



Computer Service and Repair

Fifth Edition

Richard M. Roberts



Aligned to CompTIA A+ 220-1001/220-1002 Objectives

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Preface

Support for PCs and mobile devices has evolved into one of the largest service industries in the world. The demand for skilled technicians to maintain, support, and upgrade PCs and mobile devices is ever-growing. It is a rewarding and challenging career that can take you anywhere in the world. If you wish to learn computer networking, programming, administration, or any of the computer sciences, this is the perfect place to start. A good foundation in computer technology will provide you with a base of knowledge that will make learning the other technical areas, such as networking and cybersecurity, much easier.

Computer Service and Repair was written for individuals wishing to pursue a career in information technology with a specific focus on troubleshooting, repair, maintenance, or support. The text provides specific content about information technology as well as career information needed for employment. It is an introductory text, so no previous experience is required.

This text is aligned to CompTIA A+ Certification 220-1001 and 220-1002 Exam Objectives. By studying *Computer Service and Repair* and using the ancillary study guide and laboratory manual, you can improve your level of preparation to earn an industry-recognized certification. Upon completing this course, you will be able to

- recall and identify essential components of a personal computer (PC);
- differentiate between operating systems and understand how they interact with the computer;
- understand how motherboards operate and how they work with individual components;
- compare, select, troubleshoot, and install a central processing unit;
- troubleshoot, replace, and understand the functionality of power supplies;
- upgrade, install, and understand the construction and operation of memory;
- list and identify common input devices and their interactions with computers;
- compare, troubleshoot, and install monitors and video adapter cards;
- describe characteristics of audio data and install sound cards;
- differentiate, troubleshoot, and replace both magnetic and solid-state storage devices;
- compare, contrast, and comprehend the construction and operation of optical storage technologies;
- troubleshoot and explain the operation principles of various printer types;
- compare, contrast, troubleshoot, and replace laptop and mobile device components;
- understand the differences between Internet-connection methods and troubleshooting modems;
- discuss methods to physically secure a workstation and enforce authentication;
- list common security applications and categorize malware;
- troubleshoot a number of commonly encountered symptoms, differentiate between Windows diagnostic utilities, and apply preventive maintenance procedures;

- differentiate between and apply various data recovery techniques;
- discuss the benefits of a computer network and differentiate between common network devices;
- comprehend the communication process between networks and identify network media and tools;
- manage administration functions of a network;
- understand WAN operation;
- design and install a SOHO network;
- apply communication, professionalism, and customer-support skills;
- actively and efficiently prepare for and pass the CompTIA A+ Certification Exam; and
- understand employment options and requirements for a PC technician.

Computer systems today are essentially reliable, and problems encountered 30 years ago caused by failing components are seldom found today. Computers still do occasionally fail because of faulty components, but the majority of failures are due to software problems or caused by the computer users themselves. Today, only a small percentage of computer failures require component replacement. The workplace now demands skilled technicians who can diagnose a software- or user-generated problem and reach a solution quickly without compromising data integrity or user productivity. This is the job of an IT support technician.

About the Author

Richard M. Roberts has designed curriculum; taught electricity, electronics, and computer technology; and supervised technical teachers for 45 years. He has experience as the systems administrator for Novell Netware, Microsoft NT, and IBM token ring networking systems. He is currently an adjunct instructor at South Florida Community College. His time is divided between consulting, teaching students and instructors, and writing instructional materials. He also coauthored the *Networking Fundamentals* and *Electricity and Electronics* textbooks. He holds active CompTIA A+, Network+, and Security+ certifications.

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Student Tools

Student Text

Computer Service and Repair is an up-to-date text that details computer maintenance and repair as well as introductory networking theory and concepts. It provides the skills and basic knowledge required for pursuing studies directed toward employment as an IT technician.

The text content is aligned to the CompTIA A+ Certification Exam Core 1 and Core 2 Objectives and will prepare students for certification.



Study Guide

The supplemental Study Guide provides students with a valuable means of review and practice essential for important knowledge and skills. The first half of the Study Guide contains practice exercises that reinforce concepts and skills learned in the corresponding textbook chapters. The completion of these activities greatly enhances the opportunity for students to earn A+ Certification. The second half of the Study Guide contains a CompTIA A+ Reference Guide to help students study and prepare for the CompTIA A+ Exam. The Reference Guide includes a detailed review of each CompTIA objective. This review provides a more student-friendly description of the objective's coverage, examples of the objective, and related concepts.

Laboratory Manual

The supplemental Laboratory Manual encourages students to apply the concepts they have learned in the text. It provides an opportunity to perform many of the tasks required in a typical networking employment setting and incorporates review questions at the end of each lab to reinforce understanding of the practicality and purpose of the activities. For ease of reference, the table of contents shows both the topic covered and the corresponding textbook chapter.

Instructor Tools

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Online Instructor Resources (OIR)

Online Instructor Resources provide all the support needed to make preparation and classroom instruction easier than ever. Available in one accessible location, the OIR includes a correlation between the text and the CompTIA A+ Exam Objectives, Instructor Resources, Instructor's Presentations for PowerPoint®, and Assessment Software with Question Banks. These resources are available as a subscription and can be accessed at school, at home, or on the go.

Instructor Resources One resource provides instructors with time-saving preparation tools, such as answer keys, lesson plans, pretests, posttests, and other teaching aids.

Instructor's Presentations for

PowerPoint® Instructor's Presentations for PowerPoint® provide a useful teaching tool when presenting the lessons. These fully customizable slides help you teach and visually reinforce the key concepts from each chapter. Slides include the list of Learning Outcomes and Key Terms from each chapter, definitions for each Key Term, talking points for important concepts, selected Review Questions, and selected Sample A+ Questions.

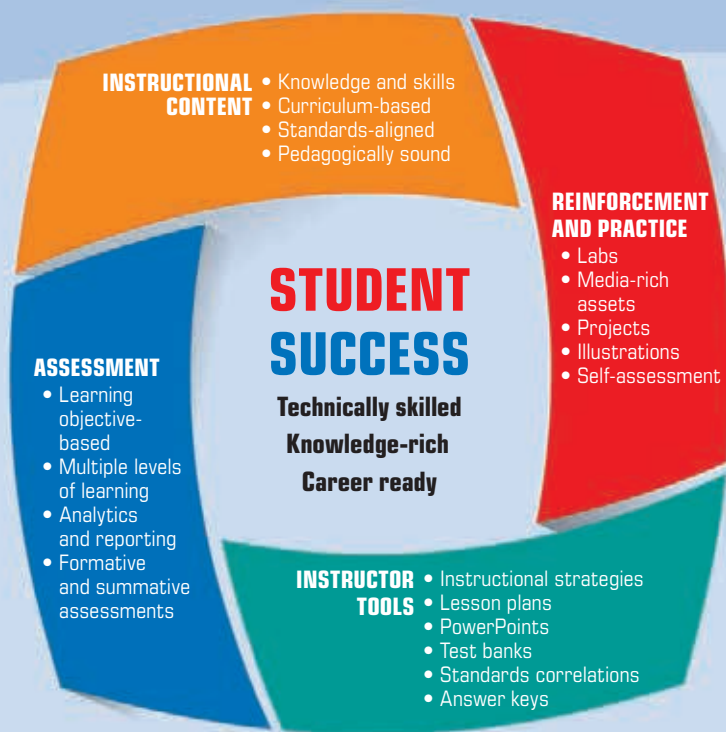
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EMPLOYABILITY SKILLS · TECHNICAL SKILLS · ACADEMIC KNOWLEDGE · INDUSTRY RECOGNIZED STANDARDS

OVERVIEW

This chapter covers the basic skills necessary to function in a customer or client-related environment. Not all computer jobs require you to meet and work with customers and clients, but most do require you to interact with customers and clients regularly. You probably assume you already know how to deal with people. However, there are some specific skills required for longer customer and client relationships of which you may not be aware.

In this chapter, you will be introduced to specific support scenarios. You will learn about the terms of customer that have been accepted as an industry standard. You may be the most skilled technician in the company, but if you do not deal with people professionally and courteously you will not likely have your job or be hired for a new position with customers and clients. You will discover the connection between leadership or management and all other career options that become limited. The importance of training the skills in this chapter cannot be emphasized enough. Reading, understanding, and being able to put into practice the skills covered in this chapter may determine your future in a customer-related career.

A+ NOTE

The CompTIA A+ Exams contain questions related to proper communication and professionalism. You will need strong customer questions related to customer relations, such as communicating clearly with the customer, listening to the customer, and ensuring a positive attitude by the technician.

Customer Support

Simply put, customer support is the delivery of customer assistance, training, and answers. This section provides an overview of customer support, giving you the big picture of how organizations work together to resolve customer and client computer problems. You will learn how different levels of support can be distributed across these models and will be made aware of the level of customer assistance typical of each model.

Customer Support Organization Models

There are several standard organization models for customer support. Some of these models include a help desk, call center, small business, service center, depot, local, and corporate enterprise support. The exact model of your company and how you fit within that model depends on three main factors:

- The number of people requiring support
 - The product being supported
 - The customer location (local or global)
- Some organizations operate on a combination of several models working together in a team. For example, a help desk service may be outsourced to a foreign country. This help desk may work closely with an organization in the United States that performs the actual physical work. In the following sections, several of the most

A+ Note

The A+ Note feature provides students with tips and facts regarding the CompTIA A+ Certification Exam. These tips will help students study for the certification exam.

Caution

The Caution feature highlights important personal- and machine-safety information students need to know before performing networking tasks. These alert students to actions that may cause personal injury or damage to a computer or electronic device.

End-of-Chapter Content

End-of-chapter material provides an opportunity for review and application of concepts.

- A concise **Chapter Summary** reiterates the Learning Outcomes and provides a brief review of the content for student reference. This helps students focus on important concepts presented in the text.
- **Review** questions highlight basic concepts presented in the chapter so students can evaluate their understanding of the material.
- **Sample A+ Exam Questions** challenge students to answer questions similar to those they will face on the CompTIA A+ Certification Exam, providing a sample of what to expect on the exam.

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Customer Service and Basics

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CAUTION

Do not use a computer monitor that is too small. You may experience eye strain and headaches. A monitor should only be used by a person with good eyesight.

Video System and Display Aspects

The video system of a computer consists of two main components: the display (monitor) and the adapter. The video adapter is often called a video card or graphics card. There are some common video cards to help you understand the development of the computer video system as well as help you identify different types of video cards. Some are still a few years old, but they are still in use. Being able to identify them can be extremely helpful and useful in the workplace. Being able to identify them can be extremely helpful and useful in the workplace. Being able to identify them can be extremely helpful and useful in the workplace.

Color Display Values

The color display quality is determined by the number of bits used to represent the individual colors of red, green, and blue. The number of bits used to represent each color can determine the possible number of color shades. A byte contains 8 bits, which equates to 256 possible combinations of 1s and 0s in a byte. This means that an 8-bit color palette can represent a 256-color palette of a specific color. By using the information of red, green, and blue, other colors can be produced. Figure 1-1 lists some common standard color display values, expressed in bits. As the number of bits increases, so does the number of possible colors produced.

The color capabilities in Figure 1-1 describe the application of 16-bit color information and the total spectrum of color produced by the monitor. This illustration is a system

Figure 1-1 The number of bits in a color display value increases, which the number of possible colors produced.

Color Display Value	Number of Colors
1 bit (1-bit color)	2
2 bits (2-bit color)	4
3 bits (3-bit color)	8
4 bits (4-bit color)	16
5 bits (5-bit color)	32
6 bits (6-bit color)	64
7 bits (7-bit color)	128
8 bits (8-bit color)	256
9 bits (9-bit color)	512
10 bits (10-bit color)	1,024
11 bits (11-bit color)	2,048
12 bits (12-bit color)	4,096
13 bits (13-bit color)	8,192
14 bits (14-bit color)	16,384
15 bits (15-bit color)	32,768
16 bits (16-bit color)	65,536
17 bits (17-bit color)	131,072
18 bits (18-bit color)	262,144
19 bits (19-bit color)	524,288
20 bits (20-bit color)	1,048,576
21 bits (21-bit color)	2,097,152
22 bits (22-bit color)	4,194,304
23 bits (23-bit color)	8,388,608
24 bits (24-bit color)	16,777,216
25 bits (25-bit color)	33,554,432
26 bits (26-bit color)	67,108,864
27 bits (27-bit color)	134,217,728
28 bits (28-bit color)	268,435,456
29 bits (29-bit color)	536,870,912
30 bits (30-bit color)	1,073,741,824
31 bits (31-bit color)	2,147,483,648
32 bits (32-bit color)	4,294,967,296

Figure 1-2 The color display in Microsoft Paint program shows 256,000 color shades, as well as the total spectrum of color produced by a monitor.



Chapter 1: Working Systems

CHAPTER SUMMARY

What Is an Operating System?

- An operating system is the underlying software that provides a computer user with the basic services of resource management in the machine, including a file system structure and a means of communication with the computer hardware.
- The core of any operating system is related to the kernel.

Operating System Characteristics

- All operating systems have a user interface, a file system structure, a file table, configuration files, and the ability to multitask.
- Operating systems, hardware devices, and software applications are considered using the terms, *data* and *code*, which refer to how much data can be processed at once by the CPU or how much total memory the operating system can access.
- There are two distinct user interfaces used to issue commands on a computer system: graphical user interfaces and command-line interfaces.
- Examples of file system formats are FAT, NTFS, and HFS.

Microsoft Windows Operating System

- The most widely used operating system is Microsoft Windows.
- The most significant differences between Windows 8 and earlier Windows operating systems are its user interface, user account settings, and the incorporation of cloud services.
- Windows 10 brought back the traditional **Start** menu.

- **Cloud** is a computer program that allows the user to interact with the computer using remote access of the command prompt.
- Most versions and editions of Windows have a similar set of features.

Microsoft Windows Installation

- An upgrade means that you can install Windows on an existing operating system and retain files, settings, and applications. A clean install means that the previous operating system is completely replaced and you will lose all files, settings, and applications.

- Carrying out a Windows installation calls for knowledge of an operating system's hardware requirements and determining whether an upgrade or clean install should be performed.

Apple Macintosh OS

- Mac OS is the operating system developed by Apple Computer to run on their Macintosh line of consumer computers.
- Mac OS is divided into **System** and **Classic** OS. Mac OS was based off the Mach kernel from CMU and the Berkeley Software Distribution (BSD) of the Unix operating system.
- Often, Macs are not found in traditional office-type work environments, but they are used almost exclusively in industries that fit these machine features.

Microsoft Windows Boot Sequence

- A cold boot, also called a **hard boot**, means that the electrical power switch is used to turn on the computer. A warm boot, or soft boot, is used to restart a computer that is already running.
- Windows 7, Windows 8, and Windows 10 share a similar boot sequence: POST, initial startup phase, Windows boot manager phase, Windows boot loader phase, kernel loading phase, and login phase. Windows 10 supports the UEFI in place of the BIOS for a faster, more flexible boot process.
- The power-on self test (POST) is a simple diagnostic program that is initiated when electrical power is applied to the computer system and is common to all operating systems.
- In a BIOS-based system, the POST is initiated by the BIOS program in the firmware. The boot sequence is slightly different for a computer equipped with UEFI, as UEFI.

Common Mobile Device Operating Systems

- Common mobile devices are cell phones, tablets, and some gaming hardware. Common portable device tasks are Internet access and collaboration activities.

Cloud Computing

- Examples of cloud computing shared resources and services are storage, application software, instant messaging, e-mail, and database support.
- The term **cloud** is synonymous with the Internet and used to mean network storage.

CompTIA A+ Certification

How to Become CompTIA Certified

This training material can help you prepare for the CompTIA A+ Certification 220-1101 and 220-1102 Exams. The Computing Technology Industry Association (CompTIA) is a nonprofit information technology (IT) trade association. Its certifications are designed by subject-matter experts. Each certification is vendor-neutral, covers multiple technologies, and requires demonstration of skills and knowledge widely sought after by employers in the IT industry. There are four general steps to achieving CompTIA certification:

1. Choose the desired IT certification from CompTIA.
2. Familiarize yourself with the exam, its objectives, and the types of questions used.
3. Begin studying, learning, and preparing for the exam.
4. Register for the exam, read and sign the Candidate Agreement, and take and pass the exam.

For more information about CompTIA certifications, such as industry acceptance, benefits, or updates, visit certification.comptia.org.

CompTIA A+ Correlation Charts

Complete mappings (correlation charts) of the CompTIA A+ Exam Objectives to the content of the *Computer Service and Repair* textbook are located on the G-W website at www.g-w.com. On this website, you will find one correlation chart per exam:

- CompTIA A+ 220-1101 (Core 1)
- CompTIA A+ 220-1102 (Core 2)

Each chart lists the exam objectives and corresponding page numbers of where to find the related content.

New to This Edition

The fifth edition of *Computer Service and Repair* was revised to align to current CompTIA A+ Exam Objectives. Additionally, updates were made in each chapter to provide coverage of the newest operating systems and recent technological developments in computing and mobile devices.

The most noticeable change to this edition is a minor reorganization of the chapters, resulting in 26 chapters rather than 22 as in the last edition. In the previous edition, many chapters were lengthy. Many of these chapters were divided to reduce the chapter's footprint in the book for ease of use and to make the content feel less daunting to the student.

- **Chapter 1 Introduction to a Typical PC** was updated and revised to include modern connection types, such as Lightning and Thunderbolt cables.
- **Chapter 2 Operating Systems** now includes new CompTIA Objectives and an updated discussion of Windows 10.
- **Chapter 3 Motherboards** remains largely intact from the previous edition but with a general update and revision.
- **Chapter 4 Central Processing Unit (CPU)** updates include new processors and features and content to meet new CompTIA Objectives.

- **Chapter 5 Power Supplies** was streamlined and revised to include information about eSATAp and external power supplies.
- **Chapter 6 Memory** reflects up-to-date information and now aligns to the revised CompTIA Objectives.
- **Chapter 7 Input Devices** was revised and updated to include information about NFC, VR/AR headsets, and chip readers.
- **Chapter 8 Video Systems** previously discussed both video and audio systems. In this edition, it is divided and appears as Chapter 8 and Chapter 9. In this chapter, the focus is on video systems and video cards.
- **Chapter 9 Audio Systems**, which was previously the second half of Chapter 8, focuses solely on audio systems and audio cards.
- **Chapter 10 Magnetic and Solid-State Storage Devices**, formerly Chapter 9, was revised and updated to remove discussion of outdated technology and expand file systems and disk management information.
- **Chapter 11 Optical Storage Technology** was previously Chapter 10. It is largely intact but given a general update and revision.
- **Chapter 12 Printers** was Chapter 11 in the previous edition. This chapter was revised to include additional information about printer sharing and virtual printers.
- **Chapter 13 Laptops and Mobile Devices**, formerly Chapter 12, was expanded to include coverage of mobile devices, smartphones, wearable technology, cloud services, and e-readers.
- **Chapter 14 Modems and Transceivers** was previously Chapter 13. This chapter is updated to reflect the revised CompTIA Objectives and to include additional information about mobile broadband connections.
- **Chapter 15 Physical Security and Authentication**, which was Chapter 14 in the fourth edition, was heavily revised and reorganized. This chapter was divided into Chapter 15 and Chapter 16. The content is revised to reflect technological updates and CompTIA A+ Objectives.
- **Chapter 16 Security Applications and Malware**, formerly part of Chapter 14 in the previous edition, now focuses solely on security applications, categories of malware, and malware removal. The content has been updated and revised to reflect new CompTIA Objectives.
- **Chapter 17 PC Troubleshooting** was previously Chapter 15. This chapter was updated to reflect CompTIA's revised troubleshooting guidelines as well as include more commonly encountered symptoms and how best to troubleshoot them.
- **Chapter 18 Data Recovery** was previously part of Chapter 15. This new chapter focuses exclusively on recovery techniques as a separate task from troubleshooting errors.
- **Chapter 19 Introduction to Networking**, formerly Chapter 16, focuses on an introduction to basic networking concepts, such as benefits, administrative models, classifications, topologies, equipment, and NICs.
- **Chapter 20 Network Communication, Media, and Tools**, formerly part of Chapter 16, now focuses primarily on the means by which networks communicate, as well as the media and tools used in network installation and troubleshooting.
- **Chapter 21 Network Administration** was Chapter 17 in the previous edition. This chapter was revised to include updated networking information for Windows 10 and Windows Server 2016, as well as meet the revised CompTIA Objectives.
- **Chapter 22 Wide Area Network (WAN)**, formerly Chapter 18, now includes coverage of cloud services and meets the new CompTIA Objectives.
- **Chapter 23 Small-Office/Home-Office (SOHO) Networking**, previously Chapter 19, was given a general update and revision to meet new CompTIA Objectives.
- **Chapter 24 Customer Support, Communication, and Professionalism** was formerly Chapter 20. This chapter is updated to reflect revised standards for documentation of best practices and document types, as well as an expansion of the information about professionalism.
- **Chapter 25 CompTIA A+ Certification Exams Preparation**, which was Chapter 21 in the previous edition, reflects current CompTIA A+ Exam percentages. In addition, both practice tests are updated and mimic the CompTIA A+ Exam in a more realistic way. Questions are no longer organized by domain.
- **Chapter 26 Employment and Advanced Education**, previously Chapter 22, now includes information such as soft skills, digital citizenship, and other qualities employers seek when hiring or promoting employees.

How to Use This Text

The *Computer Service and Repair* text and accompanying resources will help you prepare for the CompTIA A+ Certification Exam. You will learn the basics of PC maintenance, troubleshooting, repair, and component replacement. Additionally, you will learn about networking, have access to an A+ practice exam, and understand qualities employers seek in job candidates while maintaining realistic expectations about employment. These are concepts that you will need to understand not only for the certification exam, but also for your career as an information technology professional.

Each chapter in *Computer Service and Repair* begins with a set of Learning Outcomes. These are the goals you should focus on accomplishing by the time you complete each chapter. For each outcome, there is a corresponding top-level heading, review question, and summary bullet point to help ensure you understand the topics covered in the chapter. There is also a list of CompTIA A+ Certification Exam Objectives in the beginning of each chapter that outline the CompTIA content that will be discussed.

In addition to Learning Outcomes, the chapter-opening material also lists a set of key terms discussed throughout the material. These terms are in boldface when they appear in the content. This makes them easily distinguishable from the rest of the text. There are also important words or phrases printed in italic text to which you should pay special attention and consideration. Studying these terms will help you understand the material and better prepare you for your certification and employment.

Each chapter concludes with a summary of important points to remember, organized by level-one headings. This summary will help you review important topics from each section of the chapter.

Following the suggested guidelines will help you make the most of your introduction to computer servicing.

- Read the Learning Outcomes listed in the chapter opener. Each outcome is tied directly to a heading within the content. In addition, these objectives are repeated in the chapter summary and applied in end-of-chapter review questions. The connection of Learning Outcomes throughout the content helps you focus and apply important information as you read each chapter.
- Read the list of CompTIA A+ Objectives in the chapter-opening material. These objectives are also noted in the margin with an icon where the material is covered. Use the list of objectives in the chapter opener as a checklist to take inventory of CompTIA standards you understand, as well as information you need to review. The icons in the margins are there to direct you to the coverage of each objective for review.
- Pay attention to the illustrations. Each illustration is strategically created to highlight important information. By studying these, you will extend your learning and improve retention and application of the content.
- Read all A+ Note, Tech Tip, and Caution features as you progress through the material. This information helps supplement your learning by highlighting study tips, providing useful industry information, and helping you ensure personal and machine safety when working with networking devices.
- Review the summary at the end of each chapter. This will help you retain important information from the chapter.
- Answer the review questions and sample A+ questions in the end-of-chapter material. These questions provide exposure to the types of questions likely to be on the CompTIA A+ Certification Exam. By practicing these questions, you increase your chances of successfully earning CompTIA A+ certification.

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Operating Systems

LEARNING OUTCOMES

- Explain the purpose of an operating system.
- Describe the common characteristics of all operating systems.
- Compare Windows operating systems.
- List different types of Windows installations.
- Summarize the Windows boot sequence.
- Provide examples of common mobile devices and tasks.
- Recall examples of cloud computing resources and services.
- Define operating system terminology.

KEY TERMS

app	file	preemptive multitasking
application software	file extension	registry
boot sequence	file system	root directory
bootstrap program	file table	software driver
bug	graphical user interface (GUI)	software patch
cloud computing	kernel	subdirectory
cold boot	multiple-boot system	thin client
command-line interface (CLI)	multitasking	Tile
configuration files	multithreading	virtual machine
cooperative multitasking	operating system (OS)	virtualization
directory	pathname	warm boot
dual-boot system	power-on self-test (POST)	



A+ CERTIFICATION EXAM OBJECTIVES

The following A+ Certification Exam Objectives are covered in this chapter.

EXAM 220-1001

+ 1.0 Mobile Devices

- 1.4 Compare and contrast characteristics of various types of other mobile devices.
- 1.7 Given a scenario, use methods to perform mobile device synchronization.

+ 2.0 Networking

- 2.3 Given a scenario, install and configure a basic wired/wireless SOHO network.

+ 3.0 Hardware

- 3.5 Given a scenario, install and configure motherboards, CPUs, and add-on cards.
- 3.8 Given a scenario, select and configure appropriate components for a custom PC configuration to meet customer specifications or needs.
- 3.9 Given a scenario, install and configure common devices.

EXAM 220-1002

+ 1.0 Operating Systems

- 1.1 Compare and contrast common operating system types and their purposes.

- 1.2 Compare and contrast features of Microsoft Windows versions.
- 1.3 Summarize general OS installation considerations and upgrade methods.
- 1.4 Given a scenario, use appropriate Microsoft command line tools.
- 1.5 Given a scenario, use Microsoft operating system features and tools.
- 1.6 Given a scenario, use Microsoft Windows Control Panel Utilities.
- 1.7 Summarize application installation and configuration concepts.
- 1.8 Given a scenario, configure Microsoft Windows networking on a client/desktop.

+ 2.0 Security

- 2.4 Compare and contrast wireless networking protocols.
- 2.6 Compare and contrast the differences of basic Microsoft Windows OS security settings.
- 2.8 Given a scenario, implement methods for securing mobile devices.

OVERVIEW

This chapter introduces you to the Microsoft Windows 7, Windows 8, Windows 8.1, and Windows 10 operating systems. A basic understanding of operating systems is essential for troubleshooting a PC. To gain in-depth knowledge of an operating system, its various options must be put to use. It is imperative that you supplement textbook studies through hands-on practice with current Windows operating systems. The Laboratory Manual for this textbook will give you the necessary skills and first-hand knowledge required to pass the A+ Certification Exams and to become a proficient PC technician.

A+ NOTE



You must know the system requirements for Windows operating systems and be familiar with the features of each operating system. You should also know basic text-based commands such as **cmd**, **dir**, **rd**, **md**, **del**, **fdisk**, **format**, **copy**, **xcopy**, **robocopy**, **diskpart**, **sfc**, **attrib**, **defrag**, **edit**, and **chkdsk**. Many of these commands are covered in more detail in later chapters of this textbook. Even with an excellent knowledge of Microsoft Windows operating systems, the lack of sufficient knowledge of text-based commands can result in failure on the CompTIA A+ Certification Exams.

In addition, be sure you can define multitasking, both preemptive and cooperative. You should know how to navigate a directory structure from Windows Explorer and from the command-line interface and how to create and manage files and directories.



1002: 1.3, 1.7

TECH TIP



1002: 1.3

A repair installation uses various install media to overwrite an existing operating system that has become corrupt or damaged while keeping installed applications, user files, and settings.

What Is an Operating System?

An **operating system (OS)** is the underlying software that provides a computer user with all the basic services of resource management on the machine, including a file system structure for data storage and a means of communicating with all the various computer hardware. The operating system controls input and output (I/O) from disk storage units, monitors, printers, memory, and other computer components. It is also the job of the operating system to make sure programs running on the computer do not interfere with each other when competing for system resources. In the early days of computing, before operating systems were devised, users had to write code for all of the common tasks. If you wanted to save data, you had to write the code that told your computer how to do so.

Operating system software has evolved over the years. Think of the evolution of computer software and hardware as a group of inventors constantly building a better mousetrap. What is considered a leading-edge operating system one day may not be the next day. In fact, it will likely become obsolete only a few years later. The constant evolution of computers makes this concept confusing. Each operating system has its individual strengths and weaknesses.

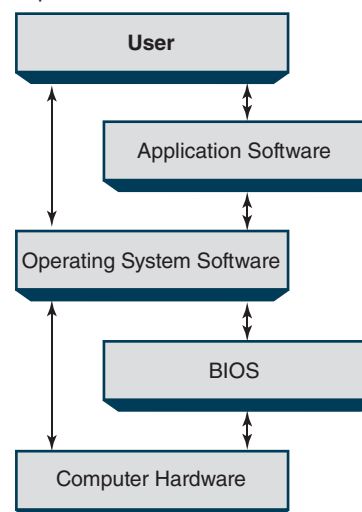
The core of any operating system is referred to as the **kernel**. Just as a plant buds and grows from a single seed or kernel, so does operating system software. The core program is enhanced by other software applications that refine the computer system. Associated with the core can be programs that provide for user interface style, security, and specialized file systems.

Operating systems allow application software to communicate with the BIOS. The BIOS translates the application software requests into instructions the hardware can understand, as outlined in Figure 2-1.

Users give instructions to the computer system via application software such as spreadsheets, word processors, or games. The user can also give instructions directly to the operating system. The operating system communicates with the BIOS, which then communicates with the computer hardware and peripherals.

For laptops, desktops, and workstations, the main operating systems in use today are Microsoft Windows, Apple macOS, and Linux. The latter two are derivatives of the Unix operating system originally developed by Bell Labs in the late 1960s.

Figure 2-1 Operating systems allow application software to communicate with the BIOS, which translates application software requests into instructions the hardware can understand.



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Linux first appeared in 1991 as an alternative to commercial operating systems and quickly gained popularity in part because of its open-source model. There are many versions of Linux OS available today, both free and commercial distributions, to meet computer users' needs.

There are varieties of ways in which an operating system can be installed. Once the most common installation method, the bootable and installation OS images are stored on a CD or DVD. However, many new systems, especially mobile computers, do not include an optical drive reader. In these situations, the OS can be installed locally via USB or flash drive, solid-state drive, removable or hot-swappable drive; via network connection or network server; or remotely through a pre-boot execution environment (PXE). For these to install correctly, the bootable and installation images of the operating system are stored on the respective device, which is loaded into the desired machine. When the computer starts, the user enters the BIOS and selects the desired device from the boot media option. The operating system could also be loaded onto a partition of the internal hard drive, but these are often reserved as recovery or repair installations.

Operating System Characteristics

The way an operating system handles activities, such as storing data, interfacing with the user, and presenting information on the screen, can be referred to as operating system characteristics. Most operating systems appear similar when judged by their screen display. However, there are many differences in the way they handle activities, especially data storage.

Multitasking

Multitasking is the ability of an operating system to support two or more programs running at the same time. When multitasking, it seems to the user that both programs are running simultaneously. However, in reality, they are not. The computer simply switches control between the programs, giving the illusion they are running at the same time.

An example of multitasking is using the printer while also using e-mail, browsing the Internet, or running another computer application. The computer runs the software in between sending packets of data to the printer.

Most operating systems support multitasking, but the hardware may not. Systems designed with minimal hardware, such as tablets and smartphones, do not support multitasking very well. If you attempt to perform more than one task, either the system will not allow you to run an additional program, or the system will run sluggishly because of the shared resources (CPU, RAM, and chipset). The two major classifications of multitasking are preemptive and cooperative.

Preemptive Multitasking

Preemptive multitasking, sometimes referred to as *time slicing*, is a process that allows multiple programs to share control of the operating system. For example, two or more programs can share the CPU for processing information. No single program can totally take charge of the computer system. All programs running in the preemptive mode of multitasking are allowed to run for a set period of time, called the *time slice*, by an operating system process known as the *scheduler*. At the end of the time slice, a process is interrupted so the next process in line can run. This way, all the processes on the computer can share the CPU fairly. Since each time slice is brief (around 20 milliseconds in Windows), the processes appear to be running in parallel.

Beginning with Windows 95, all newer versions of Windows OS, including Windows 10 and Windows Server, use preemptive multitasking. Most other modern operating systems, including OS/2, macOS (previously named Mac OS X), Unix, and Linux also use a preemptive kernel.

Cooperative Multitasking

Cooperative multitasking allows one program to dominate the CPU, but will allow another program to run while it is idle. This is a legacy multitasking classification. It was common to early macOS up to version nine. It was also used in DOS and Windows pre-Win98. Although it is rarely used in commercial operating systems today, it can still often be found in embedded systems with memory constraints used for specific applications.

Multithreading

You may have heard the term *thread* or *threads* used when referring to computer processing. These terms refer to passing small portions of a computer program through the core of the processor. **Multithreading** refers to the sharing of data and parts of a program between two or more CPUs or between the two cores of a single CPU. Note the difference between multithreading and multitasking, which is the ability of an operating system to support two or more programs running at the same time.



1002: 1.1, 1.3

32-Bit and 64-Bit

Operating systems, hardware devices, and software applications are identified using the terms *32-bit* and *64-bit*. These terms are used to describe the amount of data that can be stored or processed. In other words, *32-bit* and *64-bit* refer to how much data can be processed at once by the CPU or how much total memory the operating system can access. All modern PCs run 64-bit because it is faster and more efficient as well as backward compatible with 32-bit programs. The only reason to run a 32-bit OS is on legacy PC hardware with less than 2 GB of RAM.

The maximum amount of memory a 32-bit Windows operating system can access is 4 GB. Even if the computer contains more than 4 GB of RAM, only 4 GB will be accessible by the 32-bit operating system, and the amount of memory dedicated for video will further reduce the actual usable RAM to the 2.6–3.5 GB range. A 64-bit Windows desktop operating system recognizes a maximum from 8 GB to 512 GB of memory depending on the version and operating system edition.

When upgrading an operating system from one edition to another without a full reinstall, you are usually required to stay at the same bit level. For example, you can only directly upgrade a 32-bit operating system to another 32-bit operating system or a 64-bit operating system to another 64-bit operating system. Upgrading directly from a 32-bit operating system to a 64-bit operating system will delete all data files (documents, photos, music, etc.) stored on the computer. You need to back up all files, then perform the upgrade from 32-bit to 64-bit, and then restore the software applications and user data files. This is the recommended approach unless the system has less than 2 GB of RAM. Since all 64-bit versions of Windows come with DOS support via NT DOS Virtual Machine (NTDVM), there is no reason to run 32-bit OS solely for the sake of software compatibility.



1002: 1.2

User Interface

There are two dominant user interfaces used to issue commands on a computer system: graphical user interface and command-line interface. Graphical user interface

is referred to as GUI (pronounced *goeey*). The command-line interface is commonly referred to by Microsoft as the *command prompt*.

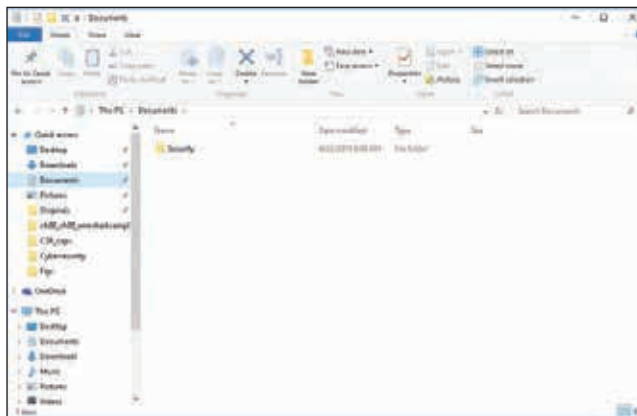
Graphical User Interface


1001: 1.5

A **graphical user interface (GUI)** allows the user to perform functions by selecting on-screen icons rather than by issuing text-based commands. Although DOS and DOS-like systems controlled over 80 percent of the early PC market during the 1980s, the user-friendly GUI of Macintosh soon gained popularity. Creating GUIs for the PC in the form of Windows 3.1 and Windows NT helped Microsoft retain control of the operating system market.

In most operating systems that are used today, the GUI displays the file system consisting of folders, icons, and names. This file system interface is called File Explorer or, more often, Explorer. One great advantage of using the GUI is that the entire file structure is easily displayed and interpreted. Figure 2-2 shows a typical GUI display of a file system organization. A typical GUI is seen in Figure 2-3. Although this is a Windows 10 desktop, all Windows GUIs are very similar. Visible on the desktop and taskbar are a number of program icons.

Figure 2-2 A graphical user interface (GUI) provides a more user-friendly method of file management than issuing text-based commands.



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Figure 2-3 The desktop GUI for all Windows operating systems is similar in look and feel.

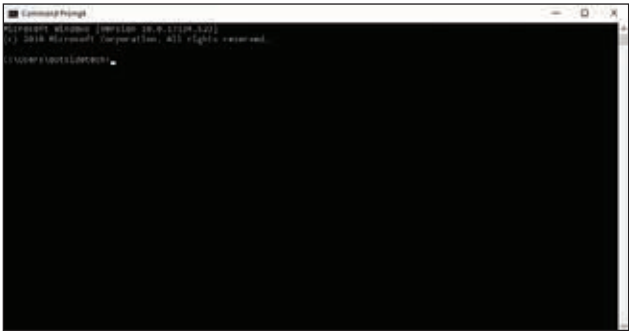


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Command-Line Interface

The **command-line interface (CLI)** allows commands for the computer to be issued by typing text at the command prompt. Figure 2-4 shows a command-line interface. Some common commands are **dir**, **cd**, and **copy**. These commands call up a directory, change directories, and copy a file or disk, respectively. See Figure 2-5 for a

Figure 2-4 The command-line interface allows commands for the computer to be issued by entering text at the command prompt.



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TECH TIP



If you ever need help working with commands, adding the **/?** switch after the command name will yield information such as available switches and what purpose they serve.

Figure 2-5 There are many commands that can be issued at the command prompt, but some are more commonly used than others.

Command	Description
..	Used as part of a command to reference the parent directory
cd	Changes from the current location in a directory to another directory
chkdsk	Checks a disk for errors and displays results
copy	Copies data from one location to another
date	Displays the date
del	Deletes a file
dir	Displays a list of files, directories, and subdirectories
DISM	Deployment Image Servicing and Management; prepares a Windows image for deployment
edit	Starts a text-editor program similar to a word processor
exit	Exits the command prompt window and returns to the Windows desktop
format	Prepares a disk for first-time use
gpresult	Displays Resultant Set of Policy (RSOP) information for a remote user
gpupdate	Modified Windows group policy settings
md	Creates a directory
print	Prints a text file to a printer
rd	Deletes a directory
rename	Changes the name of a file
robocopy	Robust file copy for mirroring directories
SFC	System File Checker; used with DISM to repair or replace missing or corrupted system files
shutdown	Change running OS state to shut down, reboot, hibernate, etc.
taskkill	Terminates one or more tasks or processes
time	Displays the time
ver	Displays the software version running on the computer

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table of additional commands. There are many more commands than the few listed, but these are some of the most commonly used. Be aware that there are some commands that can only be run by a user with administrative privileges.

DOS was the major operating system used by many PCs from 1980 to the late 1990s. However, because DOS was command-line based, it was not considered a user-friendly OS. Users had to memorize many different commands to become productive with the operating system. Today, text-based commands are still used, especially by system administrators and when troubleshooting. Text-based commands are particularly important when a PC fails to complete its startup process and take the user to the GUI. When troubleshooting with system recovery tools, the Windows admin can use the command window to enter text-based commands to check for disk- and file-system errors. It is important that the technician be familiar with command-line options to be able to use the command prompt effectively.

Modern Windows systems no longer use DOS. Instead, they are based on the NT kernel. A DOS emulator is provided for backwards compatibility. The DOS emulator has the look and feel of a real DOS prompt and functions similarly. Many of the restrictions or limitations of DOS are not found in the NT DVM. For example, many of the restricted characters not allowed in DOS file names can be used in the modern Windows command line or DVM because they are supported by the underlying NT kernel.

When a computer system fails during the startup process, there is no access to a graphical user interface. The best means of communicating with the computer system is by using a recovery CD or booting to built-in OEM recovery partition. Most of the commands used in Recovery Console look and work exactly like the original DOS commands. Figure 2-6 lists the most commonly used Recovery Console commands.

There are also newer text-based commands that complement today's more sophisticated operating systems. There will be much more about command-line support in Chapter 17.

A+ NOTE



Text-based commands are still very much a part of the A+ Certification Exams. To pass the exams, you must be familiar with each command's function.

Figure 2-6 Many of the commands used in Recovery Console look and work exactly like the DOS commands and DOS emulator.

Recovery Console Command	Function
attrib	View or set the attributes of a file or directory
cd	View or change the current directory
chkdsk	Check and display the status of a hard drive
copy	Copy a file
del	Delete a file
dir	Display the files, directories, and subdirectories of the current working directory
disable	Disable a service or a driver
diskpart	Partition a hard drive
enable	Enable a service or a driver
exit	Exit Recovery Console
fixmbr	Repair the master boot record
format	Format a hard drive
help	Display a list of Recovery Console commands
md	Create a directory
ren	Rename a file
rd	Delete a directory

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File System Structure

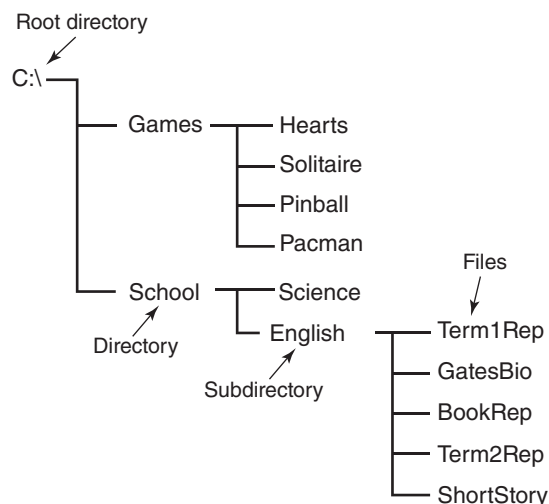
There are many different file system types supported by modern desktop and mobile operating systems. File systems all have similar or common characteristics for managing storage. Programs and user files are stored as data on computers via the file system, which handles the formatting and organizing of storage devices, such as hard drives, solid-state drives, CDs, and USB sticks. The basic structure is made of data repositories called directories, subdirectories, and files. A **directory** is a special type of file used to group or contain other files together in a hierarchical file structure. Specifically in Windows, a directory is often referred to as a *folder*. A **subdirectory** is a file that subdivides the content of a directory. A subdirectory is often referred to as a *subfolder* and is analogous to a folder within a folder. *Directory* and *subdirectory* are relative terms found in Unix, Linux and macOS, while Windows uses the term *folder* to mean the same thing. A **file** is a program or a collection of data that forms a single unit. Examine Figure 2-7, which shows a typical directory and file structure. It shows the relationship of the root directory, directories, subdirectories, and files.

In both Unix and Windows OS, the **root directory** is at the top of the directory structure. Windows uses letters to label disk drives. By default, the **C:** appears at the top for the OS or system drive in Figure 2-7. Thus, the root directory is **C:** (the hard drive). Next, there are directories or folders stemming from the root directory, for example, **Games** and **School**. Looking at the example again, you will see that **English** is a subdirectory to **School**. Both **English** and **School** are directories, but the placement in the structure determines if it is a subdirectory. Both directories and subdirectories can contain files. Under the directory **Games**, you can see several game files, such as **Hearts** and **Solitaire**.

A **pathname** is used to identify the location of a specific file. Look at Figure 2-8. The Windows pathname for the file is **This PC>C:>Users>outsidetech**. The **This PC** in the directory structure identifies the local user computer or workstation. **C:** is the root directory, **Users** is the first directory, and **outsidetech** is a subdirectory of **Users**. The bottom subdirectory reveals a collection of additional sub-folders, which are subdirectories such as **Contacts**, **Favorites**, and **Music** to give a partial listing.

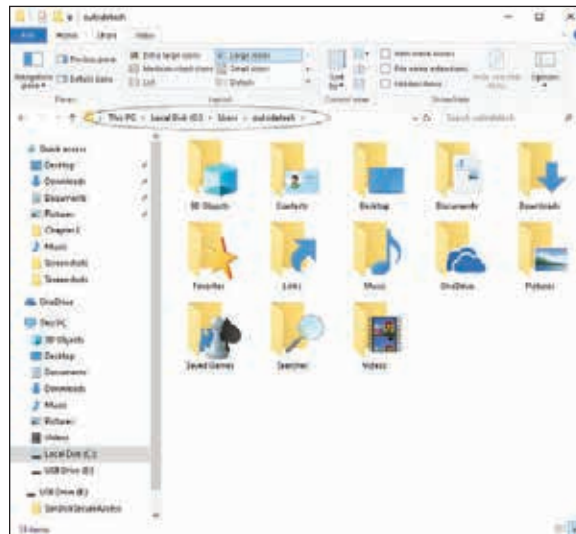
Most of the Windows operating system files are located by default in the **Windows** folder on the **C:** partition or drive. The pathname for this location is

Figure 2-7 The basic file structure used in many file systems is made of directories, subdirectories, and files.



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Figure 2-8 Pathnames indicate locations for files on a specific computer or even across a network system.



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C:\Windows. In reality, this folder can be located on any partition. In Microsoft technical literature, the exact location of the Windows folder is indicated as **%systemroot%** rather than **C:\Windows**. The **%systemroot%** variable is used in the path to represent the location of the Windows folder.

File Systems



1002: 2.6

No introduction to operating systems would be complete without mentioning file systems. A **file system** refers to the method of organizing files on a storage device. It is an indexing system used by the operating system to keep track of all files on the disk. The file system maintains a file table of all areas on the disk, and it tracks which areas are being used for data and which are free and available at any given time. A **file table** is a component of a file system used to organize files on a storage device. File systems will be covered in greater depth in Chapter 10.

Legacy file systems with which you should be familiar are FAT12, FAT16, and FAT32. Beginning with Windows NT, the default file system used by Windows operating systems has been NTFS. The basic FAT and FAT16 are options for Windows 7 when formatting flash drives. In Windows 10, FAT and FAT16 are only supported for reading older devices. Under Windows 10, USB media can only be formatted as FAT32, exFAT, or NTFS. It is important to note that the FAT file system is no longer supported for formatting or installing the OS on internal storage as of the latest Windows 10 release. As you study operating systems more in-depth, you will learn about other types of file systems, such as Apple File System (APFS). The Linux OS has support for many different file system types including ext2, ext3, ext4, Btrfs, XFS, and JFS. Each type of file system has its own features and advantages, so it is important to understand these features in order to select the best choice for a given application. There will be more about file systems in Chapter 10.

Configuration Files



1002: 1.5, 2.6

When a computer system is configured, the type of hardware and software the system has planned for use is recorded in a configuration file. **Configuration files** contain information such as the amount of memory and the type of video adapter present in

the system. Configuration information is stored in the **config.sys** file of DOS systems. The **config.sys** file is still used in newer operating systems, but it is included only to support legacy software applications.

Early Windows systems stored configuration information in the **win.ini** and **system.ini** files. Software applications also stored configuration setting in .ini files. These configuration files are replaced by the Windows registry settings for the Windows 95 and later operating systems. Many computer systems still contain .ini files to maintain a downward compatibility with some software programs.

The OS configuration file found in the Windows operating systems is called a registry. The **registry** is essentially a database that stores configuration information. The major sections of the registry are listed as follows with their purposes:

- **HKEY_CLASSES_ROOT**: Object linking and embedding (OLE) information and how files are associated with each other
- **HKEY_CURRENT_USERS**: Information for the current user of this workstation
- **HKEY_LOCAL_MACHINE**: Information specific to the local computer
- **HKEY_USERS**: Information for each user of this workstation
- **HKEY_CURRENT_CONFIG**: Display and printer settings

The registry is accessed by entering **regedit** in the **Run** dialog box found in the **Start** menu or by entering **regedit** at the command prompt. Figure 2-9 shows the Windows 10 Registry Editor.

There are two main registry files: **system.dat** and **user.dat**. The **system.dat** file contains information about the computer settings. The **user.dat** file contains information about individuals who use the computer. Registry files can be copied to disk, installed on another computer, backed up, and modified. The registry is repaired through the System Restore utility. Rarely does a technician need to access the registry files directly. When a technician does access the registry files, it is usually as part of repair steps outlined by Microsoft on its TechNet website. Direct modification of the registry should be a last resort effort.



1002: 1.1, 1.2

TECH TIP

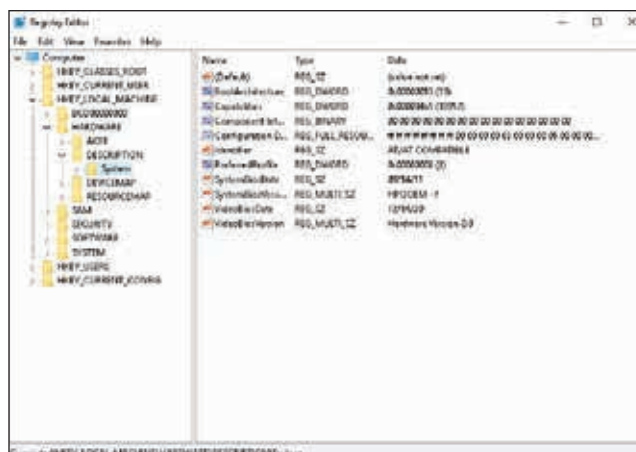


Changes in the registry can completely disable your computer operating system. Do *not* experiment with registry settings unless you fully understand the change or are under the supervision of your instructor.

Microsoft Windows Operating System

The most widely used desktop operating system is Microsoft Windows. On servers you will find a mix of Windows, Linux and legacy Unix versions. You will encounter

Figure 2-9 The registry is accessed by entering **regedit** in the **Run** box or the command prompt. Users should not experiment with registry settings unless they fully understand the change.



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Windows 7, Windows 8 or 8.1, or Windows 10 on the majority of desktop computers. This section references Windows operating system versions Windows 7 and later. Differences between operating systems are pointed out when appropriate.

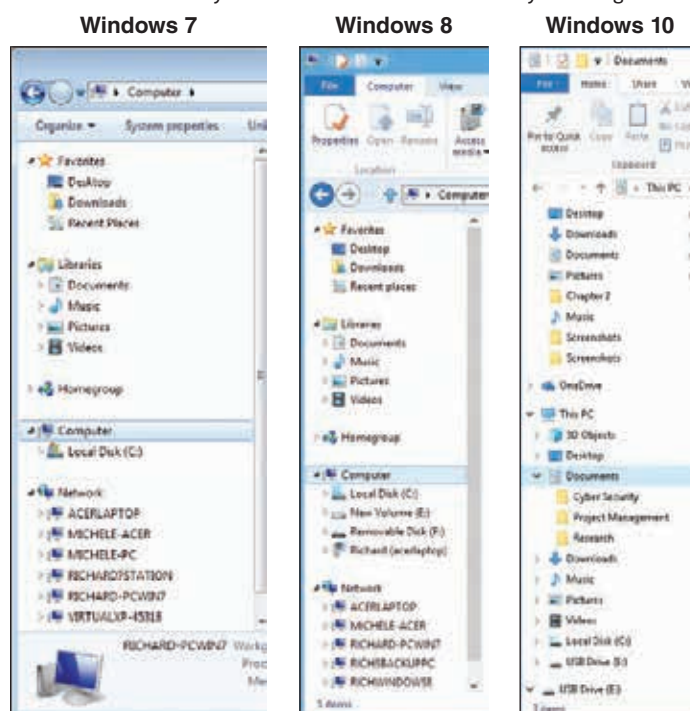
In October 2009, Microsoft released the Windows 7 operating system and announced the end of extended support to be January 14, 2020, meaning the commercial life for that OS lasted just over a decade. Windows Vista and Windows 7 shared many same or similar features, though there are some differences. In October 2012, Microsoft introduced Windows 8 with an entirely new look and feel. In this OS, Microsoft made the attempt to make the user interface in the style of emerging mobile devices. In the process, they eliminated many popular and familiar features of earlier versions of Windows. A large number of users were so unhappy, a year later Microsoft released Windows 8.1, which restored many of the missing features. Windows 10 was released in July 2015. It contains both the tablet style and the traditional look and feel of a graphical user interface—allowing users to decide which style to run. By default, Windows 10 looks more like Windows 7 rather than Windows 8. Many of the differences between these operating systems will be covered later as the major features of the Windows operating systems are reviewed.

Windows OS Directory Structure

The Microsoft approach to software is like constantly trying to improve a mousetrap. They keep reinventing existing features. Nowhere is there a better example of this process than comparing the directory structure of the various Windows operating system versions. As new approaches to old problems are solved and new technologies are introduced, changes are reflected in the directory structure.

A directory structure consists of files, folders, documents, and items such as hard drive partitions, CD/DVD drives, and network locations. To make a quick comparison of the Windows 7, Windows 8, and Windows 10 directory structures, look at Figure 2-10.

Figure 2-10 The Windows directory structure has remained relatively unchanged since Windows 7.



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The Windows XP directory was simple in comparison to Windows Vista, which introduced the concept of a **Public** folder to make sharing easier for users. The Windows 7 directory structure is even more complex than previous versions. Windows 7 introduced **Libraries** and **HomeGroup** into the directory structure. The **HomeGroup** is an improved sharing feature, and **Libraries** allows easier access to files and folders located in multiple locations. Changes in the directory structure is one of the biggest reasons people have trouble locating their files after upgrading to a new operating system or buying a computer with a newer version of an operating system. In Windows 10, the Quick Access view was added in File Explorer that shows a list of recently accessed objects. Quick Access objects are not duplicates; rather, they are simply shortcut links to the same files and folders under **This PC** and the **C:** drive views. Users will need to understand this new feature and how it works to avoid confusion.

Windows File Names

File names originally had to conform to DOS standards. DOS required that file names be no more than eight characters followed by a period and then an identifier know as a file extension. A **file extension** consists of three additional characters that allows Windows to recognize the file type, such as **.jpg** for a jpeg image. In modern operating systems, the file extension is not necessary but still helps with file identification and mapping to a default application assigned to handle a given file type. The table in Figure 2-11 lists common file extensions and the type of program to which they are related.

The file name structure allows for file names of up to 255 characters. This standard is referred to as *long file names*. Long file names allow for the content of the file to be described in some detail. This provides relief from brief, cryptic, eight-character file names. For example, a file could be saved as **Term1 Science Paper The Factors Affecting Ocean Tides**.

There are certain characters or symbols that cannot be used in the file name. The characters that are not allowed in the long file name system are the following:

| * > < ? : \ / “

Figure 2-11 A file extension consists of three additional characters used to identify the file type.

File Extension	Description
.avi	Audio video file
.bmp	Bitmap graphics file
.com	Executable file
.doc	Document file
.exe	Executable file (a program that runs when the file name is entered at the command prompt)
.ini	File containing configuration data
.jpg	Picture file
.log	File listing actions that have occurred or containing a brief record or collection of data
.mpg	Video file
.tmp	Temporary file (typically associated with Internet downloads and software installations)
.txt	Text file
.wav	Wave audio file
.wmv	Windows media video file
.wps	Microsoft Windows word-processor document

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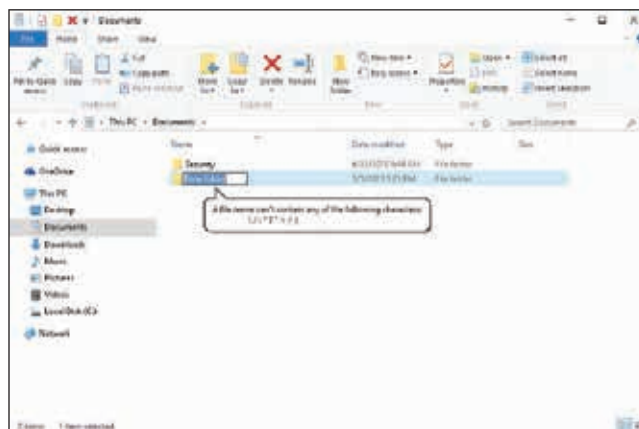
These characters have a special meaning to the operating system and will produce errors or unwanted results when used. As you can see in Figure 2-12, Windows displays an error message when the user attempts to use a restricted character in the folder file name. Restricted characters also provide backward compatibility to legacy operating systems.

Windows Desktop

The Windows desktop has maintained a similar user interface from Windows XP to Windows 7 and even Windows 10. The lone exception was Windows 8, which used a tiled interface and did away with the popular **Start** menu. After much negative feedback from the Windows user base, the **Start** menu was reintroduced in a point release to Windows 8 called Windows 8.1. The **Start** menu located at the bottom-left corner of the desktop has remained relatively uniform since its introduction. From this menu, programs are launched, folders such as **Documents** and **Pictures** are accessed, and commands such as **Shut Down** are initiated.

As mentioned, Windows 8 introduced a major change that incorporated a table-style interface totally different from previous versions of Windows. Due to this change, Windows 8 does not support the **Start** menu feature. Windows 8.1 was a free upgrade from Windows 8. The default screen is named **Start**, as shown in Figure 2-13.

Figure 2-12 An error message is displayed when a user enters a file name with a restricted character.



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Figure 2-13 Windows 8 introduced a new kind of **Start** menu featuring Tiles.



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This menu contains a set of objects called *Tiles*. A **Tile** represents a shortcut to Windows 8 program applications, referred to as *apps*. Tiles are similar to icons used on earlier Windows operating system desktops. Tiles can easily be added or removed from Start. The new design was made for devices with touch screens, such as the tablet and smartphone. However, you can still use a mouse to navigate.

An alternate desktop that resembles the traditional Windows desktop can be used instead of Start, as demonstrated in Figure 2-14. It looks similar to the desktop of earlier Windows operating systems except that it does not have a **Start** menu icon. A taskbar is displayed across the bottom of the desktop with familiar icons displayed. You can create desktop shortcuts or pin programs to the taskbar for quick access to commonly used software applications.

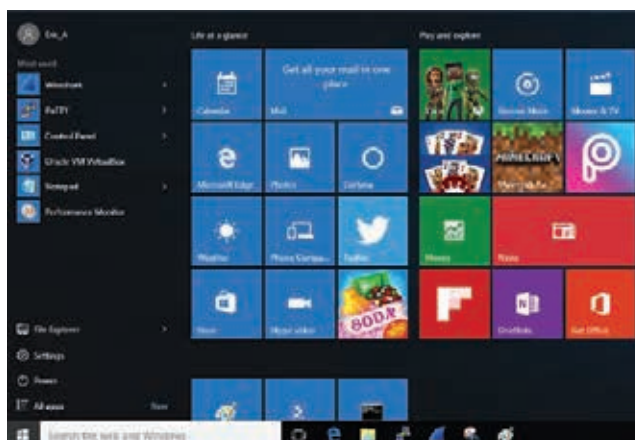
Windows 10 reintroduced the **Start** menu. However, it uses the newer Windows 8 Tiles for the menu format, as shown in Figure 2-15. Users can customize how many of the Tiles they see by selecting **Settings>Personalization>Start**. In place of Control Panel, there is now a gear icon to access a setting window. The Control Panel application is still available and can be found using Windows search located to the right of the **Start** menu icon. It can also be accessed directly through the Most Used

Figure 2-14 Windows 8 offers an alternative desktop that resembles the traditional Windows desktop, but it is not compatible with the traditional **Start** menu.



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Figure 2-15 Windows 10 reintroduced the **Start** menu, but it uses the newer Windows 8 Tiles for the menu format.



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portion of the **Start** menu or through **Start>Settings>Control Panel**. Windows 10 also introduced a personal assistant AI called Cortana, which accepts voice commands in addition to typed search commands.

Windows Features and Tools

The most important Windows features are introduced in this section. Not all of the features are available to all versions of Windows. You can use Figure 2-16 to quickly identify in which version of Windows each feature is integrated. Features unique to Windows 8 and Windows 10 are also covered in the following sections.

For a more detailed list of Windows operating system features, check the Microsoft website. You can conduct an online search using the key terms **Microsoft Windows feature comparison**. Be sure to add the operating version or edition names in the search key terms.

Figure 2-16 Some features are common from one Windows OS to another.

Windows Feature	Windows 7	Windows 8	Windows 10
Encryption	BitLocker	BitLocker	BitLocker (Professional and Enterprise editions only)
Mobile Device Encryption	BitLocker To Go	BitLocker To Go	BitLocker To Go (Professional and Enterprise editions only)
Cortana Personal Assistant	No	No	Yes
DOS Compatibility	32-bit Yes 64-bit Yes, via NTDM	32-bit Yes 64-bit Yes, via NTDM	32-bit Yes 64-bit Yes, via NTDM
Gadgets	Yes	No	Feature discontinued
Libraries	Yes	Yes	Yes
Microsoft User Account	No	Yes	Yes
Network Discovery	Yes	Yes	Yes
Picture Password	No	Yes	Yes
Recovery, Refresh, and Reset	No	Yes	Yes
Sync Your Settings	No	Yes	Yes
Tablet PC Settings	Yes	Yes	Yes
Windows Look and Feel	Aero	Tablet Style Tiles	Microsoft Fluent Design System influence
Desktop Multimedia Support	Windows Media Center	Windows Media Center as an add-on	WMC discontinued. Replaced by streaming services and other third-party applications.
Collaboration Software	Skype	Skype	Skype
Windows Mobility Center	Yes	Yes	Yes, disabled by default
Windows ReadyBoost	Yes	Yes	Yes
Windows Shadow Copy and Previous Versions	Yes	Yes	Yes
Windows To Go	No	Yes	Enterprise and Education editions only
XP Mode	Yes	No	No

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1002: 1.2

A+ NOTE



The A+ Certification requires knowledge of a variety of Windows operating systems and features. Always check the CompTIA website for a list of operating systems that are covered on the exams.

**1002: 1.6**

Control Panel

Windows Control Panel is a menu accessible from the **Start** menu that contains several utilities used to manage hardware, software, user and system settings, and troubleshooting. Users can also adjust general folder options, such as viewing hidden files, hiding or showing file extensions, changing folder icons, and customizing how files and folders appear in searches. Three important utilities, among many others, include Date and Time, Internet Options, and System.

**1002: 1.3**

Date and Time

One example of a utility in Control Panel is **Date and Time**, which allows you to set the date, time, and time zone for the installed Windows operating system. This dialog box also allows you to select an Internet clock with which to synchronize your computer.

**1002: 1.6**

Internet Options

Another example of a useful tool in Control Panel is **Internet Options**, which allows users to adjust the properties of their Internet connections. The **Internet Options** dialog box includes seven tabs:

- **General:** Allows users to change options for home page, startup, tabs, history, and appearance
- **Security:** Allows users to change options for security settings and security levels
- **Privacy:** Allows users to adjust privacy options, such as location and pop-ups
- **Content:** Allows users to view or clear certificates, change AutoComplete settings, and customize web feeds
- **Connections:** Allows users to customize their connection configuration
- **Programs:** Allows users to manage add-on programs and file associations
- **Advanced:** Allows users to customize their web browser experience further

**1002: 1.6**

System

The **System** window provides a wealth of useful information to the user. This window is where users can view performance statistics. This also permits the user to view the type of OS installed, such as 32-bit or 64-bit, and amount of memory installed, including virtual memory. The **System** window is also where users taking advantage of remote services can adjust their remote settings, such as remote assistance and remote desktop.

**1002: 1.5**

Notepad

Notepad is a plain-text editor built into Windows operating systems. It was initially released in MS-DOS as a mouse-based program. It is one of the few features that has been incorporated in every version of Microsoft Windows since the initial release in 1985. Files saved in Notepad have a **.txt** file extension, unless otherwise specified by the user. A common use for Notepad is HTML. Users can code HTML by hand in Notepad and save their work with a **.html** extension.

Windows Look and Feel

Windows Aero (Authentic, Energetic, Reflective, and Open) was an enhancement to the graphical user interface look and feel introduced in Windows Vista. Aero was designed to have a glass-like appearance (sometimes called Windows Glass) with various degrees of transparency similar to popular Linux GUIs with window

transparency of the late 1990s. The downside to the attractive look and feel is that it used more system resources and video memory to run. It was common for users to disable the feature in exchange for performance. The Windows Aero feature was one of the main reasons a greater amount of RAM and a quality 3D graphics card or motherboard was required. The glass look and feel of Aero was phased out after Windows 7 and not included in Windows 8, Windows 8.1 and Windows 10, much to the dismay of Aero fans. Another GUI feature phased out after Windows 7 is Gadgets.

Gadgets were introduced in Windows Vista. They were mini software programs that provided services, such as an online dictionary, clock, calendar, weather report, and CPU monitor. Gadgets were continued through Windows 7, but dropped for Windows 8 and later. Windows 10 has a similar basic look and feel to Windows 7 without the Aero styling and with the addition of the Tile-based **Start** menu from Windows 8. Windows 10 users see a look and feel influenced by Microsoft Fluent Design System created to establish common appearance and behavior across the OS and applications. Microsoft created UWP (the Universal Windows Platform) to support implementation of Fluent Design standards.

Drive Encryption

 1002: 1.2, 1.6, 2.6, 2.8

BitLocker Drive Encryption is an encryption feature that is available as part of many versions of the Windows OS. *Encryption* is the process of rendering the contents of a file and folder unreadable by people other than those who hold the key and are allowed to read it. BitLocker differs from earlier versions of file encryption in that it encrypts the entire volume, including the system files required for startup and log-on, rather than just data files. BitLocker ensures that data remains encrypted even when the operating system is not running. For example, if someone removes a hard drive and then attempts to access the data from another computer using a different operating system or software utility, BitLocker prevents the data from being accessed because the data remains encrypted.

BitLocker is transparent to the user after it is activated. It is designed to be used with a computer that has a Trusted Platform Module (TPM) or firmware that can read a USB flash drive. The TPM is a microchip designed to work with the BitLocker software. The TPM ensures that encryption is intact throughout the boot sequence of the computer. If the TPM is missing or has changed, the user is required to supply a password to access the encrypted data. If BitLocker is configured on a system that does not have a TPM, a startup key is required when it is first configured. A typical startup key is a software program loaded on a USB flash drive. The software program contains the encryption key used to access the encrypted drive. For Windows 7, BitLocker was a downloadable option. In Windows 10, it is a bundled option only available with Windows 10 Pro and Enterprise editions.

BitLocker To Go is an enhanced version of the BitLocker application that allows encryption of USB storage devices first introduced in Windows 7. As the name implies, you can encrypt files on a USB drive, remove the drive, and take it to another computer. Microsoft provides the BitLocker To Go Reader as a free download. It allows the user to read the contents of the encrypted flash drive. BitLocker To Go, when enabled, is automatically added to the USB flash drive or storage media by default. Starting with Windows 10, the Used Space Only encryption feature allows removable devices to be encrypted in seconds rather than minutes in most cases. There will be more discussion about BitLocker and BitLocker To Go in Chapter 15.

Desktop Multimedia Support

 1002: 1.2

Windows Media Center was a collection of media manipulation utilities and tools that was part of Windows Vista and Windows 7. Windows Media Center is available

in all Windows 7 versions. WMC was popular with users; however, it was discontinued in 2015 due to changes in the market and multimedia technologies. WMC is not included with either Windows 8 or Windows 10. It is supported as a paid add-on for Windows 8.1. With Windows Media Center, you could edit digital movies; modify or adjust digital photos; and record, copy, and create DVDs. If your PC is running Windows 7 or 8 and has a television tuner card installed, you can also watch live television.

WMC is not officially supported on Windows 10. Streaming services and third-party media applications provide similar feature sets to WMC that have replaced the need for Microsoft to provide a dedicated tool. If you are upgrading a system from Windows 7 to Windows 10, Windows Media Center will be removed and Windows DVD Player will be downloaded and installed in its place. With the advent of modern streaming services and third-party, multimedia applications, Microsoft chose not to continue with a dedicated media tool suite for Windows 10.

Windows Mobility Center

Windows Mobility Center provides a central location for accessing the most commonly used features for laptops, such as presentation configurations for a projector and energy conservation configurations. It also automatically configures common network connections, such as for the home, office, or work location. Windows Mobility Center, as viewed in Windows 10, can be seen in Figure 2-17.

The Windows Hot Start feature allows a laptop to start a selected program with the touch of a single button. There is no need to wait long periods of time while the program is located, opened, and loaded into memory. It will start an application directly out of sleep mode or hibernation and even when the computer has been turned off. The feature was designed specifically for mobile PCs.

Figure 2-17 Windows Mobility Center provides a central location for accessing the most commonly used features for laptops.



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Collaboration Tools

For collaboration, the older Windows Meeting Space has been replaced by Skype and Skype for Business. Skype is designed for video and text collaborating over a network with features such as instant message, voice, video chat, screen sharing, and conference calls. Windows 7 continued support for another collaboration tool, People Near Me, but that was phased out for Windows 8. Since 2011 with its acquisition by Microsoft, Skype has replaced Meeting Space and other legacy solutions for collaboration. The main difference between Skype and Skype for Business is that the former is designed for individual users and the latter has additional features for enterprise and business users.

Network Discovery

Network Discovery was introduced with Windows Vista and has continued to be supported by Windows 7, Windows 8, and Windows 10. It makes setting up and configuring a network easy as it automatically detects and configures a network and sets up a share and Internet connection. It also allows files to be shared much easier in a peer-to-peer network, while still providing security from the Internet. The main exception arises if there is a router or gateway being used that is not compatible with the automatic networking features.

Figure 2-18 shows the **Advanced sharing settings** menu, which is accessed from the Network and Sharing Center. Notice the **Network discovery** option in the **File and printer sharing** sections of the menu. These options let you enable and disable the respective features.

Figure 2-18 Network Discovery can be accessed by selecting **Advanced sharing settings** from the Network and Sharing Center in Windows 10.



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Windows Shadow Copy and Previous Versions

The Windows Shadow Copy feature automatically makes a copy of files that have changed and been saved. This feature allows a user to open an earlier version of a file using the Previous Versions feature. To restore a file using the Previous Versions feature, right-click the folder that held that file or the current version of that file and select **Properties** from the shortcut menu. Next, select the **Previous Versions** tab. Previous versions of the file will be listed. Select the desired file and then click **Restore**. Windows Shadow Copy was first introduced in Windows Server 2003. It is available in Windows 7, Windows 8, and Windows 10, although the features vary slightly between the various versions.

Windows ReadyBoost

Many software programs require a great deal of RAM to operate efficiently. Otherwise, the program responds slowly, may not work at all, or the system will seem to freeze up. Operating systems typically use the hard drive to store limited amounts of program information when RAM is full. For example, a computer with 1 GB of RAM may use 500 kB of memory, referred to as a *page file*, to store information temporarily. This keeps the program working reasonably well when the RAM is full. However, compared to RAM, the hard drive is notoriously slow when accessing and manipulating data.

Windows ReadyBoost allows a flash drive to store this information temporarily. Data on a flash drive can be accessed and manipulated much faster than data on a hard drive. Windows ReadyBoost is a great improvement to overall performance when a computer system is overworked. It is also an excellent feature for legacy laptops, which typically have much less memory than desktop computers.

Windows Defender

Windows Defender works directly with Internet Explorer to protect the computer from spyware. It was originally introduced to work with Internet Explorer 7. It scans files as they are downloaded to the computer through the Internet browser. Windows Defender identifies what appears to be spyware, but allows the user to decide what action to take. The possible actions are ignore, allow, quarantine, and always allow. *Quarantine* isolates and stores the suspected spyware file, allowing the user to install it later if it is found not to be spyware. Windows Defender is fully integrated with the operating system for Windows 10 and works with Microsoft Edge, the replacement for Internet Explorer.

Tablet PC Settings

Tablet PC Settings were introduced in Windows XP Service Pack 2 (SP2), and they continue through Windows 10. The enhancement to tablet settings that enabled touch screen was introduced in Windows Vista. Touch screens allow for users to input commands similarly to a mouse by touching the screen with a finger or a pen (stylus). Keyboard input can also be touch generated by displaying a keyboard on the screen and touching the desired keys. Windows 8 was designed primarily as an enhanced tablet mode GUI and eliminated the classic Windows desktop mode. Windows 10 integrated support for both desktop and tablet mode, giving the user the ability to easily transition between the two modes, and introduced touch screen gestures similar to keyboard shortcuts for touch screens.

Windows 10 tablet settings allow the user to adjust the tablet mode behavior, such as which mode to use by default and whether to ask when automatically switching tablet mode on or off. Figure 2-19A shows the **Tablet mode** settings menu. In Windows 10, touch screen and pen functionality are supported in both desktop and tablet mode so the settings for these features are no longer part of the tablet settings. The settings to configure the pen and touch display and calibrate pen input now have their own menus under **Settings**. The menu for Pen and Windows Ink settings is shown in Figure 2-19B. There is also a calibration feature to convert handwriting into text associated with typing from a keyboard. After handwriting calibration is configured, handwriting can be converted to a typed document. Tablet devices commonly have their own configuration software application and may not use the Microsoft Windows version. Windows 10 has continued feature-rich support of tablet mode.

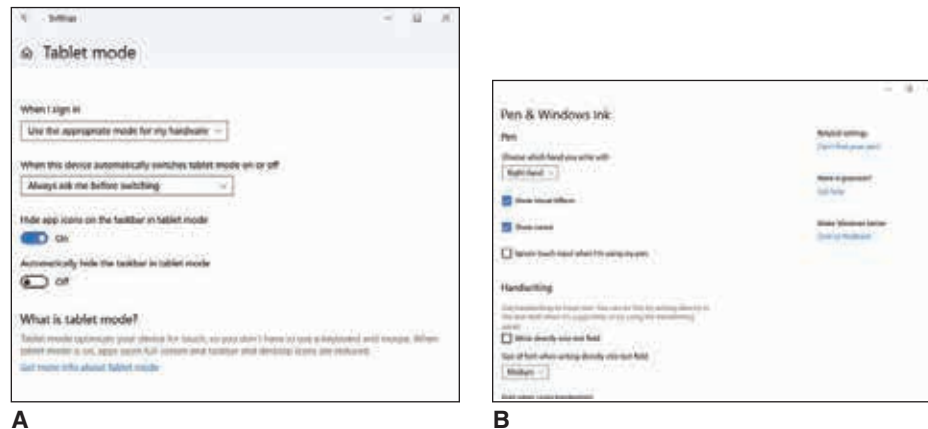


1002: 1.5

Windows Services Manager

Windows Services are applications that, most often, start when the computer is booted. They typically run in the background without the user having to interact with them. In Windows 10, the easiest way to access this menu is to enter **services.msc** into the **Run** dialog box. Once the Services menu opens, users can start, stop, or disable specific services.

Figure 2-19 Windows 10 has tablet-friendly settings to allow users to adjust pen and tablet features related to the display area.



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XP Mode

For Windows 8 and above to run XP emulation, you will need to use Hyper-V or a third-party virtualization tool. XP mode was a one-time migration feature added to Windows 7. XP Mode is not installed by default during the operating system installation. Rather, it can be installed from a free download from the Microsoft website. The download is actually two separate downloads: Windows Virtual PC and a full version of Windows XP, which is actually installed on the virtual machine.

After XP Mode is installed and configured, you can install software programs and applications that run under the Windows XP operating system onto the virtual machine. This is not a dual-boot system; rather, Windows XP is running simultaneously with Windows 7. Dual-boot systems and virtual machines are covered later in this chapter.

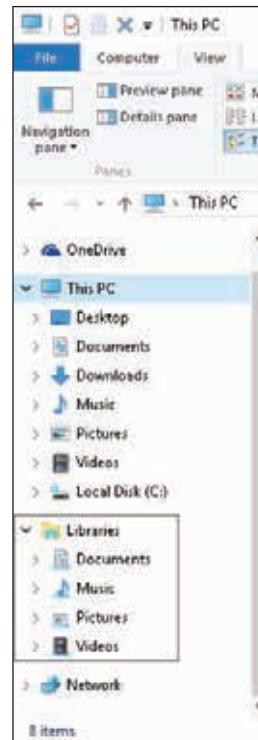
Files can be copied between the Windows XP Mode program and the Windows 7 programs. XP Mode allows you to run a software program designed for the Windows XP environment successfully. XP Mode is only available in Windows 7 Professional, Ultimate, and Enterprise editions.

Libraries

Libraries were introduced in Windows 7 as alternatives to the My Documents and Documents folders in older Windows operating systems. A *library* is a virtual container of user content, such as documents, music, and pictures. It is a virtual container because the content included in a library can be located on the local computer, remote locations, and on exterior storage devices. Libraries serve as a pointer to content. The idea is to have one central virtual storage location for the user.

There are four default folders in a library: Documents, Music, Pictures, and Videos. Libraries are not the only way folders can be organized on Windows 7 and later computers. The Public folders, which were first introduced in Windows Vista, can also be used. Libraries are supported under Windows 10, but must be enabled in File Explorer. To enable, open File Explorer and select **This PC**. Next, select **View>Navigation pane>Show libraries**. Once enabled, the four default library folders will appear, as shown in Figure 2-20.

Figure 2-20 To enable Libraries in Windows 10, open File Explore and select **This PC**. Next, select **View>Navigation pane>Show libraries**.



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1002: 1.2

BranchCache

BranchCache is a feature of Windows that allows remote, or branch, network users to download desired files to a central cache. When multiple users across a WAN are repeatedly requesting materials, the available bandwidth on the network decreases. BranchCache solved this by storing copies of the requested content, essentially creating a cache at the remote location. When other users from the same branch of the network request the same content, they receive information from the local cached data.



1002: 1.5

Task Manager

Task Manager provides a resource for users to find detailed information about a computer's applications, processes, performance, networking statistics, and user data. Users can use Task Manager for a variety of reasons, including setting processor affinity, starting and stopping services, and forcibly ending processes, among others. Task Manager can be launched by entering **task manager** in the Search field, or by using the [Ctrl][Shift][Esc] keyboard combination.



1002: 1.5

Task Scheduler

Task Scheduler is an administrative tool in Windows. As the name implies, it can be set to run tasks or programs at a future time. A common example of a task programs schedule for startup is to look for software or firmware updates. The easiest way to open Task Scheduler is to type **task scheduler** in the Search bar or enter **taskschd.msc** in the **Run** menu. Once open, you can view groups and subgroups that match the folder structure of a corresponding area in Explorer. Users can view information about each task, such as what triggers the task, the actions performed, history of this task's past actions, and related settings.

Microsoft User Account


1001: 3.9

There are two general user account types associated with Windows 8. They are the *local user account* and the *Microsoft account*. The Microsoft account is a combination of your e-mail address, such as `Student1481@email.com`, and a password. The local user account name is simply a username such as `Student1481` and a password. The e-mail address used for the Microsoft account does not need to be a Microsoft e-mail account. Any e-mail account you own can be used. For example, you could use your Gmail account or the account provided by your Internet service provider.

The Microsoft account is configured during installation of the operating system or creation of a user account. When you log on to the computer using your Microsoft account, you automatically connect to the Internet. If configured, you will also automatically connect to your e-mail account, Facebook, Twitter, LinkedIn, and to an assortment of other accounts. When you log on using the local user account, you do not automatically connect to the Internet.

Windows To Go

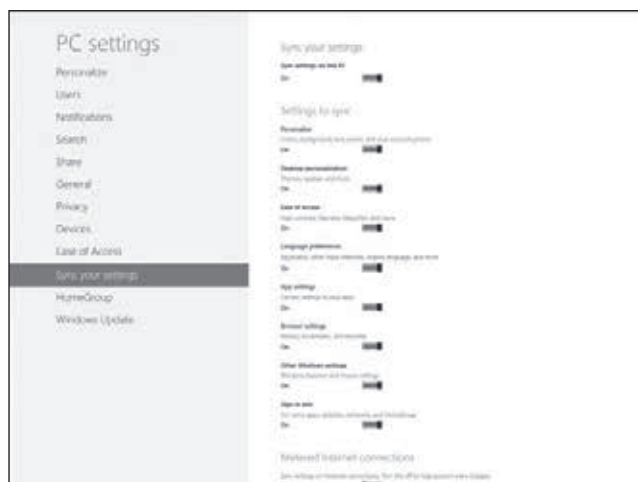
Windows To Go is a feature specific to the Windows 8 Enterprise edition. It allows a Windows Enterprise operating system and desired files and folders to run from a USB storage device, such as a flash drive or external hard drive. The idea is to allow technicians in the corporate or enterprise environment to plug their USB storage device into any computer and boot to their own personal computer configuration. This feature was retained for Windows 10.

Sync Your Settings


1001: 1.7; 1002: 1.6

File synchronization is not new to Windows, but the **Sync your settings** option in Windows 8 is redesigned with many additional features. The screen capture in Figure 2-21 shows the **Sync your settings** options in Windows 10. Notice the list of items that can be synchronized between all your Windows devices. Items that can be synchronized include contacts, applications, e-mail, pictures, music, videos, calendar, bookmarks, documents, location data, social media data, e-books, passwords, and more. This is a great improvement over earlier versions of synchronization because it requires little effort or technical skills on the user's part. To sync

Figure 2-21 The **Sync your settings** option in Windows 8 allows you to synchronize all Windows 8 devices, including PCs and mobile devices.



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your settings requires a user to log on to the computer with the Microsoft account so that the settings will be saved on any of the Microsoft cloud services. This means that when you use a device that automatically connects to cloud services using your Microsoft account, your personal settings will match on each device.

Picture Password

Windows 8 introduced two authentication methods for logging on to a Windows 8 device. The new authentication methods were designed to better accommodate touch screen devices, such as tablets and phones. A user can authenticate using either a PIN or picture. The PIN is a four-digit number created by the user. When using the picture authentication method, you first select a picture. Then you draw directly on the touch screen creating a combination of circles, straight lines, and taps locations. The size, direction, and location of your gestures become your picture password. You can still log on to your PC using a standard password.

Recovery, Refresh, and Reset

The System Recovery feature has been changed from previous versions of Windows by introducing two new wizards: **Refresh** and **Reset**. The recovery wizards are designed to repair your Windows 8 system with limited user interaction. The Windows 8 recovery options are shown in Figure 2-22.

When the **Refresh** wizard is run, the operating system is reinstalled and personal files, settings, and apps that come with Windows 8 or from the Microsoft Application Store are retained. Any apps from other vendors will not be reinstalled. A list of these apps will be created so you can reinstall them, either from the vendors or from a backup copy.

When the **Reset** wizard is run, the operating system is reinstalled and all personal files, settings, apps, and user configurations are lost. Only the standard apps that come with the operating system are reinstalled. The advanced options located under **Advanced tools** in the **Recovery** dialog box allow you to create a recovery drive, open a system restore point, or configure a system restore point. These three features were available in previous versions of the operating system.

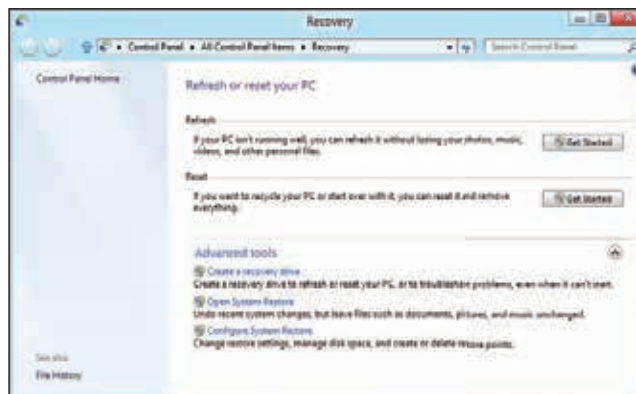


1002: 1.3

Microsoft Windows Installation

When installing Windows, you can perform an upgrade or a clean install. An *upgrade* means that you can install Windows on an existing operating system and retain files,

Figure 2-22 Windows 8 introduced two wizards to the System Recovery feature: Refresh and Reset.



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settings, and applications. A *clean install* means that either there was no OS on the hardware or the previous installation is being completely replaced, overwriting all files, settings, and applications. Microsoft uses the term *custom* to refer to a clean install on top of an existing Windows partition. Before performing a clean install or custom installation, you must back up all data. After the installation process, the data can be restored to the system.

Sometimes, upgrading from a previous version of a Windows operating system to a newer version requires a clean install. For example, to upgrade to Windows 10, the system must already be running Windows 7, 8, or 8.1. For all older versions of Windows, one would need to do a custom install, which would wipe out all data on the hard drive, and perform a clean installation of Windows 10. Be aware that hardware, software applications, and drivers used for the previous operating system may not be supported in a newer version of Windows. Before performing an upgrade or clean install, it is always a good idea to run the Windows Upgrade Advisor to ensure compatibility, especially on older hardware.

It is recommended that in most cases, you do a clean install after partitioning and reformatting the hard drive. This will eliminate any file fragments and most registry corruption from the previous operating system version. This also provides an opportunity to format the hard drive properly with the appropriate partitions and formatting needed for your installation. Before you perform a clean install, be sure you have all hardware device drivers available and a copy of all previously installed applications. Back up all files and be sure to turn off any antivirus programs.

Windows installation can also be achieved through image deployment, which refers to three categories of available options for performing a Windows installation:

1. Modern deployment is the preferred method for enterprise management using Windows autopilot to install OS and applications or using Windows Setup to do an in-place upgrade. This method supports using enterprise tools such as Microsoft Deployment Toolkit and System Center Configuration Manager.
2. Dynamic deployment methods provide tools to customize the OS install for a specific purpose like mobile devices using either subscription activation, Active Directory and Mobile Device Management (MDM), or Windows Imaging and Configuration Designer tool with provisioning packages.
3. Traditional deployment methods use standard tools and methods to deploy operating system images.

There will be much more about disk images and image deployment in Chapter 21.

Windows Versions and Editions

Not every copy of Microsoft Windows is the same. Windows is available in different versions and editions. A *version* of Windows most often refers to the major operating system releases, such as Windows 7, Windows 8, and Windows 10. An *edition* is a specific type of version, such as Home, Pro, and Enterprise. You can think of versions and editions like makes and models of vehicles. The brand, or make, of the vehicle would be the equivalent to a Windows version, and the model of the vehicle would be the equivalent to a Windows edition. Every version of Windows has various editions and requirements unique to itself. This section will discuss the differences between editions.

Windows 7 Editions

The editions of Windows 7 you will most likely encounter are Home Premium, Professional, and Ultimate. There are additional editions such as Starter, Enterprise,

A+ NOTE



The CompTIA A+ Exams often ask questions requiring you to match which operating system edition can be upgraded to another. Be sure you can answer these types of questions.

TECH TIP



Always back up the entire computer system before performing an upgrade or a custom install. Anything might go wrong. Without a complete backup, you may not be able to restore the system files or data files.

A+ NOTE



For the A+ Certification Exams, be sure to know the difference between hardware recommendations for 32-bit, 64-bit, and tablet versions.



**1001: 1.8, 3.8;
1002: 1.1, 1.7**

and those with the letter *N* affixed to the edition name. The Starter edition is limited to emerging countries and not sold as a retail copy in the United States. Only an original equipment manufacturer (OEM) may purchase the Starter edition and install it on certain minimal systems, such as tablets. The Enterprise edition is not available for retail purchase and can only be sold through the volume-licensing program. *Volume licensing* is when multiple copies of the operating system are sold to a large consumer, such as a corporation, government, or educational institution. It allows multiple copies of the same operating system to be installed using the same activation key and is based on the number of users or workstations in the organization. The Professional and Ultimate editions are also available through volume licensing, but not to the general public or OEMs. When you see the letter *N* affixed to the name of the version, it means the operating system does not include Windows Media Player or Movie Maker. Figure 2-23 lists the Windows 7 system requirements.

Not all versions of an operating system are upgradable. For some editions, you must back up all important files and then install the new operating system. During the installation process, all existing files are destroyed because the new operating system deletes existing files and replaces the old operating system. When performing an upgrade, the new operating system preserves existing user files such as documents, pictures, and movies. Even the old operating system is typically saved in a folder identified as *OldWindows*. Saving the old operating system will usually allow the installation of a new operating system to be reversed if something goes wrong. It is best to back up all important files before installing a new operating system, even before performing an upgrade. Things can go wrong, and valuable files can be lost.

An important note to consider is that, as of this writing, Mainstream Lifecycle Support for Windows 7 has ended. Additionally, extended support will end in the coming year. This means Microsoft will no longer provide security updates or support for PCs running Windows 7.

Figure 2-23 A computer must meet the minimal requirements to install Windows 7.

Hardware	32-bit	64-bit
CPU	1 GHz	1 GHz
RAM	1 GB	2 GB
Hard drive space	16 GB	20 GB
Graphics support	DirectX 9 and Windows Display Driver Model (WDDM) 1.0	
DVD drive	Required for installation or upgrade using a retail version of the operating system	

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Windows 8 Editions

Windows 8 is available in just four editions: Windows 8, Windows 8 Pro, Windows 8 Enterprise, and Windows 8 RT. Windows 8 RT edition is designed especially for portable devices, such as tablets and phones. Other editions are designed for devices with more resources such as a powerful CPU and lots of memory. Installation requirements for Windows 8 are listed in Figure 2-24.

Windows 8 will run on 32-bit or 64-bit systems and on an ARM device. ARM devices are also referred to as advanced RISC machines. They are typically portable devices with limited computer resources and are designed for very little power consumption so that the battery lasts as long as possible. ARM is used in devices such as smartphones, tablets, iPads, and some gaming devices. Some tablets use processors other than ARM, such as the Intel Atom.

Windows 8.1 Editions

Windows 8.1 has three editions: Basic, Pro, and Enterprise. These equate to a version for home users, small businesses, and large corporations, respectively. Some Pro features require a server running Windows 2012 on the local network in order to function.

An important note to consider is that Windows 8.1 will follow the same lifecycle policies as Windows 8. As of this writing, mainstream support for Windows 8 has ended, and extended support is likely to end in a handful of years.

Windows 10 Editions

Windows 10 is available in 12 different editions, each with various features and intended usage. Baseline editions of Windows 10 include Home, Pro, and Pro for Workstations. Organizational editions include Education, Pro Education, Enterprise, and Enterprise Long-Term Servicing Channel. Device-specific editions include IoT and Team. Baseline editions of Windows 10 have gone through multiple release versions. With each release update, the OS changes in a variety of ways. For example, in release version 1803, HomeGroup was replaced with a new feature called Nearby Sharing. This can make it difficult to stay up to date on features and requirements.

Figure 2-25 lists the Windows 10 minimum system requirements. To learn more about any particular operating system, visit the Microsoft website or conduct a search using the key terms Microsoft features followed by the name of the edition, such as Windows 10 Home.

Figure 2-24 System requirements for Windows 8 are similar to those for Windows 7.

Hardware	32-bit	64-bit
CPU	1 GHz	1 GHz
RAM	1 GB	2 GB
Hard drive space	16 GB	20 GB
Screen resolution, for Start interface	1024 × 768	1024 × 768
Screen resolution, for Snap feature	1366 × 768	1366 × 768
Graphics support	DirectX 9 or higher	DirectX 9 or higher

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Figure 2-25 Windows 10 requirements are the same as those for Windows 8.

Hardware	32-bit	64-bit
CPU	1 GHz	1 GHz
RAM	1 GB	2 GB
Hard drive space	16 GB	20 GB
Screen resolution, for Start interface	1024 × 768	1024 × 768
Screen resolution, for Snap feature	1366 × 768	1366 × 768
Graphics support	DirectX 9 or higher	DirectX 9 or higher

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Windows Easy Transfer

Windows Easy Transfer tool is designed to assist during a custom install to back up and transfer user files and settings. You can use it to transfer user accounts, files, and settings to a USB storage drive, similar to performing a backup. Then, after performing a custom install, use Windows Easy Transfer tool to reinstall the files and settings to the new operating system. You can also use this tool to transfer user accounts, files, and settings from an old computer to a new computer. Windows Easy Transfer is available for Windows 7, 8, and 8.1 and is not supported in Windows 10. Windows 10 users will need to use a third-party tool to replicate the functionality of Windows Easy Transfer.

TECH TIP



When possible, always use the latest version of WinPE to deploy Windows.

Windows PE

Windows Pre-installation Environment (WinPE) is a minimal 32-bit Windows operating system that prepares a disk storage system before the complete operating system is installed. In addition, Windows PE supports CD, DVD, and USB flash drives, all of which may be required for the complete operating system installation. Windows PE supports the Remote Installation Services (RIS), which allows an operating system to be installed from across a network. Windows PE is part of the Windows installation program when performing a complete installation from a Windows DVD.

The latest version at the time of this writing is based in the Windows 10 environment. In Windows 10, Windows PE functions as a small operating system. It is used to install, deploy, and repair Windows 10 for Home, Pro, Enterprise, and Education editions. It can also be used for Windows Server and other Windows operating systems.

In addition to preparing a computer for operating system installation, Windows PE can be used to recover a failed computer or for troubleshooting purposes. Windows PE is part of the Windows Automated Installation Kit (WAIK). The WAIK is a set of installation tools available for free download from the Microsoft Support website. The tools allow a computer technician to create disk images, deploy operating systems automatically to computers that have no operating systems, manage existing systems by automatically installing new device drivers, and create a Windows Pre-installation Environment on a disk or flash memory device.

A+ NOTE



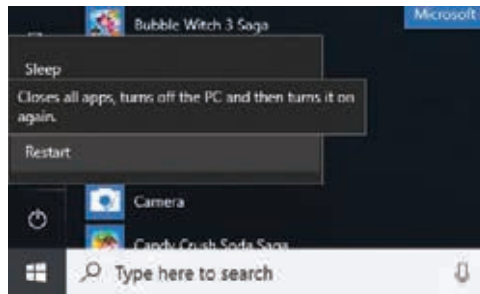
The A+ Certification Exams usually stress knowledge of the boot sequence. Exercises in the accompanying Laboratory Manual will help you understand the boot process better.

Microsoft Windows Boot Sequences

A **boot sequence** is the step-by-step process of bringing a computer to an operational state. This involves a combination of hardware and software control to initialize hardware and load operating system files. This section serves as an introduction to the boot sequences of Windows 7, Windows 8, and Windows 10. An in-depth understanding of boot sequences is essential to troubleshooting startup problems. Therefore, a more detailed description is presented in Chapter 17.

Warm and Cold Booting

A computer cannot begin the boot sequence if it is not initiated. When the boot sequence is initiated, it is called *booting the computer*. There are two styles of booting a computer: cold boot and warm boot. A **cold boot**, also called a *hard boot*, means that the electrical power switch is used to turn on the computer. A **warm boot**, or *soft boot*, is used to restart a computer that is already running. A warm boot can be initiated by a software program as part of a typical installation, such as installing a game. Another common style of initiating a warm boot is by using the [Ctrl][Alt][Delete] keyboard combination or selecting **Start>Power>Restart**, as shown in Figure 2-26.

Figure 2-26 The **Restart** command can be used to perform a warm boot.

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POST

All operating systems start with a power-on self-test. The **power-on self-test (POST)** is a simple diagnostic program that is initiated when electrical power is applied to the computer system. It is common to all operating systems, even to macOS and all versions of Linux. The POST does a quick system check to determine if all major hardware components, such as the CPU, RAM, keyboard, mouse, video system, and storage devices, are in proper working order. The devices checked may vary slightly from computer to computer depending on the firmware.

The test it performs is not as sophisticated as diagnostic software, but it will check for major problems. When the POST is finished, it usually makes one “beep” sound to let you know that the POST is complete and everything is in working order. If an error is detected during the POST, an error code is usually displayed on the screen and a series of beeps is heard that match the code. The codes and beep pattern vary according to the different BIOS or UEFI chip manufacturers. A list of error codes and beep codes can be obtained from the website of the manufacturer.

BIOS

In a BIOS-based system, the POST is initiated by the bootstrap program in the firmware. The **bootstrap program** is a short program that runs the POST; searches for the Master Boot Record (MBR), which is typically located on the first section of the hard drive; loads into memory some basic files; and then turns the boot operation over to the operating system. The word *bootstrap* comes from the expression “to pull oneself up by one’s bootstraps.”

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1001: 3.5; 1002: 1.8

UEFI

The boot sequence is slightly different for a computer equipped with UEFI or EFI. The Unified Extensible Firmware Interface (UEFI) is a modern approach to the BIOS system and an enhancement to the boot process. When a device equipped with UEFI completes POST, control is turned over to a built-in boot manager program rather than the MBR, which contains the bootstrap program. The UEFI firmware uses an improved hard drive technology known as the GUID partition table. There will be more about UEFI and GUID later in this textbook when you have a better understanding of data storage and system files.

Some computers have a UEFI boot manager and an MBR to ensure backward compatibility. UEFI is backward compatible with devices and software that require BIOS firmware. The UEFI firmware directly supports BIOS features using a compatibility support module (CSM), which is programmed into the UEFI. The CSM emulates the BIOS features. For example, when a computer system that has BIOS firmware is

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1001: 3.5

TECH TIP

Because the term *BIOS* is so ingrained in computer technician jargon, it will still be used for many years to represent the correct term *firmware* and *UEFI*. Although not technically correct, this is the way technical language commonly evolves. You will often encounter terms that are not always correct when reading resource materials and talking to other technicians.

A+ NOTE

When answering questions related to the Windows 7, Windows 8, and Windows 10 boot sequence, remember these operating systems use the Windows Boot Loader file, **winload.exe**, not the legacy **ntldr**.

upgraded to a new operating system that uses UEFI firmware and supports the GUID partition table, the UEFI technology will use CSM to support a BIOS MBR partition. This way, backward compatibility is maintained. Windows operating systems began support for EFI and UEFI with the release of Windows Vista. Windows operating systems must be 64-bit versions to use UEFI.

Windows 8 was designed with a secure boot sequence to prevent malware and unauthorized changes to the operating system. By default, Windows 8 installs the boot sequence for the use of UEFI firmware. Windows 8 does have the ability to run on computers designed with BIOS, but some of the security features will not be installed because BIOS cannot implement these features. UEFI firmware protects the computer before the start of the Windows 8 operating system. The UEFI system allows the antimalware program to begin before the operating system starts. The early start of antimalware software helps to prevent attacks on the computer before the operating system is loaded. Also, Windows 8 only allows the installation of Microsoft preapproved software applications. The purpose of this is to prevent malware applications from altering or damaging the system configuration. There will be much more about UEFI protection later in Chapters 15 and 16.

Windows Boot Sequences

Starting with Windows Vista, Microsoft made several changes to the boot sequence. For example, Windows Vista and later operating systems will boot from either the BIOS or UEFI. In Windows 10, after the POST completes, the firmware boot loader boots the UEFI instead of using the BIOS, which shortens boot times and supports more options than BIOS such as loading OEM UEFI applications.

The next phase for Windows 7, Windows 8, and Windows 10 is the Windows Boot Manager phase. In this phase, the Windows Boot Manager (**bootmgr**) reads a registry-type file called the Boot Configuration Data (BCD) file. This file stores boot configuration information, such as the names of the operating systems to list in a boot menu, the amount of time the boot menu should be displayed while waiting for user input, and the default operating system to load if no user input is entered.

The Windows Boot Manager (**bootmgr**) replaces **bootcfg.exe** used by older Windows NT-based operating systems. The Windows Boot Manager will not display a selection of operating systems if there is only one operating system on the computer. If there are two or more operating systems, the Windows Boot Manager appears for approximately 30 seconds to allow the user to select which operating system to boot. If no selection is made, the default operating system is started.

When the Windows Boot Manager phase completes, the Windows Boot Loader (**winload.exe**) phase begins. First, the kernel (**ntoskrnl.exe**) is loaded into memory but not executed. The **hal.dll** file and registry data are also loaded into memory. The Windows Boot Loader phase ends by executing the kernel. The kernel-loading phase begins.

In this phase, the kernel starts the Session Manager (**smss.exe**), which creates the system environment. Up until now, the operating system has been in a text-based mode; however, with **smss.exe** loaded, the operating system switches to graphics mode by loading the GUI. It is at this point that the familiar progress bar appears at the bottom of the screen.

The kernel interacts with **hal.dll** and the registry information in memory to load hardware drivers and other files necessary to complete the boot operation. The last phase in the boot sequence is the logon phase, which is initiated by the loading of the Logon Manager (**winlogon.exe**). After a successful user logon, the desktop appears, and the user can start using the various software applications.

Certain files are automatically loaded into RAM after a successful user logon. These files are generally referred to as startup programs. They will start quickly after they are selected from the **Start** menu or from a shortcut icon because they are already loaded into RAM. If a program is not a startup program, it will need to be loaded to RAM before it starts, thus causing a short delay in program response when selected. The following details Windows 7, Windows 8, and Windows 10 boot sequence:

For Windows 7 and 8

1. BIOS performs the POST.
2. BIOS finds the boot location via the MBR and loads it into memory.
3. BIOS locates and loads the Windows Boot Manager (**bootmgr**).

For Windows 10

1. Firmware performs the POST.
2. Firmware boot loaders bootstrap the UEFI environment (think mini-OS).
3. Run any SoC vendor, Microsoft, or OEMs UEFI level applications.
4. UEFI finds the boot location via the GUID partition table (GPT).
5. UEFI launches the Windows Boot Manager (**bootmgr**).

Common steps Windows 7, 8, and 10

- A. Windows Boot Manager reads the BCD file and displays the boot menu.
- B. Windows Boot Manager starts the Windows Boot Loader (**winload.exe**) when Windows 7, Windows 8, or Windows 10 is selected or if started automatically.
- C. The Windows Boot Manager loads **ntoskrnl.exe** and **hal.dll** into memory and scans the registry for device drivers to load. It then passes control to the kernel.
- D. The kernel loads the device drivers and **hal.dll** and initializes the computer settings using the values stored in the system registry.
- E. The kernel starts the Session Manager (**smss.exe**), which creates the system environment.
- F. The operating system switches to graphics mode and the **winlogon.exe** file is loaded, thus starting the Logon Manager (**winlogon.exe**).
- G. The Logon Manager allows the user to begin the logon process.

Dual-Boot and Multiple-Boot Systems

When two operating systems are installed on a single computer, it is referred to as a **dual-boot system**. For example, Windows 8 and Windows 10 can both be installed on the same computer, resulting in a dual-boot configuration. The Windows Boot Manager or a third-party boot loader such as GRUB allows the user to select which operating system to start. If no selection is made, the Windows 10 operating system will start by default.

You could also configure a **multiple-boot system**, which contains more than two operating systems. For example, you could have Windows 7, Windows 8, and Windows 10 installed on the same computer. You could also add a non-Microsoft operating system, such as Linux. A multiple-boot system is often referred to as a *multiboot*.

Virtual Machine

When a computer is configured as a dual-boot or multiple-boot system, you can only run one operating system at a time. However, a virtual machine can be created using

TECH TIP



You can create a dual-boot system with Windows 10 by making a spare partition on your system drive and loading it with any legacy versions of Windows, such as Windows XP, Windows Vista, Windows 7, or Windows 8.



1002: 1.3



1001: 3.8

a special software application that allows more than one operating system to be executed at the same time. A computer that runs two operating systems at the same time is referred to as a **virtual machine** or *virtual PC*. The Microsoft application for creating a virtual machine is called *Windows Virtual PC*. There is also a third-party vendor that markets virtual machine software called *VMware*.

When two operating systems are running at the same time, they must share the CPU and the RAM. Sharing the CPU and RAM negatively impacts computer performance when compared to a dual-boot or multiple-boot system.



1002: 1.1

Apple Macintosh OS

MacOS is the operating system developed by Apple, Inc. to run on their Macintosh line of computer systems. The current version is macOS Mojave and was released in September 2018. It includes many popular applications from Apple's mobile operating system, iOS. The macOS Mojave system includes a redesigned app store and *dark mode*, which is an inverse of the classic white background in the GUI.

To understand the feature set behind macOS, one should look at the history of the company. In 1996, Apple purchased a second computer company called Next Computer, which was also founded by Steve Jobs. That purchase included rights to the Next operating system known as NextSTEP.

MacOS is derived from NextSTEP, which itself was based off the Mach kernel from CMU and the Berkeley Software Distribution (BSD) of the Unix operating system. NextSTEP is also the foundation for the operating systems that run other Apple devices such as iOS and watchOS. Because of the common code base behind all of its operating systems, Apple can provide a high level of integration among their various families of products.

Macintosh computers tend to have a higher price point than standard, Windows-based PCs. However, they do have more advanced features when it comes to creative work such as graphic design and video production. Often, Macs are not found in traditional office-type work environments, but they are used almost exclusively in industries that fit their creative features.



1002: 1.1

Common Mobile Devices and Operating Systems

In general, mobile operating systems are designed for portable devices with limited hardware resources, such as cell phones or smartphones, tablets, and some gaming hardware. Although some mobile operating systems do appear on larger devices, such as laptops and tablets, they are typically designed with limited CPU and memory support. For example, they will not support extensive graphics associated with games or sophisticated graphic design programs, such as some web design software or computer-aided drafting and engineering software. In general, the mobile operating system is designed to provide the widest assortment of popular user applications on limited hardware with a minimal amount of software required to perform a task. Common portable device tasks are Internet access and collaboration activities, such as instant messaging, texting, social media, taking photos, and sharing music and photos. As mobile device operating systems and mobile devices evolve, it will soon be difficult to discern between what is considered a mobile device and what is not.

Windows Mobile is an operating system developed by Microsoft starting in the mid 1990s to run on mobile devices and pocket computers. At the time of this edition, Windows 10 Mobile is the latest and likely the last version of the product. In 2017, the company ended support for the previous version 8.1 and announced that version 10 was moving into service mode. This indicates there would be no further features

TECH TIP



1002: 1.1

The phrase *end-of-life* refers to a product that is supplied to consumers that has reached the end of its utility, according to the vendor. In response, the vendor stops marketing and selling the product, and they will eventually end or limit support for it, resulting in fewer or limited updates.

or support for new hardware added. This essentially means the Windows Mobile OS is at the end of its life.

The Android OS was introduced by Google in 2008 to power mobile phones from various manufacturers and compete with iOS. The platform is promoted by the open handset alliance—a group of technology and mobile companies that integrate the Android OS into their products. Chrome OS is another mobile operating system developed by Google. Derived from the Linux operating system, it is designed to run on a range of mobile devices other than smartphones.

Perhaps the most important thing to remember when working with mobile devices and their respective operating systems is that they are generally not compatible with one another. For example, iPhones manufactured by Apple are likely not going to be able to run Android, Chrome, or Windows Mobile and vice versa.

Cloud Computing

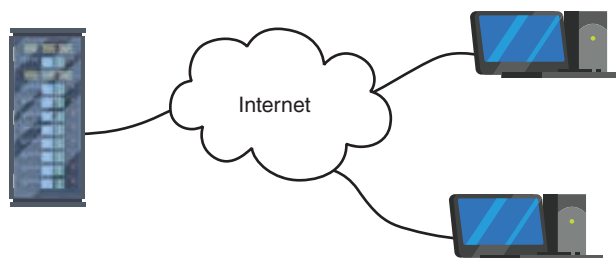
Cloud computing is accessing a shared pool of resources and specialized services over the Internet. Examples of shared resources and services are storage, application software, instant messaging, e-mail, and database support. The term *cloud* is synonymous with the Internet symbol used in network drawings, Figure 2-27. The cloud symbol represents the Internet location of a service. The cloud-computing concept is not as new as you might think. It has actually been around for many years, even before the term *cloud* was used. If you have ever used webmail, Facebook, or an online photo sharing or online gaming program, then you have used a cloud-based system.

Cloud services have expanded rapidly in recent years because of mobile devices, such as smartphones and tablets. These two types of mobile devices do not have sufficient memory, storage space, or powerful CPUs, which is why the demand for cloud services has increased. The cloud provides storage services and the ability to use large software applications, which cannot possibly be installed on the portable device. For example, a mobile user can access the complete Microsoft Office suite via the Internet using a portable device. The success of mobile devices depends greatly on cloud computing.

Typically, users install the entire software application on their computer. After installation, they have complete access and control over the use and configuration of the software application. Users can also store files on their computer as related to the software application. In a cloud computing setting, the user would install a small software application, or **app**, which allows the user to access the larger software application on the cloud service. The software appears to the user as though it is installed entirely on the PC or portable device, when in reality the software application is installed on the cloud server. A computer with minimal hardware resources that relies on cloud services for software is referred to as a **thin client**. A thin client depends on the cloud-based software application to do most of the work. The user has

+ 1001: 1.4, 2.3, 3.8, 3.9;
1002: 2.4

Figure 2-27 In most network drawings, the Internet is represented as a cloud.



Goodheart-Willcox Publisher; (server icon) fullvector/Shutterstock.com; (workstation icons) RedlineVector/Shutterstock.com

the option to store the document on the cloud location or on the computer. When software applications are provided through cloud services, it is often referred to as **virtualization**.

Cloud services can be provided free of charge or for a cost. When free of charge, fewer services and less storage space are provided as compared to pay services. There are many cloud service providers such as Google, Apple, Microsoft, Amazon, VMware, IBM, and other private companies.

The real strength of cloud computing is resource pooling and sharing. Computer resources such as documents, pictures, videos, and other types of files can be easily shared with members of the cloud service. In addition to sharing resources, the cloud service provider typically makes available software applications appropriate for each type of cloud membership. For example, word-processing, database, e-mail, and digital photo software applications may be provided as a service. The cloud member does not need to install the software application on the mobile device but instead is able to connect to the host cloud as a thin client. The advantage of the software application being installed on the cloud server means that the software application will be available no matter which device the user decides to use. Users can run the software application from their desktop, tablet, or cell phone. Another advantage is the cloud service provider is responsible for updating the software application, making backup files, and providing the necessary technical support.

Microsoft offers several versions of cloud services at this time, such as Microsoft Office 365, Windows Azure, and Microsoft Intune. Some of these services are free, but most are not. The fees vary in range based on the desired services and number of users. For example, the cost of the service can be based on the number of users determined by the number of unique e-mail accounts.

Cloud computing facilitates the configuration of devices related to the Internet of Things (IoT). The Internet of Things (IoT) is a system of devices with unique identifiers that transfer data over a network connection, which is usually wireless or Bluetooth, without the need for human interaction. Examples of IoT devices include smart-home devices, such as thermostats, light switches, security cameras, door locks, and digital assistants, as well as wearable technology such as smart watches, fitness monitors, and virtual reality or augmented reality headsets. Aside from their functions, the main difference between these IoT devices is that home-based devices typically use Z-wave communication protocols where wearable technology usually runs off ANT+ wireless technology.

Common Operating System Terminology

There is a tremendous amount of operating system terminology common to all operating systems. A few terms should be mastered early, such as application software, software driver, and software patch. There will be many more terms introduced throughout the textbook and your instruction. Be sure to master these three for now.



1001: 1.7, 3.8, 3.9;
1002: 1.1, 1.3

Application Software

Application software, also referred to as *end-user software*, is designed for a specific purpose, such as creating databases or spreadsheets, word processing, producing graphics, or just for entertainment. It is not an operating system.

Typical application software relies on the operating system to communicate with PC hardware such as the hard drive or CD-ROM drive. When a word-processing program issues a save command, the command is interpreted by the operating system, which in turn passes it through the CPU and on to the hardware. While most 32-bit software applications will run on a 64-bit computer system, some will not.

Antivirus programs are a classic example of a software application that must match the system type: 32-bit or 64-bit.

Software Driver

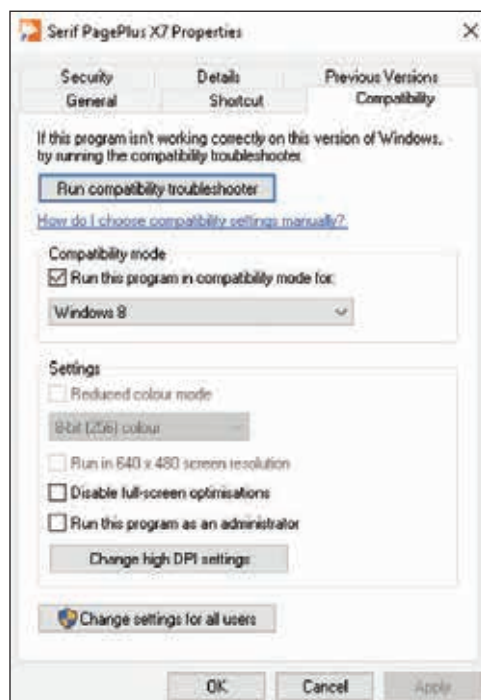
A **software driver** is a small package of programs that allow proper communication between the computer and a peripheral device. Common devices that require drivers are printers, modems, monitors, and storage devices. Software drivers act as translators, converting common commands issued from the CPU to the device in use.

PC and software systems are constantly evolving, but not necessarily in the same time frame. For example, you may install a printer that is much newer than the software installed on a computer. The computer may not have the software programs necessary to communicate correctly with the printer. A typical scenario is when a new printer is installed on a PC and the self-test runs perfectly. However, when a file you have created on the PC is sent to the printer, it prints out a garbled set of meaningless symbols or an endless stream of blank pages. This is a classic case of incorrect driver software.

Software drivers are typically classified as 32-bit or 64-bit and are not interchangeable. You must match the driver to the type of operating system. Microsoft operating systems require 64-bit driver software to be digitally signed. A digitally signed driver contains a security code that identifies and verifies the developer of the software driver. Because the driver is verified, Microsoft recognizes it as a driver from a legitimate software vendor and that does not contain malware.

Windows operating systems incorporate options to allow you to run legacy software applications and legacy drivers. The screen capture in Figure 2-28 shows the options for configuring a program to run as if it were installed on a previous version of Windows. In this example, the PagePlus 7X publishing tool installed in Windows 10 is configured to run as if it were installed on a Windows 8 version of the operating

Figure 2-28 Windows operating systems provide compatibility options for configuring legacy software applications.



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system. Microsoft provides a compatibility wizard launched via the Control Panel, as shown in Figure 2-29. The Program Compatibility Troubleshooter automatically detects possible compatibility problems associated with various legacy programs, Figure 2-30.

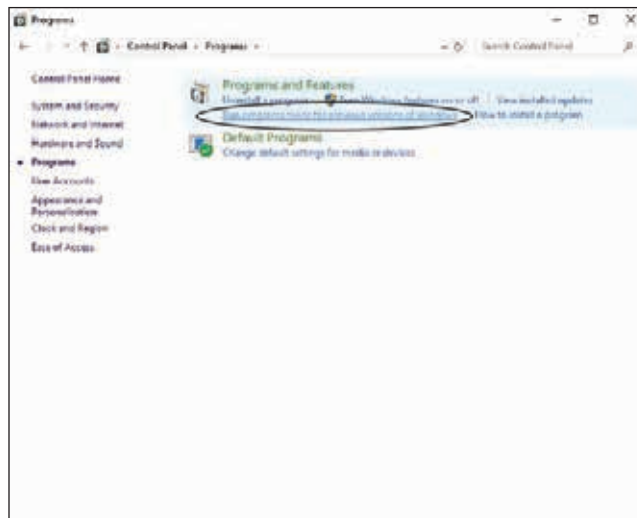


1002: 1.3, 2.6, 2.8

Software Patch

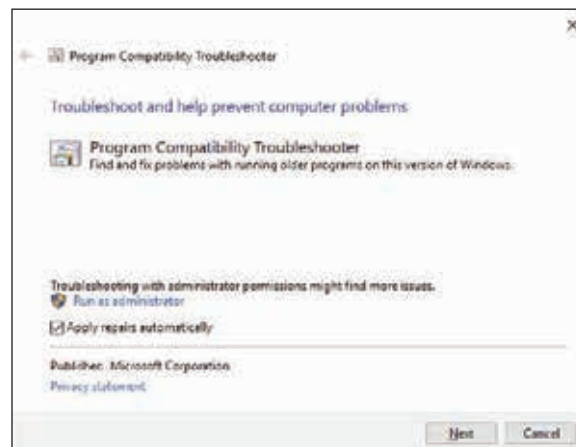
A **software patch** is a fix for operating systems and application software that have already been released. It also contains security updates when the operating system or software has been compromised. Although operating systems and software go through countless hours of testing, many have errors in programming. This type of error is referred to as a **bug**. Patches for software programs can assist in correcting bugs and are readily available for download off the Internet. Periodically, a large collection of patches is released at once and referred to as a *service pack*.

Figure 2-29 Microsoft provides a compatibility wizard launched via the Control Panel.



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Figure 2-30 The Program Compatibility Troubleshooter detects possible compatibility problems associated with legacy software applications.



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CHAPTER SUMMARY

What Is an Operating System?

- An operating system is the underlying software that provides a computer user with all the basic services of resource management on the machine, including a file system structure and a means of communicating with the computer hardware.
- The core of any operating system is referred to as the kernel.

Operating System Characteristics

- All operating systems have a user interface, a file system structure, a file table, configuration files, and the ability to multitask.
- Operating systems, hardware devices, and software applications are identified using the terms *32-bit* and *64-bit*, which refer to how much data can be processed at once by the CPU or how much total memory the operating system can access.
- There are two dominant user interfaces used to issue commands on a computer system: graphical user interface and command-line interface.
- Examples of file systems include FAT12, FAT16, FAT32, and NTFS.

Microsoft Windows Operating System

- The most widely used operating system is Microsoft Windows.
- The most significant differences between Windows 8 and earlier Windows operating systems are its user interface, user account settings, and the incorporation of cloud access.
- Windows 10 brought back the traditional **Start** menu.
- **Cmd.exe** is a compact program that allows the user to interact with the computer using commands entered at the command prompt.
- Most versions and editions of Windows have a similar set of features.

Microsoft Windows Installation

- An *upgrade* means that you can install Windows on an existing operating system and retain files, settings, and applications. A *clean install* means that the previous operating system is completely replaced and you will lose all files, settings, and applications.

- Carrying out a Windows installation calls for knowledge of an operating system's hardware requirements and determining whether an upgrade or clean install should be performed.

Microsoft Windows Boot Sequences

- A cold boot, also called a *hard boot*, means that the electrical power switch is used to turn on the computer. A warm boot, or *soft boot*, is used to restart a computer that is already running.
- Windows 7, Windows 8, and Windows 10 share a similar boot sequence: POST, initial startup phase, Windows Boot Manager phase, Windows Boot Loader phase, kernel-loading phase, and logon phase. Windows 10 supports the UEFI in place of the BIOS for a faster, more flexible boot process.
- The power-on self-test (POST) is a simple diagnostic program that is initiated when electrical power is applied to the computer system and is common to all operating systems.
- In a BIOS-based system, the POST is initiated by the bootstrap program in the firmware. The boot sequence is slightly different for a computer equipped with UEFI, or EFI.

Apple Macintosh OS

- MacOS is the operating system developed by Apple, Inc. to run on their Macintosh line of computer systems.
- MacOS is derived from NextSTEP, which itself was based off the Mach kernel from CMU and the Berkeley Software Distribution (BSD) of the Unix operating system.
- Often, Macs are not found in traditional office-type work environments, but they are used almost exclusively in industries that fit their creative features.

Common Mobile Devices and Operating Systems

- Common mobile devices are cell phones, tablets, and some gaming hardware; common portable device tasks are Internet access and collaboration activities.

Cloud Computing

- Examples of cloud computing shared resources and services are storage, application software, instant messaging, e-mail, and database support.
- The term *cloud* is synonymous with the Internet symbol used in network drawings.

- Cloud services have expanded rapidly in recent years because of mobile devices, such as smart-phones and tablets.

Common Operating System Terminology

- There is a tremendous amount of operating system terminology common to all operating systems.
- Most 32-bit software applications will run on a 64-bit computer system, some will not; 32-bit and 64-bit drivers will only run on the system for which they were designed.
- A software driver is a small package of programs that allow proper communication between the computer and the peripheral device.
- A software patch is a fix for operating systems and application software that have already been released.

REVIEW QUESTIONS

1. What does an operating system do?
2. What is a kernel?
3. List common characteristics of all operating systems.
4. Differentiate between preemptive multitasking and cooperative multitasking.
5. What are two main advantages of 64-bit systems over 32-bit systems?
6. List two dominant user interfaces used to issue commands on a computer.
7. Where is the root directory located?
8. What is the function of a pathname?
9. What does a file table do?
10. What was the main difference between Windows 7 and Windows 8?
11. Which Windows OS does not support the traditional **Start** menu feature, and which OS brought it back?
12. What is included in a directory structure?
13. What is a file extension?
14. What is the maximum number of characters allowed in a long file name?
15. List five symbols that are *not* allowed in the Windows long file name system.
16. Which operating system introduced Windows XP Mode?
17. Which Windows version introduced **Libraries** and **HomeGroup** into the directory structure?
18. What is a library in a Windows directory structure?
19. What new user account type was introduced in Windows 8?
20. What needs to be done to preserve user data before performing a clean or custom installation?
21. What is the recommended amount of RAM for a 32-bit and 64-bit Windows 7 installation?
22. What is the recommended amount of hard drive space for a 32-bit and 64-bit Windows 8 installation?
23. What is the recommended amount of RAM for a 32-bit and 64-bit Windows 10 installation?
24. Which part of the boot sequence is common to all operating systems?
25. Summarize the Windows 10 boot sequence.
26. Which Windows file is referred to as the kernel?
27. During which phase of the Windows boot sequence does the operating system switch from the text mode to the graphic mode?
28. Give at least three examples of common portable device tasks.
29. Give two examples of cloud computing resources.
30. Differentiate between application software, a software driver, and a software patch.

SAMPLE A+ EXAM QUESTIONS

1. What is the maximum RAM supported for a Windows 10 Pro 64-bit installation?
 - a. 128 GB
 - b. 4 GB
 - c. 512 GB
 - d. 2 GB
2. The operating feature that allows two programs to appear to be running simultaneously is called _____.
 - a. multiprocessing
 - b. multitasking
 - c. program coordination
 - d. kernel sharing
3. When entered at the command prompt, which command grants a user access to the registry?
 - a. cmd
 - b. help
 - c. regedit
 - d. registry32
4. What is the maximum amount of RAM supported by a 32-bit Windows 7 system?
 - a. 1 GB
 - b. 2 GB
 - c. 4 GB
 - d. 8 GB
5. Which device would contain the POST program?
 - a. Hard drive
 - b. RAM
 - c. USB flash drive
 - d. BIOS chip
6. Which of the following are no longer required by Windows? Select two.
 - a. **ntdetect**
 - b. **ntoskrnl**
 - c. **boot.ini**
 - d. POST
7. Which command entered in the **Search** box will produce the command prompt?
 - a. prompt
 - b. msdos.sys
 - c. cmd
 - d. doscom.com
8. Which program is executed first during the boot process?
 - a. **ntldr**
 - b. POST
 - c. **bootcfg**
 - d. **ntdetect**
9. Which Microsoft security feature is used to encrypt an entire hard disk drive?
 - a. Sync
 - b. BitLocker
 - c. VPN
 - d. Windows Defender
10. Which of the following allows DOS programs to run on newer 64-bit operating systems?
 - a. Dual-boot
 - b. Multiple-boot
 - c. NTDVM
 - d. Tablet mode