Microsoft

CompTIA® A+®

Exam 220-801
Exam 220-802

Darril Gibson

Training Kit

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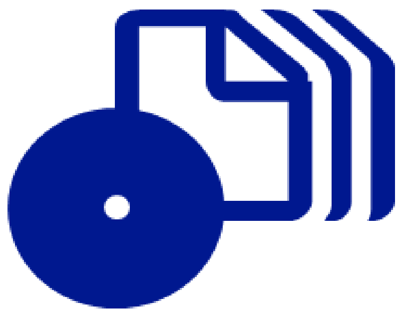

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Microsoft Press

CompTIA A+ Exam 220-801 Objective Map

OBJECTIVE		CHAPTER
1.0 PC HARDWARE (40 PERCENT)		
1.1	Configure and apply BIOS settings.	2
1.2	Differentiate between motherboard components, their purposes, and properties.	1, 2, 3
1.3	Compare and contrast RAM types and features.	3
1.4	Install and configure expansion cards.	5, 6
1.5	Install and configure storage devices and use appropriate media.	4
1.6	Differentiate among various CPU types and features and select the appropriate cooling method.	3
1.7	Compare and contrast various connection interfaces and explain their purpose.	4, 5, 6, 9, 19
1.8	Install an appropriate power supply based on a given scenario.	1
1.9	Evaluate and select appropriate components for a custom configuration, to meet customer specifications or needs.	10
1.10	Given a scenario, evaluate types and features of display devices.	6
1.11	Identify connector types and associated cables.	4, 5, 6, 19
1.12	Install and configure various peripheral devices.	5, 6, 7
2.0 NETWORKING (27 PERCENT)		
2.1	Identify types of network cables and connectors.	19
2.2	Categorize characteristics of connectors and cabling.	19
2.3	Explain properties and characteristics of TCP/IP.	20, 21, 24
2.4	Explain common TCP and UDP ports, protocols, and their purpose.	20, 21
2.5	Compare and contrast wireless networking standards and encryption types.	23
2.6	Install, configure, and deploy a SOHO wireless/wired router using appropriate settings.	22, 23
2.7	Compare and contrast Internet connection types and features.	9, 18
2.8	Identify various types of networks.	18, 19
2.9	Compare and contrast network devices and their functions and features.	18, 22
2.10	Given a scenario, use appropriate networking tools.	19, 24
3.0 LAPTOPS (11 PERCENT)		
3.1	Install and configure laptop hardware and components.	8
3.2	Compare and contrast the components within the display of a laptop.	8
3.3	Compare and contrast laptop features.	8
4.0 PRINTERS (11 PERCENT)		
4.1	Explain the differences between the various printer types and summarize the associated imaging process.	7
4.2	Given a scenario, install, and configure printers.	7
4.3	Given a scenario, perform printer maintenance.	7
5.0 OPERATIONAL PROCEDURES (11 PERCENT)		
5.1	Given a scenario, use appropriate safety procedures.	1, 6, 19
5.2	Explain environmental impacts and the purpose of environmental controls.	1, 10
5.3	Given a scenario, demonstrate proper communication and professionalism.	10
5.4	Explain the fundamentals of dealing with prohibited content/activity.	10

Exam Objectives The exam objectives listed here are current as of this book's publication date. Exam objectives are subject to change at any time without prior notice and at CompTIA's sole discretion. Please visit the CompTIA Certifications webpage for the most current listing of exam objectives: *http://certification.comptia.org/getCertified/certifications.aspx*.

CompTIA A+ Exam 220-802 Objective Map

OBJECTIVE		CHAPTER
1.0 OPERATING SYSTEMS (33 PERCENT)		
1.1	Compare and contrast the features and requirements of various Microsoft Operating Systems.	12
1.2	Given a scenario, install, and configure the operating system using the most appropriate method.	11, 12, 15, 16, 18
1.3	Given a scenario, use appropriate command line tools.	14, 16, 17, 24
1.4	Given a scenario, use appropriate operating system features and tools.	7, 12, 13, 14, 15, 16, 17, 22, 25
1.5	Given a scenario, use Control Panel utilities (the items are organized by "classic view/large icons" in Windows).	6, 8, 13, 15, 22, 25
1.6	Setup and configure Windows networking on a client/desktop.	18, 19, 21, 22, 24
1.7	Perform preventive maintenance procedures using appropriate tools.	15, 16, 17, 26
1.8	Explain the differences among basic OS security settings.	25
1.9	Explain the basics of client-side virtualization.	10
2.0 SECURITY (22 PERCENT)		
2.1	Apply and use common prevention methods.	22, 25, 26
2.2	Compare and contrast common security threats.	26
2.3	Implement security best practices to secure a workstation.	25, 26
2.4	Given a scenario, use the appropriate data destruction/disposal method.	25
2.5	Given a scenario, secure a SOHO wireless network.	23
2.6	Given a scenario, secure a SOHO wired network.	24
3.0 MOBILE DEVICES (9 PERCENT)		
3.1	Explain the basic features of mobile operating systems.	9
3.2	Establish basic network connectivity and configure email.	9
3.3	Compare and contrast methods for securing mobile devices.	9
3.4	Compare and contrast hardware differences in regards to tablets and laptops.	9
3.5	Execute and configure mobile device synchronization.	9
4.0 TROUBLESHOOTING (36 PERCENT)		
4.1	Given a scenario, explain the troubleshooting theory.	10
4.2	Given a scenario, troubleshoot common problems related to motherboards, RAM, CPU and power with appropriate tools.	1, 2, 3, 24
4.3	Given a scenario, troubleshoot hard drives and RAID arrays with appropriate tools.	4, 14, 16, 17
4.4	Given a scenario, troubleshoot common video and display issues.	6
4.5	Given a scenario, troubleshoot wired and wireless networks with appropriate tools.	19, 23, 24
4.6	Given a scenario, troubleshoot operating system problems with appropriate tools.	12, 15, 17, 26
4.7	Given a scenario, troubleshoot common security issues with appropriate tools and best practices.	26
4.8	Given a scenario, troubleshoot, and repair common laptop issues while adhering to the appropriate procedures.	8
4.9	Given a scenario, troubleshoot printers with appropriate tools.	7

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Darril Gibson

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To my wife, Nimfa. Thanks for all the support you've given me over the years. I'm grateful for my successes and I know that many of them are due to the support you provide on a daily basis.

—Darril Gibson

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Introduction

This training kit is designed for information technology (IT) professionals who want to earn the CompTIA A+ certification. It is assumed that you have a basic understanding of computers and Windows operating systems. However, the A+ certification is an entry-level certification, so you are not expected to have any in-depth knowledge to use this training kit.

To become an A+ certified technician, you must take and pass the 220-801 and 220-802 exams. The primary goal of this training kit is to help you build a solid foundation of IT knowledge so that you can successfully pass these two exams the first time you take them.

The materials covered in this training kit and on exams 220-801 and 220-802 relate to the technologies a successful personal computer (PC) technician is expected to understand. This includes PC hardware concepts, Windows operating system technologies, networking basics, and IT security. You can download the objectives for the 220-801 and 220-802 exams from the CompTIA website: *http://certification.comptia.org/Training/testingcenters/examobjectives.aspx*.

By using this training kit, you will learn how to do the following:

- Recognize hardware components used within a computer.
- Assemble a computer's hardware components.
- Install, configure, and maintain devices.
- Troubleshoot and repair hardware problems.
- Install, configure, and troubleshoot laptop computers.
- Describe, install, configure, and troubleshoot printers.
- Describe the features used in mobile operating systems.
- Configure and secure mobile devices.
- Describe the differences between common operating systems.
- Install and configure operating systems.
- Use various command line and operating system tools.
- Troubleshoot and repair operating system issues.
- Recognize common components used in a network.
- Connect a computer and configure it on a network.
- Troubleshoot basic networking issues.
- Recognize common prevention methods used to enhance security.

Refer to the objective mapping page in the front of this book to see where in the book each exam objective is covered.

About the Exams

The 220-801 exam is focused on skills required to install and maintain hardware. It includes objectives in the following five areas:

- PC Hardware (40 percent of exam)
- Networking (27 percent of exam)
- Laptops (11 percent of exam)
- Printers (11 percent of exam)
- Operational Procedures (11 percent of exam)

The 220-802 exam is focused on operating systems and troubleshooting. This includes troubleshooting operating systems, security issues, and hardware. It includes objectives in the following four areas:

- Operating Systems (33 percent of exam)
- Security (22 percent of exam)
- Mobile Devices (9 percent of exam)
- Troubleshooting (36 percent of exam)

These exams became available in late 2012 and are the fifth version of A+ exams. Previous versions came out in 1993, 2003, 2006, and 2009, and over the years, more than 900,000 people around the world have earned the A+ certification. IT professionals commonly start with the A+ certification to lay a solid foundation of IT knowledge and later move on to higher-level certifications and better-paying jobs.

As I write this, CompTIA has not published how many questions will be on each exam, how long you'll have to complete each exam, or what the passing scores are. You can look here for up to date information: *http://certification.comptia.org/aplus.aspx*.

In previous versions, each exam included 100 questions and you had 90 minutes to complete the exam. This gave you a little less than a minute to answer each question. Because of this, the questions were straightforward. For example, what's 10 + 10? Either you know it or you don't, and you won't need to spend a lot of time analyzing the question.

More than likely, you'll have the same number of questions, but you'll probably have longer to complete them due to the addition of performance-based questions. Most of the questions will be simple, but some will require you to perform a task.

Prerequisites

CompTIA recommends that test takers have a minimum of 12 months of lab or field work experience prior to taking the exams. That is, they expect that you have been studying computers (lab work) working in an IT job (field work) or a combination of both for at least 12 months.

This is different from what CompTIA has previously recommended. The 220-701 and 220-702 objectives recommended test takers have 500 hours of lab or field work, which equals about three months of 40-hour weeks.

Note that this is not a requirement to take the exams. Anyone can take the exams after paying for them, and if they pass, they earn the certification. However, you'll have the best chance of success if you have been studying and working with computers for at least 12 months.

Performance Based Testing

A significant difference in the 220-801 and 220-802 exams over previous versions is the introduction of performance-based testing. Instead of just using multiple choice questions, CompTIA is introducing questions that will require you to perform a task.

Imagine that you wanted to know if a person could ride a bike. You could ask some multiple choice questions, but you'll find that these questions aren't always reliable. A person might answer questions correctly but not be able to actually ride the bike. Put the person in front of a bike, ask the person to ride it, and you'll quickly know whether the person can or not. Performance-based testing uses this philosophy to see if someone has a skill.

Consider the following multiple choice question:

1. Which of the following commands will change a file to read-only?
   - **A.** assoc -R study.txt
   - **B.** attrib +R study.txt
   - **C.** readonly -true study.txt
   - **D.** ren -readonly study.txt

The answer is attrib, and the +R switch sets the read-only attribute to true, making it read-only.

This same knowledge might be tested in a performance-based testing question as follows:

1. "Navigate to the C:\Data folder and change the study.txt file to read-only." When you click a button, you'll be in a simulated Windows environment with a Command Prompt. You would then need to enter the following two commands:

```
cd \data
attrib +R studynotes.txt
```

When it's a multiple choice question, you have a 25-percent chance of getting it correct. Even if you didn't remember the exact syntax of the attrib command but knew the purpose of it, you would probably get the previous question correct. The performance-based testing method requires you to know the material and be able to enter the correct commands.

Throughout the book, with performance-based testing in mind, I've included steps and instructions for how to do many tasks. If you do these tasks as you work through the book, you'll be better prepared to succeed with these performance-based tests. I'll also be posting A+ notes and tips on Blogs.GetCertifiedGetAhead.com. Check it out.

Objective Changes

CompTIA includes a note in the objectives that states that, "Objectives are subject to change without notice." I don't know of any time they've changed the objectives without notice, but they have changed objectives.

For example, when the 220-701 and 220-702 objectives were published in 2009, Windows 7 wasn't available and the objectives didn't include any Windows 7 topics. However, the popularity of Windows 7 increased, and CompTIA decided to add Windows 7 topics. In September 2010, CompTIA announced objective modifications to include Windows 7. The changes became effective for anyone who took the exam after January 1, 2011.

The same timing is occurring with the 220-801/220-802 objectives and Windows 8. When the objectives were first published, Windows 8 was not available, so you won't see any Windows 8 topics on the exams.

Is it possible that Windows 8 will become popular and that CompTIA will announce changes to the objectives in 2013? Absolutely. If that happens, I plan on staying on top of the changes and will post updates on my blog at *http://blogs.getcertifiedgetahead.com*. I'll also include information on the following page: *http://getcertifiedgetahead.com/aplus.aspx*.

Study Tips

There's no single study method that works for everyone, but there are some common techniques that many people use to pass these exams, including the following:

- **Set a goal.** Pick a date when you expect to take the first exam, and set your goal to take it then. The date is dependent on how long it'll take you to read the chapters and your current knowledge level. You might set a date two months from now, four months from now, or another time. However, pick a date and set a goal.
- **Take notes.** If concepts aren't familiar to you, take the time to write them down. The process of transferring the words from the book, through your head, and down to your hand really helps to burn the knowledge into your brain.
- **Read your notes.** Go back over your notes periodically to see what you remember and what you need to review further. You can't bring notes with you into the testing area, but you can use them to review key material before the exam.

- **Use flash cards.** Some people get a lot out of flash cards that provide a quick test of your knowledge. These help you realize what you don't know and what you need to brush up on. Many practice test programs include flash cards, so you don't necessarily have to create them yourself.
- **Review the objectives.** This is what CompTIA says it will test you on. Sometimes just understanding the objective will help you predict a test question and answer it correctly.
- **Record your notes.** Many people record their notes on an MP3 player and play them back regularly. You can listen while driving, while exercising, or just about anytime. Some people have their husband/wife or boyfriend/girlfriend read the notes, which can give an interesting twist to studying.
- **Take the practice test questions on the CD.** The practice test questions on the CD are designed to test the objectives for the exam but at a deeper level than you'll have on the live exam. Each question includes detailed explanations about why the correct answer(s) is/are correct and why the incorrect answers are incorrect. Ideally, you should be able to look at the answers to any question and know not only the correct answer but also why the incorrect answers are incorrect.

System Requirements

The actual system requirements to use this book are minimal. The only requirement is a computer that you can use to install the practice tests on the Companion CD.

Ideally, you'll have an old computer that you can take apart and put back together. It isn't required, but actually removing and reinstalling a power supply, case fan, or hard drive is much more meaningful than just reading about doing it.

Starting with Chapter 11, "Introducing Windows Operating Systems," the objectives have a strong focus on Windows XP, Windows Vista, and Windows 7. As a PC technician, you should be familiar with these operating systems.

You will find that most of the tested material is the same in Windows Vista and Windows 7. Therefore, if you have Windows XP and Windows 7, it isn't important that you have Windows Vista.

Instead of having two or three separate computers, you can use a single PC with virtualization software hosting these operating systems. Chapter 2, "Understanding Motherboards and BIOS," introduces virtualization, and Chapter 10, "Working with Customers," discusses virtualization workstations. The following sections describe hardware and software requirements to set up a virtualization workstation.

Hardware Requirements for Virtualization

If you plan on using virtualization, your computer should meet the following requirements:

- A processor that includes hardware-assisted virtualization (AMD-V or Intel VT), which is enabled in the BIOS. (Note: you can run Windows Virtual PC without Intel-VT or AMD-V.) Ideally, the processor will be a 64-bit processor so that you can have more RAM.
- At least 2.0 GB of RAM, but more is recommended.
- 80 GB of available hard disk space.
- Internet connectivity.

Software Requirements

You should have a computer running Windows 7. The objectives heavily cover Windows 7, and if you have it, you can easily run Windows XP in a virtual environment.

Additional requirements include the following:

- **Windows Virtual PC and Windows XP Mode.** Windows Virtual PC allows you to run multiple virtual Windows environments. The following page introduces the Windows Virtual PC and Windows XP Mode: *http://www.microsoft.com/windows/virtual-pc/*. The following page includes the download link after you identify your operating system and the desired language: *http://www.microsoft.com/windows/virtual-pc/download.aspx*.
- **Windows 7 (32-bit).** You can download a 90-day trial copy of Windows 7 Enterprise here: *http://technet.microsoft.com/en-us/evalcenter/cc442495.aspx*.

After following the instructions to download and install Windows Virtual PC and Windows XP Mode, you will have Virtual PC installed on your system. You will also have a fully functioning copy of Windows XP that you can use for Windows XP Mode and to explore the functionality of Windows XP while you are studying.

Next, download the 90-day trial of Windows 7 and install it as a VM within Windows Virtual PC. If you haven't completed the exams by the time the 90-day trial expires, create a new VM and install it again. The experience is worth it.

As an alternative to Windows Virtual PC, you can use either VirtualBox or VMware. Oracle provides VirtualBox as a free download here: *https://www.virtualbox.org/wiki/Downloads*; and you can download a free version of VMware player here: *http://www.vmware.com/products/player/overview.html*. Both VirtualBox and VMware player support 64-bit host machines, but you can only run 32-bit hosts within Windows Virtual PC.

Using the Companion CD

A companion CD is included with this training kit. The companion CD contains the following:

- **Practice tests** You can reinforce your understanding of the topics covered in this training kit by using electronic practice tests that you can customize to meet your needs. You can practice for the 220-801 and 220-802 certification exams by using tests created from a pool of 400 realistic exam questions, which give you many practice exams to ensure that you are prepared.
- **An eBook** An electronic version (eBook) of this book is included for when you do not want to carry the printed book with you.
- **A list of video links** Throughout the book, videos are pointed out to supplement learning. The CD includes a list of all the video links mentioned in the chapters and a few more. There are also links to a few more resources that you might find valuable during your studies.
- **The CPU-Z freeware utility** Chapter 3 discusses how this utility can be used to provide information on the CPU, the motherboard, memory, and more.

> ***NOTE*** **Companion content for digital book readers**
>
> **If you bought a digital-only edition of this book, you can enjoy select content from the print edition's companion CD. Visit** *http://www.microsoftpressstore.com/title/9780735662681.* **to get your downloadable content.**

How to Install the Practice Tests

To install the practice test software from the companion CD to your hard disk, perform the following steps:

1. Insert the companion CD into your CD drive and accept the license agreement. A CD menu appears.

> **NOTE IF THE CD MENU DOES NOT APPEAR**
>
> **If the CD menu or the license agreement does not appear, AutoRun might be disabled on your computer. Refer to the Readme.txt file on the CD for alternate installation instructions.**

2. Click Practice Tests and follow the instructions on the screen.

How to Use the Practice Tests

To start the practice test software, follow these steps:

1. Click Start, All Programs, and then select Microsoft Press Training Kit Exam Prep.

   A window appears that shows all the Microsoft Press training kit exam prep suites installed on your computer.

2. Double-click the practice test you want to use.

When you start a practice test, you can choose whether to take the test in Certification Mode, Study Mode, or Custom Mode:

- **Certification Mode** Closely resembles the experience of taking a certification exam. The test has a set number of questions. It is timed, and you cannot pause and restart the timer.
- **Study Mode** Creates an untimed test during which you can review the correct answers and the explanations after you answer each question.
- **Custom Mode** Gives you full control over the test options so that you can customize them as you like.

In all modes, the user interface when you are taking the test is basically the same but with different options enabled or disabled depending on the mode.

When you review your answer to an individual practice test question, a "References" section is provided that lists where in the training kit you can find the information that relates to that question and provides links to other sources of information. After you click Test Results to score your entire practice test, you can click the Learning Plan tab to see a list of references for every objective.

How to Uninstall the Practice Tests

To uninstall the practice test software for a training kit, use the Program And Features option in Windows Control Panel.

Acknowledgments

The author's name appears on the cover of a book, but I am only one member of a much larger team. First of all, thanks to Steve Weiss for originally reaching out to me and inviting me to write this A+ Training Kit. Several editors helped throughout this process, and I am grateful for all their work. I especially appreciate the copy editing by Richard Carey and the technical editing by Bill Talbott. I extend a huge thanks to José Vargas, who helped out with some writing on two of the hardware chapters. I especially appreciate my wife putting up with

my long days and nights working on what she has nicknamed "the forever book" because it seems like I've been working on this book close to forever. Last, a special thanks to readers who have provided feedback to me over the years, letting me know what helps them learn and what things I can improve.

Support & Feedback

The following sections provide information about errata, book support, feedback, and contact information.

Errata & Book Support

We've made every effort to ensure the accuracy of this book and its companion content. Any errors that have been reported since this book was published are listed on our Microsoft Press site:

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Preparing for the Exam

Microsoft certification exams are a great way to build your résumé and let the world know about your level of expertise. Certification exams validate your on-the-job experience and product knowledge. While there is no substitution for on-the-job experience, preparation through study and hands-on practice can help you prepare for the exam. We recommend that you round out your exam preparation plan by using a combination of available study materials and courses. For example, you might use the training kit and another study guide for your "at home" preparation and take a Microsoft Official Curriculum course for the classroom experience. Choose the combination that you think works best for you.

Note that this training kit is based on publically available information about the exam and the author's experience. To safeguard the integrity of the exam, authors do not have access to the live exam.

CHAPTER 1

Introduction to Computers

In this chapter, you'll learn about some basic computer-related concepts that are important for any technician to understand. For example, different numbering systems are often unfamiliar to many people, but don't underestimate their importance in understanding how a computer works. The Numbering Systems section lays the foundation for topics in many future chapters. This chapter also includes information about cases, fans, and power supplies—core hardware computer components that often require periodic maintenance by technicians. Last, you'll learn about some basic safety issues and tools you can use when maintaining computers.

IMPORTANT

Have you read page xliv?

It contains valuable information regarding the skills you need to pass the exams.

Exam 220-801 objectives in this chapter:

- 1.2 Differentiate between motherboard components, their purposes, and properties.
  - Power connections and types
  - Fan connectors
- 1.8 Install an appropriate power supply based on a given scenario.
  - Connector types and their voltages
    - SATA
    - Molex
    - 4/8-pin 12v
    - PCIe 6/8-pin
    - 20-pin
    - 24-pin
    - Floppy
  - Specifications
    - Wattage
    - Size
    - Number of connectors

        - ATX
        - Micro-ATX
    - Dual voltage options
- 5.1 Given a scenario, use appropriate safety procedures.
    - ESD straps
    - ESD mats
    - Self-grounding
    - Equipment grounding
    - Personal safety
        - Disconnect power before repairing PC
        - Remove jewelry
        - Lifting techniques
        - Weight limitations
        - Electrical fire safety
    - Compliance with local government regulations
- 5.2 Explain environmental impacts and the purpose of environmental controls.
    - MSDS documentation for handling and disposal
    - Temperature, humidity level awareness and proper ventilation
    - Power surges, brownouts, blackouts
        - Battery backup
        - Surge suppressor
    - Protection from airborne particles
        - Enclosures
        - Air filters
    - Dust and debris
        - Compressed air
        - Vacuums
    - Component handling and protection
        - Antistatic bags
    - Compliance to local government regulations

Exam 220-802 objectives in this chapter:

- 4.2 Given a scenario, troubleshoot common problems related to motherboards, RAM, CPU and power with appropriate tools.
  - Common symptoms
    - No power
    - Overheating
    - Loud noise
    - Intermittent device failure
    - Smoke
    - Burning smell
  - Tools
    - Multimeter
    - Power supply tester

REAL WORLD **DIRTY FANS MIGHT SOUND LIKE JET ENGINES**

Not too long ago, a friend was complaining to me about a computer she had. She said she was going to have to replace it because it was just too loud and slow. I took a look, or perhaps I should say a listen, and sure enough it reminded me of being next to a jet engine. However, I knew how to solve this problem.

I bought a can of compressed air, took the computer outside, and removed the case. There was dust gunked up in just about every vent and throughout the inside of the computer. I methodically blew out all the dust and put the computer back together. Sure enough, without the extra dust, the computer was quieter and quicker.

The extra dust in the vents was making the fans work harder, and louder. The extra dust on the central processing unit (CPU) and its fan was causing the CPU to quickly overheat, and it was running slower as a result. However, with all the dust gone, the computer was humming along quietly and returned to its previous speed.

It made me wonder how many people toss out perfectly good computers when all they need to do is clean them. I certainly understand how intimidating it can be for some users to open up a computer case and look inside. However, the A+ technician (you) with just a little bit of knowledge can be the hero for these people. You can help them restore their computer to its previous glory.

Computing Basics

At the most basic level, a computer has three functions: input, processing, and output. It accepts input, performs some processing, and provides an output, as shown in Figure 1-1. This is often shortened to just *input/output (I/O)*.

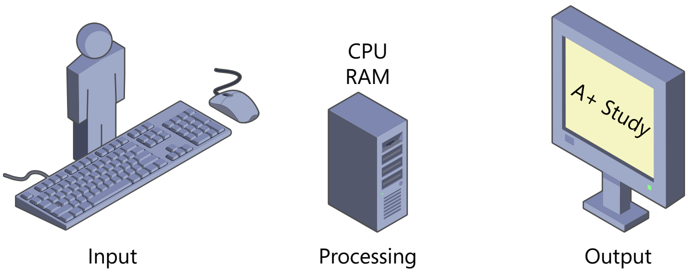


FIGURE 1-1 Input, processing, and output.

- **Input.** User-provided input comes from a keyboard, a mouse, or even a touch screen. Sometimes input is provided by other sources, such as a disk drive when opening files or a network interface card (NIC) when receiving data.
- **Processing.** The computer responds to the input by completing an action. The central processing unit (CPU) is the brain of the computer. It does the processing, and it uses random access memory (RAM) to store and manipulate data.
- **Output.** Output is commonly provided to a screen or a printer. However, computers also provide output to other destinations. These can include output to speakers or headphones to play sound, to disk drives when saving files, and to a NIC when transmitting data.

> ***NOTE*** **LONG-TERM AND SHORT-TERM STORAGE**
>
> **Computers are unable to work with data or programs until the information is in memory. Disk drives provide long-term storage, but information must be moved to the memory before the CPU can work with it. This is often transparent to the user.**

For example, imagine you wanted to open up a Microsoft Word document that has your A+ study notes. You would start by double-clicking the document, using the mouse as your input.

The computer processes your double-click with several actions:

1. It identifies the extension of the Microsoft Word file (.doc or .docx). It recognizes that this extension is associated with Microsoft Word.
2. It locates and retrieves the Microsoft Word program from the disk drive and begins moving the program from the disk drive to memory.

3. When the program is in memory, the computer can actually run it.
4. The computer begins sending results to the graphics card, showing the process of Microsoft Word starting.
5. When Microsoft Word is in memory and started, the computer locates the Word Study Notes file and moves it from the hard drive to memory.
6. When the file is in memory, the computer begins sending results to the graphics card.

> ***NOTE*** **IPO**
>
> **Computer troubleshooting can often be reduced to identifying what is not working: input, processing, or output (IPO). When you identify this, it's much easier to troubleshoot and resolve the problem.**

The preceding IPO process is constantly repeated. Consider typing your A+ notes about fans or power supplies into your study file. Each key press is another input that is processed and generates an output. The computer identifies what key you pressed, stores its value in memory, and displays it on the screen. When you save the file, it writes everything in its memory to the file on the drive.

Despite being able to do so much, it's worth pointing out that computers are pretty dumb. They can work only with numbers. Specifically, they can work only with ones and zeros. Everything that is written to a disk drive or to memory is a series of ones and zeros.

Admittedly, computers can work with these ones and zeros very quickly. Ask it to multiply two five-digit numbers, and a computer will do so in a flash. However, it must first translate any input you give it to a string of ones and zeros, process these strings, and then translate the result of ones and zeros into a usable display.

With this in mind, it's important for any A+ technician to have a rudimentary understanding of some basic numbering systems.

Numbering Systems

You and I count by using decimal numbers. We understand the meaning of the numbers 0 through 9. After you get up to 9, the next number is 10. This is also known as a numbering system with a base of ten, because there are ten digits in the numbering system.

If you see a number like 2,357, you know that its decimal parts are two thousand, three hundred, fifty, and seven. Table 1-1 shows the underlying math, which should make a lot of sense to you if you're familiar with decimal numbers.

TABLE 1-1 Decimal Values

	10^3	10^2	10^1	10^0
Decimal value	1000	100	10	1
Number	2	3	5	7
Calculated value	2,000	300	50	7

- The column on the far left is 10^3, or 10 cubed. The value of 10 x 10 x 10 is 1,000. The number 2,357 has 2 in this column, so it represents 2,000.
- The next column is 10^2, or 10 squared. The value of 10 x 10 is 100, and the number 2,357 has 3 in this column, so its value is 300.
- Any number raised to the one power is itself, so 10^1 is 10. The number 2,357 has 5 in this column, so its value is 50.
- Last, any number raised to the zero power is 1, so 10^0 is 1. The number 2,357 has 7 in this column, so its value is 7.

If you add 2,000 + 300 + 50 + 7, you get 2,357. When you see the number 2,357, you probably don't think of it this way, but you do recognize the value. For example, if I said I was going to give you your choice of $2,357 or $7,532, you'd easily recognize that the first choice is a little over $2 thousand and that the second choice is over $7 thousand. By reviewing what you know, it's easier to bridge that knowledge to something that might be new to you.

Base ten numbers aren't very efficient for computers. They result in a lot of wasted space. Because of this, computers use different numbering systems, such as *binary* and *hexadecimal*.

Binary

Binary numbers have a base of two. Instead of using numbers 0 through 9, they only use the numbers 0 and 1.

> ***NOTE*** **BINARY BIT**
>
> **In binary, a single digit is referred to as a bit. A bit can have a value of 1 or 0. When it is a 1, it is considered to be on, or true. When the bit is a 0, it's considered to be off, or false.**

Consider the binary number 1001. Table 1-2 shows how you can convert this number to a decimal value that has more meaning to you and me.

TABLE 1-2 Binary Values

	2^3	2^2	2^1	2^0
Decimal value	8	4	2	1
Binary number	1	0	0	1
Calculated value	8	0	0	1

- The column on the far left is 23, or 2 cubed. The value of 2 x 2 x 2 is 8. The number 1001 has 1 in this column, so it represents a calculated decimal value of 8.
- The second column is 2 squared. The value of 2 x 2 is 4, and the number 1001 has 0 in this column, so its value is 0.
- Any number raised to the one power is itself, so 21 is 2. The number 1001 has 0 in this column, so its value is 0.
- Last, any number raised to the zero power is 1, so 20 is 1. The number 1001 has 1 in this column, so its value is 1.

If you add 8 + 0 + 0 + 1, you get 9. Therefore, the binary number 1001 has a decimal value of 9.

Hexadecimal

Although binary and bits work well with computers, they aren't so easy for people to digest. If you need to tell someone to use the number 201, that's rather easy. But if you need to tell someone to use the binary equivalent, it's 1100 1001. That string of ones and zeros is a little difficult to communicate. However, you could also express the same number as C9 by using hexadecimal.

Hexadecimal uses the characters 0–9 and A–F, adding six extra digits to the base ten numbers of 0–9. Hexadecimal uses a base of 16. It is easier to express than binary and more efficient for computers than base 10 because it easily translates to binary.

> ***NOTE*** **BINARY GROUPING**
>
> **When grouping several binary numbers, it's common to separate groups of four with a space. This is similar to adding commas to decimal numbers. For example, 135792468 is often expressed as 135,792,468 because the commas make it easier to see that it starts with 135 million. Similarly, 11001001 isn't as easy for most people to process as 1100 1001, although both numbers mean the same thing.**

The binary number 1100 1001 can also be expressed as C9, because 1100 is C in hexadecimal and 1001 is 9 in hexadecimal. Table 1-3 shows the decimal, binary, and hexadecimal equivalent for the numbers up to hexadecimal F.

TABLE 1-3 Decimal, Binary, and Hexadecimal Values

Decimal	Binary	Hexadecimal	Decimal	Binary	Hexadecimal
0	0000	0	8	1000	8
1	0001	1	9	1001	9
2	0010	2	10	1010	A
3	0011	3	11	1011	B
4	0100	4	12	1100	C
5	0101	5	13	1101	D
6	0110	6	14	1110	E
7	0111	7	15	1111	F

NOTE **HEXADECIMAL CASE**

Hexadecimal numbers are not case sensitive. An uppercase C is the same as a lowercase c, and both equate to 1100 in binary. They are expressed both ways by different applications. Additionally, hexadecimal numbers are often preceded with 0x that to indicate that they are hexadecimal numbers. For example, if Windows 7 stops responding, the screen will display an error code such as STOP Error 0x0000002E, or hexadecimal code 2E. (This error code indicates a problem with memory.)

A common example of how hexadecimal numbers are used is with media access control (MAC) addresses. Network interface cards are assigned 48-bit MAC addresses, and these are commonly listed in six pairs of hexadecimal numbers like this: 6C-62-6D-BA-73-6C. Without hexadecimal, the MAC would be listed as a string of 48 bits.

Bits vs. Bytes

A single binary number is a *bit*, and eight bits makes up a *byte*. You can extend binary as far as you need to, but most computer technicians deal with numbers that do not go beyond a byte. This is not to say that computers can't work with more than eight bits. They certainly can. However, technicians and other Information Technology (IT) professionals still express the numbers as bytes.

Table 1-4 shows the value of each of the bits in a byte. The column on the far left is 2^7, or 2 x 2 x 2 x 2 x 2 x 2 x 2. If you convert this to decimal, it is 128.

TABLE 1-4 Bits in a Byte

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

NOTE IPV4 IS 32 BITS

In networking, IPv4 addresses are 32 bits long. These addresses are commonly divided into four groups of eight bits, or four bytes. Additionally, the groups are usually expressed in decimal format. For example, an IPv4 address of 192.168.1.5 could also be expressed in binary as 1100 0000 . 1010 1000 . 0000 0001 . 0000 0101.

Kilo, Mega, Giga, and Tera

Computers handle huge numbers of bytes, which are often expressed as *kilobytes (KB)*, *megabytes (MB)*, *gigabytes (GB)*, and *terabytes (TB)*. A KB is 1,024 bytes, but most technicians shorten this to "about a thousand" bytes.

NOTE ONE THOUSAND OR 1024

You may be wondering why a KB is 1,024 bytes instead of one thousand bytes. Kilo literally means thousand, so you'd think that one KB would be one thousand bytes. However, the bytes are calculated by using binary with the formula of 2^{10} (or 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2). If you plug these numbers into a calculator, you'll see that it works out to 1,024.

Here's a comparison of these values:

- KB = about one thousand bytes (2^{10})
- MB = about one thousand KB or about a million bytes (2^{20})
- GB = about one thousand MB or about a billion bytes (2^{30})
- TB = about one thousand GB or about trillion bytes (2^{40})

Quick Check

1. What is the decimal value of the hexadecimal character C?
2. How many bits are in a byte?

Quick Check Answers

1. 12
2. 8

Cases and Cooling

Computer cases house many of the components in the computer, and there are many different types, sizes, and shapes of cases. Standard *personal computers (PCs)* use desktop cases. Some cases are towers that stand up beside a desk, and others fit on top of a desk. The common purpose of a computer case is to house the components needed within a computer.

Figure 1-2 shows an opened computer case with several components highlighted.

FIGURE 1-2 Computer case.

1. **Power supply.** The wires coming out of the right side of the power supply are connected to different computer components.
2. **CPU fan.** This is a dedicated fan to keep the CPU cool. The CPU is directly beneath this fan and can't be seen.

3. **Case fans.** This case has two fans, a smaller one on the left and a larger one on the bottom right. These fans pull air into the case. Vents on the case are positioned so that air constantly flows over key components to keep them cool.

4. **Motherboard.** The large white square outlines the motherboard. Multiple components are located on the motherboard, including the CPU, RAM, and the graphics card. Chapter 2, "Understanding Motherboards and BIOS," provides more details on the motherboard, and Chapter 3, "Understanding Processors and RAM," covers RAM. Chapter 6, "Exploring Video and Display Devices," covers displays and graphics (including graphics cards) in more detail.

5. **Optical drive bays.** CD and DVD optical drives are located here. This system has two drives, with space for another one.

6. **Hard disk drive bays.** Hard disk drives are used for permanent storage of data. This system has two hard disk drives, with space for another one. Chapter 4, "Comparing Storage Devices," covers the different types of storage devices.

You can also see a variety of different cables within the case. The power supply cables are covered later in this chapter, and other cables and connectors are covered in future chapters.

Not all cases have this much space or this many components. However, Figure 1-2 does give you an idea of what you'll see within a computer case.

A quick exercise you can do is to open your computer's case and peer inside. Make sure you first power the computer down and unplug the power cable. One side of the case can normally be opened by removing two thumb screws on the back of the case and pulling off the side panel. There's no need to manipulate anything inside the case at this stage, but you can look at it and compare your case with the case shown in Figure 1-2.

EXAM TIP

A+ exam questions often expect you to be able to identify components within a computer. Looking at different computers will help you correctly answer these questions. If you don't have multiple computers handy, check out the pictures on *bing.com*. Type in your search phrase (such as "computer case," "motherboard," or "power supply") and select Images.

Motherboards

As you can see in Figure 1-2, the motherboard takes up a significant amount of space. The case shown in the figure is relatively large, and you will likely see other computers where the case is not much larger than the length and width of the motherboard. All the components are squeezed in. These smaller cases don't have as much room for expansion, such as adding hard drives.

An important consideration related to the motherboard and the case is ensuring that the case can adequately house it. If you ever replace a computer's motherboard with a different brand or model, you'll need to ensure that it fits within the case.

Chapter 2 covers motherboard form factors in more depth, but as an introduction, the Advanced Technology Extended (ATX) motherboard form factor is the most common. The ATX standard has been in use since 1995, with several improvements and modifications added over the years. Many cases are designed so that they will support ATX motherboards.

Case Fans

Computers can get very hot, so fans are used to keep cool air flowing over the components. They draw air in from the room, direct it over key components, and then the air exits from vents on the case.

Fans come in different levels of quality, and the most noticeable difference is in how much noise they make. Inexpensive fans have cheap bearings that are noisy, while quality fans have sophisticated bearings that are extremely quiet. Many quality fans include a thermistor, which automatically adjusts the speed of the fan based on the temperature.

Common Problems with Fans

When a case fan becomes clogged or dirty, it can be so noisy that people commonly complain it sounds like a jet engine. They never get quite that loud, but they can be a nuisance.

Even worse, if the case fan is clogged, the computer is often not getting enough air flow through it. Internal components become hotter, and it's common for the entire system to slow to a crawl. In some cases, problems with the fan can cause the system to fail.

EXAM TIP

Intermittent failures, such as random restarts, are often an indication of a heat-related problem. This is especially true if the fans are loud, indicating that they are working very hard.

The easy solution is to clean the fan along with the case as described in the Cleaning Cases section later in this chapter. This will often reduce the noise and increase the performance. If it doesn't solve the problem, you can replace it with a higher-quality fan.

If a fan fails completely, it should be replaced as soon as possible to ensure that other components do not overheat and fail.

> ***NOTE*** **CLOSE THE CASE**
>
> **In different situations, many technicians are tempted to run a computer with its case open. However, the vents on the case are strategically placed to ensure that air flows over specific components to keep them cool. If the case is left open, these components do not have enough air flow over them, which can cause them to overheat.**

Replacing a Fan

A fan is considered a *field replaceable unit (FRU),* so if a fan is too noisy or has failed, you can replace it. Many companies sell case fans, and they are relatively easy to replace on a system. If you do replace the fan, make sure that the fan you're purchasing fits in your case. The two most common sizes for case fans are 80 mm and 120 mm.

Figure 1-3 shows the case fan within a system. Take a look at it as you follow the steps to remove the fan.

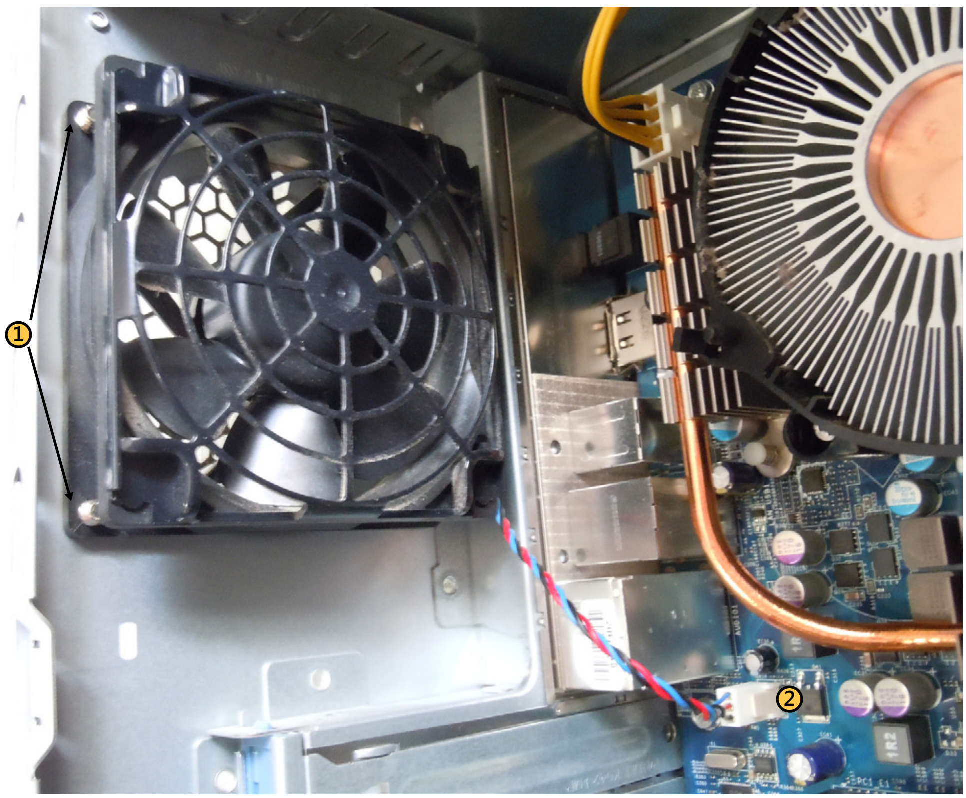


FIGURE 1-3 Removing a case fan.

IMPORTANT **TURN OFF THE POWER**

Ensure that the computer is turned off and that the power cable is removed before opening the case and replacing a fan. Power is still provided to the motherboard even if the system is turned off, and you can cause damage to the computer or yourself if the power cable is not removed.

1. **Remove four screws from the back of the case.** The arrows in Figure 1-3 point to two of the screws, and the other two screws are on the other two corners of the fan.
2. **Remove the power connector.** The power connector plugs into a specific jack on the motherboard. Take note of this jack, and ensure that you plug the new fan into the jack the same way. Fan connectors can use two, three, or four pins. The 4-pin connectors are commonly used with variable speed fans, allowing the computer to control the speed of the fan. You can also use adapters to connect some fans into a *Molex* type of connector from the motherboard.

After removing the old fan, you can install the new fan by reversing your steps. Attach the four screws and plug it in.

Even with new fans, though, if the case vents become clogged with contaminants, the fans will work harder to pull the air through the system. The easy solution is to clean the case.

Cleaning Cases

With all the air blowing into the computer case, it will gather some dust. In extreme work environments, the inside of a computer can get quite dirty. For example, a computer within a manufacturing plant will collect dirt and contaminants inside the case. Similarly, a computer with dogs or cats in the area can collect fur and hair.

It's relatively easy to clean a case. The most common method is by using a can of compressed air, which you can purchase from electronics stores. Take the computer outside, remove the cover, and use the compressed air to blow out the dust and other contaminants.

EXAM TIP

Cleaning a case and its fans can improve a computer's performance. Excessive dust creates additional heat, and many computers include components that can automatically sense the temperature. These components often increase the speed of the fans, making the system louder, and also slow down the speed of the CPU to reduce the heat.

Notification Switch for Security

Many computer cases have a special push-button switch that detects whether the case has been opened. This is also called a *biased switch,* and it stays depressed as long as the case is closed. When the case is opened, the switch opens and the change is recorded in the computer. The next time the system starts, it indicates that the system case has been opened. This is useful for detecting whether someone has been tampering with a computer.

Quick Check

1. What are the two common sizes of a case fan?
2. A computer has become louder and slower. What is a common solution?

Quick Check Answers

1. 80 mm and 120 mm.
2. Clean it.

Power Supplies

Computers run on electricity. Electricity is measured as voltage, and voltage is the difference in potential between two points. For example, an electrical signal can be 12 volts above a ground potential of zero volts, giving it a value of 12 volts. Power supplies within computers ensure that components within a system consistently have the correct voltages.

As an A+ technician, you might need to troubleshoot a system with a faulty power supply or even replace a power supply. With that in mind, you need to have a basic understanding of power supplies.

AC vs. DC

The two types of voltages are alternating current (AC) and direct current (DC). *AC voltage* alternates above and below zero volts, and *DC voltage* provides a steady voltage either above or below zero.

Commercial power companies traditionally provide power as AC, which looks like a sine wave. Power supplies within computers convert this AC voltage into DC voltage, as shown in Figure 1-4.

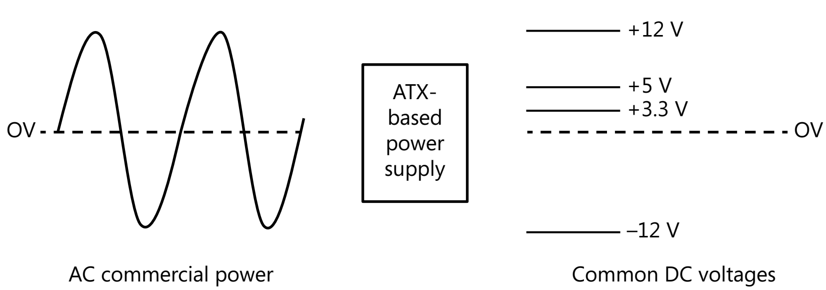


FIGURE 1-4 AC vs. DC.

Figure 1-4 isn't to scale. AC voltages vary about 115 VAC (volts AC power) above and below 0 volts in many regions, such as in the United States, and 230 VAC above and below 0 volts in other regions, such as in Europe. The key point is that AC voltage is an alternating or varying voltage, whereas DC voltage is a constant steady voltage. The DC voltages shown in the figure are common voltages used within computers, and are sometimes expressed as VDC, such as 12 VDC.

Wattage Power Ratings

Power supplies are rated based on the amount of power they can provide, and power is computed as a *watt (W)*. In simple terms, watts are computed by multiplying the voltage by the amperage. Amperage (A) refers to the rate of flow of the voltage. Higher amperage results in a higher rate of flow, and higher amperage with the same voltage provides more power.

Each individual component within a computer requires a certain amount of power. For example, it's not uncommon for a CPU to require as much as 100 W. Additionally, the motherboard, case fans, and disk drives all draw additional power. With this in mind, power supplies must not only convert AC to DC and supply the correct DC voltages, but they must also provide enough power to support all the components in the system.

When replacing a *power supply unit (PSU),* you should look for the W within the specifications to identify the power output. For example, a 600-watt PSU would be listed as 600 W. The range of common current ATX-based PSUs is about 300 W to 1,000 W.

If a system requires 600 W and you put in a 300-W power supply, you'll have some problems. In most cases, the computer simply won't work. In other cases, the power supply won't be able to provide steady voltages and the variances might damage system components.

Rails

Power supplies provide separate lines (called *rails*) for the different voltages. The voltage that draws the most power is 12 V, used for CPUs, case fans, and disk drives, and a single 12-V rail provides 18 A of power. However, this single 18-A rail often isn't enough to power all the components that need the voltage.

Many current power supplies include at least two 12-V rails, with one rail dedicated to the CPU and the second rail dedicated to everything else. Some power supplies include three or four rails. When replacing a power supply, you need to ensure that you are replacing it with one that has at least the same number of 12-V rails as the original.

EXAM TIP

The 12-V rails provide primary power to disk drives. If these rails are overworked, they will frequently cause problems for the hard drives. In other words, if hard drives are frequently failing in a computer, consider replacing the power supply with one that has an additional 12-V rail.

Power Supply Connections

The ATX standard mentioned within the Motherboards section earlier in this chapter also identifies power supply requirements. Most current desktop systems include power supplies that support ATX-based motherboards, and they provide specific voltages defined in the ATX specifications.

Figure 1-5 shows the rear view of a power supply, along with its connectors. This power supply was removed from a computer with an ATX-style motherboard. Refer to the figure as you read the following descriptions.

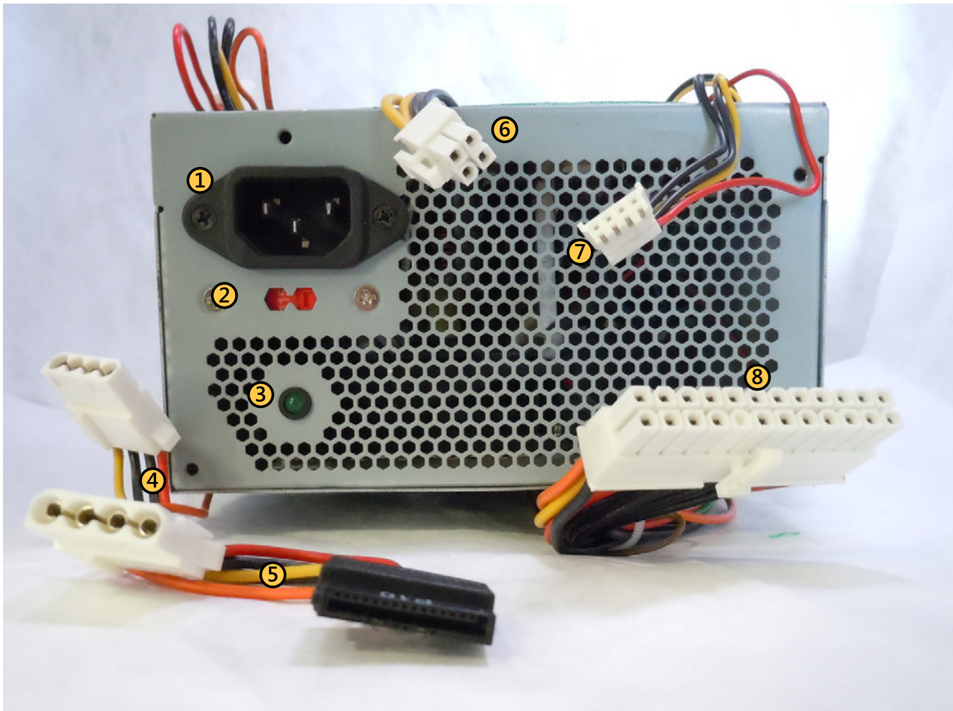


FIGURE 1-5 Power supply.

1. **AC power jack.** The power cable connects from here to a power source providing AC power.
2. **Dual voltage power selection.** Select 115 or 230 based on the commercial power provided at your location. For comparison, commercial power provided in the United States is 115 VAC, and power provided in Europe is 230 VAC. Some systems can automatically sense the voltage, so the switch isn't needed.

EXAM TIP

If you have this selection set at 230 and you plug it into a commercial power source providing 115 VAC, it won't have enough power to run the computer. On the other hand, if you set it to 115 and you plug it into a 230-VAC power source, you will likely destroy the power supply. If you hear pops, smell burning components, or smell smoke, unplug it as quickly as possible and check this switch.

3. **Power indicator.** When on, it indicates that the power supply has power. This does not indicate that the actual computer is turned on. Computers typically have a separate power button and power indicator on the front of the case.
4. **Molex connectors.** These provide 5 V and 12 V to different devices, such as Parallel Advanced Technology Attachment (PATA) disk drives.
5. **SATA power connector.** This 15-pin connector provides power to Serial Advanced Technology Attachment (SATA) disk drives. It includes 3.3-V, 5-V, and 12-V DC voltages.
6. **Secondary motherboard power connection.** Most current motherboards use a 4-pin connector that provides 12 VDC used by the CPU. This connector is formally called ATX12V but is also known as P4 because it was first used with the Pentium 4 CPUs. Systems with more than one CPU use an 8-pin connector (or two 4-pin connectors) to provide power for multiple CPUs. This is formally known as EPS12V.
7. **Floppy drive mini-connectors.** These are sometimes called Berg connectors or mini-Molex connectors. They provide 5-VDC and 12-VDC power to 3.5-inch floppy drives, when the system includes floppy drives.
8. **Primary power connector.** A 20-pin or 24-pin connector provides primary power to the motherboard. It's commonly called the P1 connector and provides 3.3 VDC, 5 VDC, and 12 VDC to the motherboard.

EXAM TIP

You might need to troubleshoot a power supply and verify that it is supplying the correct voltages. With this in mind, you should be aware of valid voltages on the different connectors. Black wires are ground (or a zero potential), orange wires carry 3.3 V, red wires carry 5 V, yellow wires carry 12 V, and blue wires carry -12 V.

Many power supplies also have a PCI Express (PCIe) power connector. This was originally a 6-pin connector, but new systems use an 8-pin connector similar to the one shown in Figure 1-6. Some power supplies use a 6+2 connector, allowing you to plug it into an older system with only 6 pins, or a newer system with 8 pins.

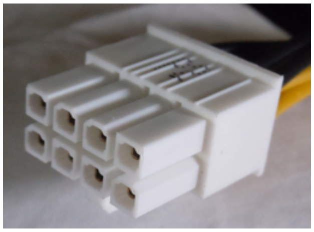


FIGURE 1-6 PCIe power connector.

Cable Keying

Most cables are keyed. That is, they are designed to fit into a jack in one way, and one way only. However, these connectors and plugs are just plastic, so it is possible to force a connector onto a plug backwards. If you do, the wrong voltages or signals will be sent to a device.

In the worst case scenario, plugging a cable in backwards can destroy a device. If you're lucky, plugging the cable in wrong will just result in the device not working. Neither result is desirable, so it's best to look for the key and ensure that you plug in the connector correctly.

Figure 1-7 shows some common methods of how cables are keyed.

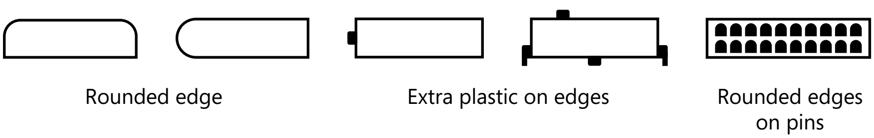


FIGURE 1-7 Cable keying examples.

It might not be apparent in Figure 1-5 shown earlier, but several of the connectors have keyed connectors similar to that shown in Figure 1-7. The Molex connectors (item 4 in Figure 1-5) have rounded edges. The SATA power connector (item 5) has an extra edge. The mini-connector (item 7) has several extra edges. The primary power connector (item 8) has rounded edges on the individual pins.

IMPORTANT **NEVER FORCE A CONNECTOR**

Plugging in any connector the wrong way can damage the computer. Although the keying does help, the connectors are plastic and in some cases it is possible to force a connector onto a plug the wrong way. If a connector doesn't seem to fit, don't try to force it. Instead, double-check the keying to ensure that it is plugged in correctly.

ATX vs. Micro-ATX Power Supplies

ATX power supplies are the standard used in many computers today. However, some smaller PCs have lower power requirements and can be powered by using smaller power supplies. Micro-ATX power supplies provide a lower amount of wattage, often between 180 and 300 watts, though some special-purpose power supplies are as low 90 watts.

The micro-ATX power supplies are smaller in size and have fewer power connectors than a regular ATX-based power supply. Also, the primary power connector (P1) usually has only 20 pins on the micro-ATX power supply, rather than the 24 pins often found on ATX-based power supplies.

Replacing a Power Supply

Many components within a computer, including the power supply, are modular. When a module fails, you need to replace only the module, not the entire computer. This is similar to a car. If your car gets a flat tire, you replace the tire, not the entire car. If the power supply fails in a computer, you replace the power supply.

EXAM TIP

When power supplies fail, you can sometimes see smoke or smell burning components. New power supplies often give off an odor for a short burn-in period, but they aren't faulty. However, if you see smoke or hear sparks, remove power immediately.

The primary indicator that the power supply has failed is that the system doesn't have any lights or indicators. Of course, you'd want to verify that the computer is plugged in and turned on. Also, some systems have a power switch on the power supply that needs to be turned on in addition to turning on the power via a switch or button in the front of the system. If you've checked these but still have no power indications, it might be time to replace the power supply.

The power supply is relatively easy to replace, but you need to keep a few important concepts in mind:

- **Turn off and remove the power plug.** You should not attempt to replace computer components while the system is plugged in. The exception is "hot swappable" components such as USB flash drives that are designed to be inserted or removed while turned on.
- **Use a suitable replacement.** Ensure that the wattage of the replacement is at least as high as the original, if not higher. Also, ensure that the power supply has at least the same number of 12-V rails as, if not more, than the original.
- **Document cable placement.** Pay attention to the cables before you take them out. Draw a diagram showing where each cable goes, or take a couple of pictures with your cell phone. Without this documentation, when the old power supply is out

and the new power supply is in, you might have trouble remembering where all the cables went. Also, ensure that you identify the keying of the cables and plug them in correctly.

When you're ready to replace the power supply, you'll find there are only four screws holding it on. Remove the cables and the screws, and you'll be able to remove the power supply. Occasionally, you might need to remove other components first to get to the power supply and remove it.

Protecting Systems from Power Problems

Commercial power isn't always stable, and it can sometimes cause problems to computers. However, there are some basic steps you can take to protect them. Some of the common problems you might see on commercial power lines are as follows:

- **Surge.** Commercial power can occasionally increase or *surge*. Instead of providing a steady 115 VAC, it can increase to 120 VAC or higher. Surges are usually short term and temporary but can sometimes be observed as lights become brighter.
- **Spike.** This is a quick, sharp increase in AC voltage. The voltage immediately returns to normal, but the *spike* can destroy unprotected equipment. Lightning strikes are a common source of spikes.
- **Sags and brownouts.** Commercial power can also reduce or *sag*. Instead of providing a steady 115 VAC, it can decrease to 110 VAC or lower. If this occurs for less than a second, it's called a sag, but if it lasts longer, it's referred to as a *brownout*. You can often see lights flicker or become dimmer during brownouts, and they can cause systems to restart.
- **Blackouts.** A *blackout* is the total loss of power (or the reduction of power to such a low level that the equipment is unable to operate). The following sections identify some of methods used to protect against power-related problems.

Surge Suppressors

A *surge suppressor* is a power strip with extra protection. It has built-in sensors that can detect when the power surges or spikes. Most surge suppressors have a circuit breaker that will pop when it detects surges or spikes. When the circuit breaker pops, the surge suppressor no longer provides voltage to any systems plugged into it. You can usually reset it by pressing a button on the surge suppressor or by turning it off and back on.

> ***NOTE*** **POWER STRIPS VS. SURGE SUPPRESSORS**
>
> **A power strip is similar to an extension cord with extra power plugs. Many people assume it protects against surges and spikes, but it does not provide any protection. Surge suppressors include some type of tag or marking indicating that they are surge suppressors.**

Battery Backup

An *uninterruptible power supply (UPS)* provides the benefits of a surge suppressor and also provides constant power to a system. It includes batteries, and if commercial power is lost or sags, it can continue to supply power to systems for a short time, for as much as 10 or 15 minutes or longer.

For example, I recently added an UPS rated at 900 watts. I plugged in my primary PC and flat screen monitor, but nothing else, to the UPS. During a power outage, the UPS continued to provide power for over an hour. If I had two PCs and two monitors plugged into it, the UPS would likely have lasted only about 30 minutes.

If power isn't restored within a certain time frame, the UPS can send a signal to the computer to perform a logical shutdown. This prevents hardware and software problems caused by unexpected power losses.

Figure 1-8 shows how the UPS is connected to the computer. The UPS plugs into the wall to receive commercial power. This power provides a continuous charge to the batteries within the UPS. The UPS provides AC power to the computer or to other systems plugged into it. If power fails, the UPS continues to provide power to the computer for a short time.

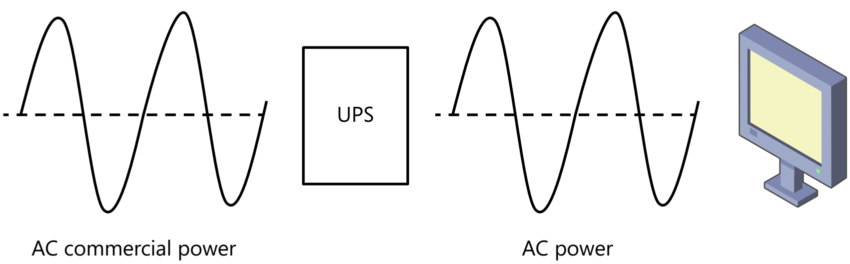


FIGURE 1-8 UPS used to protect against short-term power loss.

> ***EXAM TIP***
>
> **An UPS can be used to provide power to computers for short-term power. Laser printers draw a significant amount of power, and they should not be plugged into an UPS.**

It's important to ensure the UPS system can meet the power requirements of the systems you're trying to protect from power outages. Additionally, you should plug in only systems that you need to keep operational during short-term power failures. If you plug all your equipment into the UPS, they will draw additional power. This will reduce the amount of time that the UPS provides power to these systems during an outage. Other equipment should be plugged into a surge suppressor.

Quick Check

1. **What voltages are provided by an ATX power supply?**
2. **What should you check if you have hard drives frequently failing?**

Quick Check Answers

1. 3.3 V, 5 V, 12 V, and -12 V
2. 12-V rails

Safety Issues

When working on computers, it's important to pay attention to safety considerations. A basic premise to always keep in mind is that computers are just things that can be replaced, but we can't replace people. In other words, value people first when working with computers. By following basic safety precautions, you can prevent damage to people and to equipment.

Electrical Safety

Unless you're measuring voltages within a computer, you should never work on computers without first removing power. This includes turning the computer off and unplugging it.

Just turning off the power is not enough. ATX-based power supplies provide power to the motherboard even if the front power switch on the computer indicates that it is turned off. If you want to ensure that the computer does not have any power, unplug the power supply.

Most people consider PSUs modular units. In other words, if the PSU fails you simply replace it instead of trying to repair it. However, if you do open the power supply, don't forget the following two important warnings:

- Never open it when it is plugged in.
- Even after you unplug it, capacitors within the power supply will hold a charge. If you touch the capacitor, it can easily discharge and shock you. I learned this lesson firsthand when playing with one of my father's radio sets when I was about eight years old. It knocked me against the wall and left my mother white-faced for quite a while.

Equipment and Self-Grounding

In electronics, *ground* refers to a path to Earth. A copper cable is attached to a spike and hammered into the ground. The other end of this cable is available in the electrical system and identified as a ground. Most electrical equipment includes circuitry that will automatically redirect any dangerous voltages to ground to prevent shocks.

IMPORTANT **EQUIPMENT GROUND CONNECTIONS SHOULD ALWAYS BE CONNECTED**

Disconnecting ground connections can bypass safety circuits. Dangerous voltages can be redirected to the computer case, resulting in a shock if a user touches the case.

Ground is referred to differently based on the location of the connection. For example, Figure 1-9 shows the three primary symbols used for ground.

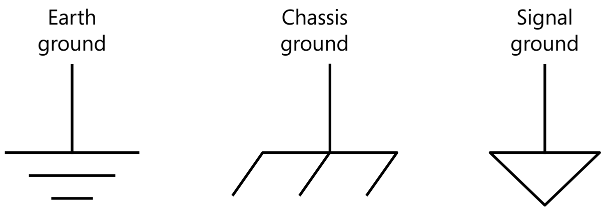


FIGURE 1-9 Ground symbols.

Earth ground is the path directly to Earth. *Chassis ground* refers to the path to the equipment case or chassis. *Signal ground* refers to the return path for a signal. Signal ground connections are commonly connected to the chassis. For example, some screws connecting a motherboard to a computer case connect the motherboard signal ground to the case. The chassis ground is then connected to the Earth ground via the power cable.

ESD

Static electricity builds up on different types of objects, and when one object touches another, the static discharges. You've probably experienced a static discharge after walking across a carpeted floor and touching a doorknob. This is also called *electrostatic discharge (ESD)*.

The shock you felt might have been unpleasant, but it wasn't harmful. However, it can be damaging to computers. If you felt it, at least 3,000 volts were discharged from your hand to the doorknob. If you actually saw the spark when it discharged, it was at least 8,000 volts. The good news is these voltages won't kill or hurt people, mostly because they aren't combined with current to generate power.

In contrast, computer components can be damaged by as little as 250 volts. You won't see it. You won't feel it. However, the damage will be real.

The primary way to prevent ESD damage is by ensuring that the worker and the equipment are at the same ground potential. Steps you can take to reduce ESD damage include the following:

- **Use an ESD wrist strap.** An ESD wrist strap wraps around your wrist and has a metal component touching your skin. A wire leads from the strap to an alligator clip that you can clip to the computer case. This results in you and the case being at the same potential, and it prevents static discharge. On work benches, ESD straps are used to connect the equipment case to a grounding bar that is connected to Earth ground. The technician can connect alligator clips from the wrist strap to the case or to the grounding bar.

- **Use antistatic bags.** When storing and transporting electronic components, they should be stored in antistatic bags. These bags help prevent static from building up and causing ESD damage to the components.
- **Use ESD mats.** Special ESD mats prevent static buildup, and they are commonly used on work benches. Technicians place computers on the antistatic mat while working on them. Larger antistatic mats can be placed on the floor in front of the technician's bench to reduce static.

EXAM TIP

Very small amounts of ESD can cause damage. This is especially true when handling sensitive components such as CPUs and memory. ESD protection such as antistatic wrist straps, antistatic component bags, and antistatic mats are valuable to protect against ESD damage when handling CPUs, memory, and other sensitive components.

- **Self-grounding.** If you touch the computer case before working on any components, built-up static will discharge harmlessly onto the case. This ensures that your body is at the same ground potential as the case. Additionally, if you keep your feet stationary after touching the case, it reduces the chances for static to build up.
- **Don't touch components or pins.** If you remove any circuit cards, don't touch the components or the pins. Instead, hold the outside edges or the plastic handles.
- **Control humidity.** When the humidity is very low, static builds up more quickly. If you live in a colder area, you'll notice that static is more common in the winter because heating systems remove humidity from the air. In contrast, when the humidity is higher, the static charges dissipate naturally. Ideally, humidity should be around 50 percent.
- **Don't place computers on carpets.** Static can build up on carpets more easily than on other floor surfaces. You've probably noticed that in a heated building you can shuffle your feet over a carpet to quickly build up static. This doesn't work on tile floors or other floor surfaces.

MSDS

Material Safety Data Sheets (MSDSs) are available for most products that have a potential to cause harm to people or equipment. This includes materials such as cleaning solutions, paints, and chemicals. The MSDS identifies important safety facts about the material including its contents, its characteristics, how to handle and store it safely, and how to dispose of it. It will also list first-aid steps to take if the material presents a danger.

As an A+ technician, you are likely to use products that have MSDS sheets. For example, you might use cleaning products that clean computer screens or keyboards. If any of these products is causing an adverse reaction to either people or the equipment, you can refer to the MSDS sheet for information about the product and additional steps to take after the exposure.

Compliance with Regulations

Any government regulations pertaining to safety or environmental controls must be followed. For example, the state of California has mandated that all batteries be disposed of as hazardous waste. Even if the batteries are the newer mercury-free alkaline batteries, the regulation still requires special handling.

> ***NOTE*** **IGNORANCE IS NO EXCUSE**
>
> **An old saying related to the law is that "ignorance is no excuse." With that in mind, organizations have a responsibility to learn what regulations apply to them where they operate, and to comply with those regulations.**

Fire Safety

Fires are classified based on what is burning, and fire extinguishers are classified based on what fires they can safely extinguish. The four primary types of fires are as follows:

- **Class A.** This type of fire involves ordinary combustible material such as paper and wood. The fire can be extinguished with water or a Class A fire extinguisher.
- **Class B.** This type of fire involves flammable liquids and gases. Class B fire extinguishers use chemicals to disrupt the chemical reaction, or they smother the fire with a gas such as carbon dioxide. Spraying water on a Class B fire is dangerous because it will spread the fire instead of extinguishing it.
- **Class C.** An electrical fire is a Class C fire, and the best way to extinguish it is by removing the power source. For example, unplugging it or turning off the circuit breaker can stop the fire. Class C fire extinguishers use special chemicals such as Purple-K or carbon dioxide to extinguish a fire.

> ***IMPORTANT*** **NEVER USE WATER TO EXTINGUISH CLASS C FIRES**
>
> **Water is conductive. Electricity can travel up the water stream and electrocute you if you spray water onto an electrical fire.**

- **Class D.** This type of fire involves combustible metals. A Class D fire extinguisher uses special chemicals to smother the fire. Water should not be used.

Lifting

When lifting equipment, it's best to lift with your legs, not your back. In other words, instead of bending down to pick up heavy equipment, you should squat, bending your knees, to pick it up.

There aren't any firm guidelines on safe weight limitations. However, it's generally recommended that individuals do not try to lift equipment weighing more than 70 pounds without help.

> **Quick Check**
>
> 1. **What can be used to protect against ESD?**
> 2. **What includes first-aid steps to take if cleaning supplies cause harm to a person?**
>
> **Quick Check Answers**
>
> 1. **Controlled humidity, antistatic wrist straps, and antistatic mats**
> 2. **MSDS sheets**

Tools

If you're going to work on computers, you'll need some tools. The following sections identify some common tools you should have.

Screwdrivers

Case fans, power supplies, and motherboards are all secured with screws, so if you need to remove them, you'll need a screwdriver. Most screws are Philips, so you'll need one or two Philips screwdrivers in addition to one or two flat-blade screwdrivers in your toolkit.

Extension Magnet

It's not uncommon to drop a screw within a system, but your fingers often won't fit into the small spaces to retrieve it. You can retrieve it with an extension magnet. An extension magnet has a handle similar to a screwdriver, but it has an extendable wand with a magnet on the end. In some situations, the screw might fall onto other electrical components, such as the motherboard. Instead of using the extension magnet, you can use a pair of plastic tweezers to avoid possible damage to system components.

Compressed Air and Compressors

As mentioned previously, compressed air can be used to clean out a computer case. You can purchase cans of compressed air online or at computer and electronics stores. They usually have plastic straws that you can attach to the spray nozzle so that you can direct the air into the nooks and crannies of the case. Compressed air is also useful for blowing out keyboards, printers, and laptop cases.

Compressors are electronic motors that build up air pressure and allow you to blow out components with a hose. For example, many gas stations have compressors that you can use to add air to your tires. Unlike compressed air cans, a compressor will never run out of air.

IMPORTANT **BE CAREFUL WHEN USING AIR COMPRESSORS**

Some compressors have very high air pressure, which can damage components within the computer if you're not careful. Additionally, some air compressors collect water that can spray into the computer. Technicians that use these often have a regulator that they use to keep the pressure below 20 pounds per square inch (psi), and they use filters to trap any water. Some technicians strongly oppose using air compressors at all.

Computer Vacuum

In some cases, it isn't feasible to take computers outside to blow out the dust. However, if you blow out the dust inside the building, you're going to make quite a mess. Instead, you can use a computer vacuum cleaner to clean out the computer.

You should use only vacuum cleaners designed for the job. Regular vacuum cleaners generate static electricity and can easily damage the sensitive components within the computer. Computer vacuums are made of special materials and often use batteries instead of AC power.

EXAM TIP

Regular vacuum cleaners and their attachments can cause ESD damage to systems. Computer vacuums are made of special material resistant to ESD.

Multimeter

Multimeters have multiple functions, and technicians commonly use them to measure power supply voltages.

For example, power supplies sometimes lose the ability to provide constant power. Instead of a steady 12 V, a power supply might waver between 10 V and 14 V. Even though a system has some tolerance for variations, generally anything beyond 5 percent can cause problems, such as random restarts. Therefore, the 12-V line should not waver more than plus or minus 0.6 V (11.2 V to 12.6 V). If you're experiencing random problems and suspect the power supply, you can use a multimeter to measure the voltages.

EXAM TIP

Random restarts can also indicate other problems. Overheating and in some cases faulty memory can cause a system to occasionally restart. Additionally, malicious software such as a virus can cause a system to randomly restart. Using a multimeter to verify that the voltages are stable can eliminate the power supply as a problem source.

Figure 1-10 shows a multimeter set to the V setting. It can measure both DC and AC voltages by using this setting. Additionally, this is an autorange digital multimeter (DMM), meaning that it can automatically sense the voltage range.

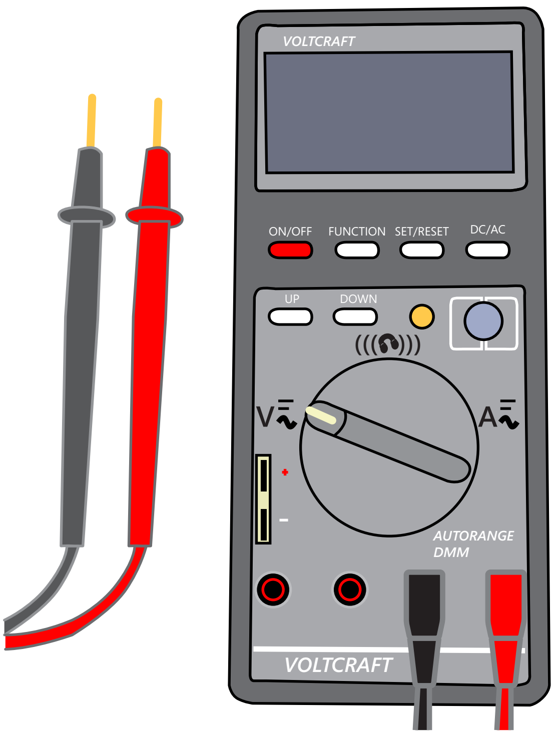


FIGURE 1-10 Digital multimeter.

Less expensive multimeters require you to set the range at the highest possible voltage to avoid damage. If you set it at a low voltage, such as 5 V, and then measure 12 V, you might damage the meter.

In Figure 1-10, you can see that the multimeter has two probes. It might not be apparent in the black-and-white picture, but one probe is red and one is black. You would connect the black probe to a ground pin of a connector (with a black wire) and connect the red probe to the voltage pin in the connector. For example, if you want to measure 12 V provided on a connector, connect it to the pin with the yellow wire. If you want to measure the 5-V line, connect the red probe to the pin with the red wire.

> ***CAUTION*** **SEVERE ELECTRICAL SHOCK POSSIBLE**
>
> **You can measure the voltage only when the power is on and supplying voltage to the system. Because of this you can be exposed to voltages when taking measurements. You should ensure that you do not touch anything within the computer except the connector. This includes touching components with your hands or with the multimeter probes.**

When taking voltage measurements, you should remove jewelry. If the jewelry touches a metal component that has voltage, it's possible to short it out and damage the equipment. It could also shock you.

Multimeters can also take other measurements. Besides voltage, the most common measurement is a continuity check. When the meter is set to do a continuity check, you can touch the probes together and the meter will beep, indicating a continuous connection. You can use this setting to check for a break in a cable. You touch one probe to the connector on one side of a cable, and the other probe to the other side. If it beeps, it indicates a continuous connection in the cable, indicating that the cable is good. If it doesn't beep, the cable has a break and should be replaced.

Power Supply Tester

Most power supplies will not provide voltages unless they are plugged into the component. For example, if you want to measure voltages on the motherboard P1 connector, the P1 connector needs to be plugged in. If it's not plugged in, the voltages are zero.

This can be a problem if you want to check a power supply but you don't have a motherboard or other components. However, a *power supply tester* simulates the load for a power supply and lets you know if you have a problem. You plug the power supply cables into the power supply tester and turn it on. The tester will display the voltages, and if any of the voltages are outside specifications, it will indicate the problem.

> ✔ **Quick Check**
>
> 1. **What should you use to clean out a computer case?**
> 2. **What can you use to verify a power supply is providing 12 VDC to a system?**

Quick Check Answers

1. Compressed air, or a computer vacuum that doesn't generate static electricity
2. Multimeter

Chapter Summary

- The three functions of a computer are input, processing, and output. These are often shortened to I/O.
- Binary numbers use only ones and zeros. Hexadecimal numbers are created from four binary bits and include the characters 0–9 and A–F. Eight bits make up a byte.
- Large numbers of bytes are expressed as KB, MB, GB, and TB.
- Computer cases house key computer components, including motherboards, case fans, and power supplies.
- Case fans help keep a system cool by drawing air into the case. Cases and fans often get dirty. They can become quite loud, and the system can slow down or intermittently fail. The easy solution is to clean them.
- Case fans can be replaced. If a fan fails, the system can overheat, so the fan should be replaced as soon as possible.
- Power supplies convert commercial AC power to DC voltages. Power supplies are rated based on the power they provide, expressed as watts (W). Replacement power supplies need to meet or exceed the power requirements of the computer.
- Dual voltage power supplies have a switch identified as 115 or 230 to identify the source voltage. Ensure that it is set to the correct voltage supplied by commercial power.
- ATX-based power supplies provide 3.3 V, 5 V, 12 V, and -12 V to system components through various power connectors. These voltages can be measured with a multimeter or a power supply tester.
- The P1 power plug is the primary power connector for the motherboard and includes 20 or 24 pins. Many systems have a secondary power plug that includes 4, 6, or 8 pins.
- Molex connectors provide 5 V and 12 V to PATA disk drives. The SATA connector provides 3.3 V, 5 V, and 12 V to SATA disk drives. Power to disk drives is provided via 12-V rails, and desktop power supplies commonly have two rails but can have more. If disk drives are failing, you might need a power supply with an additional rail.
- PCIe connectors use 6 pins, 8 pins, or 6+2 pins.

- Surge suppressors protect components against spikes and surges in power. UPS systems protect systems against sags and short-term power losses.
- ESD damage can be prevented by using ESD wrist straps and ESD mats, and by controlling the humidity.
- Extension magnets can help retrieve screws that can't normally be reached. Compressed air or special antistatic vacuum cleaners can be used to clean computers.
- MSDS sheets document characteristics about potentially hazardous material used in a work center, including how to store and dispose of hazardous material. When local regulations exist, they take precedence.
- Electrical fires are Class C fires. You should never use water on an electrical fire.
- Compressed air is the preferred method of cleaning systems. If a vacuum is used, it should be a special antistatic vacuum.
- Multimeters measure voltages and can check cable continuity. Power supply testers can check voltages on power supplies without a motherboard.

Chapter Review

Use the following questions to test your knowledge of the information in this chapter. The answers to these questions, and the explanations of why each answer choice is correct or incorrect, are located in the "Answers" section at the end of this chapter.

1. A computer is making a lot of noise. Of the following choices, what is the likely problem?
   - **A.** Faulty motherboard
   - **B.** USB flash drive
   - **C.** Power supply set to wrong voltage
   - **D.** Case fan
2. Another technician ordered a fan for a computer case. It has arrived, and you need to install it. The original fan has been removed. Where should you connect the fan power connection?
   - **A.** AC outlet
   - **B.** P1 power supply connector
   - **C.** Front panel power
   - **D.** Motherboard

3. A power supply failed after a technician added some hard drives to a desktop computer. You need to purchase an additional power supply. What is a likely power rating you'll purchase to ensure that the power supply doesn't fail again?

   A. 600 W

   B. 600 V

   C. 300 W

   D. 250 V

4. Which of the following voltages are not provided by ATX-based power supplies? (Choose two.)

   A. 12 VDC

   B. -12 VDC

   C. 115 VAC

   D. 15 VDC

5. Molex connectors provide power to disk drives from ATX-rated power supplies. What voltages are supplied through the Molex connector?

   A. 3.3 V and 5 V

   B. 5 V and 12 V

   C. 5 V and 15 V

   D. 12 V and 15 V

6. A system is no longer booting to the SATA hard drive, and you suspect that the ATX-based power supply might not be providing the correct voltages. What voltages should you see on the SATA power connector?

   A. 3.3 VDC, 5 VDC, and 12 VDC

   B. 3.3 VDC, 12 VDC, and 15 VDC

   C. 5 VDC, 12 VDC, and 15 VDC

   D. 12 VDC, 15 VDC, and 24 VDC

7. Which of the following can you use to protect against power sags?

   A. Commercial power

   B. Power supply

   C. UPS

   D. MSDS

8. Which of the following can protect against ESD damage? (Choose all that apply.)
   - **A.** ESD wrist strap
   - **B.** Reducing humidity as much as possible
   - **C.** Ensuring that computers are stored on carpets whenever possible
   - **D.** ESD mat
9. You want to verify that a power supply is providing proper voltages while it's connected to the P1 connector on the motherboard. What would you use?
   - **A.** Surge suppressor
   - **B.** Multimeter
   - **C.** Power strip
   - **D.** Power supply tester
10. You open a computer to troubleshoot it and notice an excessive amount of dust inside it. Of the following choices, what is the best choice to clean it?
    - **A.** Lint-free cloth
    - **B.** Vacuum cleaner
    - **C.** Glass cleaner
    - **D.** Compressed air
11. Which of the following can contribute to ESD damage?
    - **A.** Case fans
    - **B.** Carpet
    - **C.** Touching the computer case while working on a computer
    - **D.** ESD mats
12. After cleaning a computer screen with a cleaning compound, your fingers start to develop a rash. What can you use to quickly identify what was in the cleaning compound?
    - **A.** MSDS
    - **B.** Internet
    - **C.** Local hospital
    - **D.** Coworkers

Answers

This section contains the answers to the chapter review questions in this chapter.

1. **Correct Answer:** D
    - **A. Incorrect:** When motherboards fail, they are not noisy.
    - **B. Incorrect:** Hard disk drives sometimes make a lot of noise when they are failing, but not USB flash drives.
    - **C. Incorrect:** If the power supply is set to the wrong voltage, it might make a single loud pop when it fails, or not work at all, but it won't make a lot of noise.
    - **D. Correct:** When case fans begin to fail, they are often noisy. They can also be noisy if they are dirty.
2. **Correct Answer:** D
    - **A. Incorrect:** Case fans do not get power from AC outlets.
    - **B. Incorrect:** The P1 connector provides power to the motherboard, not to fans.
    - **C. Incorrect:** Front panels do not have power for fans.
    - **D. Correct:** Fans get power from a connector on the motherboard.
3. **Correct Answer:** A
    - **A. Correct:** A 600-W power supply is common in desktop computers and is the best choice of those given.
    - **B. Incorrect:** Power supplies are rated in watts, not volts.
    - **C. Incorrect:** A 300-W power supply is on the low range found with desktop computers. If the original failed after adding an additional load with disk drives, a larger power supply is needed.
    - **D. Incorrect:** Power supplies are rated in watts, not volts.
4. **Correct Answers:** C, D
    - **A. Incorrect:** ATX-based power supplies provide 12 VDC.
    - **B. Incorrect:** ATX-based power supplies provide -12 VDC. They also provide 5 VDC and 3.3 VDC.
    - **C. Correct:** ATX-based power supplies use AC voltage as an input but do not provide AC voltage.
    - **D. Correct:** ATX-based power supplies do not provide 15 VDC.

5. **Correct Answer:** B

   A. **Incorrect:** 3.3 V is provided to the motherboard through the 20-pin or 24-pin P1 connector, but not on the Molex connector.

   B. **Correct:** Molex connectors supply 5 V and 12 V from the power supply to different drives in a computer.

   C. **Incorrect:** 5 V is provided through both Molex and the P1 motherboard connector, but 15 V is not used in ATX power supplies.

   D. **Incorrect:** 12 V is provided through both Molex and the P1 motherboard connector, but 15 V is not used in ATX power supplies.

6. **Correct Answer:** A

   A. **Correct:** The correct voltages on a SATA connector are 3.3 VDC, 5 VDC, and 12 VDC.

   B. **Incorrect:** ATX power supplies do not provide 15 VDC.

   C. **Incorrect:** ATX power supplies do not provide 15 VDC.

   D. **Incorrect:** ATX power supplies do not provide 15 VDC or 24 VDC.

7. **Correct Answer:** C

   A. **Incorrect:** A power sag occurs when the commercial power is lower than normal, so commercial power doesn't protect against it.

   B. **Incorrect:** Power supplies convert AC to DC, but they cannot protect against power sags.

   C. **Correct:** An uninterruptible power supply (UPS) uses a battery backup to protect against power sags. Flickering lights are an indication of power sags.

   D. **Incorrect:** Material Safety Data Sheets (MSDSs) provide safety-related information for items used within a work environment.

8. **Correct Answers:** A, D

   A. **Correct:** Electrostatic discharge (ESD) wrist straps protect against ESD damage.

   B. **Incorrect:** Low humidity generates more static. Ideally, humidity should be around 50 percent.

   C. **Incorrect:** Carpets generate static easily, so it's best not to store computers on carpets.

   D. **Correct:** ESD mats also protect against ESD.

9. **Correct Answer:** B

   A. **Incorrect:** A surge suppressor will prevent power spikes from reaching a computer, but it doesn't measure voltages.

   B. **Correct:** A multimeter can measure DC voltages provided to a motherboard on the P1 connector.

   C. **Incorrect:** A power strip provides unprotected power to a system but doesn't measure voltage.

   D. **Incorrect:** A power supply tester can test an unconnected power supply, but it isn't used for a power supply plugged into a system.

10. **Correct Answer:** D

   A. **Incorrect:** Lint-free cloths are used to clean screens but would not be used for an excessive amount of dust.

   B. **Incorrect:** An antistatic vacuum cleaner could be used but a standard vacuum cleaner can cause ESD damage.

   C. **Incorrect:** Glass cleaner includes ammonia and alcohol, which might damage internal components.

   D. **Correct:** Compressed air would be the best choice for blowing out the dust.

11. **Correct Answer:** B

   A. **Incorrect:** Case fans keep a system cool but do not contribute to ESD damage.

   B. **Correct:** Static builds up on carpet, so placing computers on carpets can contribute to ESD damage.

   C. **Incorrect:** Touching the computer case while working on a computer helps keep you at the same potential as the computer and reduces static buildup.

   D. **Incorrect:** ESD mats reduce the potential for ESD damage.

12. **Correct Answer:** A

   A. **Correct:** A Material Safety Data Sheet (MSDS) documents characteristics of materials used within a workplace.

   B. **Incorrect:** You might be able to find the information on the Internet, but an MSDS sheet should be readily available.

   C. **Incorrect:** Medical personnel will likely want to know what was in the cleaning compound, but they wouldn't know what was used.

   D. **Incorrect:** Coworkers wouldn't be the best source to identify the contents, but they can retrieve the MSDS.

CHAPTER 3

Understanding RAM and CPUs

In this chapter, you'll learn about two important concepts for any A+ technician to understand: random access memory (RAM) and central processing units (CPUs). A CPU is the brain of the computer, performing most of the processing, and RAM is used to store applications and data being used by the CPU. Both continue to be steadily improved and include a significant amount of technical detail that can easily confuse a regular user. This chapter will help you understand many of the terms used when describing them.

Exam 220-801 objectives in this chapter:

- 1.2 Differentiate between motherboard components, their purposes, and properties.
  - CPU sockets
- 1.3 Compare and contrast RAM types and features.
  - Types
    - DDR
    - DDR2
    - DDR3
    - SDRAM
    - SODIMM
    - RAMBUS
    - DIMM
    - Parity vs. non-parity
    - ECC vs. non-ECC
    - RAM configurations
      - Single channel vs. dual channel vs. triple channel
    - Single sided vs. double sided
  - RAM compatibility and speed

- 1.6 Differentiate among various CPU types and features and select the appropriate cooling method.
  - Socket types
    - Intel: LGA, 775, 1155, 1156, 1366
    - AMD: 940, AM2, AM2+, AM3, AM3+, FM1, F
  - Characteristics
    - Speeds
    - Cores
    - Cache size/type
    - Hyperthreading
    - Virtualization support
    - Architecture (32-bit vs. 64-bit)
    - Integrated GPU
  - Cooling
    - Heat sink
    - Fans
    - Thermal paste
    - Liquid-based

Exam 220-802 objectives in this chapter:

- 4.2 Given a scenario, troubleshoot common problems related to motherboards, RAM, CPU and power with appropriate tools.
  - Common symptoms
    - Unexpected shutdowns
    - System lockups
    - Overheating

RAM

When technicians are talking about a computer's memory, they are primarily talking about *random access memory (RAM)*. RAM is used for short-term storage of applications or data so that the processor can access and use this information. In contrast, computers use hard drives for long-term storage of data.

Most RAM is volatile. This doesn't mean that it's explosive; it means that data in RAM is lost when power is removed.

As an introduction, the following list identifies commonly used types of RAM. All of these types of RAM are volatile.

- **Dynamic RAM (DRAM).** Dynamic refers to how bits are stored in an electrical component called a capacitor. The capacitor holds the bit as a charge, but the capacitor needs to be regularly refreshed to hold the charge. This configuration uses very few components per bit, keeping the cost low, but the constant refresh reduces the speed.
- **Synchronous DRAM (SDRAM).** *SDRAM* is synchronized with a clock for faster speeds. Almost all primary *DRAM* used in computers today is SDRAM, but it's often listed as DRAM to avoid confusion with *SRAM*.
- **Static RAM (SRAM).** Static RAM uses switching circuitry instead of capacitors and can hold a charge without a constant refresh. It requires more components per bit so it is more expensive, but due to how the switching works, it is quicker than DRAM. Due to the speed, SRAM is commonly used for CPU cache (described later in this chapter) but is rarely used as the primary RAM because of its cost.

NOTE **SRAM VS. SDRAM**

SRAM and SDRAM are often conflated; however, they are different, and the S makes the difference. The *S* in SRAM indicates *static*, but the *S* in SDRAM indicates *synchronous*. Because of its speed, SRAM is used for CPU cache. SDRAM is used as the primary RAM in computer (PCs). Almost all DRAM in personal computers is SDRAM.

Flash memory is very popular, but not as the primary RAM used in a system. USB flash drives, solid-state drives (SSDs), and memory cards used in cameras and other mobile devices all use flash memory. Flash memory is used for BIOS in many motherboards. Unlike DRAM and SRAM, flash memory is not volatile and retains data without power.

Double Data Rate SDRAM

While the original SDRAM versions were quick and efficient for their time, manufacturers have steadily improved them. *Double data rate* (*DDR*) is one of the improvements and is used in almost all SDRAM. As a reminder, SDRAM is tied to a clock, and when the clock ticks, data is transferred.

SDRAM uses only the leading edge for the clock. However, each of the *DDR SDRAM* versions uses both the leading and trailing edge of the clock. This is often called *double pumping*. Figure 3-1 compares the two over two cycles of a clock. You can see that SDRAM has two clocks from these cycles and that DDR has four clocks from the same two cycles.

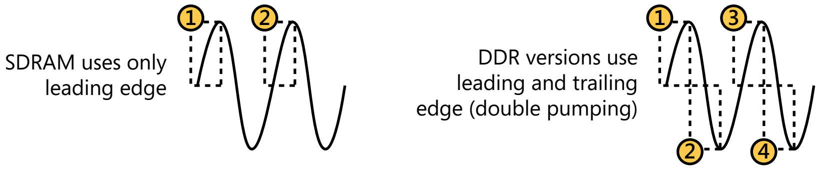


FIGURE 3-1 SDRAM compared with double-pumping DDR.

The following list provides an overview of the different DDR versions:

- **Double Data Rate (DDR) SDRAM.** DDR uses double pumping to double the data rate of SDRAM.
- **DDR2.** DDR2 doubles the data rate of DDR. In addition to double pumping, it modifies the way that data is processed and can transfer twice as much data as DDR SDRAM.
- **DDR3.** DDR3 doubles the data rate of DDR2. It uses double pumping and further modifies the way that data is processed. It can transfer four times as much data as DDR and eight times as much data as SDRAM.

EXAM TIP

DDR3 SDRAM is the primary type of RAM you see in most systems today. It supersedes SDRAM, DDR SDRAM, and DDR2 SDRAM. However, some existing systems have older RAM, and the CompTIA objectives list each type of RAM, so you'll need to be aware of all of them.

DDR4 isn't included in the objectives, but it is on the horizon as a replacement for DDR3. It's expected to double the speed of DDR3.

DIMMs and SODIMMs

RAM comes on cards plugged into the slots in the motherboard. They are smaller than expansion cards, and technicians commonly call memory cards *sticks*. The two most common types of memory sticks are:

- **Dual in-line memory module (DIMM).** A *DIMM* is the circuit board that holds the memory chips.
- **Small outline dual in-line memory module (SODIMM).** *SODIMM* chips are smaller and are used in smaller devices such as laptop computers and some printers.

Figure 3-2 shows a DIMM (top) and a SODIMM (bottom).

IMPORTANT **AVOID ELECTROSTATIC DISCHARGE DAMAGE**

The CPU and RAM are most susceptible to electrostatic discharge (ESD) damage. If you plan on touching the CPU or RAM, ensure that you use ESD wrist straps and other ESD protection as mentioned in Chapter 1, "Introduction to Computers."

FIGURE 3-2 Comparing a DIMM and a SODIMM.

DIMMs and SODIMMs have a different number of pins depending on the type used.

- **DDR SDRAM DIMM:** 184 pins
- **DDR2 SDRAM DIMM:** 240 pins
- **DDR3 SDRAM DIMM:** 240 pins
- **DDR SDRAM SODIMM:** 200 pins
- **DDR2 SDRAM SODIMM:** 144 or 200 pins
- **DDR3 SDRAM SODIMM:** 204 pins

Single Channel, Dual Channel, and Triple Channel

Many motherboards and CPUs support single-channel, dual-channel, and triple-channel memory architectures. Each *single channel* represents a separate 64-bit line of communication that can be accessed independently. With dual channel, the system can access 128 bits at a time; triple channel gives it access to 192 bits at a time.

Using dual and triple channels provides an additional performance enhancement to DDR, DDR2, and DDR3, in addition to double pumping and other enhancements provided by the DDR versions. If you use a dual-channel motherboard with DDR3, it doubles the throughput of DDR3, providing 16 times more data throughput than SDRAM.

If you are upgrading a computer's memory, it's important to understand these channels. You can purchase DIMMs in matched pairs. Where you install each DIMM determines how many channels your system will use and can affect the performance of RAM.

Single Channel vs. Dual Channel

Dual-channel motherboards are very common. If you look at a dual-channel motherboard, you see that it has four memory slots, two slots of one color and two slots of another color. Figure 3-3 shows a diagram of four memory slots labeled for a motherboard using an Intel-based CPU. Slots 1 and 3 are one color, and slots 2 and 4 are another color.

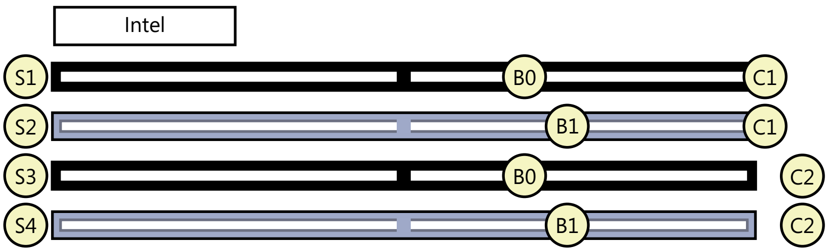


FIGURE 3-3 Intel-based DDR slots (S), banks (B), and channels (C).

- **Slots:** Each slot can accept one DIMM.
- **Banks:** A bank is composed of two slots. In Figure 3-3, Bank 0 includes slots 1 and 3 and these two slots are normally blue. Bank 1 includes slots 2 and 4 and these slots are normally black. This is standard for Intel CPU-based motherboards.
- **Channels:** Each channel represents a separate 64-bit communication path. Slots 1 and 2 make up one channel, and slots 3 and 4 make up the second channel.

EXAM TIP

On most motherboards, the slots are color-coded to identify the banks. Slots of the same color indicate the same bank, and matched pairs should be installed in these slots.

You can install a single DIMM in slot 1, and the system will have a single-channel RAM. You can purchase DIMMs in matched pairs, and it's important to know in which slots to install them. For the best performance, you should install matched DIMMs in the same bank. Looking at Figure 3-3, you should install the matched pair of DIMMs in slots 1 and 3 (Bank 0), leaving slots 2 and 4 empty. The system will take advantage of the dual-channel architecture by using two separate 64-bit channels.

What happens if you install the DIMMs in slots 1 and 2 instead? The system will still work; however, both DIMMs are installed in channel 1, so the system will work with only a single channel. RAM will be about half as fast as it could be if it were installed correctly to take advantage of the dual channels.

Figure 3-3 and the previous explanation describe the color coding, banks, and channels for Intel-based CPU motherboards. However, most motherboards designed for AMD CPUs are organized differently, as shown in Figure 3-4. On these motherboards, slots 1 and 2 make up Bank 0, and slots 3 and 4 make up Bank 1. Channel 1 includes slots 1 and 3, and channel 2 includes slots 2 and 4.

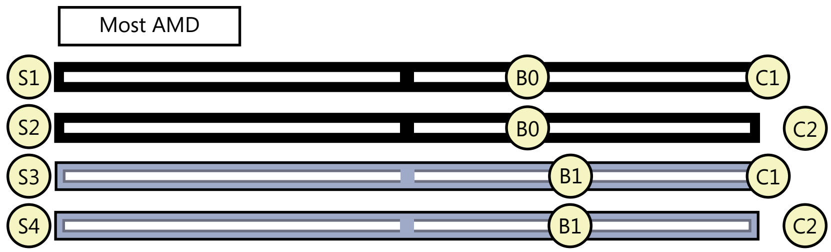


FIGURE 3-4 AMD-based DDR slots (S), banks (B), and channels (C).

While this can be confusing between different motherboards, the good news is that most motherboard manufacturers use the same color for each bank. For Intel-based motherboards, Bank 0 includes slots 1 and 3, and these will be the same color (often blue). Bank 1 includes slots 2 and 4, and they will be a different color (often black). AMD motherboards also use one color for Bank 0 (slots 1 and 2) and another color for Bank 1 (slots 3 and 4).

EXAM TIP

Many motherboards allow the use of different size DIMMs in different channels. However, for the system to use the multichannel capability, each DIMM within a bank must be the same size. If one DIMM in a bank is 1 GB and the second DIMM in the bank is 2 GB, the sizes are different and the system will use single channel. Also, you can use different speed DIMMs in the same bank, although this is not recommended. The speed of the bank will default to the lower-speed DIMM or, in some cases, to single channel.

Triple Channel

On some motherboards, you see six DIMM slots instead of four. This indicates the system supports *triple-channel* memory usage. Table 3-1 shows the configuration of the slots, banks, and channels for a motherboard using triple-channel RAM.

TABLE 3-1 Triple-Channel DIMMs

Slots	Banks	Channels
Slot 1	Bank 0	Channel 1
Slot 2	Bank 1	Channel 1
Slot 3	Bank 0	Channel 2
Slot 4	Bank 1	Channel 2
Slot 5	Bank 0	Channel 3
Slot 6	Bank 1	Channel 3

Slots in each bank are commonly the same color, so you might see a motherboard with Bank 0 slots (slots 1, 3, and 5) all blue and with Bank 1 slots all black.

Triple-channel DIMMs are sold in matched sets of three, similar to how dual-channel DIMMs are sold in matched pairs. When you install triple-channel DIMMs, you should install the matched set in the same bank. For example, if you bought one set, you'd install it in slots 1, 3, and 5.

NOTE **QUAD CHANNEL**

Quad-channel motherboards are also available and have eight DIMM slots. When buying RAM for a quad-channel motherboard, you buy the RAM in a matched set of four. Quad-channel RAM is not mentioned in the CompTIA A+ objectives.

Single Sided vs. Double Sided

You'd think that *single-sided* and *double-sided* RAM refers to how many sides of a DIMM have chips. That makes sense, but it's not entirely accurate. Instead, single sided or double sided refers to how a system can access the RAM.

In double-sided RAM, the RAM is separated into two groups known as ranks, and the system can access only one rank at a time. If it needs to access the other rank, it needs to switch to the other rank. In contrast, single-sided (or single-rank) RAM is in a single group; the system can access all RAM on the DIMM without switching.

If you have a DIMM with chips on only one side, it is most likely a single-sided (single-rank) DIMM. However, if it has chips on both sides, it can be single rank, dual rank, or even quad rank. You often have to dig into the specs to determine how many ranks it is using.

Usually, you'd think that *double* is better than *single*, but in this case, more rank is not better. Switching back and forth between ranks takes time and slows down the RAM. Single-sided RAM doesn't switch, and if all other factors are the same, single-sided RAM is faster than double-sided RAM.

NOTE **DUAL-SIDED IS NOT DUAL CHANNEL**

Dual-sided (or dual-ranked) is not the same as dual channel. Dual channel improves performance, but a dual-ranked DIMM doesn't perform as well as a single-ranked DIMM.

Quick Check

1. **A system has six RAM slots. What does this indicate?**
2. **Where should you install two new DIMMs on a dual-channel motherboard?**

Quick Check Answers

1. **Triple-channel RAM.**
2. **In the same bank, identified by slots of the same color.**

RAM Compatibility and Speed

An important point about DDR, DDR2, and DDR3 is that they aren't compatible with each other. You can't use any version in a slot designed for another type. For example, you can use DDR3 DIMMs only in DDR3 slots. From a usability perspective, that's not so great, but if you're trying to remember which types are compatible, it's a lot easier. You can't mix and match them.

Figure 3-5 shows a comparison of the keyings of DDR, DDR2, and DDR3, with a dotted line as a reference through the middle of each one. You can see that the notched key at the bottom of the circuit card is different for each. The standards aren't compatible, and this keying prevents technicians from inserting a DIMM into the wrong slot.

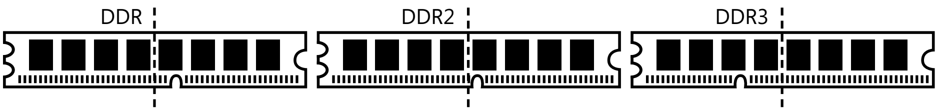


FIGURE 3-5 Comparing DDR versions.

Speeds

Some RAM is faster than other RAM, and with faster RAM you often see faster overall performance. As you'd expect, faster RAM is more expensive. If you're shopping for RAM, you want to ensure that you buy exactly what you need. This includes the correct DDR version, the correct number of channels if your motherboard supports multiple channels, and the correct speed.

The speed of RAM is expressed as the number of bytes it can transfer in a second (B/s) or, more commonly, as megabytes per second (MB/s). However, the speed of most RAM isn't listed plainly. Instead, it's listed using standard names and module names such as DDR3-800 or PC3-12800, respectively. These names indicate their speed, but not directly. If you need to shop for RAM, you need to understand these names and how they relate to the speed.

> ***NOTE*** **DIMM STICKERS**
>
> **Most DIMMs have stickers on them that include the standard name, module name, or both. If you're working at a company that has stored excess DIMMs in static-free packaging, you can identify details from these names.**

You can calculate the overall speed of any SDRAM DDR type by using a specific mathematical formula for that type. The formula includes the speed of the clock (Clk), a clock multiplier (Clk Mult) for DDR2 and DDR3, and doubling from double pumping (DP). The speed is calculated for a single channel, which is 64 bits wide, and then converted to bytes by dividing it by 8. The following formulas show how to calculate the speed of each of the DDR versions by using a 100-MHz clock:

- **DDR speed calculation:**
  - Clk × 2 (DP) × 64 (bits) / 8 (bytes)
  - 100 MHz × 2 × 64 / 8 = 1,600 MB/s
- **DDR2 speed calculation:**
  - Clk × 2 (Clk Mult) × 2 (DP) × 64 (bits) / 8 (bytes)
  - 100 MHz × 2 × 2 × 64 / 8 = 3,200 MB/s
- **DDR3 speed calculation:**
  - Clk × 4 (Clk Mult) × 2 (DP) × 64 (bits) / 8 (bytes)
  - 100 MHz × 4 × 2 × 64 / 8 = 6,400 MB/s

Table 3-2 shows how these speeds relate to the different naming conventions used with DDR types. You can see that the standard name is derived from the clock, the clock multiplier, and double pumping. For example, DDR3 uses a 4-times multiplier and double pumping. Therefore, it's eight times faster than SDRAM. The standard name is derived by multiplying the clock by 8. The module name is a little more cryptic, but if you calculate the speed by using the clock, you can see that the PC name indicates the calculated speed in MB/s. Also, you can see that the names include the version (DDR, DDR2, or DDR3).

TABLE 3-2 DDR Standard Names and Module Names

	100 MHz	**166 2/3 MHz**	**200 MHz**
DDR Standard Name DDR Module Name	DDR-200 PC-1600	DDR-333 PC-2700	DDR-400 PC-3200
DDR2 Standard Name DDR2 Module Name	DDR2-400 PC2-3200	DDR2-667 PC2-5300 PC2-5400	DDR2-800 PC2-6400
DDR3 Standard Name DDR3 Module Name	DDR3-800 PC3-6400	DDR3-1333 PC3-10600	DDR3-1600 PC3-12800

NOTE **SOME ROUNDING ALLOWED**

If you enjoy math, you can plug the fractional number 166 2/3 into the speed calculation formulas and see that they don't work out exactly. For example, DDR2-667 works out to about 5333.312 MB/s. Some manufacturers advertise this as PC2-5300, while others round it up to PC2-5400.

Each DDR version supports multiple clock speeds, and each newer version supports faster clocks. Some of the clock speeds supported by different DDR versions are as follows:

- **DDR:** 100, 133 1/3, 166 2/3, and 200 MHz
- **DDR2:** 100, 133 1/3, 166 2/3, 200, and 266 2/3 MHz
- **DDR3:** 100, 133 1/3, 166 2/3, 200, 266 2/3, and 400 MHz

A key consideration when purchasing RAM is to ensure that the RAM speeds are supported by the motherboard. If the speeds don't match, the motherboard defaults to the slower speed. For example, if your motherboard has a 100-MHz clock and you install PC3-12800 RAM, the RAM will run at 100 MHz instead of 200 MHz. It still works, but you won't get the benefit of the higher-speed RAM.

EXAM TIP

You might need to shop for memory, either to replace memory in your own system or to help someone else. If you can master how memory is named and marketed, you'll be able to identify the correct memory to purchase.

Compatibility within Banks

In addition to matching the RAM speed with the motherboard speed, you should also match the RAM speed within banks when using dual-channel and triple-channel configurations. If one DIMM in a bank fails, you should replace both with a matched set. However, if you have to replace the failed DIMM with a spare, look for a spare that uses the same speed.

For example, if Bank 0 currently has two PC3-12800 sticks and one fails, you should replace the failed stick with a PC3-12800 stick. PC3-12800 uses a 200-MHz clock. If you replaced it with a PC3-6400 (designed for a 100-MHz clock), both sticks would run at the slower speed or revert to single channel.

REAL WORLD **USING THE WRONG SLOTS RESULTS IN SLOWER RAM**

I once helped a friend troubleshoot the speed of a PC after a RAM upgrade. The system started with two 2-GB RAM sticks installed in slots 1 and 2, incorrectly using a single-channel configuration. These DIMMs were PC3-6400, using a 100-MHz clock, and they were working fine, but he wanted more RAM.

He purchased two new 2-GB PC3-12800 DIMMs designed to work with a 200-MHz clock. His motherboard supported 200 MHz, so it could take advantage of the faster RAM. However, after installing the RAM, he ran some tests and found that all the DIMMs were using 100 MHz, so he called me for some help.

Do you see the problem? It took a while to figure out and was exacerbated by the original RAM using the wrong slots. Bank 0 (in slots 1 and 3) now included one 100-MHz DIMM and one new 200-MHz DIMM, so it ran at the slower speed of 100 MHz. Similarly, Bank 1 (in slots 2 and 4) now included one 100-MHz DIMM and one 200-MHz DIMM, so it also ran at the slower speed.

Most users won't test the speed of the RAM after installing it. They're just happy that they have more memory. However, when speeds are mixed in the same bank, users won't get the higher performance.

Shopping for RAM

When shopping for RAM, you need to determine the clock speed of your computer and then determine the DDR name. You can boot into BIOS, as shown in Chapter 2, "Understanding Motherboards and BIOS," to identify the clock speed used by RAM and then plug it into the formula to determine the standard name and module name.

If you have access to the Internet, there's an easier way. You can go to one of the memory sites, such as *Crucial.com* or *Kingston.com*, and use one of their tools. You can enter the make and model of your computer, and the tool will tell you what memory is supported. *Crucial.com* also has an application that you can download and run to identify your motherboard, the type and speeds of supported RAM, how much RAM is installed, and recommendations for upgrading the RAM. Another tool that can help is CPU-Z (described at the end of this chapter).

> ***EXAM TIP***
>
> **When shopping for memory, you'll find that most memory resellers use the module name, such as PC3-6400. You'll need to match this with the speed of the clock on the target system. Also, remember that the DDR versions are not compatible. PC2-6400 indicates DDR2, and PC3-6400 indicates DDR3.**

Parity and ECC

Desktop systems rarely need extra hardware to detect or correct memory errors, but some advanced servers need this ability. The two primary error-detection technologies are *parity* and *error correction code (ECC)*. When shopping for RAM on desktop systems, you'll almost always buy non-parity and non-ECC RAM.

> ***NOTE*** **APPLICATIONS CHECK FOR ERRORS**
>
> **Applications routinely check for errors and often detect and correct errors without the need for parity or ECC RAM.**

Parity works by using 9 bits for every byte instead of 8 bits. It sets the ninth bit to a 0 or a 1 for each byte when writing data to RAM. Parity can be odd parity or even parity, referring to odd and even numbers.

Odd parity is common, and when used, it ensures that the 9 bits always have an odd number of 1s. For example, if the 8 data bits were 1010 1010, it has four 1s. Four is an even number, so the parity bit needs to be a 1. Whenever data is written to RAM, the parity bit is calculated and written with each byte.

When the data is read, the system calculates the parity from the 9 bits. If it ever detects an even number of 1s, it knows there is an error, meaning that the data isn't valid and should not be used. Parity can't fix the problem; it just reports the error.

ECC RAM uses additional circuitry and can detect and correct errors. This extra circuitry adds significantly to the cost of the RAM and should be purchased only when necessary. For example, spacecraft that might be exposed to solar flares commonly use ECC RAM. Additionally, some high-end scientific and financial servers need it to ensure that the data in RAM remains error-free.

Rambus and RDRAM

Another type of DRAM is *Rambus DRAM (RDDRAM)*. More commonly, you see it referred to as Rambus, Rambus DRAM, or RDRAM. RDRAM is not compatible with any of the DDR versions and is rarely used.

The circuit boards are called *Rambus in-line memory modules (RIMMs)* instead of DIMMs. When installing RDRAM, you must install it in pairs. In some cases, only one circuit card has memory and the second circuit card in the pair is needed to complete the circuit. The second card is called a *continuity RIMM (CRIMM)*.

EXAM TIP

Rambus and RDRAM are mentioned in the CompTIA objectives, but don't be surprised if you never see a RIMM. They aren't used in new computers, but you might see one in an older computer. You can identify RIMMs by the distinctive metal covering over the chips.

RDRAM generates quite a bit of heat. To dissipate the heat, the chips are covered with a piece of metal acting as a heat sink or heat spreader. This makes them easy to identify because DDR SDRAM is not covered with metal.

CPUs

The *processor*, or *central processing unit (CPU)*, is the brain of the computer. It does the majority of the processing work and is a key factor in the overall performance of a system. Over the years, CPUs have steadily improved, and as a computer technician, you're expected to know some basics about them.

There are two primary manufacturers of computers used in computers: *Intel* and *Advanced Micro Devices (AMD)*.

- **Intel.** Intel is the largest seller of CPUs, selling about 80 percent to 85 percent of all CPUs. It manufactures other products as well, including chipsets, motherboards, memory, and SSDs.
- **AMD.** AMD is the only significant competition to Intel for CPUs, and it sells about 10 percent to 15 percent of all CPUs. It also manufactures other products, including graphics processors, chipsets, and motherboards.

It's possible to purchase a new CPU and install it in a motherboard as part of an upgrade. An important question to ask is, "What should I buy?" When shopping, you'll see names like the following:

- Intel Core i7-960 Processor 3.2 GHz 8 MB Cache Socket LGA 1366
- Phenom II X4 965 AM3 3.4 GHz 512KB 45 NM

Will either of these fit in your motherboard? You might not know right now, but by the end of this chapter, you'll have the information to answer that question.

> ***NOTE*** **RISC**
>
> **You might hear about Advanced RISC Machine (ARM) processors. ARM uses a *reduced instruction set computer (RISC)* architecture and often runs more quickly and with less power than Intel and AMD-based CPUs, so these processors don't need fans. ARM processors are popular in tablets such as the iPad, but you can't replace CPUs in a tablet. You can replace CPUs in computers, so the Intel and AMD CPUs are more important to understand as a computer technician.**

32-bit vs. 64-bit

CPUs are identified as either 32-bit or 64-bit. Similarly, operating systems and many applications are referred to as either 32-bit or 64-bit. Key points to remember include the following:

- Windows operating systems come in both 32-bit and 64-bit versions.
- A 64-bit CPU is required to run a 64-bit operating system.
- A 64-bit operating system is required for 64-bit applications.
- A 64-bit CPU will also run 32-bit software.

The numbers 32 and 64 refer to the address bus discussed in Chapter 2. As a reminder, the address bus is used to address memory locations. A 32-bit CPU supports a 32-bit address bus and can address 2^{32} memory locations, or 4 GB of RAM. A 64-bit CPU supports a 64-bit address bus and can address 2^{64} memory locations, or about 17 EB.

> ***NOTE*** **NOT REALLY 4 GB**
>
> **The CPU also uses this address bus to address devices in the system in addition to RAM. Because of this, a 32-bit system reserves some of the address space for the other devices. If you install 4 GB of RAM in a 32-bit system, you find that operating system can use only about 3.3 GB.**

Operating systems and applications have gotten more sophisticated over the years. Developers have programmed extra features and capabilities, but all of these extras consume additional RAM. For many users, 4 GB of RAM simply isn't enough.

Due to the demand, developers such as Microsoft have created 64-bit versions of their operating systems. However, these 64-bit operating systems can run only on 64-bit CPUs. If you want to directly address more than 4 GB of RAM, you need both a 64-bit CPU and a 64-bit operating system.

- **32-bit and x86.** You often see 32-bit operating systems and software referred to as x86. This is a reference to the long line of Intel CPUs that ended in 86 and can run 32-bit software. AMD processors have different names but are also known to be x86-compatible.
- **64-bit.** Intel refers to its 64-bit processors as Intel 64, and AMD calls its 64-bit processors AMD64. Software makers often refer to 64-bit compatible software as x64.

EXAM TIP

If you want to use 64-bit operating systems, you must have a 64-bit CPU, but you do not need to have software designed specifically for a CPU model. For example, Windows operating systems will work with either Intel or AMD CPUs.

CPU Cores

Most CPUs today have multiple cores within them. Each *core* is a fully functioning processor. With multiple cores, the CPU can divide tasks among each core. The result is a faster system.

Operating systems view the multiple cores as individual CPUs. For example, a single eight-core processor will appear in Task Manager as though it is eight separate processors, as shown in Figure 3-6.

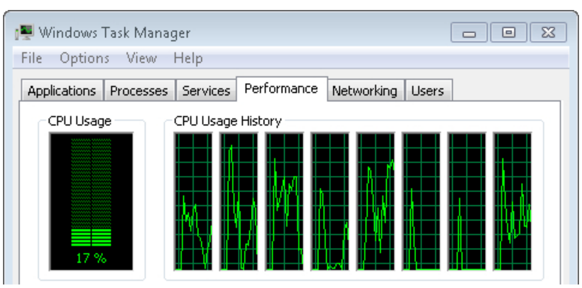


FIGURE 3-6 Task Manager showing eight cores of a single CPU.

MORE INFO **CHAPTER 13, "USING WINDOWS OPERATING SYSTEMS"**

Figure 3-6 shows a partial view of Windows Task Manager. You can start it on Windows systems by pressing Ctrl+Shift+Esc. Chapter 13 provides more details about Task Manager, including how to interpret the displays.

It's worth noting that Figure 3-6 is the same view you'd see if you had an Intel four-core processor with hyper-threading enabled. Hyper-threading is described later in this chapter.

A key point to remember is that even when a CPU has multiple cores, it is still a single chip that plugs into the motherboard. Motherboards are available that accept multiple CPUs, but they are more common on servers than on desktop systems. Most desktop systems have a single CPU, and it's common to see CPUs with multiple cores.

Hyper-Threading

Hyper-Threading Technology (HT) is used on some Intel CPUs to double the number of instruction sets the CPU can process at a time. Within a CPU, a thread is an ordered group of instructions that produce a result. When hyper-threading is used, a single CPU can process two threads at a time.

This is not physically the same as a multiple-core CPU. However, just as a dual-core CPU simulates two physical CPUs, a single-core CPU with hyper-threading simulates two physical CPUs. Operating systems can't tell the difference.

NOTE **ENABLE IN BIOS**

Hyper-threading needs to be enabled in the BIOS before the operating system is installed for it to work. This is usually listed as hyper-threading within a CPU Technology Support menu.

Intel makes use of both hyper-threading and multiple cores on some of its CPUs. For example, Figure 3-7 shows a screen shot of the System Information tool in Windows 7. It identifies the processor as an Intel Core i7 CPU with four cores and eight logical processors. Each core is using hyper-threading, and the operating system interprets it as eight CPUs.

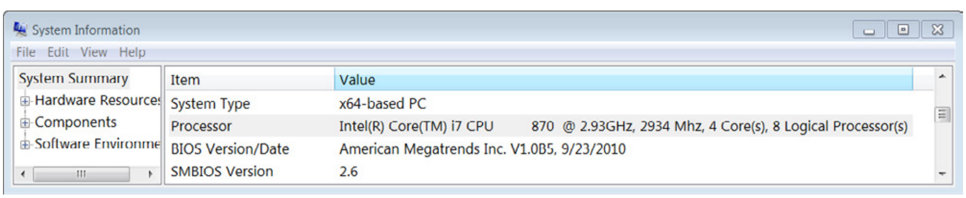


FIGURE 3-7 Msinfo32 showing that hyper-threading is enabled.

MORE INFO **CHAPTER 2 AND CHAPTER 14**

Chapter 2 introduced the System Information tool as a way to check your BIOS version. There are several ways to launch this tool, including entering msinfo32 at the command prompt. Chapter 14, "Using the Command Prompt," covers how to start and use the command prompt.

CPU Cache

Many computer components and software applications use some type of *cache*. As a simple example, web browsers use a browser cache. When you go to a website, information is transmitted over the Internet and displayed in your web browser, and it is also stored in the browser cache. If you go to the website again, data can be retrieved from the browser cache rather than downloaded from the Internet again. The browser uses different techniques to ensure that it displays current data, but if that data is on your drive, it is displayed much more quickly than it would be if it had to be downloaded again.

The CPU has cache that it uses for fast access to data. If the CPU expects to use some type of information again, it keeps that information in cache. A significant difference between the web browser cache and the CPU cache is that the CPU cache is RAM and the web browser cache is stored as a file on a hard drive.

> ***NOTE*** **CACHE**
>
> **Cache is commonly referred to as an area where data is stored for a short time for easy retrieval. It's important to realize that cache can be memory areas that are volatile or can be temporary files stored on hard drives that are kept after a system is powered down.**

CPU Cache Types

The two primary types of cache used by CPUs are:

- **L1 cache.** This is the fastest, and it's located closest to the CPU. A multiple-core CPU has a separate *L1 cache* located on each CPU core.
- **L2 cache.** *L2 cache* is a little slower than L1 cache, and it is shared by all cores of the CPU. In older systems, L2 cache was stored on the motherboard, but today it is much more common for L2 cache to be part of the CPU.

> ***NOTE*** **L3 CACHE**
>
> ***L3 cache*** **is used on some systems, but it isn't as common as L1 and L2. When used, it can be on the motherboard or on the CPU. It is slower than L2 cache and is shared among all cores.**

Figure 3-8 shows the relationship of the CPUs to cache and RAM installed on the motherboard. In the diagram, the CPU is a two-core CPU, and you can see that the L1 cache is included on each core and that L2 cache is shared by each of the cores. When the CPU needs data, it will check the L1 cache first, the L2 cache next, and then the L3 cache if it exists. If the data isn't in cache, the CPU retrieves it from RAM.

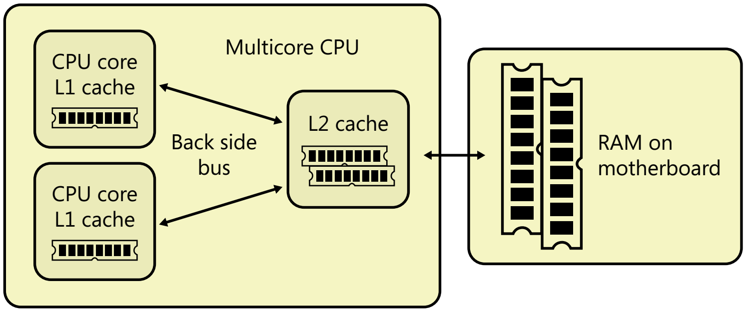


FIGURE 3-8 CPU and cache.

NOTE **ACCESSING RAM WITHOUT NORTH BRIDGE.**

As discussed in Chapter 2, newer CPUs access the motherboard RAM directly, as shown in Figure 3-8. On older CPUs, they access RAM through the north bridge portion of the chipset.

Many newer CPUs include L1 cache for each core, L2 cache for each core, and a single shared L3 cache—all on the same CPU chip.

Without cache, the CPU would have to store data in the motherboard RAM. The CPU cache is SRAM, which is much faster than the dynamic RAM used on the motherboard. Also, the motherboard RAM is physically farther away, adding more delays.

CPU Cache Size

The size of the CPU cache is small compared to the overall amount of memory in a system. For example, you might see cache sizes as low as 8 KB or as large as 20 MB. In contrast, most personal computers have 1 GB of RAM or more. The cache can be listed as just a total of all L1, L2, or L3 cache, or you might see it listed individually.

- **L1 is smallest.** L1 is sometimes stated as two numbers, such as 32 KB + 32 KB, to indicate it is using one cache for frequently used instructions and another cache for data. Sizes of 32 KB or 64 KB are common.
- **L2 is larger than L1.** When a CPU has separate L2 cache for each core, it is often identified as the amount per core. For example, a two-core CPU with 4 MB total L2 cache can be expressed as 2 × 2 MB, or just 2 MB per core. Sizes of 256 KB, 512 KB, and 1,024 KB are common.
- **L3 is larger than L2.** Sizes between 2 MB and 8 MB are common.

Quick Check

1. Which is faster: L1 or L2?
2. Where is hyper-threading enabled?

Quick Check Answers

1. L1 is the cache closest to the CPU, and it is the fastest.
2. In the BIOS.

Speeds

The speed of a CPU is based on the speed of the crystal and the multiplier. For example, if the crystal speed is 100 MHz and the multiplier is 20, the CPU has a speed of 2 GHz (20 × 100). The faster the speed, the faster the CPU.

You commonly see the speed of the processor listed as only the multiplied speed. For example, in Figure 3-7 you can see that the processor is an Intel Core 7 CPU 870 and the clock is listed as 2.93 GHz. The system is using a 133.333-MHz clock (commonly listed as 133 MHz) and a 22-times multiplier.

NOTE **SPEEDS ARE VARIABLE**

Most current processors can dynamically adjust the speed based on requests from the operating system or an application. When a boost in a CPU core is needed, the operating system can send a signal to make the core run faster. Intel refers to this as Turbo Boost, and AMD refers to it as Turbo Core.

Processors are rated based on the maximum speed they can handle, and more expensive processors can handle faster speeds. You can increase the speed by increasing the clock frequency, increasing the multiplier, or both. Most motherboards have this preselected, but it is sometimes possible to manipulate the clock or the multiplier to overclock the system. In some systems, the BIOS includes a Cell menu that enables you to increase the base frequency and increase the CPU Ratio (multiplier).

EXAM TIP

Overclocking a system is not recommended, but it is frequently done. If you overclock a system, you need to take extra steps to keep it cool, such as using liquid cooling. Liquid cooling is discussed later in this chapter.

Chapter 2 mentions the front side bus (FSB) and how it provides a direct connection between the CPU and the north bridge portion of the chipset. In the past, CPU speeds were stated as the FSB speed. Today, many CPUs have taken over the functionality of the north bridge. The CPU still needs to communicate with the chipset, and there are a few different ways this is done, including the following:

- **Intel Direct Media Interface (DMI).** The DMI can use multiple lanes, similar to Peripheral Component Interconnect Express (PCIe).
- **Intel's QuickPath Interconnect (QPI).** Each core in a processor has a separate two-way 20-lane QPI link to the chipset.
- **HyperTransport.** AMD uses *HyperTransport* with the FSB to increase the speed.

You still see CPUs advertised with a speed that you can use for comparisons. For example, one CPU might have a speed of 2.8 GHz and another might have a speed of 3.4 GHz. It's safe to assume that the 3.4-GHz CPU is faster, but the speed isn't always tied to the FSB.

Virtualization Support

Chapter 2 introduced virtualization concepts and instructions on how to enable virtualization in BIOS. As a reminder, virtualization software allows you to run multiple virtual machines (VMs) as guests within a single physical host computer. The CPU needs to support virtualization, and it usually needs to be enabled in BIOS. On many AMD-based systems, virtualization is enabled by default and cannot be disabled.

Most Intel and AMD CPUs include native support for virtualization. The exception is laptop computers, which sometimes include CPUs that do not support it. Intel refers to its virtualization support as VT-x, and AMD calls its support AMD-V. If you want to verify that a CPU or motherboard supports virtualization, look for those terms.

> ***NOTE*** **COLD BOOT REQUIRED**
>
> **If you change the virtualization setting in the BIOS, it's recommended that you do a cold boot. A cold boot completely powers down the computer. You should wait about 10 seconds and then restart the computer. In contrast, a warm boot shuts down the software and restarts it, but does not shut down the power.**

Integrated GPU

Graphics is one of the areas of a computer that has been increasing as quickly as the CPU area, and the two are starting to merge. Early computers could display only letters on a screen 80 characters wide. Today, it's common to watch high-quality video streaming from a website or to play games with computer-generated graphics and amazingly realistic scenery.

The following list describes the progression of graphics capabilities on computers:

- **Onboard graphics.** Graphics capability was built into the chipset. This was often very basic but met most needs.
- **Expansion cards.** You could install a graphics card with a dedicated graphics processing unit (GPU) and plug it into an available expansion slot. Instead of the CPU doing the graphics calculations, the GPU would do them. Peripheral Component Interconnect (PCI) cards were an early version.
- **Dedicated graphics slots.** Accelerated Graphics Port (AGP) provided a single dedicated graphics slot that worked separately from PCI. AGP did not compete with PCI, so it provided better performance. Later, PCIe allowed graphics cards to use their own dedicated lanes, and it replaced AGP.
- **Direct access graphics.** The CPU interacted with the AGP slot via the chipset. Newer CPUs bypass the chipset and interact directly with a dedicated PCIe slot used for graphics. This is common in many systems today.
- **Integrated graphics processing unit (GPU).** A recent trend in newer CPUs is to include an *integrated GPU* on the CPU. GPUs can provide high-quality graphics without the additional cost of a graphics card. However, these are not as powerful as a dedicated card.

AMD refers to some chips with a GPU as an accelerated processing unit (APU) instead of a CPU. APUs can include a GPU or other specialized capability, and the AMD Fusion is an example.

CPU Versions

There is a dizzying number of different processors. You're not expected to know the characteristics of each individual CPU, but you should be able to recognize the names and know the manufacturers. The objectives specifically list the CPU socket types you should know, but for the sockets to make sense, you need to have a little bit of knowledge about the CPU versions.

Intel and AMD use code names related to the manufacturing process and then create different processor families with the process. The manufacturing process is stated as a measurement and refers to the distance between certain components within the chip. Many current CPUs have processes of 65 nanometers (nm), 45 nm, 32 nm, and 22 nm. A nanometer is one billionth of a meter and is often used to express atomic scale dimensions, such as the width of an atom or the width of a group of molecules. In this case, smaller is better.

NOTE **MOORE'S LAW**

One of the founders of Intel, Gordon Moore, predicted in 1965 that the number of transistors that could be placed on a chip would double about every two years. This miniaturization trend has been consistent since his prediction. With more transistors, chips are faster and more complex, and the process used to create them is smaller.

The following are recent Intel and AMD code names:

- **Intel**
  - Core—65-nm and 45-nm process
  - Nehalem—45-nm process
  - Sandy Bridge—32-nm process
  - Ivy Bridge—22-nm process
- **AMD**
  - K8—65-nm, 90-nm, and 130-nm processes
  - K9—processors were never released
  - K10—65-nm process
  - K10.5—45-nm process
  - Bulldozer—22-nm process

Table 3-3 shows a list of common Intel code names and some of their related CPUs. You can see that the Core i3, i5, and i7 family names are frequently repeated.

TABLE 3-3 Intel Code Names and Processors

Architecture Name	CPU Family names
Core	Core 2 Duo, Core 2 Quad, Core 2 Extreme
Nehalem	Intel Pentium, Core i3, Core i5, Core i7, Xeon
Sandy Bridge	Celeron, Pentium, Core i3, Core i5, Core i7
Ivy Bridge	Core i5, Core i7, Xeon

The Core i3, i5, and i7 series represents a Good, Better, Best philosophy, with the i3 versions representing the basic version and the i7 versions providing the most power. The number (such as i3 or i5) doesn't refer to the number of cores.

It's also important to realize that there are significant differences between a Nehalem Core i5 and an Ivy Bridge Core i5. The Ivy Bridge versions have smaller processes and are more powerful.

MORE INFO **WIKIPEDIA**

This chapter does not list all the existing Intel and AMD CPUs. If you want to see a list of Intel or AMD processors, check out these two Wikipedia pages: *http://en.wikipedia.org/wiki/List_of_Intel_microprocessors* and *http://en.wikipedia.org/wiki/List_of_AMD_microprocessors*.

Table 3-4 shows a list of common AMD code names and their related CPUs. The primary AMD CPUs that you find in desktop computers are Sempron, Athlon, and Phenom.

TABLE 3-4 AMD Code Names and Processors

Architecture Name	CPU Family names
K8	Opteron, Athlon 64, Athlon 64 FX, Athlon 64 X2, Sempron, Turion 64, Turion 64 X2
K10	Opteron, Phenom, Athlon, Athlon X2, Sempron
K10.5	Phenom II, Athlon II, Sempron, Turion II
Bulldozer	FX (Zambezi), Interlagos Opteron

EXAM TIP

Many AMD processor names give clues as to what they include. If the name includes 64, it is a 64-bit CPU. When the name has an X (such as X2), it indicates how many cores the processor has.

CPU Socket Types

A CPU plugs into a *socket* on the motherboard. There was a time when just about every motherboard had the same socket type, but that certainly isn't the case today. Instead, there are a wide variety of different socket types for different types of CPUs. If you ever need to replace a CPU, it's important to recognize that there are different types of sockets. The following sections talk about some sockets used by Intel and AMD, with information about how they are installed.

Zero Insertion Force

It's important that each of the pins on a CPU has a good connection to the motherboard. In early versions of CPUs, this was accomplished by creating a tight connection between the pins and the socket. This required technicians to use some force to plug the CPU into the socket. Unfortunately, it was easy to bend one or more pins, and bent pins would often break, making the CPU unusable.

Manufacturers came up with a great idea to eliminate the problem—*zero insertion force (ZIF)* sockets. A ZIF socket has a locking lever. You can place a CPU into a socket without any force other than gravity, and after the CPU is in place, you lock the lever to secure it. This lever ensures that the pins are making a solid connection to the motherboard.

Figure 3-9 shows a ZIF socket with the lever raised. The CPU is removed and standing up on the left. You can see that there are some areas on the CPU where there aren't any pins. These provide a key, and they match up to areas on the socket where there aren't any pin holes.

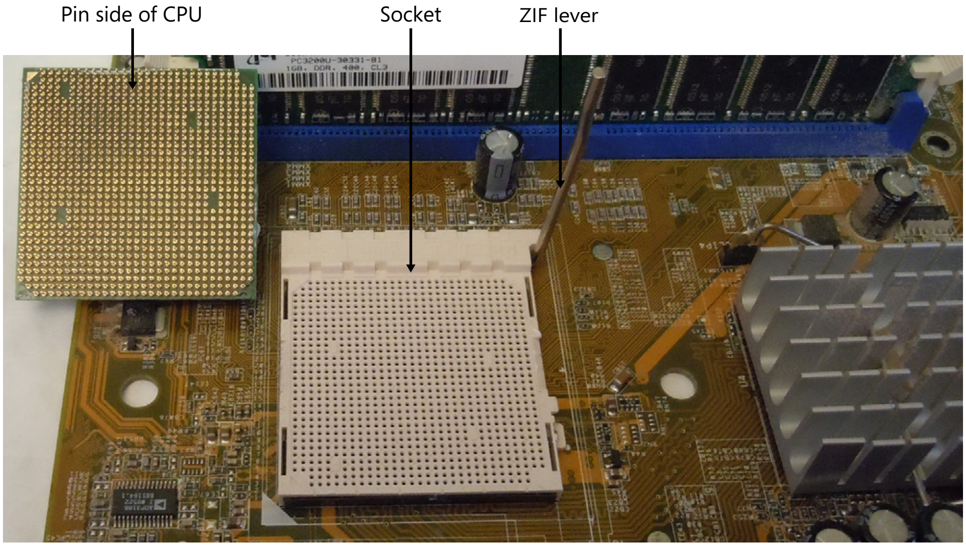


FIGURE 3-9 Processor and ZIF socket.

NOTE **CPUS ARE KEYED**

CPU sockets and CPUs are keyed so that the CPU fits into a socket in only one way. If you feel any resistance when putting a CPU into a ZIF socket, it indicates that the pins aren't lined up. You should double-check the keying and ensure that the CPU is lined up correctly. If you try to force it, you will likely bend some pins and ruin either the chip or the socket.

PGA vs. LGA

The socket shown in Figure 3-9 is a *pin grid array (PGA)* type of socket. It includes holes into which the pins can be plugged. A newer type of socket is a *land grid array (LGA)* socket. Instead of the processor having pins and plugging into a socket with holes, the socket has small pins, and the CPU has small pins created as bumps or pads. When the CPU is installed, the pins and bumps line up, making the connection.

When using an LGA socket, the CPU sits on top of the socket but is locked in place with a flip-top case. Figure 3-10 shows an example of a flip-top case used with an Intel processor.

This socket has a hinged top and a lever that locks the case when it's closed. You unlock the lever, open the case, and remove the CPU. When installing a new CPU, ensure that the keys line up, place the CPU in the case, close the top, and lock it with the lever. Remember to use ESD protection when handling the CPU.

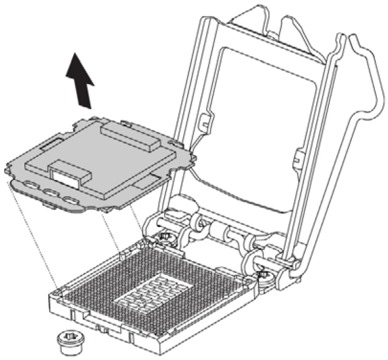


FIGURE 3-10 Removing processor from a flip-top case. Diagram provided by Intel. [Copyright © Intel Corporation. All rights reserved. Used by permission.]

Another type of array you might run across is ball grid array (BGA). In a BGA chip, the pins on the CPU are replaced with balls of solder. The chip is mounted in the socket and then heated, often in an oven, to melt the solder. Manufacturers can fit more pins on a BGA CPU, and they are sometimes used in mobile devices.

Intel CPU Sockets

The following list describes recent Intel sockets:

- **LGA 775.** 775 pins. Also called Socket T. Replaced Socket 478.
- **LGA 1366.** 1,366 pins. Also called Socket B and designed to replace LGA 755 in high-end desktop computers.
- **LGA 2011.** 2,011 pins and released in 2011. Also called Socket R. It replaces LGA 1366 sockets in high-end desktop systems.
- **LGA 1156.** 1,156 pins. Also called Socket H or Socket H1.
- **LGA 1155.** 1,155 pins. Also called Socket H2 and replaces LGA 1156 in basic desktop systems. LGA 1,156 CPUs will work in LGA 1155, but the BIOS may need to be upgraded.

EXAM TIP

Notice that the numbers indicate the number of pins and are not a reflection of newer or older sockets. Also, each of these Intel sockets is an LGA socket.

Table 3-5 lists the common Intel sockets along with some CPUs used with them, busses they support, and supported DDR channels.

TABLE 3-5 Intel Sockets and Related CPUs

Type	CPUs, Busses, DDR Channels
LGA 775 (Socket T)	Pentium 4, Pentium D, Core 2 Duo, Core 2 Quad, Celeron, Xeon Front side bus, single channel DDR2 and DDR3 RAM
LGA 1366 (Socket B)	Core i7, Xeon, Celeron QPI, triple channel DDR3 RAM
LGA 2011 (Socket R)	Core i7, Xeon QPI, DMI, quad channel DDR3 RAM
LGA 1156 (Socket H or H1)	Core i3, Core i5, Core i7, Celeron, Pentium, Xeon DMI, dual channel DDR3 RAM
LGA 1155 (Socket H2)	Core i3, Core i5, Core i7, Celeron, Pentium DMI, dual channel DDR3 RAM

AMD CPU Sockets

The following list describes recent AMD sockets:

- **Socket 940.** 940 pins (PGA).
- **Socket AM2.** 940 pins (PGA). Not compatible with Socket 940.
- **Socket AM2+.** 940 pins (PGA). Replaces AM2. CPUs that can fit in AM2 can also fit in AM2+.
- **Socket AM3.** 941 pins (PGA). Replaces AM2+. Supports DDR3. CPUs designed for AM3 will also work in AM2+ sockets, but CPUs designed for AM2+ might not work in AM3 sockets.
- **Socket AM3+.** 942 pins (PGA). Replaces AM3. CPUs that can fit in AM3 can also fit in AM3+.
- **Socket FM1.** 905 pins (PGA). Used for accelerated processing units (APUs).
- **Socket F.** 1,207 pins (LGA). Used on servers and replaced by Socket C32 and Socket G34.

Table 3-6 lists the common AMD sockets along with some CPUs used with them, busses they support, and supported DDR channels.

TABLE 3-6 AMD Sockets and Related CPUs

Socket	CPUs, Busses, DDR Channels
940	Opteron and Athlon 64 FX FSB with HyperTransport version 1, single channel DDR2 RAM
AM2	Athlon 64, Athlon 64 X2, Athlon FX, Sempron, Phenom, Opteron FSB with HyperTransport version 2, single channel DDR2 RAM
AM2+	Athlon 64, Athlon 64 X2, Athlon II, Sempron, Phenom, Phenom II, Opteron FSB with HyperTransport version 3, single channel DDR2 RAM

AM3	Phenom II, Athlon II, Sempron, Opteron FSB with HyperTransport version 3, single channel DDR2 and dual channel DDR3 RAM
AM3+	Phenom II, Athlon II, Sempron, Opteron FSB with HyperTransport version 3, dual channel DDR3 RAM
FM1	Fusion and Athlon II APUs FSB with HyperTransport version 3, dual channel DDR3 RAM
F	Opteron, Athlon 64 FX FSB with HyperTransport version 3, single channel DDR2 RAM

Comparing Names

Earlier in this chapter, I listed two CPUs using common marketing names. To tie some of this together, here are the two CPUs with an explanation of the names. I'm hoping these names make a lot more sense at this point.

- **Intel Core i7-960 Processor 3.2 GHz 8 MB Cache Socket LGA 1366.** This name indicates that it is an Intel processor in the Core i7 family with a model number of 960 and a 3.2-GHz multiplied clock. The 8-MB cache phrase refers to the total amount of cache. Last, LGA 1366 indicates the type of socket into which the processor will plug.
- **Phenom II X4 965 AM3 3.4 GHz 512 KB 45 NM.** This indicates that it is an AMD Phenom II processor with a model number of 960. X4 indicates that the processor has four cores, and AM3 indicates the socket type. The 3.4-GHz clock speed is the internal speed of the processor. Cache size is indicated by 512 KB, and in this case, it indicates the L2 cache size for each of the cores. The process is 45 nm.

Cooling

CPUs have millions—and sometimes billions—of miniaturized transistors within them, all connected with extremely small wires. If these transistors or wires get too hot, they can easily break, rendering the CPU useless. Manufacturers spend a lot of time designing these chips, and one of their goals is to keep temperatures within acceptable limits. However, most of the cooling occurs externally.

Heat Sinks, Fans, and Thermal Paste

Common methods of cooling a CPU include using a *heat sink*, a fan, and *thermal paste*. Take a look at Figure 3-11 as you read about how these components work together.

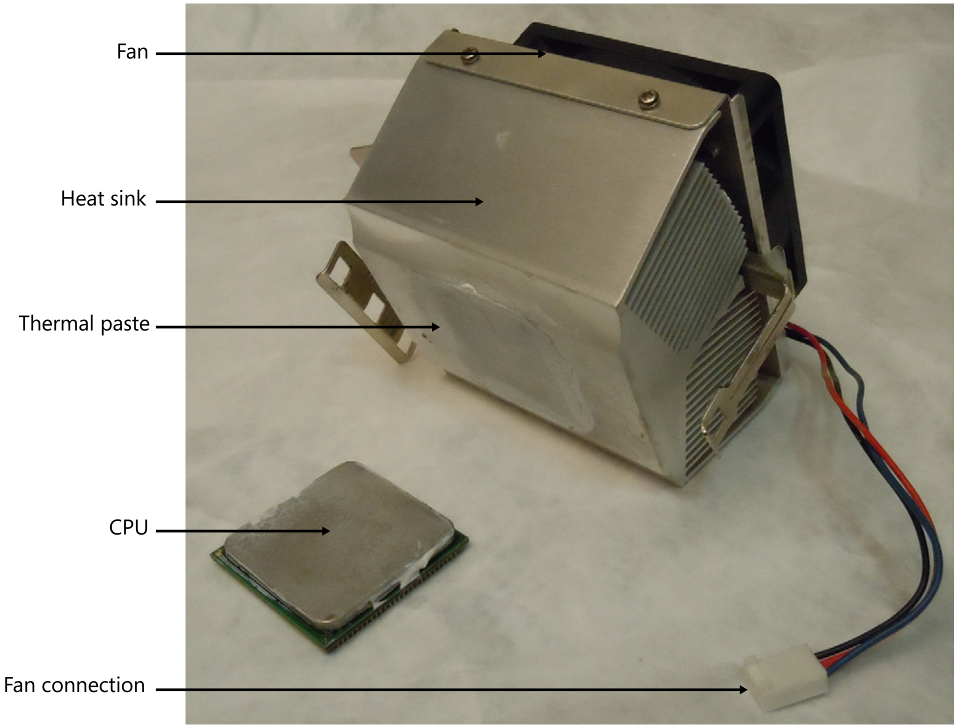


FIGURE 3-11 CPU with heat sink and attached fan.

- **Heat sink.** A heat sink is a piece of metal that draws heat from the CPU and dissipates it into the air. Heat sinks have multiple fins to increase the surface area and to allow air to easily flow through them. The fins are usually flared to allow more air through.
- **Fan.** A fan is attached to the heat sink to increase the airflow around the fins. These are called CPU fans. They aren't attached to the CPU but usually plug into the motherboard close to the CPU. Many CPU fans have variable speeds and spin faster when the CPU gets hotter.
- **Thermal paste.** Heat sinks commonly have clamps to secure them to the motherboard and provide a better connection with the CPU. However, there are microscopic gaps in the metal on both the CPU and the heat sink, so it isn't possible to get 100 percent contact between the components. Thermal paste is used to improve this connection. This paste fills these microscopic gaps and also helps draw heat from the CPU into the heat sink.

EXAM TIP

When replacing a CPU, ensure that you clean off the old thermal paste from the heat sink and apply new thermal paste.

If you are replacing a CPU, you'll need to clean off the old thermal paste from the heat sink. Some vendors sell specialized cleaning compounds to remove old paste, but you can often use cotton swabs and isopropyl alcohol to remove it.

After installing the new CPU into the socket and locking the ZIF arm, place a dab of the paste in the center of the CPU. When you attach the heat sink and clamp it down, the pressure will spread the paste evenly between the heat sink and the CPU. Be careful not to apply too much paste; you need only enough to fill the microscopic gaps between the CPU and the heat sink.

Liquid Cooling

An advanced method of keeping a system cool is using a liquid-based cooling system. Liquid-based cooling systems use water (most commonly) or some other liquid that is pumped through the cooling system.

For example, Figure 3-12 shows a basic diagram of a liquid-based cooling system. A specialized heat sink is attached to the CPU, using thermal paste just like a standard heat sink. However, this heat sink has channels so that the liquid can flow through it. Tubing is connected from the pump to the heat sink, and the pump constantly pumps the liquid through the heat sink.

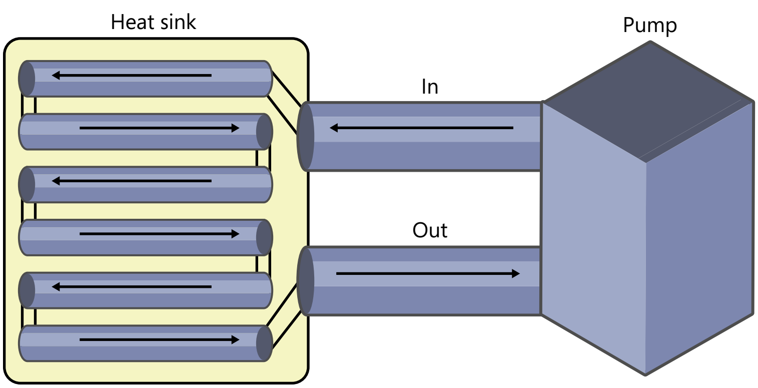


FIGURE 3-12 Liquid-cooled heat sink.

EXAM TIP

Liquid-based cooling can be used for any components that use a heat sink. This includes CPUs, GPUs, and chipsets.

One of the biggest challenges with a liquid-based cooling system is ensuring that the tubing connections do not leak. This is one place where you don't want to skimp on quality. The liquid is usually water, and if it leaks, it could easily destroy the system.

Liquid-based cooling systems are most common among gamers and hobbyists. These people often overclock the processors to get more power out of them, but overclocking generates more heat. Overclocking is sometimes possible by changing jumpers on the motherboard or by manipulating BIOS settings, but manufacturers discourage the practice.

Quick Check

1. **What is another name for Socket H2?**
2. **What's the best way to keep an overclocked CPU cool?**

Quick Check Answers

1. **LGA 1155.**
2. **Liquid cooling.**

Troubleshooting

You might occasionally run across a system that is having a problem with the CPU or RAM. Sometimes the problems are consistent, but more often they are intermittent; sometimes you'll see the problem, sometimes you won't.

Intermittent problems are frequently related to overheating, so a good first step is to ensure that the system has adequate airflow. Shut the system down, open the case, and either vacuum it with an ESD-safe vacuum or take it outside and blow it out with compressed air.

Common Symptoms

The following are some common symptoms and possible causes related to the CPU or RAM:

- **Unexpected shutdowns.** If the system is randomly shutting down or rebooting, the most likely cause is a heat problem. Check the ventilation and clean out the fans.
- **System lockups.** When a computer stops responding to inputs from the keyboard or mouse, technicians refer to it as frozen or locked up. This can also be due to heat issues. Check the ventilation.
- **Continuous reboots.** In some cases, a hardware issue can prevent the system from booting completely. It starts, gets so far, and then resets itself. This is more common after a faulty software update, but it can be due to a hardware problem. If you've just replaced hardware, double-check your steps. If that isn't the issue, boot into Safe Mode and troubleshoot the operating system using the steps provided in Chapter 17, "Troubleshooting Windows Operating Systems."

Tools

If you've cleaned out the system and you're still having intermittent problems, there are two primary things to check:

- **Power supply.** An overloaded or failing power supply can cause intermittent problems. Use a multimeter to verify the voltages. If the voltages are out of tolerance, replace the power supply.
- **RAM.** It is possible to have a certain area of RAM that is faulty. The system can work until it writes data to that area, and then it shuts down or freezes. In some cases, you receive a stop error or blue screen of death (BSOD) with an error code indicating a memory problem. If you suspect a RAM problem, use a memory checker to run memory diagnostics.

EXAM TIP

The two primary *hardware* sources of intermittent problems are the power supply and RAM. The primary *software* source of intermittent problems is a virus or some type of malicious software. Chapter 26, "Recognizing Malware and Other Threats," covers viruses in more depth, but running up-to-date antivirus software usually reveals and removes the problem. Occasionally, you'll need to boot into Safe Mode and run the up-to-date antivirus software.

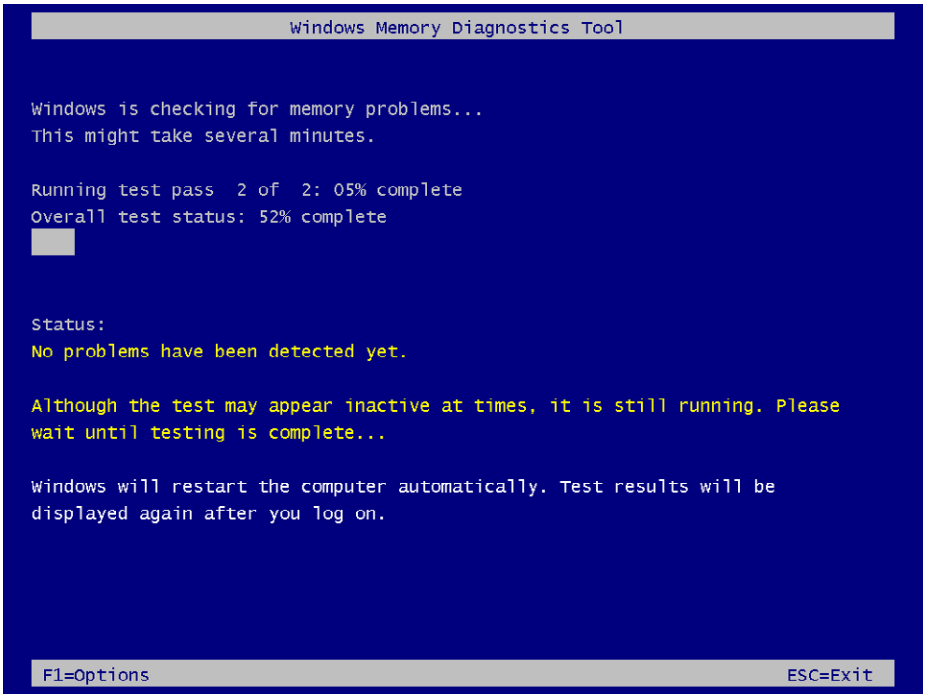
Windows Memory Diagnostics

Windows Vista and Windows 7 include the Windows Memory Diagnostic tool, and steps later in this section show how to run it. It's easy to run and can perform in-depth testing of the system RAM and the cache within the CPU.

The diagnostics include three sets of tests (basic, standard, and extended). By default, it runs two passes of the standard set of tests, and this is usually good enough. If this passes but you still suspect you have memory problems, you can choose other options by pressing F1 to modify them. For example, if you have an intermittent problem and want to do detailed tests for a day or longer, you can set the pass count to 0 and it will run continuously.

You can use the following steps on a Windows 7 system to run the Windows Memory Diagnostics tool:

1. Click Start and type **Memory** in the Search Programs And Files text box.
2. Select Windows Memory Diagnostic.
3. Select Restart Now and check for problems. After the system reboots, the tests will start and you'll see a display similar to the following graphic. If any errors are identified, they will be displayed in the Status area, but they usually won't stop the diagnostic from running. After the test completes, the system automatically reboots.



4. About a minute or so after you log on, you'll see a balloon message appear in the system tray at the bottom right indicating the results. It appears and then fades out. If you miss it, you can also view the results in the System log via the Event Viewer. It's listed with a source of MemoryDiagnostics-Results and an Event ID of 1201.

If you're unable to boot into the operating system, you can access the Windows Memory Diagnostic by using several other methods. Each of the following methods will start the Windows Recovery Environment (Windows RE), showing the System Recovery Options, as shown in Figure 3-13. You can then select Windows Memory Diagnostic.

- Press F8 as the system is booting to access the Advanced Boot Options page and select Repair Your Computer.
- Start from a Windows Vista installation DVD, select the Language, and then click Repair Your Computer.
- Create a system repair disc and use it to boot directly into the Windows RE.

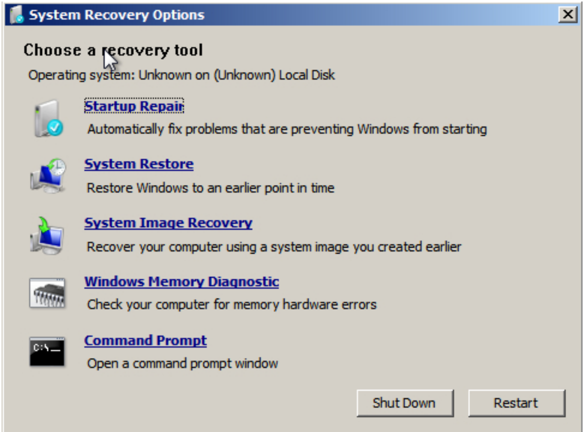


FIGURE 3-13 Running Windows Memory Diagnostic from boot DVD.

MORE INFO **CHAPTER 17**

Chapter 17 covers the Event Viewer, including how to launch it and access different log files. It also includes information on the other system recovery options and how to create a system repair disc in Windows 7.

If the memory diagnostic gives any errors, you might be able to do a quick fix by reseating the memory sticks. Power your system down and open it up. Hook up an ESD strap to ground yourself with the system and then locate the RAM. Press the tabs on each side to pop out each DIMM, and then push each back into the slot until the tabs lock. This same fix can also be used on any expansion card.

You might be wondering why this works. Electrical components expand and contract from heat and cold, causing some movement. Additionally, the electrical contacts can become tarnished, preventing a good connection. When you pop it out and push it back, the friction scrapes the tarnish off the contacts. With the tarnish removed, it has a good connection.

NOTE **CLEANING CONTACTS**

You can clean contacts with contact cleaner created specifically for this purpose. You can also use isopropyl alcohol and a lint-free cloth or cotton swab. You should not rub the contacts with a pencil eraser. The eraser removes the tarnish by scraping it off, but it leaves residue and can cause ESD damage.

CPU-Z

CPU-Z is a handy freeware utility that you can use to view some detailed information on your system. It's been around a long time and has helped many technicians. A copy is on the CD, and you can find a link about the installation here: *getcertifiedgetahead.com/aplus.aspx*.

Figure 3-14 shows a screen shot of the CPU tab of the CPU-Z application. You can see that this provides some detailed information about the processor, clocks, and cache.

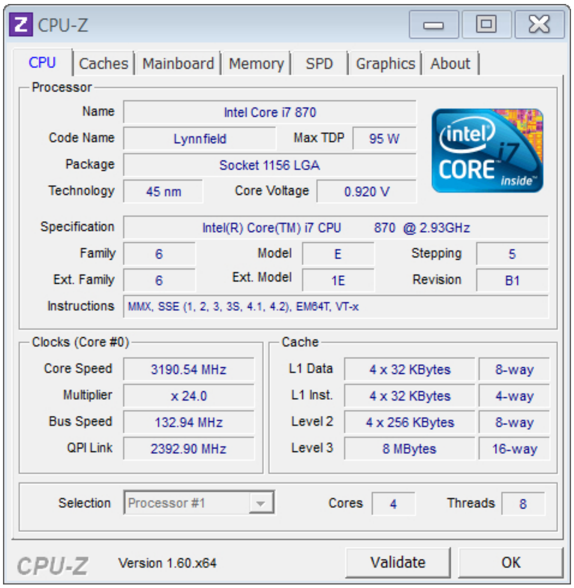


FIGURE 3-14 CPU-Z.

If you click the Mainboard tab, it gives you details about your motherboard and BIOS. The Memory tab provides overall information about installed memory, and the SPD tab enables you to select individual memory slots to determine what is installed. As you'd expect, the Graphics tab provides details about the graphics card. The About tab includes buttons you can use to save the details of the report as either a text file or an HTML file.

✔ Quick Check

1. What are two primary hardware problems that can cause system fails?
2. Where can you determine how much RAM is installed in a system?

Quick Check Answers

1. Faulty power supply or faulty RAM.
2. BIOS or System Information (msinfo32).

Chapter Summary

- Systems use synchronous dynamic RAM (SDRAM) for primary memory. Static RAM (SRAM) is used for L1, L2, and L3 cache. Common versions of SDRAM are DDR, DDR2, and DDR3.
- Memory comes on circuit cards called DIMMs for desktop computers and SODIMMs for laptops. DIMMs and SODIMMs come in different sizes for different DDR versions.
- Dual-channel and triple-channel RAM provide additional 64-bit paths for transferring data to and from RAM. When installing multichannel DIMMs, install matched sets in the same bank. Banks are normally the same color. On an Intel dual-channel motherboard, Bank 0 includes slots 1 and 3.
- A triple-channel motherboard has six slots for RAM, and RAM should be purchased in matched sets of three DIMMs.
- The speed of RAM is tied directly to the clock. The formula to calculate DDR3 RAM speed is: Clk × 4 × 2 × 64 / 8. For a 200-MHz clock, the speed is 200 × 4 × 2 × 64 / 8, or 12,800 MB/s.
- The DDR3 standard name is derived from the clock × 8. For a 200-MHz clock, the DDR3 standard name is DDR3-1600. The module name is derived from the overall speed. The DDR3 module name with a 200-MHz clock is PC3-12800.
- If matched DIMMs are not used and a bank includes different speed DIMMs, the bank will default to the slowest speed.
- CPUs come in 32-bit and 64-bit versions, referring to how many bits they use to address memory. If you want to use more than 4 GB of RAM, you need a 64-bit CPU and a 64-bit operating system.
- Multiple-core CPUs include more than one fully functioning processor, and the operating system views each core as a separate CPU. Intel uses hyper-threading, which allows each core to process two threads at a time, and each core using hyper-threading is treated as a separate CPU by the operating system.
- CPUs use fast static RAM (SRAM) as cache to improve processing. They commonly include L1, L2, and sometimes L3 cache. L1 is fastest and closest to the CPU, and L3 is slowest and farthest away. L1 is smallest, and L3 is the largest. When the CPU needs data, it looks in L1, then L2, and then L3.
- The speed of the CPU is based on the speed of the clock and a multiplier. It is usually listed as the multiplied speed, such as 3.4 GHz. Intel uses Turbo Boost and AMD uses Turbo Core to modify these speeds during operation.
- Most CPUs support virtualization. Intel refers to its support as VT-x, and AMD calls its support AMD-V. These settings can be enabled in BIOS on most systems.
- An integrated GPU refers to a graphics processor embedded within a CPU. AMD calls some of its integrated GPU chips APUs.

- Common Intel CPUs are Core i3, Core i5, and Core i7 series. Most Intel CPUs use LGA sockets. Common Intel sockets are: LGA 775 (Socket T), LGA 1366 (Socket B), LGA 2011 (Socket R), LGA 1156 (Socket H or H1), and LGA 1155 (Socket H2).
- Common AMD CPUs are Sempron, Athlon, and Phenom. Most AMD CPUs use PGA sockets, and common sockets are: Socket 940, AM2, AM2+, AM3, AM3+, FM1, and Socket F.
- CPUs are commonly kept cool with heat sinks and fans. When replacing a CPU, use thermal paste between the CPU and the heat sink. Liquid cooling is an advanced cooling practice.
- Hardware problems that can cause unexpected shutdowns and intermittent fails include overheating due to failed fans or inadequate ventilation, faulty power supply, or faulty RAM.
- Use a software memory tester to test RAM.

Chapter Review

Use the following questions to test your knowledge of the information in this chapter. The answers to these questions, and the explanations of why each answer choice is correct or incorrect, are located in the "Answers" section at the end of this chapter.

1. You are replacing two DDR3 DIMMs in an Intel dual-channel motherboard. Into which slots should you put them?

   A. Two different-colored slots

   B. Two identical-colored slots

   C. Separate banks

   D. Slots 1 and 4

2. You are shopping for replacement DDR3 RAM. Your system has a 400-MHz clock. What should you buy?

   A. PC3-400

   B. DDR3-400

   C. PC3-25600

   D. PC3-12800

3. An Intel CPU has two cores, but the operating system shows it has four CPUs. What feature allows this to happen?
   - **A.** Hyper-threading
   - **B.** HyperTransport
   - **C.** Dual-channel RAM
   - **D.** L2 cache
4. Of the following choices, which is fastest?
   - **A.** L1 cache
   - **B.** L2 cache
   - **C.** L3 cache
   - **D.** Triple-channel DDR3
5. Which of the following replaces the Intel Socket H?
   - **A.** LGA 775
   - **B.** LGA 1366
   - **C.** LGA 1156
   - **D.** LGA 1155
6. You are asked to troubleshoot a computer that is randomly rebooting or failing. Of the following choices, what hardware can cause these symptoms? (Choose all that apply.)
   - **A.** RAM
   - **B.** Fan
   - **C.** Power supply
   - **D.** Virus

Answers

1. **Correct Answer:** B
   - **A. Incorrect:** Different-colored slots indicate different banks.
   - **B. Correct:** Dual-channel RAM should be installed in the same bank, which is the same color on most motherboards.
   - **C. Incorrect:** If you place the RAM in different banks, it will be used as single-channel RAM instead of dual-channel RAM.
   - **D. Incorrect:** Slots 1 and 4 are always in different banks.
2. **Correct Answer:** C
   - **A. Incorrect:** PC3-400 indicates a clock speed of 50 MHz.
   - **B. Incorrect:** If the DDR3 name is used, it is identified as the clock times 8. 400 × 8 = 3,200, or DDR3-3200.
   - **C. Correct:** The calculation for DDR3 is Clk × 4 × 2 × 64 / 8. 400 MHz × 4 × 2 × 64 / 8 = 25,600, so it is PC3-25600.
   - **D. Incorrect:** PC3-12800 indicates a clock speed of 200 MHz.
3. **Correct Answer:** A
   - **A. Correct:** Hyper-threading is supported on Intel CPUs and allows each core to appear as two CPUs.
   - **B. Incorrect:** HyperTransport is used on AMD processors in place of a front side bus.
   - **C. Incorrect:** Dual channel RAM provides two paths to RAM, but it does not affect the CPU cores.
   - **D. Incorrect:** L2 cache is fast RAM stored on the CPU for improved performance, but it does not affect the CPU cores.
4. **Correct Answer:** A
   - **A. Correct:** L1 cache is a fast cache, close to the CPU.
   - **B. Incorrect:** L2 cache is slower than L1 cache.
   - **C. Incorrect:** L3 cache is slower than L1 and L2 cache.
   - **D. Incorrect:** Any type of DDR RAM is slower than L1, L2, or L3 cache.
5. **Correct Answer:** D
   - **A. Incorrect:** LGA 775 is Socket T and was replaced by Socket B.
   - **B. Incorrect:** LGA 1366 is Socket B.
   - **C. Incorrect:** LGA 1156 is Socket H.
   - **D. Correct:** The LGA 1155 is also known as Socket H2 and replaces Socket H or H1.

6. **Correct Answers:** A, B, C
   - **A. Correct:** Faulty RAM can cause these symptoms.
   - **B. Correct:** Failing or dirty fans can result in overheating problems, causing these symptoms.
   - **C. Correct:** A power supply providing varying voltages or voltages out of specifications can cause these symptoms.
   - **D. Incorrect:** Viruses can cause these types of symptoms, but a virus is software, not hardware.

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