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QUENTIN DOCTER

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IT Fundamentals+ (ITF+)
Study Guide Exam FC0-U61
Second Edition

Quentin Docter

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In memory of grandpa Joe, who taught me the fundamentals of IT and so much more.

Acknowledgments

First and foremost, I need to thank my family. Without their support and patience, I would never be able to work on projects like this.

This edition was more special than most, in that it left me with an unusual sense of pride as well as a realization of how long the road has been. When I wrote my first book, I dedicated it to my still-baking-in-the-oven oldest daughter. Now, she has enough expertise to be my SME and first proofreader for the programming chapter. She can code circles around me, and I'm proud of her (and my other kids too!).

They say it takes a village to produce a book, and it always amazes me at the number of people who are involved. I have been fortunate to work with a great Sybex crew yet again. Gary Schwartz was the development editor. Thanks, Gary, for keeping me on track and answering all of my mundane questions. Kenyon Brown was the acquisitions editor for this book—thank you, Kenyon, for asking me to take on this book.

In addition, Christine O'Connor was an excellent production editor; I appreciate her professionalism and pragmatism. Jon Buhagiar and Chris Crayton were my technical editors—thank you both for all of your ideas; you really made this book better. To Kim Wimpsett, the copy editor, thank you so much for dealing with my consistent grammar mistakes. I may not have the best grammar, but at least I am consistent about it!

About the Author

Quentin Docter started in the IT industry as a tech support agent for Packard Bell in 1994. Since then he has worked in tech support, network administration, consulting, training, web development, and project management. During his career, he has achieved certifications from CompTIA (including IT Fundamentals+ (ITF+)), Microsoft, Cisco, Novell, and Sun Microsystems. He is the author of several books, including the CompTIA A+ Complete Study Guide by Sybex, an imprint of Wiley.

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Introduction

If you're picking up this book, it means it's likely that either you're thinking about getting into the IT industry or you are relatively new to it. Either way, you are probably getting advice from nearly everyone you meet. One of the common refrains you probably hear is "Get certified!" With so many certifications out there, you might wonder where to start—CompTIA IT Fundamentals+ (ITF+) is that place.

Certification is one of the best things you can do for your career if you are working in, or want to break into, the IT profession, because it proves that you know what you're talking about regarding the subjects in which you're certified. It also powerfully endorses you as a professional in a way that's similar to a physician being board certified in a certain area of expertise. It can add to your résumé and make you more attractive to potential employers and more valuable as an employee. In these challenging economic times, keeping ahead of the competition—even standing out among your present colleagues—could make a big difference in whether you gain a promotion or not!

In this book, you'll find out what the IT Fundamentals+ (ITF+) exam is all about because each chapter covers a part of the exam. I've included some great review questions at the end of each chapter to help crystallize the information you learned and solidly prepare you to ace the exam. This book covers more than just the exam, though. I believe in providing my students with a foundation of IT knowledge that will prepare them for real jobs, not just to pass a test. After all, life is not a multiple-choice test with the answers clearly laid out in front of you!

A really cool thing about working in IT is that it's constantly evolving, so there are always new things to learn and fresh challenges to master. Once you obtain your IT Fundamentals+ (ITF+) certification and discover that you're interested in taking it further by getting into more complex topics (and making more money), the CompTIA A+ certification is definitely your next step.

What Is the CompTIA IT Fundamentals+ (ITF+) Certification?

IT Fundamentals+ (ITF+) is a certification developed by the Computing Technology Industry Association (CompTIA) that exists to provide resources and education for the computer and technology community. This is the same body that developed the A+ exam for PC technicians, Network+ for networking experts, and Security+ for security practitioners.

Way back in 1995, members of the organization got together to develop a new certification that tests skills for IT. To ensure industry-wide support, it was sponsored by many past and present IT industry leaders like these:

- Compaq Computers
- Digital Equipment Corporation (a part of Compaq)

- IBM
- Lotus
- Microsoft
- Novell
- TSS
- U.S. Robotics
- US West
- Wave Technologies

The IT Fundamentals+ (ITF+) exam was designed to test the skills of those with little to no experience in the field but who want to show that they have a broad general understanding of core IT topics. It tests areas such as computer hardware, operating systems and applications, basic networking, security, and setting up and maintaining a computer.

Why Become IT Fundamentals+ (ITF+) Certified?

Because CompTIA is a well-respected developer of vendor-neutral industry certifications, becoming IT Fundamentals+ (ITF+) certified proves that you have a base level of knowledge in the specific areas tested by the IT Fundamentals+ (ITF+) objectives.

Four major benefits are associated with becoming IT Fundamentals+ (ITF+) certified:

Proof of Professional Achievement Computer professionals are pretty competitive when it comes to collecting more certifications than their peers. And because the IT Fundamentals+ (ITF+) certification broadly covers the entire field of computers, it's a great stepping-stone to prove that you have what it takes to succeed in this industry. Because it's rare to gain something that's worth a lot with little effort, I'll be honest—preparing for the IT Fundamentals+ (ITF+) exam isn't exactly a lazy day at the beach. But passing the test is worth it because it will get the attention of potential employers.

Opportunity for Advancement We all like to get ahead in our careers—advancement results in more responsibility and prestige, and it usually means a fatter paycheck, greater opportunities, and added options. In the IT sector, a great way to make sure all that good stuff happens is by earning a lot of technology certifications, including IT Fundamentals+ (ITF+).

Fulfillment of Training Requirements IT Fundamentals+ (ITF+), because of its wide-reaching industry support, is recognized as a baseline of computer knowledge. This can potentially fulfill IT-related training requirements set forth by your company.

Customer Confidence As companies discover the CompTIA advantage, they will undoubtedly require qualified staff to achieve these certifications. Many companies outsource their work to consulting firms with experience working with security. Firms that have certified staff have a definite advantage over firms that don't.

How to Become IT Fundamentals+ (ITF+) Certified

As this book goes to press, Pearson VUE is the sole IT Fundamentals+ (ITF+) exam provider. The following is the necessary contact information and exam-specific details for registering. Exam pricing might vary by country or by CompTIA membership.

Vendor	Website	Phone Number
Pearson VUE	`www.pearsonvue.com/comptia`	U.S. and Canada: 877-551-PLUS (7587)

When you schedule the exam, you'll receive instructions regarding appointment and cancellation procedures, ID requirements, and information about the testing center location. In addition, you'll receive a registration and payment confirmation letter. Exams can be scheduled up to six weeks out or as late as the next day (or, in some cases, even the same day).

NOTE

Exam prices and codes may vary based on the country in which the exam is administered. For detailed pricing and exam registration procedures, refer to CompTIA's website at `www.comptia.org`.

After you've successfully passed your IT Fundamentals+ (ITF+) exam, CompTIA will award you a certification. Within four to six weeks of passing the exam, you'll receive your official CompTIA IT Fundamentals+ (ITF+) certificate and ID card. (If you don't receive these within eight weeks of taking the test, contact CompTIA directly using the information found in your registration packet.)

Tips for Taking the IT Fundamentals+ (ITF+) Exam

Here are some general tips for taking your exam successfully:

- Bring two forms of ID with you. One must be a photo ID, such as a driver's license. The other can be a major credit card or a passport. Both forms must include a signature.
- Arrive early at the exam center so you can relax and review your study materials, particularly tables and lists of exam-related information. Once you are ready to enter the testing room, you will need to leave everything outside; you won't be able to bring any materials into the testing area.
- Read the questions carefully. Don't be tempted to jump to an early conclusion. Make sure you know exactly what each question is asking.
- Don't leave any unanswered questions. Unanswered questions are scored against you. There will be questions with multiple correct responses. When there is more than one correct answer, a message at the bottom of the screen will prompt you either to

"choose two" or "choose all that apply." Be sure to read the messages displayed to know how many correct answers you must choose.

- When answering multiple-choice questions about which you're unsure, use a process of elimination to get rid of the obviously incorrect answers first. Doing so will improve your odds if you need to make an educated guess.
- On form-based tests (nonadaptive), because the hard questions will take the most time, save them for last. You can move forward and backward through the exam.
- For the latest pricing on the exams and updates to the registration procedures, visit CompTIA's website at `www.comptia.org`.

Who Should Read This Book?

You—if want to pass the IT Fundamentals+ (ITF+) exam and pass it confidently! This book is chock-full of the exact information you need and directly maps to IT Fundamentals+ (ITF+) exam objectives (listed later in this Introduction), so if you use it to study for the exam, your odds of passing shoot way up.

In addition to including every bit of knowledge you need to learn to pass the exam, I've included some really great tips and solid wisdom to equip you even further to work successfully in the real IT world.

What Does This Book Cover?

This book covers everything you need to know to pass the CompTIA IT Fundamentals+ (ITF+) exam. But in addition to studying the book, it's a good idea to practice on actual computers if you can.

Here's a list of the 11 chapters in this book:

Chapter 1, "Core Hardware Components" This chapter introduces you to the core insides of a computer, specifically motherboards, processors, memory, storage, expansion slots, power, and cooling systems.

Chapter 2, "Peripherals and Connectors" While core hardware is important, users can truly customize their computer experience by adding peripheral hardware. To connect all of those toys to your system, you need to know which connectors to use, and this chapter teaches you all of that.

Chapter 3, "Computing Devices and the Internet of Things" Now that you've learned about all of the individual hardware components, how do they all work together? This chapter discusses features of servers, workstations, laptops, tablets, smartphones, and gaming consoles. It also introduces the Internet of Things (IoT), which can turn practically anything into a device.

Chapter 4, "Operating Systems" Without an operating system, computer hardware makes a pretty good doorstop. The operating system is the most critical piece of software on a computer, because it coordinates the efforts of the hardware and provides an interface for the user to interact with the machine.

Chapter 5, "Software Applications" This chapter covers a variety of common application types that reside on computers, such as productivity software, collaboration software, business software, anti-malware utilities, and web browsers. It also teaches you about application design concepts, software management, and the proper ways to install, uninstall, and manage applications.

Chapter 6, "Software Development" Have you ever wondered how applications get created? This chapter will teach you the characteristics of several classes of programming languages. You will also see examples of code, programming logic, and organizational methods.

Chapter 7, "Database Fundamentals" Databases are a key part of computing systems today. Data is the new currency, and therefore databases are like a bank vault. This chapter walks you through database concepts and structures, and it shows you some methods to interact with databases.

Chapter 8, "Networking Concepts and Technologies" Who doesn't want to get on the Internet? Wireless networks are popular today as a method to get Internet connectivity. You'll learn about key networking technologies and how to configure a wireless router in this chapter.

Chapter 9, "Security Concepts and Threats" The downside to computers is that it seems like hackers are everywhere. This chapter will introduce you to common threats posed by would-be attackers so you know how to avoid them. It also introduces a security framework and access control concepts.

Chapter 10, "Security Best Practices" This chapter builds on Chapter 9 by showing you how to set up your system to protect it against attacks. You will learn about hardening devices, managing users, and using data encryption.

Chapter 11, "Business Continuity and Computer Support" Inevitably, computers will run into problems—it's the nature of electronic components. This chapter will show you how to troubleshoot any issues that pop up. *Warning*: After reading this chapter, all of your family members will call on you for technical support (if they don't already)! This chapter also shows you how to plan for eventual computer problems so that you don't totally lose your data.

What's Included in the Book

I've included the following study tools throughout the book:

Assessment Test At the end of this Introduction is an Assessment Test that you can use to check your readiness for the exam. Take this test before you start reading the book; it will help you determine the areas where you might need to brush up. The answers to the Assessment Test questions appear on separate pages after the last question of the test. Each answer includes an explanation and a note telling you the chapter in which the material appears.

Objective Map and Opening List of Objectives Just before the Assessment Test, you'll find a detailed exam objective map, showing you where each of the CompTIA exam objectives is covered in this book. In addition, each chapter opens with a list of the exam objectives it covers. Use these to see exactly where each of the exam topics is covered.

Exam Essentials Each chapter, just after the summary, includes a number of exam essentials. These are the key topics that you should take from the chapter in terms of areas to focus on when preparing for the exam.

Lab Exercises Each chapter includes a hands-on lab to give you more experience. These exercises map to the exam objectives. Some ask specific questions, and you can find the answers to those questions in Appendix A.

Chapter Review Questions To test your knowledge as you progress through the book, there are 20 review questions at the end of each chapter. As you finish each chapter, answer the review questions and then check your answers—the correct answers and explanations are in Appendix B. You can go back to reread the section that deals with each question you got wrong in order to ensure that you answer correctly the next time you're tested on the material.

Interactive Online Learning Environment and Test Bank

The interactive online learning environment that accompanies *CompTIA IT Fundamentals+ (ITF+) Study Guide: Exam FC0-U61, Second Edition*, provides a test bank with study tools to help you prepare for the certification exam and increase your chances of passing it the first time! The test bank includes the following:

Sample Tests All of the questions in this book are provided online, including the Assessment Test, which you'll find at the end of this Introduction, and the Chapter Tests, which include the review questions at the end of each chapter. In addition, there are two Practice Exams. Use these questions to test your knowledge of the study guide material. The online test bank runs on multiple devices.

Flashcards Questions are provided in digital flashcard format (a question followed by a single correct answer). You can use the flashcards to reinforce your learning and provide last-minute test prep before the exam.

Other Study Tools A glossary of key terms from this book and their definitions is available as a fully searchable PDF.

NOTE

Go to `www.wiley.com/go/sybextestprep` to register and gain access to this interactive online learning environment and test bank with study tools.

How to Use This Book

If you want a solid foundation for the serious effort of preparing for the IT Fundamentals+ (ITF+) exam, then look no further because I've spent countless hours putting together this book with the sole intention of helping you to pass it!

This book is loaded with valuable information, and you will get the most out of your study time if you understand how I put the book together. Here's a list that describes how to approach studying:

1. Take the Assessment Test immediately following this Introduction. (The answers are at the end of the test, but no peeking!) It's okay if you don't know any of the answers—that's what this book is for. Carefully read over the explanations for any question you get wrong, and make note of the chapters where that material is covered.
2. Study each chapter carefully, making sure you fully understand the information and the exam objectives listed at the beginning of each one. Again, pay extra-close attention to any chapter that includes material covered in questions you missed on the Assessment Test.
3. Complete the lab exercise at the end of each chapter. Do *not* skip these exercises. One reason is that they directly map to the CompTIA objectives and reinforce the material. Another reason is that it gives you hands-on experience, which is crucial.
4. Answer all the review questions related to each chapter. Specifically, note any questions that confuse you, and study the corresponding sections of the book again. And don't just skim these questions—make sure you understand each answer completely.
5. Try your hand at the Practice Exams. The more questions you practice, the better you will be when you sit for the real exam.
6. Test yourself using all of the electronic flashcards. This is a new and updated flashcard program to help you prepare for the latest CompTIA IT Fundamentals+ (ITF+) exam, and it is a really great study tool.

Learning every bit of the material in this book is going to require you to apply yourself with a good measure of discipline. So, try to set aside the same time period every day to study, and select a comfortable and quiet place to do so. If you work hard, you will be surprised at how quickly you learn this material.

If you follow the steps listed here and study with the Review Questions, Practice Exams, electronic flashcards, and all of the written labs, you would almost have to try to fail the CompTIA IT Fundamentals+ (ITF+) exam. However, studying for the IT Fundamentals+ (ITF+) exam is like training for a marathon—if you don't go for a good run every day, you're not likely to finish very well.

Exam Objectives

Speaking of objectives, you're probably pretty curious about them, right? CompTIA asked groups of IT professionals to fill out a survey rating the skills they felt were important in their jobs, and the results were grouped into objectives for the exam and divided into six domains.

This table gives you the extent by percentage in which each domain is represented on the actual examination.

Domain	% of Examination
1.0 IT Concepts and Terminology	17%
2.0 Infrastructure	22%
3.0 Applications and Software	18%
4.0 Software Development	12%
5.0 Database Fundamentals	11%
6.0 Security	20%
Total	100%

NOTE

Exam objectives are subject to change at any time without prior notice and at CompTIA's sole discretion. Please visit CompTIA's website (`www.comptia.org`) for the most current listing of exam objectives.

CompTIA IT Fundamentals+ (ITF+) Study Guide

FC0-U61 Exam Objectives

Objective	Chapter
1.0 IT Concepts and Terminology	
1.1 Compare and contrast notational systems.	6
1.2 Compare and contrast fundamental data types and their characteristics.	6
1.3 Illustrate the basics of computing and processing.	1
1.4 Explain the value of data and information.	9
1.5 Compare and contrast common units of measure.	1, 2
1.6 Explain the troubleshooting methodology.	11

Objective	Chapter
2.0 Infrastructure	
2.1 Classify common types of input/output device interfaces.	2
2.2 Given a scenario, set up and install common peripheral devices to a laptop/PC.	2
2.3 Explain the purpose of common internal computing components.	1
2.4 Compare and contrast common Internet service types.	8
2.5 Compare and contrast storage types.	1, 8
2.6 Compare and contrast common computing devices and their purposes.	3
2.7 Explain basic networking concepts.	8
2.8 Given a scenario, install, configure and secure a basic wireless network.	8
3.0 Applications and Software	
3.1 Manage applications and software.	4
3.2 Compare and contrast components of an operating system.	4
3.3 Explain the purpose and proper use of software.	5
3.4 Explain methods of application architecture and delivery models.	5
3.5 Given a scenario, configure and use web browsers.	5
3.6 Compare and contrast general application concepts and uses.	5
4.0 Software Development Concepts	
4.1 Compare and contrast programming language categories.	6
4.2 Given a scenario, use programming organizational techniques and interpret logic.	6
4.3 Explain the purpose and use of programming concepts.	6

Objective	Chapter
5.0 Database Fundamentals	
5.1 Explain database concepts and the purpose of a database.	7
5.2 Compare and contrast various database structures.	7
5.3 Summarize methods used to interface with databases.	7
6.0 Security	
6.1 Summarize confidentiality, integrity, and availability concepts.	9
6.2 Explain methods to secure devices and best practices.	10
6.3 Summarize behavioral security concepts.	10
6.4 Compare and contrast authentication, authorization, accounting, and non-repudiation concepts.	9
6.5 Explain password best practices.	10
6.6 Explain common uses of encryption.	10
6.7 Explain business continuity concepts.	11

Assessment Test

1. Which of the following optical discs will store the most data?
   A. CD-ROM
   B. DVD-ROM DL
   C. DVD-ROM DS
   D. RS-ROM
2. Which of the following devices are used for persistent user data storage in a computer? (Choose two.)
   A. HDD
   B. RAM
   C. ROM
   D. SSD
3. Which of the following on your computer is considered firmware?
   A. RAM
   B. SSD
   C. CMOS
   D. BIOS
4. What was the first widely adopted video connector standard?
   A. CGA
   B. VGA
   C. XGA
   D. DVI
5. What type of removable storage is often used in digital cameras?
   A. Flash drive
   B. NAS
   C. Memory card
   D. Mobile media card
6. Which of the following peripherals is considered an input device?
   A. Scanner
   B. Printer
   C. Touchscreen
   D. Flash drive

7. Angela has an iPhone with a biometric scanner enabled. She powered the device off and just turned it back on. What methods can she use to unlock her phone?
   - A. Fingerprint only
   - B. Passcode only
   - C. Fingerprint or passcode
   - D. Fingerprint, passcode, or iris scan
8. You are setting up a new Wi-Fi connection on your iPad. What is the first step in the process?
   - A. Enter wireless password
   - B. Verify Internet connection
   - C. Verify wireless capabilities
   - D. Locate SSID
   - E. Turn on Wi-Fi
9. What type of security is involved when pairing two Bluetooth devices together?
   - A. SSL certificates are exchanged.
   - B. A PIN is provided by the Bluetooth device.
   - C. The Bluetooth security layer negotiates the security mechanism.
   - D. There is no security involved.
10. Which operating system named its versions after large cats?
    - A. iOS
    - B. OS X
    - C. Android
    - D. Chrome OS
11. Your computer has a 64-bit CPU. Which statement is true regarding which operating systems you can install on it?
    - A. 64-bit operating systems only
    - B. 64-bit or 32-bit operating systems
    - C. 32-bit operating systems only
    - D. It depends on how much RAM is in your system.
12. Which type of operating system allows you to run multiple operating systems at once on one computer?
    - A. Embedded OS
    - B. Server OS
    - C. Hypervisor
    - D. Mobile device OS

13. Which of the following is not considered productivity software?
    - **A.** Spreadsheet software
    - **B.** Web browser
    - **C.** Online workspace
    - **D.** Visual diagramming software

14. Which of the following is required for a website to show up as a secure website in a browser?
    - **A.** Private browsing
    - **B.** Client-side scripting
    - **C.** Valid certificate
    - **D.** Compatible browser

15. Which of the following terms best describes an application with separate database, business logic, and application layers?
    - **A.** N-tier
    - **B.** Cloud hosted
    - **C.** Local network hosted
    - **D.** Three tier

16. Which data type exists only in true and false states?
    - **A.** Binary
    - **B.** Boolean
    - **C.** Char
    - **D.** Float

17. Code that is not part of the functionality of the program but is intended to be easy for people to read is called what?
    - **A.** Compiled
    - **B.** Interpreted
    - **C.** Commented
    - **D.** Pseudocode

18. Which of the following container types has a fixed length?
    - **A.** Constant
    - **B.** Array
    - **C.** Vector
    - **D.** String

19. When creating a relational database, what is the name of the rules and structure?
    A. Forms
    B. Tables
    C. Schema
    D. Constraints

20. Which of the following statements is true regarding a foreign key in a relational database?
    A. They are required.
    B. There can be only one per table.
    C. They are automatically indexed.
    D. Null values are allowed.

21. David, a database administrator, needs to remove a column from an existing database. Which command should he use?
    A. `ALTER`
    B. `DELETE`
    C. `DROP`
    D. `REMOVE`

22. You open your web browser and type in `www.google.com`, but your computer can't find the website. Your neighbor's computer finds it just fine. What is most likely the cause?
    A. Incorrect DNS configuration
    B. Incorrect DHCP configuration
    C. Incorrect WPA2 configuration
    D. The website is down.

23. Your friend Marcos asks you which of the following are the most secure. What do you tell him?
    A. 802.11n
    B. Infrared
    C. Fiber-optic
    D. UTP

24. Your need to set up a wireless router for a friend. He wants to be sure that his network is secure. Which wireless security method should you implement?
    A. WPA2
    B. WPA
    C. NAT
    D. WEP

25. You have just created a new logo for your company. What should you get to protect the intellectual property?
    A. Trademark
    B. Copyright
    C. Patent
    D. Asset protection
26. A user has been accused of hacking into a server. Which of the following would keep him from denying that he did it?
    A. Authentication
    B. Authorization
    C. Accounting
    D. Nonrepudiation
27. Your manager read about a replay attack and is worried a hacker will try to use it on your network. What type of concern is this?
    A. Confidentiality
    B. Integrity
    C. Availability
    D. Authentication
28. Which of the following are considered device-hardening techniques? (Choose two.)
    A. Disabling Bluetooth
    B. Requiring complex passwords
    C. Enabling single sign-on
    D. Installing antispyware software
29. For security purposes, which of the following user accounts are disabled by default?
    A. Guest
    B. Users
    C. Power Users
    D. Administrator
30. You are browsing the Internet to purchase a gift for a friend. What two things should you look for to ensure that it's safe to enter your credit card information? (Choose two.)
    A. Security seal of approval
    B. RSA Secure Access symbol
    C. A lock symbol
    D. HTTPS://

31. You just installed a new HP printer on your Dell computer and it's not printing. What is the first source to check for information on the problem?

    A. Dell's website
    B. HP's website
    C. Google search
    D. Internet technical community groups

32. When configuring a backup solution for your computer, you decide that speed is the most important factor. Which storage option should you choose?

    A. Locally attached storage
    B. Network attached storage
    C. Cloud storage
    D. Offline storage

33. You have just completed a backup of your PC onto an optical disc. What is the next step you need to take?

    A. Store the backup in a secure location.
    B. Burn the disc to ensure the data is saved.
    C. Test the backup to verify it works.
    D. Copy the backup data to a cloud.

Answers to the Assessment Test

1. C. A double-sided DVD-ROM can store more data than a dual-layer DVD-ROM, and both can store much more than a CD-ROM. There is no RS-ROM. See Chapter 1 for more information.

2. A, D. Hard disk drives (HDDs) are used to store user data in a persistent manner, meaning that data is retained after the power is turned off. Solid-state drives (SSDs) are one type of hard drive. See Chapter 1 for more information.

3. D. The basic input output system (BIOS) is firmware. It's stored on a hardware chip called the CMOS. See Chapter 1 for more information.

4. B. VGA was the first widely used video connector standard, and it was released in 1987. See Chapter 2 for more information.

5. C. Digital cameras use memory cards. The most popular form of memory card on the market today is the SD card. See Chapter 2 for more information.

6. A. Scanners are input devices. Printers produce output. Touchscreens and flash drives are both input and output devices. See Chapter 2 for more information.

7. B. With biometrics enabled, you can use either the passcode or your fingerprint to access a locked device. However, if it was just powered off, the only option is to enter the passcode. See Chapter 3 for more information.

8. C. The proper steps in order are to verify wireless capabilities, turn on Wi-Fi, locate SSID, enter wireless password, and verify Internet connection. See Chapter 3 for more information.

9. B. When pairing two Bluetooth devices, you need to enter the PIN into your mobile device that allows it to connect to the Bluetooth device. See Chapter 3 for more information.

10. B. Apple's OS X was named for large cats. Now versions are named after locations in California. See Chapter 4 for more information.

11. B. A 64-bit processor can handle 32-bit or 64-bit OSs. It is a waste of power to use a 32-bit OS on it, but it will work. See Chapter 4 for more information.

12. C. A hypervisor is a program that allows you to run a virtual operating system within another operating system. See Chapter 4 for more information.

13. C. Online workspace is an example of collaboration software. See Chapter 5 for more information.

14. C. Secure websites are required to have a valid security certificate. See Chapter 5 for more information.

15. D. A three-tier application will have separate database, business logic, and application layers. Three tier is a specific type of n-tier application architecture model. See Chapter 5 for more information.

16. B. The Boolean data type uses only true and false. Oftentimes they are represented with a 1 for True and a 0 for False, but this does not have to be the case. See Chapter 6 for more information.

17. D. Pseudocode is used for annotation, and it does not affect the functionality of the program. See Chapter 6 for more information.

18. B. Arrays and vectors are the two container types. Arrays have a fixed length, and vectors can have a dynamically allocated length. See Chapter 6 for more information.

19. C. The schema is the rules and structure of a relational database. See Chapter 7 for more information.

20. D. A foreign key is one or more columns in a table that refers to the primary key in another table. Unlike primary keys, null values are allowed. Foreign keys are not required, there can be more than one per table, and they are not automatically indexed. See Chapter 7 for more information.

21. A. The `ALTER` command is used to add, remove, or modify columns in a database. `DROP` is used to remove a table or database. `DELETE` is used to delete a record, and there is no `REMOVE` command. See Chapter 7 for more information.

22. A. DNS servers resolve host names to IP addresses. It's possible that your computer has the wrong address for the DNS server. DHCP automatically configures TCP/IP clients, and WPA2 is a security protocol. If the website was down, your neighbor would not be able to access it either. See Chapter 8 for more information.

23. C. Wired connections are more secure than wireless ones. Fiber-optic cable is also immune to wiretaps, which makes it more secure than UTP. See Chapter 8 for more information.

24. A. WPA2 is the most secure wireless security protocol in use today. See Chapter 8 for more information.

25. A. A trademark is used to protect a word, words, or a symbol legally registered as representing a company or a product. See Chapter 9 for more information.

26. D. The framework for access control is AAA—authentication, authorization, and accounting. Nonrepudiation is added, which makes it so people can't deny that an event took place. See Chapter 9 for more information.

27. B. A replay attack is an example of an integrity concern. Other examples are man-in-the-middle attacks, impersonation, and unauthorized information alteration. See Chapter 9 for more information.

28. A, D. Device hardening makes it harder for attackers to gain access to your system by reducing the potential areas of attack. Two examples of device hardening are disabling unused or unneeded services and installing anti-malware. See Chapter 10 for more information.

29. A. The Guest account is disabled by default, and it should remain disabled if it is not being used. See Chapter 10 for more information.

30. C, D. Secure websites will start with `HTTPS://` instead of `HTTP://`. In addition, there will be a lock symbol near the address in the address bar. See Chapter 10 for more information.

31. B. Always check the manufacturer's website first. Since it's an HP printer, check its site and not Dell's. See Chapter 11 for more information.

32. A. When choosing a backup solution, know that locally attached storage devices will always be faster than network storage or cloud-based solutions. See Chapter 11 for more information.

33. C. After completing a backup, you should verify that the backup is working properly. See Chapter 11 for more information.

Chapter 1

Core Hardware Components

THE FOLLOWING COMPTIA IT FUNDAMENTALS+ (ITF+) FC0-U61 EXAM OBJECTIVES ARE COVERED IN THIS CHAPTER:

✓ **1.3 Illustrate the basics of computing and processing**

- Input
- Processing
- Output
- Storage

✓ **1.5 Compare and contrast common units of measure**

- Storage unit
  - Bit
  - Byte
  - KB
  - MB
  - GB
  - TB
  - PB
- Processing speed
  - MHz
  - GHz

✓ **2.3 Explain the purpose of common internal computing components**

- Motherboard/system board
- Firmware/BIOS

- RAM
- CPU
  - ARM
    - Mobile phone
    - Tablet
  - 32-bit
    - Laptop
    - Workstation
    - Server
  - 64-bit
    - Laptop
    - Workstation
    - Server
- GPU
- Storage
  - Hard drive
  - SSD
- Cooling
- NIC
  - Wired vs. wireless
  - Onboard vs. add-on card

✓ 2.5 Compare and contrast storage types

- Volatile vs. non-volatile
- Local storage types
  - RAM
  - Hard drive
    - Solid state vs. spinning disk
  - Optical
  - Flash drive

What better way to kick off a book on IT Fundamentals+ (ITF+) than to talk about the most fundamental components of all—core hardware? When you really break it down to the basics, computers are simply collections of specialized hardware devices that work together (with software) to provide you with the functionality you want. For most users, the desired functionality is to take input, somehow process it, produce output (video or printed), and store data. Sometimes the hardware is in your hands, and at other times it's halfway around the world—but it's always necessary. Even soft and fluffy-sounding terms such as "the cloud" (which I will introduce in Chapter 5, "Software Applications") rely on much of the same hardware that sits snugly within your tablet or smartphone case.

To begin your journey of understanding fundamental IT concepts, I will discuss components that are commonly included inside the case. Some are absolutely critical, while others just provide features that are nice to have, such as sound or a network connection. In this way, I'll start from the inside out so that you understand what makes computers work the way they do.

Introducing Internal Components

In this section, I will talk about the components that are generally inside the computer case. Some of them are exclusively found inside the case, such as the motherboard and the processor, whereas others can be internal or external. For example, internal hard drives (for storage) are standard in desktop and laptop computers, but you can also buy external hard drives for expanded storage. Network cards are another great example. Today, the circuitry is generally built into the computer, but you can easily find external ones as well. Regardless of the location of your hard drive or network card, it still provides the same functionality.

Most home computer components are modular. That is, they can be removed and replaced by another piece of hardware that does the same thing, provided that it's compatible and that it fits. For example, if the hard drive in your laptop fails, it can be removed and replaced by another hard drive. This isn't always the case, of course, and the general rule is that the smaller the device, the less modular it is. This is because to achieve the smaller size, manufacturers need to integrate more functionality into the same component. It's usually quicker and just as cost-effective to replace a device such as a smartphone rather than repair it if a part fails. If a component is modular and can be replaced, you will sometimes hear it referred to as a *field replaceable unit (FRU)*.

Since I'm talking about components that are inside the case, it would be unfortunate to ignore the case itself. Cases are usually a combination of metal and plastic and serve these two primary functions:

- Keeping all the components securely in place
- Protecting the components from harm

Protecting the components is the key. Water and other liquids are obviously bad for electronic devices, and direct exposure to sunlight and dust can cause parts to overheat and fail. The case guards against all these things. Moreover, in some cases (pun intended), it can make your device easily mobile.

NOTE Throughout this section, I will specifically talk about PC (desktop and laptop) hardware. Many of the principles here apply to smaller devices such as tablets and smartphones as well.

Exploring Motherboards, Processors, and Memory

These three components—motherboards, processors, and memory—are the holy trinity of computers. Pretty much every personal computing device made today requires all three of these parts. So, without further ado, let's dive in.

Motherboards

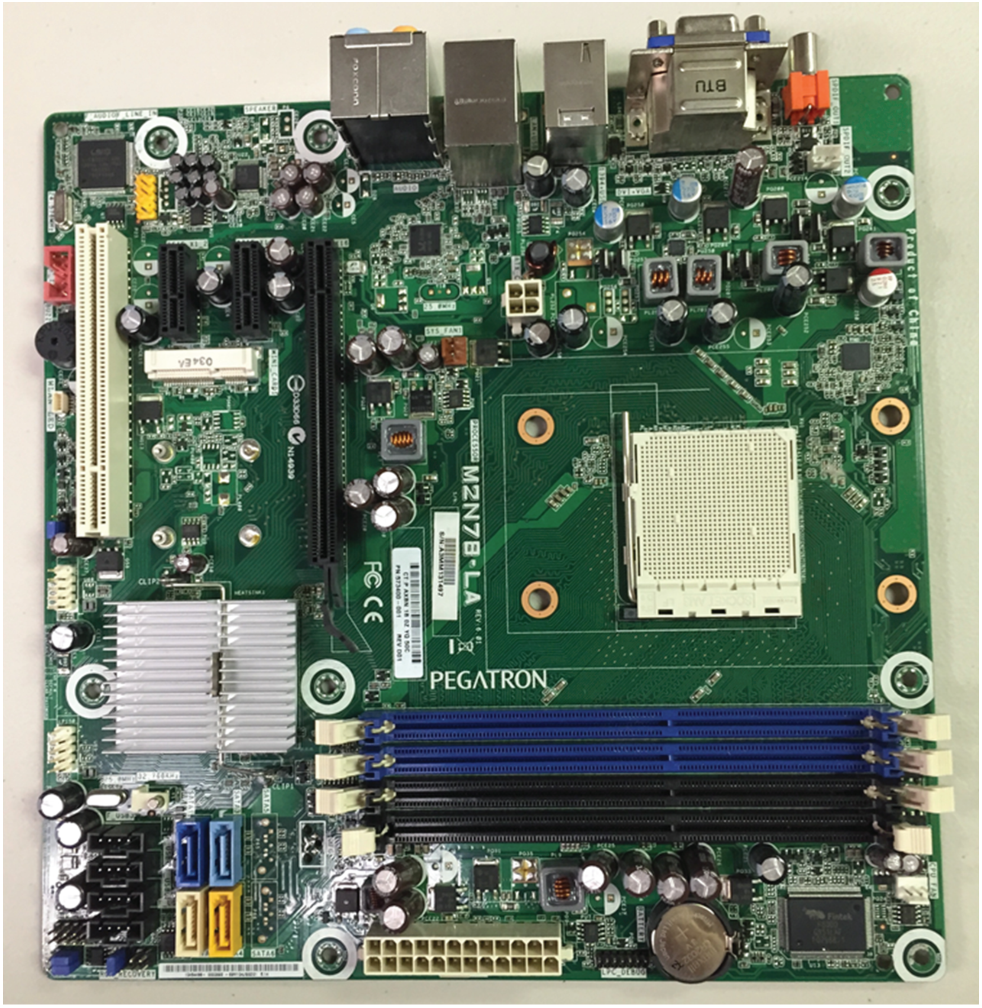
The *motherboard* is the most important component in the computer because it connects all the other components. Functionally, it acts much like the nervous system of the computer. You will also hear it called the *system board* or the *mainboard*. With this introduction, you might think that this piece of hardware is complex—and you'd be right! Manufacturers and hardware resellers don't make it easy to understand what you're dealing with either. Here's the description of a motherboard for sale on an Internet hardware site:

> Asus X99-PRO/USB 3.1 Intel X99 Chipset Core i7 Socket R3 (LGA2011) ATX Motherboard, DDR4, PCI-E 3.0 x16, SATA/M.2 Socket 3, GBLAN, Wi-Fi/Bluetooth, USB

What does that all mean? Is it even human language? Don't worry. By the end of this section on motherboards, you will understand what it all means.

The first thing to know about motherboards is that they are a *printed circuit board (PCB)*, that is, a conductive series of pathways laminated to a nonconductive substrate that lines the bottom of the computer. Most of the time they are green, but you will also see brown, blue, red, and black ones. If you look at the bottom of a motherboard, you will see all the conductive pathways. Some of the most popular brands right now are ASUS, GIGABYTE, and MicroStar (MSI). Figure 1.1 shows a typical motherboard.

FIGURE 1.1 A motherboard



All other components are attached to this circuit board. Some are physically attached directly to the board and aren't intended to be removed, such as the underlying circuitry, the central processing unit (CPU) socket, random access memory (RAM) slots, expansion slots, and a variety of other chips. Components such as the CPU and the RAM get physically attached to the motherboard. Other devices, such as hard drives and power supplies, are attached via their own connectors.

NOTE

Manufacturers can also integrate components such as the CPU, video card, network card, and others directly onto the motherboard as opposed to having slots into which they are inserted. As a rule of thumb, the smaller the motherboard, the more likely it is to have integrated components.

Let's start breaking down the features and components typically associated with motherboards. The following list might look long, but breaking each one down separately will help you to understand the importance of each one. Here are the topics coming up shortly:

- Form factors
- Chipsets
- Processor sockets
- Memory slots
- Expansion slots
- Disk controllers
- Power connectors
- BIOS/firmware
- CMOS and CMOS battery
- Back-panel connectors
- Front-panel connectors

In the following sections, you will learn about some of the most common components of a motherboard and what they do. I'll show you what each component looks like so that you can identify it on almost any motherboard you run across.

Form Factors

Motherboards are classified by their design, which is called a *form factor*. There are dozens of form factors in existence. Because motherboards mount to the system case, it's important to know what types of motherboards your case supports before replacing one. Desktop computer cases often support multiple sizes of motherboards, but laptops are another story. With laptops, you almost always need to replace an old motherboard with the same version.

The most common form factors used today are Advanced Technology Extended (ATX), micro ATX, and ITX.

NOTE

ITX is not one specific form factor but a collection of small form factor (SFF) boards.

The form factors differ in size and configuration of the components on the motherboard. In addition, they may have different power requirements. Micro ATX and ITX are specifically designed to be paired with low-wattage power supplies to reduce the amount of heat produced by the computer. Because these two are smaller, they also offer fewer options for adding expansion cards versus the ATX design.

NOTE Here's a quick history lesson. The XT form factor was developed by IBM in 1983, and it is generally considered the first industry-standard PC form factor. In 1985, IBM released the Baby-AT, which because of its smaller size quickly became the most popular form factor in the market. The Baby-AT was king until 1996 when Intel released the ATX standard. As of this writing, the ATX and micro ATX (which is similar in configuration to ATX, only smaller) are still the most popular computer form factors.

Table 1.1 provides the dimensions of common form factors.

TABLE 1.1 Motherboard form factors

Form Factor	Release Year	Size
Baby-AT	1985	8.5 × 10–13 in (216 × 254–330 mm)
ATX	1996	12 × 9.6 in (305 × 244 mm)
Micro ATX	1996	9.6 × 9.66 in (244 × 244 mm)
Mini-ITX	2001	6.7 × 6.7 in (170 × 170 mm)
Nano-ITX	2003	4.7 × 4.7 in (120 × 120 mm)
Pico-ITX	2007	3.9 × 2.8 in (100 × 72 mm)
Mobile-ITX	2007	2.95 × 1.77 in (75 × 45 mm)
Neo-ITX	2012	6.7 × 3.35 in (170 × 85 mm)

In view of how quickly computer technology evolves, it is amazing that the form factors remain popular for as long as they do. The advent of smaller devices such as tablets and smartphones has driven the most recent form factor design changes.

Chipsets

The motherboard's *chipset* is a collection of chips or circuits that perform interface and peripheral functions for the processor. Said differently, this collection of chips provides interfaces for memory, expansion cards, and onboard peripherals, and it generally dictates how a motherboard will communicate with the installed peripherals.

Chipsets are usually given a name and model number by the original manufacturer, for example, Intel's X99. What features make the X99 so great? I will be honest; I have no idea. There are so many chipsets out there that it's impossible to know the features of every one. But, if you need to know, having the manufacturer and model can help you look up the features of that particular chipset, such as the type of RAM supported, the type and brand of onboard video, and so on.

NOTE The best place to look for motherboard specifications is on the manufacturer's website. For example, `https://www.asus.com/us/Motherboards/PRIME-Z370-A/specifications/` tells you everything that you need to know about the ASUS PRIME Z370-A motherboard.

The functions of chipsets can be divided into two major groups: Northbridge and Southbridge. It's unlikely that you'll be tested on these on the IT Fundamentals+ (ITF+) exam, but I want to introduce them just in case you hear the terms. Plus, I think it helps better explain exactly what the chipset does.

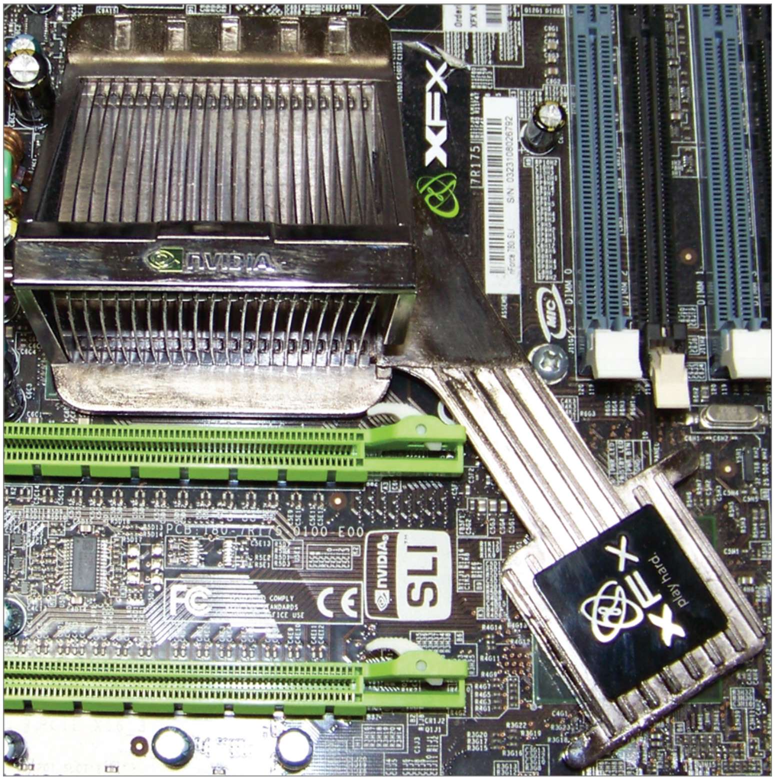
Northbridge The Northbridge subset of a motherboard's chipset performs one important function: management of high-speed peripheral communications. The Northbridge is responsible primarily for communications with integrated video and processor-to-memory communications.

The communications between the CPU and memory occur over what is known as the *front-side bus (FSB)*, which is just a set of signal pathways connecting the CPU and main memory. The *back-side bus (BSB)*, if present, is a set of signal pathways between the CPU and any external cache memory.

Southbridge The Southbridge subset of the chipset is responsible for providing support to the onboard slower peripherals (PS/2, parallel ports, serial ports, Serial and Parallel ATA, and so on) and managing their communications with the rest of the computer and the resources given to them. If you're thinking about any component other than the CPU, memory and cache, or integrated video, the Southbridge is in charge.

Figure 1.2 shows the chipset of a motherboard, with the heat sink of the Northbridge, at the top left, connected to the heat-spreading cover of the Southbridge, at the bottom right.

FIGURE 1.2 Northbridge and Southbridge



Real World Scenario

Who's Driving the Bus?

When talking about the Northbridge, I mentioned a bus (specifically a front-side bus), so now is a good time to talk about what a bus does and to give you some historical context. You'll probably hear the term come up often when talking about computer hardware, such as in discussions about the system bus, expansion bus, parallel bus, and serial bus.

A *bus* is a common collection of signal pathways over which related devices communicate within the computer system. It refers specifically to a data path or the way that the computer communicates over that path.

Take serial and parallel buses, for example. A serial bus communicates one bit of data at a time, whereas a parallel bus communicates in several parallel channels (eight, for example) at once. Based on this explanation, you might think that parallel is faster than serial. After all, eight lanes should move more data than one lane, right? Sometimes, but not always. It depends on how fast you can get each lane to move.

Serial was developed before parallel, because at its core it's an easier technology to implement. In the late 1980s, parallel became much more popular for printers because it was a lot faster. The only downside to parallel was that the different streams of data needed to be carefully synchronized. This slowed down transmissions so that they weren't exactly eight times faster than the comparable serial connections.

By 1996, manufacturers had advanced the speed of serial technology enough so that it was faster than parallel, and the world saw the introduction of Universal Serial Bus (USB). It was faster than parallel, and it had a lot of additional features, such as the ability to hot plug devices (that is, plug and unplug them without needing to shut the system down). Today, many of the fastest peripheral-connection technologies in use, such as USB, FireWire, and Serial ATA (SATA), are all serial.

Thus, while parallel was king for a day, you can now get faster transmissions via serial technology.

Processor Sockets

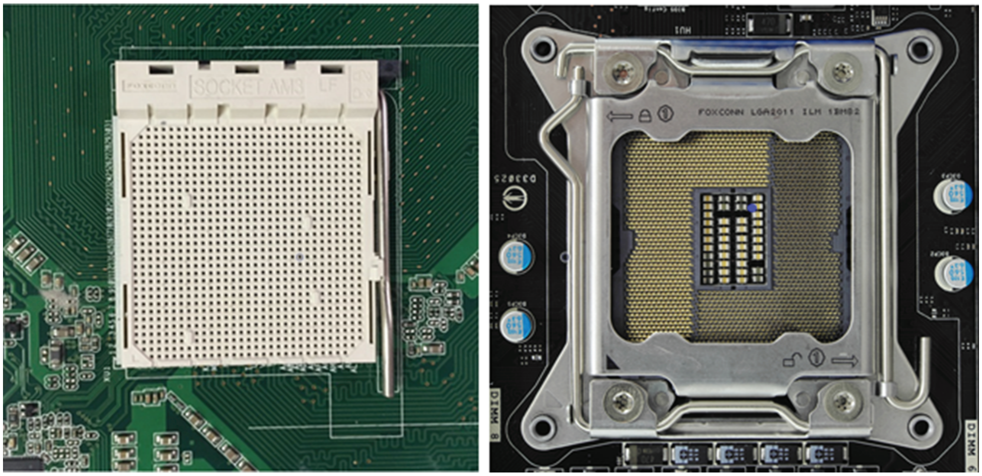
The *central processing unit (CPU)* is the "brain" of any computer. There are many different types of processors for computers, and the processor you have must fit into the socket on the motherboard. Typically, in today's computers, the processor is the easiest component to identify on the motherboard. It is usually the component that has either a large fan and/or a *heat sink* (usually both) attached to it.

CPU sockets are almost as varied as the processors they hold. Sockets are basically flat and have several columns and rows of holes or pins arranged in a square, as shown in Figure 1.3. You'll hear terms like pin grid array (PGA) or land grid array (LGA) to describe the socket type. In Figure 1.3, the left socket is PGA, and the right one is an LGA 2011. PGA sockets have holes, and the processors have pins that fit into the holes. LGA sockets have contacts (often pins) built in to them, which connect with contacts on the CPU. Both sockets have locking mechanisms to hold the processor in place. PGA uses a simple lever, while LGA has a more complex locking harness (which is closed in Figure 1.3). You might also see ball grid array (BGA) sockets, which use small balls as their contact points.

NOTE

At the beginning of this section, I gave you a description of a motherboard for sale. LGA 2011 is the socket shown in the example.

FIGURE 1.3 CPU sockets



Intel Socket 2011 by smial (talk). Licensed under FAL via Wikimedia Commons (`http://commons.wikimedia.org/wiki/File:Socket_2011_IMGP3918.jpg#/media/File:Socket_2011_IMGP3918.jpg`).

Memory Slots

Random access memory (RAM) slots are for the modules that hold memory chips. RAM is the primary memory used to store currently used data and instructions for the CPU. Many and varied types of memory are available for PCs today. Examples include DDR2, DDR3, and DDR4. Memory for desktops comes on circuit boards called *dual inline memory modules (DIMMs)* and for laptops on *small outline DIMMs (SODIMMs)*. (I will talk about what these acronyms mean in the "Memory" section later in this chapter.)

Memory slots are easy to identify on a motherboard. First, they are long and slender and generally close to the CPU socket. Classic DIMM slots were usually black and, like all memory slots, were placed very close together. (Today manufacturers make memory slots of various colors.) Metal pins in the bottom make contact with the metallic pins on each memory module. Small metal or plastic tabs on each side of the slot keep the memory module securely in its slot. Figure 1.4 shows some memory slots on a desktop motherboard.

Laptops are space constrained, so they use the smaller form factor SODIMM chips. SODIMM slots are configured so that the chips lie nearly parallel to the motherboard, as shown in Figure 1.5.

Motherboard designers can also speed up the system by adding *cache memory* between the CPU and RAM. Cache is a fast form of memory, and it improves system performance by predicting what the CPU will ask for next and prefetching this information before being asked. I will talk about cache more in the "Processors" section later in this chapter.

If there is cache on your motherboard, it is not likely to be a removable component. Therefore, it does not have a slot or connector like RAM does.

FIGURE 1.4 DIMM slots

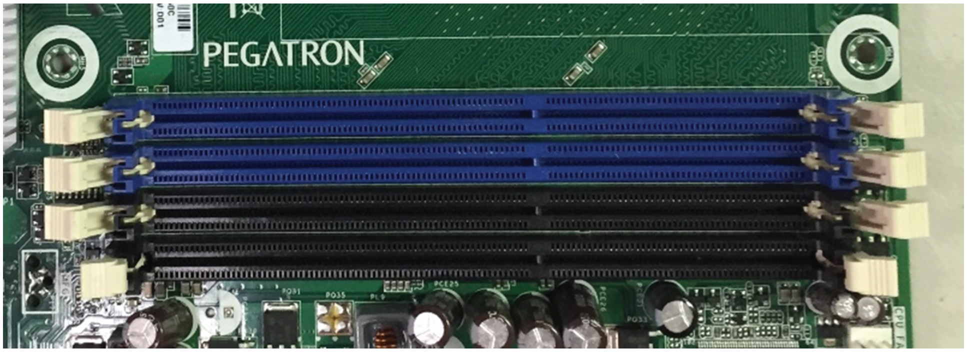


FIGURE 1.5 SODIMM slots

Expansion Slots

The most visible parts of any motherboard are the *expansion slots*. These are small plastic slots, usually from 1 to 6 inches long and approximately ½ inch wide. As their name suggests, these slots are used to install various devices in the computer to expand its capabilities. Some expansion devices that might be installed in these slots include video, network, sound, and disk interface cards.

If you look at the motherboard in your computer, you will more than likely see one of these main types of expansion slots used in computers today:

- PCI
- AGP
- PCIe

Each type differs in appearance and function. In the following sections, I will cover how to identify visually the different expansion slots on the motherboard.

PCI Expansion Slots

Some of the most common expansion slots for many years were the 32-bit *Peripheral Component Interconnect (PCI)* slots. They are easily recognizable because they are only around 3 inches long and classically white, although modern boards take liberties with the color. Although popularity has shifted from PCI to PCIe, the PCI slot's service to the industry cannot be ignored; it has been an incredibly prolific architecture for many years.

PCI expansion buses operate at 33 MHz or 66 MHz over a 32-bit (4-byte) channel, resulting in data rates of 133 megabytes per second (MBps) and 266 MBps, respectively, with 133 MBps being the most common. PCI is a shared-bus topology, which means that mixing 33 MHz and 66 MHz adapters in a 66 MHz system will slow all adapters to 33 MHz.

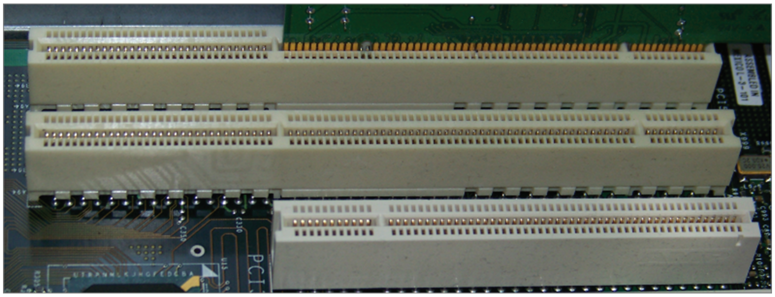
Real World Scenario

Understanding Data Rates

It can be a bit confusing trying to understand how bus speeds relate to data rates, but it doesn't have to be so. The quick way to figure it out is to take the bus speed (how fast it is) and multiply it by the channel width (how much it can push through in bytes) to get the data rate. Now, you might be thinking, "Wait. 33 times 4 is 132, and 66 times 4 is 264. That's different than 133 MBps or 266 MBps." You're absolutely correct. In a creative use of marketing math, some rounding was applied. You'll see this a lot in the computer industry; many specs will end in 33 or 66, even if the real math doesn't quite work out that way.

PCI slots and adapters are manufactured in 3.3V and 5V versions. Universal adapters are keyed to fit in slots based on either of the two voltages. The notch in the card edge of the common 5V slots and adapters is oriented toward the front of the motherboard, and the notch in the 3.3V adapters is oriented toward the rear. Figure 1.6 shows several PCI expansion slots. Note the 5V 32-bit slot in the foreground and the 3.3V 64-bit slots. Also notice that a universal 32-bit card, which has notches in both positions, is inserted into and operates fine in the 64-bit 3.3V slot in the background.

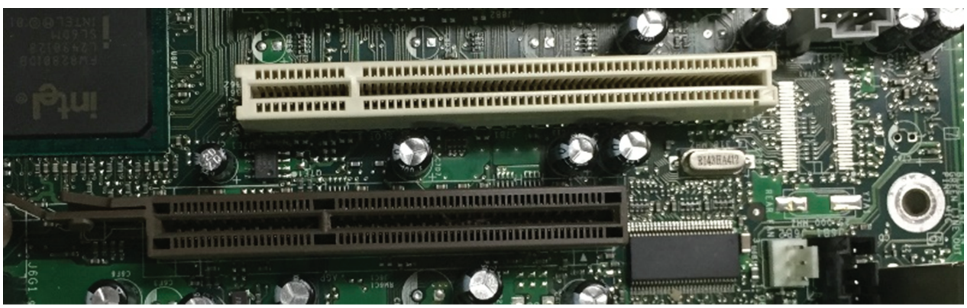
FIGURE 1.6 PCI expansion slots



AGP Expansion Slots

Accelerated Graphics Port (AGP) slots are known mostly for legacy video card use and have been supplanted in new installations by PCI Express slots and their adapters. AGP slots were designed to be a direct connection between the video circuitry and the PC's memory. They are also easily recognizable because they are usually brown and located right next to the PCI slots on the motherboard. AGP slots are slightly shorter than PCI slots and are pushed back from the rear of the motherboard in comparison with the position of the PCI slots. Figure 1.7 shows an example of an older AGP slot, along with a white PCI slot for comparison. Notice the difference in length between the two.

FIGURE 1.7 An AGP slot compared to a PCI slot



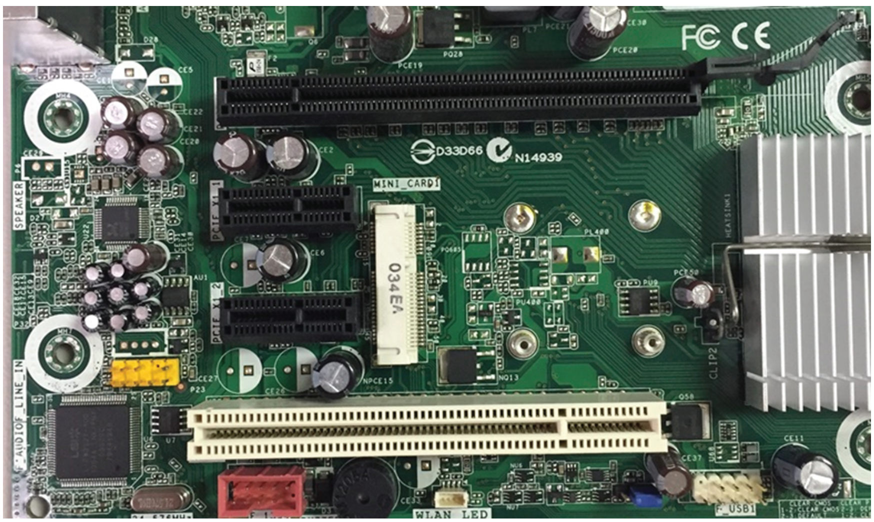
AGP performance is based on the original specification, known as AGP 1x. It uses a 32-bit (4-byte) channel and a 66 MHz clock, resulting in a data rate of 266 MBps. AGP 2x, 4x, and 8x specifications multiply the 66 MHz clock they receive to increase throughput linearly. For instance, AGP 8x uses the 66 MHz clock to produce an effective clock frequency of 533 MHz, resulting in throughput of 2133 MBps over the 4-byte channel. Note that this maximum throughput is only a fraction of the throughput of PCIe x16, which is covered in the following section.

PCIe Expansion Slots

Today's most common expansion slot architecture on motherboards is *PCI Express (PCIe)*. It was designed to be a replacement for AGP and PCI. PCIe has the advantage of being faster than AGP while maintaining the flexibility of PCI. PCIe has no plug compatibility with either AGP or PCI. As a result, some modern PCIe motherboards still have a regular PCI slot for backward compatibility, but AGP slots are rarely included.

There are seven different speeds supported by PCIe, designated ×1 (pronounced "by 1"), ×2, ×4, ×8, ×12, ×16, and ×32, with ×1, ×4, and ×16 being the most common. A slot that supports a particular speed will be of a specific physical size because faster cards require more wires and therefore are longer. As a result, a ×8 slot is longer than a ×1 slot but shorter than a ×16 slot. Every PCIe slot has a 22-pin portion in common toward the rear of the motherboard, as shown in Figure 1.8, in which the rear of the motherboard is to the left. These 22 pins comprise mostly voltage and ground leads. Figure 1.8 shows, from top to bottom, a ×16 slot, two ×1 slots, and a legacy PCI slot.

FIGURE 1.8 PCIe expansion slots



Compared to its predecessors, PCIe is fast. Even at the older PCIe 2.0 standard, a PCIe ×1 card will run at 500 MBps, which is comparable to the best that PCI can offer (533 MBps). The current PCIe standard is PCIe 4.0, and with it a ×16 card can operate at a screaming 31.5 GBps. PCIe 4.0 slots are backward compatible with older PCIe cards.

> **NOTE** PCIe 4.0 was released in October 2017, seven years after PCI 3.0. It provides double the throughput to support virtual reality and augmented reality applications. The next generation PCIe 5.0 is tentatively slated for a mid-2019 release. It should double the throughput of PCIe 4.0.

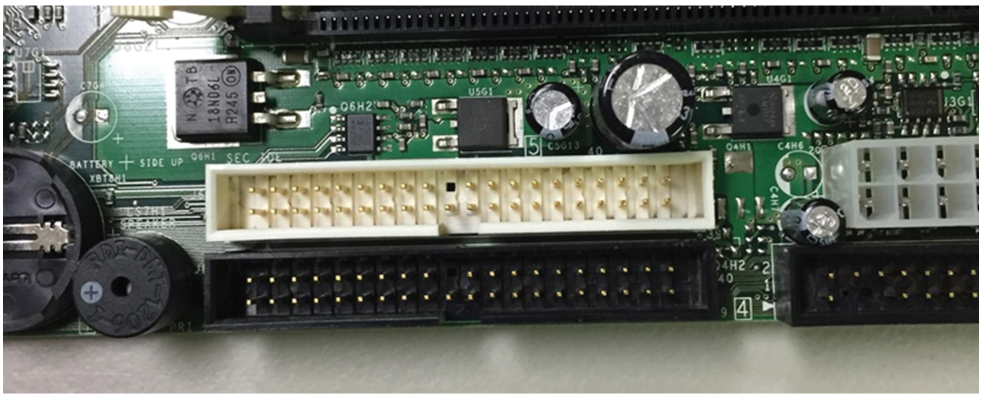
Its high data rate makes PCIe the current choice of gaming aficionados. The only downside with PCIe (and with later AGP slots) is that any movement of these high-performance devices can result in temporary failure or poor performance. Consequently, both PCIe and AGP slots have a latch and tab that secure the adapters in place.

Disk Controllers

One of the endearing features of computers is that they store data and allow it to be retrieved later. (It's true that they sometimes mysteriously lose our data too, but that's another story.) The long-term storage device is called a *hard drive*, and it plugs into the motherboard.

There are a few different hard drive standard connectors. The older one that you will run into is called *Integrated Drive Electronics (IDE)* or *Parallel ATA (PATA)*. The newer and much faster one is called *Serial ATA (SATA)*. Figure 1.9 shows the two IDE connectors (the black and white ones are the same). Figure 1.10 shows four SATA connectors. Notice how they are conveniently labeled for you on the motherboard!

FIGURE 1.9 IDE hard drive connectors



Power Connectors

Computers are obviously electronic devices, and electronics, of course, require power. In addition to the other sockets and slots on the motherboard, a special connector (the 24-pin block connector shown in Figure 1.11) allows the motherboard to be connected to the power supply to receive power. This connector is where the ATX power adapter plugs in. Older AT-style motherboards used a 20-pin connector, and other devices such as hard drives and optical drives use smaller connectors that we will talk about later.

FIGURE 1.10 SATA hard drive connectors

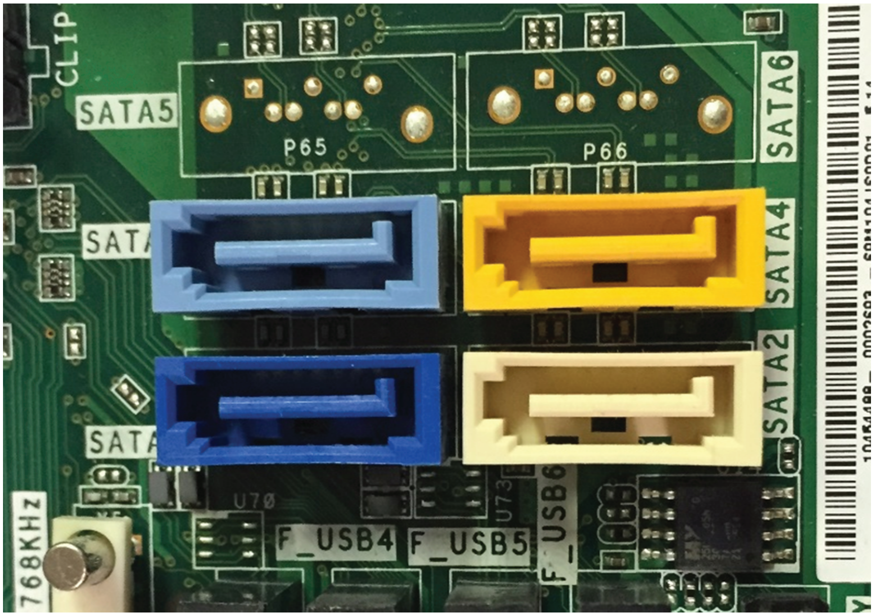
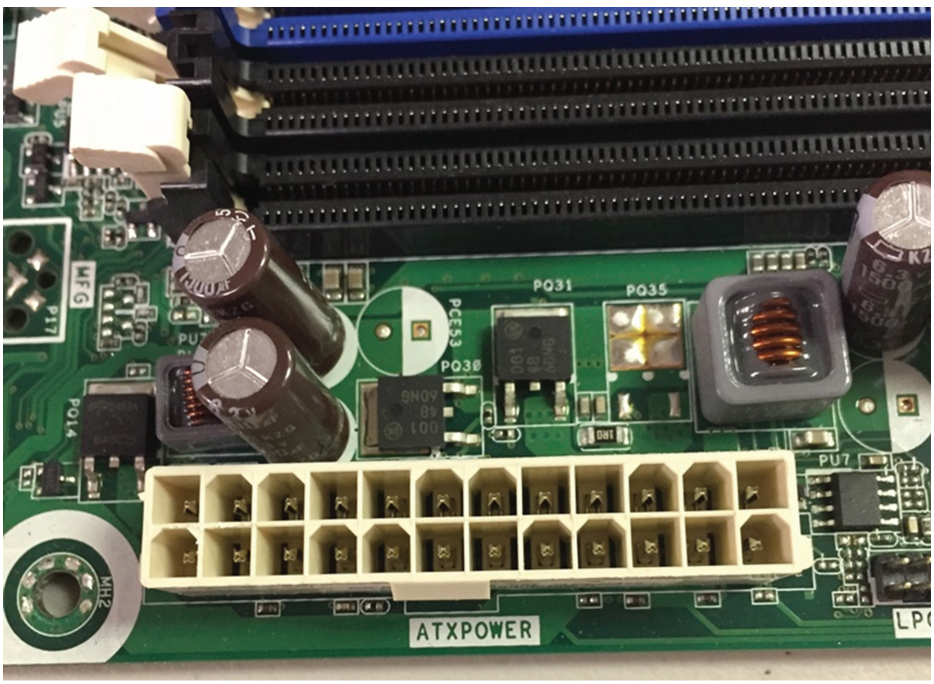


FIGURE 1.11 A 24-pin ATX power connector



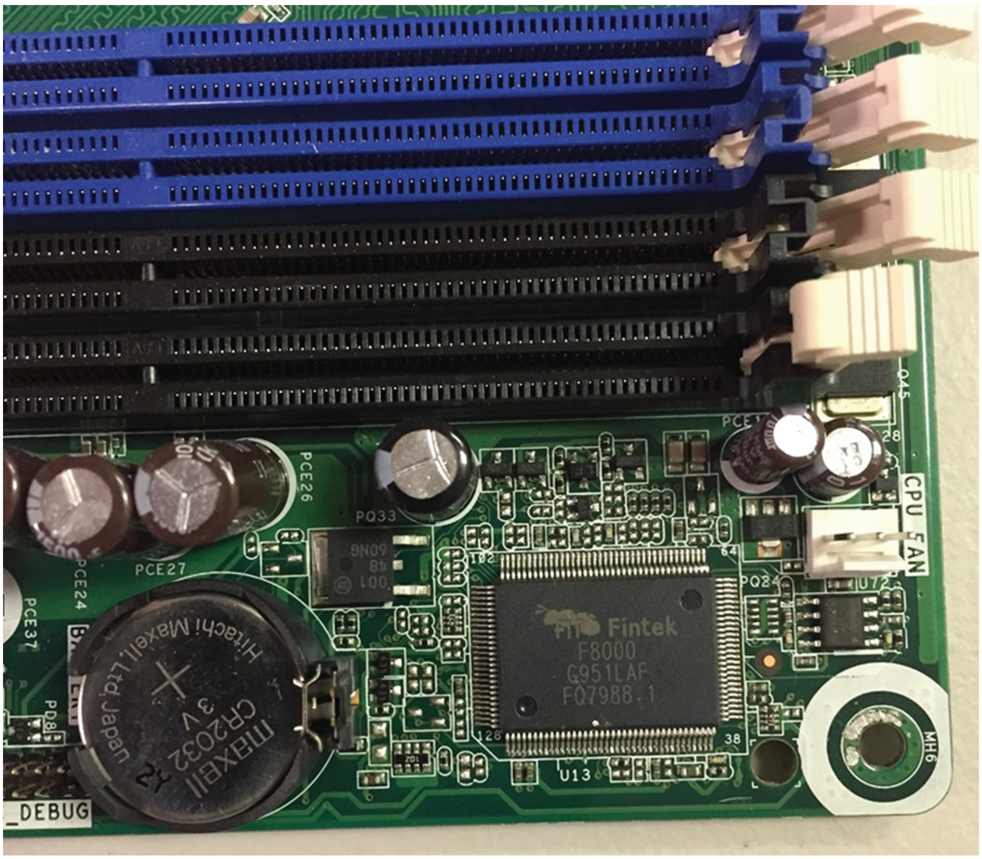
BIOS/Firmware

Firmware is the name given to any software that is encoded in hardware, usually a read-only memory (ROM) chip, and can be run without extra instructions from the operating system. Most computers and large printers use firmware in some sense. The best example of firmware is a computer's *Basic Input/Output System (BIOS)* routine, which is burned into a flash memory chip located on the motherboard. Also, some expansion cards, such as video cards, use their own firmware utilities for setting up peripherals.

Aside from the processor, the most important chip on the motherboard is the BIOS chip. This special memory chip contains the BIOS system software that boots the system and initiates the memory and hard drive to allow the operating system to start.

The BIOS chip is easily identified. If you have a brand-name computer, this chip might have the name of the manufacturer on it and usually the word *BIOS*. For clones, the chip usually has a sticker or printing on it from one of the major BIOS manufacturers (AMI, Phoenix/Award, Winbond, and so on). Figure 1.12 gives you an idea of what a BIOS chip might look like. This one is made by Fintek.

FIGURE 1.12 A BIOS chip on a motherboard

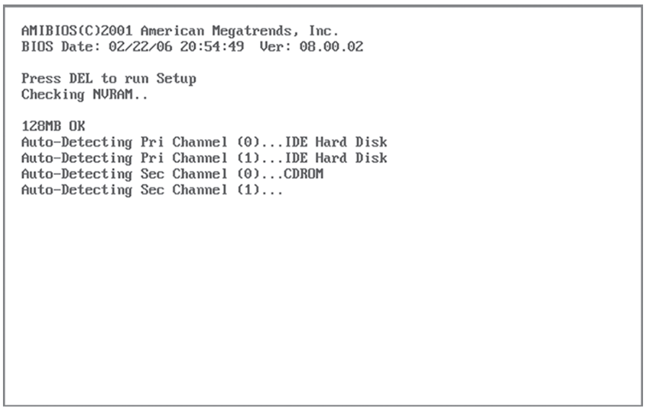


When you power on your computer, the BIOS initializes and runs a system-checking routine called the *power-on self-test (POST)*. The POST routine does the following things:

- Verifies the integrity of the BIOS itself
- Verifies and confirms the size of primary memory
- Analyzes and catalogs other forms of hardware, such as buses and boot devices
- Offers the user a key sequence to enter the configuration screen
- Hands over control to the boot device (usually a hard drive) highest in the configured boot order to load the operating system

If all its tests complete successfully, the POST process finishes. If there is an error, it can produce a beep code or displayed code that indicates there is an issue. Each BIOS publisher has its own series of codes that can be generated. Figure 1.13 shows a simplified POST display during the initial boot sequence of a computer.

FIGURE 1.13 An example of a BIOS boot screen



As mentioned, the POST routine offers the user a chance to enter the BIOS and change the configuration settings. This is usually done by pressing a key during the boot process, such as F2 or F12, or in the case of Figure 1.13, the Delete key. The computer will prompt you, but usually the prompt goes by quickly. If you get a screen showing that the operating system has started, you're too late.

Inside the BIOS, you can make system configuration selections (such as changing the system time or selecting a preferred boot device) and save the results. Also, many BIOSs offer diagnostic routines that you can use to have the BIOS analyze the state and quality of the same components it inspects during bootup but at a much deeper level.

Flashing the BIOS

When you upgrade your system's hardware, the system BIOS typically recognizes it upon bootup. If you upgraded your hard drive, processor, or memory and it's not recognized, though, you might need to update your system BIOS. This is done through a process called *flashing the BIOS*.

To flash the BIOS, you will need to download the most current version from the manufacturer of your computer (or motherboard, if you built your own system) and follow the instructions.

CMOS and CMOS Battery

Your PC has to keep certain settings when it's turned off and its power cord is unplugged, such as the date and time, hard drive configuration, memory and CPU settings, boot sequence, and power management features.

These settings are kept in a special memory chip called the *complementary metal oxide semiconductor (CMOS)*. CMOS (pronounced *see-moss*) is actually a manufacturing technology for integrated circuits, but since the first commonly used chip made from CMOS technology was a BIOS memory chip, the terms have become somewhat interchangeable. To be technically correct, though, the name of the chip is the CMOS, and the BIOS settings are stored on the chip.

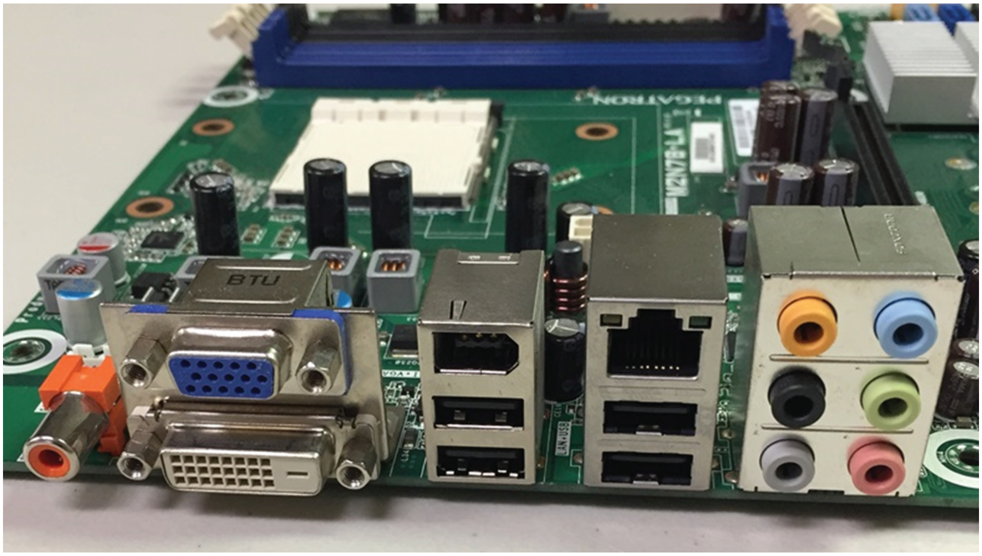
The CMOS chip must have power constantly or it will lose its information (just like RAM does when your computer is powered off). To prevent CMOS from losing its rather important information, motherboard manufacturers include a small battery called the *CMOS battery* to power the CMOS memory. Most CMOS batteries look like watch batteries or small cylindrical batteries. If you look back at Figure 1.12, you will see the CMOS battery next to the BIOS.

If your system does not retain its configuration information after it's been powered off, it's possible that the CMOS battery has failed. Replacing it is similar to replacing a watch battery.

Back-Panel Connectors

If you've ever looked at the back of a computer, you know that there's a lot going on back there. There could be a dozen or so different types of connectors, including ones for power, video, audio, a keyboard and mouse, networking (such as Gigabit Ethernet), and other devices. Generally speaking, all of these connectors are connected to one of two things: the motherboard or an expansion card that's attached to the motherboard. I will talk about all of these in Chapter 2, "Peripherals and Connectors." For now, I offer you Figure 1.14, showing several connectors on the back panel.

FIGURE 1.14 Computer back panel



Front-Panel Connectors

Even though the front panel of the computer isn't as chaotic as the back panel, there's still a lot happening. The front of your computer might have one or more memory card readers or optical drives such as a DVD-ROM. It's kind of old-school to have these devices accessible from the front of your system. Years ago, you might have had 3½″ or even 5¼″ floppy drives on the front of your system too. (Google them!)

With the obsolescence of floppy drives, a lot more real estate opened up on the front of your computer. Computer manufacturers realized that accessibility was a big deal and started moving connectors that used to be found only on the backs of systems to the front. Now, your system will likely have most if not all of the following types of connectors on the front panel. All of them get connected to the motherboard in some fashion.

Power Button Having a *power button* in an easily accessible place seems kind of obvious, doesn't it? Well, they used to be on the back or side of computers too. Many times, your power button will also double as a power light, letting you know that the system is on.

Reset Button Reset buttons are hit-or-miss on computers today. The idea is that this button would reboot your computer from a cold startup without removing power from the components. The reset button is incredibly handy to have when a software application locks up your entire system. Because power is not completely lost, the reset button may not help if you had a memory issue.

Drive Activity Lights These little lights often look like circular platters (like a hard drive) or have a hard drive icon next to them. They let you know that your hard drive is working.

Audio Ports The front of most computers now has a port for headphones as well as a microphone. Long gone are the days where you had to put your computer in a certain spot on or under your desk, just so your short headphones cord could reach all the way to the back of the box.

Other Connectors Trying to get to the back of your computer to plug in a flash drive is about as convenient as ripping out the back seat of your car to get stuff out of the trunk. It might actually be faster just to remove your hard drive and give it to your friend so they can copy the files they need. (Okay, not really.) Fortunately, most new computers have one or more USB ports on the front of the box, in addition to FireWire, Thunderbolt, or external SATA (eSATA). Other systems will have memory card readers built into the front of the case as well. I will cover these different connectors in Chapter 2.

Real World Scenario

Motherboard, Revisited

At the beginning of this section, I gave you a description of a motherboard for sale.

> Asus X99-PRO/USB 3.1 Intel X99 Chipset Core i7 Socket R3 (LGA2011) ATX Motherboard, DDR4, PCI-E 3.0 x16, SATA/M.2 Socket 3, GBLAN, Wi-Fi/Bluetooth, USB

Now that you've learned about motherboards, let's translate the acronym string. Asus P99-PRO is the manufacturer and model of the motherboard, which supports Universal Serial Bus 3.1 (which I will talk about in Chapter 2). It has the Intel X99 chipset, supports the Intel Core i7 processor with an LGA 2011 CPU socket, and uses DDR4 RAM (which you will learn about in the "Memory" section later in this chapter). It has three PCIe ×16 slots, SATA/M.2 connectors, and supports gigabyte networking (GBLAN), Wi-Fi and Bluetooth, and USB.

Armed with this information, you can now compare motherboards to each other to determine which one has some of the features you are seeking!

Processors

The processor is the most important component on the motherboard. The role of the *central processing unit (CPU)* is to control and direct all the activities of the computer. Because of this role, the CPU often is called the brain of the computer. The analogy isn't perfect because the processor isn't capable of thinking independently. It just does what it's instructed to do, which is processing math. Still, the analogy of the processor as the computer's brain is close enough.

Processors are small silicon chips consisting of an array of *millions* of transistors. Intel and Advanced Micro Devices (AMD) are the two largest PC-compatible CPU manufacturers.

NOTE The terms *processor* and *CPU* are interchangeable.

CPUs are generally square, with contacts arranged in rows of pins. Older CPU sockets were in a configuration called a *pin grid array (PGA)*. The newer version uses a configuration called the *land grid array (LGA)*. LGA is sturdier than PGA because it has the pins in the socket versus on the processor, which results in less damage to processors from trying to insert them incorrectly into their sockets. Figure 1.15 shows an AMD processor.

FIGURE 1.15 AMD Athlon processor

As powerful as processors are, they don't look that impressive from the outside. Moreover, rarely will you see a processor without an accompanying heat-removal system. Your processor will have either a metal heat sink (it looks like rows of aluminum fins sticking up from it), a fan, or a combination of the two. Without a heat sink and/or fan, a modern processor would generate enough heat to destroy itself within a few seconds.

CPU Characteristics

The most important characteristic your processor can have is compatibility. Does it fit into your motherboard? Beyond this, there are literally dozens of different characteristics that CPUs have, such as hyperthreading and virtualization support. Most of those topics are beyond the scope of this book. Here, I'll focus on three key characteristics: architecture, speed, and cache.

Architecture

Three architecture-related terms with which you should be familiar are 32-bit, and 64-bit, and ARM. Processors that you find today will be labeled as 32-bit or 64-bit. What this refers to is the set of data lines between the CPU and the primary memory of the system; they can be 32- or 64-bits wide, among other widths. The wider the bus, the more data that can be processed per unit of time, and hence, the more work that can be performed. For true 64-bit CPUs, which have 64-bit internal registers and can run x64 versions of Microsoft operating systems, the external system data bus will always be 64-bits wide or some larger multiple thereof. You will find 32-bit and 64-bit processors designed for all types of computers, such as laptops, desktops, workstations, and servers. In today's world, though, using a 32-bit processor on a server would be a bit like entering a bicycle into a sports car race.

ARM (Advanced RISC Machines) refers to a type of processor that uses an architecture known as *reduced instruction set computing (RISC)*. That's in contrast to Intel's (and clones) x86 architecture, which employs *complex instruction set computing (CISC)*. Confused yet? Remember that processors do math. The differences between RISC and CISC is how the processors do the math and the instructions that the software needs to give them to do the math. Long story short, RISC processors may take more steps to do the same math problem than would a CISC processor. While that might sound inefficient and therefore slower, RISC processors have some advantages that compensate, eliminating most performance gaps. On the positive side, RISC processors can be made much smaller than their CISC cousins and produce less heat. The differences between RISC and CISC are way beyond the scope of the IT Fundamentals+ (ITF+) exam, but the context helps me explain these two key things that you *do* need know about ARM:

- ARM processors are made in both 32-bit and 64-bit versions, so you will find them in workstations and servers, albeit not very often.
- Because they can be made smaller and produce less heat, ARM processors are generally used in devices that are tablet-sized and smaller, like mobile phones. Roughly 90 percent of all small devices use ARM chips.

Another term that you will hear in terms of architecture is the number of cores a processor has. You might see something labeled dual-core, quad-core, or even 16-core. To keep making better and faster processors every year, manufacturers constantly have to find ways to increase the number of instructions a processor can handle per second. For the past several years, they've done it mostly by adding cores. Multicore means that the CPU is actually made up of several processors working in unison within the same package.

Speed

Hertz (Hz) are electrical cycles per second. Each time the internal clock of the processor completes a full cycle, a single Hz has passed. Back in 1981, IBM's first PC ran at 4.77 megahertz (MHz), which is 4.77 million cycles per second. Modern processors operate at billions (gigahertz, GHz) of cycles per second. For example, you might see a processor that runs at 3.5 GHz. Generally speaking, faster is better.

To save power during times when it's not busy, many CPUs can throttle down their speed to reduce the amount of energy used. CPU throttling is common in processors for mobile devices, where heat generation and system-battery drain are key issues of full power usage.

Cache

I already mentioned cache when discussing motherboards, but many of today's processors also include their own built-in cache. Cache is a quick form of memory that greatly speeds up the performance of your computer.

You'll see three different cache designations. Level 1 cache (*L1 cache*) is the smallest and fastest, and it's on the processor die itself. In other words, it's an integrated part of the manufacturing pattern that's used to stamp the processor pathways into the silicon chip. You can't get any closer to the processor than that.

While the definition of L1 cache has not changed much over the years, the same is not true for other cache levels. L2 and L3 cache used to be on the motherboard but now have moved on the die in most processors as well. The biggest differences are the speed and whether they are shared. L2 cache is larger but a little slower than L1 cache. For processors with multiple cores, each core will generally have its own dedicated L1 and L2 caches. A few processors share a common L2 cache among the cores. L3 cache is larger and slower than L1 or L2, and it is usually shared among all processor cores.

The typical increasing order of capacity and distance from the processor die is L1 cache, L2 cache, L3 cache, and RAM. This is also the typical decreasing order of speed. The following list includes representative capacities of these memory types. The cache capacities are for each core of the original Intel Core i7 processor. The RAM capacity is simply a modern example.

- **L1 cache:** 64 KB (32 KB each for data and instructions)
- **L2 cache:** 256 KB
- **L3 cache:** 4 MB–12 MB
- **RAM:** 4 GB–64 GB

CPU Functionality

I've talked a lot about the features of processors, but what is it that they really do? (To quote the movie *Office Space*, perhaps the other components look at the processor and ask, "What would you say you *do* here?") The short answer is: "math."

Processors are made up of millions of transistors, which are electrical gates that let power through or not depending on their current state. They're the basis of binary processing, that is, processing based on things being in one of two states: on or off, 1 or 0.

At their most basic level, all that computers understand is 1s and 0s; it's the processor's job to do math on strings of 1s and 0s. The math that it performs is based on what's known as an *instruction set*—rules on how to do the math. It accepts numbers as input, performs calculations on them, and delivers other numbers as output. How many numbers the processor can accept at a time varies. Earlier, I mentioned 32-bit versus 64-bit architecture. Processors with 64-bit architecture can accept more data at once, and as you can imagine, that can make them much faster than their 32-bit cousins.

Binary numbering is a bit unfamiliar to most people, because we're more accustomed to using the decimal numbering system (0–9). Exercise 1.1 will get you more familiar with the binary numbering system.

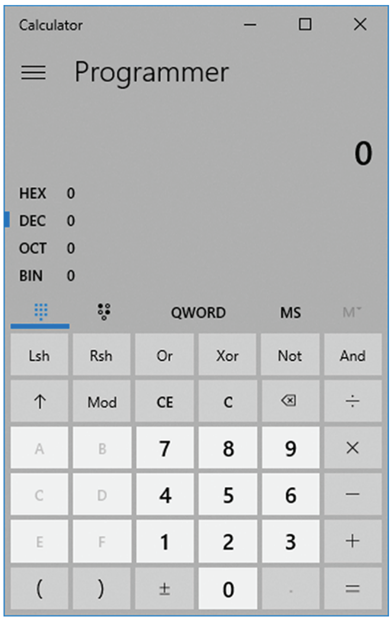
NOTE I'll talk a lot more about binary, decimal, and hexadecimal in Chapter 6, "Software Development."

EXERCISE 1.1

Converting Between Decimal and Other Numbering Systems

1. In Windows 10, open the Calculator application.
2. Click the Calculator menu button, and choose Programmer to switch to Programmer view, as shown in Figure 1.16. Notice on the left that there is a mark next to the DEC option because that is what's selected. DEC is short for Decimal.

FIGURE 1.16 Calculator in Programmer view



3. Enter the number **267**.
4. Notice that the calculator shows you the hexadecimal (HEX), decimal (DEC), octal (OCT), and binary (BIN) conversions of the number. If you have an older version of Calculator, you will need to click the radio buttons next to these options to perform the conversion. The number in binary is 100001011.