Official Cert Guide

Cisco Certified Support Technician (CCST)

IT Support 100-140

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Cisco Press

Cisco Certified Support Technician (CCST) IT Support 100-140 Official Cert Guide

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David Bayne has spent years teaching IT, both at the high school and community college levels, and has prepared hundreds of students for careers in IT. He holds CCNA and CompTIA A+ certifications, as well as a master's degree in educational technology. He currently teaches Internet of Things, drone programming, and inventing design courses. When David is not teaching, he reads (mostly mysteries and sci-fi) and spends time with family. He lives near Sacramento, California, with his wife and daughters and their three cats.

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Scott Stephenson was born and raised in Texas, where he has spent his entire career as a public education teacher. He has taught for the Cisco Networking Academy for 25 years and has been an instructor trainer for the past 11 years. He was recognized by the Cisco Academy as the National Instructor of the Year in 2007. He holds a bachelor's degree in music education and a master's degree in management information systems and a master's degree in educational leadership. He holds 27 technology certifications and 7 teaching certifications. He has worked on projects from the National Science Foundation and the Department of Labor as an information and communication technology curriculum writer. He retired in 2016 after 30 years in public education but continues to lecture, teach, and work with instructors to help inspire and enrich the lives of young people. He now spends time traveling the world and teaching for several Cisco Networking Academy Instructor Training Centers.

Dedications

Mark Smith: I'd like to dedicate this book to my wife, my partner, my friend, Michelle. You have been a huge support for me in both my professional and personal endeavors. Thank you.

I would also like to dedicate this book to my three incredible children: Cheyenne, Sage, and Skyler. I am immensely proud of the incredible humans you have all become! I love you and thank you for being who you are. Now call and visit more often!

David Bayne: I'd like to dedicate this book to my mom, who was a great supporter of me broadening my horizons to even write the book but who unfortunately didn't make it to see the book in print. To my aunt Elaine, who has been an unwavering supporter throughout my teaching career, and to my wife, Karen, who put up with my being away for long hours writing and editing. Thanks for all the support!

John Pickard: This book is dedicated to my beloved wife, Lisa, whose unwavering patience and support carried me through the long hours of work over many years. Her understanding and love have been my foundation. I also dedicate this to my father, whose enduring belief in the power of persistence inspired me to push beyond my limits. Your guidance and encouragement have shaped me into who I am today.

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David Bayne:

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John Pickard:

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Contents at a Glance

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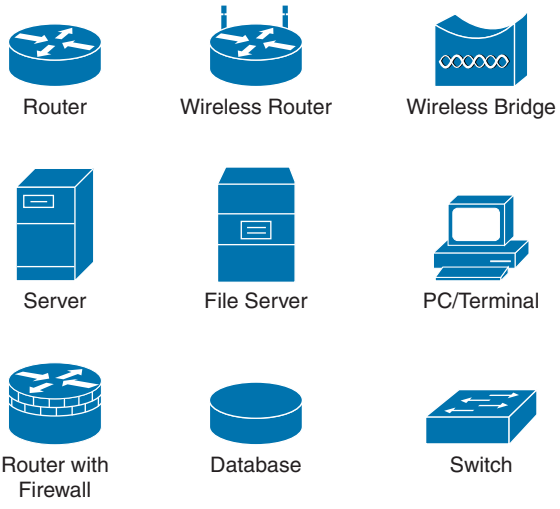

Command Syntax Conventions

The conventions used to present command syntax in this book are the same conventions used in the IOS Command Reference. The Command Reference describes these conventions as follows:

- **Boldface** indicates commands and keywords that are entered literally as shown. In actual configuration examples and output (not general command syntax), boldface indicates commands that are manually input by the user (such as a **show** command).
- *Italic* indicates arguments for which you supply actual values.
- Vertical bars (|) separate alternative, mutually exclusive elements.
- Square brackets ([ ]) indicate an optional element.
- Braces ({ }) indicate a required choice.
- Braces within brackets ([{ }]) indicate a required choice within an optional element.

Introduction

Congratulations! If you are reading this introduction, then you have probably decided that a career as an IT support technician is an important first step for your future success, and obtaining the CCST IT Support certification will prove that you have a solid understanding of help desk–related topics and concepts.

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

This book was written to help up-and-coming IT professionals build a solid foundational understanding of what it takes to be an IT support technician. It is structured specifically to prepare candidates for the Cisco Certified Support Technician (CCST) IT Support 100-140 exam but aims to equip you with knowledge that will stay useful long after you earn the certification.

Goals and Methods

The most important and somewhat obvious goal of this book is to help you pass the CCST IT Support (100-140) exam. While this book has more than enough questions to help you prepare for the actual exam, the goal isn't to have you simply memorize as many questions and answers as you possibly can.

One key methodology used in this book is to help you discover the exam topics that you need to review in more depth, to help you fully understand and remember those details, and to help you prove to yourself that you have retained your knowledge of those topics. This book does not try to help you pass by memorization but helps you truly learn and understand the topics. The knowledge the CCST IT Support exam covers is vital for any IT support professional. This book would do you a disservice if it didn't attempt to help you learn the material. To that end, the book will help you pass the CCST IT Support exam by using the following methods:

- Helping you discover which test topics you have not mastered
- Providing explanations and information to fill in your knowledge gaps
- Providing practice exercises on the topics and the testing process

Who Should Read This Book?

This book is geared toward new IT professionals and those with an interest in becoming IT support technicians; however, veteran IT professionals just getting into the help desk or needing to obtain the certification will benefit as well. Although other objectives can be achieved from using this book, the book is written with one goal in mind: to help you pass the exam.

So why should you want to pass the CCST IT Support exam? Earning the certification validates your understanding of core IT support concepts and techniques. Furthermore, the CCST IT Support certification will serve as a springboard to more advanced certifications down the road. Many of the concepts and themes we introduce here are practically universal in IT Support exams.

Strategies for Exam Preparation

The strategy you use for CCST IT Support might be slightly different than strategies used by other readers, mainly based on the skills, knowledge, and experience you already have obtained. For instance, if you already have familiarity with help desk and other IT Support concepts and techniques, your approach will likely differ from someone who's brand new and does not have any prior knowledge.

Regardless of the strategy you use or the background you have, the book is designed to help you get to the point where you can pass the exam with the least amount of time required. For instance, there is no need for you to practice or read about IPv6 addresses or Active Directory if you fully understand it already. However, many people like to make sure that they truly know a topic and thus read over material that they already know. Several book features will help you gain the confidence that you need to be convinced that you know some material already, and to also help you know what topics you need to study more.

How This Book Is Organized

Although this book could be read cover-to-cover, it is designed to be flexible and allow you to easily move between chapters and sections of chapters to cover just the material that you need more work with. Chapters 1 through 8 are the core chapters and can be covered in any order. If you do intend to read them all, the order in the book is an excellent sequence to use.

The core chapters, Chapters 1 through 8, cover the following topics:

- **Chapter 1, "Help Desk":** This chapter covers the essential functions and skills required in a modern IT help desk, starting by examining the IT support technician's roles and responsibilities. Key customer service communication skills are discussed, highlighting the importance of clear interactions. The chapter covers time management and explores queue management techniques, including triage processes and technologies. It also details the role of service-level agreements (SLAs) in maintaining standards, key performance indicators (KPIs) for measuring success, and the functionality of ticketing systems. Best practices for documentation and an eight-step problem-solving process are also introduced.
- **Chapter 2, "Hardware":** This chapter discusses IT safety; computer ports and interfaces; how to identify, install, and upgrade computer components; and common hardware/peripheral issues.
- **Chapter 3, "Networking and Network Connectivity":** This chapter discusses networking, where students locate basic network information, basic end-to-end network connectivity and testing, and authentication to secure network connection.

- **Chapter 4, "Windows OS":** This chapter covers common Windows operating system issues and how to resolve them. It covers the installation and repair of collaboration and productivity software. It also discusses Windows system and security tools, including Active Directory. Finally, it goes over how to map drives in Windows to simplify management.
- **Chapter 5, "macOS":** This chapter discusses macOS. It covers important system tools as well as built-in security tools and provides a brief history of how macOS came to be.
- **Chapter 6, "Virtualization, Cloud, and Remote Access":** This chapter explores the critical roles of virtualization, cloud computing, and remote access in modern IT environments. It covers the basics of cloud computing, its benefits, and major providers. The chapter also explains cloud service models (SaaS, PaaS, IaaS) and deployment options (public, private, hybrid, community), comparing cloud computing to on-premise data centers. Virtualization is introduced, detailing hypervisors and virtual machines, and how it integrates with software-defined networking (SDN). Finally, the chapter covers remote access tools.
- **Chapter 7, "Security":** This chapter introduces fundamental cybersecurity concepts. This includes security threats and security threat mitigation. The chapter looks at who is behind security threats and the common types of threats that the IT professional will often encounter.
- **Chapter 8, "The IT Professional":** IT support technicians need to practice professionalism, follow company policies, and support confidentiality. They also must be able to use remote access tools while troubleshooting. In addition, they must be able to research issues their users are seeing and document the solutions they implement. Finally, in this chapter, we revisit the troubleshooting process.

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NOTE After you register your book, your code can always be found in your account under the Registered Products tab.

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Step 2. Click the **Practice Exams** button.

Step 3. Follow the instructions listed there for both installing the desktop app and using the web app.

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CHAPTER 2

Hardware

This chapter covers the following topics:

- **Safety:** This section explores physical and environmental safety of hardware as well as individual safety.
- **Ports and Interfaces:** The section describes various ports and interfaces used for video as well as data communication.
- **Identifying, Installing, and Upgrading Computer Components:** This section explores key computer components, their functions, as well as basic installation tips and upgrading guidelines.
- **Hardware and Peripheral Issues:** This section details some common troubleshooting tips and issues you might encounter with hardware and peripheral devices.

This chapter covers the basics of computer hardware and topics related to computer hardware. Safety, ports and interfaces, computer components, and common hardware/peripheral issues are all covered in this chapter. While it would take an entire book to cover the breadth of computer hardware, this chapter will help give you an overview as well as prepare you for certification.

The chapter covers information related to the following Cisco Certified Support Technician (CCST) IT Support exam objectives:

- 2.1 Demonstrate how to follow basic safety procedures.
- 2.3 Assist end users in locating, identifying, and understanding the characteristics of various ports and cables.
- 2.4 Identify, install and upgrade various components in a desktop computer.
- 2.5 Investigate commonly encountered hardware issues.
- 3.2 Troubleshoot commonly encountered connectivity issues with peripherals.

"Do I Know This Already?" Quiz

The "Do I Know This Already?" quiz allows you to assess whether you should read this entire chapter thoroughly or jump to the "Exam Preparation Tasks" section. If you are in doubt about your answers to these questions or your own assessment of your knowledge of the topics, read the entire chapter. Table 2-1 lists the major headings in this chapter and their corresponding "Do I Know This Already?" quiz questions. You can find the answers in Appendix A, "Answers to the 'Do I Know This Already?' Quizzes."

Table 2-1 "Do I Know This Already?" Section-to-Question Mapping

Foundation Topics Section	Questions
Safety	1–3
Ports and Interfaces	4–6
Identifying, Installing, and Upgrading Computer Components	7–9
Hardware and Peripheral Issues	10

CAUTION The goal of self-assessment is to gauge your mastery of the topics in this chapter. If you do not know the answer to a question or are only partially sure of the answer, you should mark that question as wrong for purposes of the self-assessment. Giving yourself credit for an answer you correctly guess skews your self-assessment results and might provide you with a false sense of security.

1. What is the minimum number of volts of static electricity that can harm computer components?
   - **a.** 30 volts
   - **b.** 100 volts
   - **c.** 3,000 volts
   - **d.** 5,000 volts
2. What is the acronym to help you remember how to use a fire extinguisher?
   - **a.** P.A.S.T.
   - **b.** A.I.M.M.
   - **c.** P.A.S.S.
   - **d.** C.L.E.A.R.
3. What is the study of engineering and designing of products and systems to help people called?
   - **a.** Kinesiology
   - **b.** Applied biomechanics
   - **c.** Physiology
   - **d.** Ergonomics
4. What video port is not considered high definition and carries only an analog port?
   - **a.** VGA
   - **b.** DVI-D
   - **c.** HDMI
   - **d.** DisplayPort
5. What USB form factor is capable of carrying audio, video, and power?
   - **a.** USB-A
   - **b.** USB-B

c. USB-C

d. Micro-USB

6. What is the most common connector for an Ethernet cable?

a. RJ-11

b. RJ-45

c. BNC

d. LC-ST

7. What computer component is known as the brain of the computer?

a. Processor

b. Chipset

c. Motherboard

d. RAM

8. What storage device doesn't need external power and data cables?

a. Hard drive

b. SSD

c. Optical drive

d. M.2

9. What three computer components must be compatible with each other?

a. CPU, motherboard, storage device

b. CPU, motherboard, RAM

c. Motherboard, power supply, chipset

d. Motherboard, RAM, storage device

10. If a certain piece of software is not installing, what could be a probable cause?

a. The software is 64-bit and trying to be installed on a 32-bit operating system.

b. The software is incompatible with the storage device.

c. The computer has too much RAM for the software to function properly.

d. The computer is lacking an optical drive.

Foundation Topics

Safety

Lots of jobs require safety training and require their employees to be mindful of best safety practices. For instance, a mechanic should know the dangers of working on an engine. Likewise, an electrician should know the dangers of working with electricity. This is true with the IT support technician as well. Safety to the individual as well as safety to the parts you work on is vital to understand.

Electrical Shock

Key Topic

Electrical shock occurs when uncontrolled electricity flows through your body. This electrical flow can range from the tingle of a 9-volt battery on your tongue—an old, not advisable way people would test 9-volt batteries to see if they were still good—to severe injury and even death. There is an adage that states, "amps kill, not volts."

NOTE This is an overly simplistic deduction of Ohm's law because you can't have amps without volts, but it does help answer why touching a plasma globe doesn't instantly kill you (higher volts and lower amps).

As shown in Figure 2-1, **Ohm's law** states W = VA or Watts = Volts × Amps.

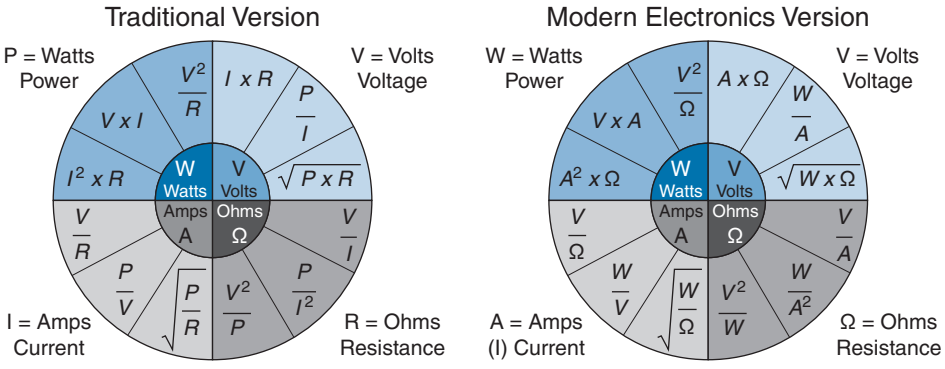

Figure 2-1 *Ohm's Law*

In a reductionist method of describing electricity, the water hose analogy is often used. **Amps**, or current, is often described as the volume of water moving through the water hose, and **volts**, or voltage, is the water pressure. Notice, you can't have one without the other. However, this analogy helps you have a basic understanding that amps are the amount of electricity and consequently what can cause serious harm. You don't need a degree in electrical engineering to be an IT support technician, but it is a good idea to have a basic understanding of electricity so as not to harm yourself.

There is one component that an IT support technician needs to be especially careful around: this is a computer's power supply unit, or **PSU**. Unless specifically trained, you should never open a PSU to fix it. A damaged PSU should be sent back to the factory for repair because they have capacitors in them that hold lethal electrical charge—even after unplugged! This holds true with monitors as well. Never open a monitor for the same reason.

You should be aware of these specific electrical shock hazards when working in IT:

- **Damaged cords and equipment:** Exposed or frayed wires on cords or inside equipment can be a shock hazard.
- **Improperly grounded equipment:** Most surge protectors will help with this, but you should make sure the grounded light is illuminated. Equipment plugged directly into the wall should have the third grounding pin utilized if applicable in your country, as well as the receptacle unless using a two-prong "double insulated" type.
- **Working on live equipment:** For the most part, don't do this unless you know there is zero risk of electrical shock.
- **Liquids:** Water conducts electricity, so keep liquids away from electrical components that are not waterproofed.

Safety tips to minimize electrical shock:

- Do inspect cords and equipment for damage.
- Don't overload power strips/surge protectors and don't daisy-chain them either (plugging one into another one).
- Don't work on electrical equipment while it's plugged in or on.
- Don't eat or drink near electrical equipment.
- Do look around your surroundings to look for potential electrical hazards; be aware.

ESD

Remember shuffling your feet on carpet and touching your friends to give them a shock of static electricity? You were, in fact, giving them electrostatic discharge, or **ESD**. ESD is the releasing of that static electricity. What might seem as harmless fun between two people can be extremely damaging to computer components. Hard drives, solid-state drives, RAM, graphic cards, and motherboards are especially sensitive to static electricity. Basically, any component that has electronic chips and/or memory modules is susceptible to ESD damage. While the results aren't always instantaneous damage, it can be cumulative and ultimately destroy the device.

To go back to the example of "shocking" your friend, it takes over 3,000 volts for a regular person to feel ESD. Ever hear or see the spark of static electricity when, say, touching a doorknob? That's over 5,000+ volts! As previously covered in this chapter, the reason it doesn't kill us is that the amps are very low. Unfortunately, computer components can be damaged with as little as 30 volts. If you're working on sensitive computer components—say, replacing a motherboard—and you feel ESD, there's a good chance you have already done irreversible damage to that part. There are many videos circulating online that try to refute the claim that ESD can cause damage to computer components. It can.

ESD prevention tips:

- Don't work on computer components while standing on carpet (or rugs) unless the carpet/rug has been specifically treated for ESD.
- Don't work on computer components under blowing air from an HVAC system or similar because it can increase static electricity.
- Don't wear wool or synthetic fabrics that can conduct static electricity.
- Don't wear metal jewelry when working on computer components.
- Do adjust the humidity in your room if at all possible—under 40 percent humidity increases static electricity while over 55 percent can cause moisture damage, so try to aim between 45 and 55 percent humidity if at all possible.
- Do store sensitive computer components in antistatic bags (remember the inside of the bag helps reduce static electricity, not the outside; so don't place your motherboard on top of that antistatic bag to work on it).
- Do use an antistatic mat to place your parts on.
- Do wear an antistatic wrist strap.

A note on antistatic wrist straps: these are invaluable tools for the IT support technician. One connects the wrist strap to one hand—usually your nondominant hand so it doesn't cross in front of your work path as often—and the other end, usually with an alligator clip, to the metal chassis of the computer case if you're working on that. There is a misnomer that this process "grounds" you. That is not really the case. Rather, it's important to remember that electricity flows between positive and negative or negative and positive. The antistatic wrist strap equalizes the charge between you and the component you're working on, thus eliminating the flow or discharge of the static electricity. This is why it is important to place the alligator clip to something, ideally metal, near the component you're working on—to help dissipate the electrostatic charge. It is not advisable to clip on to the power supply, because if the alligator clip were to inadvertently touch any of the internal components of the power supply, it could send a dangerous volt to you.

Fire Safety

Fire safety is important in every industry and should be important to every individual as well. Far too many people have had their kitchens burned down from a fire on the stove. Unfortunately, that scenario often goes like this: John heats up a pan of oil to make some fries. The pan catches on fire from the oil heating up too much. Panicked, John sees his kitchen faucet nearby and rushes the flaming pan under the water to put out the fire. Oil and water do not mix. The water displaces the flaming oil and sends shooting, flaming oil all over his kitchen. Don't be John; learn fire types and the proper ways to stop those fire types.

Figure 2-2 depicts the common classes of fires.

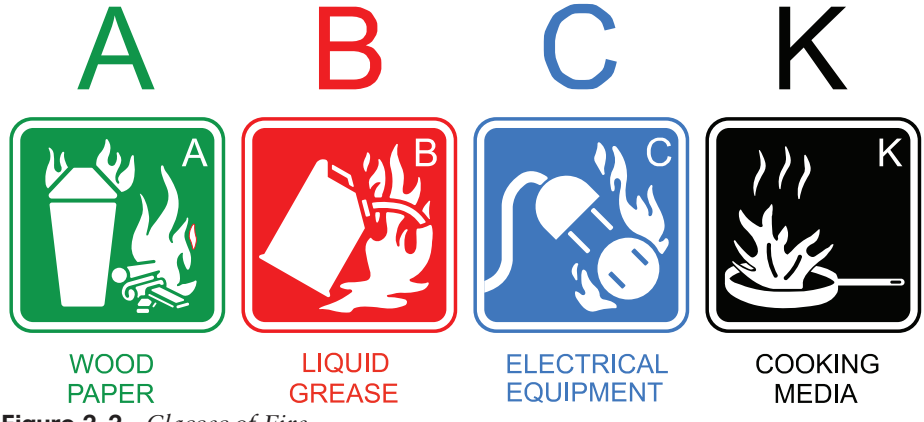

Figure 2-2 *Classes of Fire*

Every home and business should have at least one ABC fire extinguisher within easy access—more than one if in a larger area. An ABC fire extinguisher will put out type A, B, and C classes of fires listed in Figure 2-2. If you're working in a specialty industry, such as a restaurant, then a Class K, specifically for grease/oil fires, would be beneficial as well. In IT, you might deal with a wood or paper fire, which a Class A fire extinguisher would work on, but you might also deal with an electrical fire. Again, water is conductive, so you would not want to put out an electrical fire with water. Instead, a typical ABC fire extinguisher, because of the Class C in particular, will be able to put out most electrical fires.

A note on fire extinguishers: fire extinguishers do not last forever. The propellant inside of them dissipates over time. This is why it is critical to have them checked annually (or sooner) or replaced. While most fire extinguishers have a gauge that reads green for good and red for bad, it is not recommended to rely on this gauge alone. Fire extinguishers should be serviced by a reputable company. It is good advice to contact your local fire agency to see if there is an opportunity to learn fire safety and use a fire extinguisher before an emergency.

To use a fire extinguisher, remember the acronym **P.A.S.S.**:

Key Topic

- **P** is for pull the pin on the fire extinguisher. While this might seem obvious, in the heat of the moment, people often forget.
- **A** is for aim. Aim the nozzle to the base of the fire to smother it. It is human nature to aim at the top of the flames because that is what you see. Resist that urge and aim at the base to smother the source/fuel of the fire.
- **S** is for squeeze. Squeeze the trigger slowly and evenly so as to not use all of the extinguishing agents too quickly.
- **S** is for sweep. Whiling aiming at the base of the fire, sweep the nozzle from side to side to make sure to cover as much of the base of the flames as possible.

If applicable, call your local emergency services before the fire is too large for you to put out or after if you are afraid there might still be hot spots.

Prevention of fires is of utmost importance to the IT support technician. The first step is to reduce fire hazards in your workplace. Keep your workplace free of clutter: don't stockpile papers, wires, and other combustible material to reduce the risks of something catching fire. Regularly inspect equipment for damaged cords, overheating components, and overloaded power strips/surge protectors. Have a fire safety plan in your workplace and schedule regular checks of your fire alarms to make sure they are working.

Personal Safety

While the standard IT support technician might not be breathing in dangerous chemicals or working with highly explosive materials in normal working conditions, that doesn't mean there aren't personal safety issues to consider. One major threat to IT technicians is online safety. Often, it is the IT staff who are targeted by **threat actors** to gain access to a network/computer system. However, that topic will be covered in more depth in Chapter 7, "Security."

Key Topic

Another often-overlooked risk to the IT support technician is physical safety. One area of focus in recent decades has been on repetitive strain injuries, or **RSI**s. You will often be working long hours at a desk typing on your keyboard and clicking away with your mouse. Carpal tunnel syndrome is a very real condition that affects many office workers and involves pinching the nerve in your wrist. It is a condition that often causes pain in the hand and wrist. This condition occurs because of the repetitive motion of typing and using your mouse. To help prevent carpal tunnel, take breaks from your computer when at all possible—stand up, stretch, hydrate, and move your body. Another prevention technique is the use of ergonomic devices.

Key Topic

Ergonomics is the study of engineering and designing of products and systems to help people. This can be as simple as chairs to help promote better posture when sitting at a desk, the rise of adjustable desks to allow for standing and working, mouse pads with wrist guards to

help the posturing of your hand, and even keyboards to help your hands be in a more natural position when typing.

Figure 2-3 shows an example of an ergonomic keyboard.

Figure 2-3 *Ergonomic Keyboard*

In addition to RSIs, injuring yourself lifting is also a possible safety risk. You might often be tasked with moving around heavy pieces of equipment. Even lighter equipment can pose a risk of injury if not carried or placed correctly. Use a dolly or moving cart when at all possible. If you must lift an object, use your legs and don't pull up with your back muscles. Ask for help if a piece of equipment needs more than one person to move it.

In addition to injuring yourself physically through moving a heavy object or getting an RSI, you also need to be careful not to be the target of a physical attack. You will often be working alone or late at night. You might be transporting valuable IT equipment from one office to another. This makes you a target for a would-be thief. Be aware of your surroundings and communicate with your colleagues about when and where you're at if it could be a risky situation.

Finally, maintain a healthy lifestyle. Drink plenty of water, eat a balanced diet, take breaks from the computer (in accordance with your company policy), use blue light filters on your monitor to help prevent eyestrain (most operating systems, including phones, have a "night light" feature to help reduce harmful blue light), and get sleep.

"An ounce of prevention is worth a pound of cure."—Benjamin Franklin

Ports and Interfaces

Key Topic

One commonly confused concept in IT is the difference between an interface and a port. You will often hear these terms used interchangeably, but there is a difference. An **interface** is how a device communicates. For example, a mouse is a hardware interface. In particular, it is an input interface. The mouse lets the user send x and y coordinates to the operating

system to move the cursor around the screen. Consequently, the mouse is a hardware interface that is also an input interface. How it connects to the computer is through a port.

NOTE You will often hear terms like an *input* or *output device*. You need to think of it from the perspective of the computer itself. If the information is going into the computer, it is an input device. If the information is going out of the computer, it is an output device. Common input devices are mice, keyboards, scanners, and the like. Common output devices are monitors, speakers, printers, and so forth. If you have an all-in-one printer, then you have an **input/output device**. The printer is an output device, but the scanner is an input device.

The mouse also communicates with a software interface called a driver. The **driver** is software that translates the raw input from the hardware to the operating system. It can also translate output from the operating system to the hardware (think of an image being displayed on your monitor).

Key Topic

A **port** is often the physical connection to the computer. Most mice in the past decade are USB. The USB is the port that the mouse uses to connect to the computer. The physical port is what transfers the electrical signals back and forth. To clarify, the mouse is a hardware input interface that sends x and y coordinates to the operating system through the software interface of a driver so that the operating system can understand the data being fed to it. The mouse itself is plugged into a USB port. The USB port itself is capable of inputting and outputting data—think of a flash drive—but is only inputting data from the mouse.

NOTE When talking about hardware, we usually speak of physical ports—an actual electrical part you can touch. However, there are virtual ports as well. For example, when you go on the Web and search a vital question like what music artist said what to whom, you are often using Hypertext Transfer Protocol Secure, or https, which uses port 443. Port 443 is a virtual port for https communication. You can't physically touch the port.

A wireless card, or wireless NIC, is a physical port, not a virtual port. While you don't plug anything into it, you could touch the actual chip that is sending and receiving radio waves to communicate.

Video Ports

Video ports are just what they sound like—ports that output video. Before we delve into the various video ports every IT technician should know, it is important to know the difference between analog and digital video signals. An analog video signal is presented in a waveform, whereas a digital video signal is discrete binary bits of 0 or 1 (see Figure 2-4).

Binary is how computers function and dates back to early circuits. A circuit was either open, or off (0), or it was closed, or on (1). If you look on a PSU, you will see a switch with a 0 and a 1. Zero means off, and one means on. Early video ports were analog, so if the monitor received analog signals, the computer would have to convert from binary to analog for the monitor to understand it. Today, most monitors are digital, so the move from analog to digital makes sense.

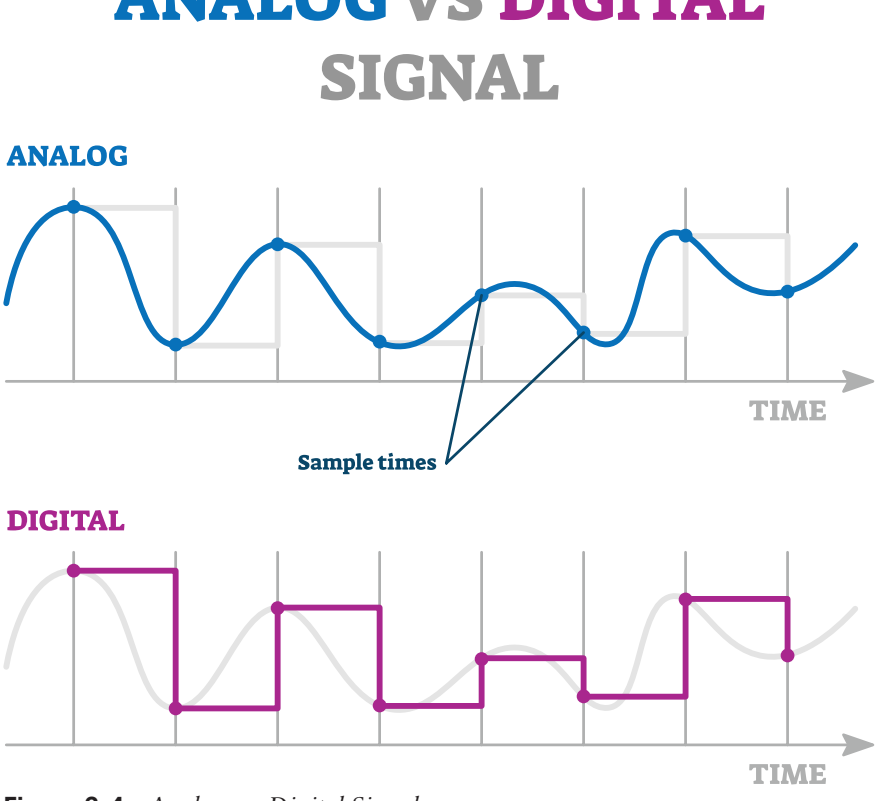

Figure 2-4 *Analog vs. Digital Signal*

NOTE Consumers have been inundated with various technical/marketing terms for their televisions for the past two decades. Terms such as *HD*, *Full HD*, *UHD*, and now *8k*—not to mention *QLED*, *OLED*, and so forth—have saturated the marketplace. While the latter is beyond the scope of this certification, you should know the former. *HD* stands for high definition and is 1280×720 pixels. A **pixel** is merely a single dot of color on a screen. So, HD is 1280 pixels horizontally and 720 pixels vertically. Interestingly, display resolutions for HD and FHD are often referred to as the vertical pixels rather than the horizontal pixels; hence, HD is often called *720(p)*. The *p* stands for progressive because it allows the television to display all lines at once rather than interlaced, which writes odd lines on the first pass and even lines on the second pass. *Full HD* is 1920×1080, 1080(p), or (i); *UHD* is 3840×2160, or 4k; and now we're seeing 7680×4320, or 8k! While these resolutions are more specific to televisions, you will see them marketed in computer monitors as well. One more common monitor resolution that never really came to television is 2k, or 2560×1440, and often called *1440p*. This does not mean all computer monitors follow these resolutions. In fact, many laptops have a 4:3 aspect ratio—making it more square than rectangular—and will have very different resolutions. Today, most of these HD resolutions are digital in port communication, with the one major exception of the aging component port, which is an analog port that is capable of HD resolution.

HDMI

Key Topic

High-Definition Multimedia Interface, or **HDMI**, ports are one of the most common video ports for both televisions and monitors. It is a digital port consisting of 19 pins that can transmit both audio *and* video. With the introduction of the HDMI 2.1 standard, an HDMI 2.1 port can support 4k, 5k, 8k, and 10k at 120 Hz and 48 gigabits per second (Gbps) of bandwidth/data. This is a huge improvement from the previous HDMI standard, which could only support up to 4k at 60 Hz. The two most common HDMI ports are standard (Type A) and Mini (Type C, not to be confused with USB C). See Figure 2-5.

Figure 2-5 *Mini HDMI (on Left) and Standard HDMI (on Right)*

NOTE *Hz* stands for hertz and is the number of times a screen refreshes, or is redrawn, in one second. The official 4k standard for television is 4k at 60 Hz. Gamers will often speak about achieving the maximum frames per second, or fps, when playing video games. This is a direct relation to how often the graphics card can refresh the screen and thereby has a correlation to the hertz of the monitor. For example, if a gamer is receiving stats from the game stating they are playing at 120 fps, but they are using an older HDMI port that is capable of displaying only 60 Hz, then they are only seeing 60 fps on their monitor even if their video card is capable of displaying more. This is why many "gaming" monitors sold use DisplayPorts because it is capable of displaying more hertz.

DisplayPort

Key Topic

DisplayPort is a popular digital, 20-pin, video port that many gamers prefer over HDMI. It supports both video and audio like HDMI. While it has never really gained traction in the television space, it is fairly common on modern video cards and monitors. It can output, on the high end, 8k at 240 Hz with 77.37 Gbps of bandwidth/data! For some, it is easy to confuse a DisplayPort and an HDMI port because one side looks identical to the other. However, a DisplayPort has a flat end on one side. There is also a mini DisplayPort that looks quite different. See Figure 2-6.

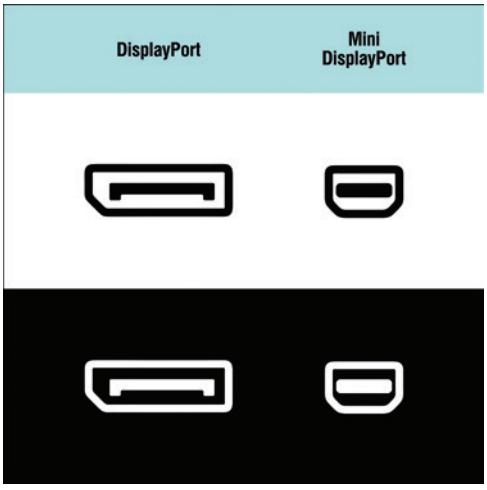

Figure 2-6 *DisplayPort and Mini DisplayPort Illustration*

DVI

Key Topic

A **DVI** is an older 24-pin port that can be both digital and analog and carries only video and *not* audio. Unfortunately, marketing of this port made it more confusing for consumers. There are several variations of DVI: DVI-D Single Link, DVI-D Dual Link, DVI-I Single Link, DVI-I Dual Link, and DVI-A. DVI-A was pure analog and is not used anymore. However, you will still see DVI-D and DVI-I in some older computers. DVI-D is a pure digital connection. It is capable of a max resolution of 3840×2400 at 30 Hz in Dual Link. You will still see people use DVI-D today because it can display 1080p at 144 Hz, but you would have to have a separate audio cable. See Figure 2-7 to see what a DVI-D looks like.

Figure 2-7 *DVI-D Cable*

DVI-I is another port you might still see. It is capable of carrying an analog and a digital signal on separate pins. It does not convert digital to analog signals or vice versa. Rather, it can pass through analog signals on certain pins and digital signals on other pins. This is

important because you can't plug a DVI-A or DVI-I cable into a DVI-D port, but you can plug a DVI-D cable into a DVI-I port. See Figure 2-8 to see a DVI-I port. Notice the cross formation with four dots around it. Those four dots are for analog signals.

Figure 2-8 *DVI-I Port*

VGA

Key Topic

A **VGA** cable is a 15-pin analog port. It does not carry audio signals much like DVI. VGA is one of the original video ports. While it can display up to 2048×1536 at 85 Hz, it is *not* considered a high-definition port. This means you can display 1920×1080 at 60 Hz, but it will be an analog signal and HD is a digital signal. Component ports are the only analog ports that are capable of being called HD because they still carry a digital signal over the analog communication. VGA would have to convert the digital signal to analog and, consequently, is not labeled as true HD. In fact, if you were to compare an HDMI display at 1920×1080 to a VGA display at 1920×1080, you would notice that the VGA display is fuzzier and not as crisp. VGA cables are often blue (see Figure 2-9) but can come in other colors.

Figure 2-9 *Traditional Blue VGA Cable*

USB-C

USB-C can carry audio and video. However, it can do more than that. USB-C, while a port, is also a form factor. This means that it's one of the more complicated concepts for consumers. See the subsection "USB-C" later for more information.

USB

Universal Serial Bus, or **USB**, is a common port type found in most computers today. By design, it can transmit both power and data. The *serial* in its name is an important distinction because it is an evolution of the original 9-pin **serial port**, also called an RS-232 port. While serial ports have all but disappeared from modern computers, they are still in use in industrial control systems and commercial routers and switches. While serial ports are slow in data transfer and do not support power over their wires like USB, they are reliable and easily programmed. Luckily, while most modern computers do not include serial ports anymore, there are many serial-to-USB adapters on the market to communicate with serial port devices. Some people confuse serial ports with VGA ports because of the similar external design, but there are two ways to identify them easily. First, serial ports have only 9 pins, whereas VGA ports have 15 pins. Also, most serial ports are male (pins sticking out), whereas most VGA ports are female (holes for the male pins on the cable to plug in to). In other words, serial ports are male and their cables are female, whereas VGA ports are female and their cables are male. See Figure 2-10 to see a serial port next to a VGA port on the rear input/output panel of a motherboard.

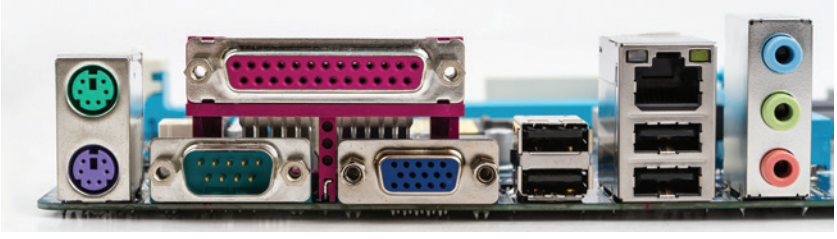

Figure 2-10 *Directly Below the Large Pink Parallel Port Is a Serial Port (Left) and a Blue VGA Port (Right)*

USB speeds have dramatically improved over the years. The first USB version, USB 1.0, was capable of 1.5 megabits per second (Mbps); USB 1.1, 12 Mbps; USB 2.0, 480 Mbps; USB 3.0, 5 gigabits per second (Gbps); USB 3.1, 10 Gbps; USB 3.2, 20 Gbps; USB 4, 40 Gbps; and USB 4 2.0, 80 Gbps.

USB Form Factors

Key Topic

In addition to the different USB versions, which primarily affect speed, there are also different **USB form factors**. Consequently, USBs can look different from each other. Traditionally, when most consumers think USB, they are thinking of USB-A. This is the original rectangular port that has a singular orientation, which means you can only plug it in one way. USB-B is more square and has been traditionally used to connect to printers and is now a popular connection to 3D printers. Mini-USB was a popular standard for phones and portable electronic devices for some time before micro-USB replaced it. Both are singular orientation, and the plug can only be plugged in one way. The newer form factor that has been gaining rapid momentum is USB-C. USB-C is not singular orientation and can be plugged in right side up or upside down. It is now becoming common on most electronic devices, including phones. In addition to the ease of plugging in, there are a multitude of other benefits to USB-C. See the following section for more information. Figure 2-11 helps you visualize the different USB form factors.

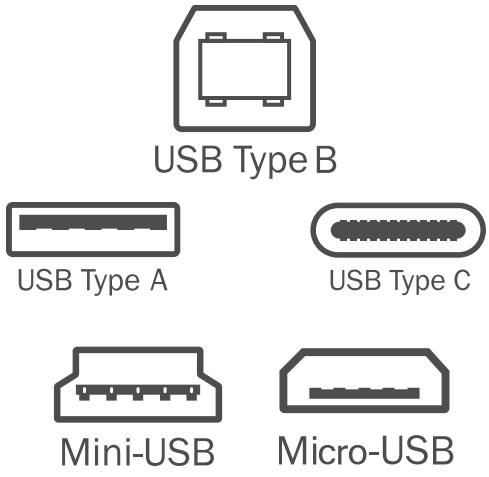

Figure 2-11 *USB Form Factors*

USB-C

Key Topic

USB-C is fast becoming the most ubiquitous of USB form factors. It is also one of the more complicated form factors. By definition, USB-C can carry data and power like the original USB standard. It is now being used as the favored port to power many laptops out there. However, it is also capable of carrying video and audio. Its bidirectional method of plugging in—so you don't have to worry about which side is up—and smaller footprint have made this a prolific form factor. However, the capabilities of USB-C vary wildly and depend on the actual interface technology being used behind the form factor.

USB 3.0, capable of 5 Gbps, can be a USB Type A or USB Type C form factor. USB 3.1, capable of 10 Gbps, can also be Type A or C. However, USB 3.2 is almost exclusively USB Type C, which is capable of 20 Gbps. How do you know which USB type your USB-C port is? Read the documentation for the specific electronic component that has the USB-C connection.

To add to the complexity, USB 4 is often called **Thunderbolt**, but technically Thunderbolt 3/4 is one **proprietary** implementation of USB 3.1/4 capable of 40 Gbps. Non-Thunderbolt USB 4 is only capable of 20 Gbps. Thunderbolt 5 uses USB-C as well and is capable of 80 Gbps. So, all Thunderbolt 3/4/5 interfaces are USB-C ports, but not all USB-C ports are Thunderbolt. Again, how do you know if you have a regular USB-C port or a Thunderbolt USB-C port? Read the documentation or look for the proprietary lightning bolt icon next to the port. See Figure 2-12.

Ethernet Ports

The most common interface for an Ethernet port is an **RJ-45** connector (see Figure 2-13) plugged into a network interface card (NIC). The Ethernet port on the NIC is what you would use to physically connect the Ethernet cable to the Internet or local network. If you connect wirelessly, you use a wireless NIC, and no physical cable is needed. There are also fiber connections to connect to networks, but they are typically not found as direct connections to consumer devices at this time.

Figure 2-12 *Thunderbolt USB-C Port (Look for a Lightning Bolt by the Port)*

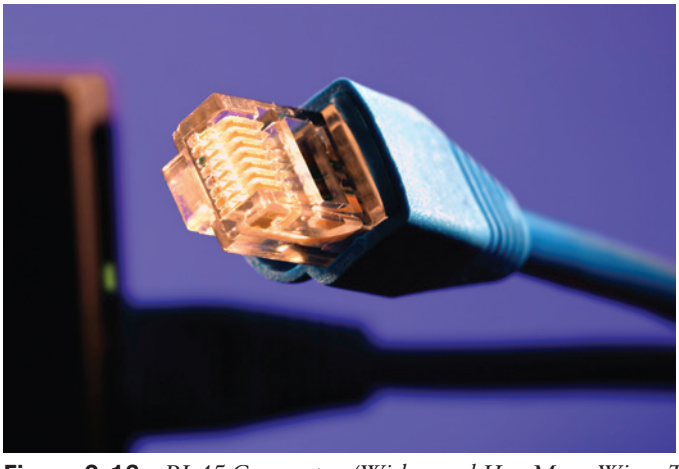

Figure 2-13 *RJ-45 Connector (Wider and Has More Wires Than the Older Telephone Connector, Which Was an RJ-11)*

Key Topic

An Ethernet cable to connect to a network might be called a CAT 5e, UTP, 1000BASE-T cable with an RJ-45 connector. Let's break this down:

- An Ethernet cable is often categorized as a CAT cable, with *CAT* abbreviated from Category. There are currently eight categories of Ethernet cables: CAT 1–5 are rarely used anymore; CAT 5e and 6/6a are commonly used, and CAT 7/8 are used for short runs in data centers. The higher the category, the faster the Ethernet cables can transfer the data. This explanation is a tad oversimplistic but helps in the general overview. CAT 5e is still used in many places and is capable of delivering 1 Gbps of data. CAT 6a can deliver 10 Gbps of data. Both CAT 5e and CAT 6 are capable of sending

data 100 meters before needing a signal repeater. CAT 7/8 can deliver 40 Gbps of data but only between 10 and 30 meters and are typically used only in data centers.

- The *TP* stands for twisted pair. Starting with CAT 3, electrical engineers started twisting the wires together to reduce electrical interference. Now, we have eight wires twisted in four pairs to reduce interference and gain speed (see Figure 2-14). When cutting your own Ethernet wiring, you must untwist the ends of these wires to slide them into an RJ-45 connector. In addition to TP, which all Ethernet cabling uses now, you can also purchase **STP** or **UTP**. Both are twisted pair, but *U* stands for unshielded and *S* stands for shielded.
  - Unshielded is what it sounds like. The cable is unshielded from any sort of electromagnetic interference. The cables are generally cheaper and more flexible than shielded cables. For most smaller runs inside a home or office, UTP is acceptable.
  - Shielded twisted pair means the cable itself is made of a material to help protect against electromagnetic interference. It is often made of PVC or plenum. Plenum is often required if running Ethernet in walls because it has flame-retardant properties. Often the individual wires will also have a foil shielding to protect against interference. STP is often used in commercial projects or for long runs. However, STP is usually more expensive than STP and not as flexible.

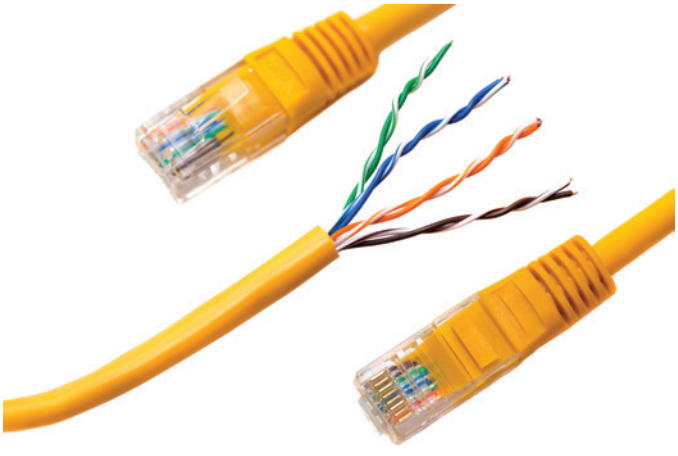

Figure 2-14 *Twisted Pairs in Ethernet*

- *PVC* is polyvinyl chloride, which can produce toxic fumes and should be used in open-air situations.
- Plenum cables have a fire-resistant jacket and should be used inside walls, drop ceilings, or under raised floors.
- The 1000BASE-T part means that there is 1000 Mbps of bandwidth. You will also see this written as 1GBASE as well. The *G* stands for gigabit, which is equal to 1000 megabits. The *BASE* merely refers to baseband signaling, which means only Ethernet signals are carried on it. The *T* stands for twisted pair. Yes, this is redundant because the *T* in UTP and STP also stands for twisted pair.

NOTE Another term you will hear with Ethernet is *PoE*, which stands for Power over Ethernet. Normally, Ethernet is for data. However, if the switch supports it or you use an externally powered POE injector, you can deliver up to 95 watts of power to the end device with the newest standards. However, it is more typical to deliver 15–30 watts on most devices. PoE is used to power IP telephones, IP cameras, and more. This means the IP phone could have only one Ethernet cable plugged in to deliver data and power to run the phone! While the consumer space has not really started seeing an adoption of PoE, the commercial space has been using it for some time. You must use a CAT 5e or greater cable to use POE.

Common Power Cables (Desktop, Laptop, Mobile)

Key Topic

Most desktop computers use a C13 power cord on one end and a country-specific plug on the other end. This cord then connects to the computer's PSU. This common cable allows for easy shipping to many countries because the C13 is a universal standard and readily matched with the correct country-specific plug on the other end (see Figure 2-15). Some computer manufacturers use a proprietary power adapter, but it is rare in the desktop marketplace. The power cable will go from the wall directly to the PSU the majority of the time. The PSU will then convert the AC electricity from the wall outlet to DC electricity for the computer to run.

Figure 2-15 *Typical Desktop Power Cable with C13 Plug (Left) and Country-Specific Plug (Right)*

Unfortunately, for many decades, laptops have used proprietary power adapters. There are dozens of proprietary charging tips/types for different manufacturers. Even the same manufacturer often has different charging tips/types for different models. To make it even more confusing, even if two laptops have the same charging tip, that doesn't mean you can use one charging cable on the other because often it has different voltage and amperage output. Luckily, because of the USB-C's capability to carry enough power to power many laptops, we are starting to see an adoption of that universal standard.

NOTE The European Union has made great strides in making USB-C a universal charging port to reduce e-waste. The EU has mandated that by the end of 2024 all phones, tablets, and cameras will have to be USB-C if they are sold in EU countries. In addition, the EU is pushing for all laptops to be the same. As a result, many manufacturers have quickly adopted the USB-C standard so that they do not lose sales in EU countries. Notably, this mandate caused Apple to ditch its proprietary Lightning phone cable and move to USB-C with the release of the iPhone 15.

Like laptops, mobile phones have had a litany of various power cables. There are dozens of proprietary phone cables. Most notably was Apple's Lightning cable, which was the follow-up to the company's proprietary 30-pin connector in use previously. Luckily, with the introduction of the iPhone 15, Apple has moved to the universal standard of USB-C. Most phones out now use USB-C. There are still some proprietary cables out there, but they are fewer than before. Before USB-C, phones started out with almost entirely proprietary adapters, then moved to mini-USB, then micro-USB (refer to Figure 2-11).

Converters vs. Adapters

Key Topic

One important distinction when needing to convert from one type of cable to another is whether you need a converter or an adapter. An **adapter** changes the plug type but must be the same signal. For example, you can go from an HDMI plug on one side to a DisplayPort plug on the other side with an adapter. They are both digital signals, so you are just adapting one plug to the other.

Key Topic

However, you will need a **converter** if going from a digital signal to an analog signal or vice versa. For instance, if you want to go from VGA (analog) to HDMI (digital), you will need a converter. Converters require power and are often more expensive than adapters. There are unscrupulous people on the Internet who will sell you an HDMI-to-VGA adapter where they just rewire the pins to each other. However, it will not work because you can't just send an analog signal to a digital signal without first converting it.

NOTE This distinction between adapters and converters also applies to electrical plugs. When traveling, people often buy adapters to plug in their equipment to the wall socket that matches the country's specifications. For most electronics, this is fine because most of the power bricks for modern electronics are rated with an input of 100–240 volts. Therefore, the adapter merely changes the plug style for the wall receptacle. However, you need to check the power brick, which is the box that is in the middle between the wall plug and the plug for the device that converts AC to DC, to see what the input range is. Most of North America and parts of South America use 110–120 volts, whereas most of the rest of the world uses 220–240 volts. Again, most modern electronics can accept the full range of voltage input, but you should always double-check first. There are many horror stories of fires because someone plugged a hair dryer into the wall outlet when traveling with an adapter and not a converter. The reason is that most hair dryers are not dual voltage and only accept the voltage of the country where it was bought. In this case, you would need to purchase a converter to convert from one voltage to another, not just an adapter!

Identifying, Installing, and Upgrading Computer Components

Whether you are building a computer, upgrading, or fixing one, it is vital to be able to identify computer components to be successful.

Identifying Computer Components

An IT support technician needs to be able to identify many essential computer components to be able to install or upgrade them. While the following sections do not provide an exhaustive list of every computer component, they include the major components you need to be able to identify.

Processor

Key Topic

The **processor** is the brain of the computer. It processes instructions of the programs sent to it. It is also called a central processing unit, or CPU. Most modern CPUs have multiple cores. These cores act as *almost* independent processors and allow the CPU to process many workloads or tasks at one time. Early CPUs had one core. As a result, it could perform only one task at a time. Today, some high-end CPUs have as many as 96 cores! In many server setups, the motherboards can support multiple processors with each CPU having multiple cores.

In addition, many CPUs are capable of multithreading or hyperthreading. Think of a CPU core as an independent brain. If I have a dual-core CPU, it would be like having two brains with each brain being able to do very different tasks. Multithreading is like having a right brain and left brain in one core. You can perform different tasks in each brain half, but they can't be radically different from each other. For example, with a multithreaded-capable core in this analogy, you could perform simple arithmetic while listening to classical music. However, you would not be able to do calculus while painting a complex scene in oil. Basically, the program being sent to a multithreaded core must be written to take advantage of this multithreading. Otherwise, it would just use another core. So, a dual-core CPU with multithreading has two cores but can split tasks in each core to have a pseudo four-core performance. In fact, Windows 11 shows these multithreaded cores as logical processors, so that a dual-core example would state two cores with four logical processors.

The way that a CPU processes instructions is separated into two camps: CISC and RISC. *CISC* stands for complex instruction set computer, and *RISC* stands for reduced instruction set computer. To simplify this distinction, let's use the analogy of a complex calculus problem. A CISC processor would take the entire problem and work on solving it. In contrast, a RISC processor would break up the problem into smaller chunks and solve it. On one hand, the benefit of a CISC processor is the raw horsepower to deal with complex instructions. On the other hand, a RISC processor has the benefit of energy efficiency and speed in small instruction sets. Traditionally, desktop/laptop computers have used CISC processors, whereas mobile devices have used RISC processors.

NOTE The lines between CISC being for desktops/laptops and RISC being for mobile devices have blurred recently. Apple has released M series processors for its laptops that use a RISC architecture. Meanwhile, Intel has CPUs that advertise performance cores and efficiency cores. The performance cores are CISC, and the efficiency cores are RISC.

The CPU architecture types **x86/x64** versus **ARM** showcase the CISC/RISC division. *ARM*, which stands for Advanced RISC Machine, is RISC, as the name implies, and is used on most mobile devices for energy efficiency. The x86 is an older CISC architecture type that was limited to 32-bit processing. Today, most desktop computers run on x64, also CISC, which allows 64-bit processing and is backward-compatible with 32-bit processing.

NOTE Modern ARM processors are 64 bit and backward-compatible to 32 bit. The x64 is the same but in CISC form. To understand the difference between a 32-bit processor and a 64-bit processor, it is important to understand what each means. Computers work in binary, so a 32-bit processor is capable of understanding 2^{32}, or 4,294,967,295 bits. This is an important number because a 32-bit processor can only understand up to this number in calculations. Therefore, with 32-bit CPUs, you can't have more than 4 gigabytes of RAM installed because the CPU can't understand a larger number. Technically, you can install more than 4 GB, but the processor will only see 4 GB as useable. In contrast, a 64-bit processor can have over 17 billion gigabytes of installed RAM. Remember that 2^{64} is a lot more than double 2^{32}—it's exponentially bigger.

The two CPU socket types for x64 processors are **PGA** and **LGA**. *PGA* stands for pin grid array. A PGA CPU has the pins on the CPU with the motherboard having the holes for the pins to be inserted into (see Figure 2-16). *LGA* stands for land grid array. In this style, the pins are on the motherboard with the CPU having flat contact points for the pins to touch (see Figure 2-17). Traditionally, Intel has supported LGA, and AMD has supported PGA. However, this has recently changed with AMD's new AM5 CPU socket being LGA. Both PGA and LGA have many generations of sockets, so you can't merely put any LGA CPU in an Intel-compatible motherboard. You would need to know whether it is an LGA 1700 or an LGA 1200, among many others.

NOTE You might also encounter a *BGA*, or ball grid array. This style is commonly found on laptops, phones, tablets, and gaming consoles. The CPU is soldered directly to the motherboard with this style.

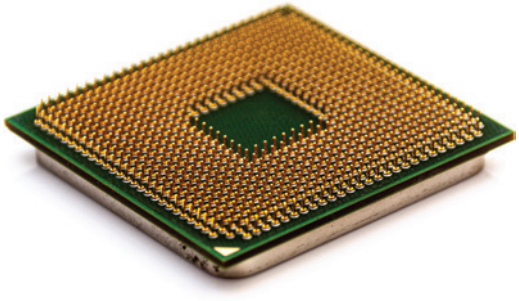

Figure 2-16 *PGA CPU (the Pins Are on the CPU)*

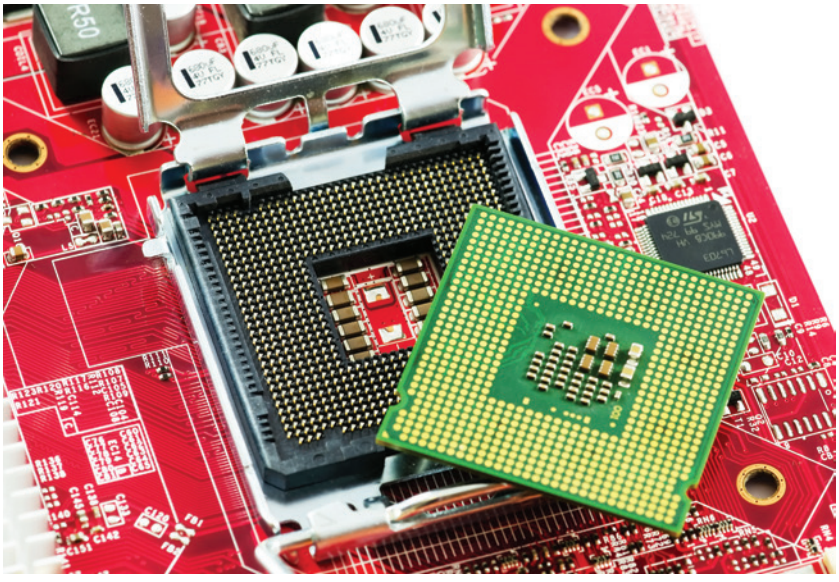

Figure 2-17 *LGA CPU and LGA Motherboard Socket (the Pins Are on the Motherboard)*

Motherboard

Key Topic

If a processor is the brain of the computer, then the motherboard is the central nervous system. The CPU is installed on a motherboard. The **motherboard** is a large circuit board that is foundational for other components to connect and communicate through. It serves three main functions:

1. **Connectivity:** It allows vital communication between the CPU, RAM, graphics cards (also called video cards), storage devices, and more with the chipset working as the intermediary.
2. **Power Delivery:** The PSU supplies power directly to the motherboard through the 24-pin PSU cable; subsequently, the motherboard delivers power to various connected components such as the RAM, M.2 storage, and some lower-powered graphic cards.
3. **Expansion:** The motherboard often provides slots for expanding functionality like graphic cards, sound cards, video capture cards, Wi-Fi, and more.

Regarding connectivity and how the motherboard communicates between components, this is often done through the **chipset** on the motherboard. Originally, the chipset consisted of the Northbridge and Southbridge chipsets. The Northbridge handles communication between the CPU and extreme time-sensitive components such as RAM and the graphics card. The Southbridge chipset handles communication between the CPU and hard drives, optical drives, I/O ports, and less time-sensitive devices. On modern motherboards, most of the Northbridge's chipset functions have been moved directly to the CPU for speed while remaining functions have been merged with the Southbridge chipset. Today, we rarely refer to Northbridge and Southbridge chipsets and merely call it *the chipset*.

Key Topic

If you are not sure of the processor and/or motherboard in a current machine, the easiest way to identify it in Windows is to press Windows+R to open the Run dialog box. Then type **msinfo32** and press Enter. Here, you will see the CPU/Processor name, the

motherboard manufacturer and specific model (labeled as BaseBoard Manufacturer/Product), and more detailed system information. You can also run **systeminfo** from the command prompt to see relevant information. For macOS, you will need to look in the "About This Mac" section. See the "macOS System Tools" section in Chapter 5, "macOS."

RAM

Key Topic

To continue with the analogy of the human body and computer components, **RAM** would be short-term memory. RAM, or random-access memory, is where the operating system stores everything that is currently opened and being used. This includes operating system programs, files that are opened, and web pages currently being displayed in your browser. It is volatile in nature, which means that what is stored in RAM disappears when you restart your computer or shut it down. This is contrasted to storage devices such as hard drives or solid-state drives. Those are long-term storage devices and are nonvolatile. If you have a saved document, it will be saved on a storage device. However, when you open that saved document, the operating system will place a copy of its contents in RAM for speed of accessing it.

When referring to RAM, people often use the term *RAM stick*. A RAM stick is merely a piece of silicone with many memory modules on it that collectively form what is called RAM. While there are various forms of RAM, including the very fast static random-access memory (SRAM) that is used in CPU caches, most RAM being referred to is DDR SDRAM or GDDR SDRAM. *DDR SDRAM*, which stands for Double Data Rate Synchronous Dynamic Random Access Memory, is often shortened to just *DDR RAM* and is used on modern computers. GDDR SDRAM is DDR RAM tuned for graphic cards and often called *GDDR RAM* (short for Graphics DDR RAM). DDR has gone through many iterations. With each iteration, speed and bandwidth have increased. As of this writing, the most modern motherboards utilize DDR5, and the most modern graphic cards utilize GDDR6. It is common that graphics cards utilize newer DDR standards because speed over cost is a priority for modern graphics cards. Also, you usually have lower amounts of RAM on a graphics card than you do on the main system. However, many gaming graphics cards have 16 gigabytes of GDDR, which often rivals what people have installed on their motherboard.

NOTE How much RAM do you need? The short answer is you need enough RAM to comfortably run the programs that you have open at one time. A large chunk of your RAM will be used by your operating system, and the rest will be used by active programs you have open. If you edit videos or play games, you will want more RAM than someone who does minimal web browsing and opens a word processing document sometimes. If you have ever opened just one more tab on your web browser to discover your computer starts running incredibly slow, you probably ran out of RAM. When you run out of RAM, the operating system must write those temporary files to your storage device, which is incredibly slow compared to RAM. On Windows, this would be a file on your operating system drive called *pagefile.sys*. As the programs you use become more complex, the need for more RAM increases. A decade ago, 8 GB of RAM was considered a lot. Today, it is a recommended minimum on most builds.

Peripherals

Key Topic

In addition to a CPU, motherboard, and RAM, computers also have peripherals. **Peripherals** can be both input and output devices. They can also be external or internal. A keyboard is an external, input peripheral device. The devices connected directly to the motherboard are internal peripheral devices. Video/graphics cards, wireless network cards, Bluetooth cards, and even storage devices such as hard drives and solid-state drives are all peripheral devices. These internal peripherals can be integrated on the motherboard from the factory, such as wireless and Ethernet NICs, or installed afterward, such as graphics cards and storage devices. These can be installed in expansion slots such as **PCIe** slots or dedicated ports such as SATA or M.2.

Storage Devices

Key Topic

Traditionally, **hard drives** were the long-term, nonvolatile, storage device in computers. Hard drives are magnetically written storage devices that have a spinning metal platter, almost looking like a miniature metal record player, that reads and writes data. The issues with hard drives are those two defining characteristics. First, hard drives store their information magnetically. This makes them susceptible to magnetic interference, and that interference can even cause data corruption. In fact, the official way to erase a hard drive for recycling purposes is to use a degausser. A degausser creates a strong magnetic field that erases the hard drive. Additionally, magnetic storage will degrade over time, much like an old VHS tape that loses its information over time (it is magnetically stored as well). A hard drive could last 5 years, or it could last 20 years. The problem is that over time data degradation is inevitable.

The second issue with hard drives is the spinning of that metal platter with the moving actuator arm (think of a tone arm on a record player). Because these parts are mechanical in nature, they can break. Are hard drives dead technology? No. In a cost to performance to storage size comparison, hard drives still win when looking at large storage needs. Yes, SSDs perform much faster than hard drives, but as the storage size increases, so do their prices. As of this writing, an 8 TB SSD is three times more expensive than an 8 TB hard drive. For smaller sizes, the price is less of a difference, but the larger sizes see a large difference. Hard drives come in two main form factors: 3.5 inch, which is typical for desktop computers, and 2.5 inch, which is typical for laptops.

Key Topic

Solid-state drive, or **SSD**, is a newer long-term, nonvolatile, storage device in computers. SSDs are neither mechanical nor magnetic. Instead, they use a type of flash memory to store the data. This means there are no moving parts to break and no issue with magnetic fields. While there can still be quality control issues with the actual flash memory modules that are installed that can cause premature failure, they usually have a finite number of read and write cycles. This means that it is normally possible to calculate exactly how long the SSD will last by looking at how many times the SSD has been read/written. There are two main form factors for SSDs: 2.5 inch, the same size as a laptop hard drive, and M.2.

NOTE Hard drives and 2.5-inch SSDs normally plug into the SATA port on a motherboard for data transfer. However, **M.2** is a new form factor for SSDs and can be confusing for those new to the IT field. M.2 is a port that is on the motherboard. It allows an M.2 drive to be directly inserted onto the motherboard. This direct insertion means the drive can get power and transfer data directly from the one M.2 port on the motherboard. Normally, a hard drive and SSD need a data cable plugged into the motherboard and a power cable from the PSU plugged into it. With M.2, you don't need either cable. The often-confusing part for consumers is understanding that M.2 is a form factor. There are two technologies behind M.2. You can have an SSD M.2 or an NVMe M.2 drive. They look identical, but how they transfer data is different. An SSD M.2 transfers data over the SATA interface. This means that it is exactly as fast as what a regular 2.5-inch SSD is because both use the SATA interface. However, an NVMe M.2 drive uses the PCIe interface. This is the same interface your graphics card uses and is substantially faster than SATA. Most M.2 ports on motherboards will accept either technology, so it is important to distinguish between the two. As you can imagine, SSD M.2 is usually cheaper than NVMe M.2.

Installing and Upgrading Computer Components

With the exception of the PSU, you should always wear an antistatic wrist strap and use ESD safety when working with computer components. Whether building a new computer or upgrading components on a computer, it is important to know the relationships between the components. The two sets of relationships you need to understand are form factor and compatibility factor. The following information mainly applies to desktop computers and not laptop/all-in-one computers.

NOTE While technically, you can replace motherboards and processors on laptops and all-in-one computers (where the computer and the screen are one unit), most of them are proprietary. This means that you can replace a motherboard on a laptop, but you will have to buy the motherboard from the laptop manufacturer because even their form factor is proprietary. The only items that are replaceable (usually, because there are exceptions) that aren't proprietary are items such as RAM, optical drive, and maybe the ability to swap out a hard drive with an SSD if both are 2.5-inch form factor.

Form Factor

Key Topic

The form factor relationship is usually defined as the physical dimension relationship between the motherboard, case (sometimes called tower), and PSU. Motherboards come in various physical sizes, such as ATX-E, ATX, Micro ATX, and ITX boards (listed from largest to smallest). As a rule of thumb, the larger the motherboard, the more physical connections and features it has. If you are building a simple home theater computer to play movies and music, you probably don't need an ATX-E but could get away with a smaller board like a Mini-ITX or Mini PC board like the Intel NUC. The motherboard's size will determine the computer case you use as well. A small case designed for a Mini-ITX board will not fit ATX-sized boards. However, a large computer case could fit an ATX-E board all the way down to a Mini-ITX board, but you might have a lot of wasted space inside. You will read terms such as *full-sized tower*, *mid-sized tower*, and *small form factor cases* when researching cases. Unfortunately, there is no agreed-upon consensus on what physical dimensions make up

these terms. Some mid-sized towers can hold an ATX board or a Micro ATX, whereas some only support Micro ATX and smaller. Basically, you need to read the case's dimensions to see what size motherboard it can hold. The two most common sized desktop motherboards are ATX and Micro ATX.

In addition to the relationship between the size of the motherboard and the size of the case to hold it, you also need to look at the size of the PSU. Traditional desktop power supply units are ATX PS/2 form factor. These fit in most mid-sized towers and above. There is also the smaller SFX PSU form factor for smaller cases like those that might fit a Mini-ITX board, and the even smaller TFX for some Mini-PC cases. These terms refer only to the physical dimensions of the PSUs. You need to choose the wattage of the PSU based on what you're running inside the computer.

Compatibility Factor

In addition to the form factor compatibility, you also need to look at the compatibility factor. This is especially important when looking at the CPU, motherboard, and RAM relationship. With desktop computers, you basically have two manufacturers of CPUs: Intel and AMD. An Intel CPU will not install on an AMD-compatible motherboard or vice versa. Furthermore, the specific CPU will run only on certain chipsets and socket types on the motherboard. Consequently, if you have a computer with an Intel Core i5-9300 CPU, it must be installed on an Intel-compatible motherboard with an LGA 1151 socket type and a compatible chipset like the H310 chipset. This makes it much harder to upgrade computer components. If you wanted to upgrade that same Intel Core i5-9300 CPU to a newer Intel Core i5-14600, you would also have to replace the motherboard because the socket type changed from an LGA 1151 to an LGA 1700 in that time, and you would need a newer 600 or 700 series chipset.

Using the same example, in addition to changing the motherboard for the new CPU, you will also probably need to change the RAM. The Intel Core i5-9300 compatible motherboards utilized DDR4. Most of the newer Intel boards utilize DDR5. Luckily, the iteration of RAM is not dependent on whether it's an Intel or AMD CPU, but rather on the motherboard and chipset. The new AMD motherboards, utilizing the AM5 CPU socket, have transitioned to using DDR5 while the newer Intel motherboards are starting that transition over to DDR5 as well. The number after the DDR on the RAM denotes a different generation or iteration of the RAM. You cannot stick a DDR4 RAM stick in a motherboard designed for DDR5 RAM because it won't fit. There is a notch in the bottom of the RAM stick that is in a different place on the different generations of RAM. This notch helps to make sure you place the RAM in the correct orientation and to help with putting the wrong generation of RAM in (see Figure 2-18). In DDR5 the notch is closer to the center of the RAM stick, so DDR4 RAM will not insert correctly.

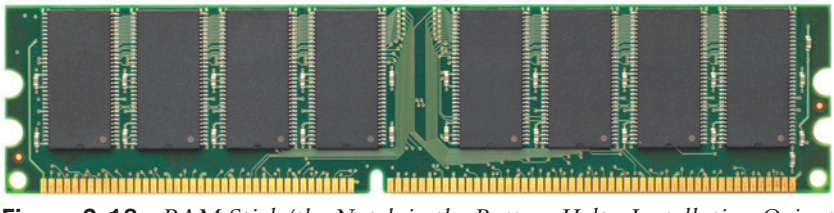

Figure 2-18 *RAM Stick (the Notch in the Bottom Helps Installation Orientation)*

Key Topic

To simplify, before you start assembling a computer or upgrading parts, make sure that you understand the physical form factor relationship of the case, motherboard, and power supply. Additionally, the motherboard, CPU, and RAM must be compatible with each other whether you're building new or upgrading.

Installing/Upgrading: Processor/Motherboard

Always read the motherboard manual to see the exact steps to install a motherboard and the CPU. The model of the motherboard is generally written on the motherboard itself.

To install the motherboard, follow these steps:

Key Topic

1. **For new builds, prepare the case:** Take the side panel of the case and locate the standoffs (threaded metal posts). If they're not preinstalled, screw them into the holes designated for the motherboard size (ATX, Micro ATX, and so on) according to your motherboard manual (some cases have labels next to the holes that state ATX, Micro ATX, and so on, to help with the process).

   For existing builds, double-check the standoffs to make sure they are in the correct position for the replacement motherboard. It is critical that a standoff does not exist where there is not a hole on the motherboard for a screw; otherwise, the standoff could be touching the back of the motherboard and possibly short-circuit it!
2. **Install the rear input/output (I/O) shield:** Some motherboards have this shield or backplate preinstalled on the motherboard itself, but most don't. This metal shield should come with the motherboard and is placed on the rear of the case matching the cutouts for your motherboard's ports.
3. **Place the motherboard:** Lower the motherboard onto the standoffs while making sure the motherboard holes align with the standoff screw holes.
4. **Secure the motherboard:** Screw the motherboard down to the standoffs using the included screws that come with the case. Don't overtighten because you risk unscrewing the standoffs when trying to loosen the screws on top of the motherboard if you need to remove it.

For PGA CPUs, hold the CPU up to the light and carefully look down the rows of pins to make sure none are bent. Don't touch the pins or top of the CPU while doing this because you don't want your finger oils to create hot spots anywhere on the CPU. There are special gloves you can wear when handling the CPU, but wearing an antistatic wrist strap and carefully holding the CPU only on its sides are usually okay as well. If you see a bent pin, you can either return the CPU or try to carefully use a razor blade to bend the pin straight again. Understand that if you do the latter, you run the risk of bending the pin too much and it breaking off because it's thin metal!

For LGA CPUs, make sure the pins are not bent on the CPU socket on the motherboard. This is harder to see than bent pins on a PGA CPU, so you might take a flashlight to shine on the socket to see if you see any bent pins. Unfortunately, if you see a bent pin on the motherboard socket, it is nearly impossible to fix. You will probably be returning the motherboard.

To install the CPU, follow these steps:

Key Topic

1. **Locate the CPU socket:** It's usually a square socket in the center of the motherboard.
2. **Open the socket lever:** Carefully release the lever that secures the CPU in place (refer to your motherboard manual for specifics).

3. **Place the CPU:** Hold the CPU by the edges, aligning the notches or triangles on the CPU with the corresponding markers on the socket. Gently lower it into the socket.
   a. Use zero-force insertion! This means that you merely lower the CPU onto the socket and do not press down. Imagine setting a delicate plate down on a hard counter. You don't drop it down, you don't press it down, you just gently place it down.
   b. Once you've set it down, you can very gently wiggle the CPU from side to side and front to back to make sure it's in place. Sometimes, you will feel it fall into place; this is okay if you didn't put pressure downward when wiggling it. Make sure that you still do not touch the top of the CPU.
4. **Close the socket lever:** Secure the CPU by gently closing the lever.
5. **Apply thermal paste (optional):** If your CPU cooler doesn't come with pre-applied thermal paste, you'll need to put a small, pea-sized amount in the center of the CPU. More is not better!
6. **Place the active cooling:** Install the heat sink/CPU cooler, being sure to follow the directions that came with it. Aftermarket heat sinks are often for various CPU sockets, so be sure to read the directions on those extra carefully.

Installing/Upgrading: RAM/Storage Devices/Internal Peripherals

With DDR RAM, you get the most speed by installing them in pairs. The reason is that motherboards have memory channels. If you are installing a pair of DDR RAM sticks, you will want to install them in the same channel, which is often color coded on the dual-inline memory module (DIMM) slots themselves on the motherboard. The DIMM slots are where you install RAM (see Figure 2-19).

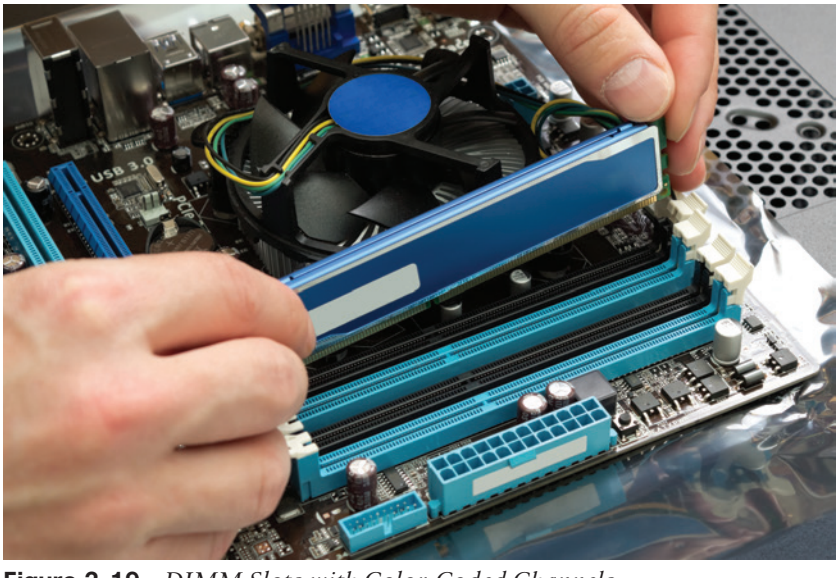

Figure 2-19 *DIMM Slots with Color-Coded Channels*

To install the RAM, follow these steps (make sure computer is off):

Key Topic

1. **Open the locking mechanisms:** On the motherboard, the DIMM slots will have two locking mechanisms that you need to open by flipping outward. Some motherboard DIMM slots have only one side that will open; this is normal.
2. **Find the notch:** RAM sticks have two notches on each side with a single notch on the bottom. This bottom notch needs to line up with a matching notch or ridge on the RAM slot. This helps to correctly orient the RAM and make sure you don't put a different generation of RAM in.
3. **Align and insert:** Hold the RAM by the edges, aligning the notch with the slot's notch and gently slide in evenly before applying pressure.
4. **Apply pressure:** Once it is in position and slid down evenly with very little pressure to just put in position, gently but firmly press the RAM stick further down into the slot until you hear a click from both locking mechanisms on the sides.

On modern computers, you will connect your hard drives, SSDs, and optical drives to a SATA port on the motherboard with a SATA data cable. Figure 2-20 shows a SATA port on a motherboard. In addition to connecting to a SATA data port, you will also need to connect to a SATA power cable coming from the PSU.

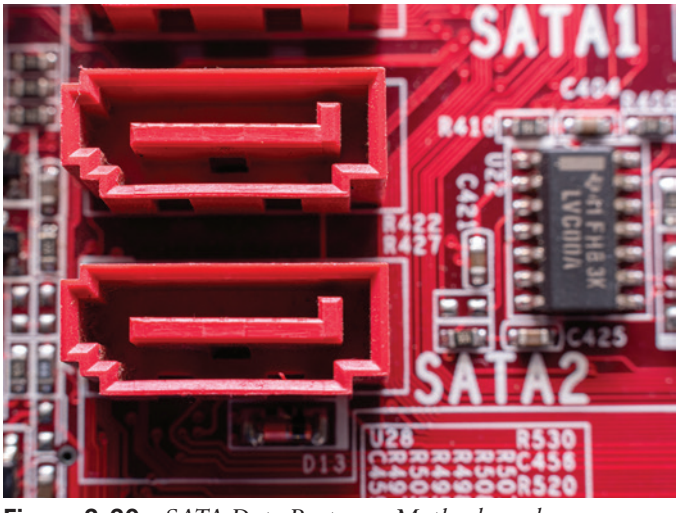

Figure 2-20 *SATA Data Port on a Motherboard*

For an M.2 form factor drive, you will install it directly on the motherboard with no additional data or power cable needed. There are different sizes of M.2 with 2280 being the most common. The M.2 port is often located between the PCIe expansion slots on the motherboard.

To install an M.2 storage drive, follow these steps (make sure the computer is powered off and you are using an antistatic wrist strap):

1. **Unscrew the M.2 slot cover:** The M.2 slot might have two small screws holding a cover in place. Remove the screws and the cover if present. Some motherboards

have the cover, and some do not. The cover acts as a heatsink to help keep the drive cool. There is often a thin plastic film on the downward-facing side that needs to be removed to expose the sticky adhesive before placing it back.

2. **Find the correct standoff position:** M.2 comes in many sizes with 2280 being the most common. There should be a standoff located next to a number. This indicates the size of the M.2 drive and what the drive will rest on and be secured to. Remove the standoff and place it into the correct position if not in it already. Some motherboards do not have the standoff preinstalled. If it's not, it will come in a bag with the motherboard. Find it and put it in the correct position. The end with the notch will fit into the actual M.2 port, and the other end will lie down and be secured with one screw in the standoff.
3. **Identify the notch:** Both the M.2 drive and the port/slot will have a notch. These notches must be lined up for proper installation.
4. **Insert the drive:** Carefully insert the M.2 drive into the port/slot at an angle (between 30 and 45 degrees) while aligning the notch on the drive with the notch on the port/slot (see Figure 2-21). Apply gentle pressure at the angle to have it fully inserted. When done correctly, the drive will remain in the angled position when let go.

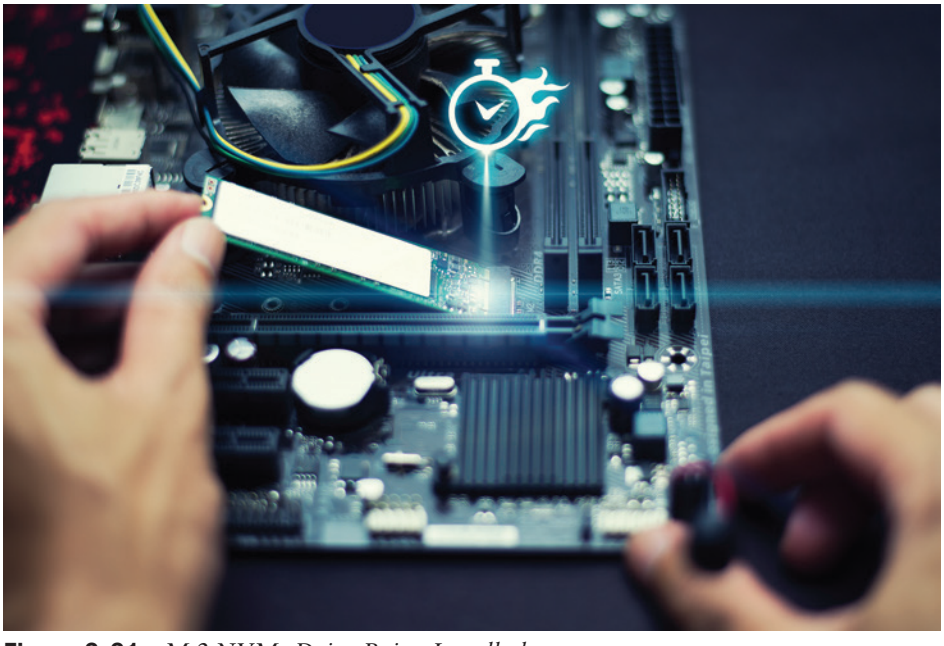

Figure 2-21 *M.2 NVMe Drive Being Installed*

5. **Tilt and secure:** Once it is inserted, gently tilt the drive down until it lies flat on the standoff on the opposite side of the port. Secure it with the screw in the standoff or from the motherboard bag that contains the standoff and screw. Don't overtighten because it is easy to snap off the standoff.

Key Topic

While some CPUs come with a built-in graphics processing unit (**GPU**) to output video to the monitor, many do not. In this case, you would need to install a graphics or video card. This would be considered an internal peripheral expansion card. Other expansion cards you might want to install would be wireless NICs to connect wirelessly to the Internet if your motherboard doesn't have one built in, video capture cards for editing video, Bluetooth cards for Bluetooth connectivity, audio cards for higher-quality audio output, and more. While external peripherals are usually connected to USB, internal peripherals are usually connected to PCI or PCIe slots/ports located directly on the motherboard. Peripheral Component Interconnect (PCI) is an older technology to connect expansion cards to. It is being replaced by PCI Express (PCIe). PCIe is capable of much faster data transfer as well as more bandwidth of data transfer. There are four PCIe expansion slots you might find on a motherboard: PCIe x1, PCIe x4, PCIe x8, and PCIe x16. The x and the number refer to the number of lanes of data communication the port can use. Typical motherboards often have one or two PCIe x16 slots and one or two PCIe x1 slots. Graphics cards will use PCIe x16 slots because they need more bandwidth than a wireless NIC, which might need only a PCIe x1 slot. If you have a PCIe x8 expansion card and no PCIe x8 slot/port on the motherboard, it will not fit in a PCIex1 slot, but you can use a PCIe x16 slot. It won't fill all the pins, but it will work. See Figure 2-22 for a motherboard with both PCIe x16 and PCIe x1 slots.

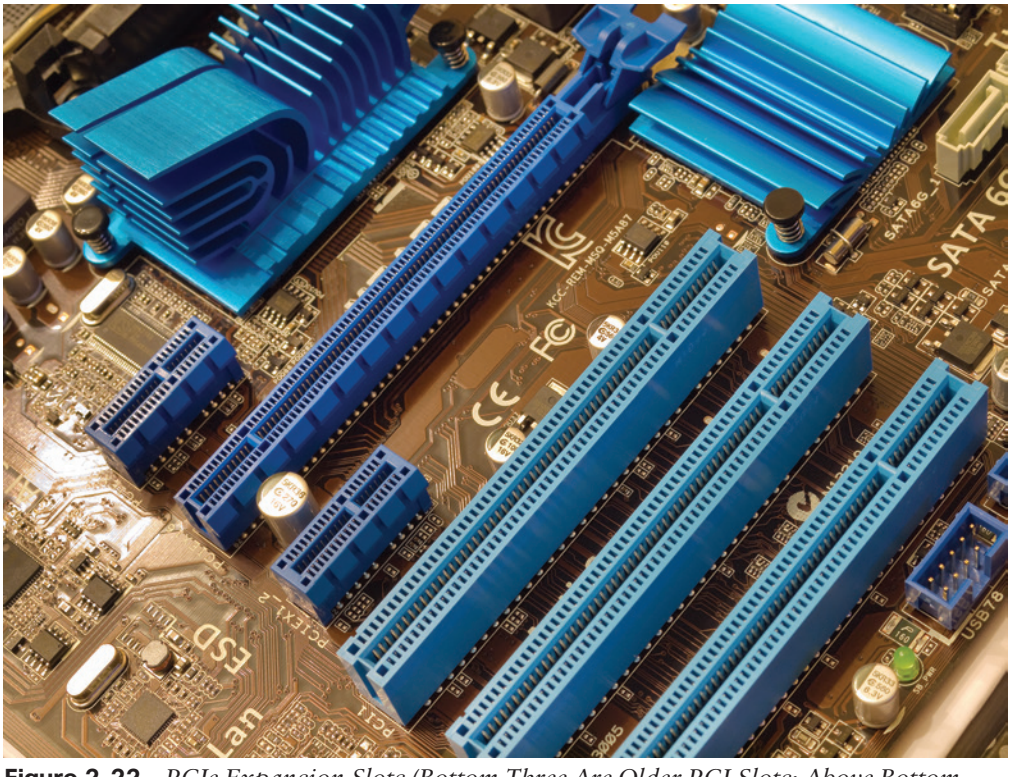

Figure 2-22 *PCIe Expansion Slots (Bottom Three Are Older PCI Slots; Above Bottom Three Is PCIe x1, Followed by PCIe x16, and Top Is PCIe x1)*

NOTE To know if a CPU includes onboard graphics, you need to look at the processor suffix. For example, you might buy an Intel Core i5-14400F. The i5-14400 is the specific model number. The *F* is the suffix. In this case, with Intel, *F* means it does not include onboard graphics and you must buy a dedicated graphics card. If you see a *K*, it means unlocked and can be overclocked for faster performance, which is not covered in this certification and generally advised against because it can cause stability issues. There are many other Intel-specific suffixes, but *F* and *K* are common ones. As a rule of thumb, if the Intel CPU does not have an *F*, it includes at least basic graphic capabilities.

Conversely, no AMD includes graphics unless it has the *G* suffix. The *X* suffix means overclockable and roughly equivalent to Intel's *K* suffix. As with all technology, this is true as of the time of this writing, but both companies are changing and adding suffixes for marketing purposes with each new generational launch of CPUs.

To install an expansion card, follow these steps (make sure the computer is powered off):

1. **Remove the cover screw:** Some cases may have a small screw holding a metal cover plate over the empty expansion slot on the back of the computer case. Remove this screw and the cover plate if present.
2. **Align the card:** Carefully hold the expansion card by its edges or mounting bracket. Align the gold connector edge of the card with the corresponding slot on the motherboard.
3. **Insert and secure:** Gently but firmly press the card straight down into the slot until it's fully seated. You should hear a click from the latch on the slot. Secure the card in place with the screw you removed earlier (if applicable). Don't force the card.

Post Installation Checklist

After you are finished installing or upgrading your PC, there are a couple of steps you should follow:

Key Topic

1. Power on the computer after double-checking all cables and parts are correctly positioned or installed.
2. If a new build, you will need to install an operating system at this point.
3. If you installed Windows, you will need to go to **Device Manager** to make sure you have no missing drivers or issues with your hardware (see Figure 2-23).
    a. In Windows, click the **Start** menu icon and type **device manager** in the search bar to find it. You can also press Windows+R on your keyboard to open the Run dialog box. Then type **devmgmt.msc** in the open box and press Enter/OK. Other ways to reach Device Manager include right-clicking the Windows logo and selecting **Device Manager** from the context menu. They will all get you to the same place.

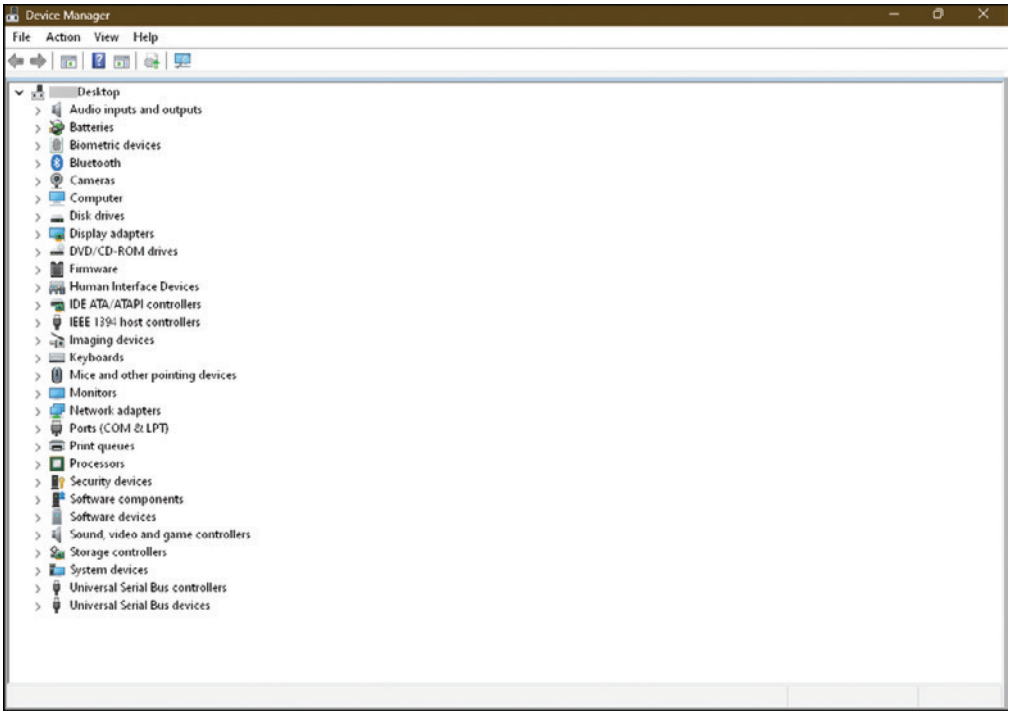

Figure 2-23 *Windows Device Manager*

b. You will see device categories listed here. If you see a yellow exclamation mark next to an item, you are missing a driver or Windows is using a generic driver. You might also see the yellow exclamation point with the words "Unknown Device" by it. Either way, you will need to fix this. There are two ways to approach this issue.

i. Right-click the item with the yellow exclamation point and choose **Update Driver Software** from the context menu (the context menu is the right-click menu in Windows). Then choose **Search Automatically for Updated Driver Software** from the next menu. This sometimes will allow Windows to find the correct driver, but you must be connected to the Internet.

ii. If the previous method didn't work and the device is listed, but it has a yellow exclamation mark by it, you can go to the motherboard manufacturer's website, or the company website if a prebuilt computer, and search for the specific driver. If it states something like Biometric reader, look on the motherboard support website for your specific model and see if there is a fingerprint driver or the like. Download and install the driver and look to see if it is resolved in Device Manager.

iii. For stubborn drivers or unknown devices, you can right-click the item and choose **Properties**. From there, choose the **Details** tab and select **Hardware Ids**. You can then copy the value and paste it into a search engine.

You will often find what the device is from various sites that cross-reference the hardware ID with the actual device. Do not download a driver from a random site! Always use the motherboard's official support site or the manufacturer's site.

4. After making sure your drivers are installed correctly, update your operating system for optimum performance.
5. Do not throw old parts in the trash! Many computer components contain dangerous chemicals and elements that are harmful to the environment. Always follow e-waste best practices to dispose of old parts. Often, your city's website or local fire department can help direct you to e-waste centers for proper disposal.

Hardware and Peripheral Issues

When you're troubleshooting hardware issues, it is always important to follow the problem-solving process as outlined in the "Problem-Solving Process" section in Chapter 1, "Help Desk." The following sections cover some common issues IT technicians might encounter with hardware and peripheral devices.

Basic Hardware/Software Troubleshooting

One of the most demanding skills of the IT technician is to learn how to troubleshoot hardware and software. These are some basic issues you might encounter. It is by no means a complete list, but more of an example of some issues you might encounter.

Power and Connectivity:

- Verify the device is plugged in securely to a functioning power outlet.
- Ensure all cables (power, data) are properly connected to both the device and the computer.
- Check for any physical damage to the cables or ports.
- Ensure the computer is powered on if it has a power switch.
  - Check to make sure the PSU switch is also in the 1 (or on) position.
  - If the power button on the computer case doesn't seem to work, double-check that the front panel header cables that connect from the case to the motherboard are connected correctly.
  - If you're working on a laptop, ensure it's plugged in or has sufficient battery life. Sometimes, if a laptop battery is malfunctioning or completely dead, the laptop will not turn on even if plugged in. Disconnect the battery from the laptop and plug the laptop into a wall outlet with no battery attached. If the laptop turns on, you need to replace your battery.

Device Status Indicators:

- Many devices have LED lights that indicate their status (e.g., blinking for errors, solid for power on). Consult the device's manual to understand the meaning of the lights particular to the device.

Key Topic

Firmware Updates:

- The most common firmware update for computer hardware is the **BIOS** of the motherboard. The basic input/output system, or BIOS, is a minimalistic operating system that allows a computer to turn on and understand basic devices. It allows various configuration settings including system clock/date, RAM overclocking settings called XMP/DOCP/EXPO depending on the manufacturer, boot order selection, and more. The settings are stored in another chip called the CMOS chip, and the BIOS reads setting changes from the CMOS upon boot. It is important to note that the changes or settings you adjust in BIOS are actually stored in the CMOS chip. The BIOS itself is a special type of read-only memory (ROM) chip called an EEPROM, which is short for electrically erasable programmable read-only memory. You can easily cause your computer to not boot if incorrect settings are applied in the BIOS. Therefore, if you do cause an issue, you can unplug your computer, pull the CMOS battery, and clear those configurations. Without a BIOS chip on the motherboard, your computer would do nothing when you turn it on. When you turn on your computer, the BIOS recognizes basic devices like a monitor, keyboard, mouse, RAM, and storage devices, and then does a power-on self test (POST) to make sure the devices are working. POST then passes on the startup process to the boot loader on your storage device that begins actual loading of the operating system.

  Having a basic understanding of BIOS is important because it is vital to your computer's performance. It used to be that you would not update your BIOS firmware unless you were having a problem. This is called **flashing**. Unfortunately, in the past decade, motherboard manufacturers are racing to put out new motherboard models for the seemingly endless choices of CPUs and chipsets that Intel and AMD have been releasing. As such, many new motherboards have critical errors upon release. Therefore, you might have to flash, or update the firmware, of your BIOS.

- Benefits of firmware updates involve improved performance, bug fixes, and new features added to the hardware.

- Possible dangers of firmware updates include faulty updates that can brick your device. *Bricking* is a term meaning to cause it to become permanently nonoperational. Also, not obtaining the firmware from a trusted source like the motherboard manufacturer's website directly could open the possibility of malware being installed at the hardware level, which is extremely dangerous.

NOTE If you are going to flash your motherboard to update the BIOS, make sure to get the update only from the manufacturer's website. Also, it is advisable to have it plugged into an uninterruptable power supply (UPS) while performing the update. If power cuts out during the process, you could end up with a device that is completely dead. Luckily, many motherboard manufacturers have backup BIOS files and ways to restore the BIOS if the updating process goes bad. However, you should never rely on those mechanisms because they can fail too.

Key Topic

Software Compatibility:

- If devices are working properly on Windows, check the Device Manager to see if the drivers are loaded and working (refer to Figure 2-23).
- Check whether the software you're trying to use meets your system's specifications. Look for information on processor type (32 bit versus 64 bit), minimum RAM, graphics card compatibility, and required disk space.

Key Topic

Peripheral Troubleshooting

A multitude of issues can arise with peripherals. While the following list is not exhaustive, here are some common issues:

- **Printers:**
  - **Drivers:** Always install your printer driver before plugging in or setting up your printer.
  - **Connectivity:** Ensure the printer is connected properly (USB, Wi-Fi) and turned on.
  - **Multifunction Devices:** Consult the printer's manual for specific instructions on using its scanning, copying, and faxing functions. Drivers have notoriously been problematic for all-in-one or multifunction printers.
  - **Loading Paper:** Refer to the manual for instructions on loading paper based on the paper size and type (tray selection).
  - **Paper Jams:** Carefully follow the manufacturer's instructions on clearing paper jams to avoid damaging the printer. As a rule, never pull jammed paper out the opposite way as it was going through the rollers. Paper jams are often caused by rollers that are losing their special coating that grips the paper; you might have to replace the worn printer roller.
  - **Print Queue:** Access the print queue from your computer (**Settings > Printers & Scanners**) to view and manage printing jobs. You can cancel or restart stuck jobs there.
  - **Ink Replacement:** For inkjet printers, consult the manual for instructions on replacing ink cartridges specific to your printer model. Before replacing inkjet cartridges, try to run Clean Printhead from your printer's menu. This will often help alleviate streaking or faded text/graphics.
  - **Toner Replacement:** For laser printers, consult the manual for instructions on replacing toner cartridges specific to your printer model.
- **Fax:**
  - Most modern computers lack built-in fax functionality. If you need to fax from your computer, you can rely on websites that will allow you to upload a document to be faxed from their service, or you will need to buy a dedicated fax machine or a multifunction printer that includes fax capabilities.

- If you have a multifunction printer with fax capabilities, but you cannot send a fax out, check that your printer is plugged into a telephone port with an RJ-11 cable. Also note that many Internet-based telephones (IP telephones) can be problematic when faxing because they can have jitter, or unevenness in transmission speed, that faxes can't account for.

- **Headphones/Microphones:**
  - Check the connection (wired or wireless) and ensure the volume is turned up on both the device and your computer.
  - Test the microphone using the Sound Settings in Windows.
  - Make sure the right Sound Output is selected in Sound Settings in Windows. For example, if you have speakers built into your monitor, you will want to make sure the Sound Output is HDMI or DisplayPort and not speaker output.
- **External Drives:**
  - Verify the drive is properly connected and recognized in File Explorer.
  - Some external drives require additional power (a separate power adapter).
- **Scanners:**
  - Like printers, scanners often need specific software to function. Install the scanner driver and software from the manufacturer's website.
- **Webcams:**
  - Ensure the webcam is enabled in your computer's settings and privacy settings.
  - Check whether applications have permission to access the webcam.
- **Keyboard/Mouse (wired/wireless):**
  - Try using a different USB port for wired connections.
  - Replace batteries for wireless keyboards/mice.
  - If using a Bluetooth wireless keyboard/mouse, ensure you have a Bluetooth receiver on your computer because not all desktop computers come with a Bluetooth expansion card built in. Begin by pairing the device to get it to work.
  - For wireless keyboards/mice, move your wireless router away from your computer because many wireless peripherals operate in the 2.4 GHz range, which is one Wi-Fi frequency your router uses for network connectivity.
- **Teleconferencing Devices:**
  - One main issue you might encounter with teleconferencing devices such as Cisco's Webex Desk Pro screens is insufficient bandwidth. If the video call is lagging or dropping out, try to switch from a wireless connection to a wired connection. If this doesn't help, you might need to check your Internet speed and possibly upgrade your Internet plan for a faster connection.

- If the device is not recognized by your operating system, try updating drivers and/or using a different port for connection.

- **Tactile/Interactive Input Devices:**
  - Touch screens can lose calibration, which can cause inaccurate touches. Use the device's built-in settings to recalibrate the screen.
  - Clean dirty or wet input devices with a microfiber cloth.
  - Check for physical damage to the device itself.
  - Check for loose cables.
  - Check for outdated drivers.
  - Check for firmware updates to the device itself.

Exam Preparation Tasks

As mentioned in the Introduction, you can customize your strategy for exam preparation. Suggested tasks include the exercises here, Chapter 9, "Final Preparation," and the exam simulation questions on the companion website.

Review All Key Topics

Review the most important topics in this chapter, noted with the Key Topic icon in the outer margin of the page. Table 2-2 lists a reference of these key topics and the page numbers on which each is found.

Key Topic

Table 2-2 Key Topics for Chapter 2

Key Topic Element	Description	Page Number
Paragraph	Electrical shock	34
Paragraph	ESD	36
List	How to use a fire extinguisher; P.A.S.S.	38
Paragraph	Repetitive Strain Injuries	38
Paragraph	Ergonomics	38
Paragraph	Interfaces	39
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Key Topic Element	Description	Page Number
Paragraph	Converters	50
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Paragraph	Checking processor and motherboard	53
Paragraph	RAM	54
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Paragraph	Storage devices	55
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Paragraph	Software compatibility	67
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Define Key Terms

Define the following key terms from this chapter and check your answers in the glossary:

adapter, amps, ARM, BIOS, chipset, converter, Device Manager, DisplayPort, driver, DVI, ergonomics, ESD, flashing, GPU, hard drive, HDMI, input/output device, interface, LGA, M.2, motherboard, Ohm's law, P.A.S.S., PCIe, peripheral, PGA, pixel, port, processor, proprietary, PSU, RAM, RJ-45, RSI, serial port, SSD, STP, threat actors, Thunderbolt, USB, USB form factors, USB-C, UTP, VGA, volts, x86/x64

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