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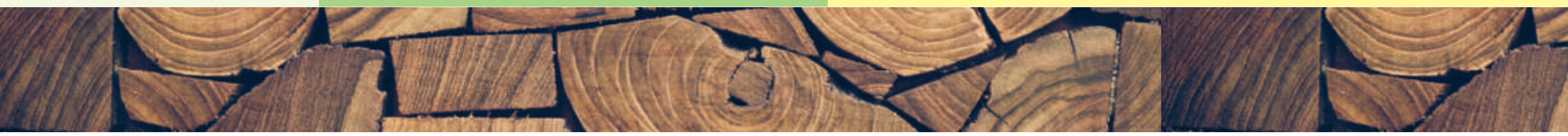

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New Perspectives on Computer Concepts 2018

Preface

COLLEGE GRADUATES OF THE 21ST CENTURY

are expected to have a **BROAD BASE OF KNOWLEDGE** to intelligently address social, political, economic, and legal issues associated with rapidly evolving digital technology.

Today's students have a patchwork of knowledge, acquired from using various digital devices. *New Perspectives on Computer Concepts* (NP2018) helps students build a cohesive framework that organizes this acquired knowledge and serves as a foundation for assimilating new concepts **ESSENTIAL TO CAREERS AND LIFESTYLES** in our digital world.

FULLY REVISED. NP2018 has been newly **REVISED AND UPDATED** to increase learning effectiveness and to reflect the wide scope of digital devices in use today, with an enhanced focus on the connectivity that pervades modern life and the security necessary to protect it.

TARGETED LEARNING SUPPORT. This award-winning textbook contains layers of targeted learning support for **ACTIVE LEARNING** that keeps students engaged and helps them succeed. Using the **MINDTAP DIGITAL PLATFORM**, students benefit from interactive feedback and new collaborative opportunities.

READING IN THE DISCIPLINE. Short paragraphs and a clear narrative style help students grasp concepts and learn **HOW TO READ TECHNICAL MATERIAL**.

RETENTION. What's the most effective study technique: Taking notes? Reviewing? According to researchers, students study most effectively by simply trying to recall the material they've read, seen, or heard. That's why NP2018 offers **CONTINUOUS ASSESSMENT**. Embedded QuickChecks on just about every page help students recall key concepts while reading and later while reviewing. QuickQuizzes and end-of-module reinforcement promote **SUCCESSFUL LEARNING OUTCOMES**.

HANDS-ON. NP2018 contains plenty of practical information about how to use apps, manage files, create content, configure security software, and more. Try It! activities throughout the book show students how to **IMMEDIATELY APPLY CONCEPTS IN REAL-WORLD CONTEXTS**.

FLIPPED CLASSROOMS. Flipping a course is easy with NP2018, which includes flipped class projects for **CRITICAL THINKING**, cyberclassroom exploration, **COLLABORATIVE GROUP WORK**, multimedia integration, career building, and **GLOBALIZATION**. End-of-module features, such as Issues and Information Tools, offer additional topics for hands-on in-class activities.

EXTENDED INTRO MODULE. The Introduction module puts technology into context with in-depth coverage of the multi-phased digital revolution. For NP2018, this introduction has been expanded to include **VIRTUAL REALITY, AUGMENTED REALITY, AND AUTONOMOUS VEHICLES**.

A FRESH APPROACH TO SOCIAL MEDIA. Sure, students use social media, but are they familiar with underlying concepts, such as the **SOCIAL MEDIA HONEYCOMB, GEOLOCATION, AND SOCIOGRAMS**? Are they up to speed with Creative Commons and intellectual property concepts? Do they recognize **FAKE NEWS**? And do they understand the relevance of **ONLINE IDENTITY, PRIVACY, AND REPUTATION MANAGEMENT**? Module 5 offers a fresh approach to social media that delves into concepts while also providing practical how-to tips.

NEW IMAGING TECHNOLOGIES. In an increasingly visual world, graphical imaging is becoming ever more sophisticated. Module 1 is packed with new information about 360-degree video, stereoscopic graphics, and spherical imaging popularized by **GOPRO CAMERAS, YOUTUBE 360, POKEMON GO, AND GOOGLE CARDBOARD**.

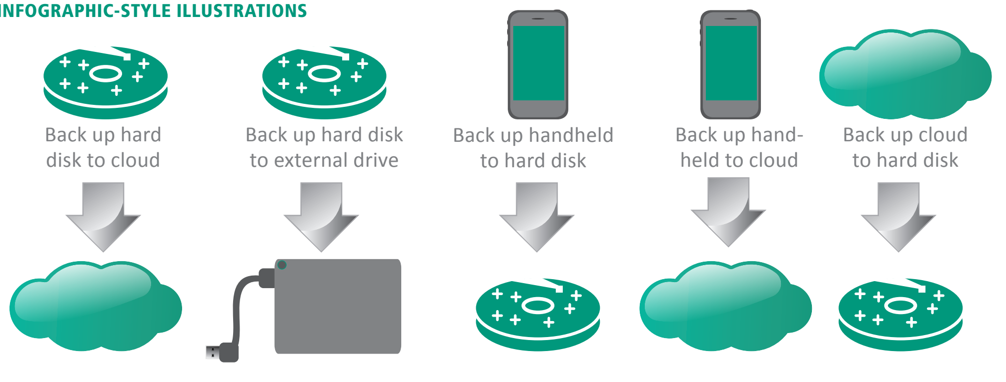
NEW SECURITY ISSUE. Module 7 contains a new Issue, **HOW SECURE IS DEMOCRACY?**, that explores the challenges required to secure voting machines, voter registration data, campaign Web sites, campaign email messages, fund-raising bank accounts, lists of campaign workers, and donor databases.

THE LATEST TECHNOLOGY. Digital technology evolves at a fast pace. NP2018 keeps students up to date with **RASPBERRY PI**, 3D printers, smart appliances, lightning ports, USB-C, accelerometers, gyro sensors, magnetometers, macOS, **WINDOWS 10**, virtual reality headsets, Microsoft Edge, hypervisors, **TWO-FACTOR AUTHENTICATION**, Locky ransomware, and more!

HANDS-ON PROGRAMMING MODULE. Programming with Python provides highly interactive programming activities that **INTRODUCE STUDENTS TO THE WORLD OF PROGRAMMING** without requiring any prior experience. Python is an easy-to-learn language that supports procedural and object-oriented programs.

INFOGRAPHIC ILLUSTRATIONS. Illustrations based on popular infographic visuals are carefully integrated into the learning path to provide **VISUAL SCAFFOLDING** that is so important to understanding technical concepts.

INFOGRAPHIC-STYLE ILLUSTRATIONS



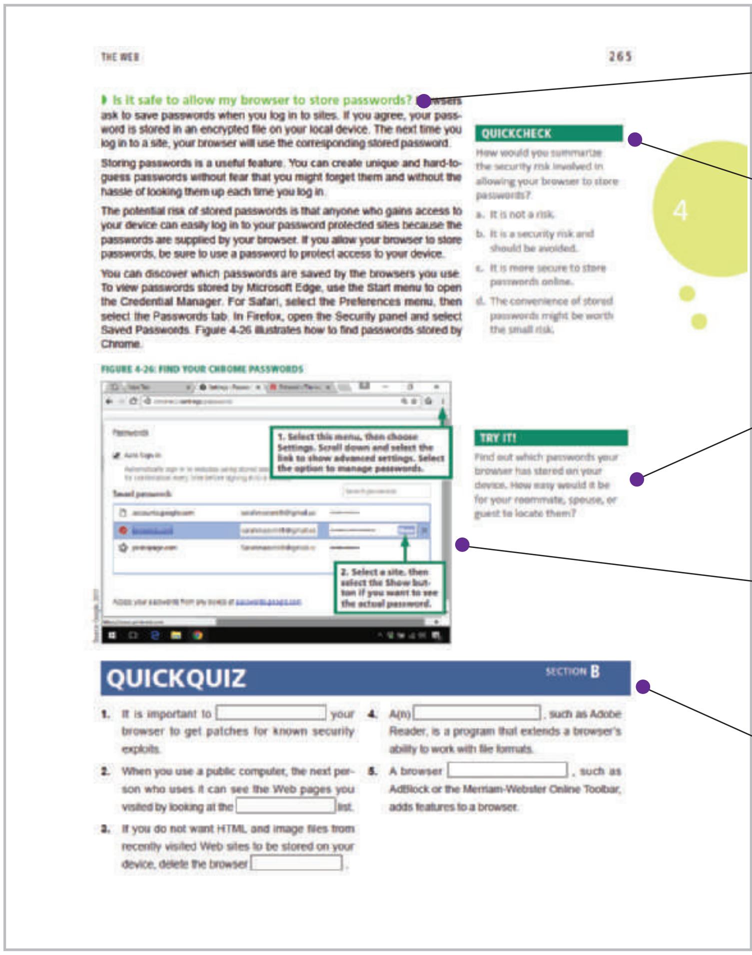
Student Resources: The Book

WHETHER YOU USE THE PRINTED BOOK OR DIGITAL VERSIONS, NP2018 GIVES YOU THE STRAIGHT STORY ON TODAY'S TECHNOLOGY.

EASY TO READ. Each module is divided into five **SECTIONS**, beginning with a **CONCEPT MAP** that provides a visual overview of topics. **FAQs** answer commonly asked questions about technology and help you follow the flow of the presentation.

KEEPS YOU ON TRACK. As you read each page, watch for **QUICKCHECKS**. They'll help you gauge if you comprehend key concepts. And take some time to complete the **TRY IT! ACTIVITIES**. They bring concepts to the real world and help you hone your digital skills. **QUICKQUIZZES** at the end of each section provide a chance to find out if you remember the most important concepts. **END-OF-MODULE REVIEW** activities such as Key Terms, Interactive Situation Questions, and Interactive Summary Questions are great for test prep.

HELPS YOU EXPLORE. The **ISSUE** section in each module highlights controversial aspects of technology. In the **TECHNOLOGY IN CONTEXT** section, you'll discover how technology plays a role in careers such as film-making, architecture, banking, and fashion design. The **INFORMATION TOOLS** section helps you sharpen your digital research techniques. Check out the **LABS** at the end of each module for some step-by-step exploration into your digital devices.



THE WEB 265

Is it safe to allow my browser to store passwords? …wsers ask to save passwords when you log in to sites. If you agree, your password is stored in an encrypted file on your local device. The next time you log in to a site, your browser will use the corresponding stored password.

Storing passwords is a useful feature. You can create unique and hard-to-guess passwords without fear that you might forget them and without the hassle of looking them up each time you log in.

The potential risk of stored passwords is that anyone who gains access to your device can easily log in to your password protected sites because the passwords are supplied by your browser. If you allow your browser to store passwords, be sure to use a password to protect access to your device.

You can discover which passwords are saved by the browsers you use. To view passwords stored by Microsoft Edge, use the Start menu to open the Credential Manager. For Safari, select the Preferences menu, then select the Passwords tab. In Firefox, open the Security panel and select Saved Passwords. Figure 4-26 illustrates how to find passwords stored by Chrome.

QUICKCHECK

How would you summarize the security risk involved in allowing your browser to store passwords?

a. It is not a risk.
b. It is a security risk and should be avoided.
c. It is more secure to store passwords online.
d. The convenience of stored passwords might be worth the small risk.

FIGURE 4-26: FIND YOUR CHROME PASSWORDS

TRY IT!

Find out which passwords your browser has stored on your device. How easy would it be for your roommate, spouse, or guest to locate them?

QUICKQUIZ SECTION B

1. It is important to [ ] your browser to get patches for known security exploits.
2. When you use a public computer, the next person who uses it can see the Web pages you visited by looking at the [ ] list.
3. If you do not want HTML and image files from recently visited Web sites to be stored on your device, delete the browser [ ].
4. A(n) [ ], such as Adobe Reader, is a program that extends a browser's ability to work with file formats.
5. A browser [ ], such as AdBlock or the Merriam-Webster Online Toolbar, adds features to a browser.

FAQs break down concepts into manageable chunks of information.

QUICKCHECK questions embedded throughout the module keep learning interactive. Answers are at the end of the book.

TRY IT! ACTIVITIES show how to apply concepts to the real world and help hone your digital skills.

DIAGRAMS AND SCREENSHOTS on every page make it easy to visualize concepts.

QUICKQUIZ questions at the end of each section give you a chance to review the main concepts.

Student Resources: NP2018 Online

DIGITAL VERSIONS OF YOUR TEXTBOOK INCLUDE MULTIMEDIA AND HANDS-ON ACTIVITIES DESIGNED TO ENHANCE YOUR LEARNING EXPERIENCE.

NP2018 MINDTAP. The digital version of NP2018 is available in **MINDTAP**, a personalized online learning platform. In addition to the full text contained in the printed book, the digital NP2018 includes videos, animations, software tours, and activities based on a learning path designed by your instructor that **GUIDES YOU THROUGH THE COURSE**.

MindTap is a cost-effective alternative to a printed textbook. You can purchase access to NP2018 MindTap from *www.cengagebrain.com*.

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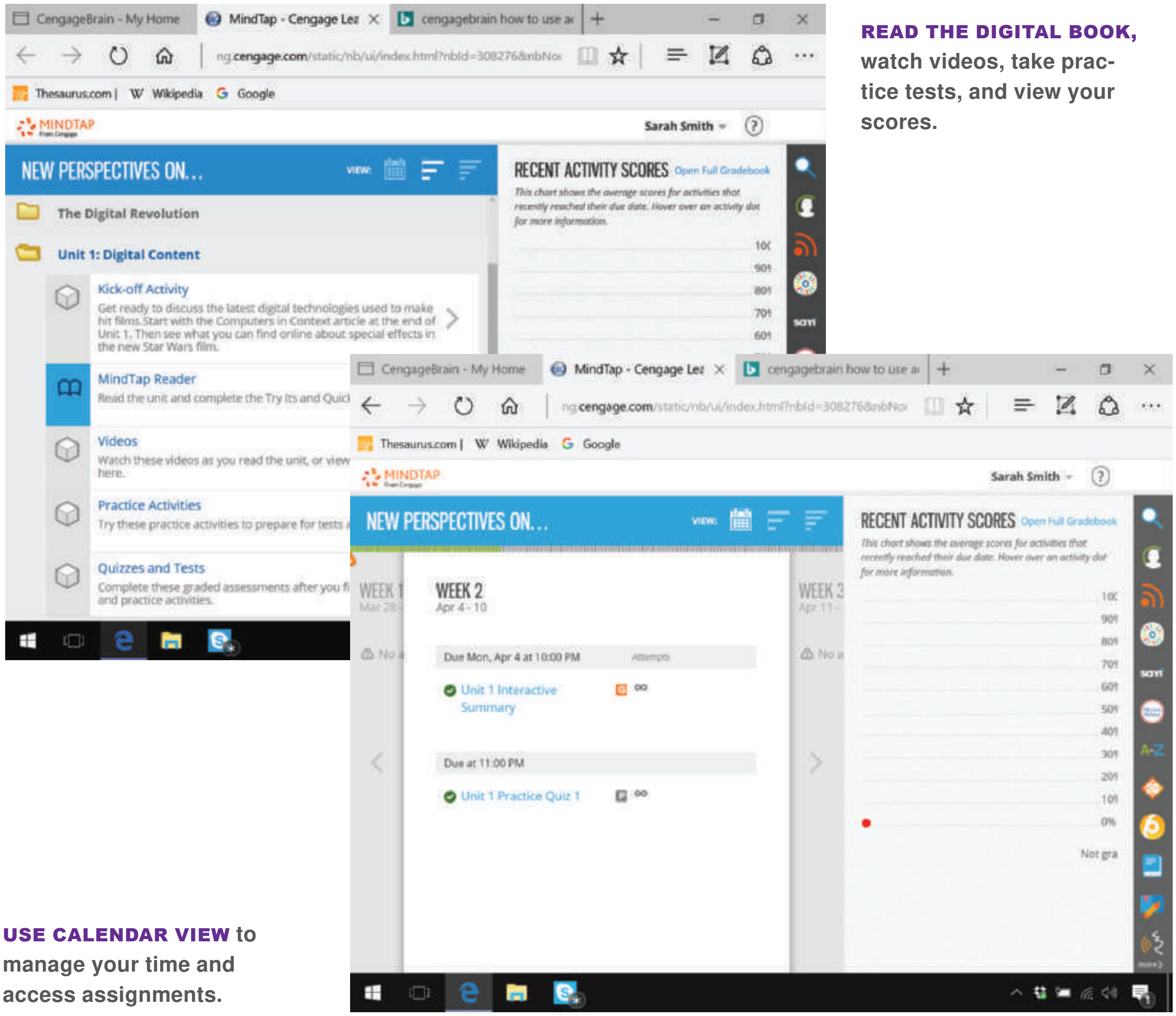
READ THE DIGITAL BOOK, watch videos, take practice tests, and view your scores.



USE CALENDAR VIEW to manage your time and access assignments.

Student Resources: Hone Your Technical Reading Skills

IF YOU WOULD LIKE TO IMPROVE THE WAY YOU COMPREHEND AND RETAIN THE INFORMATION FOUND IN TECHNICAL BOOKS AND DOCUMENTATION, READ ON.

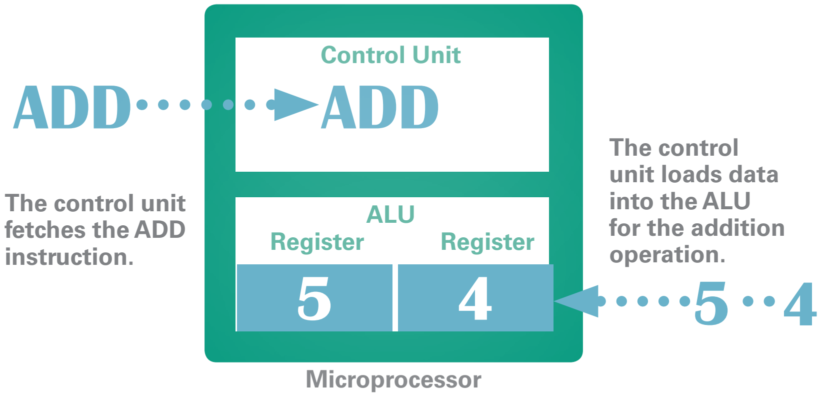
PREPARE. Your goal is to complete one section of a module. That's a sufficient amount of material for one session. **LOOK AT THE CONCEPT MAP** at the beginning of the section. It is designed to help you connect concepts in a web of relationships, so they become more than random facts.

DIVIDE AND CONQUER. Don't expect to read technical material in the same way you'd read a novel. Trying to read without stopping from the beginning to the end of a module, chapter, or section is likely to produce more confusion than confidence. Instead, **TAKE IT ONE PAGE AT A TIME**. Read the page and then pause. Imagine that you are going to teach that material to someone else. Then summarize the main points in your own words.

TAKE NOTES. When you come across a fact that you want to remember, make a note. A study conducted by researchers at UCLA and Princeton University revealed that students who take lecture notes using a pen or pencil scored better on tests than students who took notes on their laptops. The same effect may come into play when taking notes as you read. Whether you make notes on screen or on paper, make sure to **USE YOUR OWN WORDS**. That will help you understand the essence of a concept and retain it for future use.

HIGHLIGHT. Use highlights to **MARK PASSAGES YOU DO NOT UNDERSTAND**. This advice may seem contrary to the idea of highlighting key concepts, but simply marking something in the book—or worse, copying and pasting passages from a digital book—does little to help you internalize a concept. Highlighting passages that you do not understand allows you to return to them after you've completed a section. You may find that the passage now makes sense. If not, you've marked a concept that will be a great question for your instructor.

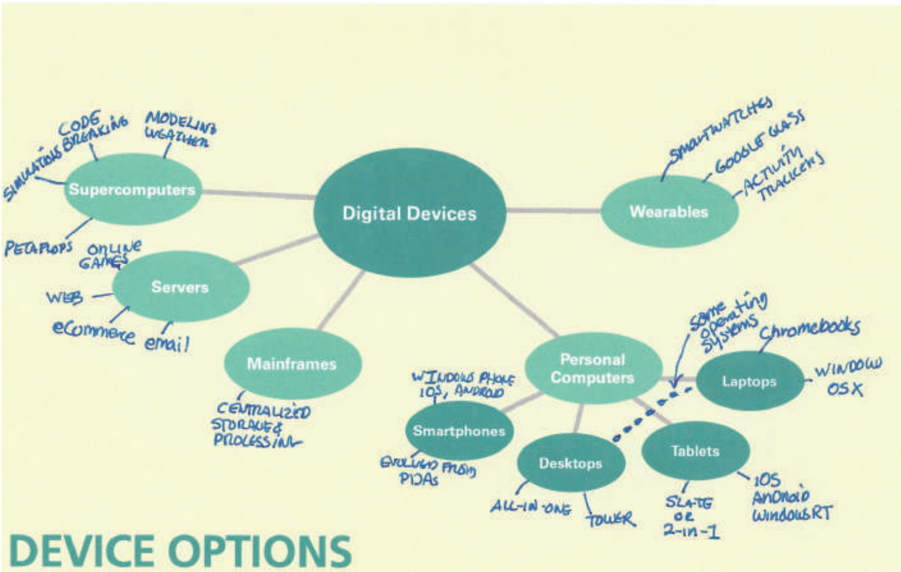
READ THE PICTURES. The figures in this book are included to reinforce, explain, and **EXPAND THE INFORMATION PRESENTED IN THE WRITTEN NARRATIVE**. Concepts that may seem complex when explained in words can be much easier to understand when you see an illustration, screenshot, or photo. So, take some time with each figure to make sure you understand how it is related to the text that precedes it.



TEST YOURSELF. Researchers at Purdue University discovered that "practicing retrieval" through self-testing is one of the **MOST EFFECTIVE TECHNIQUES FOR LEARNING**. NP2018 supplies you with lots of opportunities to retrieve material. Make sure to use the QuickChecks, QuickQuizzes, Interactive Summaries, and Interactive Situation Questions. Additional resources, such as flashcards and module quizzes, are available with the NP2018 MindTap.

BE AN ACTIVE LEARNER. The concepts in NP2018 are not abstract theories. Most have practical applications for today's digital lifestyles. You'll find that concepts are much easier to remember if you can apply them and understand how they are relevant. The **TRY IT! ACTIVITIES** throughout every module show you how to apply concepts. The best learning strategy is to complete these activities as you encounter them. They'll give you a break from reading and help you to understand how all the practical and conceptual pieces fit together.

GET THE CONNECTIONS. The bubble diagrams supplied at the beginning of each section provide an overview of concepts and their linkages. After reading a section, you might want to **EXTEND THE CONCEPT MAPS** by adding more details. You can add another level of concepts. Also, think of additional relationships between the existing concepts and mark them with dotted lines.



CORRECTIONS. Despite intensive attention to quality, occasional typos and other errata slip into the book. Corrections are posted to your student companion site, which you can access by logging in to your account at *login.cengage.com*.

Instructor Resources

NP2018 RESOURCES PROVIDE INSTRUCTORS WITH A WIDE RANGE OF TOOLS THAT ENHANCE TEACHING AND LEARNING. THESE RESOURCES AND MORE CAN BE ACCESSED FROM THE NP2018 INSTRUCTOR COMPANION SITE. LOG IN AT WWW.CENGAGEBRAIN.COM.

INSTRUCTOR'S MANUAL. The NP2018 Instructor's Manual offers the following comprehensive instructional materials:

- Module objectives and key terms
- Bullet-point lecture notes for each module section
- Classroom activities and teaching tips

SOLUTION FILES. Your password-protected instructor resources provide answers to all the QuickChecks, Lab Assignments, Interactive Summaries, Interactive Situation Questions, Issue Try It! activities, and Information Tools Try It! activities.

TABBING GUIDE. If you've used previous editions of *New Perspectives on Computer Concepts*, you'll appreciate the Tabbing Guide that lets you see at a glance what's been updated for this edition. Use it to make revisions to your syllabus, as necessary.

FLEXIBLE POWERPOINTS. Instructors can customize and deliver engaging and visually impressive lectures for each module with the professionally designed PowerPoint slides.

TESTBANKS AND TESTING SOFTWARE. Cengage Learning Testing powered by Cognero is a flexible, online system that allows instructors to author, edit, and manage test bank content from multiple Cengage Learning solutions and to create multiple test versions. It works on any operating system or browser with no special installs or downloads needed, so tests can be created from anywhere with Internet access.

SAM AND MINDTAP READER EBOOK. SAM (Skills Assessment Manager) is a robust assessment, training, and project-based system that enables students to be active participants in learning valuable Microsoft Office skills. The MindTap Reader version of *New Perspectives on Computer Concepts 2018* works within the SAM environment for courses that combine concepts and Office skills. Let SAM be an integral part of your students' learning experience! Please visit *www.cengage.com/sam*.

MINDTAP. This powerful online environment includes analytics and reports that provide a snapshot of class progress, time in course, engagement, and completion rates.

FROM THE AUTHOR

So much has changed since the first edition of Computer Concepts was published in 1994! From year to year, the changes have been subtle, but looking back, it is clear that technology, students, and even education has progressed in amazing and sometimes unexpected directions. As digital technology continues to evolve, New Perspectives continues to keep pace, providing students with up-to-date content and cognitive tools that engage and ensure successful learning outcomes.

Many of today's students have substantially more practical experience with digital devices than their counterparts of twenty years ago, but even these students may lack a cohesive framework for their knowledge.

The goal of *New Perspectives on Computer Concepts* is to bring every student up to speed with computer basics, and then go beyond basic computer literacy to provide students with technical and practical information that every college-educated person would be expected to know.

Whether you are an instructor or a student, we hope that you enjoy the learning experience provided by our text-based and technology-based materials.

ACKNOWLEDGEMENTS

The book would not exist—and certainly wouldn't arrive on schedule—were it not for the efforts of our media, editorial, and production teams. Grateful thanks to Kate Russillo for her developmental edit and tireless work on every detail of the project; Kathleen McMahon and Amanda Lyons-Li for their executive leadership of the New Perspectives series; Abigail Pufpaff for quickly getting up to speed on all the dimensions of this project; Sumathy Kumaran and the team at Lumina for managing production; Stacey Lamodi for managing the day-to-day schedule; and our brilliant sales reps for encouraging instructors to adopt this book to enhance their introductory courses.

The MediaTechnics team worked tirelessly and deserve a round of applause. Thank you to Tensi Parsons for her extraordinary devotion to desktop publishing and infographic design; Keefe Crowley for his versatile skills in creating videos, taking photos, and compiling test banks; and Chris Robbert for his clear narrations. Dan Oja is our technical guru and digital education visionary; his pioneering efforts to create the first online testing system and interactive digital textbook set a high standard for today's developers.

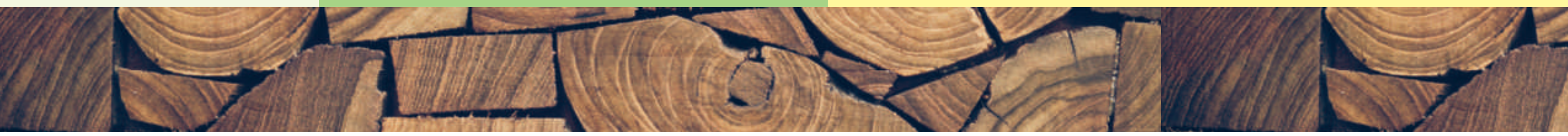
A special shout-out in this edition goes to my father, John X. Jamrich, who as a lifelong educator and president of Northern Michigan University showed me the value of helping students achieve their goals through education.

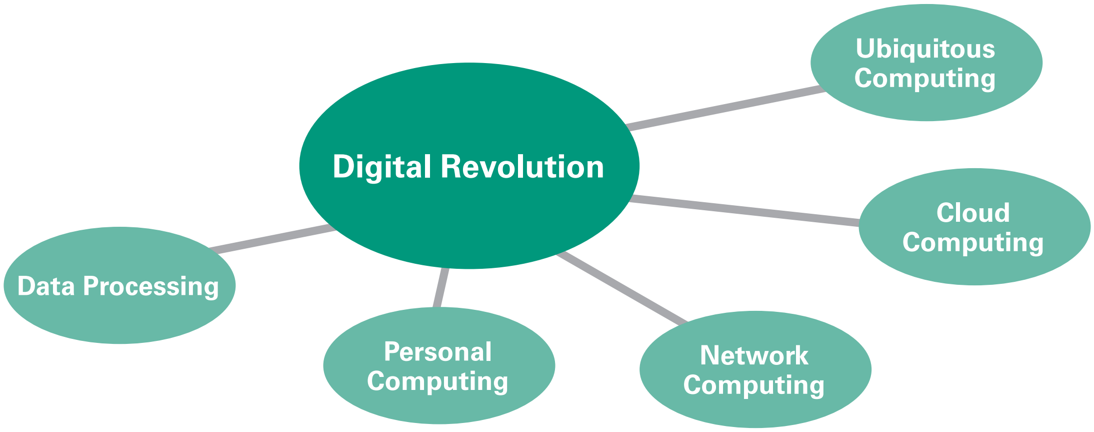
Additional acknowledgements go to the New Perspectives Advisory Committee members, reviewers, and students who have made a tremendous contribution to every edition of Computer Concepts. Thank you all!

June Jamrich Parsons

NEW PERSPECTIVES

Computer Concepts 2018





INTRODUCTION

WE LIVE IN THE INFORMATION AGE:

a period in history when information is easy to access and affects many aspects of everyday life, from the economy to politics and social relationships. The importance of information is not new. It has always been a powerful tool. Scrolls treasured by monks during the Middle Ages, scientific knowledge collected during the Renaissance, and intelligence data collected during the Cold War were all critical in shaping world events. The Information Age is unique because of its underlying technology based on digital electronics. This introduction offers an overview of the digital revolution that continues to reinvent the Information Age.

Terminology

digital revolution digital digital content user interface computer terminal centralized computing data processing personal computing local software computer network Internet Web cloud computing convergence Web 2.0 social media sharing economy ubiquitous computing virtual reality augmented reality Internet of Things autonomous vehicles

Objectives

- Name the five phases of the digital revolution and place each on a timeline.
- Describe the digital devices that were popular during each phase of the digital revolution.
- List at least five characteristics of each phase of the digital revolution.
- Find two similarities and two differences between technology in the data processing era and technology in the cloud computing era.
- Evaluate the strengths and weaknesses of today's digital environment.
- Distinguish between virtual reality and augmented reality.
- Consider the tradeoffs we make when living in a digital society.

THE DIGITAL REVOLUTION

The **digital revolution** is an ongoing process of social, political, and economic change brought about by digital technology, such as microchips, computers, and the Internet.

◗ **What is digital?** **Digital** is a type of technology that represents written, visual, audio, and quantitative data as numbers, such as 1s and 0s. The word *digital* comes from the root *digit*. In the language of mathematics, a digit is the symbol used to write the numerals 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

Like the agricultural revolution and the industrial revolution, the digital revolution offers advantages but requires adaptations. Digital innovations challenge the status quo and require societies to make adjustments to traditions, lifestyles, and legislation.

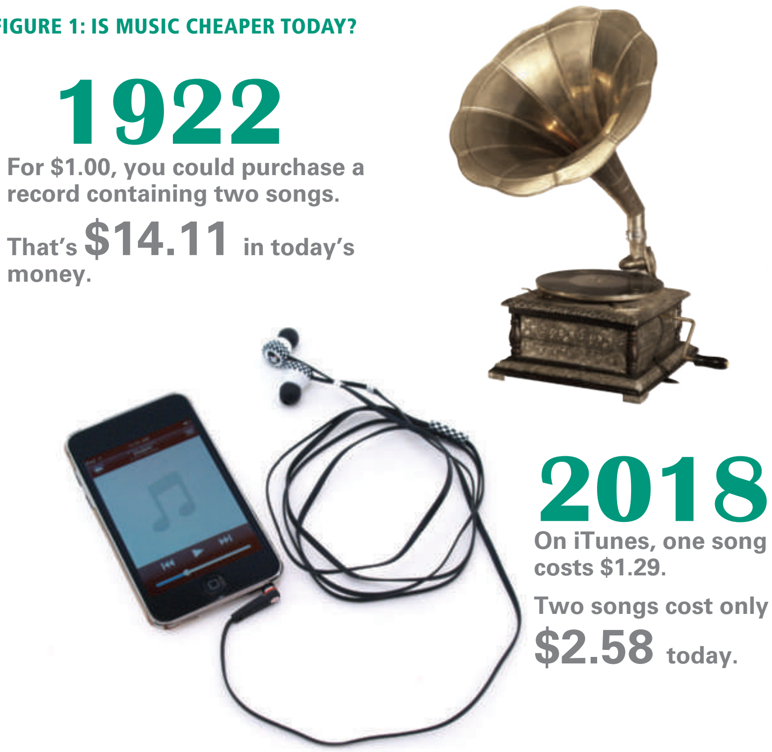
Digital devices were originally called *computer hardware* or *computing machines*. The programs and data they contain were referred to as *computer software*. Today, software is commonly referred to as *apps*.

The technology driving the digital revolution is based on digital electronics and the idea that electrical signals can represent data, such as numbers, words, pictures, and music. We often call this data **digital content**.

◗ **What is the significance of digital content?** An interesting characteristic of digital content is that it can be easily duplicated with no loss of quality. Before digital technology, photocopies of paper documents usually looked blurred. Copying a movie on tape reduced its quality, and every subsequent copy became progressively worse. Now, digital copies are essentially indistinguishable from originals, which has created new possibilities for content distribution on platforms such as iTunes and Netflix.

Digital devices, including computers and smartphones, transformed our world. Without them, your favorite form of entertainment would probably be foosball, and you'd be listening to a bulky old Victrola instead of carrying a sleek iPod (Figure 1).

FIGURE 1: IS MUSIC CHEAPER TODAY?



TRY IT!

Music is clearly less expensive today than it was back in 1922, but what about books? Can you find the price of a book during the 1920s and the price of an equivalent Kindle book today? Don't forget to convert the cost into today's dollars. (Search online for *inflation calculator*.)

DATA PROCESSING

Some historians mark the 1980s as the beginning of the digital revolution, but engineers built the first digital computers during World War II for breaking codes and calculating missile trajectories. In the 1950s, computers were marketed for business applications, such as payroll and inventory management.

◗ **What was computing like back then?** In the first phase of the digital revolution, computers were huge, complex, and expensive devices that stored data on reels of magnetic tape. They existed in limited numbers, primarily housed in big corporations and government agencies. Computers were operated by trained technicians. Each computer installation required specialized software. The idea that computers might be used by ordinary people in their homes was only a glimmer of an idea in the minds of science fiction writers.

One drawback to computer use was the **user interface**, the mechanism for entering and viewing data. Back then, processing components for computers were housed in closet-sized cabinets. The main computer unit was separate from the devices used for input and output. Initially, data was entered on punched cards and results were printed on continuous form paper. Later, computers were accessed using the keyboard and display screen of a terminal. A **computer terminal** has little processing capability of its own, so it was simply used to enter data and view results produced by software that ran on the main computer (Figure 2).

This method of computing, in which a main computer holds all of the data and performs all of the processing, is called **centralized computing**. It was the main technology model used during the data processing era. Devices such as terminals and printers were connected to a centralized computer with cables, as shown in Figure 2.

QUICKCHECK

Data processing was characterized by _________.

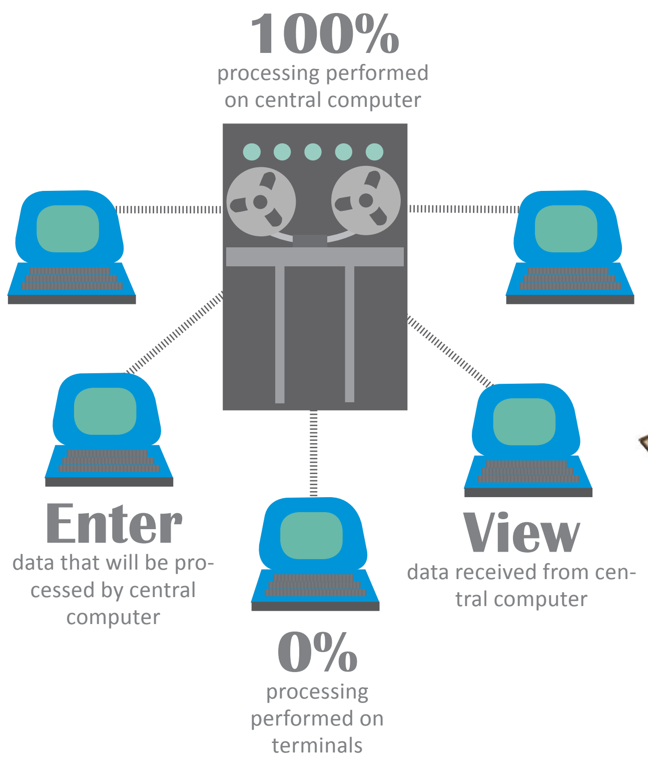
a. centralized computing

b. primitive digital devices such as calculators and watches

c. standalone computers such as Apple IIs and IBM PCs

d. local software and data storage

FIGURE 2: CENTRALIZED COMPUTING



TRY IT!

A computer terminal, like the one shown below, is an input and output device that depends on a centralized "host" computer for processing and storing data. Can you identify similarities between these old-fashioned devices and the way today's digital devices interact with the Internet?

Who had access to computers? During the antiestablishment era of the 1960s, the digital revolution was beginning to transform organizations, but ordinary people had little direct contact with computers.

As with many new technologies, computers were initially viewed with suspicion by consumers. IBM's corporate slogan "THINK" conveyed to some people a disturbing image of giant machine "brains."

Computers seemed remote. They were housed out of sight in special facilities and were inaccessible to ordinary people. Computers also seemed impersonal. To uniquely identify people, computers used sequences of numbers such as Social Security numbers. The fact that computers tracked people by numbers, rather than by their names, alienated many students and workers.

In the 1960s, computers and punched cards became a symbol of the establishment. Students were uncomfortable with the use of punched cards for storing academic records (Figure 3). The leader of a protest on the University of California, Berkeley campus complained, "You're processed. You become a number on a set of file cards that go through an IBM machine."

What is data processing? Throughout the first phase of the digital revolution, businesses adopted computers with increasing enthusiasm based on benefits such as cutting costs and managing mountains of data. Computers and data processing became crucial tools for effective business operations. **Data processing** is based on an input-processing-output cycle. Data goes into a computer, it is processed, and then it is output (Figure 4).

The data processing era lasted from the 1940s through the 1970s. Data processing installations still exist today, but other technologies emerged, making computing available to a more diverse group of users.

FIGURE 3: ANTIESTABLISHMENT
In the 1950s and 1960s, data used by government and business computers was coded onto punched cards that contained the warning "Do not fold, tear, or mutilate this card." Similar slogans were used by protesters who were concerned that computers would have a dehumanizing effect on society.

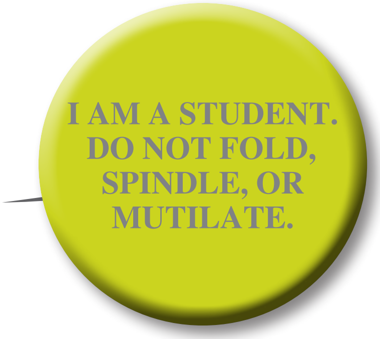
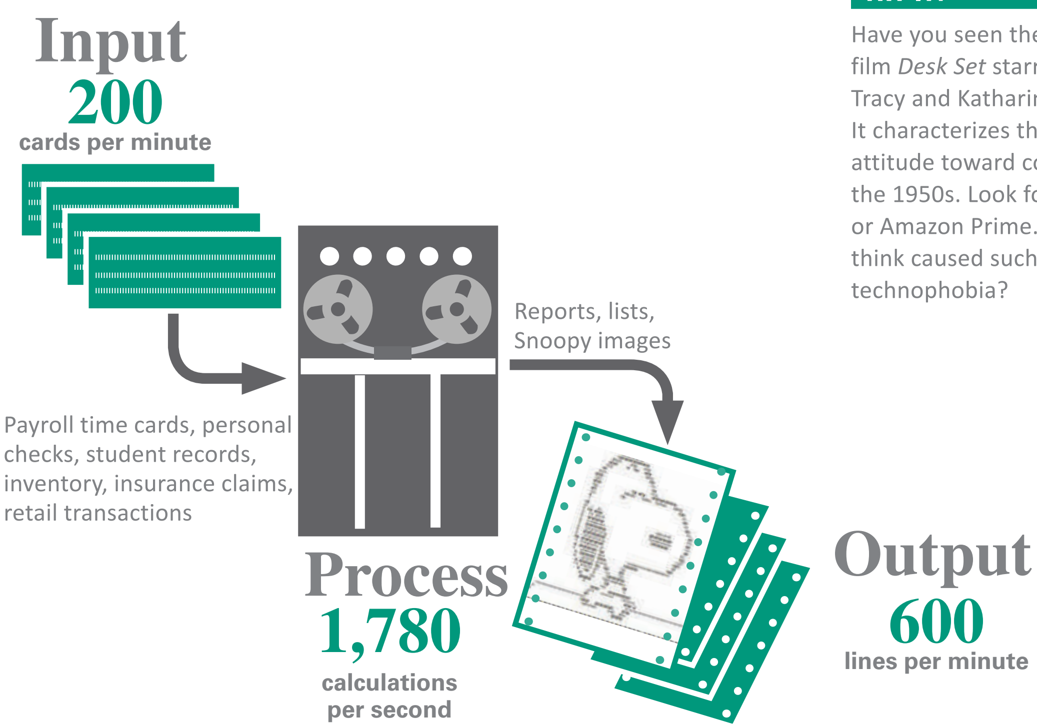


FIGURE 4: DATA PROCESSING



TRY IT!

Have you seen the classic film *Desk Set* starring Spencer Tracy and Katharine Hepburn? It characterizes the public's attitude toward computers in the 1950s. Look for it on Netflix or Amazon Prime. What do you think caused such widespread technophobia?

PERSONAL COMPUTING

Digital devices were first available to consumers in the 1970s, when handheld calculators and digital watches hit store shelves. The first personal computers made their debut in 1976, but sales got off to a slow start. Without compelling software applications, personal computers, such as the Apple II and IBM PC, seemed to offer little for their $3,000 price tag. As the variety of software increased, however, consumer interest grew.

What is personal computing? The second phase of the digital revolution, **personal computing**, is characterized by standalone computers powered by local software. **Local software** refers to any software that is installed on a computer's storage device. Today, local software resides on hard disks, solid state drives, and flash drives. In the personal computing era, local software was often stored on floppy disks.

During this phase of the digital revolution, computers were used to enhance productivity. Writing, gathering numbers into easily understood charts, and scheduling were popular computer-based activities. Computers and videogame machines emerged as entertainment devices, and the game industry drove the development of ever faster and more sophisticated digital components.

During the personal computing phase of the digital revolution, computers were not connected to networks, so they were essentially self-contained units that allowed users to interact only with installed software. On the business front, centralized computer systems continued to run payroll, inventory, and financial software. Some managers used personal computers and spreadsheet software to crunch numbers for business planning.

If you had owned a computer back in the second phase of the digital revolution, it was probably a standalone machine with primitive sound capabilities. The display device looked like an old-fashioned television (Figure 5).

QUICKCHECK

Personal computing was characterized by ________.

a. software housed on a centralized computer

b. sophisticated software applications

c. storing data in the cloud

d. local software and data storage

TRY IT!

Imagine that there is no Internet. Take a look at your computer and make a quick list of programs that you'd be able to use in a world without the Internet.

FIGURE 5: PERSONAL COMPUTING CIRCA 1985

How extensive was computer use? In contrast to the corporate focus of the data processing phase, personal computing promised to put the power of digital devices in the hands of ordinary people. Computers were no longer a symbol of the corporate establishment. As a new generation of computing devices evolved, IBM's "THINK" slogan was upstaged by Apple's message: "Think Different."

The promise of populist computing, however, was not backed up with compelling reasons to invest in a computer. In 1982, fewer than 10% of U.S. households had a computer. Working on a standalone computer wasn't for everyone. People without an interest in typing up corporate reports or school papers, crunching numbers for accounting, or playing computer games weren't tempted to become active soldiers in the digital revolution.

Social scientists even worried that if personal computing became widespread, people would become increasingly isolated as they focused on computer activities rather than social ones. Although rudimentary email systems existed on centralized corporate computer systems, home computers were not connected, so there was no way to transmit email messages.

How long was the second phase of the digital revolution? Computer ownership increased at a gradual pace until the mid-1990s, and then it accelerated into the third phase of the digital revolution (Figure 6).

QUICKCHECK

What problem arising from personal computing worried social scientists?

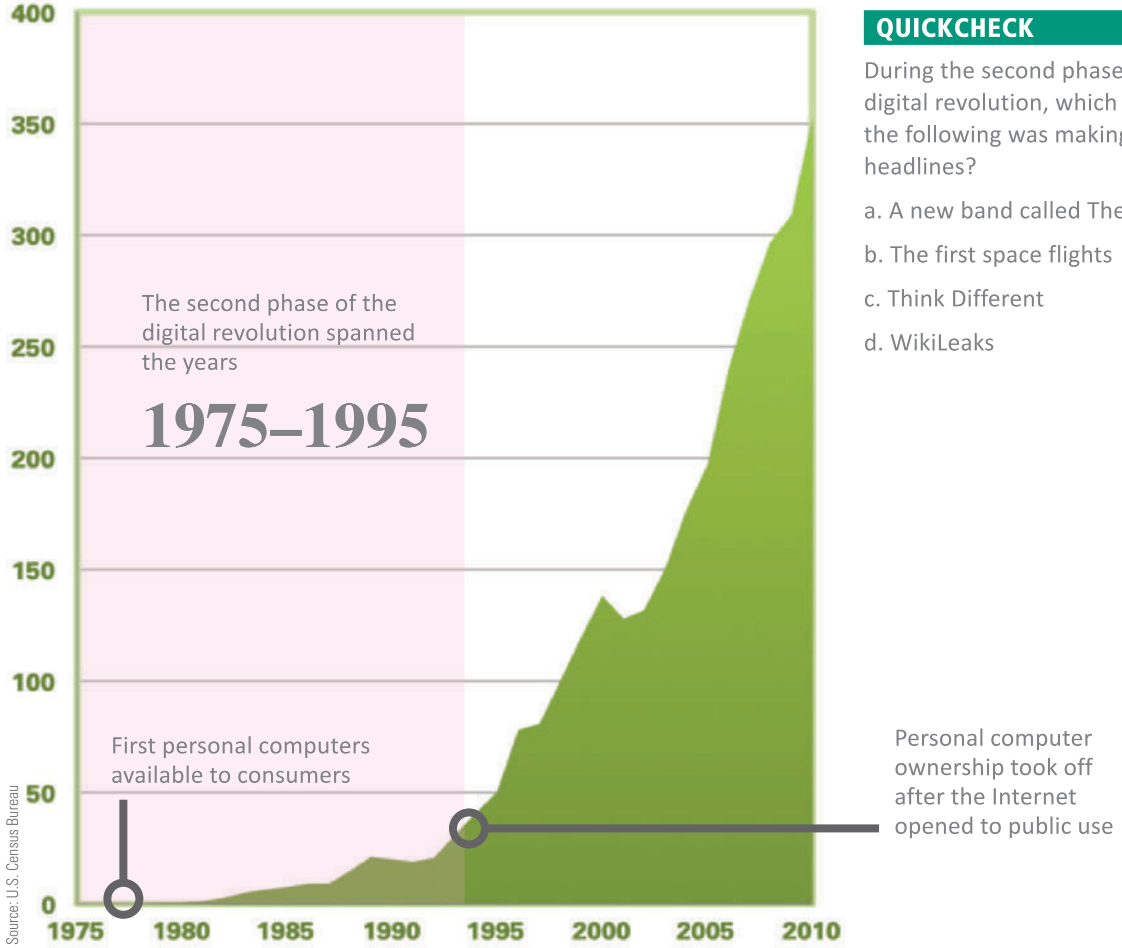
a. Big corporations spying on customer behavior

b. Increasing isolation as people spent more and more time using a computer

c. Privacy

d. Piracy

FIGURE 6: PERSONAL COMPUTER OWNERSHIP (MILLIONS OF HOUSEHOLDS)



QUICKCHECK

During the second phase of the digital revolution, which one of the following was making news headlines?

a. A new band called The Beatles

b. The first space flights

c. Think Different

d. WikiLeaks

NETWORK COMPUTING

The third phase of the digital revolution materialized as computers became networked and when the Internet was opened to public use. A **computer network** is a group of computers linked together to share data and resources.

◗ **What kinds of networks were available?** Network technology existed before the Internet became popular, but these networks were mainly deployed to connect computers within a school or business. For the most part, these networks connected devices using cables; wireless networks were not available.

During this era, networks were complicated to set up and they were often unreliable. Before the Internet opened to public use, online services such as CompuServe and America Online operated centralized computer networks that could be accessed by the public from dial-up modems.

◗ **What role did the Internet play?** The **Internet** is a global computer network that was originally developed as a military project and was later handed over to the National Science Foundation for research and academic use. When restrictions on commercial use of the Internet were lifted in the early 1990s, newly emerged ISPs offered fee-based Internet access. America Online, CompuServe, and other online services expanded to offer Internet-based chat and Web access. Excerpts from the AOL ad in Figure 7 may help you to appreciate the digital environment during this phase of the digital revolution.

TRY IT!

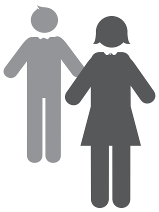
Internet connections were initially made over telephone lines with a device called an acoustic modem. You'll be surprised to see how these modems work. Search for a photo of one online. Could you use this type of modem with your smartphone?

FIGURE 7: USING AN ONLINE SERVICE IN THE 1990s

Step 1: Mail in your application and wait to receive your software.

Step 2: Your software arrives on a floppy disk. Insert it in the disk drive and install it.

Step 3: Fire up the software and your modem to make a connection. If you have an acoustic modem, put your telephone handset into it.



Step 4: Download software, send email, post messages, and mingle with people from all over the world in online chat rooms.

Own a Modem?

Try America Online for FREE

If you own a computer and modem, we invite you to take this opportunity to **try the nation's most exciting online service**.

Build a software library by downloading selected files from a library of thousands—productivity software, games, and more!

Get computing support from industry experts at online conferences and through easy-to-use message boards.

DETACH AND MAIL TODAY

YES, I want to try America Online! Send me FREE software and a FREE trial membership to try the service.

Name: ____________________

Address: ____________________

City: ____________________

State: __________ Zip: __________

Disk type and size: ❑ 5.25 ❑ 3.5

❑ High Density ❑ Double Density

Source: *Wired*, May 1993

◗ **What about the Web?** When historians look back on the digital revolution, they are certain to identify the Web as a major transformative influence. The **Web** (short for *World Wide Web*) is a collection of linked documents, graphics, and audio that can be accessed over the Internet.

A key aspect of the Web is that it adds content and substance to the Internet. Without the Web, the Internet would be like a library without any books or a railroad without any trains. Online storefronts, auction sites, news, sports, travel reservations, and music downloads made the Web a compelling digital technology for just about everyone.

◗ **So what was computing like during this phase?** From 1995 to 2010, computing was characterized by the increasing use of laptops (Figure 8) and the following elements:

Sophisticated software. The network computing phase may have been the peak for productivity software. Computer owners amassed large collections of software, purchased in boxes containing multiple distribution CDs. Software such as Microsoft Office, Norton's Internet Security suite, and Corel Digital Studio required local installation and provided more features than most people had any desire to use. This trend reverses during the next phase of the digital revolution, when applications become simpler and more focused on specific tasks.

Stationary Internet access. Even as laptop computers began to displace desktop models, connecting to the Internet required a cable that effectively tethered computers to a nearby phone jack or cable outlet. In the next phase of the digital revolution, Internet access breaks free from cables and goes mobile.

Online communication. Email was the first widespread technology used to communicate over the Internet. Online services such as CompuServe and AOL pioneered chat rooms, which were primitive versions of Google Hangouts. Early forums and message boards were similar to Facebook timelines. A technology called Voice over IP allowed participants to bypass the telephone company to make phone calls over the Internet. That technology eventually developed into Skype and similar video chat services.

Multiplayer games. Sophisticated computer games reached a peak during the network phase of the digital revolution. Audio and visual hardware components improved to support video-realistic game environments, artificial intelligence opponents, and multiple players logging in remotely and chatting with other players over headsets. In the next phase, mobile devices become popular gaming platforms, but hardware limitations restrict the feature set.

Music downloads. During the network computing phase, an online business called Napster pioneered the concept of sharing and downloading music. Subscribers exchanged millions of music files, which they played through the speakers of their computers. The music was protected by copyright, however, making sharing and distribution illegal. This type of file sharing activity and rampant software piracy became one of the defining problems associated with the network phase of the digital revolution.

iTunes and other services for legally downloading music soon appeared, along with dedicated playback devices, such as the iPod. Video distribution over the Internet lagged behind until connection speeds increased in the next phase of the digital revolution.

QUICKCHECK

The Web and the Internet are not the same. Why?

a. The Internet is a communication network, but the Web consists of content that is distributed by the Internet.

b. The Internet consists of sites such as Twitter and Facebook, whereas the Web links devices such as iPods and computers.

FIGURE 8: LAPTOPS
Laptop computers were the primary devices for accessing the Internet prior to 2010. User interfaces evolved to include color, graphics, and mice.

CLOUD COMPUTING

Around 2010, the Information Age eased into a new phase called **cloud computing**, which provided access to information, applications, communications, and storage over the Internet.

What did cloud computing change? Before cloud computing, most computers ran software based locally. For example, to use a word processor, you might fire up the latest edition of Microsoft Word, which you'd installed on your computer's hard disk. Prior to the cloud, you stored data locally, too. Email, documents, photos, and music all resided on your computer's hard disk or flash drive.

With cloud computing, all that changed. In the cloud, you can use your browser to access word processing applications that run from the Internet instead of software that you have installed on your local hard disk. You can use online applications to manage your email, create floor plans, produce presentations, and carry out a host of other activities. You can store your data in the cloud, too, making it available on any of your digital devices that connect to the Internet.

The cloud gets its name from diagrams like the one in Figure 9, which shows Internet-based applications, storage, and other services outlined by a cloud-like shape designed to help you visualize the idea that cloud services are "out there" somewhere on the Internet.

QUICKCHECK

Which characteristic of cloud computing most sets it apart from network computing?

a. Internet access

b. Sophisticated software

c. The migration of applications and data off of local devices

d. File sharing

FIGURE 9: THE CLOUD HOSTS APPLICATIONS, CONTENT, AND SERVICES

Wait, this sounds familiar! If cloud computing sounds a bit like centralized computing, you're paying attention. The concept of applications and data residing somewhere other than on a local device is common to both centralized and cloud computing. The cloud concept reawakens the idea of monolithic computing facilities, as opposed to distributed architectures of the network era. The fact that your cloud-based data is not stored on devices under your direct control is a potential privacy and security concern, which is a topic for later modules.

Are smartphones the signature device of the cloud computing era? The cloud itself is populated by commercial-grade high-speed computers and high-capacity storage devices. The consumer side is dominated by smartphones (Figure 10) and their close cousins, tablet computers. These handheld devices—a product of convergence—were the driving force for many cloud innovations.

What is convergence? The expansion of cloud computing is due in part to **convergence**, a process by which several technologies with distinct functionalities evolve to form a single product. Convergence was important to the digital revolution because it created sophisticated mobile devices whose owners demanded access to the same services available from a full-size desktop computer. Those services became available in the cloud.

Your computer plays movies. Your cell phone has a camera. Your clock has a radio. Your watch functions as a communications device. You can store data on your iPod Touch. All these are examples of technological convergence.

Convergence worked its magic on cell phones, computers, portable media players, televisions, digital cameras, GPSs, watches, and ebook readers. Now you get features from all of them by purchasing a single digital device, such as a smartphone or tablet computer (Figure 11).

FIGURE 10: SMARTPHONES
Cloud computing caters to smartphones and other mobile devices that are a product of convergence. They access and share data from the cloud using apps.

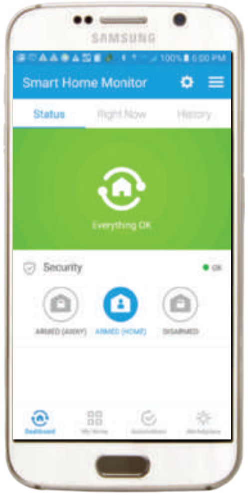
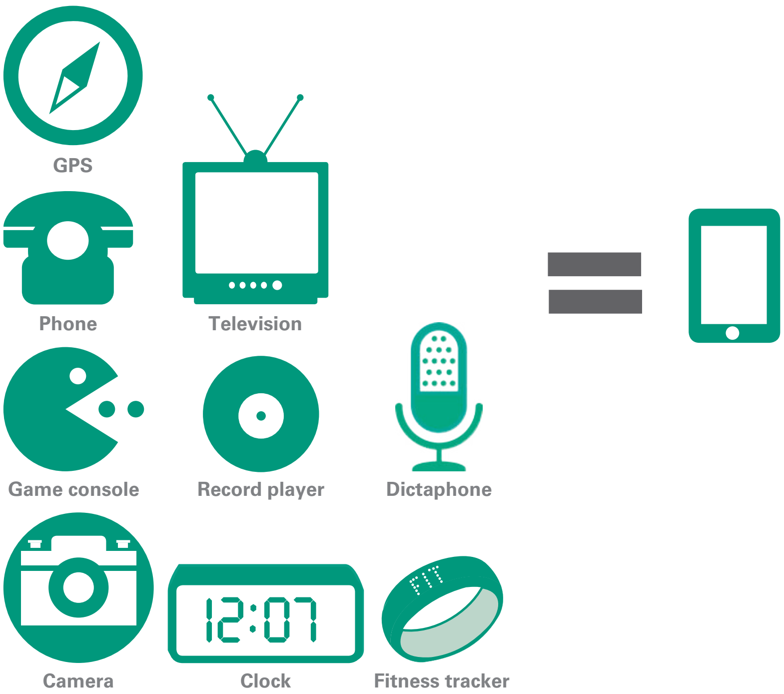


FIGURE 11: SMARTPHONES ARE A PRIME EXAMPLE OF CONVERGENCE



Why do these devices need the cloud? Smartphones are portable. Compared to desktop and laptop computers, smartphones have small screens, lack a proper keyboard, and have limited space for storing apps and data. The cloud offers a convenient place to store data and applications. Think of the cloud as a repository for streaming videos, music, photos, and apps. With that concept in mind, you will begin to understand the cloud's importance to today's consumers.

QUICKCHECK

Which of the following instigated the move to cloud computing?

a. Social media

b. Mobile devices

c. Touchscreens

d. Music downloads

Did the cloud kill the Web? A 2010 *Wired* magazine cover announced “The Web Is Dead.” That pronouncement was premature. The cloud consumed the Web but did not kill it. As a legacy technology from the networking era, the Web continues to be a global marketplace where Amazon, Alibaba, and other retailers sell directly to consumers.

That said, Facebook, Twitter, and Google Apps sent the Web in new directions. Once a collection of storefronts run exclusively by businesses and corporations, the Web expanded into a global hub where content was created by individuals, shared on social media sites, and uploaded to content sharing platforms. This grassroots Web of user-created content is sometimes referred to as **Web 2.0**.

What role do social media play in the cloud era? Facebook, Twitter, and other social media turned the worry of social isolation on its head; instead of computers decreasing human interaction, social media encourage interpersonal communications and relationships. **Social media** are digitally mediated applications designed for communication, social interaction, and consumer-generated content.

Many factors influenced the popularity of these sites, but one important factor is their ease of use. Initially offered as Web sites, there was no software to install and no updates to worry about. Getting started was as simple as registering your name and creating a password. Now, access to social media is also available from mobile apps, which can be installed on a smartphone or tablet with a single touch.

The connections that social media offer come at a price, and that price is not just monetary. Today’s digital citizens surrender a substantial amount of privacy, exposing information that can be used by predators. Privacy, or the lack of it, may be the defining challenge of cloud computing.

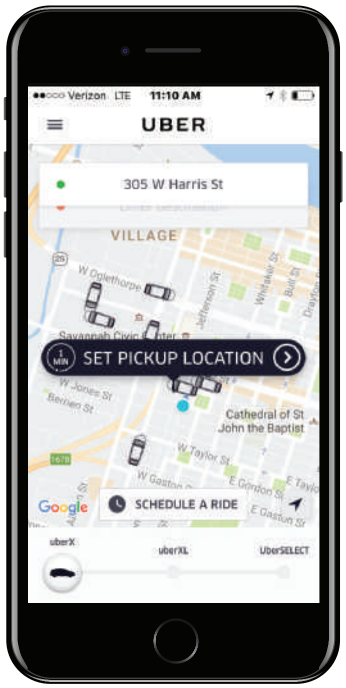
Another challenge is the growing pervasiveness of advertising. Where social media was once a platform for exchanging information between friends and colleagues, intrusive advertising is now found on virtually every Web page, Facebook timeline, and Twitter stream.

Cloud-enabled apps? A key characteristic of the cloud computing era is globe-spanning sharing services. Cloud-based services such as Uber, Airbnb, and Etsy are part of the **sharing economy** in which consumers offer goods and services to other consumers through a shared digital platform.

These sharing services use the cloud to communicate and process data. The apps used by consumers may look simple (Figure 12), but behind the scenes an amazing amount of computer power handles the necessary data and logistics.

TRY IT!

In 2011, the United Nations declared that the Internet “is an indispensable tool for realizing a range of human rights....” Visit the Internet World Stats site to find out what percentage of the world’s population has Internet access.



2017 Uber Technologies Inc.

FIGURE 12: THE UBER APP

UBIQUITOUS COMPUTING

As 2020 nears, a new phase of the digital revolution is taking shape. **Ubiquitous computing** is characterized by a focus on manipulating real-world objects instead of data. Earlier computing technologies used data to represent things in the real world. Photos represented people. Maps showed the location of places. Videos gave us a glimpse of events. Screen-based fantasy worlds and characters entertained us. But all of this was conjured from data. None of it was tangible reality.

Virtual reality, augmented reality, the Internet of Things, and automated vehicles are shaping a new digital era in which technologies bring computing beyond the screen and into the world of tangible objects.

Terminology

Ubiquitous computing is sometimes referred to as *pervasive computing*. The idea is not new. In the 1990s, Mark Weiser predicted that computers will "weave themselves into the fabric of everyday life until they are indistinguishable from it."

I

◗ **What is virtual reality?** In the *Star Trek* series, the starship *Enterprise* had a recreational facility called the holodeck. It was actually an empty room, but fictional "hard light" projectors created touchable and temporarily solid objects to replicate indoor and outdoor spaces. The holodeck is a futuristic version of **virtual reality**, the use of technology to create a simulated three-dimensional world.

Today's virtual reality is far from a holodeck, but donning a virtual reality headset can give you the impression that you are in the middle of a three-dimensional environment. You can look up and down and swivel your head to see your surroundings (Figure 13).

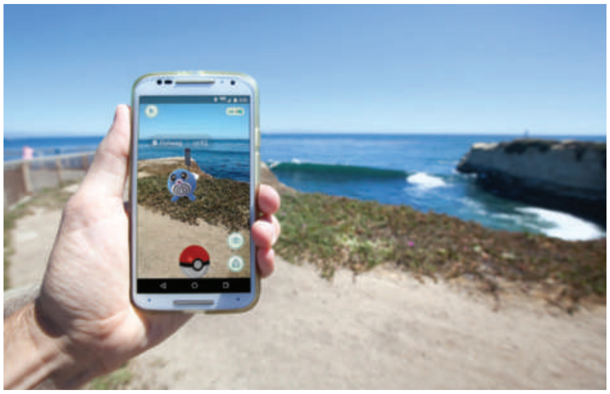
FIGURE 13: VIRTUAL REALITY SIMULATES THE REAL WORLD

ArtFamily/Shutterstock.com

◗ **How is augmented reality different than virtual reality?** Instead of creating a simulated world, **augmented reality** superimposes data over the real world. Pokémon GO popularized augmented reality and provides a great example of how it works.

The reality of Pokémon GO is the real world in your vicinity. It can be shown on your smartphone screen as a map or as a pass-through image from the camera. Pokémon characters are superimposed on the landscape and can be seen through the camera lens. The characters are the augmentation (Figure 14).

FIGURE 14: POKÉMON GO IS AUGMENTED REALITY



Matthew Corley/Shutterstock.com

What is the Internet of Things? The **Internet of Things** (IoT) connects sensors embedded in machines, clothing, and other objects to the Internet, where they can report data and receive commands. It provides a clear example of digital technology controlling objects in the real world.

On a basic level, an IoT device can report to a smartphone. Nest Protect is a smoke and carbon monoxide alarm that not only contains sensors but also contains circuitry that connects to a home Wi-Fi network. That Wi-Fi network can establish communication with a smartphone to report its status and accept commands. For example, if Nest Protect senses smoke when you are away from home, it sends an alarm to your phone. The phone can be used to silence a false alarm—such as when your roommate burns a bagel in the toaster.

But the Internet of Things also connects multiple devices so that they can communicate with each other. The Nest Thermostat is designed to control a home's heating and cooling systems. These systems, when faulty, may output dangerous carbon monoxide. Suppose the Nest Protect detects a high level of carbon monoxide. It can send a message to the thermostat to turn off the furnace (Figure 15).

FIGURE 15: THE INTERNET OF THINGS LINKS DEVICES WITH EMBEDDED SENSORS

What about autonomous vehicles? Self-driving cars and robots are related to the Internet of Things because they require sensor-equipped parts to communicate with each other. **Autonomous vehicles**, for example, navigate without human intervention using sensors to detect the surrounding environment, physical location, speed, and other parameters. They send data and receive commands from an onboard computer running sophisticated artificial intelligence software.

Autonomous vehicles are clear examples of ubiquitous computing—the use of digital technology to manipulate objects in the real world, instead of abstract data. You'll delve into some of these ubiquitous technologies in future chapters. For now, try to guess the year in which you take your first ride in a self-driving car (Figure 16).

FIGURE 16: AUTONOMOUS VEHICLES EXEMPLIFY UBIQUITOUS COMPUTING

Are there more changes to come? If we can learn one thing from the evolving Information Age, it is this: Change is inevitable. Today, your favorite social media platform is Facebook; in the future, Facebook may go the way of CompuServe. Figure 17 summarizes changes through each era of the digital revolution.

FIGURE 17: THE INFORMATION AGE EVOLVES

EXPIRED	TIRED	UNINSPIRED	DESIRED	ADMIRED
Data processing	Personal computing	Network computing	Cloud computing	Ubiquitous
Big corporate and government computers	Desktop computers	Laptop computers	Smartphones and tablets	Autonomous vehicles
Custom applications	Standalone applications	Software suites	Mobile apps and cloud-based apps	Embedded apps
CB radios	Dial-up Internet access	Cable and satellite Internet access	4G and Wi-Fi Internet access	Internet of Things
ARPANET	AOL and CompuServe	The Web and email	Social media	Augmented reality
Arcade games	2D action games	3D multiplayer games	Touchscreen microgames	Virtual reality
Printer	Keyboard	Mouse	Touchscreen	Voice

So what's the point? Learning about digital technology is not just about circuits and electronics, nor is it only about digital gadgets, such as computers and portable music players. Digital technology permeates the very core of modern life.

Understanding how this technology works and thinking about its potential can help you comprehend many issues related to privacy, security, freedom of speech, and intellectual property. It will help you become a better consumer and give you insights into local and world events.

As you continue to read this textbook, don't lose sight of the big picture. On one level, you might be simply learning about how to use a computer and software in this course. On a more profound level, however, you are accumulating knowledge about how digital technology applies to broader cultural and legal issues that are certain to affect your life far into the future.

QUICKCHECK

According to Figure 17, AOL and CompuServe were popular when ________.

a. data processing was the main digital technology

b. most people had dial-up Internet access and used desktop computers

c. smartphones and tablets were introduced

d. people stopped using cloud computing

QUICKQUIZ

INTRODUCTION

1. Data processing is based on an ________ -processing-output cycle.
2. In the personal computing phase of the digital revolution, data and software were stored on ________ devices, such as hard drives.
3. The idea that several technologies evolve into a single device is called ________.
4. Two major technologies that defined the network computing era were the ________ and the Web.
5. ________ computing provides access to information, applications, communications, and storage over the Internet.

1 Digital Content

Module Contents

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DIGITAL BASICS
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Representing Text
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ISSUE:
WHAT IS FAIR USE?

INFORMATION TOOLS:
PHOTO FORENSICS

TECHNOLOGY IN CONTEXT:
FILM

MODULE ACTIVITIES

LAB:
THE DIGITAL WORLD WITH EYES SHUT

So many aspects of life today are digital: music, photos, movies, news, and communications. How can all this diverse "stuff" be accessed through one device, such as a laptop or an iPhone? It's all about digitization.

TRY IT! Apply what you learn.

- Compress files containing various types of data, including text, photos, music, and videos.
- Record audio files.
- Select an audio sampling rate and file format for high-quality sound in files that won't use up all your storage space.
- Convert audio files from one format to another.
- Use voice commands to control your digital devices.
- Select the best file format for digital images, such as photos and scans, taking into account which formats reduce image quality with lossy compression.
- Convert a paper document into a digital file that can be edited using word processing software.
- Work with RGB colors in decimal, hexadecimal, or binary notation.
- Use resolution to gauge the maximum size for an image.
- Use "photoshopping" techniques to enhance, colorize, clone, inpaint, clip, and merge photo images.
- Capture 360-degree images on your smartphone.
- Draw vector images for logos and infographics.
- Convert vector images into bitmaps.
- Render a 3D image from a wireframe.
- Use video editing software to combine video footage with a soundtrack.
- Select output settings for a video, including aspect ratio, resolution, bit rate, compression level, and file format.
- Transcode a video from one file format to another.
- View vector and bitmap images in a VR headset.

1

Digital Content

PRE-CHECK Gauge your level of expertise. The answers are in the module.

6

How do you write it in binary?

How do you write it in ASCII?

A sound wave is digitized by ________ its height thousands of times per second.

Which type of compression makes files smaller without any data loss?

LOSSY

LOSSLESS

List **FIVE** bitmap graphics formats:

What is the basic unit of sound in speech synthesis?

#EE82EE

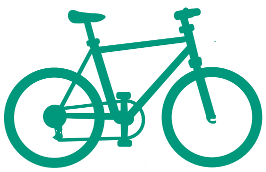
is the hexadecimal number for what color?

BLACK

GREEN

VIOLET

WHITE

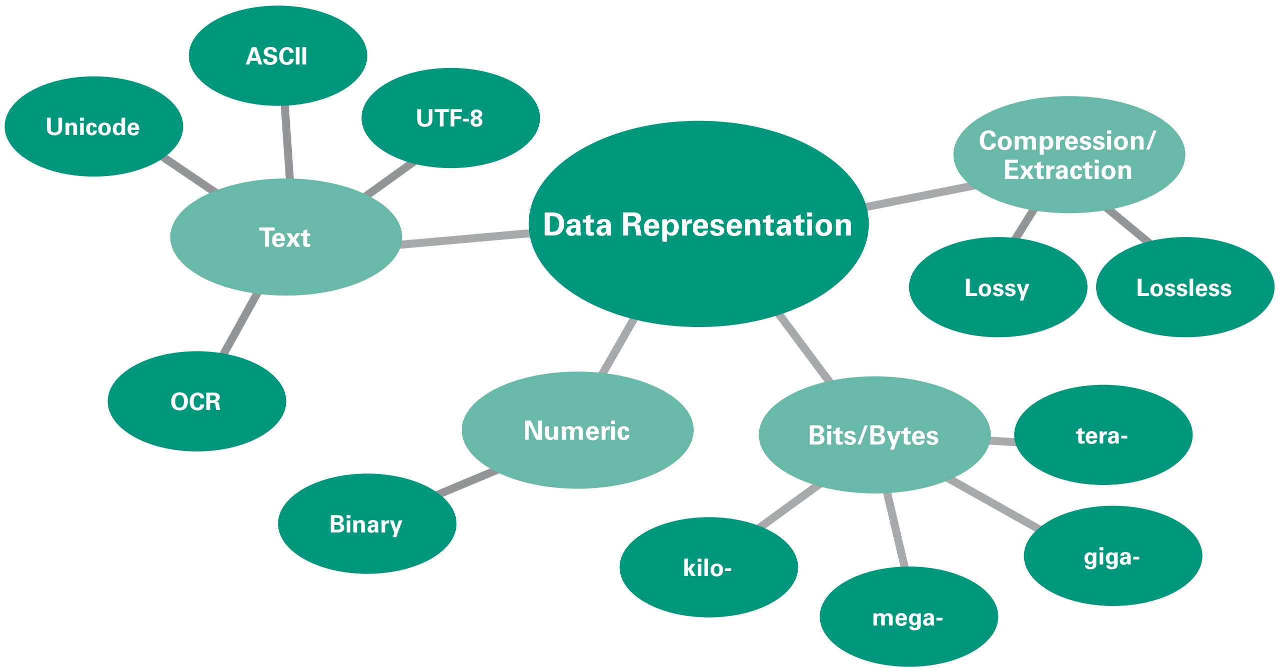


Bike.svg

Bitmap or vector?

List two popular video codecs:

Adding light and shadows is part of what process that creates an image from a wireframe?



SECTION A DIGITAL BASICS

TEXT, NUMBERS, MUSIC, VIDEOS, images, and speech; all of this "stuff" is digital content. The amazing aspect of digital technology is that it distills such diverse content into 0s and 1s and stores them as pulses of electricity. Understanding the data representation concepts presented in Section A will help you grasp the essence of the digital world and get a handle on all the jargon pertaining to bits, bytes, megahertz, and gigabytes.

Terminology

data data representation digital data analog data binary digitization bit File file name extension file format numeric data binary number system character data ASCII Extended ASCII Unicode UTF-8 ASCII text delimiter OCR byte kilobit kilobyte megabit megabyte gigabit gigabyte data compression lossless compression lossy compression

Objectives

- List three technologies that digital devices use to physically store or transmit 1s and 0s.
- Write the numbers 1 through 10 in binary.
- Decipher ASCII text.
- Demonstrate how to use the terms *bit, byte, megabyte, megabit,* and *gigabyte* in the context of data storage and digital devices.
- Distinguish between data that would be represented by binary numbers and data that would be represented by ASCII or Unicode.
- Explain how OCR relates to ASCII and Unicode.
- Describe the difference between lossy and lossless compression.
- Demonstrate how to compress a file.

DATA REPRESENTATION BASICS

Digital content, such as ebooks, documents, images, music, and video, is a compilation of data. **Data** refers to the symbols that represent people, events, things, and ideas. Data can be a name, a number, the colors in a photograph, or the notes in a musical composition.

Is there a difference between data and information? In everyday conversation, people use the terms *data* and *information* interchangeably. However, some technology professionals make a distinction between the two terms. They define data as the symbols that represent people, events, things, and ideas. Data becomes information when it is presented in a format that people can understand and use. As a general rule, remember that (technically speaking) data is used by machines, such as computers; information is used by humans.

What is data representation? **Data representation** refers to the form in which data is stored, processed, and transmitted. Devices such as smartphones, iPods, and computers store data in digital formats that can be handled by electronic circuitry. Today, digital data representation has replaced the analog methods previously used for storing and transmitting photos, videos, and text.

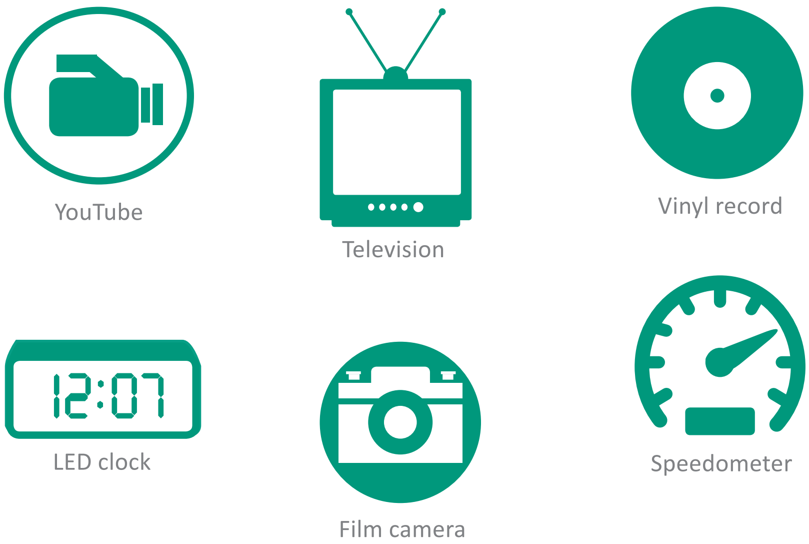
What's the difference between analog and digital? **Digital data** is text, numbers, graphics, sound, and video that have been converted into discrete digits such as 0s and 1s. In contrast, **analog data** is represented using an infinite scale of values. For a simple illustration of the difference between analog and digital, consider the way you can control the lights in a room using a traditional light switch or a dimmer switch.

A dimmer switch has a rotating dial that controls a continuous range of brightness. It is, therefore, analog. A traditional light switch, on the other hand, has two discrete states: on and off. There are no in-between states, so this type of light switch is digital.

A traditional light switch is also **binary** because there are only two possible states. Technically, a digital device could represent data using more than two states. Some of the earliest computers represented numbers using the decimal system. Today, however, most digital devices represent numbers and other data using the binary system.

Terminology

The word *data* can be correctly treated either as a plural noun or as an abstract mass noun, so the phrases "The data are being processed" and "The data is being processed" are both correct usage. In this textbook, the word *data* is paired with singular verbs and modifiers.



QUICKCHECK

Which of the devices on the left illustrate analog data representation?

a. The speedometer and YouTube

b. The television and the vinyl record

c. All but the speedometer

d. All but YouTube and the clock

How does digital data work? The process of converting information, such as text, numbers, photos, or music, into digital data that can be manipulated by electronic devices is called **digitization**.

Imagine that you want to send a message by flashing a light. Your light switch offers two states: on and off. You can use sequences of ons and offs to represent various letters of the alphabet. To write down the representation for each letter, you can use 0s and 1s. The 0s represent the off state of your light switch; the 1s indicate the on state. For example, the sequence *on on off off* would be written as 1100, and you might decide that sequence represents the letter *A*.

The 0s and 1s used to represent digital data are referred to as binary digits. It is from this term that we get the word *bit*—*bi*nary digi*t*. A **bit** is a 0 or 1 used in the digital representation of data.

Digital devices are electronic and so you can envision bits flowing within these devices as pulses of light. But digital signals can take many forms, as shown in Figure 1-1.

QUICKCHECK

Digital devices work with bits in all of the following ways except:

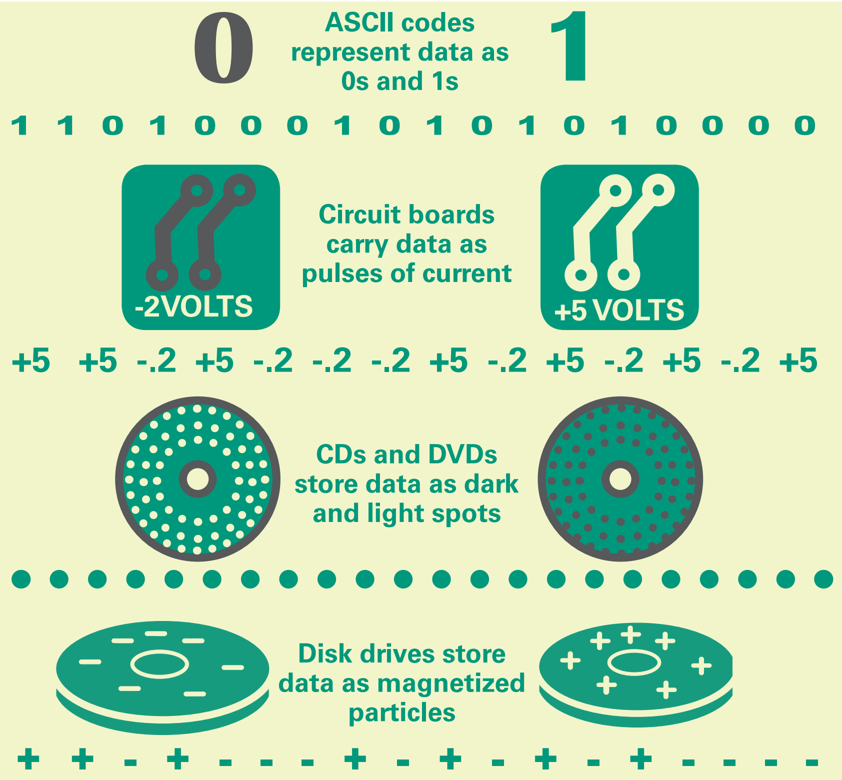
a. voltage variations

b. light and dark spots

c. analog values

d. orientation of magnetized particles

FIGURE 1-1: MANY WAYS TO REPRESENT DIGITAL DATA



How is digital data stored? Digital data is typically stored in files. A digital file, usually referred to simply as a **file**, is a named collection of data that exists on a storage medium, such as a hard disk, CD, DVD, or flash drive. A file can contain data for a term paper, Web page, email message, or video, for example.

Every file has a unique name, such as Thriller.mp3. A **file name extension**, such as .mp3, can be appended to the end of the file name after a period. This extension indicates the **file format**; the type of data in the file and the way it is encoded. Let's take a look at how numbers, text, images, sound, and video are encoded into digital formats that become computer files.

REPRESENTING NUMBERS

Numeric data consists of numbers that can be used in arithmetic operations. For example, your annual income is numeric data, as is your age. That concept seems obvious, but some data that looks numeric is represented differently. Social Security numbers, telephone numbers, street numbers, and similar data are not represented by numeric data. These "numerals" are not considered numeric data because they are never used in mathematical calculations. This numeric quirk is a key concept in the digital world and turns up when you work with spreadsheets, databases, and computer programming.

How do digital devices represent numbers? Digital devices represent numeric data using the binary number system, also called base 2. The **binary number system** has only two digits: 0 and 1. No numeral like 2 exists in this system, so the number "two" is represented in binary as 10 (pronounced "one zero"). You'll understand why if you think about what happens when you're counting from 1 to 10 in the familiar decimal system. After reaching 9, you run out of digits. For ten, you have to use the digits 10—zero is a placeholder and the 1 indicates one group of tens.

In binary, you just run out of digits sooner—right after you count to 1. To get to the next number, you use 0 as a placeholder and 1 indicates one group of twos. In binary, then, you count 0 (zero), 1 (one), 10 (one zero), instead of counting 0, 1, 2 in decimal. If you need to brush up on binary numbers, refer to Figure 1-2.

QUICKCHECK

Which one of the following is considered numeric data?

a. Passport number 47756902231
b. Telephone number 906-222-3450
c. The $28,995.00 cost of a car
d. The address 22 E. Main Street

FIGURE 1-2: BINARY EQUIVALENT OF DECIMAL NUMBERS

DECIMAL (BASE 10)	BINARY (BASE 2)
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010
11	1011
1000	1111101000

QUICKCHECK

Figure 1-2 shows the binary equivalent for numbers 0 through 11 and 1000. What is the binary equivalent for the number 12?

a. 10111
b. 1100
c. 10000
d. 1111

The important point to understand is that the binary number system allows digital devices to represent virtually any number simply by using 0s and 1s. Digital devices can then perform calculations using these numbers. The ability to perform rapid and accurate calculations was the key feature of the first computers, and it now provides the foundation for online banking, ecommerce, and many other number-crunching applications.

REPRESENTING TEXT

Character data is composed of letters, symbols, and numerals that are not used in calculations. Examples of character data include your name, address, and hair color. Character data is commonly referred to as “text.”

How do digital devices represent text? Digital devices employ several types of codes to represent character data, including ASCII, Unicode, and their variants. **ASCII** (American Standard Code for Information Interchange, pronounced “ASK ee”) requires seven bits for each character. For example, the ASCII code for an uppercase *A* is 1000001. ASCII provides codes for 128 characters, including uppercase letters, lowercase letters, punctuation symbols, and numerals.

Extended ASCII is a superset of ASCII that uses eight bits for each character. For example, Extended ASCII represents the uppercase letter *A* as 01000001. Using eight bits instead of seven bits allows Extended ASCII to provide codes for 256 characters. The additional Extended ASCII characters include boxes and other graphical symbols.

Unicode (pronounced “YOU ni code”) uses sixteen bits and provides codes for 65,000 characters—a real bonus for representing the alphabets of multiple languages.

UTF-8 is a variable-length coding scheme that uses seven bits for common ASCII characters, but uses 16-bit Unicode as necessary.

Take a look at the ASCII codes in Figure 1-3. Notice there is a code for the space character in addition to codes for symbols, numerals, uppercase letters, and lowercase letters.

QUICKCHECK

Write out **Hi!** in Extended ASCII code. (Hint: Use an uppercase *H*, but a lowercase *i*.)

H

i

!

FIGURE 1-3: ASCII CODES

00100000	Space	00110011	3	01000110	F	01011001	Y	01101100	l
00100001	!	00110100	4	01000111	G	01011010	Z	01101101	m
00100010	"	00110101	5	01001000	H	01011011	[	01101110	n
00100011	#	00110110	6	01001001	I	01011100	\	01101111	o
00100100	$	00110111	7	01001010	J	01011101	]	01110000	p
00100101	%	00111000	8	01001011	K	01011110	^	01110001	q
00100110	&	00111001	9	01001100	L	01011111	_	01110010	r
00100111	'	00111010	:	01001101	M	01100000	`	01110011	s
00101000	(	00111011	;	01001110	N	01100001	a	01110100	t
00101001	)	00111100	<	01001111	O	01100010	b	01110101	u
00101010	*	00111101	=	01010000	P	01100011	c	01110110	v
00101011	+	00111110	>	01010001	Q	01100100	d	01110111	w
00101100	,	00111111	?	01010010	R	01100101	e	01111000	x
00101101	-	01000000	@	01010011	S	01100110	f	01111001	y
00101110	.	01000001	A	01010100	T	01100111	g	01111010	z
00101111	/	01000010	B	01010101	U	01101000	h	01111011	{
00110000	0	01000011	C	01010110	V	01101001	i	01111100	|
00110001	1	01000100	D	01010111	W	01101010	j	01111101	}
00110010	2	01000101	E	01011000	X	01101011	k	01111110	~

Why are there ASCII codes for numbers? While glancing at the table of ASCII codes in Figure 1-3, you might have wondered why the table contains codes for 0, 1, 2, 3, and so on. Aren't these numbers represented by the binary number system? Yes, the binary number system is used for representing numeric data, but these ASCII codes are used for numerals, such as Social Security numbers and phone numbers that are not used for calculations. For example, 475-6677 is a phone number; it is not a formula that means subtract 6677 from 475.

Where is digital text used? Digital text is everywhere. It is the foundation for all kinds of digital documents, Web sites, social media sites, games, and email. It is also the basis for ebooks designed for Kindles and other ebook readers.

Documents produced on a digital device are stored as a string of 1s and 0s encoded as ASCII, Unicode, or UTF-8. Some kinds of documents simply contain this plain text, whereas other documents contain formatting codes to produce bold fonts, columns, and other effects.

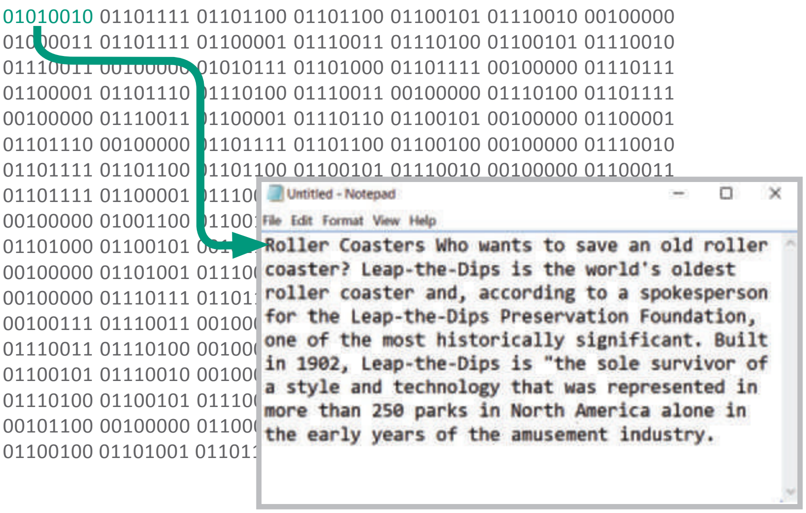
What is plain text? Plain, unformatted text is sometimes called **ASCII text** and is stored in a so-called "text file" with a name ending in .txt. On Apple devices, these files are labeled "Plain Text." In Windows, these files are labeled "Text Document," like this:

Roller Coasters.txt Text Document 2 KB

ASCII text files can be created with text editors, such as TextEdit and Notepad. They are typically used for writing computer programs because executable program code cannot include formatting such as underlining and special fonts. They can also be used for creating Web pages.

Text files can usually be opened by any word processing software regardless of the type of device. In that sense, they are universal. Figure 1-4 illustrates an ASCII text file and the actual binary code that is stored for it.

FIGURE 1-4: ASCII TEXT FILES CONTAIN NO FORMATTING CODES



QUICKCHECK

If your address is 10 B Street, what are the first three bytes in ASCII?

a. 00110001 00110000 01000010

b. 00110001 00110000 00100000

c. 00110001 00110111 00100000

QUICKCHECK

What is the seventh byte in the Roller Coasters file?

a. Uppercase C (01000011)

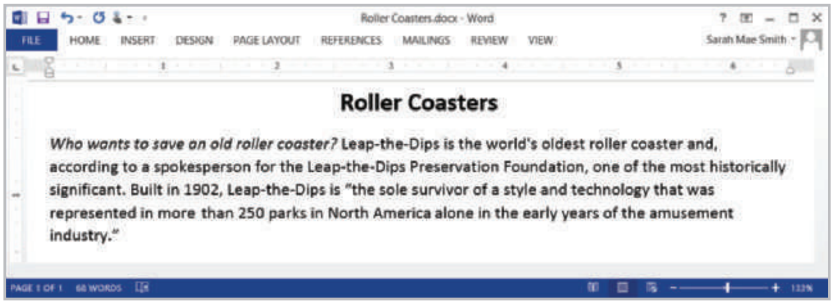
b. Lowercase c (01100011)

c. Space (00100000)

d. Carriage return (00001101)

How does formatting get added to documents? ASCII text files contain no formatting. They have no bold, italics, underlining, or font colors. There are no margins, columns, bullets, headers, or page numbers.

Suppose you want the title of the Roller Coasters document to be centered and shown in a large, bold font, like this:



To create documents with styles and formats, formatting codes have to be embedded in the text. There are many techniques for doing so, and each one produces a unique file format. These formats can be opened by the software that produced them. Opening those files with other kinds of software requires conversion.

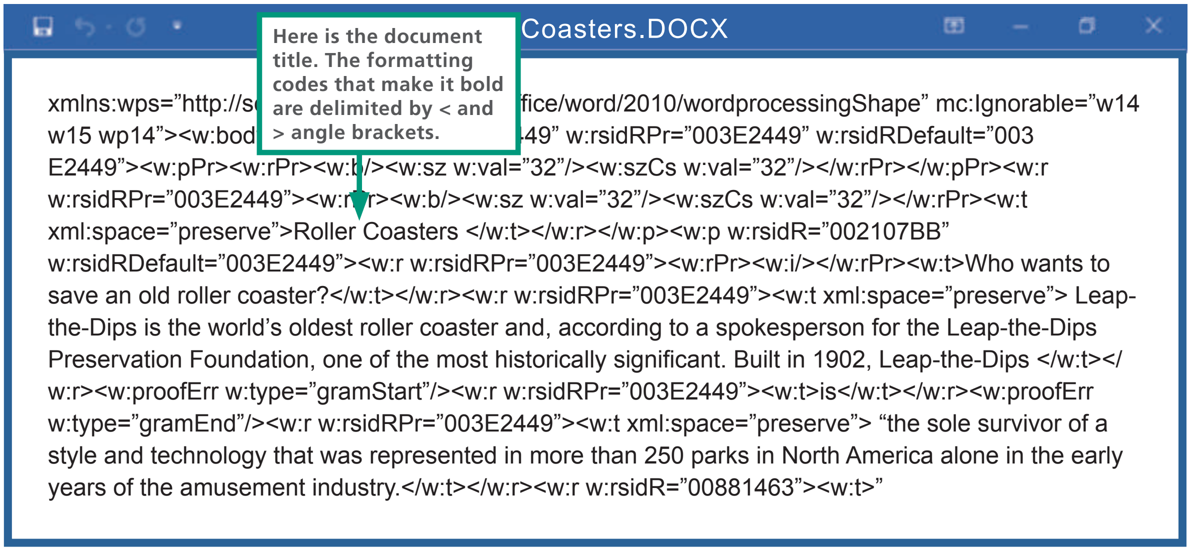
Microsoft Word produces formatted text and creates documents in DOCX format, whereas Apple Pages produces documents in PAGES format. Adobe Acrobat produces documents in PDF format. The HTML markup language used for Web pages produces documents in HTML format. Ebooks are created using the EPUB format.

Formatting codes can be added to documents directly within the text stream, using some sort of **delimiter** to signal the beginning and end of the formatting command. When the document is displayed, the formatting codes are hidden. What do those hidden codes look like? Figure 1-5 gives you a behind-the-scenes look at the Roller Coasters document with all the embedded formatting codes revealed.

Terminology

A *delimiter* is a special character used to separate commands or formatting characters from the rest of the text in a file. Slashes // and angle brackets < > are commonly used delimiters.

FIGURE 1-5: FORMATTING CODES WITHIN A DOCUMENT



What happens when I scan a document? When using a scanner to digitize a document, you may have a choice between graphics formats and OCR. Graphics formats, presented later in the module, essentially capture a photo of the document. Individual letters and punctuation marks are not encoded as ASCII. A document scanned into a graphics format cannot be edited using a word processor.

OCR (optical character recognition) is a process that interprets individual characters during or after a scan. It assigns the appropriate ASCII code to each letter and outputs the document in a format that can be edited using word processing software. OCR software is available for most scanners and is handy when you have a printed copy of a document that you want to modify, but would prefer not to retype.

BITS AND BYTES

All of the data stored and transmitted by digital devices is encoded as bits. Terminology related to bits and bytes is extensively used to describe storage capacity and network access speed. As a digital-goods consumer, you'll want to have this terminology handy.

What is the difference between bits and bytes? Even though the word *bit* is an abbreviation for *binary digit*, it can be further abbreviated, usually as a lowercase *b*. A group of eight bits is called a **byte** and is usually abbreviated as an uppercase *B*.

Transmission speeds are expressed in bits, whereas storage space is expressed in bytes. For example, a cable Internet connection might transfer data from the Internet to your computer at 50 mega*bits* per second. In an iPad ad, you might notice that it can store up to 60 giga*bytes* of music and video.

What do the prefixes kilo-, mega-, giga-, and tera- mean? When reading about digital devices, you'll frequently encounter references such as 90 kilobits per second, 1.44 megabytes, 2.4 gigahertz, and 2 terabytes. *Kilo*, *mega*, *giga*, *tera*, and similar terms are used to quantify digital data as shown in Figure 1-6.

FIGURE 1-6: DIGITAL QUANTITIES

Bit	One binary digit
Byte	8 bits
Kilobit	1,024 or 2^{10} bits
Kilobyte	1,024 or 2^{10} bytes
Megabit	1,048,576 or 2^{20} bits
Megabyte	1,048,576 or 2^{20} bytes

Gigabit	2^{30} bits
Gigabyte	2^{30} bytes
Terabyte	2^{40} bytes
Petabyte	2^{50} bytes
Exabyte	2^{60} bytes

Why such odd numbers? In common usage, kilo, abbreviated as K, means a thousand. For example, $50K means $50,000. In the context of computers, however, 50K means 51,200. Why the difference? In the decimal number system we use on a daily basis, the number 1,000 is 10 to the third power, or 10^3. For digital devices where base 2 is the norm, a kilo is precisely 1,024, or 2^{10}. Mega is derived from 2^{20} and giga from 2^{30}.

QUICKCHECK

Which one of the following would most likely require OCR?

a. A two-page bibliography of award-winning books from 1945 that you would like to annotate

b. An excerpt from a magazine article that you want to include in a term paper

c. A football poster containing the home game schedule

d. A page from a handwritten diary that you want to include in a historical biography

TRY IT!

Scan a one-page document using a scanner or a multifunction printer. The default format for the scan is probably a JPEG or PNG graphic. Try using your scanner's OCR feature or a free online OCR service to convert the scan into a document that can be edited using word processing software.

Terminology

What's a *kibibyte*? Some computer scientists have proposed alternative terminology to dispel the ambiguity in terms such as *kilo* that can mean 1,000 or 1,024. They suggest the following prefixes:

Kibi = 1,024

Mebi = 1,048,576

Gibi = 1,073,741,824

1

When do I use bits and when do I use bytes? As a general rule, use bits for data rates, such as Internet connection speeds and movie download speeds. Use bytes for file sizes and storage capacities. Figure 1-7 provides some examples.

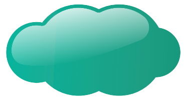
FIGURE 1-7: BITS OR BYTES?

56 Kbps

Kilobit (Kb or Kbit) can be used for slow data rates, such as a 56 Kbps (kilobits per second) dial-up connection.

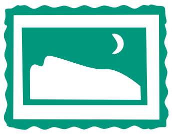
104 KB

Kilobyte (KB or Kbyte) is often used when referring to the size of small computer files.



50 Mbps

Megabit (Mb or Mbit) is used for faster data rates, such as a 50 Mbps (megabits per second) Internet connection.

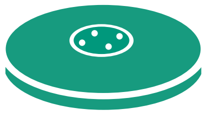


3.2 MB

Megabyte (MB or MByte) is typically used when referring to the size of files containing photos and videos.

100 Gbit

Gigabit (Gb or Gbit) is used for really fast network speeds.



16 GB

Gigabyte (GB or GByte) is commonly used to refer to storage capacity.

QUICKCHECK

My iPhone has 8 ______ of storage space; I uploaded a high-resolution 8-______ graphic; and I am going to download a small 8 ______ file.

a. GB, MB, Mbps

b. MB, GB, KB

c. GB, MB, KB

d. Mbps, MB, GB

COMPRESSION

All those 1s and 0s can quickly expand the size of digital files. Whereas an “A” is simply one character in a printed document, it requires seven bits when represented as ASCII and sixteen bits when represented as Unicode. That “1” in “1st place” seems like it could be represented by a simple 1 bit, but it requires multiple bits when encoded. Numeric data also requires lots of bits. The number 10 is 1010 in binary and requires four bits.

To reduce file size and transmission times, digital data can be compressed. **Data compression** refers to any technique that recodes the data in a file so that it contains fewer bits. Compression is commonly referred to as “zipping.” Many compression techniques exist. They can be divided into two categories: lossless and lossy.

What is the difference between lossless and lossy compression? **Lossless compression** provides a way to compress data and reconstitute it into its original state. Character data and numeric data in documents and spreadsheets are compressed using lossless techniques so that the uncompressed data is exactly the same as the original data.

Lossy compression throws away some of the original data during the compression process. After the data is uncompressed, it is not exactly the same as the original. This type of compression is typically used for music, images, and videos because the human ear or eye cannot discern minor changes. Later in the module, you’ll learn more about the compression techniques used to shrink the size of music, image, and video files.

QUICKCHECK

Which one of the following requires lossless compression?

a. A very large document that you intend to send as an email attachment

b. A photo of your class reunion that you intend to post on your Facebook page

c. An iTunes track saved to your iPod that you want to back up on your computer

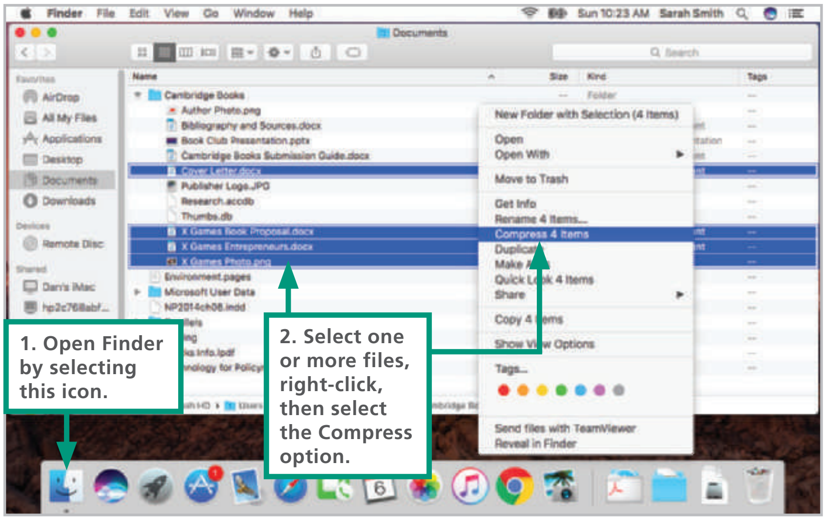
How do I compress data? The software for compressing data is sometimes referred to as a compression utility or a zip tool. Most computers include software for compressing data, but tablets and smartphones may require a third-party app for working with compressed data.

On laptops and desktop computers, the compression utility is accessed from the same screen used to manage files. You can compress the data in a single file or you can combine multiple files to create a single zipped file that is reconstituted to the original files when unzipped (Figure 1-8).

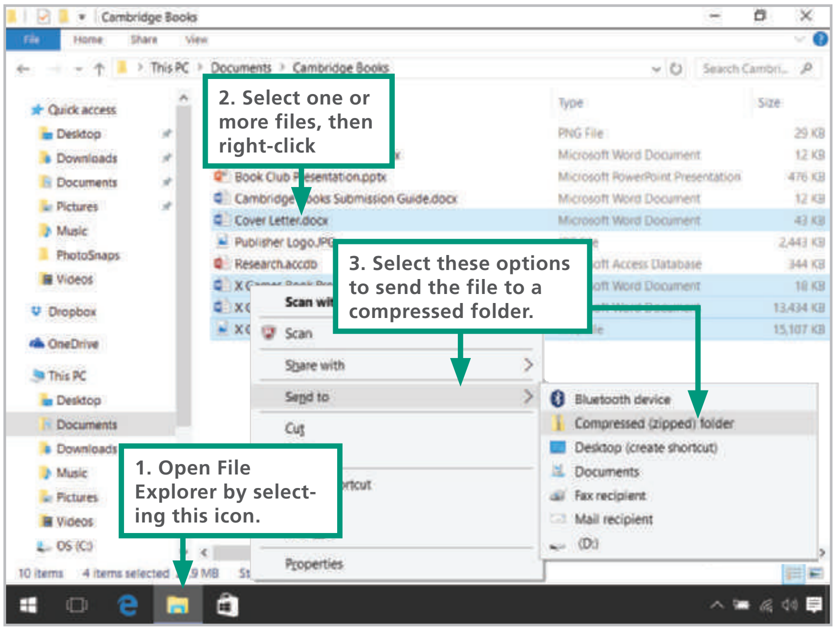
TRY IT!

Experiment with compressing files to see how much they shrink. Try compressing a document, then try a graphic.

FIGURE 1-8: COMPRESSING FILES



Compressing files using Finder on a Mac



Compressing files using File Explorer on a PC

QUICKCHECK

Compression utilities can be used to accomplish all of the following except:

a. bundle two or more files into a single small file

b. enlarge a file to increase its resolution

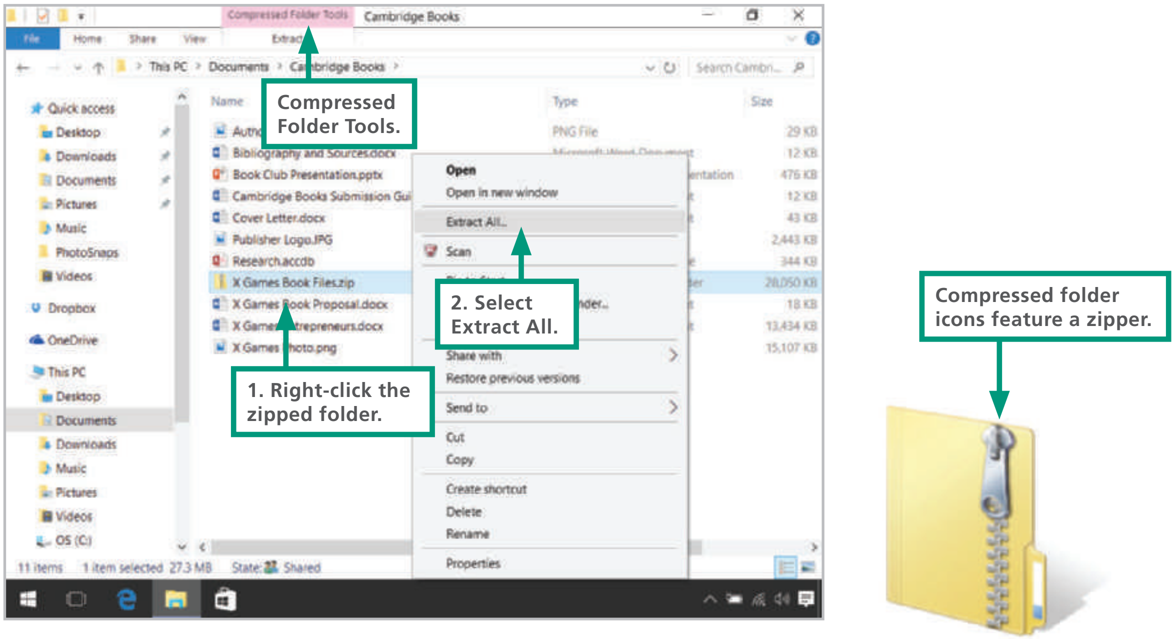
c. zip a single file to decrease its size

d. extract a file to its original size and content

How do I return files to their uncompressed state? The process of reconstituting files is called extracting or unzipping. As with compression, most laptops and desktop computers include extraction and unzipping software; tablets and smartphones may require a third-party app.

Compressed files usually have .zip at the end of the file name and are represented with specialty icons. Compressed files may also end with .gz, .pkg, or .tar.gz. These files have to be extracted or unzipped before you can view the data they contain. The process is easy. To extract a file on a Mac, simply double-click the zipped folder. With Windows (Figure 1-9), use the Compressed Folder Tools or Extract All option.

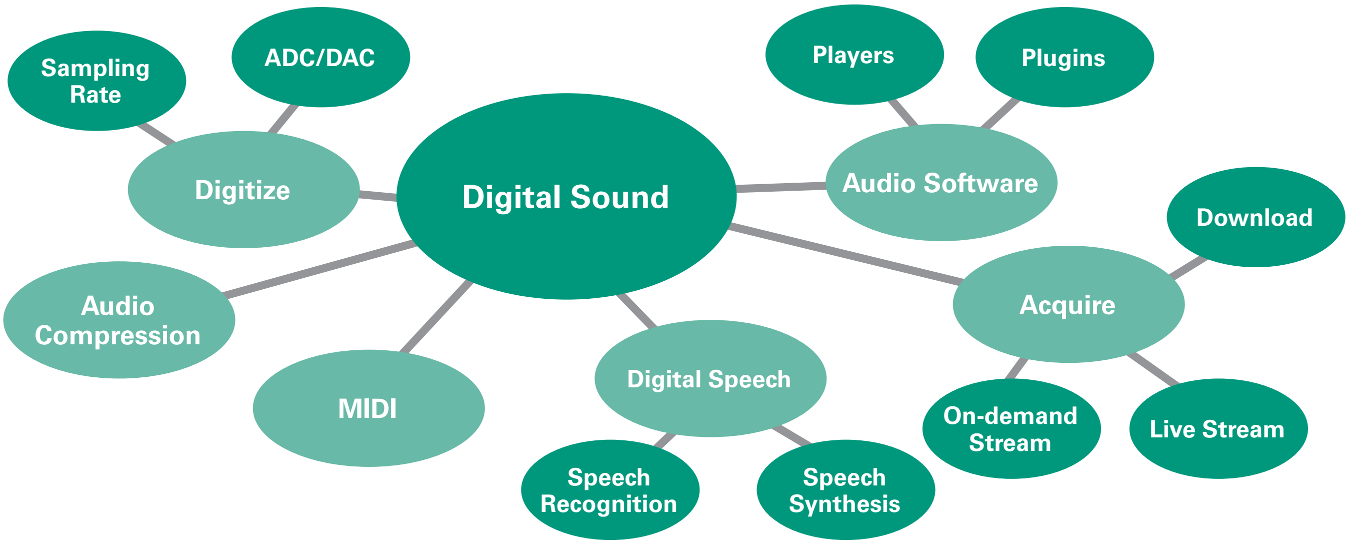
FIGURE 1-9: EXTRACTING FILES IN WINDOWS



QUICKQUIZ

SECTION A

1. A(n) ______ is a 0 or 1 used in the digital representation of data.
2. Most computers use Unicode, UTF-8, or Extended ______ code to represent character data. (Hint: Use the acronym.)
3. Formatting codes can be added to documents using a(n) ______, such as slashes // and angle brackets< >.
4. In the computer world, TB is the abbreviation for ______.
5. The data files containing photos, videos, and music are typically compressed using ______ compression that throws away some of the original data.



SECTION B DIGITAL SOUND

MUSIC DOWNLOADS were one of the first massively popular types of digital content, but audio technology plays a key role in other interesting applications. This section covers a wide-ranging selection of digital audio concepts and technologies that you're likely to find handy for personal and professional use.

Terminology

digital audio analog-to-digital converter digital-to-analog converter sampling rate audio compression AAC MP3 Ogg Vorbis WAV FLAC WMA audio interface digital audio extraction download live stream on-demand stream audio player audio plugin synthesized sound MIDI MIDI messages speech synthesis speech recognition phoneme text-to-speech software

Objectives

- Describe the process of digital sampling.
- Select the appropriate sampling rate for a digital audio recording.
- Identify digital audio files by their file name extensions.
- Convert digital audio files from one format to another.
- Understand why most audio files are compressed and how this affects sound quality.
- Decide when to download, live stream, or stream music on demand.
- Explain the difference between digital audio and MIDI.
- Explain how Siri and similar services work.

DIGITAL AUDIO BASICS

Digital audio is music, speech, and other sounds represented in binary format for use in digital devices. It is a key technology used by popular music services such as iTunes and Spotify. It also plays a role in natural language interactions, such as voice messaging, Google Voice Search, and Siri.

How do I record sound? Most digital devices have a built-in microphone and audio software, so recording external sounds, such as narrations, is easy. Additional software, such as Soundflower, might be required to capture and save sound that is playing on your computer from Internet radio, podcasts, or online television shows.

How is sound digitized? Sound is produced by the vibration of matter such as a violin string or a drum head. This vibration causes pressure changes in the surrounding air, creating waves. The smooth, continuous curve of a sound wave can be directly recorded on analog media, such as vinyl records or cassette tape, but digital recordings are based on samples of a sound wave.

To digitally record sound, samples of a sound wave are collected at periodic intervals and stored as numeric data in an audio file. For example, when recording a voice message on your phone, the sound waves of your voice are sampled many times per second by an **analog-to-digital converter** (ADC). Those samples are converted into binary 1s and 0s, which are stored in an audio file. When the audio file is played, a **digital-to-analog converter** (DAC) transforms the digital bits into analog sound waves and outputs them through speakers. Figure 1-10 shows how a sound wave is digitally sampled.

QUICKCHECK

What is the purpose of sampling?

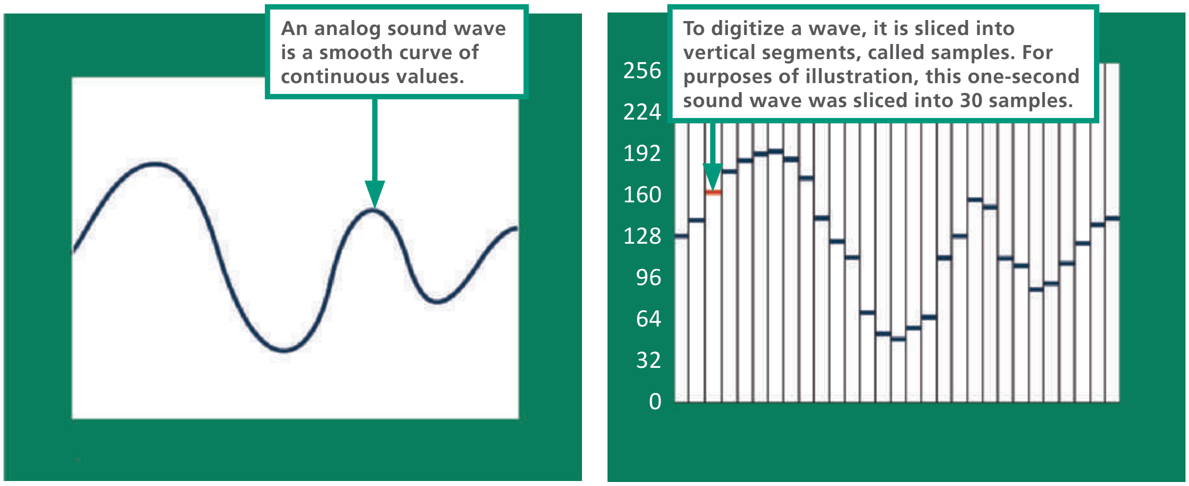
a. To measure the height of each sound wave

b. To take multiple height measurements of a wave and convert them into binary

c. To determine the type of instrument that makes each sound

d. To record a sound at the highest fidelity

FIGURE 1-10: DIGITIZING A SOUND WAVE



SAMPLE	SAMPLE HEIGHT (DECIMAL)	SAMPLE HEIGHT (BINARY)
1	130	10000010
2	140	1000110
3	160	10100000
4	175	10101111

The height of each sample is converted into a binary number and stored. The height of sample 3 is 160 (decimal), so it is stored as its binary equivalent—10100000.

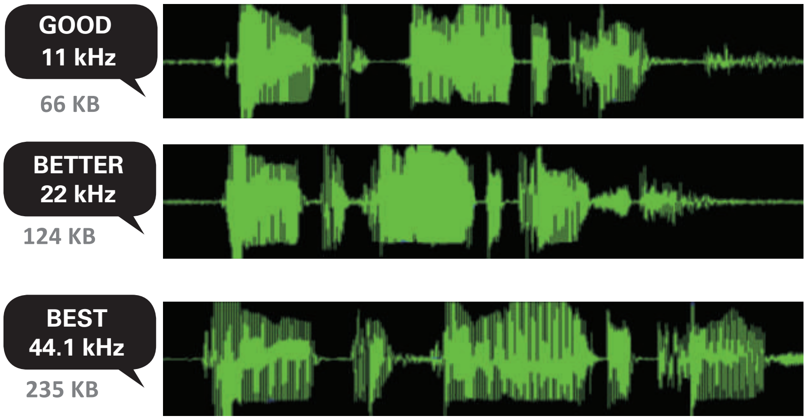
Does sampling rate affect sound quality? **Sampling rate** refers to the number of times per second that a sound is measured during the recording process. It is expressed in hertz (Hz). One thousand samples per second is expressed as 1,000 Hz or 1 kHz (kilohertz). Higher sampling rates increase the quality of the recording but require more storage space than lower sampling rates.

To conserve space, applications that do not require high-quality sound use low sampling rates. Voice-overs and narrations are often recorded with sampling rates of 11 kHz (11,000 samples per second). This rate results in lower quality sound, but the file is about one-fourth the size of a file for the same sound recorded at 44.1 kHz. Figure 1-11 illustrates how sampling rate affects sound quality and file size.

TRY IT!

Try recording a short narration. Does your digital device have a built-in microphone and recording software?

FIGURE 1-11: SAMPLING RATE, SOUND QUALITY, AND FILE SIZE



How much space is required to store an audio file? When sampling stereo high-fidelity music at 44.1 kHz, one second of music requires about 0.176 MB of storage space. Forty-five minutes of music—the length of a typical album—requires about 475 MB. You might wonder how audio files rack up so much space.

The height of each sound sample is saved as a 16-bit number for high-fidelity recordings. To achieve stereo effects, you must take two of these 16-bit samples. Therefore, each sample requires 32 bits of storage space. A sampling rate of 44.1 kHz records 44,100 32-bit samples per second. Here is the calculation:

32 X 44,100 = 1,411,200

32	44,100	1,411,200
bits in one stereo sample	samples per second	bits (176,400 bytes) for each second of music

QUICKCHECK

In this calculation, the sampling rate is _____________.

a. 32 bits

b. 44.1 kHz

c. 1.4 Mbps

d. None of the above

Is there any way to compress audio files? Regardless of sampling rate, digital audio file size can be reduced using audio compression techniques. **Audio compression** reduces the size of a sound file by removing bits that represent extraneous noise and sounds that are beyond the frequencies of normal hearing.

Most music for portable media players is stored in compressed audio file formats. These lossy formats reduce the size of audio files, but also reduce their quality. Sophisticated listeners can tell the difference, but most casual listeners are content with the quality produced by compressed files streaming from an iPod or a similar device. Files in compressed formats, such as MP3, don't get much smaller if you subsequently use general compression tools provided by Finder and File Explorer.

Files containing "raw" noncompressed audio can be compressed using the same general compression tools used for text and numeric data. For example, using lossless tools provided by Finder and File Explorer, you can compress a large audio file before attaching it to an email message. The recipient of the compressed files will have to unzip the file before listening to it, however.

QUICKCHECK

Audio compression is usually ______________ .

a. lossy

b. lossless

c. raw

DIGITAL AUDIO FILE FORMATS

You can recognize a digital audio file by looking at its type or its file extension. For example, Thriller.mp3 is an audio file, not a music video.

Thriller.mp3 Michael Jackson MP3 Format Sound

File extension File type

Which audio formats are most popular? Digital audio is stored in a variety of file formats. The table in Figure 1-12 provides an overview of the most popular digital audio formats, which include **AAC**, **MP3**, **Ogg Vorbis**, **WAV**, **FLAC**, and **WMA**.

TRY IT!

Make a short audio recording using your favorite digital device. What are the default file format and sampling rate? If you record at a higher sampling rate, can you tell the difference in sound quality?

FIGURE 1-12: POPULAR AUDIO FILE FORMATS

AUDIO FORMAT	EXTENSION	ADVANTAGES	DISADVANTAGES
AAC (Advanced Audio Coding)	.aac, .m4p, or .mp4	Very good sound quality based on MPEG-4; lossy compression; used for iTunes music	Files can be copy protected so that use is limited to approved devices
MP3 (also called MPEG-1 Layer 3)	.mp3	Good sound quality; lossy compression; can be streamed over the Web	Might require a standalone player or browser plugin
Ogg Vorbis	.ogg	Free, open standard; lossy compression; supported by some browsers	Slow to catch on as a popular standard; part of Google's WebM format
WAV	.wav	Good sound quality; supported in browsers without a plugin	Audio data is stored in raw, noncompressed format, so files are very large
FLAC (Free Lossless Audio Compression)	.flac	Excellent sound quality; lossless compression	Open source format supported by many devices
WMA (Windows Media Audio)	.wma	Lossy or lossless compression; very good sound quality; used on several music download sites	Files can be copy protected; requires an add-on player for some devices

What are the best sources for digital music? There are several options for obtaining audio content, such as music, soundtracks, narrations, and sound effects.

Live recording is an option for obtaining digital sound files from concerts or lectures. For casual recording, Voice Memos and similar apps work well. Professional recordings require more sophisticated software and hardware tools. A device called an **audio interface** accepts input from a standalone microphone and feeds it into a computer.

Ripping CD tracks is handy for someone who inherits a stack of old CDs and wants to convert the music into a format that plays on a smartphone or other mobile device. *Ripping* is a slang term that refers to the process of importing tracks from a CD or DVD to your computer's hard disk. The technical term for ripping music tracks is **digital audio extraction**.

Downloading is popular for saving audio files on local devices. A **download** copies a file from a private network or Internet server to a local device. The file is transferred as an unit and cannot be played until the entire file has arrived.

Streaming offers yet another way of obtaining audio content. Unlike some digital content, such as photos, that must be accessed as a whole piece, audio content plays back over a period of time. Audio files can be acquired as a **live stream** or **on-demand stream** in addition to downloads (Figure 1-13).

TRY IT!

Find the names of two live streaming music services and the names of two on-demand streaming services.

QUICKCHECK

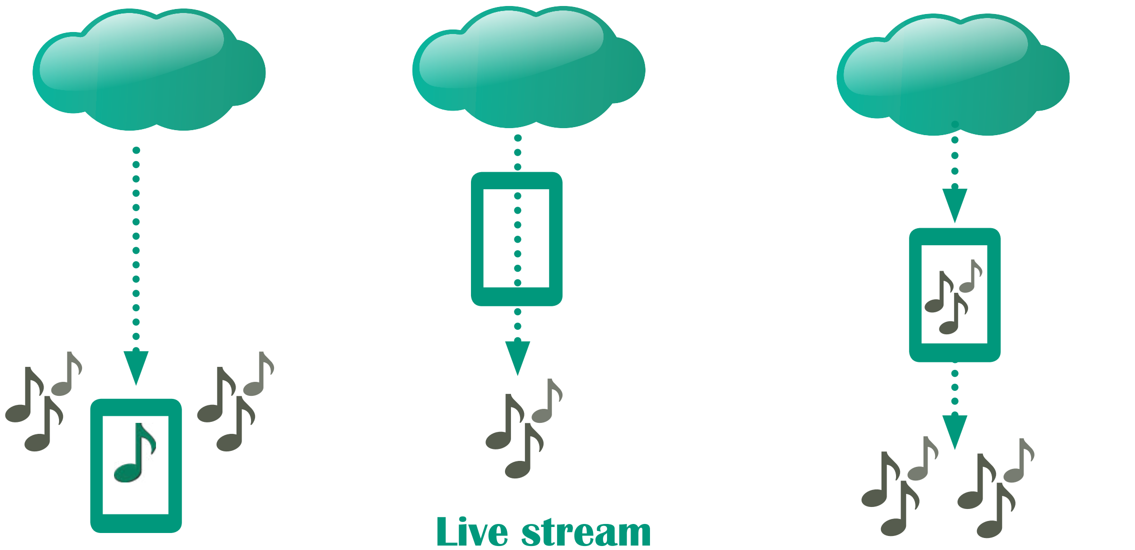
You've selected a music track on your smartphone, but there is a pause before it begins. This pause is associated with ____________.

a. downloading audio tracks

b. live streaming audio

c. on-demand streaming

FIGURE 1-13: DOWNLOADING AND STREAMING



Download

A download transfers an audio file from a server to your local device.

You can play back the file even when your device is not online.

The file can be played with any compatible software or player.

Live stream

A live stream sends media from a server to your local device, where it is played, but not stored.

This method is also known as Webcasting.

You have to be online while listening.

The content stream cannot be paused, stored, or rewound.

On-demand stream

An on-demand stream sends the media to your local device, where it is stored temporarily, or "buffered," until there is enough data to begin playback.

You can fast-forward to any point in the stream without waiting for the entire file to download.

What type of software is required to work with digital audio files? To play a digital audio file, you must use some type of audio software. Whether you can use general-purpose audio software, a special-purpose player, or a browser plugin depends on the source and type of audio.

Audio players. An **audio player** is a small standalone software application or mobile app that offers tools for listening to digital audio and managing playlists, but may not provide tools for making your own recordings. Audio players might be included with your computer's operating system, packaged with your sound card, installed in a handheld device, or available as a download.

Audio plugins. An **audio plugin** is software that works in conjunction with your computer's browser to manage and play audio that you are accessing from a Web page. Each audio plugin tends to work with only one audio format, so multiple plugins are necessary when you have audio files in several formats.

Audio software. General-purpose audio software and apps provide tools for recording, playing, and modifying audio files. Popular audio software includes iTunes, Windows Media Player, and Audacity (Figure 1-14).

QUICKCHECK

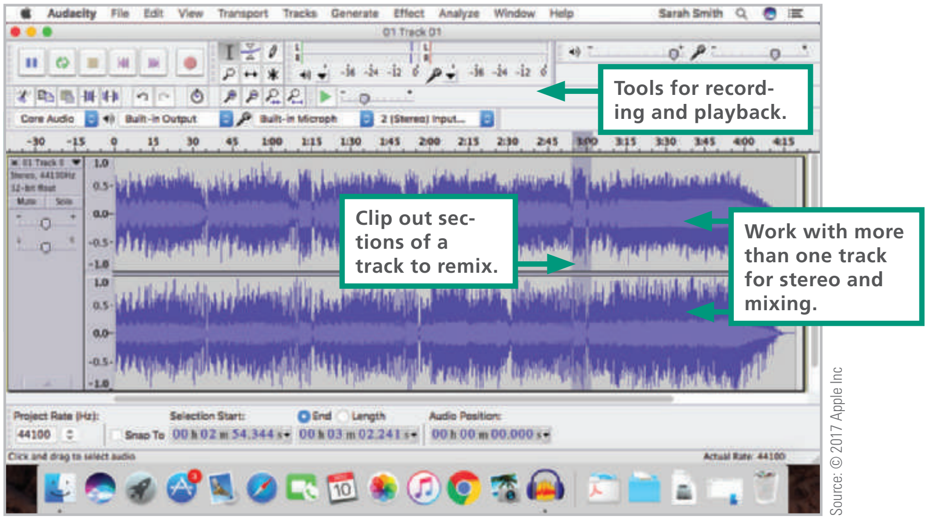
The term *ripping* applies to:

a. converting CD tracks to formats such as MP3 and AAC

b. downloading MP3 files illegally from the Internet

c. compressing AAC files with digital audio extraction

FIGURE 1-14: AUDACITY AUDIO SOFTWARE



Source: © 2017 Apple Inc

MIDI

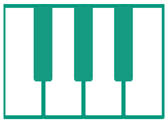
Digital audio is a recording of real analog sound signals. In contrast, **synthesized sound** is an artificially created, or synthetic, sound. The first music synthesizers were analog. When digital synthesizers became popular, MIDI was developed as a way to control them.

What is MIDI music? **MIDI** (Musical Instrument Digital Interface) specifies a standard way to store music data for synthesizers, electronic MIDI instruments, and computers. Unlike digital audio files, which contain digitized recordings of real performances, MIDI files contain instructions, called **MIDI messages**, specifying the pitch of a note, the point at which the note begins, the instrument that plays the note, the volume of the note, and the point at which the note ends. MIDI music is usually stored in .mid files.

What is the data representation for a MIDI message? As with all digital data, MIDI messages are distilled into a series of bits represented by 1s and 0s. A MIDI message might look like this:

1001 Note on

0001 Channel 1 designates piano



01010100 Note number 84 designates high C

0111000 Velocity 112 designates loud volume

What are the advantages and disadvantages of MIDI? MIDI files are much more compact than digital audio files. Depending on the exact piece of music, three minutes of MIDI music might require only 10 KB of storage space, whereas the same piece of music stored in a high-quality, noncompressed digital audio file might require 30,000 KB of storage space.

One of the main disadvantages of MIDI is that it cannot produce vocals. Another disadvantage is that the quality of MIDI music depends on the play-back device, which stores a collection of synthesized sounds. MIDI music might sound great on a computer equipped with high-end MIDI equipment, but the same MIDI sequence might sound artificial on a handheld device.

Who uses MIDI? Today, MIDI is primarily a tool used by studio musicians, performers, and composers. Musicians can input notes for several instrumental parts directly from a MIDI keyboard and create backup instrumentation for performances. One or two musicians with MIDI gear can sound like a large band.

Music composition software with MIDI support makes it easy to place notes on a screen-based music staff, then play back the composition on a MIDI keyboard or through the speakers of a digital device (Figure 1-15).

QUICKCHECK

Which of the following files is likely to contain synthesized music?

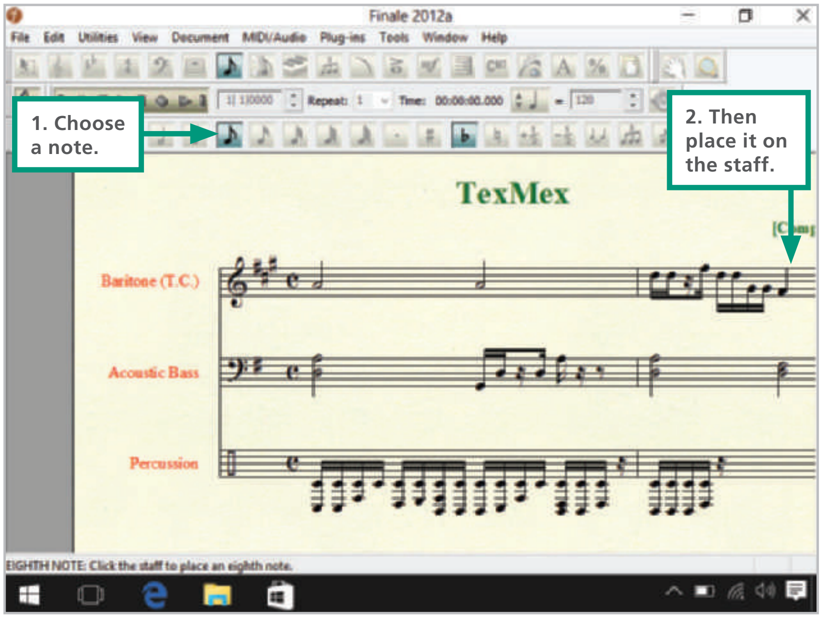
a. Bongos.mp3

b. Screech.wav

c. Waltz.ogg

d. Sugar.mid

FIGURE 1-15: MIDI MUSIC COMPOSITION



Software © MakeMusic, Inc. Music © MediaTechnics

DIGITIZED SPEECH

Speech technologies are used to collect information from callers using telephone-based services such as Directory Assistance. They are the foundation for interactive voice response systems such as Google Voice Search, Siri, and Cortana. Speech recognition enables people to control software with spoken commands, as well as dictate text into a word processing document. Speech technologies can also read a computer screen aloud, which unlocks access to computers and the Internet for individuals with visual disabilities.

▶ **What's the difference between speech synthesis and speech recognition?** **Speech synthesis** is the process by which machines produce sound that resembles spoken words. **Speech recognition** (or voice recognition) refers to the ability of a machine to understand spoken words.

▶ **How does speech synthesis work?** A basic sound unit, such as "reh" or "gay," is called a **phoneme**. Most speech synthesizers string together phonemes to form words. For example, the phonemes "reh" and "gay" produce the word "reggae." Phonemes are usually derived from recordings of human voices reading specially prepared passages of text. **Text-to-speech software** analyzes the words in a section of text, finds corresponding phonemes, and combines them into sentences for output.

▶ **How does speech recognition work?** On a personal computer or smartphone, a speech recognition system collects words spoken into a microphone that's connected to sound processing circuitry. This circuitry's analog-to-digital converter transforms the analog sound of your voice into digital data. This data is then processed by speech recognition software.

Speech recognition software analyzes the sounds of your voice and converts each word into groups of phonemes. Next, the software compares the groups of phonemes to the words in a digital dictionary that lists phoneme combinations along with their corresponding English (or French, Spanish, and so on) words. When a match is found, the software can display the word on the screen or use it to carry out a command. Most digital devices offer a way to use spoken commands (Figure 1-16).

QUICKCHECK

Which one of the following requires digital-to-analog conversion?

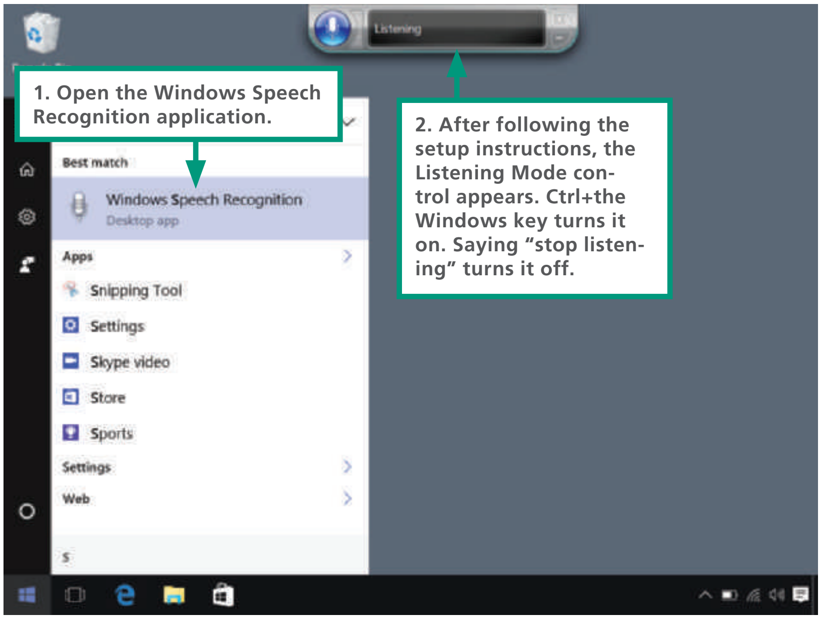
a. Speech synthesis

b. Speech recognition

c. Entering a Google Voice command

d. Voice dialing

FIGURE 1-16: MICROSOFT CORTANA SPEECH RECOGNITION



TRY IT!

If you have a laptop with Windows 10, it includes a comprehensive speech recognition system called Cortana. Try it out. You can speak commands to launch apps, navigate menus, and dictate text for email messages and documents.