces

Interface	Drives per Channel	Number of Pins	Hot Swappable	Need to Know (In Order of Importance)
PATA, ATA, IDE, EIDE	2	40 80	No	Old standard. Two drives per channel. Jumpers assign master and slave drives.
SCSI	8 or 16	50 68 80	Yes	Typically found on servers. Drives are arranged along a bus-like cable with terminators on both ends. Jumpers or dip switches assign drive numbers in binary.
SATA	1	7	Yes	Small cable improves air cooling. Faster than PATA. One drive per channel No jumpers, no master, and no slave.
FDD	1	34	No	Only for the FDD. Pin 1 is usually oriented closest to the power connector, but look for the red strip e. Some old FDD cables support multiple FDDs. They have a twist in the middle of the ribbon connectors.

Adapter Cards

3.6.1, 3.9.2: Adapter cards convert binary communication into a format that other devices or humans can understand. There is always an adapter card between an external port and the motherboard. Many fundamental adapter cards are built (integrated) into the motherboard. A driver is a small piece of software that explains to the OS how to use the device, not unlike a translation guide or instruction manual. It is common to install an OS and then need to install additional drivers afterward, even for commonly integrated devices such as sound cards and network interface cards (NIC). USB is an external port and is a common interface for external adapter cards. The devices that connect through an adapter card also need drivers.

Daughter Boards Versus Riser Boards

A classic A+ exam question focuses on the difference between daughter and riser boards. Daughter boards and risers are essentially the same device. They are smaller boards that plug into the motherboard that expand the number of expansion slots, ports, or in some cases, add devices. If the board is used solely to add extra PCI slots or turn the angle of adapter cards to fit into smaller cases, then it is a riser. The two exceptions are Audio Modem Riser (AMR) and Communications Network Risers (CNR). They are an evolutionary missing link between true integrated devices and full-fledged expansion cards.

Adapter Card Interfaces

1.4.5: Whereas there are countless ports and external devices, there are a finite number of expansion slots though which adapter cards and motherboards connect. What you need to know about adapter cards and interfaces is explained here in order of learning importance. Check out the Cisco IT Essentials v4.0 course curriculum for great photos of these cards. You should be able to identify them by sight and description.

Table 31-3 describes internal side of the cards and the kinds of expansion slots. Table 31-4 describes the external aspects, such as which devices or ports are commonly supported by specific cards.

Table 31-3 Expansion Slots

Adapter Card/ Bus Name	Bus Width	Need to Know (In Order of Importance)
PCI	64 32	Current standard, 32 bit and 64 bit, shorter than ISA. Usually white. 32 bit have two in-line slots; 64 bit have 3.
AGP	32	Dedicated graphics card slot, 32 bit, shorter than PCI. Brown.
PCIe	x1 x4 x8 x16	Full duplex lets data be sent and received simultaneously. Measured in throughput as a multiple of 250 MBps. For example a x4 PCIe slot and card can transfer data at 1000 Mbps. (250 MBps × 4 = 1000 MBps)

Table 31-3 Expansion Slots *continued*

Adapter Card/ Bus Name	Bus Width	Need to Know (In Order of Importance)
EISA ISA	32 16 8	Old technology, slot 8- and 16-bit versions (32-bit EISA). Black. Common in older PCs.
MCA	32	Old proprietary IBM version competitor of 32-bit EISA.

Table 31-4 Adapter Cards

Adapter	Uses These Buses	Need to Know (In Order of Importance)
NIC	PCI, PCIe, or USB	Connects the PC to a network.
Wireless NIC	PCI, PCIe, or USB	Connects a PC to a wireless network.
Video adapter	PCIe, AGP, or PCI	Translates data into video signal for the monitor.
USB	PCI	Is an adapter in this case. Like a SCSI, it forwards data onto another kind of bus. It often provides both internal and external USB ports.
FireWire	PCI or PCIe	Is similar to USB but nearly twice as fast. Commonly used to transfer video or other data-intensive applications.
Sound/audio adapter	PCI or PCIe	Translates data into audio signals for speakers.
SCSI adapter	PCI or PCIe	Is an additional bus link, like a transfer station. It forwards data to and from the PC to SCSI HDDs and devices.
RAID adapter	PCI or PCIe	Controls the spreading of data across multiple HDDs. Commonly used for SCSI but can also be used for SATA.
Modem	PCI or USB	Is like a combination NIC and sound adapter. It connects the PC to an audio/telephone-based network.
Parallel port	PCI	Connects peripheral parallel devices to the PC. Although somewhat rare today, it was the predominant method to connect to printer, scanners, and fax machines. The distinctive cable has a 25-pin D plug on the computer end and a 36-pin Centronics port on the other. Moves data along multiple channels simultaneously (parallel).
Serial port	PCI	Connects peripheral parallel devices to the PC. Not commonly used today. Moves data along one channel, bit by bit (serial).

Motherboards

1.4.1: Motherboards are the unsung heroes in the PC. They are responsible for practically all the communication and physical connections. The vintage advanced technology (AT) and Baby AT motherboards of the 1990s are not a major focus on the A+ exam. You need to know that they supported mostly ISA expansion cards and have 66-MHz busses.

Advanced technology extended (ATX) motherboards have been continually upgraded and modified over the past 15 years. There have been letter designations along the way to thicken the alphabet soup. The ATX and its offspring make up the majority of the current marketplace. Table 31-5 describes the different motherboard form factors.

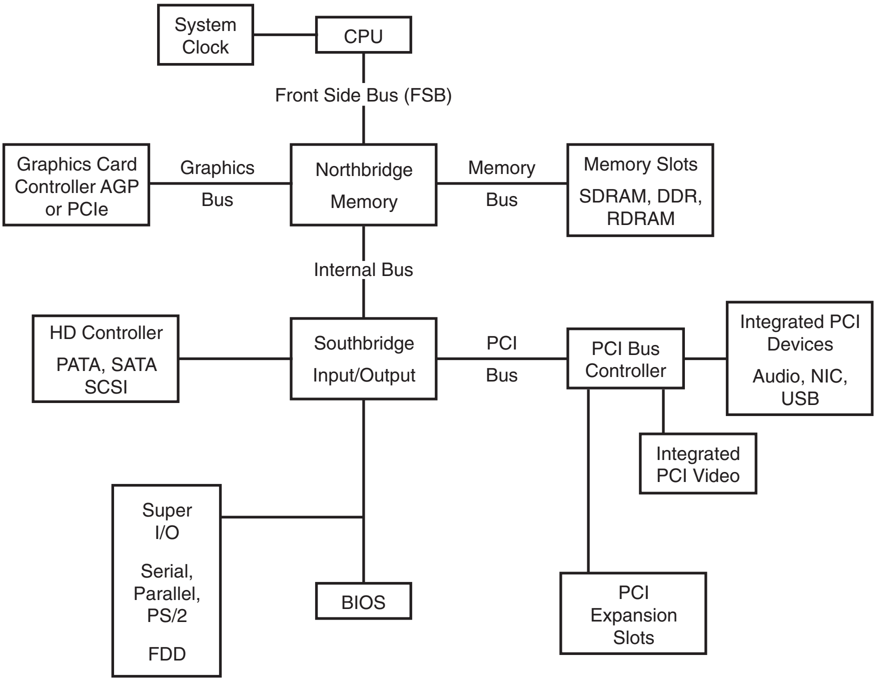
Table 31-5 Motherboard Form Factors

Motherboard Name	Need to Know (In Order of Importance)
ATX	Introduced riser boards and daughter boards. Integrated keyboard, mouse, and video. Single 20-pin power-supply connection.
BTX (balanced technology extended)	This progeny of the ATX is the most common motherboard on the market today. First to integrate SATA, PCIe, and USB 2.0.
NLX	Integrated AGP, NIC, and USB support.
Mini ATX	Smaller and fewer expansion slots than ATX.
Micro ATX	Even smaller than Mini ATX.
LPX	Expansion cards run parallel to motherboard and can therefore fit in to a smaller case. Proprietary designs complicate repair. Typically must use original equipment manufacturer's (OEM) parts.
Mini LPX	Smaller and fewer expansion slots than LPX.

The chipset and buses on the motherboard determine a great deal about the computer that is built around it. The general architecture of motherboards is a great source of A+ questions.

Figure 31-1 shows the map of a motherboard, which is hierarchal. That means that it is organized from top to bottom in order of importance. Basically, the farther away a device is from the CPU, the less priority it has. Like the human body, the really important organs (devices) are inside, close to the core, and protected.

Figure 31-1 Motherboard Map



The CPU is only a processor, fast but not able to do anything but follow instructions. It uses a clock like a metronome to keep everything synchronous (on the beat), just as a marching band uses drums to stay together. The clock rate is the actual speed of the processor. The speed of this clock is measured in gigahertz (GHz) and is either set by jumpers (like those on PATA drives) on older systems or in the basic input/output system (BIOS) in newer PCs. The front-side bus (FSB) is the front door to the CPU. The width of the FSB determines whether the chip is a 32- or 64-bit processor. The speed of this bus is critical to the performance of the PC. All too often, novice technicians or manufacturers trying to save money will build and sell super-fast processors on cheap motherboards that have very slow FSBs. This is akin to driving a race car on a one-lane dirt road.

The northbridge controls two of the most important tasks on a PC: It sends instructions from RAM to the CPU, and it sends graphic data to the video card. The video card is a fast, dedicated card very much like a small motherboard complete with RAM and a graphic processing unit (GPU). Video cards often have their own cooling system. This allows the PC to worry about tasks other than constantly redrawing the monitor 60 or more times a second. RAM often has its own group of devices to support ever-faster access times and increasing capacities.

The other requests and data that are not RAM or video are forwarded on to the southbridge. That is where storage devices, adapter cards, and ports are located. This is collectively referred to as the input/output (I/O) controller. If your PC is using the integrated video, all that data must be processed by the southbridge. It is often busy with HDD and CD data, network traffic, and so on. Using AGP or PCIe cards tied into the northbridge used for video greatly increases the overall efficiency of the machine.

CPU Slots and Sockets

1.4.2: CPUs connect to the motherboard in only two ways. A socket is designed to receive flat, square, tile-like CPUs with hundreds of tiny pins on one side. The socket uses zero-insertion-force (ZIF) to avoid bending pins during installation. The latching lever sits alongside the socket. Pull it away from the socket to free the catch. Then move the lever upward to release the CPU. The CPU sets into the pin grid array (PGA). During installation, note the orientation with the missing pin in the corner. The lever is returned to its position. Thermal compound is used to help transfer heat from the CPU to the heat sink. This material is toxic, and gloves should be used. The slot-style CPUs are built to receive a blade that contains the contacts. They simply slide in guided by posts and snap into place. Slot-style CPUs were common on older motherboards.

Table 31-6 shows CPU socket and slot specifications. Memorizing these specifications is universally disliked by A+ exam candidates. If you are good at memorizing, enjoy. For the rest of us, here are some patterns and a few tricks:

- PGA and the first number in the number of pins is almost always the same in the early CPUs.
- PGAs are always square (21 × 21), or the new ones are simply a number (949 grid PGA).
- Slots don't use PGAs (because they are slots).
- Socket 6 is not used at all and is not likely tested.
- In general, the newer the CPU, the less voltage it uses.
- The names of the later connectors include the number of pins (socket 370, for example).

Table 31-6 CPUs

Connector	CPU	Pins	Voltage
Socket 4	Pentium 60/66	273 pins 21 × 21 PGA	5V
Socket 5	Pentium 75/90/100/120/133	320 pins	3.3V 37 × 37 SPGA
Socket 7	Pentium MMX, AMD KS, Cyrix M	321 pins 37 × 37 SPGA	2.5V to 3.3V
Super Socket 7	AMD KS-2, AMD KS-III	321 pins 37 × 37 SPGA	2.5V to 3.3V
Socket 8	Pentium Pro	387 pins 24 × 26 SPGA	3.3V
Socket 370 or PGA 370 Socket	Pentium III FC-PGA, Celeron PPGA, Cyrix III	370 pins 37 × 37 SPGA	1.5V or 2V
Slot 1 or SC242	Pentium II, Pentium III	242 pins 2 rows	2.8V and 3.3V
Slot A	AMD Athlon	242 pins 2 rows	1.3V to 2.05V

Table 31-6 CPUs *continued*

Connector	CPU	Pins	Voltage
Socket A or Socket 462	AMD Athlon and Duron	462 pins SPGA	1.1V to 1.85V
Slot 2 or SC330	Pentium II Xeon, Pentium III Xeon	330 pins 2 rows	1.5V to 3.5V
Socket 423	Pentium 4	423 pins 39 × 39 SPGA	1.7V and 1.75V
Socket 478	Pentium 4	478 pins micro PGA (mPGA)	1.7V and 1.75V
Socket PAC418	Itanium	418 pins	3.3V
Socket PAC611	Itanium 2	611 pins	3.3V
Socket 603	Xeon DP and MP	603 pins	1.5V and 1.7V
Socket 754	AMD Athlon 64, Sempron, Turion 64	754 pins PGA	0.8V to 1.55V
Socket 775 or Socket T	Pentium 4, Celeron D, Pentium 4 Extreme Edition, Pentium D, Pentium Extreme Edition, Core 2 Duo, Core 2 Extreme	755 pins LGA	
Socket 939	AMD Athlon 64, Athlon 64 FX, Athlon 64 X2, Opteron, Sempron	939 pins PGA	0.8V to 1.55V
Socket 940	AMD Athlon 64 FX and Opteron	940 pins PGA	0.8V to 1.55V
Socket AM2	AMD Athlon 64, Athlon 64 X2, Athlon 64 FX, Sempron	940 pins PGA	1.35V

The reality is technicians always refer to the documentation to verify compatibility before purchasing CPUs and motherboards. A quick lookup is well worth avoiding a pricey mistake.

RISC and CISC

There are two families of CPUs: Complex Instruction Set Computing (CISC) and Reduced Instruction Set Computing (RISC). When asked to multiply 4 x 5, a CISC chip will spend more time looking for the multiplication tool among the many possible methods than completing the task quickly. A RISC will quickly find the addition tool among the fewer options available to it and add 4 + 4 + 4 + 4 + 4. The calculation will take longer, but locating the tool took less time. RISC is outstanding for repetitive tasks such as packet routing in Cisco routers, display adapters, servers. CISC chips are great for multipurpose PCs that face many different kinds of requests. Most CPUs are CISC, but only recently did Macintosh switch. For many years, it used RISC chips by Motorola. Today, Intel and American Micro Devices (AMD) dominate the PC CPU market.

Power Supplies

1.3.2: Power supplies switch alternating current (AC) power from the wall to direct current (DC) power for the PC. There is a switch on the outside of the power supply that chooses 115 volts (V) AC in North America versus 230, the European standard. A switch near the power plug allows power supplies to accept U.S. or European standards. Power supplies are measured in watts (W); the more watts, the better. You need to provide more watts than the PC consumes. A 500-W supply is about standard. Gaming systems and other high-end graphics applications tend to use more than that.

The standard form factor for power supplies is the ATX. A 20-pin block connects the motherboard. Another small block of 4 to 8 pins lets the BIOS and OS control the power supply. The communication between computer and power supply is called advanced configuration and power interface (ACPI). All the other devices in the PC are powered by 12V yellow, 5V red, and a black ground wire. There are two sizes of plugs: Molex and Berg. Molex is bigger than Berg. An easy trick to remember this is that the name Molex (five letters) is longer than the name Berg (four letters). Newer power supplies provide special 15-pin power connectors for SATA drives. You can power SATA HDDs with either, but not both.

Use a multimeter to test the DC output. Set the multimeter to read volts DC (20V DC on older, non-auto-ranging multimeters). Put the common lead on the black ground wire or directly on the chassis (metal frame). The chassis is the electrical ground. Use the test lead to contact the other colors on a plug. The colors should read as shown in Table 31-7.

Table 31-7 Power-Supply Voltages

Color	Voltage	Mnemonic
Yellow	12V	**Y**ou
Red	5V	**R**eally
Orange	3.3V	**O**ughta
Black	0V	**B**elieve
White	–5V	**W**arren
Blue	–12V	**B**uffett

Green, gray, and purple are signal wires and standby features, so they are not a major focus on the A+ exam.

To test the wall outlet, the multimeter must be set to read volts AC. Connect the black common lead on the round ground hole or the large (neutral) slot, and put the test lead in the small (phase) slot. A properly functioning outlet should read 110 to 120 VAC. In the absence of a multimeter, use a working lamp or appliance to test the outlet.

WARNING: These colors are not standard among all electrical systems. The black ground in DC should never be confused with the black wire in AC systems that carry 110V, usually at 20 amps or more, which is more than enough to kill you.

A technician should never, ever open three specific PC components: the power supply, laser printers, and cathode-ray tube (CRT) monitors. These contain capacitors and charges that are still "live," even when unplugged. The A+ exam uses these as distracters.

If you are not fully confident about electricity, find an experienced electrician and ask for a fuller explanation. You need to "own" this knowledge to be a PC technician.

Uninterruptible power supplies (UPS) are an external battery-powered device that supply power to computer and network devices during a power outage. Battery UPSs are frequently used on mission-critical devices like servers and routers. UPS power is usually limited to about 30 minutes and is normally designed to provide enough power to automatically shut down the PCs. For extreme cases, diesel generators are used to generate "unlimited" electricity (provided unlimited fuel is available) for banks, air traffic control, hospitals, and so on.

Homework

1. Practice drawing the motherboard map for memory.
2. Practice the power-supply mnemonic until you can re-create the chart from memory.
3. Wiki the ATX and BTX motherboards.
4. Have someone quiz you on the PCI, PCIe, AGP, and ISA need-to-know details.

Funwork

There are several build-a-PC activities in this book. You don't need to actually purchase the equipment. These activities are like fantasy football or using a website to customize a car or shoe *without* actually buying it. These activities are designed to immerse you in the details and force you to "speak" your future language.

The first build-a-PC exercise is for a high-end, money-is-no-object, over-the-top (imaginary) game system. Start by reading online techie forums about video cards and motherboards. Immerse yourself in geekspeak, and it will get easier to understand. Ask techies questions, but watch out for IT bravado. Many hard-core techies are not kind to newbies. Also understand that these dream machines are not really tested on the A+ exam. State-of-the-art expert opinion and the A+ exam seldom line up. It is like asking a NASCAR driver how to parallel park for your driver's license exam.

"Purchase" a motherboard, CPU, HDD, and CD drive. Keep in mind that the motherboard determines the kind of storage interfaces, adapter cards, and RAM you can use in the future. Hint: The FSB and video adapter and RAM bus are common bottlenecks. Choose carefully. Next, figure out what kind of case and power supply best suits your needs. Tomorrow, we will add RAM and install the devices. Good luck and have fun. Check out computers by Alienware and other game-oriented PCs to see how the pros build them and to check your work.

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