
FUNDAMENTALS OF INFORMATION
TECHNOLOGY: Textbook – English

The Modernization of Digital Information
Technology

2023

Fundamentals of Information Technology

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FUNDAMENTALS OF INFORMATION TECHNOLOGY

**SHAMBHAVI ROY
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Where is the “any” key?

—Homer Simpson, in response to the message, “Press any key.”

Overview

In today’s digital age, technology permeates every aspect of our lives. Understanding the fundamentals of information technology is increasingly critical for personal satisfaction and professional success. Whether you are a curious novice or an aspiring technology professional, this book is your gateway to unlocking the mysteries and endless possibilities of the world of computing.

This book aims to give someone with no background in information technology the essential working knowledge of computers while also offering a sweeping view of the more complex topics. Whether you aspire to build cutting-edge applications, do groundbreaking research, or simply want to gain a deeper understanding of technology to be proficient at your job, this book will equip you with the essential knowledge and tools to thrive.

By the end of this book, you will know the history of computers; be comfortable using the common productivity tools to write a document, create a spreadsheet, make a presentation, send an email; organize your files; use the web for research; understand the ethical issues associated with information technology; and know the pitfalls of social media. This will help you participate in intelligent conversations about current and upcoming technologies with professionals in the field.

Through clear explanations, practical examples, and hands-on exercises, we aim to demystify complex concepts like cybersecurity and computer networks, empower you to think critically, and encourage you to embrace a creative and problem-solving mindset that lies at the heart of information technology. We also hope that this information will encourage you to consider college and career options in the dynamic world of digital information technologies.

Are you ready to embark on this adventure? Let’s dive into the captivating realm of digital information technologies and unlock the boundless opportunities therein.

Key Features and Outline

This book is divided into a few sections. The first section covers the fundamentals and provides an overview of the components of digital information technologies. [Chapter 2](#) covers the history of information technology, from the time women served as “computers” to today’s mobile revolution. In [Chapter 3](#), you will learn about all the possible career options and the skills necessary to be a proficient worker in the digital age. [Chapter 4](#) will equip you with skills to navigate the web, find online training, and make you aware of the risks associated with online information. [Chapter 5](#) is all about the architecture of microcomputers, including tablets, smartphones, and smartwatches. [Chapter 6](#) will give you the basics of file and folder management, including compression, decompression, and backup. The next section focuses on personal productivity applications. [Chapter 7](#) provides an overview of production by apps. Chapters [8, 9, 10](#), and [11](#) delve into the intricacies of word processing, spreadsheets, presentation applications, and emails. After productivity applications, we introduce enterprise technologies, the core technologies used by large companies to manage their operations. You will spend a lot of time using these technologies if you choose information technologies as your career. [Chapter 12](#) teaches basic HTML and website development skills. Chapters [13](#) and [14](#)

introduce computer languages and databases to give you a taste of what it might be like to work as a programmer. Chapters 15 and 16 offer the basics of computer networks and cybersecurity. The last section focuses on issues of personal and social concern. Chapter 17 talks about ethical issues and Chapter 18 discusses social media.

Digital Information Technology Standards

This book supports a course titled Digital Information Technology (DIT) (8207310) used within the Florida Department of Education (FDOE) public school system. The content included in this book aligns with the FDOE Student Performance Standards for DIT. The FDOE describes the DIT course as:

This core course is designed to provide a basic overview of current business and information systems and trends, and to introduce students to fundamental skills required for today's business and academic environments. Emphasis is placed on developing fundamental computer skills. The intention of this course is to prepare students to be successful both personally and professionally in an information-based society. Digital Information Technology includes the exploration and use of: databases, the internet, social media, spreadsheets, presentation applications, management of personal information and email, word processing and document manipulation, HTML, web page design, and the integration of these programs using software that meets industry standards.

This definition is taken from the DIT website, Business Management & Administration, Digital Information Technology (8207310), 2023-24 CTE Curriculum Frameworks, <https://www.fl DOE.org/academics/career-adult-edu/career-tech-edu/curriculum-frameworks/2023-24-frameworks/business-management-administration.shtml>. This link is current as of June 2023.

Beyond this textbook, there are additional resources that can be used to supplement the DIT course. These resources can be downloaded from here: <https://digitalcommons.usf.edu/dit/>. These supplemental course resources include a comic book and a learning management system course designed using Canvas. The comic book serves as an alternative medium to learning topics covered in DIT. The Canvas course includes resources that can help students learn and instructors teach DIT according to the FDOE standards.

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Section 1

Fundamentals

History of Information Technology

2

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What is Apple, after all? Apple is about people who think “outside the box,” people who want to use computers to help them change the world, to help them create things that make a difference, and not just to get a job done.

—Steve Jobs, co-founder of Apple

Overview

How do you spend your free time? How do you communicate with friends? How do you complete schoolwork? How do you find the information you need? How do you buy things you like? What are some of your most prized possessions? What do some of the business celebrities you admire do? On completing school, what are some of the popular high-paying jobs in your town that you might be interested in doing? In the first half of the 21st century, Digital Information Technologies (DIT), or **Information Technologies** (IT) for short, are likely to be part of the answer to all these questions. Slowly but steadily, DIT has dramatically influenced our lives to the point where it is now necessary for all students to know the essentials of using DIT to improve their lives. This book, the accompanying materials, and the DIT course aim to do just that. At the end of this class, you should be able to explain to friends and family how **computers** work. You should also feel comfortable using computers to improve your own effectiveness.

Information technologies are powerful because people crave information, and IT makes it easy for people to get this information. The world is teeming with information about who we are, where we live, and what we do to sustain ourselves. Until very recently, before the advent of computers in approximately 1990, this information was written on paper, published in newspapers or magazines, and stored in libraries and stacks of files in offices. In your own personal lives, you and your parents probably cherish family photo albums with printed photographs. Before computers, there was no easy way for people to share information with each other. Businesses did not have easy access to **data** about their own customers to understand larger patterns and take corrective actions.

Beginning in the 1990s, computers became popular, and starting in the 21st century, computers got connected to each other through the Internet, and the field of **Information Technology** (IT) was born. IT is the use of computers and networking technologies to store, process, and retrieve information. IT is now so important to organizations that IT investments, which include computers, **networks**, **software**, and employees are now one of the largest expenses for most organizations.

Regardless of what type of work you plan to do when you complete school, you will be expected to be as comfortable using IT effectively as you are using your first language. Doctors are expected to read and write electronic medical records as they interact with patients, CEOs, and business owners are expected to interpret reports generated by IT, and government staff is expected to work with citizen records as they respond to user queries. In turn, some of the most desirable jobs in the economy are emerging from this infusion of technology, which we will explore more in [Chapter 3](#).

The Department of Motor Vehicles (DMV) is a great example of the impact of IT on our lives. See [Figure 1](#). Today, when you buy a car and go to the Department of Motor Vehicles (DMV) to get it registered, the clerk at the DMV office will record all the information about you and your car (make, model, VIN number) in a computer to establish your ownership of the car.



FIGURE 1 — At a typical DMV office, you interact with people who gather data and provide services.

Your data will be cleaned, processed, and moved across several computers and finally stored in a [data center](#). See [Figure 2](#). This data center will also hold similar data about all car owners across the state.

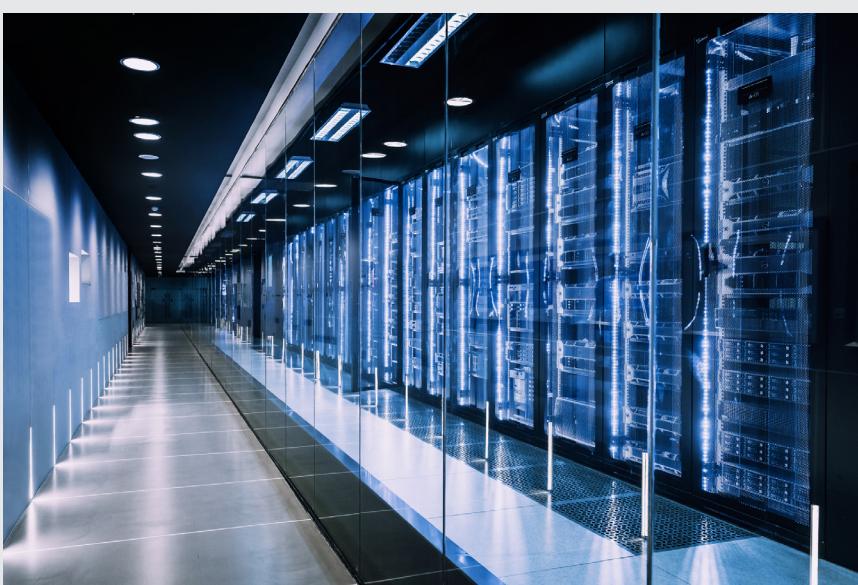


FIGURE 2 — A data center is a warehouse optimized for running thousands of computers. A typical data center can consume the power equivalent of a small town and provide backend IT applications for social media and [mobile apps](#) like maps and searches.

How does IT help you and the DMV? Why should your state government invest millions of dollars each year to computerize the DMV? In 2020, there were 276 million vehicles registered in the US.¹ The DMV needs to store information about all these vehicles and drivers safely. The DMV must also make the information available quickly when necessary. For example, when you buy a car, the DMV must make sure that the seller is the owner of the car and has the right to sell the car to you. When police officers stop drivers on the highway for speeding, it is very useful for officers to be able to check the driver's license and car registration information. This keeps the roads safe for other drivers. Less interestingly, computerization also makes it easy for the DMV to send drivers automated reminders to make annual registration payments. Can you imagine doing all this across all 50 states in the nation without IT?

To pull off this feat of information technology, the DMV uses lots of expensive computers that are connected through complex networks and software programs that interact with the information stored in the **system**. They hire many trained people to maintain these data centers, upgrade **hardware** and software regularly, and maximize the efficiency of the DMV. These employees are very well compensated because their skills are valuable. The DIT course sets you on a path to acquire these skills so you can work in these roles across government and industry.

However, the DMV's IT system (hardware, software, **IT personnel**, and processes) will be very different from that of the Department of Homeland Security (DHS) or any other organization for that matter. Even within organizations, IT systems evolve constantly based on how we want to gather information, what bits of information we want to gather, and what information has lost meaning over time. Some IT systems need to be highly secure, some are spread across the world, and some may be small enough to need just one employee and a desktop.

Until around 2015, there was a distinction between personal electronic devices such as cell phones and office IT systems like PCs. But now with powerful **smartphones** and cheap mobile Internet, this distinction is disappearing. Employees expect business applications to be as user-friendly as consumer applications and consumer services to be as secure as business services. Employees can be responsive round-the-clock from work and home. Employees of the **gig economy** (e.g., Uber drivers, Door Dash delivery people, Amazon/FedEx drivers) use personal phones as their primary work devices to process orders. In this example, their personal mobile devices are part of the company's IT system. See [Figure 3](#). The Covid pandemic and the work-from-home trend have further reduced the distinction between personal and professional IT.



FIGURE 3 — Uber drivers use an app on their personal phones to select drives, communicate with passengers, navigate to locations, get paid, and gather feedback. Their phone is part of Uber's IT system.

¹ Federal Highway Administration, Highway Statistics 2020, <https://www.fhwa.dot.gov/policy-information/statistics/2020/mv1.cfm> (accessed June 2023).

How Information Technology Began

This section provides a quick tour through the history of how we have reached the current state of “information technology everywhere.” We show how innovative teams have responded to human needs and commercial incentives to create the technologies we take for granted today. If you find this interesting, we hope you will read more about these individuals and technologies on the Internet.

The history of information technology includes the history of computer hardware and software. Charles Babbage is credited with building the first mechanical computer in the 1820s. Over a hundred years later in 1946, a team at the University of Pennsylvania publicly reported the first programmable, general-purpose computer. It was called the Electronic Numerical Integrator and Computer (ENIAC). The ENIAC weighed 30 tons and took up 1800 square feet of space. See [Figure 4](#). It supported most hardware and software components that modern programmers recognize. The ENIAC could read inputted data, hold information in memory, step through programming instructions, create and call sub-programs, loop through code, and print output.^{2 & 3}

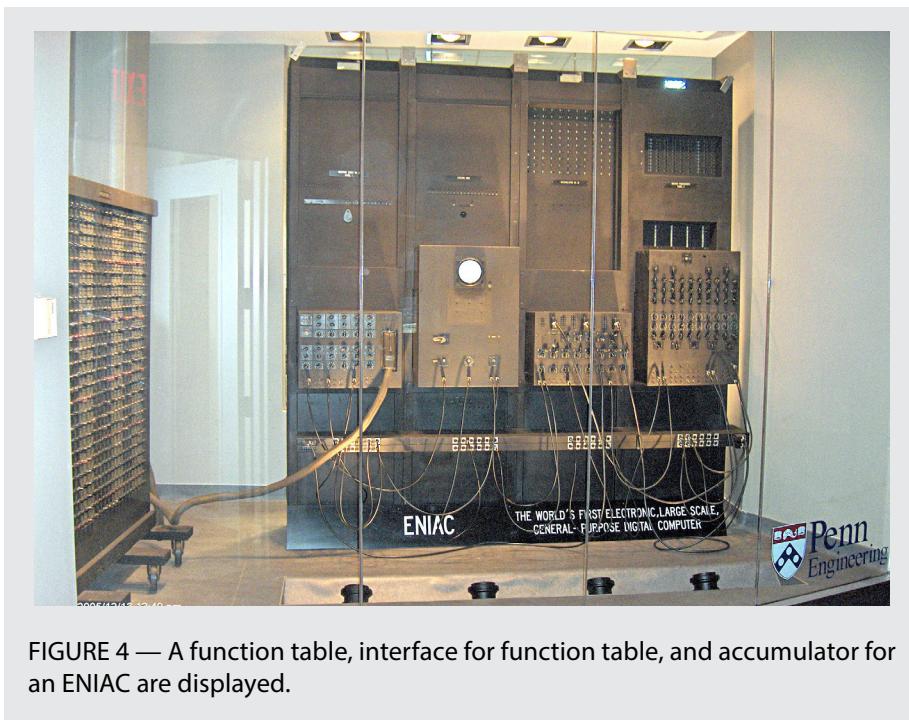


FIGURE 4 — A function table, interface for function table, and accumulator for an ENIAC are displayed.

The ENIAC didn't have a lot of modern peripherals we take for granted now, such as monitors, [keyboards](#), and printers. To use the ENIAC, programmers had to write instructions (code) into punched paper cards (cards with holes that could be read by computers). It took weeks of code-writing and debugging before the computer could do anything useful. The US Army funded the development of

-
- 2 The specifications of the ENIAC are available from the Smithsonian archives: <https://library.si.edu/digital-library/book/report-eniac-electronic-numerical-integrator-and-computer> (accessed June 2023).
 - 3 The ENIAC page at the Computer History Museum has pictures and videos of the ENIAC computer and its key operators: <https://www.computerhistory.org/revolution/birth-of-the-computer/4/78> (accessed June 2023).

the ENIAC to compute firing tables during WWII.⁴ Firing tables provided recommendations to gun operators on the optimal specifications to hit a target, taking into account terrain conditions, weapon wear-and-tear, ammunition type, etc.⁵ While the ENIAC was created to serve a specific military purpose, its general computing capabilities captured the imagination of the public.

The ENIAC was a computer like any modern computer, but it did not use software as we understand it today. Every instruction for every task was hard coded by experts. If the task was to be repeated, the instructions were written again on punch cards, which could take days. A lot of these instructions involved tasks such as reading data and writing outputs, which are common to all computer programs.

Eventually, these shared tasks were aggregated into computer programs called **operating systems**. The Operating System (OS) is the brain of the computer and controls all the parts of a computer. A computer **mouse**, keyboard, display monitor, **motherboards**, and **storage drives** are all components of a computer, and they act together as one computer only when the operating system recognizes them and orchestrates a symphony of coordinated actions to complete the task you tell the computer to perform. When you move your mouse, tab your screen, type on your keyboard, or make a phone call, it is the operating system that recognizes the action and tells the components how to act to bring about the desired outcome.

What Does an Operating System Do?

Operating systems are to computers what front offices are to schools.

Most complex entities offer a “front office” that makes it simple for users to request and offer services. At most schools, for example, the front office is where students report absences and get their schedules, teachers report grades and request supplies, and parents make inquiries. The front office staff are experts in handling these requests and orchestrating the necessary actions to complete these requests. The front office staff also ensures that any administrative requirements, such as student privacy, are protected as these actions are performed. Operating systems perform the same role for computers. They receive inputs from users and applications and coordinate all necessary actions until the appropriate output is presented to users.

Operating systems evolved rapidly in the 1960s and 70s. In 1971, AT&T, the dominant phone company at the time, built an operating system called **Unix**. See [Figure 5](#). Unix and its variants were freely distributed across the world in the 1970s and 1980s, and some of the world’s best computer scientists and engineers volunteered their contributions to make Unix extremely capable. These experts were guided by the principle of using the “*minimum number of keystrokes [to] achieve the maximum*

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- 4 If you’re looking for an interesting math project, or seeing how the military uses calculus, this article on the ENIAC may be useful: Harry L. Reed Jr, “Firing table computations on the ENIAC,” Proceedings of the 1952 ACM national meeting (Pittsburgh), May 1952 Pages 103–106, <https://dl.acm.org/doi/pdf/10.1145/609784.609796> (accessed June 2023).
- 5 Examples of firing tables are at <https://www.globalsecurity.org/military/library/policy/army/fm/6-40/Ch7.htm> (accessed June 2023).

effort.”⁶ Because of their powerful capabilities and low to no costs, Unix and its variants including the popular [Linux](#) operating system, now power most computers around the world, including all major smartphones. Windows is another popular operating system, used extensively on desktops and in data centers.



FIGURE 5 — Scientists at AT&T Bell Labs created the Unix system, thereby laying the foundation for modern computers. Ken Thompson (seated) and Dennis Ritchie (standing) are credited with inventing Unix.

The Origin of Unix

Unix began as one developer’s attempt to support games on office machines.⁷

Ken Thompson used his spare time at AT&T Bell Labs to write nerdy computer games and developed software to support his game, *Space Travel*. Because the software only supported one user (Ken Thompson), the software became famous at the lab as Thompson’s *Un-multiplexed Information and Computing Service*, or Unics, and later was abbreviated as Unix. Eventually, Unix acquired capabilities for multiple users to share the resources of a central processor, so the Unix name is not really representative of the operating system’s single-user limitations anymore. But names stick, and the Unix name remains popular. The first edition of Unix was just 4,200 lines of code indicating how powerful good computer code can be. Even in these earliest editions, Unix included games such as Blackjack, and this contributed to its popularity.

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- 6 Peter Collinson, “On the design of the Unix operating system,” Hillside Systems—On the Design of the UNIX operating System, <https://www.hillside.co.uk/articles/typing.html> (accessed June 2023).
- 7 Warren Toomey, “The strange birth and long life of Unix,” IEEE Spectrum, Dec 2011, pgs. 34–37, 52–55.

A powerful economic force also contributed to Unix's widespread adoption. While AT&T funded the development of Unix, 15 years earlier, in 1956, AT&T had reached an agreement with the federal government that gave it monopoly status on long-distance telephony. In exchange, AT&T agreed not to sell any product that was not directly related to long-distance telephony. Eventually, AT&T shared the source code to Unix with multiple organizations, and they released their adaptations to the world. One of the most popular of these adaptations was developed at UC Berkeley and was called Berkeley Systems Distribution (BSD) Unix. The licensing for BSD Unix allowed adopters to make their own modifications without releasing them back to the community. This was very useful to commercial vendors. Among the most popular current commercial releases tracing their lineage to BSD are the operating systems on all Apple products, including MacOS on laptops and iOS on smartphones. The popularity of Unix is the result of technology excellence and economic incentives.

The Era of Personal Computers

Until the early 1980s, computers were too expensive for personal use. As the cost to manufacture computer components came down, IBM saw an opportunity to make small, self-contained personal computers (PCs) that had their own Central Processing Units (CPUs). Since Unix was designed for giant centralized machines and [dumb terminals](#), there was a need for an operating system that could run on these personal devices. IBM partnered with Microsoft to create an operating system for personal computers. This operating system was called [Disk Operating System](#) (DOS). Although DOS wasn't easy to use (users still needed to type commands manually on a line), the idea of owning a computer caught on, and the IBM PC started the PC revolution by becoming the world's first popular personal computer.



While IBM was not the first to make a personal computer, its entry into the market in 1981 with its PC priced at \$1565, significantly cheaper than others, revolutionized the market.

The IBM PC and Florida

The IBM personal computer was invented in Florida.⁸ Boca Raton to be precise. Since 1967, IBM had operated a unit in Boca Raton to develop, build, and sell inexpensive computers. A team at this unit built the inexpensive personal computer (PC) by creating an open design where components from multiple vendors could interoperate. The IBM PC used processors from Intel, operating systems from Microsoft, and components from several other vendors. Competition among these vendors brought costs down, while the popularity of personal computers helped many of these suppliers become large companies themselves. As of 2022, Microsoft (valued at \$2Tr) and Intel (valued at \$130bn) are worth more than IBM itself (\$118bn). As of 2022, IBM, Intel, and Microsoft employ over 600,000 people.

Along with inexpensive hardware, in the mid-1980s came user-friendly software. In 1985, Microsoft launched **Microsoft Windows**, an easy-to-use **Graphical User Interface** (GUI) based operating system. Microsoft also released Excel for financial calculations in 1985 and Word for text editing in 1989. Doug Klunder (Microsoft's first college hire⁹) led the development of Excel and Charles Simonyi (the world's first repeat space tourist¹⁰) led the development of Word. Both programs leveraged the special capabilities of graphical user interfaces and propelled personal computers to widespread adoption in businesses. Computers also turned into convenient home devices for everyday users to write letters, manage personal finances, communicate with friends and family, create music, and watch entertainment shows. Between 250 million and 350 million personal computers sell each year to meet this demand.

The Era of Networked Computers and the Internet

Communication is a very fundamental human activity and information exchange has been one of the most popular uses of computers. **Computer engineers** recognized this need for information exchange early on and developed technologies for computers to talk to each other. The initial networks were limited in scope, connecting computers located within an office, and allowing users within an office to send emails to each other and share expensive resources such as printers.

8 Boca Raton Historical Society, <https://www.bocahistory.org/ibm-boca-raton> (accessed June 2023).

9 In 1992, Doug left software development and has since pursued a career as a lawyer, <https://alum.mit.edu/slice/heres-why-creator-microsoft-excel-left-software-career-work-civil-liberties> (accessed June 2023).

10 Simonyi paid \$20million for his first space trip, <https://www.britannica.com/biography/Charles-Simonyi>; https://en.wikipedia.org/wiki/Charles_Simonyi (accessed June 2023).

Mother of All Demos¹¹

One of the most famous demonstrations of technology happened on December 9, 1968. Douglas Engelbart delivered a 90-minute demonstration of essentially all the personal networked computer technology we use today. The demo included networking, graphical user interfaces, web-like pages (hypertext), images, the computer mouse, video conferencing, and word processing. In about 20 years, the technology was available in stores. For its far-reaching impact, the technology industry gave it the name "*mother of all demos*."

As networks grew, **network effects** emerged. To understand the network effect, imagine a village with just two telephones connected to each other by a wire. The telephones will not be very useful since they only connect two people in the village. Conversations with all other users happen outside this network. However, as more people in the village connect to the network, every telephone in the network becomes increasingly useful. The same telephone allows users to connect to more people in the village. The free increase in benefit to the community as more members join a network is called the network effect.

The network effect generated powerful incentives within the industry to network computers. By 1981, the core computer networking technology we use today was specified. Since that time, the development of computers is closely associated with the development of computer networks, the Internet, and the World Wide Web.

The Internet and the World Wide Web

Since the beginning of the 21st century, computer networks have become robust and globally available like water and electricity. Users and businesses have taken advantage of this networking capability to share information and do business with people around the world. The global network of computers that share information with each other is called the Internet. Information on the Internet can be linked to any other information on the Internet and these links can be considered as a web of information. Therefore, the information shared on the Internet is called the World Wide Web.¹²

Information traveling on the Internet is like cars traveling on a highway system. The Internet is a vast network connecting many smaller local networks, in the same way that the highway network connects all local roads. You can start from any point and drive to any other point using the network of roads as long as the roads are connected. The World Wide Web enables the same capability for information.

11 "The Mother of All Demos," Wikipedia; Video recording of the demo, <https://douengelbart.org/content/view/209/> (accessed June 2023).

12 More visualizations, including videos of the evolution of the Internet are available from the Opte project, <https://www.opte.org/> (accessed June 2023). The site has been maintained for over 15 years by Barrett Lyon, an artist and Internet enthusiast. Information on the site may be interesting and useful for projects in other classes, including how governments can strangle Internet access, <https://www.opte.org/about> (accessed June 2023).

Networks and Development

Until about 1870, the United States was about as economically advanced as the rest of the world. But by 1920, the United States had advanced decisively in comparison. Much of this is attributed to the construction of five networks—water, sewage, electricity, roads, and telephones. By the end of the 20th century, the information network was added to this list of networks contributing to American prosperity.

The Internet is built by connecting two types of networks—small networks within buildings and large networks that connect these small networks. The small networks connecting workers inside an office building or a school are called Local Area Networks (LANs). The network at your school or home is an example of a LAN. LANs help the computers in an office share files, emails, printers, and the Internet connection with each other. The networks that connect these small networks to each other are called Wide Area Networks (WANs). WANs are typically large networks spread across a wide geographic area such as a state or country and are used to connect the LANs within corporate and satellite offices. WANs are typically operated by Internet providers such as Verizon, Frontier, and Spectrum and users pay subscription fees to access WANs.¹³

The Mobile Revolution

Computing technologies have evolved rapidly and the technology industry has succeeded in shrinking computers to the size of mobile phones. Soon after the PC became a household device, developments in related technologies like storage, battery capacity, screens, materials, and networking fueled the mobile revolution. As a result, the traditional phone is now mostly replaced by powerful computers called smartphones, which users around the world carry in their pockets and purses. While Windows was the dominant operating system for the personal computer era, two operating systems are dominant in the mobile era—Apple's [iOS](#) and Google's [Android](#). Both these operating systems trace their lineage to Unix. While the iPhone's iOS is a version of Unix, Android is based on Linux, a Unix-compatible operating system initially created in 1991 by Linus Torvalds when he was a student at the University of Helsinki in Finland.



Steven Jobs shows off the iPhone 4 at the 2010 Worldwide Developers Conference.

13 The universities in Florida operate a WAN called Florida Lambda Rail, <https://www.flrnet.org/> (accessed June 2023) that connects them to each other and other research institutions around the globe.

Moore's Law

The availability of computers gave us the ability to design more powerful computers. The virtuous cycle was the basis of [Moore's law](#) named after Gordon Moore, one of the founders of Intel, a computer chip pioneer. Gordon Moore noted that the number of transistors on a [microchip](#) doubled every two years. The transistor is the core component of a computer chip and is a tiny electronic device used to store and process information. Its size is measured in nanometers (one-millionth of the width of a human hair). To understand the kind of progress we have made, consider the fact that a cutting-edge computer microchip in 1970 had about 2000 transistors in it, but the latest Apple M1 computer chip, released in 2020, has 114 billion transistors.

Today, even street vendors with modest incomes in developing countries around the world own mobile phones; and people living in distant countries can be as accessible as your next-door neighbors, all thanks to the availability of free audio and video phone apps. You can use your phone to do office work while being entertained, whether at home or waiting in a line at a grocery store.

Women in Technology

The World's First Programmer

Did you know that the person often regarded as the world's first programmer was a woman, Ada Lovelace? Early on, women didn't get sufficient credit for their work. The dedicated team of women programmers who worked on the ENIAC received recognition for their work only in the 1980s.



Women were the original “computers,” doing complex math problems by hand for the military before the machine that took their name replaced them.... During the 1940s and 50s, women remained the dominant sex in programming, and in 1967 Cosmopolitan magazine published “The Computer Girls,” an article encouraging women into programming. “It’s just like planning a dinner,” explained computing pioneer Grace Hopper. “You have to plan ahead and schedule everything so that it’s ready when you need it. Programming requires patience and the ability to handle detail. Women are ‘naturals’ at computer programming.”

—Caroline Criado Perez, *Invisible Women*, 2019

However, the moment it became clear that there was money to be made in computers, the moment it became clear that programmers needed to be brilliant, men ended up replacing women as programmers. Women faced significant hurdles in getting hired as programmers. Clearly, women had the programming skills since they were already doing the job. However, we, as a society, have a *brilliance bias*¹⁴—we rarely see women as brilliant. Rather than trying to figure out an applicant's suitability for a job, tech companies stereotyped male characteristics as brilliant—a nerdy attitude, unkempt hair and face, staying up all night to program, loitering on programming websites that often also have content that women may find offensive. Hiring managers failed to account for the fact that a girl programmer may look different and even express her love for programming differently. For example, the tech-hiring platform Gild combed through applicants' social data to assess their suitability.

According to Gild's data, frequenting a particular Japanese manga site is a "solid predictor of strong coding." Programmers who visit this site therefore receive higher scores. Which all sounds very exciting, but as O'Neil points out, awarding marks for this rings immediate alarm bells for anyone who cares about diversity. Women, who as we have seen do 75% of the world's unpaid care work, may not have the spare leisure time to spend hours chatting about manga online. O'Neil also points out that "if, like most of techdom, that manga site is dominated by males and has a sexist tone, a good number of the women in the industry will probably avoid it."

—Caroline Criado Perez, *Invisible Women*, 2019

But the bias against women doesn't end at hiring.

More than 40% of women leave tech companies after ten years compared to 17% of men. A report by the Center for Talent Innovation found that women didn't leave for family reasons or because they didn't enjoy the work. They left because of "workplace conditions," "undermining behavior from managers," and "a sense of feeling stalled in one's career." A feature for the Los Angeles Times similarly found that women left because they were repeatedly passed up for promotion and had their projects dismissed. Does this sound like a meritocracy? Or does it look more like institutionalized bias?

—Caroline Criado Perez, *Invisible Women*, 2019

14 Caroline Criado Perez, *Invisible Women*, 2019.



Chapter Terms and Definitions

Android: Mobile OS developed by Google and available as open-source software

Computer: A programmable computing device capable of receiving input, manipulating data, and outputting information

Computer Engineer: An individual that focuses on the research, design, and development of computer hardware and systems

Data: Representation of facts in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means

Data Center: Centralized location of servers and networking equipment that facilitates processing and storage of data

Disk Operating System (DOS): Early user-oriented operating system created from a partnership between Microsoft and IBM

Dumb Terminal: A simple device consisting of a monitor and keyboard meant to facilitate communication to a separate computing device

Gig Economy: A labor market characterized by short-term employment, typically involving an intermediary platform

Graphical User Interface (GUI): Visual medium of interacting with computers

Hardware: The physical and often modular components of a computer system

Information Technology: Any equipment or system responsible for data manipulation; also refers to the disciplines of science and engineering that interact with these systems and data

iOS: Mobile OS developed by Apple, used in iPhones

IT Personnel: Technically proficient individuals capable of optimizing the use of technological resources and soft skills to assist organizations with their IT needs

Keyboard: A physical or digital device capable of communicating with a connected computer system through assigned key inputs

Linux: Highly versatile operating system created by Linus Torvalds

Microchip: Electronic components comprised of transistors and circuits

Microsoft Windows: A GUI-based operating system developed by Microsoft, which is one of the most popular computer operating systems globally

Mobile App: Application specifically developed to run on smartphones and other mobile computing devices

Moore's Law: A "law" proposed by Gordon Moore, Intel co-founder, stating that the number of transistors in microchips would double every two years due to advancing computing performance

Motherboard: Computer component that connects various other pieces of computer hardware

Mouse: An input device capable of detecting user manipulation to facilitate interactions with computer systems

Network Effect: Increase in benefit to a community as membership grows

Networks: Computers that are connected through either wired or wireless means with the purpose of sharing data

Operating System: Software that facilitates sharing, allocation, and effective utilization of computer resources

Smartphone: A small form factor computer combined with a mobile phone based around touch screen input

Software: Instructions that computer hardware can interpret and execute in order to achieve desired tasks

Storage Drives: Physical devices to store data

System: Separate components working together to fulfill a function

Unix: The early and powerful operating system built by Bell Laboratories



Chapter Case

Anthony's Learners Permit

Anthony finally turned 15 years old and he was ready for his Florida Learners Permit (restricted driver's license). The permit was required for him to drive the old family car parked in the driveway of his house. He had just successfully completed the required **online** Drug and Alcohol (DATA) course and the Department of Motor Vehicle (DMV) Permit Test. This was the day he had waited for so long.

Anthony opened up an Internet browser on his laptop and navigated to the Florida Learners Permit information guide (<https://www.dmvflorida.org/learners-permit/>) to verify he had everything ready to go before his parents would take him to the DMV to get his restricted license. As he looked over the website, he noticed an interesting statement:

*"After completing both the DATA Course and Permit Test you are then eligible to get a Florida Learners Permit. The DMV approved course and test providers **automatically transmit your information to the DMV** upon your completion."*

Anthony thought to himself, "I hope all of my online DATA course and Permit Test information gets transmitted to the DMV before my parents take me to get my license today."

As Anthony and his parents walked into the entrance of the local DMV office, he noticed that he was surrounded by technology everywhere. There were so many systems displaying and collecting information. All he could think about was how amazing the first drive with his new learner's permit would be.

.....

Question 1: What kinds of technology do you think your local DMV office would use to issue Anthony's learner's permit?

Careers in Information Technology

3

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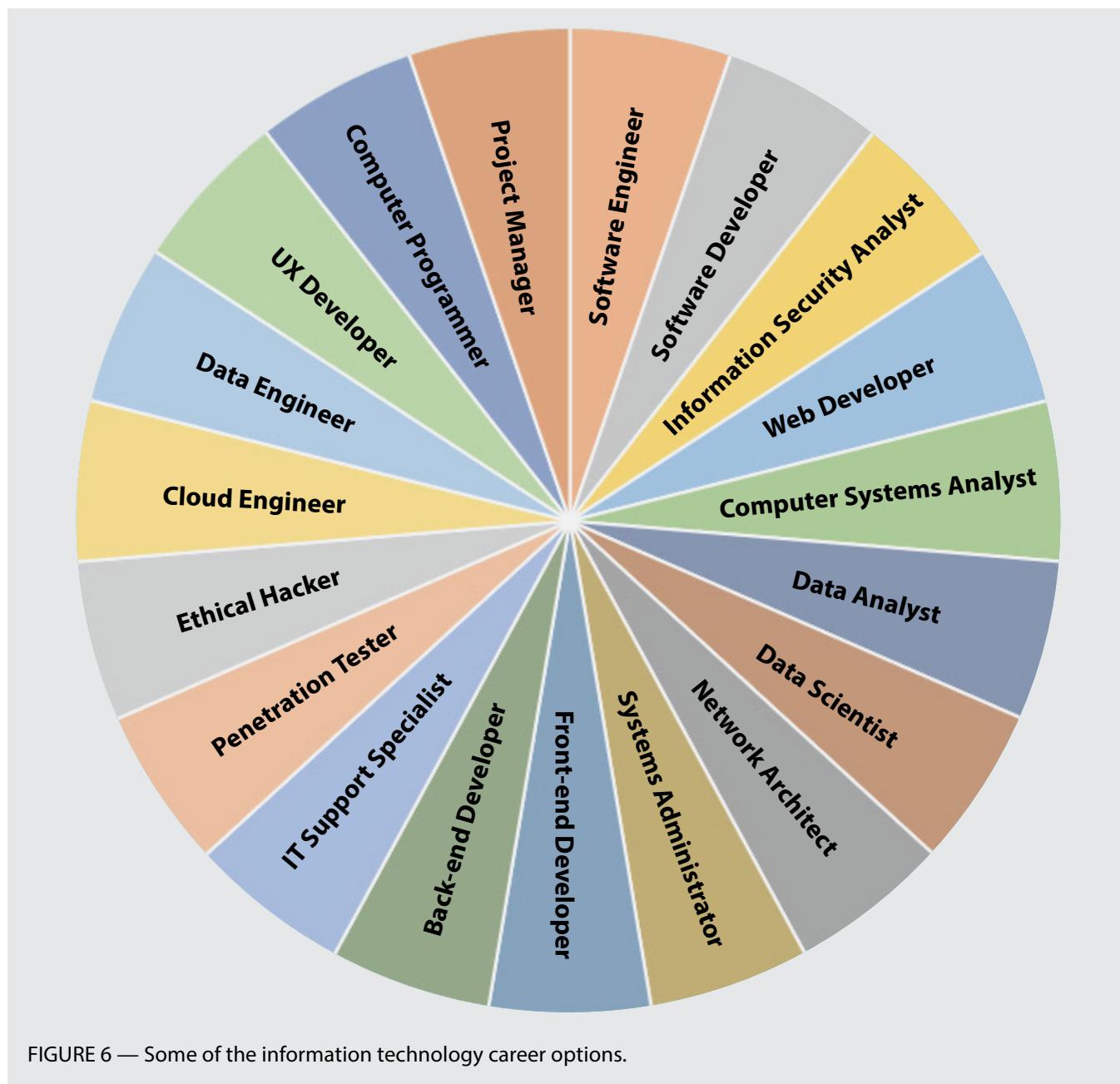
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The quality, relevance, and impact of the products and services output by the technology sector can only be improved by having the people who are building them be demographically representative of the people who are using them.

—Tracy Chou, software engineer at Pinterest

Overview

Information technology now offers a range of attractive career options for workers with a wide variety of interests, skill levels, and career ambitions. See Figure 6. Some of these roles are highlighted in this chapter.



Software Development

Perhaps the first career option that comes to mind when thinking of information technology is related to creating these technologies. The majority of these jobs fall in the category of **software** development. Software developers are the builders of the IT world, writing code and fixing errors in code (called debugging) to either create components for other software developers or applications for end users. There is a wide range of software developer roles, from simple to complex. Relatively simple roles might involve tasks such as using spreadsheets to display annual expense reports for companies. Where complex roles could involve tasks such as automating robots for drug development.¹⁵ Software developer roles include:

- Application development: these developers create user-facing applications that interact with people, take their input, generate reports, and help them make decisions. If you choose this field, you'd most likely either be a **front-end developer** and create **user interfaces** that people interact with when they open applications; or you'd be a **back-end developer** and create linkages between software applications and **databases**. Many programmers do both front-end and back-end development to increase their versatility and the breadth of available job opportunities.¹⁶
- System software development: these developers build the core technologies used in servers to manage databases, email, and business transactions. They also take care of back-end processes like source-code control and network-related issues.
- Mobile application development: these developers build applications for **smartphones**. This is an exciting field in which developers build applications optimized for small screens and powerful capabilities (e.g., cameras, payments) of smartphones and **tablet computers**. This field is growing every day as many potential applications are yet to be built.
- **Embedded developers** create software to manage **non-PC devices** like cars, dishwashers, refrigerators, and Wi-Fi routers. Embedded software is written specifically with a device in mind and controls the overall operation of the device. Embedded software is usually optimized for simple operation, immediate startup, and minimal maintenance. Users typically pay for the software as part of the cost of the product.

Software is assisting human work in more and more areas, and the demand for software developers seems never-ending. Writing code and building applications is challenging, and most companies hire software developers who have an engineering or MIS (management information systems) background and know at least a few **programming languages**, so they can handle a variety of tasks.

15 "AI: From Drug Discovery to Robotics," Forbes Magazine, July 27, 2022 <https://www.forbes.com/sites/forbestechcouncil/2022/07/27/ai-from-drug-discovery-to-robotics/?sh=689994a33d7f> (accessed June 2023).

16 If you are interested in application development, we recommend W3Schools as the starting point, <https://www.w3schools.com/> (accessed June 2023), and following their recommended learning trajectory.

IT Infrastructure

All large organizations buy, deploy, and maintain their IT infrastructure, which includes hardware, software, and networking components. All these organizations have an IT Infrastructure group to keep systems up and running and to minimize losses due to unexpected downtime. See [Figure 7](#). Some of the typical job roles supporting this field are systems administrators, user managers, network managers, and email administrators. Employees in these roles come from all academic backgrounds, including those with high school diplomas and associates degrees, and college degrees. Typically, industry certification in a specific technology helps with initial entry into the profession.

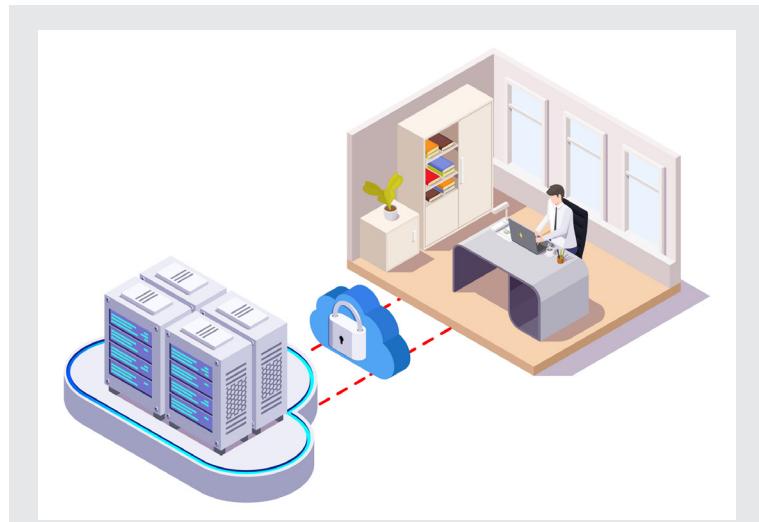


FIGURE 7 — IT infrastructure including data storage and cloud computing.

IT Support

IT support groups provide technical support to resolve issues related to computers, phones, networks, printers, and other devices. Support groups communicate with end users and sometimes act as the interface between users and software developers. Typical job roles in this field are support staff, support engineers, business analysts, and support managers. Employees in these roles also come from all academic backgrounds. Many university students work as IT support staff in the beginning of their careers.

Data Management

This group focuses on storing, structuring, and retrieving data efficiently. They design databases to ensure data is accurate and available for decision-making and strategic planning activities. Typical job roles in this field are database administrators, data architects, data modelers, and cloud specialists. Organizations are now increasingly interested in using their available data to improve decision-making (e.g., which students may benefit most from scholarships), and new roles, such as data engineers and data scientists, are emerging. Data management involves a mix of general programming abilities and specialized data handling abilities (using programming languages like SQL). Employees in these roles typically come from engineering or MIS backgrounds.

Cybersecurity

Cybersecurity experts keep organizations safe from hackers and malicious users by constantly monitoring threats and taking remedial action. They ensure that all computers and embedded devices in the organization are running the correct versions of software and that unauthorized users cannot access systems. As employees can and often do reveal company secrets and information accidentally, cybersecurity experts must also train employees in security best practices to always keep one step

ahead of hackers. Cybersecurity roles include end-user training and network monitoring. Employees in these roles share many characteristics with employees in IT infrastructure. A critical difference is that employees in cybersecurity also need to be able to act under pressure when the organization faces an active cybersecurity threat.

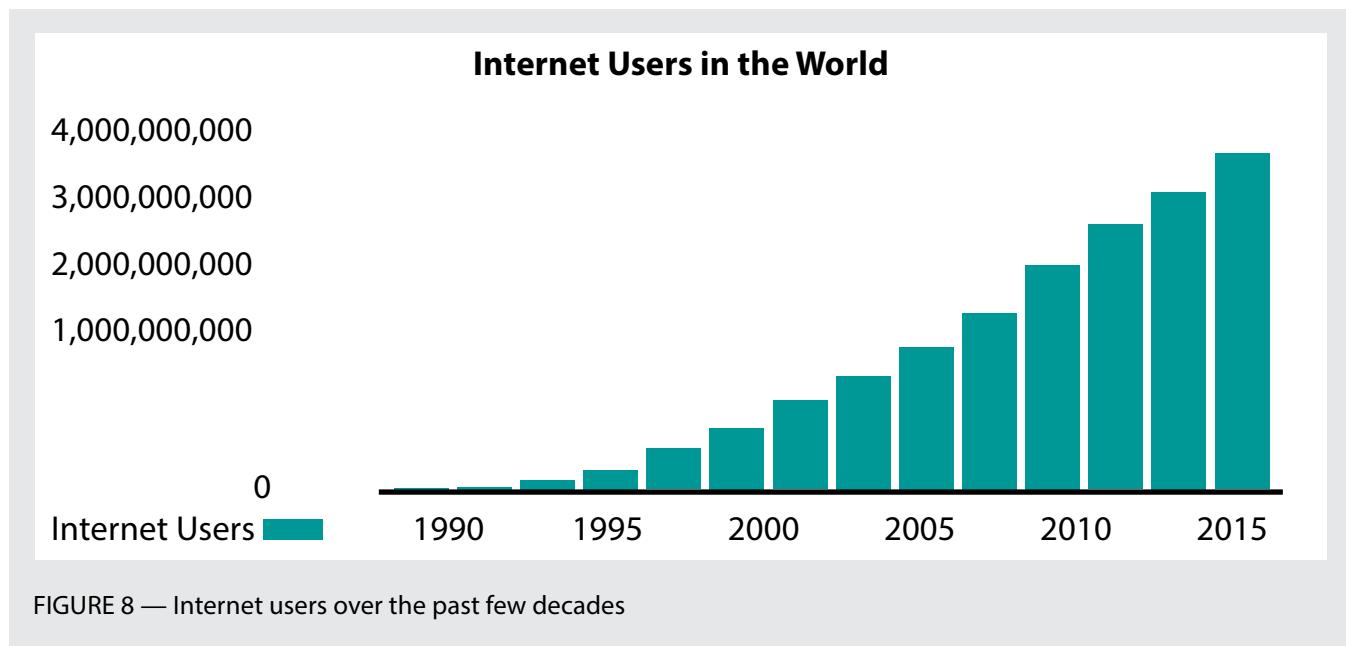


Computer Forensics

Computer forensics is the collection and preservation of evidence from computers for presentation in courts of law. This field is becoming increasingly important for cops and investigators because computers are used to plan many crimes, for example, to locate targets, plan escape routes and communicate with collaborators. Computer forensic experts recover deleted files and track digital information to figure out how a computer, network, or cell phone was used in a crime. With a few keystrokes, they can collect the required proof to connect a criminal to a crime. Most police departments hire cybersecurity experts and many cops take college classes and upskill themselves to become computer forensics experts.

Internet Infrastructure

The increase in the number of Internet users and embedded devices presents many challenges and opportunities. In 1980 the Internet barely existed and had only about 200 users. See [Figure 8](#). In 2030, about 7.5 billion people across the world will be connected to the Internet.



In addition, it is expected that there will be 30 billion devices and sensors capable of talking to each other and accomplishing tasks automatically. This network of Internet-connected devices is called the Internet of Things (IoT). IoT will require a reliable Internet connection and hardware to remain alert and functioning. This vast network will also require IoT infrastructure technologists, who are

expected to be in high demand. These employees are also expected to share many characteristics with cybersecurity and IT infrastructure employees.

Research and Development

As computing and networking become increasingly integrated with human life, research and development will be needed to make IT simpler to use, economical to own, secure to operate, and efficient in using resources. All this will require research and development in all areas related to IT, including hardware, software, algorithms, development practices, and user interactivity. While the number of jobs in R&D is not likely to be large, they will be significant drivers of IT growth and can be exciting places to work for people who enjoy exploration and experimentation.



Careers Supporting IT

Other than the specific job roles listed above, most organizations also have other roles in IT including business analysts, user-interface designers, architects, engineering managers, quality assurance engineers, testers, and many other roles supporting the core team of developers. All these are great career options.

Even if you do not have any interest in IT and do not wish to work in an IT company, you will need some level of familiarity with technology in any job in the modern age. For example, teachers are expected to know how to use email to communicate with parents, schedule meetings using online calendars, store data about students in Excel, share teaching materials using Google Cloud, and use web conferencing technologies to help students. We, therefore, believe that the lessons in this book are relevant for any career option you choose.



Skills Needed to Succeed in IT

The skills needed to succeed in IT are quite similar to the skills needed to succeed in any modern high-performing team or organization. A few basic computer skills and awareness of common tools are expected. We broadly divide the IT skills required in the modern workplace into these five categories:

- **Soft skills**
- Organizational and **project management** skills
- Basic computer skills
- Familiarity with office tools
- Web and collaboration skills

Soft Skills

To get any work done, you need to communicate, listen, manage time, honor your commitments, be respectful of others, and show empathy for your colleagues. These interpersonal skills are called soft skills and affect your ability to work effectively with other people in a modern workplace. Soft skills are less important at the time of starting a career. However, as you progress in your career and take responsibility for guiding colleagues and junior employees, soft skills become increasingly important, eventually becoming more important than core technology expertise. All the years of hard work trying to acquire technical skills may get derailed if you do not have the necessary soft skills to become a successful team leader. Empathy, compassion, honesty, and the ability to celebrate your coworkers' successes make you a valuable partner and someone others will always want to have on their team.

Even when other team members don't share your opinion, you should be able to express yourself and disagree with others without being disagreeable. You should be able to regulate your emotions when receiving critical feedback and try to see the feedback as an improvement opportunity. Giving constructive feedback to help other team members grow is also an asset. These skills will help you in every walk of life, not just within the boundaries of your workplace. For those who have mastered soft skills, the workplace is an environment full of positivity, a place where you can be productive while having fun.

Organizational and Project Management Skills

Most modern jobs require dealing with complexity and shifting goals. Dealing with this requires organizational and project management skills. You may need to coordinate with your team and potentially even with vendors and customers to solve common problems. You may need to gather business and functional requirements and test cases. To see this in context, imagine you and a group of friends deciding to build a gaming PC. You will get together and define its capabilities, the amount of money you are willing to spend, and how soon you need to build the PC. You can think of the above parameters as your high-level requirements. High-level requirements are typically called business or product requirements. You can break the business requirements into more detailed requirements, like the type of CPU, amount of RAM, storage, the number of disk drives, and the size of the box. These are your lower-level or functional requirements. You can then define test cases that will ensure the computer works as expected once it is assembled. Typically, validation results are stored as test results. Once you have defined all your requirements (business, functional, and test cases), you will identify a list of tasks and the order in which they need to be accomplished to build the PC. For example, if you buy the box because it was on sale but the box doesn't have space for all your components, you would either have to compromise on your PC capabilities or buy another box to accommodate the necessary components and throw away the box that you thought was a great buy.

Working with a team requires additional activities to ensure that each item completes on time. You must provide regular (daily, weekly, or monthly) updates to your team, management, and customers in order to deliver results most efficiently. Thankfully, you can take advantage of Excel and other project management tools to give yourself a head start. You will learn more about Excel in Chapter 9, "Introduction to Spreadsheets."

Basic Computer Skills

In any modern workplace, you will usually be assigned a computer on your first day at work, which you will use to do most of your office work. You must know how to turn the device on, shut it down, connect

it to your office network, and install and upgrade software as directed by the company's IT group. You must also be familiar with common peripherals like monitors, external keyboards, mousepads, cameras, and headphones. To be able to make copies of documents, you will need to connect to office printers, be aware of common printer settings, and know how to send files for printing.

As most of the work you do on your computer will be stored in files, you must know how to create files, save changes to files, and store files in the correct folders. You should know about common file extensions and what software program will open a particular file type. We will discuss more about files and file management in Chapter 6.

As a lot of meetings are scheduled online, you need to know how to create and accept meeting invitations using common calendaring tools. If a meeting is in a physical room, you will also need to know how to book a room and what hardware will be necessary for the meeting.

While some of the above jobs may sound daunting, most offices have people who will help you with the initial setup and find solutions to malfunctioning hardware and software. For example, your IT support team can help you connect to your printer. The IT support team is responsible for ensuring that employees are productive with IT and don't waste time fixing minor technical issues.

Familiarity with Office Tools

Your office computer will most likely come equipped with some common office software like Microsoft Office, G Suite, and Outlook. You will use these tools to create documents, spreadsheets, and presentations, and to send and receive emails. Here's a list of common office tools you should know how and when to use. You'll learn more about these tools in later chapters.

Product	Purpose
Microsoft Word and Google Docs	Write letters and create invoices, documentation, and job offers.
Microsoft Excel and Google Sheets	Store data in rows and columns to record sales, do calculations, summarize information, and create reports and invoices.
PowerPoint and Google Slides	Create presentations for colleagues, managers, and customers.
Outlook and Gmail	Send and receive emails and manage meetings.

Web Skills

Most jobs will expect you to be proficient in using the web to do your daily tasks. For example, you may have to use Google Maps to find directions to the nearest warehouse or factory. You may have to log in to a client's accounts tool to submit your invoices. The starting point for each of these skills is the ability to launch a browser, organize commonly used links as bookmarks, log into websites, and follow instructions. Popular browsers are depicted in [Figure 9](#).



FIGURE 9 — There are many popular browsers such as Google, Safari, Microsoft Edge, and Firefox.

Wi-Fi Access

A web browser is going to be of no use unless your computer is connected to the Internet. Users now generally connect to the Internet using wireless networks, commonly called Wi-Fi. Most libraries, schools, universities, and even coffee shops offer free Wi-Fi. Wi-Fi is a wireless network that allows phones, laptops, and desktops to connect wirelessly to the Internet. Most Wi-Fi networks are password protected and available only to patrons. At any new location, you should be able to talk to the staff and get the Wi-Fi name and password. You will then need to select the correct Wi-Fi name on your computer from a list of available Wi-Fi networks and enter the appropriate credentials to join the network. See [Figure 10](#).

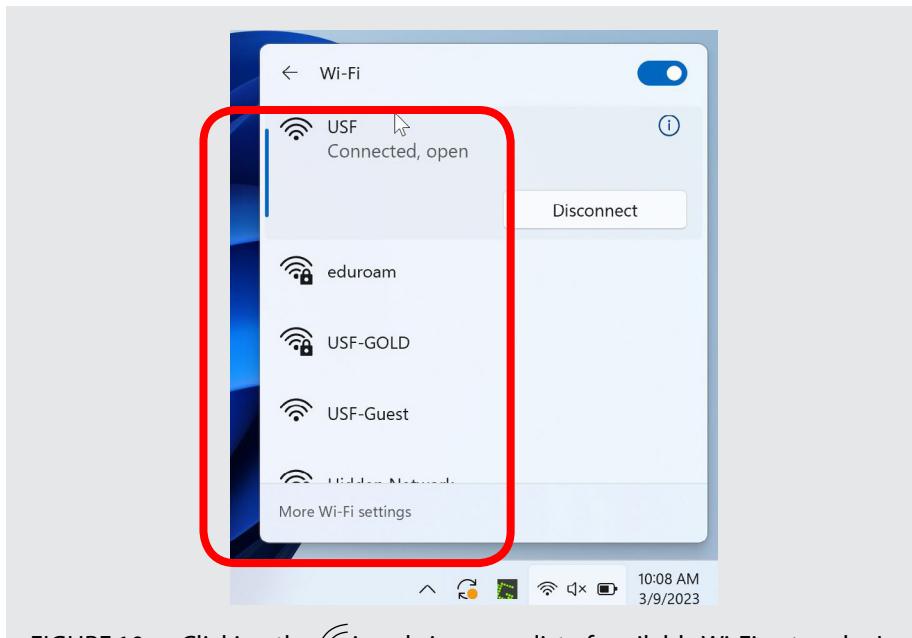


FIGURE 10 — Clicking the icon brings up a list of available Wi-Fi networks. In this example, the red rectangle highlights the names of the available networks.

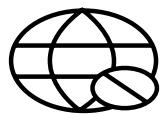
Below are three Wi-Fi connection icons found on your computer and their meanings.



You are connected to Wi-Fi and the Internet.



You are connected to Wi-Fi, but there is no Internet connection.



You are not connected to the Internet. Click to see the available Wi-Fi networks.

Collaboration Skills

Most offices rely heavily on collaboration software for employees to connect with each other easily. Chat software like Microsoft Teams or Slack, and web conferencing tools like Zoom, Webex, and

Google Hangouts are popular. You are probably already using variations of these in your personal life on personal mobile devices to send messages to and meet with friends. WhatsApp, Discord, and FaceTime are other popular chat/collaboration/web-conferencing tools.

In the post-Covid world, technology jobs have become more flexible and can be onsite, remote, or hybrid. If a job is onsite, then you are required to go to work. However, if you get a remote job, you'll be a virtual worker who must attend online meetings and be available on Teams or Slack to participate in discussions with your coworkers. The work-from-home trend that started with the Covid lockdowns is a novel development. It will be interesting to see how it affects employee productivity in different tasks and whether employees end up working longer hours, compensating for the comfort of home.

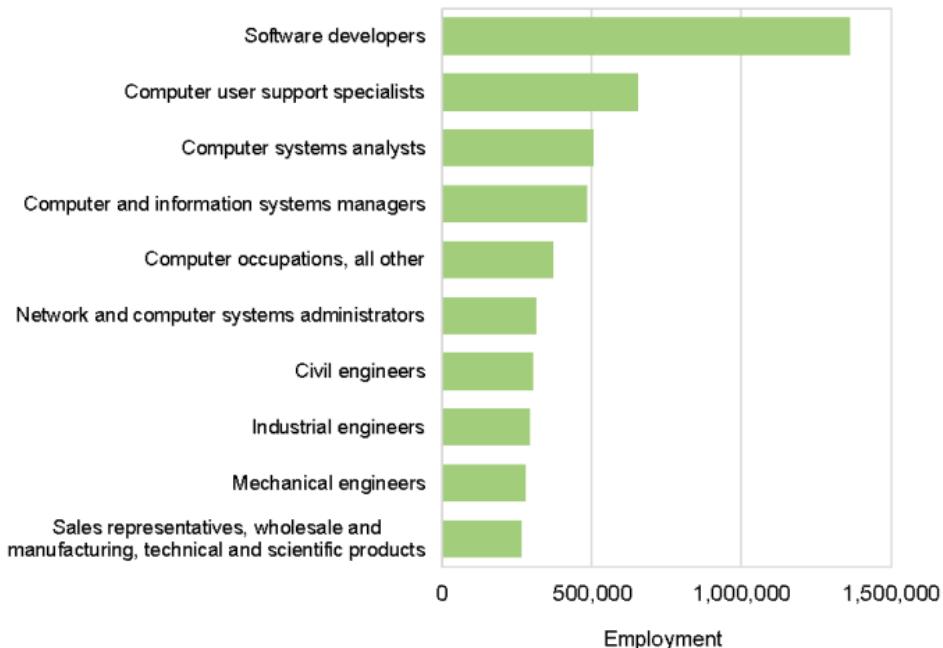
A career choice is one of the most important decisions you will make in your life. It will affect how you will be compensated, where you can work, how you will balance your life and work, and what you will do during most of your waking hours. Therefore, do your best to be deliberate about the choice. Before you make a career choice, assess your skills to understand your aptitude, likes, and dislikes. Being good at a hobby may not necessarily mean you'll enjoy it as a career for decades. This is particularly true if the activity is not well compensated in the market. While making a career choice without accounting for your financial needs may not be smart, choosing a career option solely for money may also prove to be disastrous in the long run. This is particularly true if you do not like the hours, stress, or customer interactions involved in the job. If you are unsure of your career choices, consider volunteering for non-profit groups and joining school clubs related to your career choices. This will give you a better feel for the job roles associated with the field. Medical schools, for example, expect students to have spent considerable time volunteering within medical establishments to know what they are getting into.¹⁷ This is because they have experienced high drop-out rates in their programs when students join to find a high-paying career.

Students taking this class should consider a career in IT. If you are good academically, particularly in classes like math and science that require structured thinking, we believe you should consider careers in software or hardware development. You might like the work environment and find the work meaningful. Certainly, the jobs in this field offer good salaries and the number of jobs will continue to grow in the foreseeable future. See [Figure 11](#). Also, the United States is a dynamic economy where 60% of the jobs in 2018 did not exist in 1940.¹⁸ IT is even more dynamic, and we expect new job types to appear by the time you enter the workforce.

17 Clinical volunteering, <https://www.usf.edu/arts-sciences/health-professions/involvement/clinical-volunteering.aspx> (accessed June 2023).

18 David Autor, David A. Mindell and Elisabeth B. Reynolds, "The Work of the Future: Building Better Jobs in an Age of Intelligent Machines," MIT Press, ISBN 9780262046367.

Employment for the largest STEM occupations, May 2021



Source: U.S. Bureau of Labor Statistics, Occupational Employment and Wage Statistics.

FIGURE 11 — STEM occupation growth.

You will most likely need postsecondary education to have a career in IT. Postsecondary education is any education you receive after high school. You should start planning for postsecondary education as soon as you are ready, probably as early as middle school. Gathering information may be the first step to figuring out the types of training, certifications, or degrees necessary to get to your goal. You can do the following to get a head start:

- talk to friends with similar interests;
- meet with your school counselor;
- talk to adults who work in IT;
- search on the web.

A few organizations do offer summer internships to school students with the idea of grooming future IT professionals. Both volunteering and internships can prove to be especially advantageous. If you are thinking about applying for a two- or four-year college, you'll be able to make your resume stand out by pitching your past experiences.



Chapter Terms and Definitions

Back-end Developer: Programmers who create linkages between software applications and databases

Business Analyst: A person responsible for managing information and synthesizing it to understand what decisions to take in the company

Cloud Specialist: Individuals who can advise businesses on cloud computing solutions

Computer: A programmable computing device capable of receiving input, manipulating data, and outputting information

Computer Forensics: Collection and preservation of evidence from computers for presentation in courts of law

Cybersecurity: Field of IT that encompasses the security of information technology using policies and procedures

Data: Representation of facts in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means

Data Architect: A person who develops the systems involved in data capture, storage, and analysis

Data Management: Ensure data security, reliability, and accuracy of data

Data Modeler: A person responsible for analyzing data and identifying relationships that can improve databases

Database: Software to store and retrieve structured data

Email Administrator: A person responsible for maintaining an organization's email systems

Embedded Developer: Software developers who create software for non-PC devices; embedded software is written specifically with a device in mind

Front-end Developer: Programmers who create user interfaces that people interact with when they open applications and focus on the user experience

Hardware: The physical and often modular components of a computer system

Information Technology: Any equipment or system responsible for data manipulation; also refers to the disciplines of science and engineering that interact with these systems and data

IT Support: Individuals who provide technical support to resolve issues related to computers, phones, networks, printers, and related devices

Keyboard: A physical or digital device capable of communicating with a connected computer system through assigned key inputs

Network Manager: A person responsible for a firm's network architecture

Networks: Computers that are connected through either wired or wireless means to share data

Non-PC Devices: Commonly referred to as embedded systems, these are devices that contain computer hardware but are developed and programmed for specific functions

Programming Language: An integrated set of commands used to write software

Project Management: The efficient coordination of a business's resources to accomplish its objectives

Smartphone: A small form factor computer combined with a mobile phone based around touch screen input

Soft Skills: Skills related to human interaction and reaction through communication and perception

Software: Instructions that computer hardware can interpret and execute to achieve desired tasks

Support Engineer: Engineers who develop, maintain, and troubleshoot software and hardware used within an organization

Support Manager: A person focused on helping end users with computer resources

System: Separate components working together to fulfill a function

Systems Administrator: A person responsible for the implementation, maintenance, and security of a firm's computers

Tablet Computer: Larger and more powerful mobile computer than a smartphone

User Interface: Any medium that allows users to interact with computers

User Manager: A person responsible for managing computer privileges given to individuals within the organization



Chapter Case

Anthony's Learners Permit

Let's look again at the case from Chapter 2.

Anthony finally turned 15 years old and he was ready for his Florida Learners Permit (restricted driver's license). The permit was required for him to drive the old family car parked in the driveway of his house. He had just successfully completed the required **online** Drug and Alcohol (DATA) course and the Department of Motor Vehicle (DMV) Permit Test. This was the day he had waited for so long.

Anthony opened up an Internet browser on his laptop and navigated to the Florida Learners Permit information guide (<https://www.dmvflorida.org/learners-permit/>) to verify he had everything ready to go before his parents would take him to the DMV to get his restricted license. As he looked over the website, he noticed an interesting statement:

*"After completing both the DATA Course and Permit Test you are then eligible to get a Florida Learners Permit. The DMV approved course and test providers **automatically transmit your information to the DMV** upon your completion."*

Anthony thought to himself, "I hope all of my online DATA course and Permit Test information gets transmitted to the DMV before my parents take me to get my license today."

As Anthony and his parents walked into the entrance of the local DMV office, he noticed that he was surrounded by technology everywhere. There were so many systems displaying and collecting information. All he could think about was how amazing the first drive with his new learner's permit would be.

.....

Question 1: What types of careers do you think are required for people to develop and manage the information technology used to issue Anthony's learner's permit?

Researching and Using the Web



4

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The city's central computer told you? R2D2, you know better than to trust a strange computer!

—C3PO, “Star Wars: Episode V—The Empire Strikes Back”

Overview

Never in history have we had so much knowledge stored, organized, and ready to be consumed with the click of a mouse or the tap of a button. If we step back for a moment and think about what is available on the web, we will be amazed by the information close at hand, all thanks to computers and the Internet. You can find the score of any weekend football game, the price of grain in Nebraska, the weather in Antarctica, the tide schedules in South Australia, and the outcome of an election in Britain by typing your question into any [search engine](#). If you are so inclined, you could have someone explain to you the Theory of Relativity, how to lay a brick wall, how to plan a party, or how to edit genes. If you want to learn to play the piano, understand road regulations in Florida, or learn about mountaineering, you can do it all from the comfort of your couch.

IT gives you more power in terms of access to knowledge than kings and emperors of yesteryears ever had. However, as with any powerful tool, you should know how to handle it with care and caution to avoid getting into trouble and not harming yourself or others. In this chapter, we will introduce some of the common sources of information online and evaluate their pros and cons.

Information Sources

Search engines are the most common source of online information. However, depending on your needs, there are also other information sources including review sites, multimedia sites, and educational sites. We will briefly introduce them here.

Search Engines

Search engines are software that allows users to search for information of interest. Search engines have been with us ever since the Internet became popular and have evolved to yield super-accurate results. Google as well as Microsoft have built their reputations and fortunes by providing answers to your questions, accurately and reliably. Both Google Search and Microsoft Bing constantly refine their [algorithms](#) and can even predict and propose suggestions to autofill your queries. Their search engines are integrated with extensive external databases to answer all sorts of questions in the most helpful way possible.



The basic capability of a search engine is to find documents on the Internet that correspond most closely to the search term entered by the user. For example, if you search for “USF,” search engines locate all pages related to USF, sort the pages by their relevance to the search term, and display the results, with the most relevant results on top. Results for “USF” from two popular search engines—Google and Bing—are shown in [Figure 12](#). We see that the results are not identical, reflecting differences in the algorithms used by the two search engines to process searches.

The figure displays two side-by-side screenshots of web browsers showing search results for the query "usf".

Google Search Results:

- Top Result:** <https://www.usf.edu> - Welcome to the University of South Florida | Tampa, St ...
The University of South Florida (USF) is a high-impact, global research university dedicated to student success serving Tampa, St. Petersburg and ...
- Image:** A collage of three images: a modern building, a map of the University of South Florida campus, and a person walking outside.
- Section:** Work (University of South Florida)
University In Hillsborough County, Florida
- Text:** The University of South Florida is a public research university with its main campus located in Tampa, Florida; and other campuses in St. Petersburg and Sarasota. It is one of 12 members of the State University System of Florida. [Wikipedia](#)
- Metrics:** Avg cost after aid \$8,346, Graduation rate 72%, Acceptance rate 49%

Bing Search Results:

- Top Result:** <https://www.usf.edu> - University of South Florida
- Image:** A large image of a modern building with the text "University of South Florida".
- Section:** Flexible & Convenient Options | Making Education Work For You
<https://degrees.keiseruniversity.edu/tampa> ▾
Start Your Path Toward a New Career at Keiser in Tampa. Request Info! Prepare for Your New Career at Keiser University in Tampa. Learn More!
keiseruniversity.edu has been visited by 10K+ users in the past month
- Section:** Programs
View a List of Programs Offered by Keiser University.
- Section:** Admission Requirements
View Admission Requirements For Keiser University of Golf.

FIGURE 12 — Search engine results will populate differently depending on the search engine used.

Search Engine Revenue Models

The search results for USF show how search engines make money. In the results from Bing, the first result is labeled as an “Ad” and encourages users to check out Keiser University. Organizations pay search engines for placement in search results, and this is one of the most profitable businesses in modern times. If a few visitors searching for USF register for courses at Keiser University, the investment in the search ads can be profitable for Keiser.

Search engines are expanding their capabilities to offer a single point of entry for any information-based capability. For example, if you search for the price of a ticket to fly from Tampa to San Francisco, search engines can fetch the prices from different airline databases and show them to you in a comparative list. If you search for sneakers, they will not only bring you information about sneakers but also show you the prices and availability in nearby stores. When you search for the weather in New York, the search engine may not have the information stored directly in its database, but it will query external services such as weather.com on your behalf and present the information. All these capabilities make search engines very powerful as we become more and more dependent on information.

Recent developments in artificial intelligence have enabled powerful voice recognition capabilities in inexpensive consumer devices. See [Figure 13](#). With the popularity of these hands-free devices and the increased accuracy of voice recognition, you don’t even need to type your question. You can just ask Siri for the local weather, Google for a stock price, and Alexa to order cereals for the family.

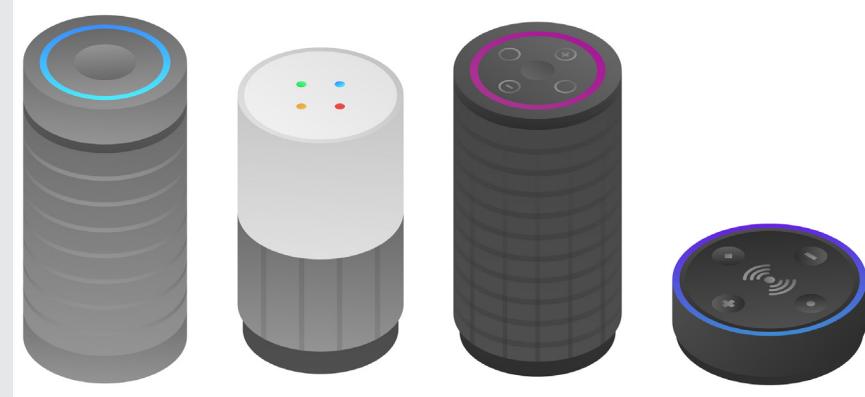


FIGURE 13 — Smart speakers.

Search Engine Evolution

Search engines have evolved through four primary stages: (1) manually curated table of contents (e.g., Yahoo starting in 1994); (2) keyword-based indexes of webpages (e.g., Lycos, Excite, Alta Vista starting in 1996); (3) link-based ranking of webpages (e.g., Google starting in 1998); and (4) embedded goal-specific search engines (e.g., Amazon, TikTok starting in 2003). In 1994, Jerry Yang and Dave Filo began manually creating a hierarchical directory of websites to help users find interesting sites on different topics.¹⁹ Yahoo is credited with giving Amazon its first boost. Three days after Amazon was founded, Jerry Yang emailed Jeff Bezos asking for permission to list Amazon in the “What’s cool” section of Yahoo. Amazon received \$12,000 worth of orders in the first week of being listed on Yahoo.

The National Science Foundation started the Digital Library Initiative (DLI) in 1994 to simplify information finding on the nascent Internet.²⁰ Several projects to index webpages based on keywords emerged from this and related projects and became popular between 1996–1999. Eventually in 1998, one of the DLI projects led to the basic technology used by Google. Instead of ranking webpages based on keywords, Google’s technology relies on the judgment of website authors to link to other websites. Such links are considered reliable indicators of a webpage’s relevance and are used to create the page rank.

In recent years, sites have begun to develop search engines customized to their needs. **Social media** sites such as TikTok have developed search engines to show what a user is most likely to be interested in watching next. Shopping sites such as Amazon have developed search engines that show the most profitable products that a user is likely to buy next.

Specialized Review Platforms

General search engines like Google and Bing are very good at pulling up relevant information from the web in response to a query. However, search engines do not generate information on their own. In recent years, several companies have recognized business opportunities in helping users generate content that meets some specialized information needs of other users. Typically, such **User Generated Content (UGC)** helps other users decide which products and services to buy. Companies that help users add their reviews to products and services are known as specialized review platforms. See [Figure 14](#). Examples include Yelp for restaurants and TripAdvisor for travel destinations. Specialized review platforms also help businesses. G2 for example, is a popular specialized review platform for business software. Search engines have also begun facilitating such reviews. If you want to know

19 “History of Yahoo!,” https://en.wikipedia.org/wiki/History_of_Yahoo! (accessed June 2023).

20 “On the origins of Google,” <https://beta.nsf.gov/news/origins-google> (accessed June 2023). The NSF award, which funded the work that eventually became Google, can be seen at https://www.nsf.gov/awardsearch/showAward?AWD_ID=9411306 (accessed June 2023).

what others have to say about something, a specialized review platform might be a good starting point. For example, if you want to buy a car, check out a restaurant, research the quality of a business, find a good dentist, get more information about your current medication, or buy a new refrigerator, these review platforms can be of great help.



FIGURE 14 — Review platforms can help users decide which product to use or buy.

Specialized review platforms can be categorized into two broad types: those offering expert opinions and those publishing crowd-sourced reviews.

Expert opinion platforms like WebMD, Consumer Reports, Edmunds.com, and Nolo.com hire experts in specific fields (health, household appliances, cars, laws) to write articles and reviews offering in-depth information about products and services in their areas of specialty.

Crowd-sourced review platforms gather information from users and use voting algorithms to identify the most relevant and useful reviews. One of Amazon's secret recipes to success has been its extensive collection of user reviews on products. Yelp, a crowd-sourced review platform, collects diner feedback on restaurants and can quickly recommend a restaurant you might like. Since these sites aggregate a community's feedback, you might end up with a greater diversity of opinions than those provided by experts.

As with any recommendation, you must keep an eye out for potential fraud and misdirection. The review platforms may be more favorable towards the products of their business associates. Another problem is fake reviews. As positive ratings lead to increased sales, product manufacturers are tempted to influence reviews. Be aware of the possibility that even Amazon and Yelp reviews might be written by ghost review writers compensated by product manufacturers.

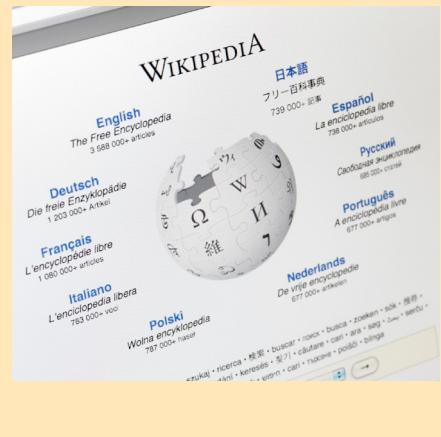
Public Wikis/Encyclopedias

Wikipedia, a great knowledge base on the Internet, is an open encyclopedia that allows users to edit content. Wikipedia is one of the most popular sites on the Internet with over 59 million articles,

and it has a large and passionate community constantly editing and updating articles to keep them up to date and accurate. On the other hand, paid encyclopedias, like Encyclopedia Britannica, are commercial products that curate articles written by subject matter experts.²¹ Investigations suggest that there is little observable difference in the reliability of information between the two.²²

Wikipedia's Origins in St. Petersburg, FL²³

Wikipedia was founded in St Pete, FL in 2003. The company combined founder James Wales' love for encyclopedias with the Wiki technology created by Ward Cunningham in Portland in 1995. The wiki technology enabled users to edit pages on their own, which helped Wikipedia to grow and find a niche in the market between Yahoo's manual hierarchy and Google's automated search.



However, Wikipedia has had its share of issues and controversies. In 2005, the biography of an American journalist, John L. Seigenthaler, Jr., on Wikipedia falsely identified him as a conspirator in the assassinations of John F. Kennedy and Robert F. Kennedy. These claims survived Wikipedia's community policing for 132 days.

Since Wikipedia is based on the wisdom of the community, the less commonly accessed and reviewed portions of the site may have less accurate information than the more common ones. There is also potential for "mob activity" where a group of biased and motivated individuals influence the tone and content of an article.

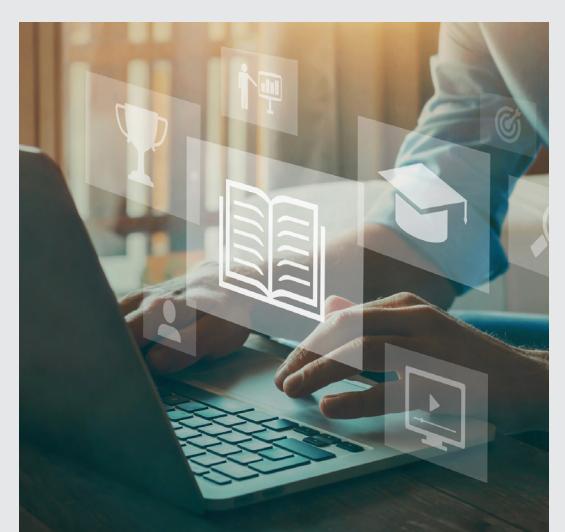
Online Training

Information sources are abundant on the Internet, which opens many learning opportunities. Educational opportunities are found in a variety of formats on the Internet. Online training has become very popular and can fit many learning styles.

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- 21 Encyclopedia Britannica's subscription page, <https://subscription.britannica.com/subscribe> (accessed June 2023).
- 22 Jim Giles, "Internet encyclopedias go head-to-head," *Nature*, 438, pgs. 900–901 (12/14/2005), <https://www.nature.com/articles/438900a> (accessed April 2023). The article found that whereas Wikipedia had about four errors per item, Britannica had about three errors per item. *Nature* responded to Encyclopedia Britannica's statement regarding the article in "Britannica attacks," *Nature*, 440, pgs. 582 (3/29/2006), <https://www.nature.com/articles/440582b> (accessed June 2023).
- 23 The information in this section is from "An oral history of Wikipedia, the web's encyclopedia," <https://onezero.medium.com/an-oral-history-of-wikipedia-the-webs-encyclopedia-1672eea57d2> (accessed June 2023).

Informal Training Sites

In recent years, popular media and entertainment sites like YouTube have also become useful sources of information, particularly for tutorials on specific topics. Whether you want to troubleshoot your dishwasher, learn how to program in Python, or prepare for a job interview, you are pretty much guaranteed to find a suite of videos tailored to your specific need. As the videos are rated by the community (with likes, dislikes, and subscribes), the YouTube algorithm combines the search capabilities of a search engine with an understanding of the viewing habits of similar users. This enables YouTube to constantly tune its suggestions for videos most likely to solve your problem.²⁴ You can also interact with the content provider by commenting on the videos and contributing further to the content.



The Internet offers a variety of learning opportunities.

Apart from the benefits of curation and ratings by the community, videos have a distinct advantage as a learning medium. You can rewind and watch the difficult parts multiple times, increase the speed if you are already familiar with the content, skip portions you understand, and watch content at your own convenience on a device of your choice.

However, there are several caveats to using YouTube as a learning medium:

- identifying the right training yourself can be difficult
- having the time and discipline to see the training through can be challenging
- not receiving any certification after the training is demoralizing.

Massive Open Online Courses (MOOCs)

Massive Open Online Courses (MOOCs) are online educational courses open to anybody in the world. These educational platforms are provided by individuals, organizations, and firms. Some MOOCs, like Khan Academy, focus on free courses and some, like Coursera, offer a mix of free and paid courses. Some MOOCs like EdX even offer proctored examinations and certificates of completion.

Many leading universities are experimenting with MOOCs to bring the expertise of their faculty to students around the world. MIT offers most of its class materials for free on MIT Open Courseware.²⁵ Several leading universities including MIT and Harvard are collaborating on a shared learning platform called EdX to offer free and low-cost courses.²⁶ These universities are also exploring how the

²⁴ For an overview of how YouTube develops its recommendations, refer to “On YouTube’s recommendation system,” by Cristos Goodrow, <https://blog.youtube/inside-youtube/on-youtubes-recommendation-system/> (accessed June 2023).

²⁵ MIT Open Courseware homepage, <https://ocw.mit.edu/> (accessed June 2023).

²⁶ About the EdX platform, <https://www.edx.org/about-us> (accessed June 2023).

EdX MOOC platform can be used to offer students low-cost credentials such as micro-bachelors and micro-masters.



Most MOOC classes tend to be structured and take you on a step-by-step journey from novice to expert. Whether you are interested in researching, furthering your career, or just learning, MOOCs are a great way to go and have, not surprisingly, exploded in popularity in recent years.

Training by Industry-Specific Organizations

Once you enter your chosen profession, your industry or vendor-specific platform will usually offer several training options. One such training that is currently quite popular is offered by Amazon for their Amazon Web Services (AWS) technologies. This training is available for free and is very popular among folks eager to become AWS experts.²⁷ Similarly, other leading technology companies including SAP²⁸ (for large business operations), Oracle²⁹ (for Data management), and Cisco³⁰ (for Network Administration) offer extensive training globally both online and in person. There are also certification programs offered by industry-specific organizations for general technology expertise such as **Scrum Master** (for product development), Program Manager, and Business Analyst, and these can be extremely helpful in acquiring the relevant skills and finding jobs in these roles.

Using the Web: Risks, Pitfalls, and Strategies

Although the web makes it easy to find information, not every bit of data obtained online is equally reliable. Before you act on information received online, you should be aware of the deceptions and traps. Here are some things to keep in mind when evaluating information received from online sources.

27 Amazon Web Services (AWS) training, <https://www.aws.training/> (accessed June 2023).

28 SAP training, <https://training.sap.com/> (accessed June 2023).

29 Oracle University, <https://education.oracle.com/> (accessed June 2023).

30 Cisco training, <https://www.cisco.com/c/en/us/training-events/training-certifications.html> (accessed June 2023).

Is the Source Reputable?

Print publications with patterns of incorrect information usually do not survive for long. Therefore, print publications with wide circulation (e.g., popular magazines and newspapers) generally put in considerable effort to ensure the correctness of the information. This is part of their gatekeeping role. Gatekeeping is the process that publications follow to select and present information to their readers.³¹ Mechanisms that increase the reliability of the information include hiring experienced editors and validating the reliability of sources. When you read something in a print publication, you can be reasonably confident that the publisher put in their best effort to ensure the information is correct.

However, many people who post information online are not trained to verify information. Therefore, online information has a greater likelihood of being incorrect than print information. It also does not cost money to post information on blogs, social media, and other online platforms, which leads to vast amounts of information getting posted. Online information can reach wide audiences through search engines and social media even if incorrect. Social media platforms such as Twitter are widely considered the “Digital Town Square.” What should a reader do to get reliable information from online sources?

One mechanism is being aware of the source’s reputation. As every high schooler knows, reputations take a long time to earn, and no time to lose. A reputation for correctness is, therefore, an indicator that the online source has mechanisms in place to validate information before publishing it. Information posted by reputable sources is more likely to be correct. Although it is hard to judge the reputability of an online source, you can take some precautions. Look up the business name of a source on search engines to check reviews in other places on the web. On social media, you can look up a user’s list of followers. Users followed by other reputable users are likely to be reputable themselves.³²

Check the URL

Unethical businesses often create look-alike websites to confuse people and grab user credentials and sales. This is called website **spoofing**. Even if you think you are getting information from university websites, banks, or other well-known private institutions, you should double-check the **URL** to make sure you are where you think you are.³³

Look at Multiple Sources

Checking out information on several websites will help you look at the problem/solution from

31 You can find more information about gatekeeping online. One overview article we like is “Gatekeeping Theory,” <https://masscommtheory.com/theory-overviews/gatekeeping-theory/> (accessed June 2023).

32 Twitter has a mechanism to verify user accounts, indicated by . You can read about the verification procedure at <https://help.twitter.com/en/managing-your-account/about-twitter-verified-accounts> (accessed June 2023).

33 There are many variants of spoofing. You can look these up online including at this article: Sagar Joshi, “What is spoofing? How to Protect Yourself Against It?” <https://www.g2.com/articles/spoofing> (accessed June 2023).

different perspectives. One source might focus on the ease of use of a device while another may bring attention to its price. If you get the same information from multiple reputable sources, it is a good indication of its authenticity. For example, if several car review websites agree that the model you want to buy is safe, reliable, and a good value for your money, then you can feel assured about having made the right choice.

What's Beyond the Headline?

As users are reluctant to pay subscription fees for online publications, there is increasing pressure on websites to earn revenues by drawing traffic and showing ads to visitors. A popular way to do this is by using attention-grabbing headlines that may have little to do with the content of the article. These headlines serve as clickbait to draw readers to the site, not to summarize the information on the page or explain nuances. Therefore, when consuming online information, do not rely on the headlines alone and make it a point to read all the available information in the article, not just the first few sentences. It is common to see subjective conclusions at the top with caveats and drawbacks buried near the end of the article.

Is the Author an Expert in the Field?

Online ad revenues have created a business model for **influencers**. Influencers are people who are able to encourage potential buyers of a product or service by recommending items online, usually on social media. Influencers make money by ensuring their content is visible and by having a lot of followers. When you search for product recommendations, you are likely to come across content that is popular or promoted by influencers, but not necessarily accurate or relevant to you. What works for the influencer's specific circumstances may not work for you. It is, therefore, useful to verify the expertise of the person handing out advice. For example, if you want information about a type of diet, a nutritionist is more likely to have studied the impact of the diet under a variety of conditions compared to a popular sports star who may have followed the diet under the strict supervision of a team of experts.

Check Your Biases

The ease of finding the information we like makes the Internet great at confirming our biases and dragging us into an echo chamber that magnifies our beliefs. As the World Wide Web has dramatically increased our ability to connect with others, even the most outlandish ideas and conspiracy theories can have large groups of enthusiastic subscribers, egging each other on.

This is an issue, particularly with subjective opinions. There is a reason why we maintain our biases: either we aren't aware of their existence or wholeheartedly believe in their authenticity. Before reaching out to the web to validate your opinions, you should take a moment to be honest with yourself and understand if you are actually willing to change your initial opinion. Are you looking for new information just to prove your point? Are you only seeking out people who'll agree with you? Can you argue the issue from the perspective of those holding the opposing view?

Bounce Your Ideas With Others

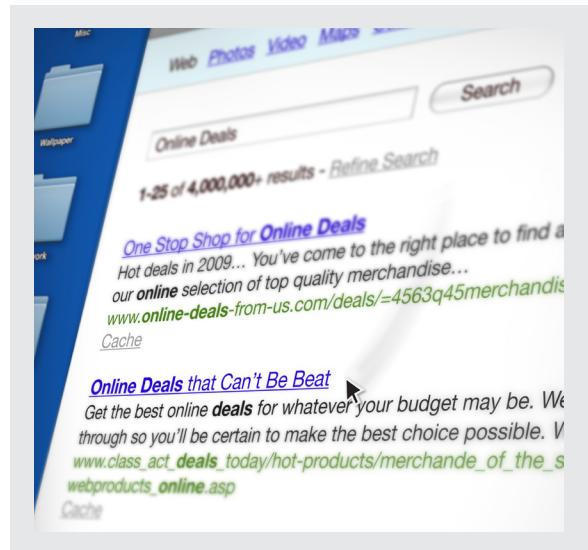
It is always a good idea to discuss what you have found on the web with friends, family, and teachers. The power of the community to sift out good ideas from bad ones can never be underestimated.

What Motivates the Source?

Websites and search engines increasingly make money by encouraging you to buy things. They are, therefore, motivated to prioritize displaying information for which they get paid. When you search for a particular laptop, for example, the first few search results are likely to be advertisements by competing merchants and not necessarily the best/cheapest places to buy. The burden is on you to check the results and pick the one that makes the most sense.

Similarly, if you search for insurance agents on a search engine, the first results are mainly advertisements from various insurance companies. When you click on any of the links, the advertiser pays Google a “click-through” fee. Google stands to gain by showing advertisers who pay the most, not necessarily those with the best products and services.

Therefore, it is useful to be on the lookout to understand if your source of information makes money by influencing your decision. Reputable sites clearly separate advertisements from other content, but others tend to blur the difference.



Search Tracking

Another pitfall of searching for things online is search tracking. Most search engines tend to hold on to queries and use them to gauge your potential needs, often showing targeted advertisements on other sites you visit in the future. Your information might be shared or sold to other Internet merchants, who will likely be storing the information in databases around the world. You might be surprised by related ads long after you have abandoned the primary search engine. We will cover more about this in [Chapter 17](#) on “Ethical Issues in Information Technology.”



Chapter Terms and Definitions

Algorithm: A systematic and logical sequence of steps designed to solve a problem

Influencers: Individuals who have a large audience through a social media platform

Massive Open Online Courses (MOOC): Open access educational courses available to participants using an online platform

Scrum Master: In the Scrum approach to agile project management, the team member whose responsibility is to effectively get the team closer to the goals and keep everyone on track

Search Engine: An algorithm designed to find resources related to what is input into a search interface

Social Media: A digital platform for interaction between people

Spoofing: Disguising the true or trusted identity of a person or device

Uniform Resource Locator (URL): The website/address of a resource on the Internet.

User Generated Content (UGC): An individual's content creation on platforms; platforms include Instagram, Twitter, or YouTube

Wiki: User-generated content on a digital platform that facilitates collaboration



Chapter Case

Christopher's Google Search

Christopher stepped off the school bus and started to walk home as he thought about the homework assignment his teacher had assigned him earlier that day. His teacher asked him to use a search engine to find information about the Florida state bird. He was to research the topic and think about how the search engine works.

Christopher sat down at his home computer, opened an Internet browser, and navigated to google.com. While on the Google search engine page, he typed the search term, "Florida state bird." The top result displayed the following:

About 144,000,000 results (0.84 seconds)

Florida / State bird

Northern mockingbird

The common mockingbird (*Mimus polyglottos*) is a superb songbird and mimic. Its own song has a pleasant lilting sound and is, at times, both varied and repetitive. Often, the mockingbird sings all night long, especially under bright springtime moonlight.

<https://dos.myflorida.com/florida-facts/state-bird>

[State Bird - Florida Department of State](#)

"Wow!" Christopher yelled. "*144,000,000 results in .84 seconds!*". "It looks like the Northern mockingbird is the Florida state bird." Christopher thought to himself, "How did Google know to put this reference to the Florida state bird in front of 144,000,000 other results?".

To understand how the Google search engine worked to display the results, Christopher looked over Google's Documentation website:

<https://developers.google.com/search/docs/fundamentals/how-search-works>

After he reviewed the information on the website, he realized that the Google search engine works in three stages, and not all pages make it through each stage. The stages include crawling, indexing, and then finally serving the search results.

.....

Question 1: Research the terms "crawling" and "indexing" as they relate to the topic "search engine." Based on the results of your research, how do these terms help search engines work?

Question 2: The results of a search using Google can vary depending on how relevant the information is to the search engine user. According to Google, relevancy can be determined by many factors including information such as the user's location, language, and device (desktop or cell phone). Why do you think Google considers this type of relevant information when displaying the results of a search?

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If you're not looking toward the future or trying to improve the current technology, you'll be left behind.

—Gwynne Shotwell, president of SpaceX

Overview

In the previous [chapter](#), we saw how computers are used in organizations. In this chapter, we will introduce the common types of computers and provide an overview of the parts of a typical computer. This will allow you to compare computers with different specifications and make the right choices when selecting a computer for a specific task.

Microcomputers

A microcomputer is a small, standalone computer designed to be used by one person at a time. Almost all computers you have used so far are likely to fall in the category of microcomputers. Microcomputers are less expensive than large corporate computers designed to handle much heavier computational tasks. These corporate computers are also called servers. Microcomputers are also known as [Personal Computers \(PCs\)](#) and are typically used for personal tasks such as writing emails, searching for information on the web, creating documents, making presentations, updating spreadsheets, watching movies, listening to music, and playing computer games.

Microcomputers come in many formats. The most common types are desktop computers, laptops, tablets, mobile phones, and [smartwatches](#) on your wrist.

While desktop computers bear no resemblance to smartwatches, both share surprisingly similar architectures. Both have similar hardware components such as memory, storage, input, output, and [Central Processing Unit \(CPU\)](#). Both also have similar software components including an operating system and applications that run on the operating system.

Modern microcomputers can talk to each other and share information. When you snap a photo using your phone, it can become immediately visible on your desktop. Similarly, when you get a phone call or a message on your phone, it can pop up on your desktop, smartwatch, and phone simultaneously. We begin by taking a brief look at each type of microcomputer.

Desktop Computer

A desktop computer is a microcomputer primarily designed to meet the computational needs of a single user at a fixed location. If you have a comfortable desk where you do most of your work and would like a computer to use on the desk without moving it around, a desktop computer may be ideal for you.

While laptops are very popular for their mobility, desktops continue to be very popular for several reasons. Desktop computers generally offer the best value for your money since the components in a desktop do not have to be optimized for size, weight, or power consumption. Also, since desktops don't have to be light, small, or portable, they can typically use larger power supplies and bigger fans to support far



more powerful processors (CPUs) and video cards. They can be configured with multiple **hard disk drives** and optical disk drives, and support multiple peripherals like large external monitors, external speakers, microphones, and cameras. Also, since they are designed to be stationary, users can create setups with multiple peripherals and full-size **keyboards** that do not have to be dismantled each time the device is moved. For their economy as well as setup convenience, desktop computers are very common in organizations, particularly for office staff who do not need portable computers to deliver presentations or take notes in meetings. Desktops are also popular for gaming because they can simultaneously support the most powerful computing units, video cards, and highest-resolution monitors without the need to worry about optimizing battery performance.

One additional benefit of owning a desktop computer is the ease of upgrade. Desktops are enclosed in cases that are usually easy to open. Desktops typically offer expansion slots that you can use to add additional memory and Graphic Processing Units (GPUs) over time for a better video gaming experience. Since desktops are larger, they also have several extra ports (**USB**, **USB-C**, **HDMI**, audio, and memory card slots) readily available to add storage and connect peripherals.

As desktops are stationary, they also typically last much longer because they do not encounter shocks from being tossed around. You are also not likely to misplace your desktop at your local coffee shop or drop it from your backpack.

Typically, you'll choose one of the two operating system dominating the desktop market—Microsoft Windows or Apple Mac OS. Microsoft desktops are generally less expensive and have a significantly larger share of the market compared to Apple Mac OS-based desktops.

Linux is also an option for a desktop operating system. Ubuntu is a version of Linux optimized for desktops and laptops.³⁴ The lack of end-user applications such as Office and vendor-specific drivers for peripherals such as printers and cameras limit the usability of Linux desktops for many end users. In recent years, however, as web-based applications such as Office 365 and Google Docs gain popularity for most personal productivity tasks, Linux is becoming an increasingly viable option, particularly for enthusiasts.

Laptop

Laptops, small enough to fit in your lap, have a clamshell unit, a screen on the top half, and an integrated keyboard and trackpad on the bottom. The great advantage of a laptop is its portability, which allows you to work from anywhere—school, home, and coffee shops. In the post-Covid world, with most offices offering hybrid work models, a laptop may be an indispensable possession offering you the ability to work from wherever you want. As laptop prices drop, colleges are increasingly requiring students to own a personal laptop for use in class.



Manufacturers aim to design laptops that are as light as possible and work all day without the need for an external power source. To optimize for portability, the components inside a typical laptop,

³⁴ The open-source Ubuntu desktop can be downloaded here, <https://ubuntu.com/download/desktop> (accessed June 2023).

including the CPU, [Random-Access Memory \(RAM\)](#), storage, keyboard, monitor, camera, microphone, and speakers, focus on power efficiency and compromise on performance metrics such as speed to keep the unit light. As the CPU is optimized to use less power and minimize heat generation, it may not be as powerful as your desktop CPU. This can be noticeable in demanding tasks such as video conferencing, software development, or when working on large spreadsheets with a lot of formulae.

Powerful chips generate a lot of heat and drain the battery fast, so this design optimization makes sense. Also, laptops typically have expensive Solid State Drive (SSD) storage because SSDs consume little power and are lightweight. Laptop keyboards can also lack features common in full-sized keyboards such as a dedicated numbers keypad.

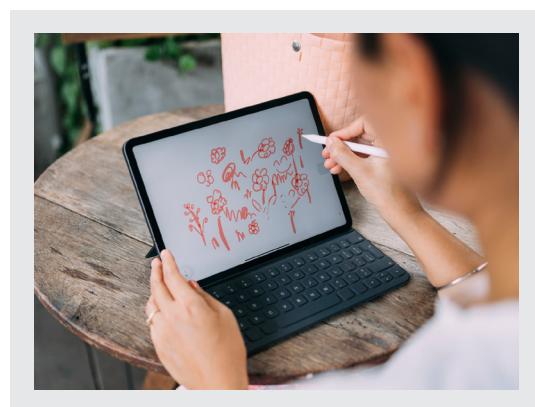
However, the benefits of being able to sit at a park bench, airport, or meeting room, pull out your laptop, and work or be entertained far outweigh the performance compromises of laptops for most users. As laptops come with a built-in rechargeable lithium-ion battery, you won't need to find a charging source for several hours, even with continuous use. To address some of the limitations of laptops, you can carry a [mouse](#) and headphones or wireless earbuds. Some people keep a full-sized monitor, keyboard, and mousepad connected to a docking station at their home or office, so the laptop easily converts into a full-fledged desktop when they work for long hours.

Just like the desktop PC market, even the laptop market is dominated by Microsoft Windows and Apple Mac OS. As Apple manufactures its own hardware, a Mac PC will have Mac OS. However, since Microsoft licenses its operating system to other hardware manufacturers, you are likely to find Microsoft Windows on laptops manufactured by several manufacturers including Samsung, LG, Dell, HP, Acer, and others.

An increasingly popular laptop option, particularly for high school students, is the Chromebook. Chromebooks use an operating system developed by Google, which saves very limited data on the local device and uses data storage on the cloud instead. This reduces hardware needs on the local device, reducing costs significantly. This approach becomes increasingly effective as more and more applications move to the cloud.

Tablet

A tablet computer (known simply as a tablet) is a microcomputer designed for portability and media consumption. They have screen sizes comparable to that of a laptop but lack the input/output capabilities of a laptop such as keyboards and mice. Instead, they use touchscreens for input and output, much like a [smartphone](#). Tablets have the same components as other microcomputers—RAM, CPU, storage, microphone, camera, and speakers, and they connect to the Internet through [Wi-Fi](#), just like most other portable devices. Some tablet models also support Internet connectivity over a cellular network.



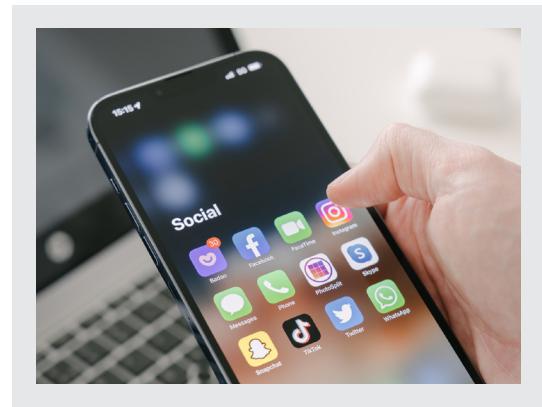
The motivation behind tablets is to have a basic computer that is inexpensive, can be carried easily, and be turned on quickly. If you want to watch cooking shows in your kitchen, read books in subway stations, or attend web conferences from airport lounges, a tablet may be the optimal device for

you. To make them as easy to use as phones, they rely on mobile operating systems like Apple IOS or Google's Android. Touching and swiping the screen is a fun and engaging experience for most users.

Today, there are about 5 billion mobile devices (smartphones and tablets) in the world. The two primary mobile OS makers (Apple and Google) have app stores where independent software developers offer games and applications. These app stores have unleashed the creative potential of software developers who build applications for tablets and smartphones. As a mobile phone or tablet user, you can access a tremendous array of games and all sorts of applications to enhance productivity, including apps to receive therapy, simplify communication, identify trees, improve vocabulary, and learn new languages.

Smartphone

Smartphones are portable computers that connect to the Internet using cellular telephone networks. Apple kickstarted the smartphone era by launching the iPhone in 2007. While mobile phones with rudimentary Internet capabilities (e.g., messages and text-based web browsers) existed before iPhones, Apple managed to package almost all the capabilities of microcomputers into an easy-to-use device that you could use not only to make calls and send a text but also to run most microcomputer applications such as email, word processors, and spreadsheets. The iPhone brought together a purpose-built mobile OS based on UNIX, a touchscreen, and an App store, all into one easy package.



Keep in mind, today's smartphones are far more powerful than even the Apollo 11 guidance computers, which helped us land on the moon and return safely. At the core, a smartphone is also a microcomputer that has CPU, RAM, storage, display, speakers, and a microphone, with the touchscreen and microphone serving as primary inputs. The app stores (available in Apple's IOS and Google's Android) add to the versatility and usefulness of smartphones. Connectivity applications such as Snapchat and Instagram enhance the entertainment value of phones, particularly for younger users; the mobile versions of Zoom, Gmail, and Microsoft's Office suite turn them into productivity tools; WhatsApp, Slack, and Discord ease casual communication. These applications, created by third-party vendors, greatly enrich the value of smartphones.

Before smartphones, we had feature phones that had a non-touch display, press-button-based inputs, and a set of built-in features. However, the smartphone is dynamic. You can add new apps, remove old apps, and play a newly released game by buying it on the app store. It is possible to download and use new applications because the Application Programming Interfaces (APIs) of mobile operating systems allow third-party software to integrate tightly with the phone's software and hardware.

Smartphones have eliminated many electronic utilities. Since smartphones became popular, people have stopped carrying cameras and camcorders and even use their phones as a flashlight at night. Hotels are beginning to eliminate alarm clocks³⁵ and it is becoming increasingly difficult to find radio clocks, which were standard fixtures in bedrooms for decades.

35 Ben Schlappig, "Good Riddance: Marriott Looks to Cut Alarm Clocks," <https://onemileatatime.com/news/marriott-cuts-alarm-clocks/> (accessed June 2023).

Smartwatch

A smartwatch is a microcomputer that you can wear on your wrist. Smartwatches are the newest entrants to the microcomputer line-up. Smartwatches have RAM, internal storage, and a CPU. They either use their own cellular chips or pair with phones to connect to networks. Because of their size limitations, they don't have a keyboard or mouse. But smartwatches make up for that shortcoming in other ways, primarily by leveraging their seamless connectivity with smartphones. Streaming services make it easy for you to save music on your watch. Because smartwatches use [Bluetooth](#) to connect with peripherals, you can put your earbuds on and go for a walk, while listening to your favorite songs streaming out of your watch. You can also make phone calls and send/receive messages while you are exercising and don't have access to your phone.

The main unique selling proposition (USP) of smartwatches is their impact on health. As microcomputers closest to users and wrapped around wrists, smartwatches have the potential to accurately sense many health parameters. Current technologies already allow smartwatches to monitor heart rates, blood oxygen levels, body temperature, step count, and sleep cycles. Some smartwatches can detect a fall and automatically notify nearby emergency services. Other smartwatches can detect irregular heartbeats and remind you to get yourself checked.



The industry is working hard to add additional capabilities, including blood pressure and sugar monitors. If these efforts are successful, smartwatches could help mitigate many common lifestyle health issues like diabetes, blood pressure, and obesity. In the coming years, smartwatches may be our greatest asset in improving health. Some of you may be the ones to write future software applications that leverage the hardware capabilities of smartwatches to detect and monitor diseases.

Form Factor

The differences in the types of computers discussed in this section can also be described as differences in their form factors.³⁶ Form factor is the term used to describe the physical size and shape of a computer device measured by outside dimensions.³⁷ For many common components, the form factor is also used as an identifier for a class of components. For example, a 3.5" or 5.25" hard drive, or a 1U or 2U server. These specifications define the space needed to fit the components, not the drive's storage capacity or a server's processing capacity.

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- 36 Dwight Pavlovic, "Computer Form Factors: A Guying Guide," <https://www.hp.com/us-en/shop/tech-takes/computer-form-factor-buying-guide> (accessed June 2023).
- 37 "What does form factor mean?" University Information Technology Services, <https://kb.iu.edu/d/ahvq> (accessed June 2023).

Architecture of a Microcomputer

Microcomputers (or computers for short) take signals from **input devices**, process these inputs in the CPU using instructions loaded in memory, and send the output to an **output device**. This general processing sequence is used to understand keyboard strokes. The general architecture of a computer was specified in 1945 in a report produced by the University of Pennsylvania for the US Military.³⁸ The report is known in the industry as the Von Neumann report. Section 2 of the report is shown in [Figure 15](#). Remarkably, the basic **computer architecture** and the flow of input and output signals is almost unchanged since the original 1945 report.

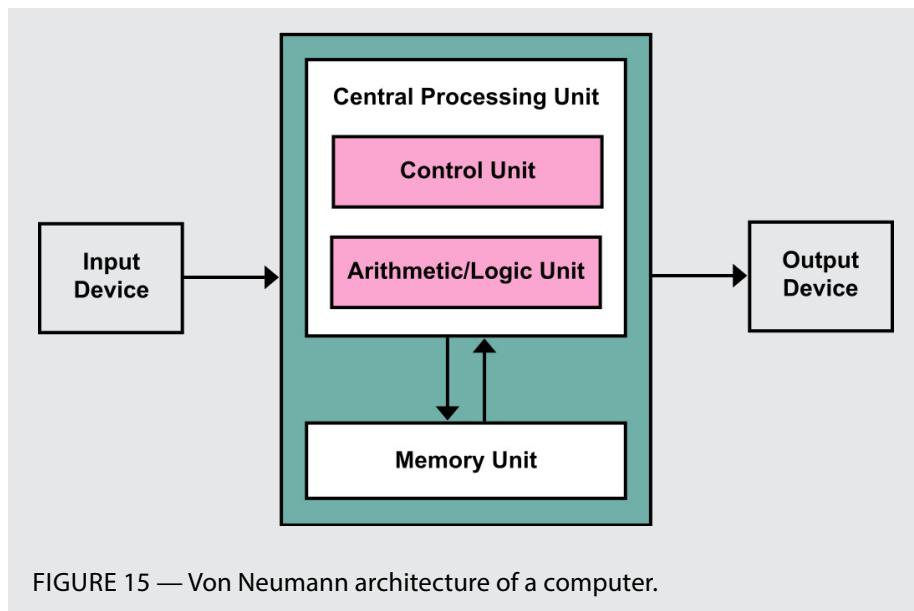


FIGURE 15 — Von Neumann architecture of a computer.

We will now look at the computer hardware—the physical parts of a computer you can touch and feel. We will then examine the core parts of computer software—the instructions that tell a computer what to do.

Motherboard

The **motherboard** is the wiring that connects all the components of a computer. The motherboard of a computer is analogous to the layout of a city or town. The layouts of most towns and cities have well-designed roads connecting homes, schools, parks, libraries, and office complexes. When a city or town is planned, the designers anticipate user needs and come up with an architecture to connect the different parts of the town and facilitate the quick movement of people and goods. They take into consideration the flow of traffic, utilities, and sewage to ensure the city roads do not get choked, and the residents don't have



The layout of a town.

³⁸ John Von Neumann, "First Draft of a Report on the EDVAC," <https://web.mit.edu/STS.035/www/PDFs/edvac.pdf> (accessed June 2023).

to deal with electrical and plumbing disasters every few days. Traffic rules and signs are established for orderly movement. Once the architecture is laid out, and the parts built in accordance with the architecture, the town can continue to function like a well-oiled machine.

The motherboard does for a computer what the layout does for a city. The motherboard is a plan to place various computer parts (CPU, RAM, storage, input, and output devices) in the right locations and connect them to each other, so all the parts get the necessary power and can communicate with each other at their rated speeds. See [Figure 16](#).

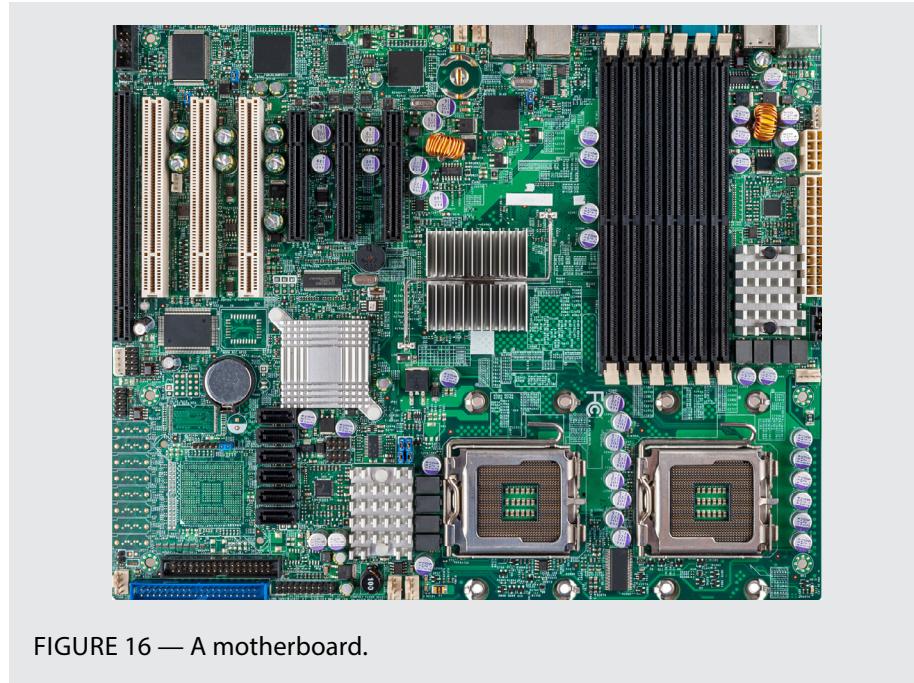


FIGURE 16 — A motherboard.

A motherboard not only has designated slots for the core components but it also distributes the right amount of power to each component. To dissipate the heat generated by high-performance CPUs, motherboards also have mechanisms to attach heat sinks and fans. The motherboard also has data paths called a [bus](#) to move data at high speeds between the components. The motherboard may also have expansion slots for you to add additional RAM (storage) and [GPUs \(Graphical Processing Units\)](#) to allow the computer to scale if needed.

CPU

The Central Processing Unit (CPU) is the brain of the computer and performs all the computations necessary to execute commands. Modern CPUs implement the Von Neumann architecture ([Figure 15](#)). The core technological marvel that enables CPU capabilities is the [transistor](#). A transistor is an electronic device that amplifies a signal. To create the binary behavior necessary for computer operation, the transistors used in computers are highly sensitive and effectively act as switches. When the input is low, these transistors block the connection (interpreted as 0) and when the input is high,

the transistors enable the connection (interpreted as 1).³⁹ By rapidly switching between 0 and 1 as directed by the software instructions, transistors help CPUs perform the necessary computations for users. Modern CPUs have many transistors to do complex data processing. CPUs in popular computers today can have over 100 billion transistors.⁴⁰

Transistors are one of the world's most sustained innovations. In 1971, Intel's first CPU, the Intel 4004⁴¹ had 2,300 transistors⁴² and cost \$200,⁴³ for a cost of \$0.10/ transistor. The transistors in the Intel 4004 were able to switch between 0 and 1 about 740,000 times per second. Performing each instruction took about 8 switches, and the Intel 4004 was able to complete about 92,000 instructions per second.⁴⁴ In 2022, the AMD Epyc 7773X⁴⁵ chip has 26 billion transistors, and sells for ~\$9,000, for a cost of \$0.0000003 per transistor. While instructions are now considered a simplistic metric, this chip is likely to perform the equivalent of 1.8 trillion instructions per second. So, while the cost per transistor has fallen by a factor of 250,000 between 1971 and 2022, the capabilities have gone up by a factor of almost 20 million. This revolution in costs and capabilities is the key enabler of digitally driven changes in our economy, which make a class like Digital Information Technologies relevant to our society.

CPUs tend to follow [Moore's law](#), the observation made by Gordon Moore (founder and CEO of Intel) in 1965 that the number of transistors on a microchip doubles approximately every two years. This is seen in the graph in [Figure 17](#), the growth in the number of transistors on microchips for 50 years since 1970.



A Central Processing Unit (CPU).

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- 39 There are more detailed explanations online, e.g., "How Transistors Work—The Learning Circuit," <https://www.youtube.com/watch?v=R0Uy4EL4xWs> (accessed June 2023).
- 40 "Apple unveils M1 Ultra," <https://www.apple.com/newsroom/2022/03/apple-unveils-m1-ultra-the-worlds-most-powerful-chip-for-a-personal-computer/> (accessed June 2023).
- 41 "The Intel 4004 Microprocessor and the Silicon Gate Technology," <http://web.archive.org/web/20211225184908/http://www.intel4004.com/> (accessed June 2023).
- 42 "The Story of the Intel 4004," <https://www.intel.com/content/www/us/en/history/museum-story-of-intel-4004.html> (accessed June 2023).
- 43 "Intel 4004," Gunkies, https://gunkies.org/wiki/Intel_4004 (accessed June 2023).
- 44 Margareet Rouse, "Intel 4004," <https://www.techopedia.com/definition/20057/intel-4004> (accessed June 2023).
- 45 "Nothing Stacks up to EPYC," <https://www.amd.com/en/products/cpu/amd-epyc-7773x> (accessed June 2023).

Moore's Law: The number of transistors on microchips doubles every two years

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

Our World
in Data

Transistor count

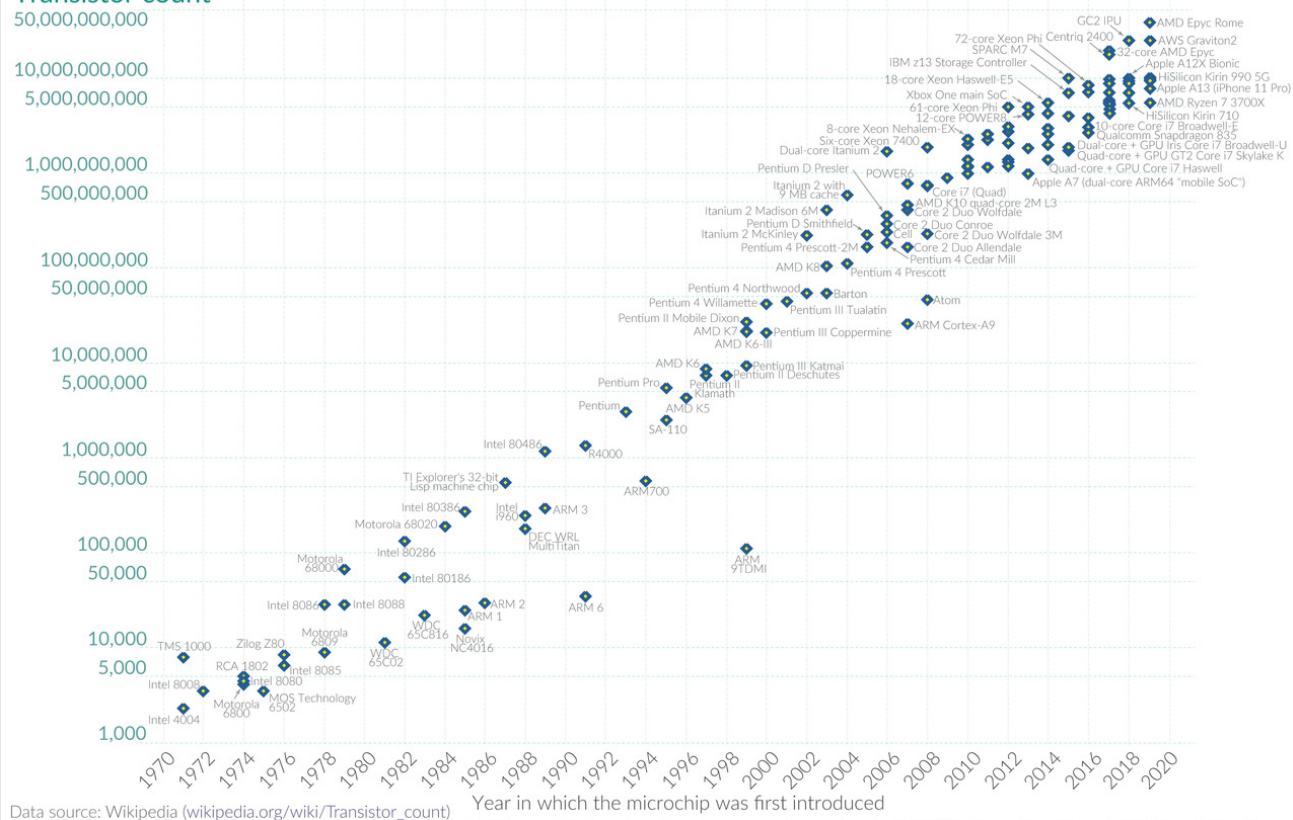


FIGURE 17 — The exponential increase in transistor counts per microchips doubles every two years.

This exponential growth has not only given us faster computers but has also made them smaller, cheaper, and less power-hungry. This has enabled form factors such as smartwatches and enabled even low-income people in developing countries to own computers and smartphones and communicate over the World Wide Web.

Buying Tip

Before you decide to buy a computer with the latest, most powerful CPU, you should keep in mind that the CPU is also typically the most expensive part of your computer. You may never utilize the power of the CPU if you plan to use the computer just to create Word documents and PowerPoint presentations, write emails, and browse the web.

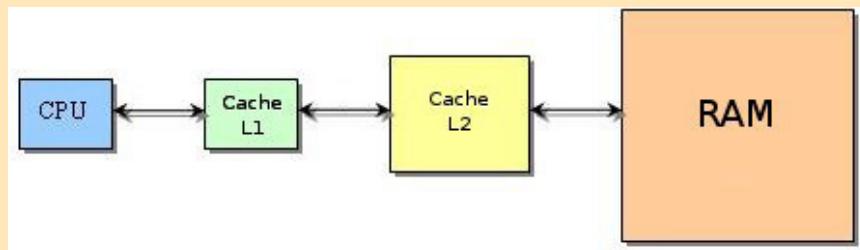
RAM

Random Access Memory (RAM) is much faster than all other kinds of storage devices like hard disk drives (HDDs), solid-state drives (SSDs), and optical drives.

It is used to temporarily store computer instructions that need to be accessed frequently, along with the data processed by these instructions. For example, when you launch the Chrome browser, the CPU needs a place to temporarily store the Chrome program as well as the webpages you are viewing and track all the changes you are making.

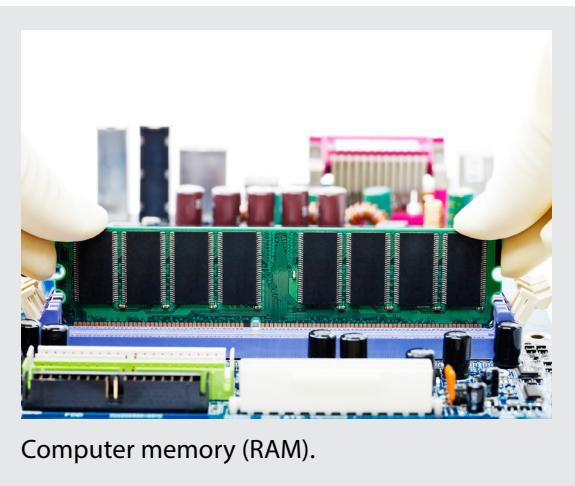
Memory Types

Memory comes in many types. In addition to RAM, modern CPUs also have extra-fast memory within the processor chip called the cache.⁴⁶ The cache is designed for instructions and data to be readily available within the CPU for instant access. In fact, there are multiple levels of cache in modern processors as seen here.



As of 2020, the cache memory within the processor chip is 10–100 times faster than RAM memory.⁴⁷ It takes 1–4 nanoseconds to retrieve data from the cache, and about 100 nanoseconds to retrieve data from RAM.

If you happen to open many tabs on your browser and end up consuming all the available RAM, your browser will become slow and might even crash. Computers try to augment RAM by using space on the hard drive as an extension of the computer's RAM. This additional space is called the page file, or virtual memory.⁴⁸ Since the hard drive is usually many times slower than the RAM, your computer's performance could get noticeably slower as the page file use increases. In these cases, it is useful to open the Task Manager to kill some unused programs and free up RAM to regain computer speed.



Computer memory (RAM).

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- 46 "Intel Processor Identification Utility—Windows Version," download page, <https://www.intel.com/content/www/us/en/download/12136/intel-processor-identification-utility-windows-version.html> (accessed June 2023).
- 47 "Latency Numbers Every Programmer Should Know," https://colin-scott.github.io/personal_website/research/interactive_latency.html (accessed June 2023).
- 48 "How to Manage Virtual Memory (Pagefile) in Windows 10," <https://www.tomshardware.com/news/how-to-manage-virtual-memory-pagefile-windows-10,36929.html> (accessed June 2023).

Opening the Task Manager

In Windows, right-click the start (or Windows) button on your taskbar to access the Task Manager. In the Task Manager, the “Processes” tab will clearly identify the programs that are consuming the most memory and CPU. You can also open the Task Manager by using the “Ctrl+Shift+Esc” keyboard shortcut.

In Figure 18, the Google Chrome app is consuming the most memory.

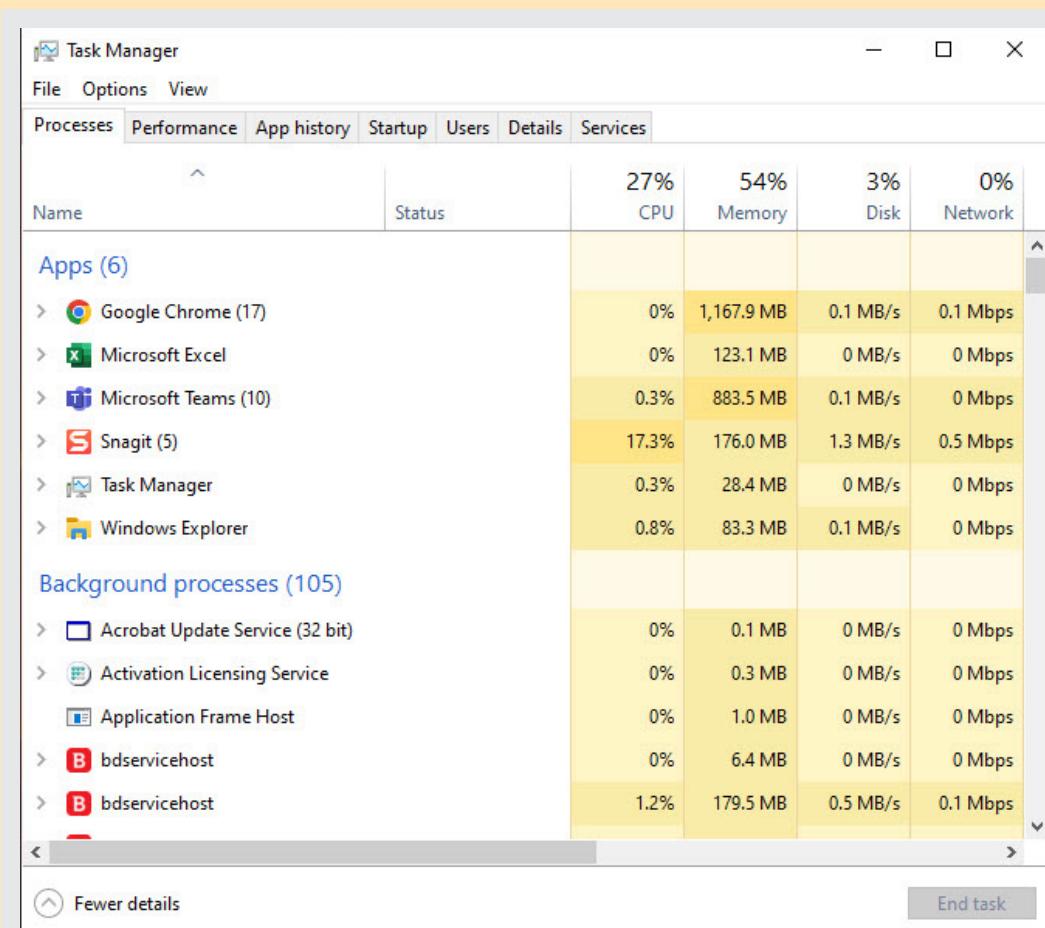


FIGURE 18 — Task Manager on Windows.

RAM is typically measured in **gigabytes** (GBs). A **byte** is equal to 8 bits. A **bit**, the basic unit of computer information, is a binary digit and takes a value of either a 1 or a 0. For example, the state of a light bulb—on or off, can indicate a 1 or 0. All information, whether in text, photo, audio, or video format, is converted into binary format and represented as bytes. Once this translation happens the computer can store it in RAM and process it in the CPU.

RAM is one of the most critical components to speed up a computer. Your RAM requirement is one of the key decisions you'll need to make before purchasing a computer.

How Much RAM Do You Need?

Here are the RAM recommendations from Crucial, one of the leading manufacturers of RAM.^{49 & 50}

Generally, we recommend 8GB of RAM for casual computer usage and Internet browsing, 16GB for spreadsheets and other office programs, and at least 32GB for gamers and multimedia creators. How you use your computer influences how much RAM you need, so use this as a guideline.

IF THIS IS HOW YOU USE YOUR COMPUTER

HERE'S HOW MUCH MEMORY WE RECOMMEND

Casual User

Internet browsing, email, listening to music,
or watching videos

At least 8GB

Intermediate User

Internet browsing, email, Word Processing,
spreadsheets, running simple graphics
programs, flash games, music, videos
or multitasking

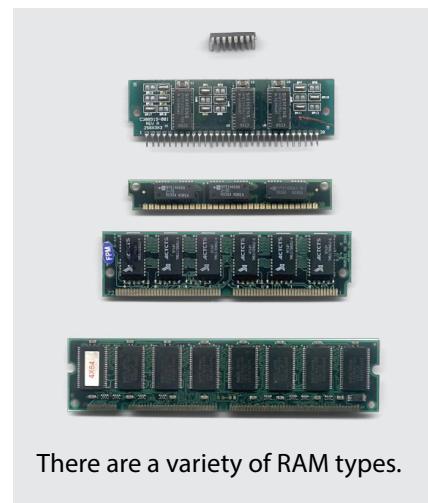
At least 16GB

Professional User/Gamer/Graphic Designer

High-performance gaming, multimedia
editing, high-definition video, graphic
design/3D modeling, intensive multitasking

At least 32GB

Unfortunately, RAM is only operational when it is powered. Even a momentary power loss clears up the contents in RAM.



There are a variety of RAM types.

-
- 49 For enthusiasts interested in building their own computer, here's a helpful article with some more details by Tony Polanco, "How much RAM do I need?" <https://www.tomsguide.com/features/how-much-ram-do-i-need-heres-how-to-know> (accessed June 2023).
- 50 "How Much RAM Do You Need For Your Computer Memory?" <https://www.crucial.com/articles/about-memory/how-much-ram-does-my-computer-need> (accessed June 2023).

RAM and a Worker's Pocket of Tools⁵¹

You can think of RAM as being analogous to a worker's pockets. The data and instructions in RAM are analogous to the tools a plumber or an electrician carries when performing tasks inside homes. The workers have the entire set of tools and supplies in their parked truck but it would take forever to complete any job if they had to go back to the truck every time they needed a screwdriver or tape. Instead, having these tools ready at hand speeds up their work. Similarly, having data and instructions at hand in RAM and cache helps the CPU speed up execution.

Storage

Computer storage is the technology that stores the software (e.g., operating systems and applications) and data on the computer. Storage is also popularly known as hard drives. A critical feature of storage technology that differentiates it from RAM is that applications and data are retained in storage even after the power is turned off. This ability to retain data for long periods without power or external connectivity allows you to store software and relevant data (e.g., documents, games, songs, and movies) in your computer throughout your school years and beyond. When the computer is powered on, the computer loads the operating system from storage into memory. As RAM cannot store data unless the computer is on, every computer comes with in-built secondary storage to keep your content safe when it is powered off.

Modern storage devices have reasonably large capacities and can store all the data and applications most users need. If your storage needs exceed the capacity of the built-in storage device, you have a few options. Most users connect external storage devices to augment the storage capacity of their computers. External storage is typically connected to your computer using a USB cable.

Cloud storage services such as DropBox, Box, OneDrive, iCloud, and Google Drive are also options to store personal data for a fee. Cloud services eliminate the risk of data loss. Cloud services like Backblaze⁵² offer even more comprehensive backup capabilities, saving



Disk drives in a typical desktop computer.



External storage devices.

51 Examples of holders for worker's tools <https://bucketboss.com/> (accessed June 2023).

52 Backblaze offers cloud services, <https://www.backblaze.com/> (accessed June 2023).

all the files on a computer. Both external drives and cloud services can also be used to back up your data and move it between computers.

Your storage needs depend upon the kind of information you work with. If you work mostly with text, your typical Word document will be a few kilobytes (1 kilobyte = 1000 bytes) in size. Photos are usually larger, about 4–5 megabytes (1 megabyte = 1000 kilobytes or 1 million bytes) in size. Higher-resolution photos can be even larger. Audio files are comparable in size to photos, with each song typically taking up about 5MB (in compressed formats like MP3) and about 50MB in CD-quality uncompressed formats. 4k videos in current smartphones take up about 1 gigabyte (1 gigabyte = 1,000 MB or 1,000,000 bytes) per minute. The table below shows the common prefixes for file sizes.

Memory unit	Description
Kilo Byte	1 KB = 1024 Bytes
Mega Byte	1 MB = 1024 KB
Giga Byte	1 GB = 1024 MB
Tera Byte	1 TB = 1024 GB
Peta Byte	1 PB = 1024 TB
Hexa Byte	1 EB = 1024 PB
Zetta Byte	1 ZB = 1024 EB
Yotta Byte	1 YB = 1024 ZB
Bronto Byte	1 Bronto Byte = 1024 YB
Geop Byte	1 Geo Byte = 1024 Bronto Bytes

HDD vs SSD vs Portable Flash Drives

There are two popular storage technologies currently in use—magnetic disks and solid state disks. Magnetic disks store data as changes in magnetization on tracks on a disk. Solid state disks (SSD) store data as the charge state of a transistor. Let's take a quick look at each type of storage.

Magnetic disks, also called hard disk drives (HDDs), are a legacy technology that stores digital data on glass platters coated with magnetic material. Data is stored as the direction of magnetism of the material. HDDs have a reader head that can magnetize portions of the disk during the writing process and read the direction of magnetization during the reading process. The disks in an HDD spin as fast as possible, while the head writes or reads data on the disk. The weight of the rotating platter makes hard disks heavy, slow, noisy, and hungry for power. However, at the current time, HDDs are cheaper than SSDs and can store significantly more data than SSDs. So, if you plan to store a lot of media files (songs, movies, and games), hard disk drives may be a good secondary storage option for you.



A hard-disk drive (HDD).



Solid-state drives (SSD).

Solid-state drives (SSDs) are a newer type of storage device that use transistors to store data. The transistors used in SSDs can save a charge even when not connected to power, enabling them to save data over long periods. SSDs do not have any moving parts, unlike HDDs. Not having any moving mechanical parts allows SSDs to be faster, longer lasting, and power efficient. Most newer computers come installed with SSDs as the primary internal storage.

As of 2020, it takes 16,000 nanoseconds (16 microseconds) to read data from an SSD and 2,000,000 nanoseconds (2 milliseconds) to read data from a hard disk drive.⁵³ Thus, L1 cache is the fastest, L2 cache is 4 times slower than L1 cache, RAM is 25 times slower than L2 cache, SSD is 160 times slower than RAM, and magnetic disks are 125 times slower than solid state disks.

A popular small version of an SSD is called a [portable flash drive](#) (also known as a USB stick). These devices are designed to be compact and are often given out as company swag for marketing purposes. If you plug the flash drive or USB stick into your computer, the operating system will automatically detect the USB key as a storage device and the contents of the key become available in your File Explorer. You can treat the USB key like a storage device into which you can add or remove files. USB sticks are useful when you want to move content from one computer to another.



Flash drives are also called USB sticks or thumb drives.

File Safety With Portable Drives

Before you remove the USB stick or other external storage device from the USB port of your computer, you should remember to "Eject" to avoid corrupting the data on the device. To "Eject," right-click on the USB drive in your File Explorer and select "Eject." You'll get a message stating it is now safe to disconnect the device. Properly removing the external device ensures that the operating system has cleaned up and closed files to avoid damaging the contents of the external storage device.

Bus

The bus in a computer is a communication system that transfers data between a set of components. As we have seen, the components of a computer operate at vastly different speeds. Buses allow the CPU to operate at the highest speeds possible, without getting slowed down by the slowest components. The buses in the earliest computers were simply a set of wires connecting components. Developments in bus technologies have enabled CPUs to become significantly faster even as peripherals like printers and keyboards (and human users) have not evolved at a comparable pace. Modern micro-computers have several buses, each operating at its own speed.

⁵³ "Latency Numbers Every Programmer Should Know," https://colin-scott.github.io/personal_website/research/interactive_latency.html (accessed June 2023).

Buses in General

The term “bus” is a general term for a shared connection that maintains uniform properties across its span to which several consumers are connected in parallel. Thus, the power distribution lines delivering power at a fixed voltage to electrical substations can be considered a distribution bus, and the power lines supplying power to homes in a neighborhood at the constant 120 volts and 60 Hertz can be considered load buses. Similarly in a computer, each bus operates at the same clock speed and has the same data across its span at any given time.

GPU

A graphics processing unit (GPU) is a computing technology designed to run several small programs simultaneously. While modern CPUs have multiple cores and threads and can run tens of multiple programs in parallel, GPUs can run thousands of programs in parallel. The overall size of the processor chip is about the same in both CPUs and GPUs. While CPUs are organized as a small number of highly capable processors, GPUs are organized as many relatively simple processors with relatively limited capabilities.⁵⁴ For most tasks, the complexity of CPUs is sufficient. However, for a small subset of tasks, mostly in image processing and [machine learning \(ML\)](#), there is a need to perform many simple operations in parallel. As image processing becomes popular for gaming and machine learning becomes popular for artificial intelligence, GPUs become increasingly popular. This is also reflected in the valuations of the principal CPU manufacturer, Intel (\$120 billion), and the principal GPU manufacturer, Nvidia (\$400 billion).

A lot of young people use personal computers primarily to play video games. Over time, the games have become hyper-realistic and take place in a fantasy world where artificially created characters interact with each other. Complex lighting and shadow patterns on high-resolution monitors with fast refresh rates can make these games very realistic. For a while, CPUs were stretched thin dealing with complex gaming algorithms and high-resolution images designed to simulate a true-to-life experience.

The computing industry addressed the problem by introducing chips dedicated to processing graphics and rendering video content on the screen. These chips, known as GPUs, work in tandem with the CPU of the computer. The CPU handles the user input and does all the computations (e.g., Did two objects collide? What is the location of objects on the screen). So, the CPU is still the overall boss, but it can send video gaming/image processing workloads to the GPU, which does the computations needed to render each pixel (e.g., color, shading, brightness) in the frame.⁵⁵ Modern high-resolution gaming monitors can have over 8 million pixels (3,840 x 2,160), and with frames refreshed 60 times a second (refresh rates), about 500 million computations are needed each second to display the images

54 Peter Ashman, “Why do CPUs have so few cores compared to GPUs?” <https://qr.ae/pr8Rkp> (accessed June 2023).

55 “What role does the CPU, GPU, and RAM play during gaming?” <https://www.quora.com/What-role-does-the-CPU-GPU-and-RAM-play-during-gaming-I-know-their-functions-and-what-they-do-but-what-are-they-responsible-for> (accessed June 2023).

on the screen.⁵⁶ While this is a lot of computations, all the computations are similar and simple. These are a perfect fit for GPUs. Therefore, CPUs delegate these computations to GPUs for optimal performance.

GPUs themselves come in two formats: Integrated GPU ([Figure 19](#)) and Discrete GPU ([Figure 20](#)). Integrated GPUs look like just another chip on the motherboard and cannot be upgraded by the end user. On the other hand, Discrete GPUs can be purchased, replaced, and upgraded by the end user. It connects to the motherboard through an expansion slot on the PCIe bus and comes with its own cooling fans. Typically, Discrete GPUs are far more powerful than Integrated GPUs.

GPUs for Video Content Creation

Because GPUs were originally designed to handle fast/high-resolution video rendering, they have become the go-to choice for video content creators, too. If you like to capture videos, edit them, and splice them with additional audio/video content, then a powerful GPU on your PC will make your video editing program much faster. Whether you are an anime creator, an Adobe Photoshop user, or a producer of content for educational purposes, you may consider buying a computer with a powerful GPU or adding one to your current system.

GPUs for ML and Crypto Mining

Even though GPUs were designed primarily for graphics and video rendering, data scientists working on machine learning (ML) models also found GPUs useful. The job of going through all photos uploaded by users to Facebook and removing objectionable content is a difficult and expensive task for humans. Facebook users upload more than 350 million photos per day. To manually view each one and determine if it is suitable for consumption can be daunting. Machine learning algorithms are an effective and cheap way to do the job. As most machine learning algorithms involve a lot of identical operations (addition and multiplication), GPUs are great ML use cases.

During 2015–2022, [crypto mining](#) became very popular. In crypto mining, computers search for solutions to cryptographic problems for the right to add a block to a chain and get the reward associated with adding the block to the chain. GPUs can search far more options than CPUs in a given time. Therefore, during the recent crypto boom, it became difficult for regular users to purchase GPUs as they were in high demand by crypto miners, who were willing to pay premium prices for these GPUs.

⁵⁶ “What is Monitor Resolutions? Resolutions and Aspect Ratios Explained,” <https://www.viewsonic.com/library/tech/monitor-resolution-aspect-ratio/> (accessed June 2023).

The Two Formats of GPUs



FIGURE 19 — Intel’s integrated GPU.



FIGURE 20 — Intel’s Discrete GPU.

GPUs—The Florida Connection

One of the world's leaders in GPU development is Nvidia. One of the three co-founders of Nvidia is Chris Malachowsky, an alum of the University of Florida. He received a BS in EE from UF in 1986 and co-founded Nvidia with Curtis Priem and Jen-Hsun Huang in 1993. In 2020, he gifted \$25 million to the University of Florida to build HiperGator AI, one of the world's fastest AI supercomputers and made it available to students, researchers, and businesses across Florida.⁵⁷

Input Devices

As computers are designed to interact with humans, they need a mechanism to take our commands and return responses. An input device is a medium through which we can provide actionable tasks for computers. Let's look at some common input devices to understand them better.

Keyboard

A keyboard is the primary input mechanism of a computer. Keyboard commands get translated into emails, chat messages, clicks on a browser screen, video game movements, or others depending on the program receiving the input. As the standard English keyboard has the letters Q, W, E, R, T, and Y on the top row, it is known as QWERTY. See [Figure 21](#). This arrangement, designed for typewriters, was intended to avoid jamming typebars striking on paper and is, unfortunately, not the most efficient layout for modern computers.



FIGURE 21 — A standard English keyboard, also known as QWERTY.

For touch typists (those who type without looking at keys), the letters F and J have a small, raised dot. The dots are meant to help you place your forefingers on the keyboard before you begin typing.

⁵⁷ "UF Announces \$70 Million Artificial Intelligence Partnership with Nvidia," <https://www.uff.ul.edu/your-impact/uf-announces-70-million-artificial-intelligence-partnership-nvidia/> (accessed June 2023).

QWERTY vs Dvorak and the Path Dependence of History⁵⁸

The QWERTY layout was designed to slow typists down to prevent key jamming in mechanical typewriters.⁵⁹ This was done by placing the most popular keys, e.g., e, t, a in relatively awkward positions, as opposed to convenient locations in the center of the keyboard. Also, the QWERTY layout makes disproportionate use of the left hand, which is not the dominant hand for most people. However, the layout, created in 1873, became popular with typewriters.

August Dvorak created an alternate keyboard layout in 1936 to reduce finger movement for common words by placing common keys closer to the center of the keyboard, thereby increasing typing speed, reducing errors, and increasing comfort. However, the Dvorak keyboard never gained popularity despite its potential advantages. Another persistent historical artifact is the staggered arrangement of keys on different rows, which was done to accommodate the key levers from different rows. This staggering is not needed in electronic keyboards, but the design persists. Many modern designs can be traced to historical constraints that no longer apply. Identifying these opportunities to relax constraints is a potential avenue for innovation.

If you don't want to adjust to the standard keyboard size, you may want to consider ergonomic keyboards designed to fit your fingers (see [Figure 22](#)). You can connect any new keyboard to your desktop or laptop through USB or Bluetooth.

Mouse and Trackpad

If you look closely at your computer screen, you will see a small arrow like the one in [Figure 23](#).

This arrow tells the computer where to focus. You can use your mouse/trackpad to shift the point of focus at any time. Your mouse/trackpad typically has two buttons, left and right. We use the left button to click and select objects, and the right button is used to open contextual menus that change based on your location. The mouse also has a wheel to scroll through multiple pages easily. If you have a wireless mouse, you can connect it to your device via Bluetooth software.



FIGURE 22 — An ergonomic keyboard.



FIGURE 23 — Cursor arrow.

58 "Dvorak keyboard layout," https://en.wikipedia.org/wiki/Dvorak_keyboard_layout (accessed June 2023).

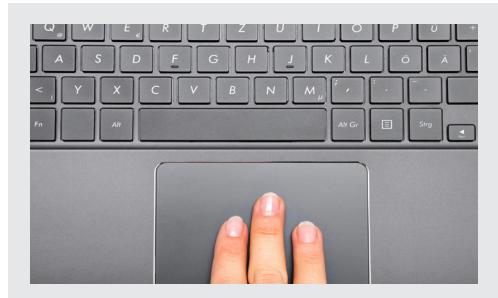
59 However, also see Yasuoka, Koichi; Yasuoka, Motoko, "On the Prehistory of QWERTY," https://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/139379/1/42_161.pdf (accessed June 2023).

The mouse is popular with desktop computers and office areas with sufficient desktop space to move the mouse. Since laptops are often used in tight spaces (e.g., airport seats) with no room to place a mouse, most modern laptops come with touchpads to replace the mouse as a tactile input device. Touchpads or trackpads use a specialized surface to translate the position of a user's fingers on the device to a location on the screen. The screens of modern smartphones also serve as touchpads.



Camera and Microphone

With the popularity of remote work in the post-Covid world, most employees use Zoom, Webex, GoTo, Teams, or Google Hangouts daily to join meetings and conferences. Often, you'll be required to keep your video and audio on to participate and have the feeling of being in a room with other participants. All these programs depend on the camera and microphone on your computer to share your video and audio with other meeting participants. As online meetings become increasingly important for school and work, the quality of the camera and microphone are becoming increasingly important differentiators of laptops. If these devices are not satisfactory, you can buy and connect an external high-resolution camera and a high-fidelity microphone to your computer to improve your remote-working experience.



Output Devices

After a computer accomplishes your tasks, the output devices will communicate the outcome of the actions. A monitor is the primary output medium that you will interact with all the time, whether you watch a movie on Netflix, type an email to a friend, or work on a spreadsheet.

Since you will spend most of your time on the computer looking at the monitor, the monitor has a significant impact on your end-user experience. Fortunately, most modern monitors provide excellent performance at an affordable price. Some extra monitor features may come at a price. For example, touch screens are interesting, but they also consume more power and add weight to the laptop cover. Similarly, large screens are useful during work but reduce portability. It is, therefore, useful to carefully assess your needs before you select a monitor.⁵⁰



Join a video call or participate in a video conference using a webcam.



The screen of a laptop is its primary visual output.

60 Scharon Harding, "How to Buy a PC Monitor," <https://www.tomshardware.com/reviews/monitor-buying-guide,5699.html> (accessed June 2023).

To improve your productivity, you can attach more than one display screen to your computer (see [Figure 24](#)). You can use the HDMI or USB-C ports on your computer to connect multiple displays.

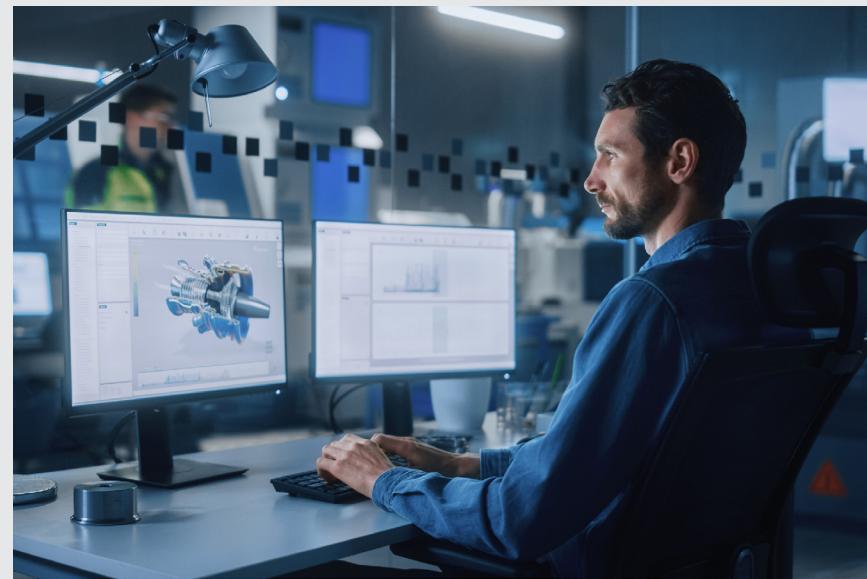


FIGURE 24 — The use of two screens can improve productivity.

Speakers

Most Laptops and PCs come with built-in speakers to play audio. Most laptops today have very good sound output, including some models that use four speakers to produce rich, realistic sound. It is also becoming increasingly common for users to use earbuds or headphones to minimize disturbance to nearby users. Further, to improve the quality of sound, particularly if you watch videos on YouTube or listen to music on Spotify, you may attach your high-fidelity speaker through the USB ports or use Bluetooth to connect to wireless earbuds.



Conclusion

Have you ever opened the outside case of a desktop to peek at the inside parts? The inside looks like a tightly placed collection of parts, which may be confusing at first glance (see [Figure 25](#)). But now that you know the key parts of a computer, you should be able to recognize most parts. If your computer is too outdated or slow, you may even explore opening it up and adding memory to make it faster and last longer.



FIGURE 25 — Computer internals.

To make these hardware parts work in a coordinated manner, computers have software that tells these hardware components what to do. While the operating system (Microsoft Windows, Apple Mac OS, or Linux) is the main software acting as the brain of the computer, you'll generally need to install many other end-user applications (e.g., Chrome, Snapchat, Instagram, DropBox, Google Maps, Spotify, Paint, Snagit, and others) to turn the computer into a versatile assistant.

As seen in [Figure 26](#), end users interact with applications that request the operating system to have the hardware to perform the needed tasks to meet user needs.

Any software program is a collection of instructions to the CPU to perform a task. These instructions are expressed in binary code for the CPU to perform the required operations. Afterward, the output is conveyed to us through the correct output device, which translates the 1s and 0s into images, sounds, and text.

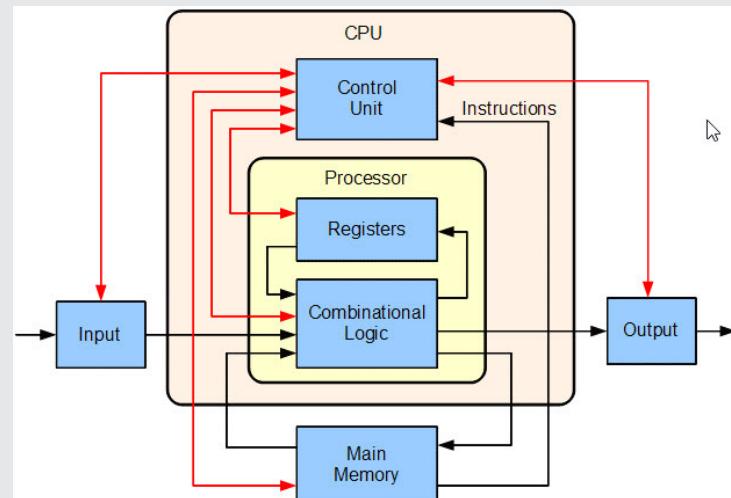


FIGURE 26 — The overall architecture of a computer.



Chapter Terms and Definitions

Bit: A binary digit and a unit of computer information; a bit takes a value of either a 1 or a 0

Bluetooth: A technology designed for exchanging data wirelessly between electronic devices over short distances

Bus: In a computer, a bus is a communication system that transfers data between a set of components

Byte: A byte consists of eight binary digits and is commonly used to store various types of data, such as text, images, audio files, and program code

Central Processing Unit (CPU): An electronic circuitry component of a personal computer that is designed to interpret, process, and execute instructions from hardware or software programs

Computer Architecture: The way a computer is designed, including its various hardware components and how they work together to perform tasks; it determines the overall functionality and performance of the computer system

Crypto Mining: Using the computational power of a computer to solve complex problems that produce money in the form of cryptocurrency such as bitcoin

Gigabyte: A unit of digital information that represents one billion bytes; it is commonly used to measure the storage capacity of computer memory and storage devices, such as hard disk drives, solid-state drives, and memory cards

Graphical Processing Unit (GPU): Electronic circuit technology designed to speed up the creation of images displayed on a device such as a computer monitor

Hard Disk Drive (HDD): A type of computer storage device that uses rotating disks coated with magnetic material to store data permanently

High Definition Multimedia Interface (HDMI): A hardware connection technology designed to transmit digital audio and a video signals through a cable between HDMI-compatible devices

Input Device: A device such as a computer mouse or keyboard that delivers data and can manipulate the components of the computer

Keyboard: Concerning computer peripherals, a physical or digital device capable of communicating with a connected computer system through assigned key inputs

Machine Learning (ML): Programmed parameters where data is passed through statistical models in which the model increases accuracy with more data; this presents itself in the form of intelligence that is artificial

Moore's Law: A "law" proposed by Gordon Moore, Intel co-founder, stating that the number of transistors in microchips would double every two years due to advancing computing performance

Motherboard: A computer component that acts as a dock, is responsible for controlling the core computer processor, and connecting various other pieces of computer hardware

Mouse: Regarding computer peripherals, a hand-held input device capable of detecting user manipulation through motion to facilitate interactions with computer systems

Optical Drive: A type of computer hardware that uses lasers to read data from or write data to optical discs, such as CDs, DVDs, and Blu-ray discs

Output Device: Computer hardware such as a computer monitor or mobile device screen that is designed to convert information into a visual display easily understood by humans

Personal Computer (PC): Also referred to as a microcomputer; a device that processes computing functions that serve one or multiple personal or business purposes

Portable Flash Drives: Small, portable devices, easily connected to a computer via USB ports, that store digital data using flash memory

Random-Access Memory (RAM): Sometimes called the memory of a computing device such as a smartphone or PC; a component within a computing device capable of temporarily storing data that can be accessed by the CPU whenever processing is required

Smartphone: A portable computer that can connect to the Internet through cellular networks and offers a range of features such as web browsing, email access, social media apps, multimedia playback, and various downloadable applications

Smartwatch: A microcomputer that you can wear on your wrist

Solid-State Drive (SSD): A type of computer storage device that has no moving parts and uses flash memory to store data permanently

Transistor: A basic electronic component used in computer architecture to amplify and switch electronic signals; it acts as a tiny switch that controls the flow of electrical current by using a small voltage input to control a larger current output

Universal Serial Bus (USB): A standard used by the computing industry to specify how the hardware in devices can connect, communicate, and supply power across personal computers

Wi-Fi: Wi-Fi is a wireless networking technology that enables electronic devices, such as computers, smartphones, and tablets, to connect and communicate with each other via a wireless medium



Chapter Case

Gaming Consoles Yesterday, Today, and Tomorrow

Atari is a company founded in 1972 that developed an iconic gaming console that enabled millions of users to play games such as "Pong," "Asteroids," "Centipede," and "Missile Command." According to atari.com, "Atari played an integral role in the development of the arcade game, game console, and personal computer industries." In 1977 Atari released the Atari 2600 gaming console (also called the Atari Video Computer System), which featured microprocessor-based hardware that included swappable gaming cartridges capable of storing Kilobytes (KB) of gaming information. Additionally, the gaming console included a motherboard that could control hardware components such as a CPU, RAM, input devices (joysticks), and output devices.

More than 50 years have passed since Atari was founded and gaming consoles today have been innovated far beyond the computing capabilities of the 1977 Atari 2600. Use the Internet to research any gaming console system (for example, Microsoft Xbox, Sony PlayStation, etc.) of your choice. Answer the following questions based on the results of your online research:

.....

Question 1: List the hardware specifications for the gaming console of your choice. Be sure to list as many hardware components as you can (ex. CPU, memory, input devices, output devices, etc.). After listing each hardware component, briefly describe what the component is used for. Finally, provide a weblink to document where you retrieved the information.

Question 2: Write a short paragraph describing what you imagine gaming consoles will be capable of doing 50 years in the future.

File Management

6

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Basically, our goal is to organize the world's information and to make it universally accessible and useful.

—Larry Page, co-founder of Google

Overview

File management is about creating an organized structure to store information on your computer for easy retrieval and use. As more and more of our information becomes digital and ends up in our digital devices—e.g., school assignments on laptops, photos on smartphones, emails in the cloud—it becomes increasingly important to create an organized structure to store this information, so it is available when needed. After all, what is the point of taking that keepsake picture with a friend if you can't find it later when you need it?

Think of file management as a small-scale/personal version of Google. Google's vision statement is "to organize the world's information and make it universally accessible and useful."⁶¹ Both file management and Google involve organizing and managing large amounts of data, even if the methods are different. File management involves developing good habits in naming and organizing files on a computer. Google uses complex algorithms to organize the vast amounts of data that it collects from around the world. The end goals are the same. Both file management and Google aim to make data easily accessible later. As ChatGPT puts it, "in many ways, file management is doing for your computer what Google aims to do for the Internet."⁶²

Taking a few minutes to learn how your computer organizes files and to develop good file management practices may be one of the best investments you make in learning to use your computer effectively. This chapter will show you how. Experienced computer users consider their **file manager** as the starting point of any work. Microsoft computers have File Explorer for file management. Similarly, Finder—also known as Mac Desktop Experience—is the default file manager on Mac computers. The icon for Finder⁶³ is "Happy Mac,"⁶⁴ ().⁶⁵

Information management in the computer context is called file management because all information on computers is made available to end users as files. Files have properties such as names, last modified date, size, etc. These properties help with information location and retrieval. In the rest of this chapter, we use information management and file management interchangeably.

61 "About Google," <https://about.google/> (accessed June 2023).

62 "How is file management analogous to what Google does?" <https://chat.openai.com/chat> (accessed June 2023).

63 For more on the origins of some of these icons, you may like this article in Quartz magazine about Susan Kare, the designer for the original Mac icons, <https://qz.com/1666437/mac-icon-designer-susan-kare-explains-the-inspiration-for-her-designs> (accessed June 2023).

64 "Finder (software)," Wikipedia, [https://en.wikipedia.org/wiki/Finder_\(software\)](https://en.wikipedia.org/wiki/Finder_(software)) (accessed June 2023).

65 "Get to know the Finder on your Mac," <https://support.apple.com/en-us/HT201732> (accessed June 2023).

Why Manage Files?

To have a sense of balance and order and to be efficient in your home, you need to have some basic organization skills to find what you need in the jumble of things. For example, look at some of the many things you have in your home: table lamp, desk, paper clips, speakers, camera, side tables, fans, shirts, pants, towels, toasters, vacuum cleaner, sewing kits, hangers, shoes, watches, keyboards, bags of chips, bottles of syrup, saltshakers, tea bags, rolling pins, and coffee makers. Do you instantly know where to go if you want a clean towel?

Would you go to the bedroom looking for a kitchen knife? Not unless you have some sinister plan for which you hid the kitchen knife under the mattress, right? Imagine if everything you have in your home were to get placed in a pile in the center of your living room. Would you be able to grab a can opener and a tin of chickpeas from the heap to prepare dinner? Probably not. It might be easier for you to go to a store and buy food than spend an hour looking for the can opener and chickpeas.

Having a well-organized home and pantry will not only save time but also energy and money. A place for everything, and everything in its place, as the saying goes.

A file management system does for your computer what home organization does for your physical items at home. File management involves creating folders and subfolders for information, categorizing your information appropriately, and saving information as files in the right folders with a consistent file-naming convention. Having a good naming convention for files and folders is very helpful to identify what's inside. Imagine having to open a bunch of files to figure out which one has the homework questions for a math assignment due tomorrow. You could easily end up spending more time searching for the file than you might've spent doing the assignment.

The technology industry has spent considerable effort trying to understand how users work with information and has attempted to make it as simple as possible to perform common operations. By following users around their offices, early researchers found that file management involves not only information retrieval, but also information reminder. Users keep documents on their desks not just to find them, but also to remind them of tasks that they need to do.⁶⁶ Researchers also found that correctly classifying information was challenging for most users. For example, for any given school year, should you have folders like assignments, notes, or should you have folders like Math and English? As a result of this complexity, users tend to dump information into unorganized piles. These findings have led to metaphors such as "desktops," designed to facilitate reminders and automatic classifications by date, file name, and other parameters. We explore the common file management utilities and operations in the rest of this chapter.

Since file management is a core function of an operating system, file management utilities come bundled with the operating system. While we focus on the file management utilities in the common



A good example of home organization is a well organized kitchen pantry.

⁶⁶ Malone, T., "How Do People Organize Their Desks? Implications for the Design of Office Information Systems," *ACM Transactions on Office Information Systems*, 1(1), 99-112 (1983).

operating systems—Windows (File Explorer) (see [Figure 27](#)) and MacOS (Finder) (see [Figure 28](#))—other operating systems offer similar utilities and support similar operations. For example, Nautilus, the file manager in Linux, looks and feels much like the file managers you see in this chapter.

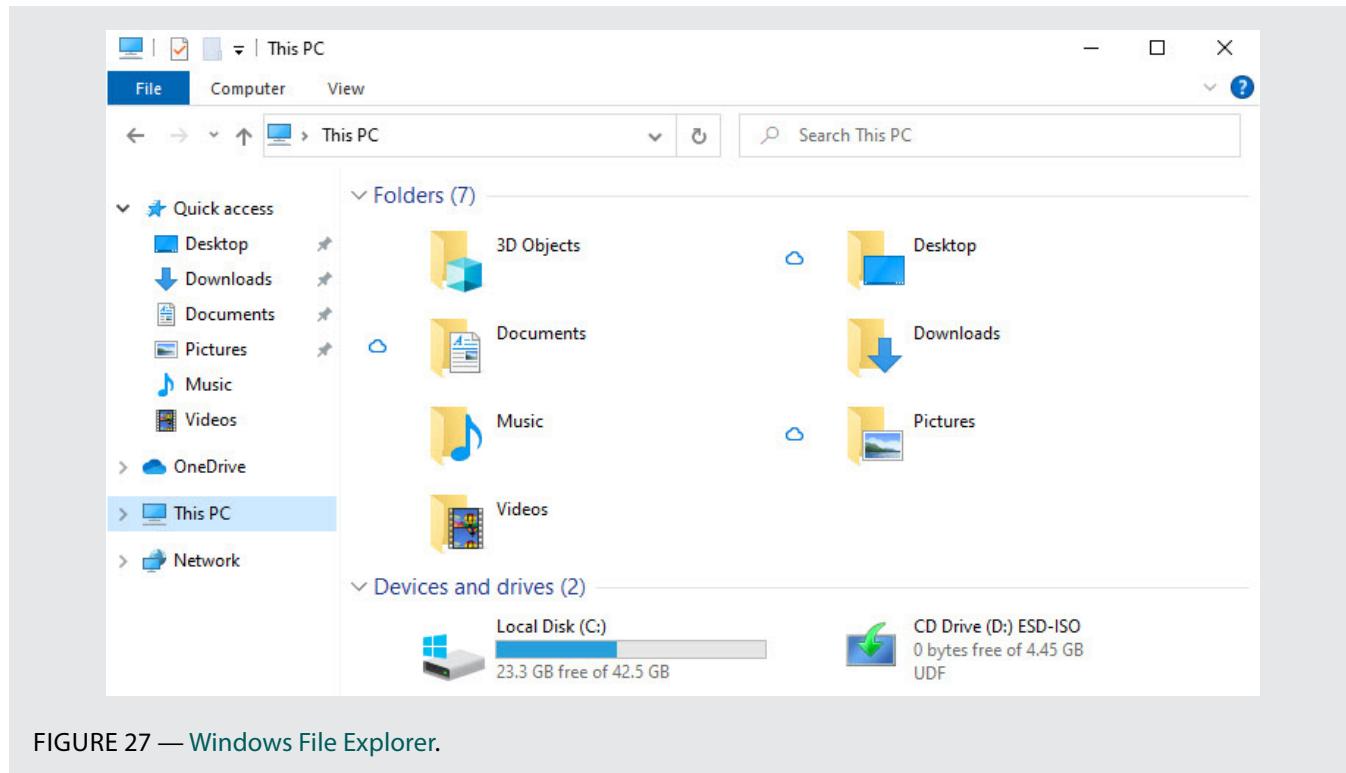


FIGURE 27 — [Windows File Explorer](#).

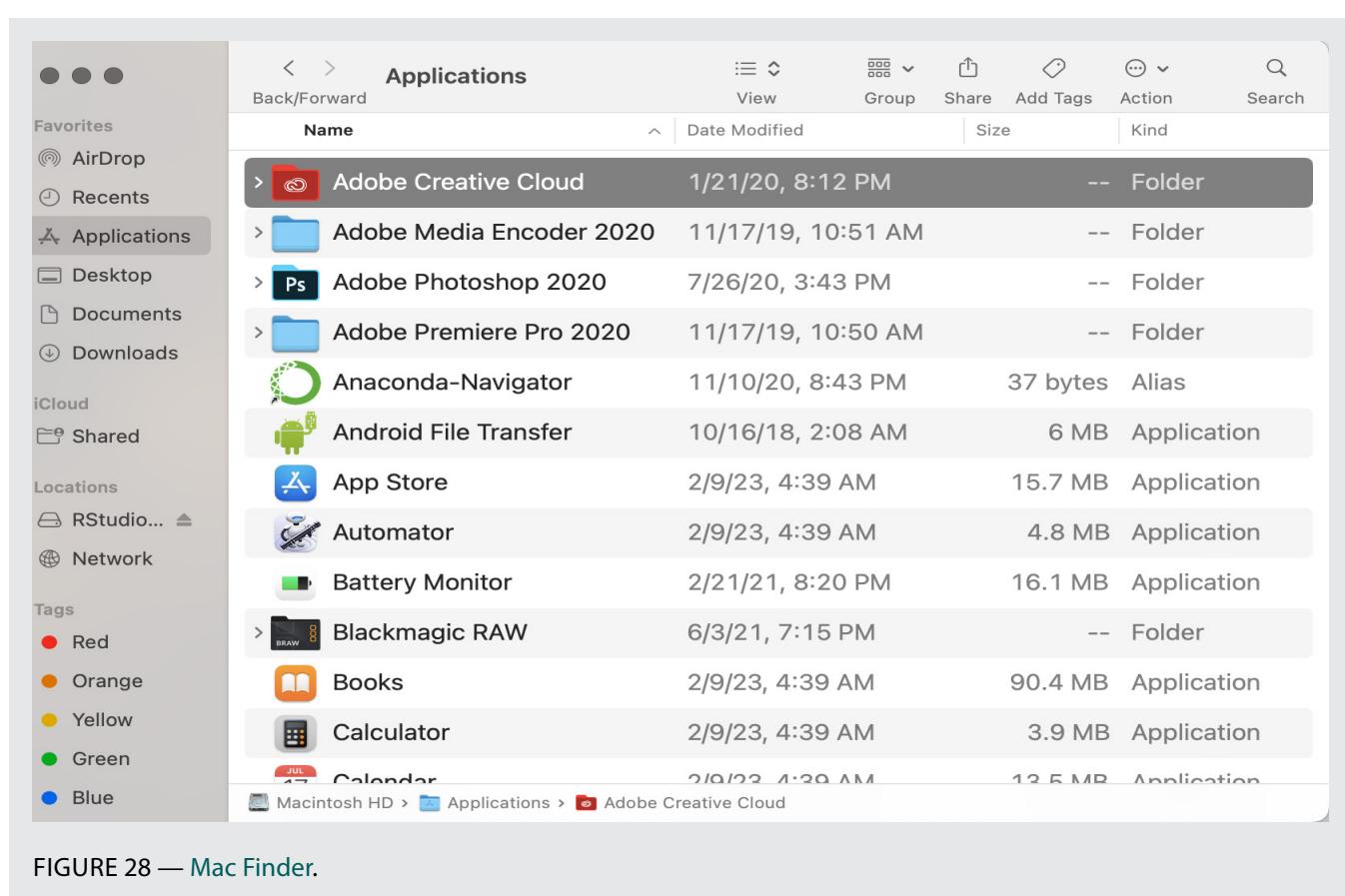


FIGURE 28 — [Mac Finder](#).

Using File Managing Utilities

The most common [file operations](#) involve creating, storing (saving), finding, opening, emailing, moving, and deleting files. You may occasionally need to do bulk operations on files to avoid wasting time by handling them one at a time. For example, you may want to reorganize all your music files, so they are grouped by artist and album rather than by the year of release. Or you may decide that you no longer need your 7th grade notes and projects and want to delete them all to make space for new assignments. It would be efficient to select a group of files and perform bulk operations on this group of files rather than try to move, copy, or delete them one at a time. File management supports all these common tasks. In addition, file management also supports restoring files deleted by accident.

As mentioned earlier, Microsoft's file manager is called File Explorer. In versions of Windows before Windows 10, File Explorer was called Windows Explorer.⁶⁷ The first File Explorer was released in 1995 as Windows Explorer with Windows 95. The file manager on MacOS is called Finder and was released in 1984. The capabilities of these file managers have improved substantially over time.

Opening the File Managers

On Windows, you can launch File Explorer by clicking the Windows icon (⊞) and typing File Explorer in the search bar (see [Figure 29](#)). To open File Explorer, you can also use the keyboard shortcut, press E while holding the Windows key, (⊞ + E). On the Mac, you can open the Finder by clicking the Finder icon in the Dock (Dock icon), or by using the shortcut, Command + Option + Space Bar (⌘ + ⌥ + _).

Given how useful file managers are, most users find it great to have a quick way to access file managers. The most effective way to set this up on Windows is to press the Windows key (⊞) or click the Windows icon (⊞) on the desktop, scroll through the list of programs to Windows System, expand the group by clicking on it to find the icon for File Explorer. You can now right-click the File Explorer icon, select "More" and select "Pin to Taskbar." The File Explorer icon will now show up at the bottom of your desktop, and you can click on the icon anytime you want to open File Explorer. On the Mac, the Finder icon is typically located in the Dock by default.

⁶⁷ Please do not confuse File Explorer with Internet Explorer, which was the earliest version of the web browser made by Microsoft and was used for surfing the Internet.

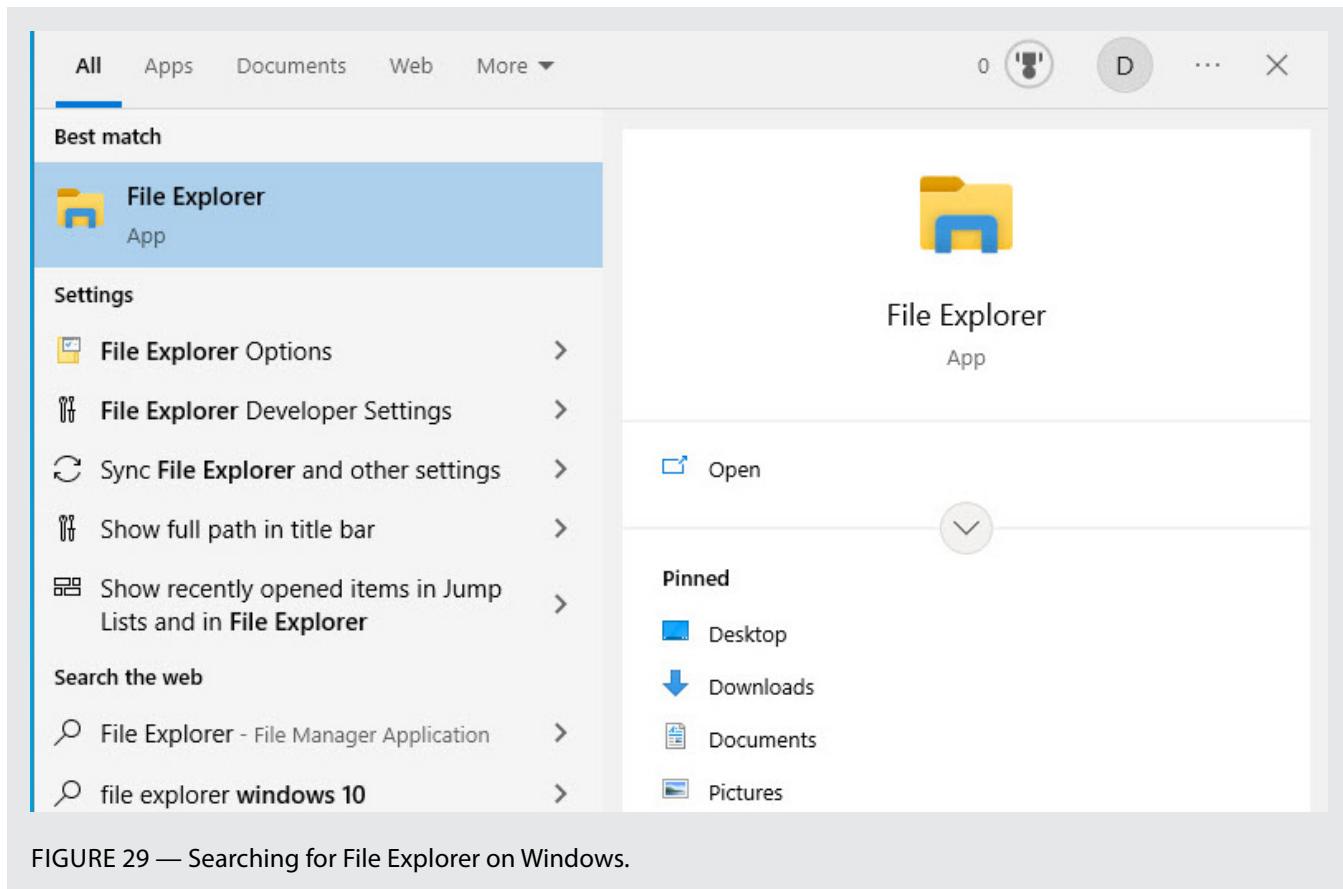


FIGURE 29 — Searching for File Explorer on Windows.

File Manager Components

When File Explorer opens, you will see a “Quick Access” section on the left-hand side (the first box in [Figure 30](#)). Here you’ll find your frequently used folders, including “Desktop,” “Documents,” and “Downloads.” If you have installed any cloud storage service (e.g., DropBox), you may also see a link to that folder in your “Quick Access” menu. On the right (Section 3 in [Figure 30](#)), you will see all your recently accessed folders and files.

Click on any folder on the left side of File Explorer (sections 1 or 2 in [Figure 30](#)) and the contents of that folder will appear on the right-hand side (section 3).

One item on the left in File Explorer is of particular interest—“This PC.” Clicking “This PC” (highlighted as section 2 in [Figure 30](#)) brings up the storage layout of your PC, including the internal and external disk drives. If you plug in a USB storage, a smartphone, or smartwatch, it will show up as a separate device in this section.

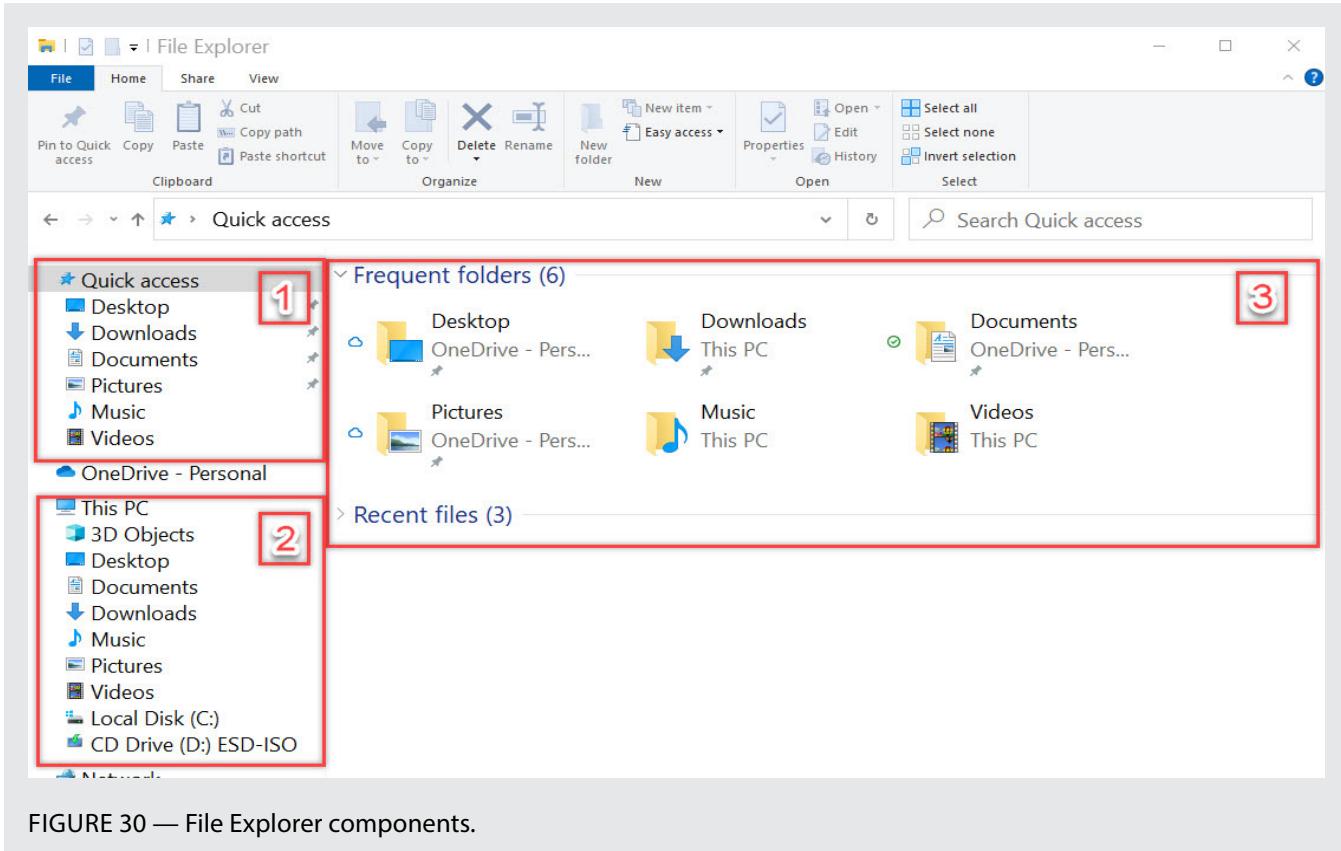


FIGURE 30 — File Explorer components.

Device-Centric vs Storage-Centric Views in File Managers

While they do the same task, the Windows' File Explorer and the Mac's Finder have slightly different views of the computer. While File Explorer is storage-centric, Finder and all versions of Unix are device-centric. On Windows, each storage device gets a unique letter as a top-level identifier. By convention, the hard drive with the operating system gets the "C:" identifier. The next storage device gets "D:" and so on. If you connect your smartphone to your Windows PC, it may get the "P:" top-level identifier.

On Macs, the entire computer, with all attached storage devices, is seen as one top-level entity, identified by the "/" label. All attached storage is said to be mounted on the computer and are typically accessible under the "/mount" folder. Finder provides a friendly [user interface](#) to simplify locating these external storage devices.

File and Folder Properties

A file is the basic chunk of information available to computer users and applications.⁶⁸ A folder is a container for a group of files and other folders. Files and folders have several properties that allow users and applications to locate and use the correct files and folders.

Names

Perhaps the most important property of a file or folder is the name. All files and folders are identified by human readable names. File names should help you easily identify the contents of the file. This is like labeling a notebook to be able to tell what's in it. Before a file or folder can be created, it needs a name. To simplify the user experience, all applications have default methods to assign file names, even if the user does not provide one. For example, Microsoft's Office Suite uses the first few letters in the file to create the default file name. Image programs assign default file names such as "Untitled.png." As you can see, while these file names allow the files to be created, they are not very useful to find the file later. For this reason, one best practice in computer use is to develop a file naming convention and to use it consistently.

For files that only you are likely to use, a simple convention of naming files by their title or purpose is sufficient. For example, "hamlet_shakespeare.pdf" would be a suitable name for a personal copy of the public domain version⁶⁹ of the famous play. "assn1_english_classx.docx" would be a suitable name for your first assignment in the English Class in grade X. If you are likely to have multiple copies of *Hamlet*, you may like to disambiguate the files by adding the source of these files, e.g., "hamlet_shakespeare_gutenberg.pdf" and "hamlet_shakespeare_w3.pdf." Remember, the goal of the file name is to help you quickly locate and identify the file years later, when the context is no longer fresh in your mind.⁷⁰

For files that are likely to be used by multiple users, it is useful to develop a convention that makes it easy for all users to quickly organize and locate the files. A simple convention can be to include the project name, group/subsection name, and the name of the author. For example, if your English teacher asks you to submit assignments, it will greatly help the teacher locate and grade the assignments if each student adopted a convention to include their own names as well as the name of the assignment in their submission. For example, "assn1_english_classx_johndoe.docx," "assn1_english_classx_janedoe.

68 According to Wikipedia, the word "file" to refer to a basic chunk of information on a computer comes from the earliest days of computers in the 1940s. Program instructions were written on punch cards and all cards associated with a program were carefully kept in a file. Similarly, the data associated with a program was also written on punch cards kept in a separate file. You can imagine computer operators using language such as "load the program from the file." This name has stuck. "Computer file," Wikipedia, https://en.wikipedia.org/wiki/Computer_file (accessed June 2023).

69 E.g., William Shakespeare, *Hamlet*, Prince of Denmark, Project Gutenberg, <https://www.gutenberg.org/ebooks/1524> (accessed June 2023).

70 You may have noticed that the examples use lower cases for all file names. This is a matter of personal preference. Many web servers are configured to be case sensitive and when files are to be uploaded to the web, it is often easier to just type the file names in lower case. Since the authors frequently upload files to a case sensitive webserver, they use lower cases for simplicity. Develop and follow your own convention for file names.

docx" and so on. This naming convention will also help the teacher pull up the assignment a month later if a student had a question about their grade.⁷¹

The file name should not be too long and should avoid characters that have special meanings for the operating system. These are called reserved characters. Long file names can be difficult to read in file managers. Consider separating different sections of the file name with an underscore to make it easy to read, as we have done in the examples.

Since your file could be read by users in different operating systems, each with its own set of special characters,⁷² it is generally best to stick to letters, numbers, and underscores (_) in file names. The special characters you should avoid in file names include the following:⁷³

- < (less than);
- > (greater than);
- :
- :
- (colon);
- " (double quote);
- / (forward slash);
- \ (backslash);
- | (vertical bar or pipe);
- ? (question mark);
- * (asterisk).

We also recommend avoiding spaces in file names, e.g., "hamlet_shakespeare.pdf" is preferable to "hamlet shakespeare.pdf." While spaces are not fatal, web browsers often replace spaces with "%20"⁷⁴ and it is possible to miss the characters following a space if they get hidden by column separators in file managers. Spaces are just enough of a nuisance that avoiding them is usually a good idea.

Parts of File Names

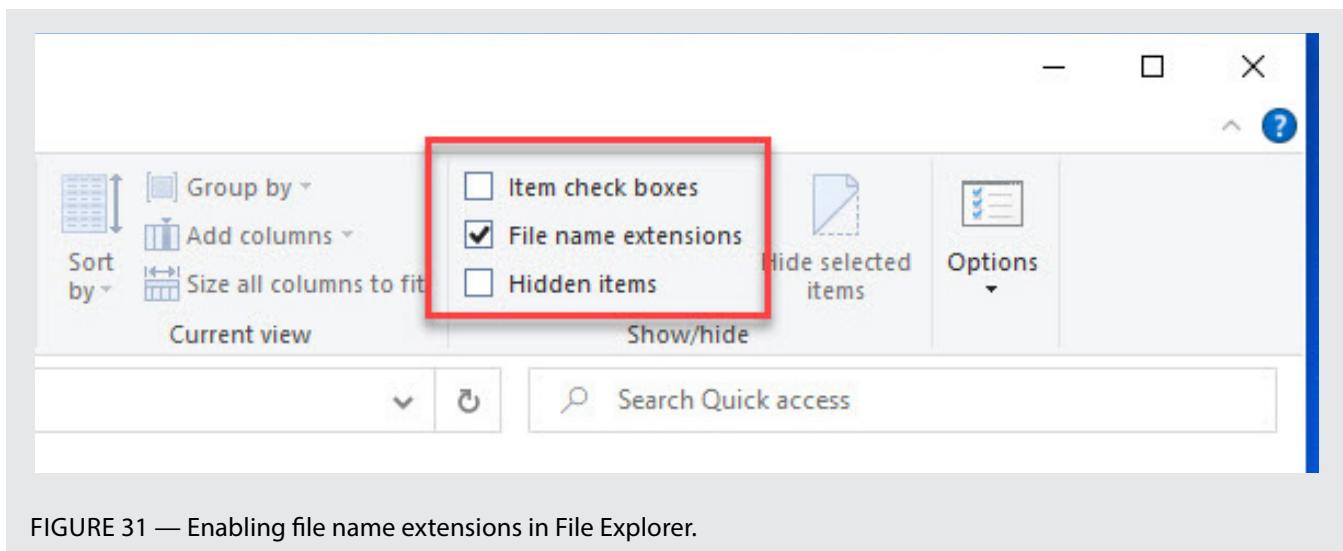
A file name has two parts. The actual name you chose for the file and a short name identifying the file type. The two parts are separated by a ". The short name is known as the extension. For example, in "hamlet_shakespeare.pdf," "hamlet_shakespeare" is the file name and "pdf" is the **file extension**.

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- 71 For more detailed examples, including the file naming conventions used at Disney, please see Jason Boone, "Speed Up Your Workflow with Good File Naming Practices," <https://blog.frame.io/2018/10/22/file-naming-conventions/> (accessed June 2023).
 - 72 The rules for Windows are in the article "Naming Files, Paths, and Namespaces," <https://learn.microsoft.com/en-us/windows/win32/fileio/naming-a-file> (accessed June 2023).
 - 73 "What characters are forbidden in Windows and Linux directory names?" <https://stackoverflow.com/questions/1976007/what-characters-are-forbidden-in-windows-and-linux-directory-names> (accessed June 2023).
 - 74 Learn more about this here: "%20 in URL—What Does it Mean? [Answered]," <https://www.raymond.cc/blog/decoding-percent-with-numbers-encoding-in-urls/> (accessed June 2023).

The operating system uses the file extension to determine the application program required to open the file. This is called file associations and is used in all modern operating systems.⁷⁵ This use of the file extension is like peeking inside your kitchen pantry and being able to distinguish a box of Cheerios from Rice Krispies without opening all cereal boxes. For example, your computer will typically use Microsoft Word to open a word document by looking at the “.doc” or “.docx” extension. Similarly, your computer can recognize an image file by the “jpg,” “png,” “gif,” or other extensions that identify them as images and display the file using a program that can handle images.

For user convenience, file managers typically hide file extensions. However, it is useful to see them if you prefer to have greater control over your files. If you don’t see file name extensions when you view files in File Explorer, do the following:

- 1) Open File Explorer
- 2) Under “View,” select the “File name extensions” check box as shown in Figure 31.



The cover should tell you what’s inside.

⁷⁵ A good article on file associations is Tim Fisher’s “How to Change File Associations in Windows,” <https://www.lifewire.com/how-to-change-file-associations-in-windows-2624477> (accessed June 2023).

Extension	File type
aac, adt, adts, cda, m4a, mp3, wav	Audio Files
mdb, accdb	Microsoft Access Database File (before and after Access 2007)
bmp, gif, jpg, jpeg, png	Image Files
csv	Comma-separated File
doc, docx	Microsoft Word Document
exe	Executable Program File
htm, html	Hypertext Markup Language File
jar	Java Architecture File
mov, mp4, mpeg, wmv	Video Files
pdf	Portable Document Format File
ppt, ptx	Microsoft PowerPoint Format (before/after PowerPoint 2007)
tmp	Temporary Data File
txt	Unformatted Text File
xls, xlsx	Microsoft Excel Workbooks (Before and after Excel 2007)
zip	Compressed File

This table shows a list of common file name extensions and the associated file formats.

File Extensions and File Associations

While file extensions simplify the identification of the right program to open a file, they are not required to open a file with the correct associated program. For example, you can rename a Word document and remove the “.docx” file extension. Double clicking the file will no longer automatically start Word and open the file in it. However, if you open Word and select the file, it will open just fine. File extensions are just a convenient shortcut to help the operating system select the right application.

Locating Files

File managers also help you locate, move, delete, or open files easily. Both Microsoft’s File Explorer and Apple’s Finder show file names, folder structures, disk drives, and frequently accessed files and folders. Imagine if you spent hours working on a file but have no idea where you put it. Worse, say you don’t even remember the name of the file. Before you give up and begin to redo your work, you should try these two main techniques to locate files on a computer: navigation and search.

Navigation

Navigating to the correct folder to find a file will not be difficult if you have a systematic way of naming folders and subfolders. As discussed earlier, the folder structure is akin to having a process to store things in your house to easily locate what you want. Ideally, to find spoons and forks quickly, you should have a space for “spoons and forks” and remember to store all your spoons and forks in the space.

In short, navigation relies on labeling folders (storage areas) correctly and placing files in the correct folders. A few minutes invested in developing a naming convention you want for your files and folders can save hours of lost and wasted time and energy.

File Paths

In the computer world, finding a file relies heavily on the address of the file. The address, aka (also known as) path, is the location where a file is stored relative to the top level of storage on the computer. As you navigate from one folder to another in File Explorer, you can see the current address in the address bar at the top of the file manager (highlighted as a blue rectangle in [Figure 32](#)). In the address bar, you can see the path taken to get to the downloads folder is This PC → Local Disk (C:) → Users → Public → Public Downloads.

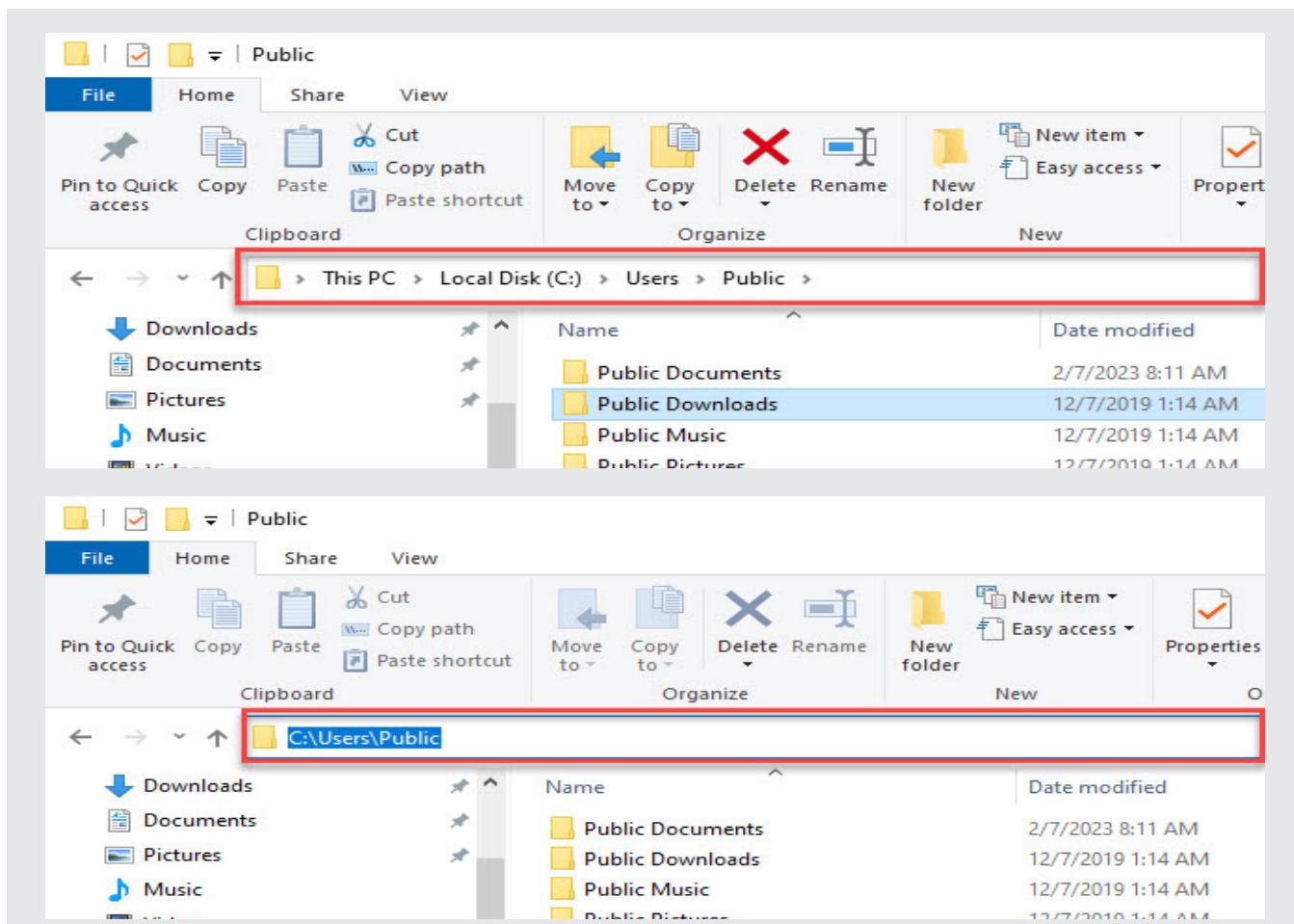


FIGURE 32 — [File paths](#) displayed graphically (top) and as text (bottom).

The path of the above folder is written as C:\Users\Administrators\Downloads. The backslash is a separator that represents a “contains” relationship. In this example, the C Drive (C:) contains a folder called Users, which in turn contains Administrator, which contains Downloads.

Search

If you cannot find a file by navigation, file managers also support search operations. The powerful search feature will look through all the accessible storage media, both internal and external, to find the file.

- 1) Enter the name of the file in the search box (see [Figure 33](#)).
- 2) Press “Enter” on your keyboard to begin searching.

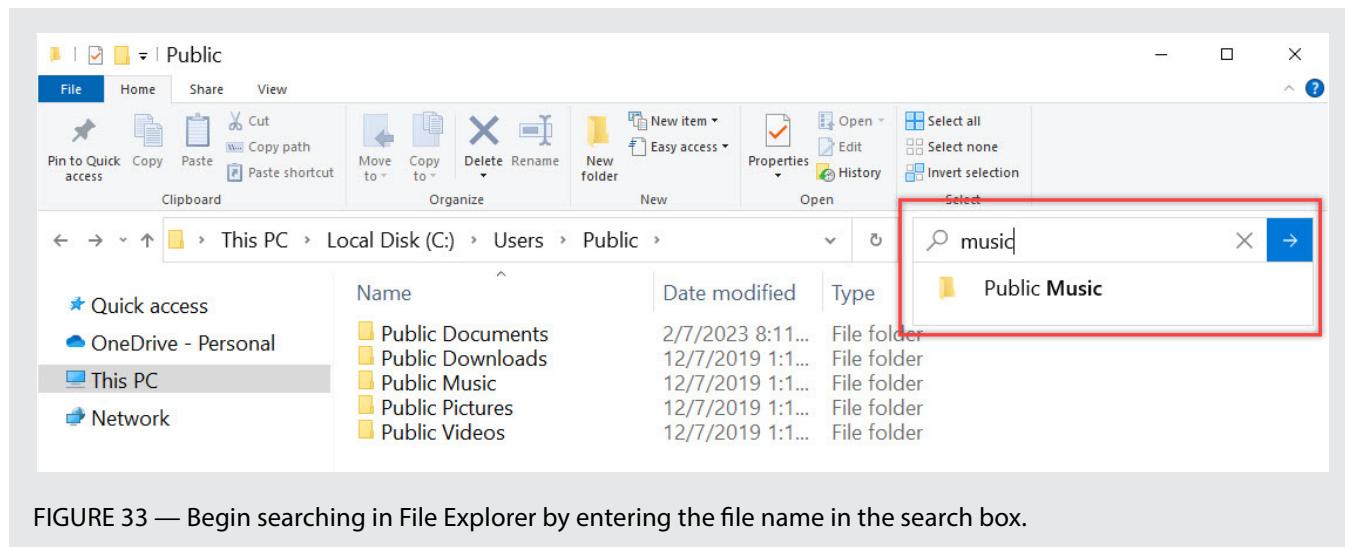


FIGURE 33 — Begin searching in File Explorer by entering the file name in the search box.

You can also specify a search criterion to narrow down the search and find the file more quickly. Just as you can find a favorite lost pen more easily if you know where you last used it, you can tell the computer where the file might be located to make it easier to find. For example, if you know that your file is in the Documents folder, you should select the Documents folder, but not any of the subfolders, to have the best chance of finding the file. File Explorer has a “search ribbon” (highlighted in [Figure 34](#)) with many options to narrow your search criteria.

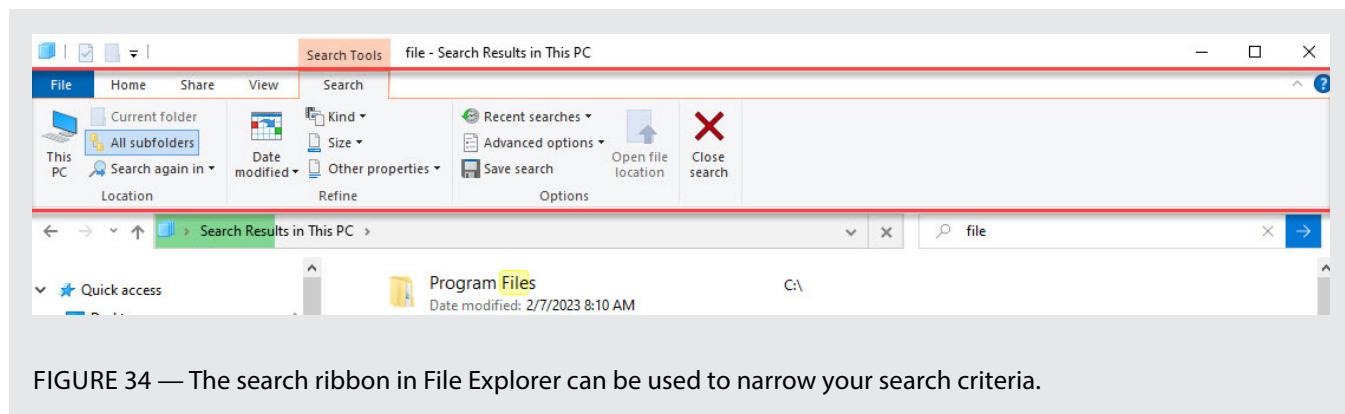


FIGURE 34 — The search ribbon in File Explorer can be used to narrow your search criteria.

Narrow searches are faster because they filter out more options. It is, therefore, better to specify as much of the file name and extension as possible, if you happen to remember it.

If you have an estimate of when you last worked on the file, you can search for files by their modification dates. To do this, click on “Date Modified” to specify a date range of when you think you last modified the file (see [Figure 35](#)).

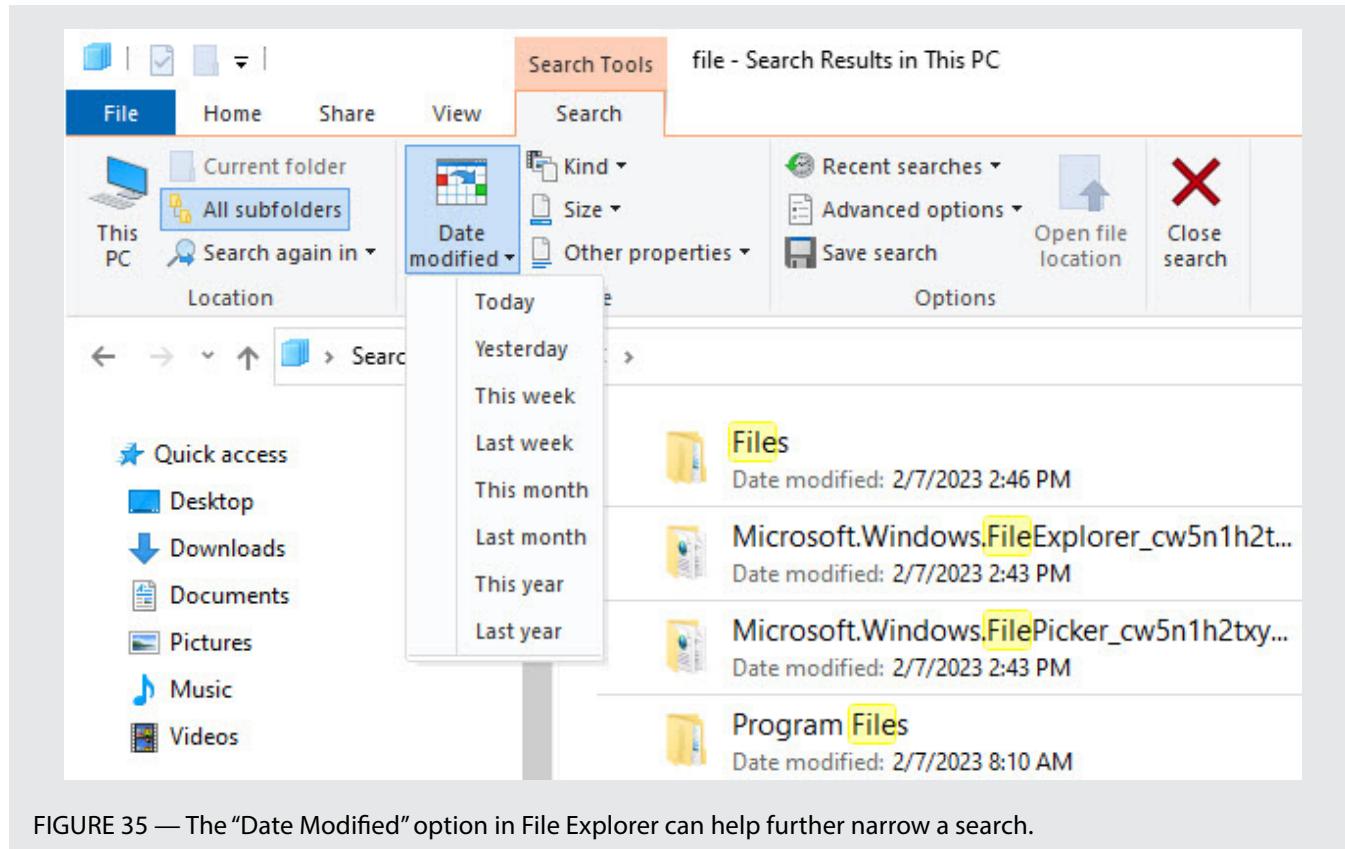


FIGURE 35 — The “Date Modified” option in File Explorer can help further narrow a search.

If you know the type of file you are looking for, you can limit your search to files of that type. To do so, click on “Kind” and specify the type of file you are looking for (see [Figure 36](#)).

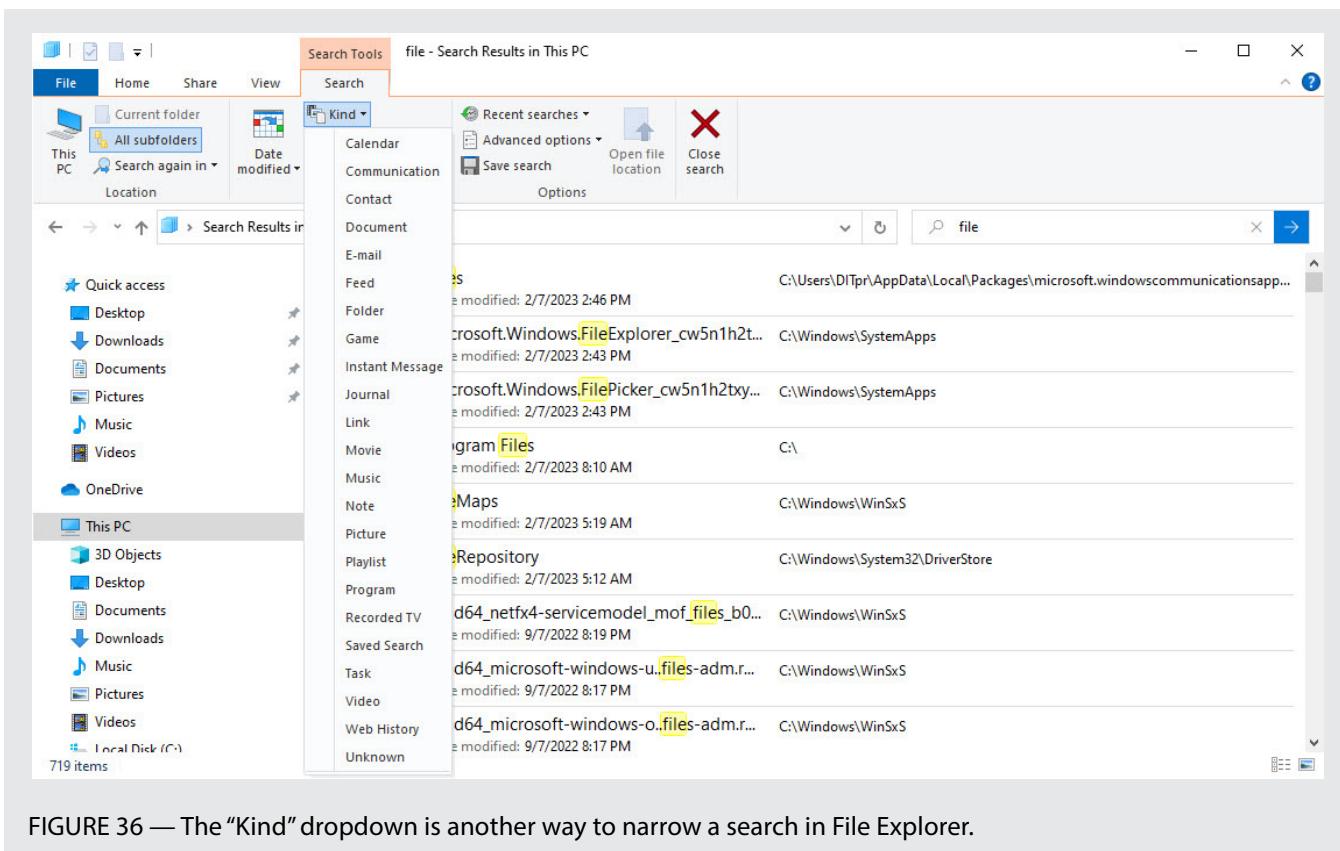


FIGURE 36 — The “Kind” dropdown is another way to narrow a search in File Explorer.

You can also specify the “Size” of the file to further narrow the search criteria (see Figure 37).

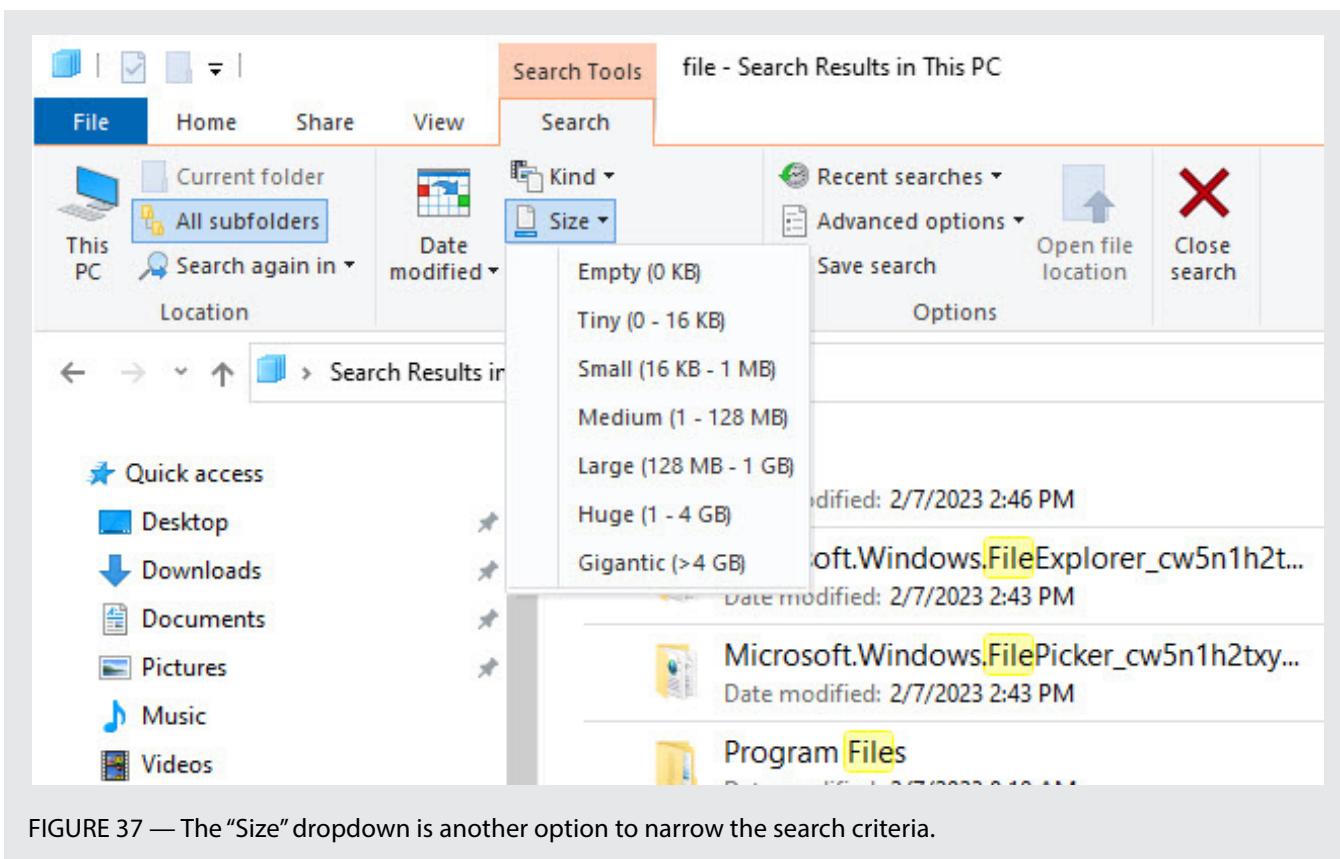


FIGURE 37 — The “Size” dropdown is another option to narrow the search criteria.

Check your results to find your file (see [Figure 38](#)). If you do not see your file, you should change the search criteria. You may be searching for the file in the wrong folder, or you may not have the correct file name. If you are not sure about the file name, specify only the part you remember. Also, you may want to specify a generic folder name (a level or two above in the folder hierarchy) to avoid missing the file. This will slow the search considerably but increase the likelihood of finding the file.

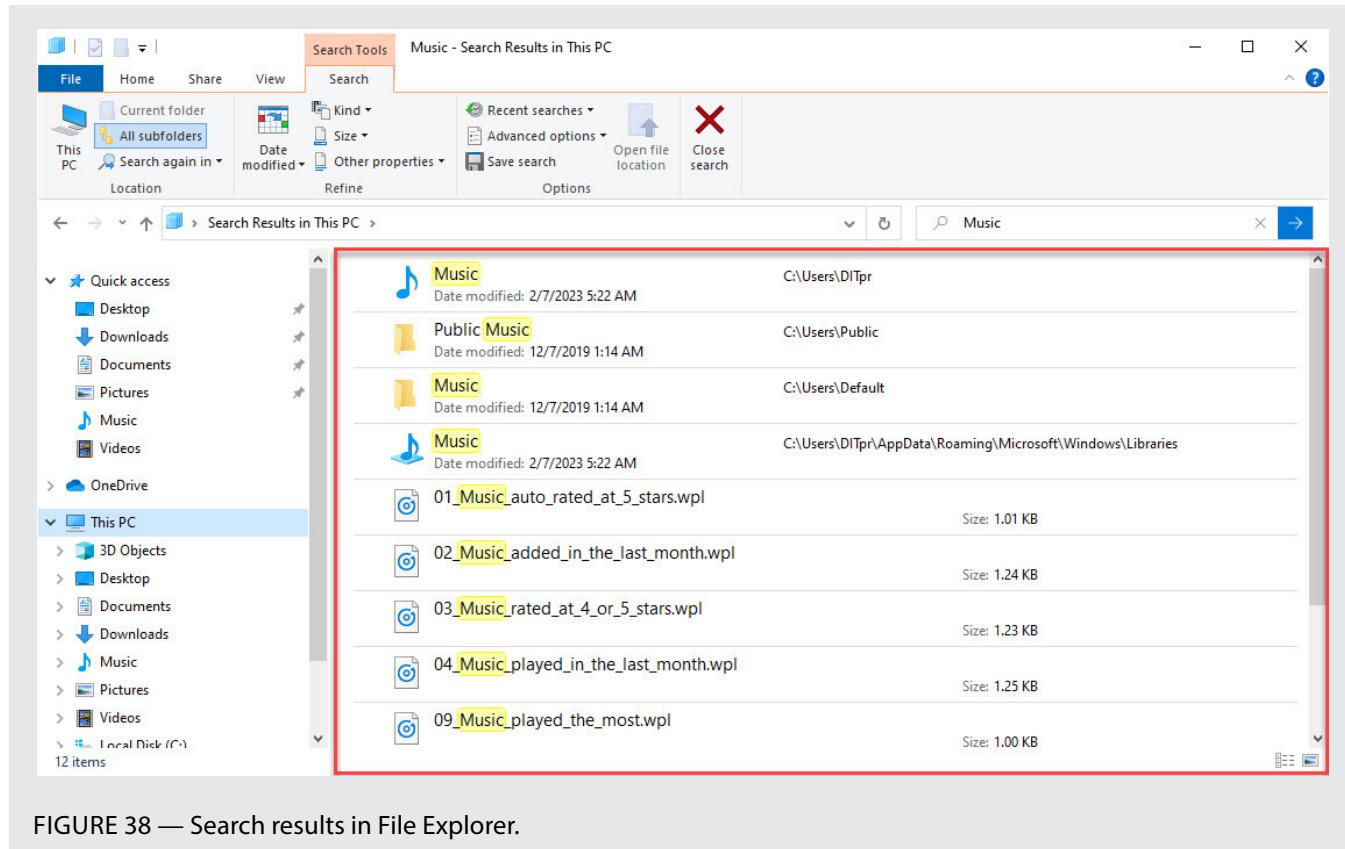


FIGURE 38 — Search results in File Explorer.

System Generated Folders

For end-user convenience, operating systems create default locations to store files. All computers using the same operating system will use these default locations. It is, therefore, very useful to be aware of some of the common locations where the operating system (e.g., Microsoft Windows) stores files of each type.

Location	Type of Content
Users	This top-level folder contains folders for all users with accounts on the computer. Each of these user-specific folders is called the home folder for the user and is named after the user's ID. Files associated with a user are placed within the user's home folder by default.

Location	Type of Content
Desktop	The default screen you see when you boot your computer. All the files you see on the default screen can be found in the folder called "Desktop." The desktop view adopts the metaphor of a physical desktop to visually display files of interest. This is a sub-folder within the user's home folder.
Downloads	Any time you download files from the Internet (e.g., using a browser or from an email), they get stored in the Downloads folder. This is also a sub-folder within the user's home folder.
Pictures	Default location for images you create or photos you upload to your computer. This is also a sub-folder within the user's home folder.
This PC	This is the top level of storage in File Explorer. Every folder/disk drive/storage media on your computer is contained in This PC.
C; D; E:	Every storage media recognized by your computer is given a letter name. For example, the internal disk drive that has your OS is C drive (represented by C:). When you plug an external USB drive, it might show up as a D drive (represented by D:)
Dropbox, Box, Google Drive	Cloud storage systems like Dropbox create their own folder within the user's home folder. You can access your cloud files in this folder. If you make any changes to files in this folder, these changes will get synchronized on cloud storage. More on cloud-based file management later in this chapter.
Desktop/Recycle Bin	All the files you delete are temporarily stored in the Recycle Bin on your Desktop. If you accidentally delete any file on your computer, you can always go to your Desktop, open the Recycle Bin folder, and restore the previously deleted file. To clean your computer to have more space, you can permanently delete files in the Recycle Bin.
Program Files	All the programs you install on your computer (Microsoft Office, Word, Excel, Chrome browser, etc.) are stored in the Program Files folder.
Program Data	If a program needs to store data on your computer, the data will be in C:/Program Data. For example, if you are using a database software, typically the software will be in C:/Program Files/<Database Vendor>/<Software Name>, and the actual data will be in C:/Program Data/<Database Vendor>/<Data>.

File Operations

Renaming Files and Folders

All file managers (e.g., File Explorer, Finder) make it easy to rename files and folders. There are multiple ways to rename a file using File Explorer:

- 1) Select the file you want to rename by clicking on it (single click). Then click the “Rename” button in the Home ribbon at the top. A text box will open for the new name.
- 2) Alternately, after selecting any file in File Explorer, right-clicking on the file name with your mouse will open a context-menu that gives you options to “Cut,” “Copy,” “Delete,” and “Rename.” (See [Figure 39](#) and [Figure 40](#).)

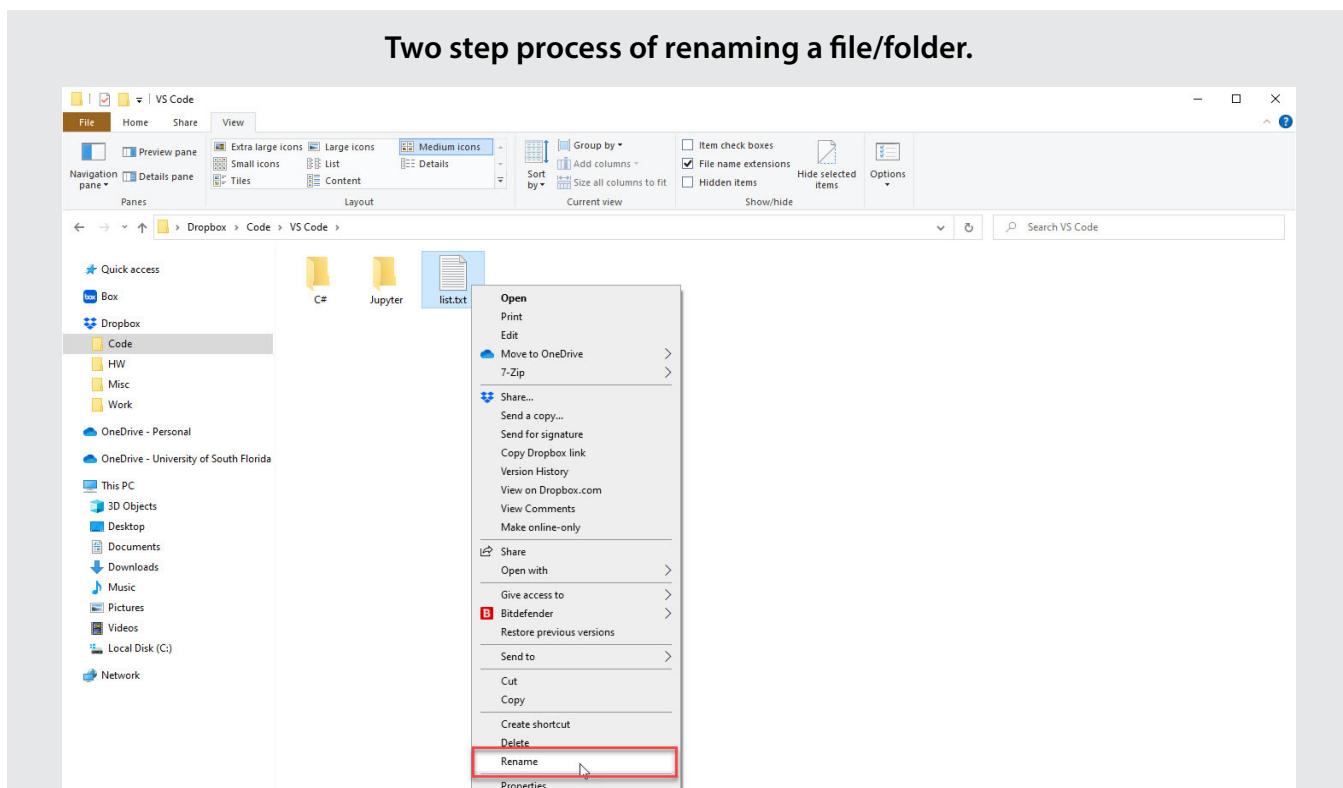


FIGURE 39 — First step—Right-click on the file/folder.

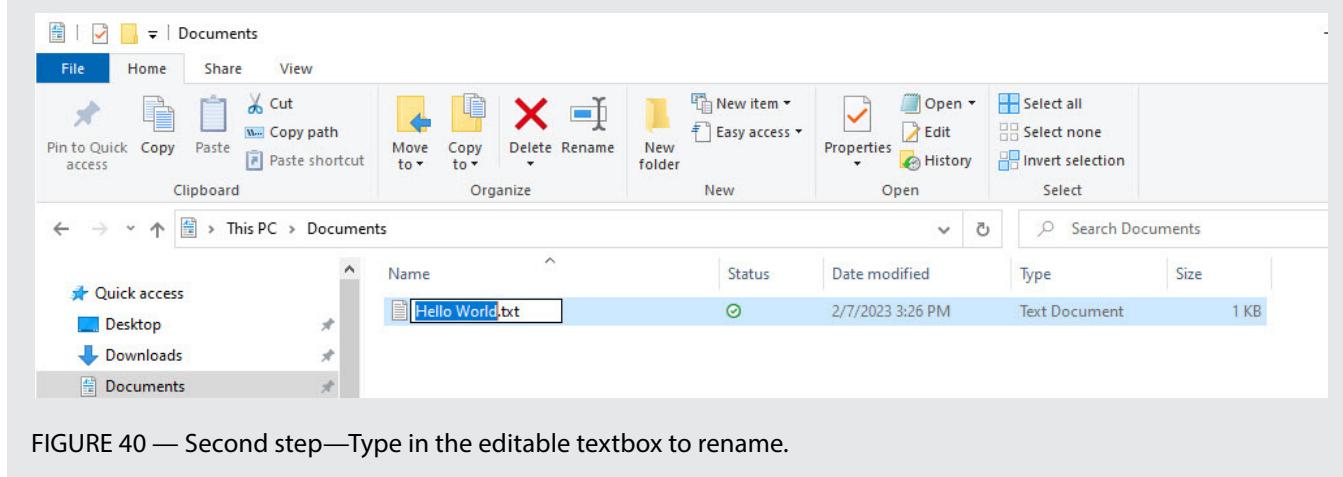


FIGURE 40 — Second step—Type in the editable textbox to rename.

Use the same file-renaming technique to rename folders. Select a folder by clicking on it in File Explorer, then right-click your mouse to open the context menu that offers options to manipulate the folder.

Most application programs also give you menu options to rename files. You can save a copy of a file under a different name if you select “Save As” or “Save a Copy” under the “File” menu option (see [Figure 41](#)).

Copying Files

By copying a file, you create a duplicate. Copying is useful in many situations. For example, you may want to make a copy and start working on it to preserve the original file. You may also like to copy files to a backup storage device. There are several ways to copy files. Some of the most common ways are presented here.

If you are working on a file in an application program, using the “Save As” option under the “File” menu allows you to save the file using a new name in the current location or anywhere else in the computer’s file system ([Figure 41](#)).

You can also use the “Copy” and “Paste” features of your file manager to copy a file and paste it in any location. In File Explorer, navigate to the file location, identify the file you want to copy, select it, then right-click for the context menu, and choose “Copy” ([Figure 42](#)).

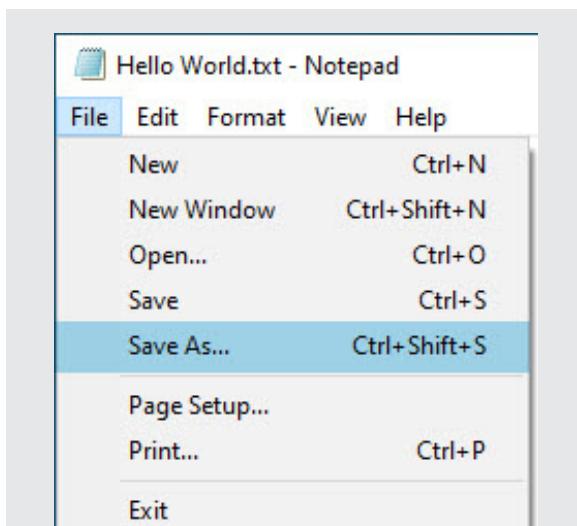


FIGURE 41 — Select “Save As” to save with a new name.

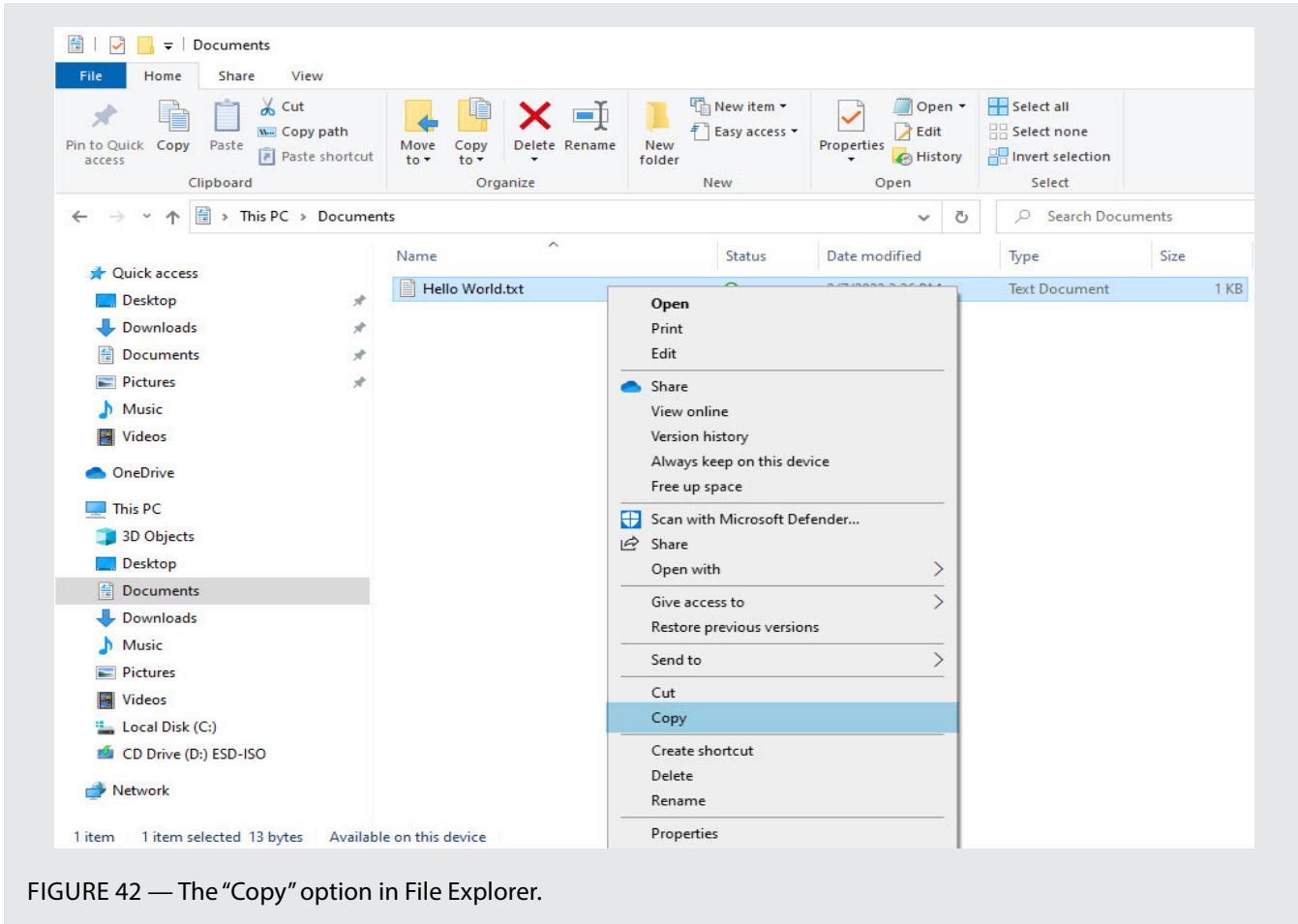


FIGURE 42 — The “Copy” option in File Explorer.

Once you copy a file, it is in the computer’s memory. You can then tell the computer what to do with it. To paste it in any location, navigate to the correct folder in File Explorer, click anywhere in the white space of the folder, right-click to open the context menu, and choose “Paste” (Figure 43).

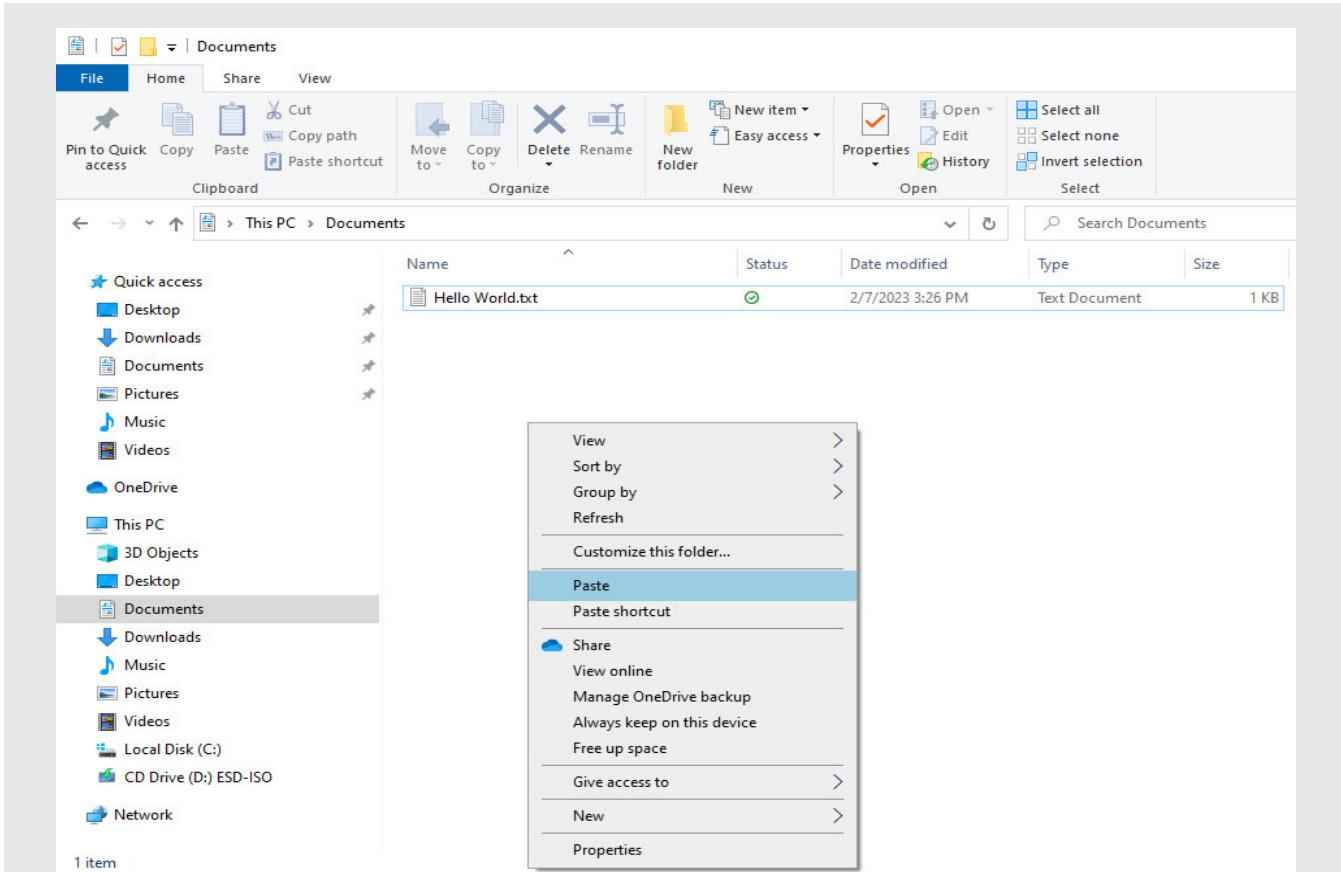


FIGURE 43 — If a file is in memory, right-clicking in the white space in a folder will open the context-menu option to paste.

Copying files to memory is not limited to one file. You can also copy a folder containing many files and paste it in any location. You can also [copy](#) and [paste](#) multiple files. To select files to copy, just press the “Ctrl” button on your keyboard as you click on the files you want to copy. Then right-click on any selected file to bring up the context menu and select “Copy.” The OS will now have the collection of all selected files in its memory. Right-clicking on an empty space in a folder will bring up the context menu for this folder and selecting “Paste” will paste these selected files into the target folder.

Keep in mind, copying is an overwrite operation. Every time you copy something to memory, it erases the previously copied content in memory. Only the last “Copy” (a file, a folder, or a collection of files) is in memory during the copy and paste process. After copying File A, if you decide to click on File B and choose “Copy,” then the computer has File B in its memory. If you paste, you will paste File B.

Moving Files

Moving a file transfers the original file to a new location. Whereas the copy and paste operation creates multiple copies of a file, moving files transfers the original file to a new location. Multiple copies are not created. Moving files is useful in many situations, including reorganizing files, or transferring from a computer’s hard disk to a cloud storage folder. File managers support multiple mechanisms to move files.

Rhyming with “copy and paste” is the “[cut and paste](#)” operation to move file. The process to cut and paste is the same as the copy and paste operation. Locate the file you want to move, right-click on your file to bring up the context menu and choose the “Cut” option. Once you choose the “Cut” option, the file is in the memory of the computer and has been marked for deletion from the original location. Navigate to the new folder and click anywhere in the white space of the folder. Then right-click on your mouse to bring the context menu and choose the “Paste” option to transfer the file to the new folder. The file will also be deleted from the old location.

The cut and paste technique works with folders as well as files. Just like with the copy and paste operation, you can move a group of files and/or folders by first selecting multiple files by pressing “Control” (“Ctrl”) and clicking on each file you want to move. Once highlighted you would use the cut and paste process to move all the files and/or folders to a new location.

You can also use a [drag and drop](#) operation to move files and folders. To drag and drop easily, open two File Explorer windows and set them up side-by-side. To do that, open a File Explorer window. Then open a second File Explorer window by choosing the “Open new window” option under the “File” menu ([Figure 44](#)). You can resize the two File Explorer windows, if needed, so they are both visible on your computer. This can be done by clicking in the corner or on the edge of the window and dragging it so it becomes larger or smaller as needed. In one window, open the source folder that contains the files you want to move and in the other open the target folder where you want to move the files.

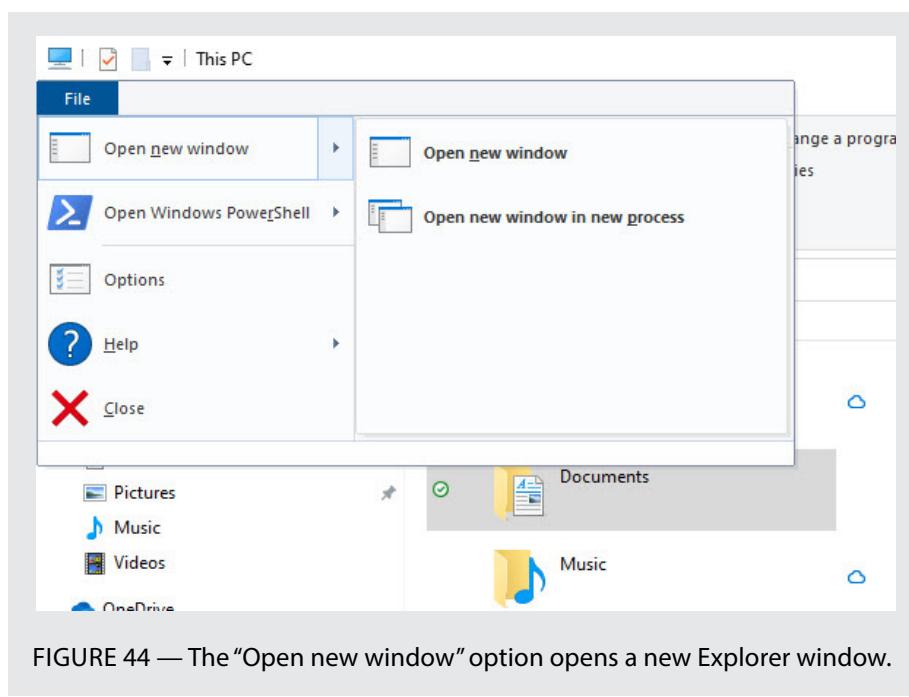


FIGURE 44 — The “Open new window” option opens a new Explorer window.

Once you select the files you want to move by clicking on them in the first File Explorer window, hold the left mouse button and drag the files to the desired folder in the second File Explorer window. You will see the files being removed from the source window and being added to the target window.

Using the Drag Operation to Copy and Paste

A variant of the cut and paste drag operation allows you to “copy and paste.” To copy and paste files using the drag and drop option, hold the “Ctrl” key along with the left mouse button. This use of the “Ctrl” key to switch between the copy and cut operations is a common use of the “Ctrl” key.

Deleting Files

It is good practice to delete files regularly to save space, reduce clutter, and make it easier to find what you are looking for. One common reason to delete files is to get rid of redundant copies of photos or videos. Purging unnecessary media files not only saves a lot of space, but also makes it easier to find interesting pictures. If you are worried about losing important information, you can create a suitably named folder such as “Unwanted Files” and then organize all unnecessary files in easily identifiable subfolders within it.

To delete a file, click on the file in the file manager, right-click your mouse on the file to bring up the context menu, and choose the “Delete” option. Another way to delete a file or a collection of files is to first select them in the file manager, then click the “Home” tab on the File Explorer ribbon. Clicking on the “Delete” option will delete all the selected files (see [Figure 45](#)).

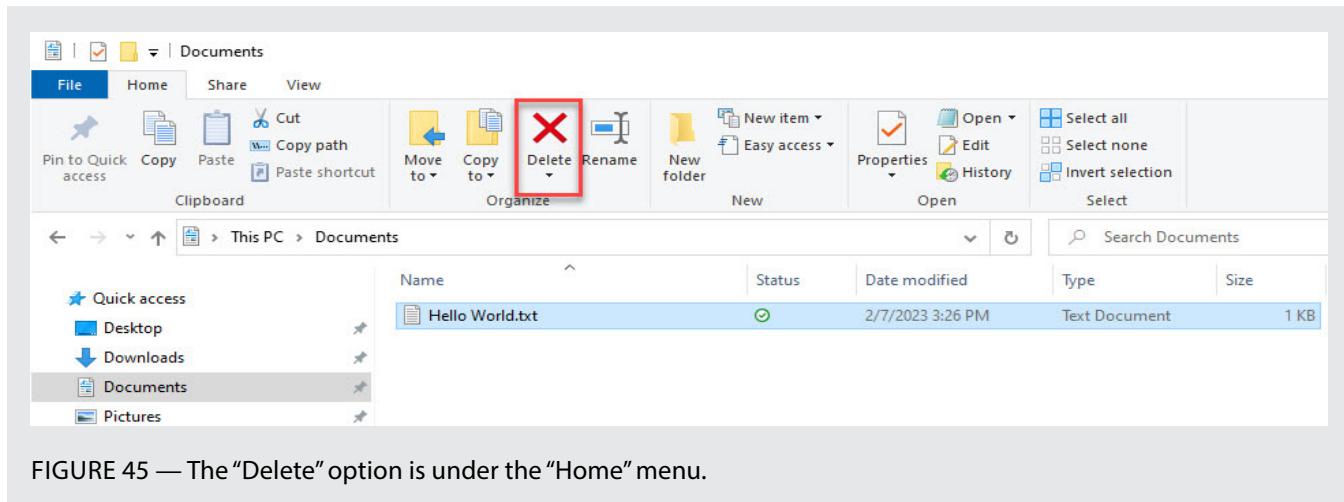
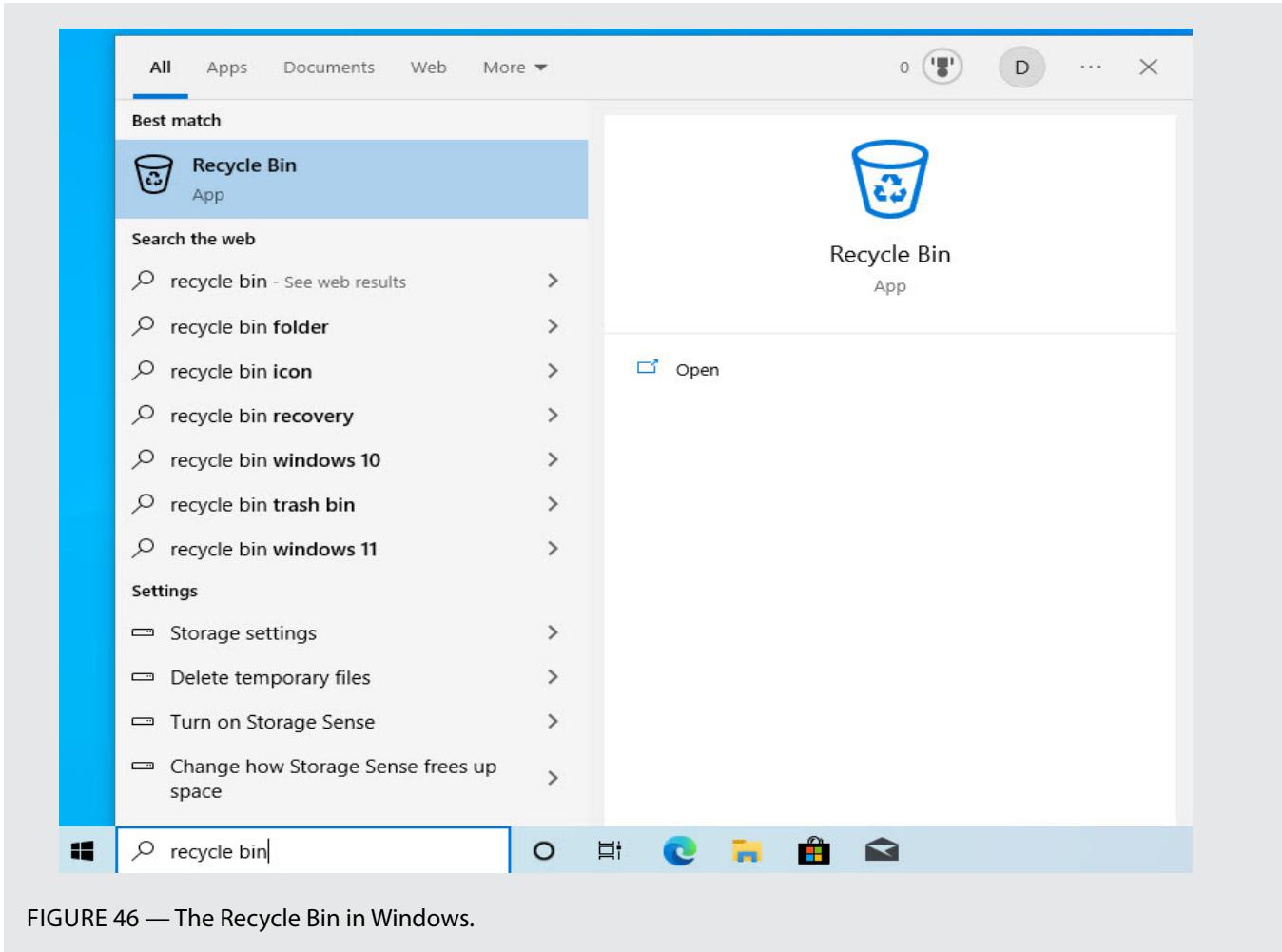


FIGURE 45 — The “Delete” option is under the “Home” menu.

Restoring Files

If you accidentally delete a file and want to get it back, the operating system offers a neat trick to save your day. When you delete a file, it is flagged as deleted, no longer visible to you in the file manager, and gets moved to [Recycle Bin](#) in Windows and [Trash](#) on Macs. The Recycle Bin, like Trash, is a giant trash can that holds all your deleted files. In Windows systems, you can find the Recycle Bin on your Desktop. You can also click the Windows Start icon and type “Recycle Bin” (see [Figure 46](#)).



If you have many deleted files in the Recycle Bin, you can use the column headers to click and sort. You can sort by "Name," "Location," "Date Deleted," and "Size," or use the search box to find files by name. Right-click on any file to get the context menu to view file properties, restore, or permanently delete the file.

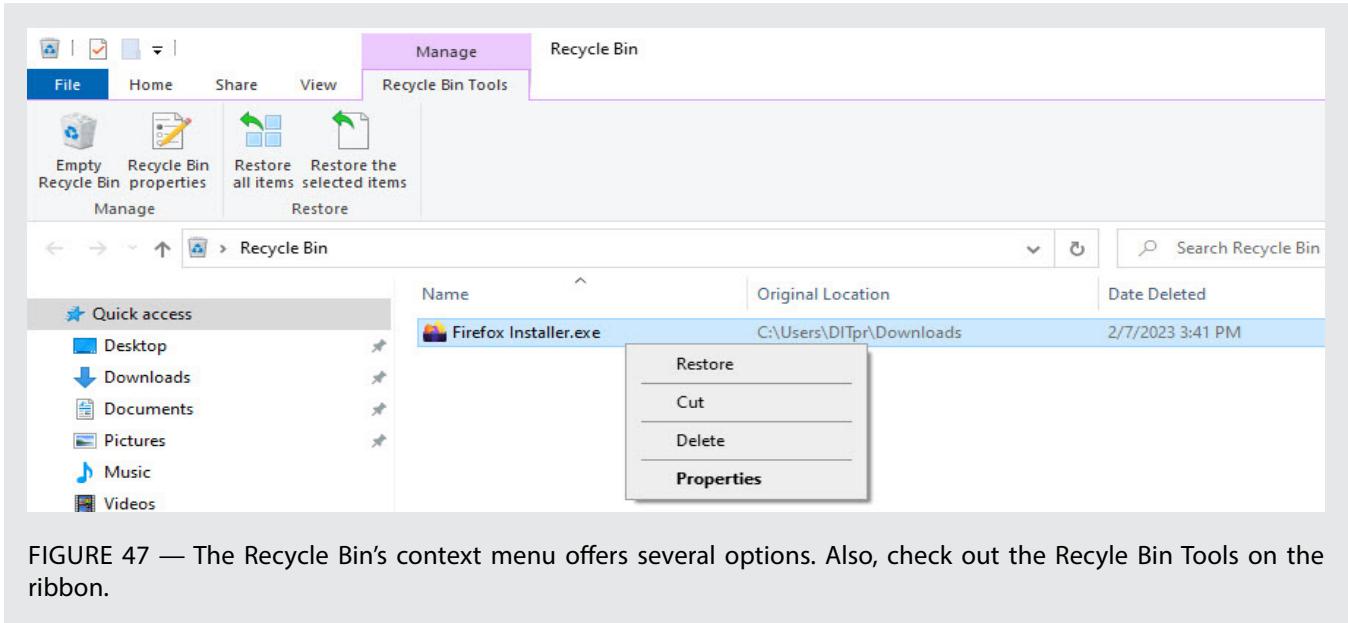


FIGURE 47 — The Recycle Bin's context menu offers several options. Also, check out the Recycle Bin Tools on the ribbon.

On the ribbon under the “Recycle Bin Tools” menu, you have the option to completely empty the bin or restore all or selected items (see [Figure 47](#)).

You should consider emptying your recycling bin periodically. Right-clicking on Recycle Bin on Windows or Trash on Mac and selecting “Empty” permanently gets rid of all the deleted files from the computer.

File Compression and Decompression

File compression is the process of rewriting a file to a smaller size. File compression is very useful in many situations. Imagine if it takes an hour to download a music file over the Internet; you desperately need to send an email that has a huge attachment; or it takes forever to copy a large file to a USB stick—file compression is the common solution to all these problems. When a compressed file is to be read, **decompression** utilities can restore the contents of the file.

File managers include utilities to compress and decompress files. Compression works not only for files, but also for folders. When a folder is decompressed after transfer, the entire folder structure along with the contents are regenerated just the way the files were at the time of compression.

To compress a file or folder in File Explorer, select the file or folder, then right-click to bring up the context menu. Choose “Send to” and then “Compressed (zipped) folder” ([Figure 48](#)). This will apply the file compression algorithm and create a significantly smaller file. A new compressed file called My_Important_files.zip is created without impacting the original folder in any way. To restore the original contents from the compressed file, just select the zipped file and right-click to bring the context menu. Choose “Extract All” to decompress the folder and rebuild the file structure.

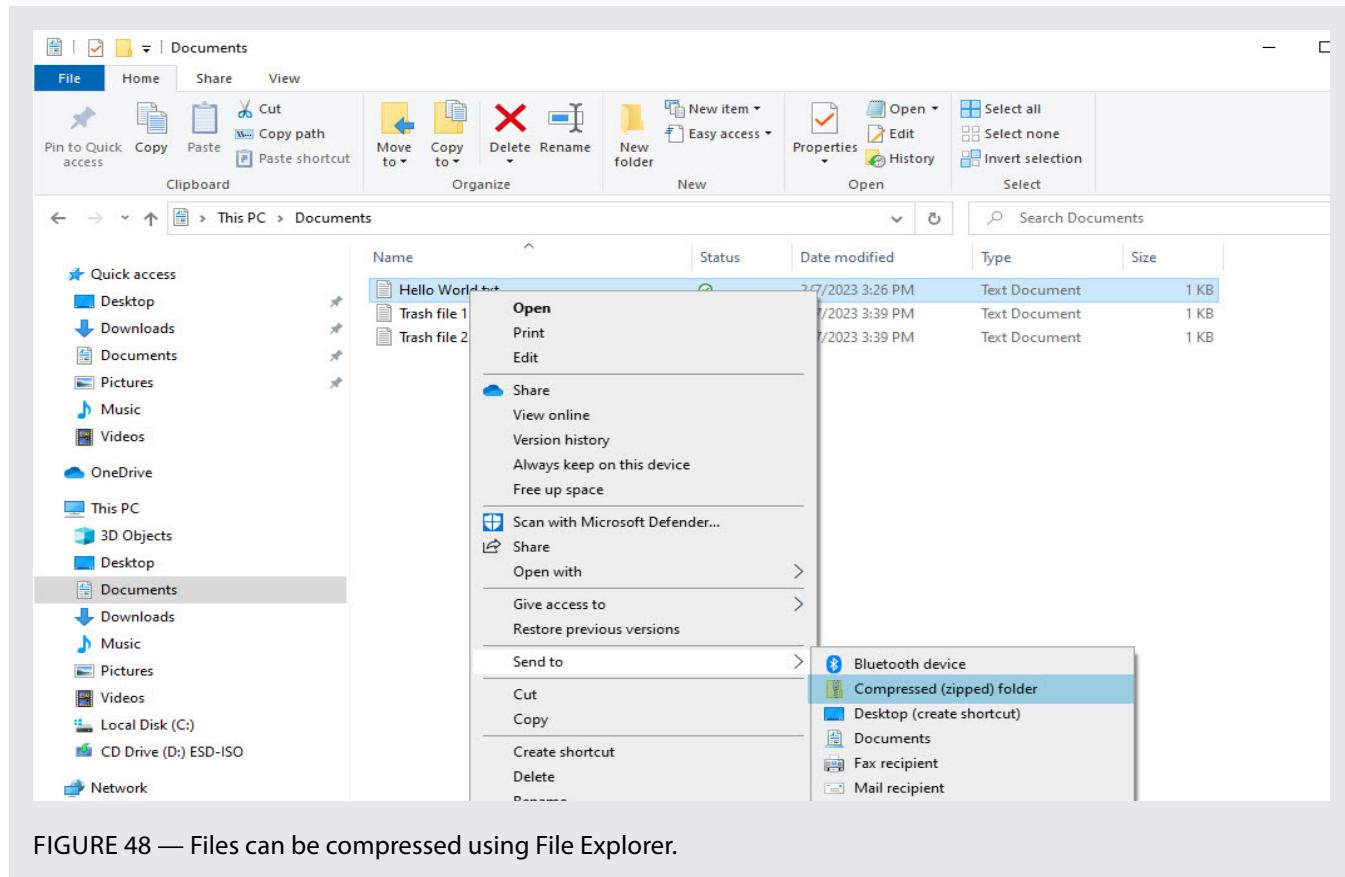


FIGURE 48 — Files can be compressed using File Explorer.

The extent of compression is called compression ratio. The compression ratio depends upon the algorithm used, the data type,⁷⁶ and the type of file. Typically, media files (e.g., video, audio, images) can be compressed to a greater extent than text files such as Word and Excel files containing characters and numbers.

Lossy vs Lossless Compression

There are two general approaches to data compression—lossy and lossless. Lossy compression algorithms can remove some data from the original file to reduce its size. The original data cannot be recreated by decompressing a file compressed using a lossy algorithm. Lossless compression preserves all the original data in the file and all the original data can be recovered upon decompression. The zip compression algorithm we have discussed in this chapter is a lossless compression algorithm. Compression algorithms used in business typically need to be lossless.

Lossy compression algorithms can typically achieve very high levels of compression. Lossy compression is typically used in media files by removing features in audio, video, and images that are less noticeable to our senses. Almost all the media you consume, including Netflix, Spotify, Apple Music etc. use lossy compression though this is not noticeable because our eyes and ears do not notice any difference. Lossy compression is also used to transmit data to your Bluetooth earbuds. So, if you subscribe to a lossless audio service, you will need to get special headphones that do not compress audio in its journey from the device to the earpiece.

File Backup

File backup, or data backup, is the process of creating and storing a copy of data in such a way that the copy may be used to restore the original in case of data loss. At the end of the day, your computer is an appliance, just like your dishwasher or a refrigerator. You must always consider the possibility of losing all the critical files on your computer at any time. While the computer may run for years at end, it may refuse to start on any given day, without any notice.

Data on computers can become inaccessible for various reasons. A computer has moving parts, like fans, power supplies, disk drives, and accessories like cameras, microphones, speakers, and printers. These parts can fail from mechanical shocks or the heat generated by the processor.

What is the solution to protecting critical data files on your computer? The common procedure is to periodically copy critical files and folders into a USB stick or an external drive that can be reconnected to a new computer when the old one dies. However, this manual process of copying into external storage may not work well if you have hundreds of files. It also requires considerable discipline to do

⁷⁶ A good comparison of several compression algorithms is at “Comparison of Brotli, Deflate, Zopfli, LZMA, LZHAM and Bzip2 Compression Algorithms,” <https://cran.r-project.org/web/packages/brotli/vignettes/brotli-2015-09-22.pdf> (accessed June 2023).

manual backup on a regular basis. Cloud storage, covered in the [next section](#) is potentially a great alternate solution to protecting critical data.

Industrial Backups

Data backups in the industrial environment can get very complicated very fast. When your computers are serving large numbers of customers, not only do you have to worry about these computer devices failing, but you also must also worry about power supplies to these devices, as well as the connectivity of these devices to the Internet. For this reason, TV broadcasters have developed a complicated solution. They maintain battery backups, which are backed up by redundant generators that are supplied by diesel fuel sources from multiple vendors. The broadcasters also maintain multiple connections to the Internet, deliberately choosing providers with non-overlapping connections to the Internet. By taking these precautions, a natural disaster such as a hurricane does not bring the station down.

Cloud-Based File Management

Cloud-based file management is the process of storing data with a service provider off-site while still being able to work with the data as if it were stored on the local computer. Cloud-based file management has many uses, including file safety, security, and convenience. Having files on your computer is problematic in many ways. There is no easy way to share a file on your computer with colleagues. Imagine sharing photo albums stored in your computer with family members spread across the globe. What if you and your friends wanted to work on the same file? Would you mail the document and wait for others to make their changes one by one? What if you needed to revert the file to an older version that was better in some respects? What if you wanted to see the incremental changes you made to a file in the past year?

The solution to all these problems is cloud-based file management. Recent solutions like Dropbox, Box, Google Drive, and OneDrive offer cloud-based file management services that are very convenient technically and economically. These services take care of backing up data, so users do not have to worry about device failures.

Dropbox is a popular cloud-based file management system. After you create an account at [dropbox.com](https://www.dropbox.com) and install the software on your computer, Dropbox will show up as a folder on your desktop (see [Figure 49](#)).

You can treat Dropbox like any other folder on your computer. Under the Dropbox folder, you can create folders, subfolders, and files. As you create or modify a file, a copy of the file is sent to

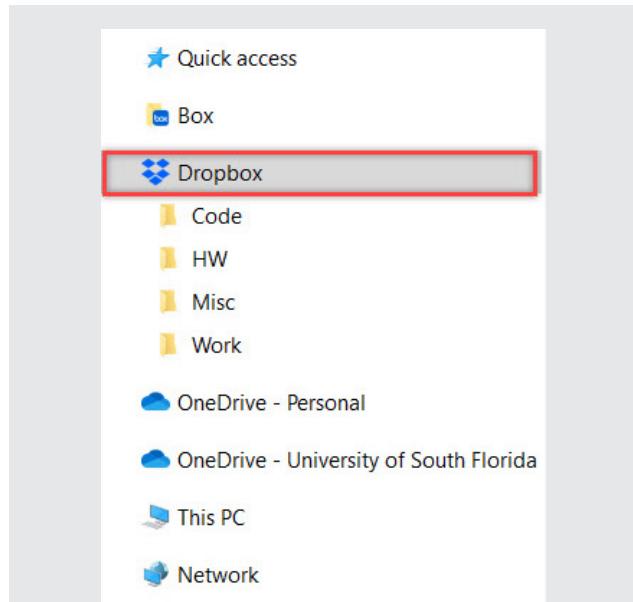
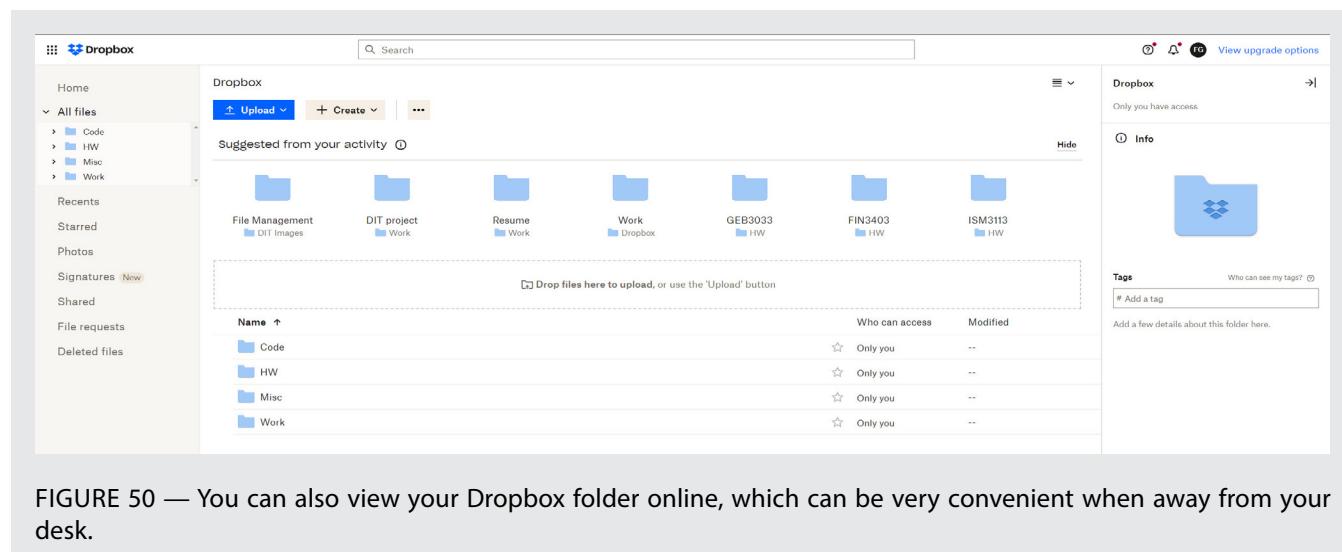


FIGURE 49 — Once an account is created, the Dropbox folder will appear in File Explorer.

the Dropbox servers in the cloud, where your file is backed-up magically without any effort on your behalf.⁷⁷

If you have multiple computers, you can install Dropbox on all the machines and connect them to the same Dropbox account. Any change you make to one computer's Dropbox folder appears on all other computers. Cloud-based file management has taken away the headache associated with saving and sharing files manually. You simply put all your critical files in a Dropbox folder, and they are there for all your friends on the Dropbox servers. If a computer dies and you buy a new computer, you only need to install Dropbox on the new computer and log in to the application with your Dropbox user-id and password. Within minutes, all your files will show up on the new computer in the Dropbox folder.

If you go on a vacation and forget to bring your computer, you can go to any computer at an Internet café, open a browser, go to www.dropbox.com, and login to access all your files (see [Figure 50](#)). Your online Dropbox account will show who has access to files. You can even look at the entire version history of any file, see what changes were made when, and revert to any older version.



The screenshot shows the Dropbox web interface. On the left, a sidebar lists 'Home', 'All files' (with subfolders 'Code', 'HW', 'Misc', 'Work'), 'Recents', 'Starred', 'Photos', 'Signatures', 'Shared', 'File requests', and 'Deleted files'. The main area displays a 'Dropbox' folder containing several subfolders: 'File Management' (DIT Images), 'DIT project' (Work), 'Resume' (Work), 'Work' (Dropbox), 'GEB3033' (HW), 'FIN3403' (HW), and 'ISM313' (HW). A central text box says 'Drop files here to upload, or use the "Upload" button'. Below this is a table showing file details:

Name	Who can access	Modified
Code	Only you	--
HW	Only you	--
Misc	Only you	--
Work	Only you	--

On the right, a panel titled 'Info' shows a blue folder icon and a 'Tags' section with a placeholder 'Add a tag'. At the top right, there are 'View upgrade options' and a user profile icon.

FIGURE 50 — You can also view your Dropbox folder online, which can be very convenient when away from your desk.

To share any file with others, right-click on the file to bring up the context menu and select "Share." (See [Figure 51](#).)

77 You may like to see the original video created by Drew Houston, the founder of DropBox, describing the service, "Dropbox Original MVP Video," https://www.youtube.com/watch?v=qxFfY7_Gqw (accessed June 2023).

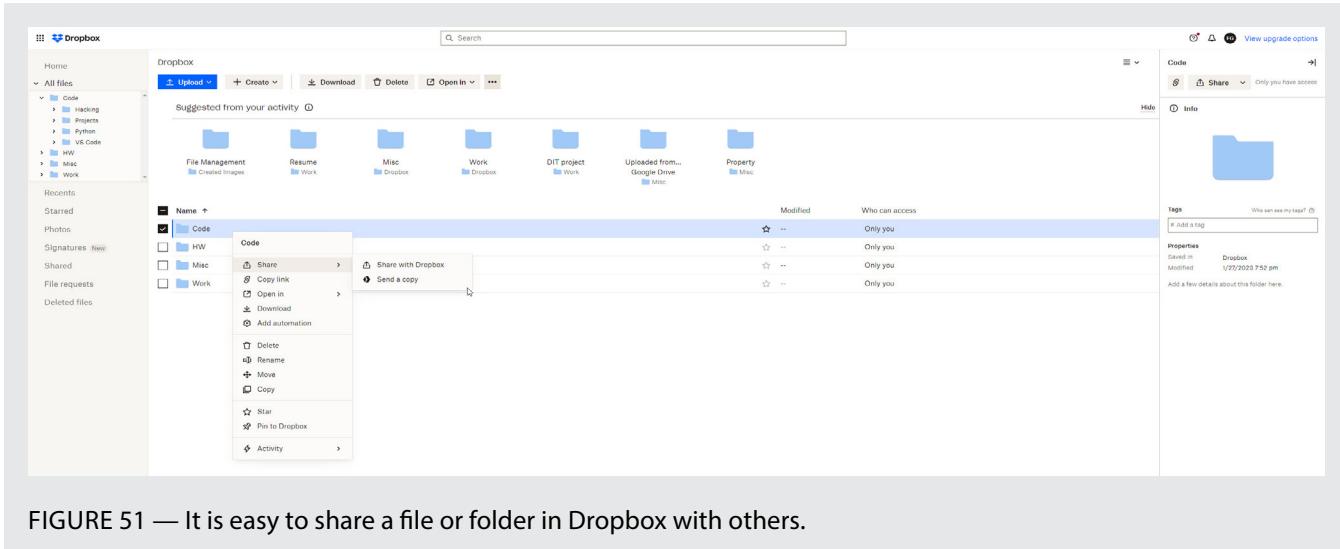


FIGURE 51 — It is easy to share a file or folder in Dropbox with others.

While Dropbox is designed for regular consumers, Box is designed more for organizations. Box focuses on integrating tightly with the security systems of universities and companies. Employees can use their company credentials to use Box and send files to other employees for review and approval.

OneDrive is Microsoft's alternative to Dropbox. Typically geared for enterprises and Office 365 users, it also offers versioning and collaboration capabilities and a way to access files across many computers. Just like Dropbox, OneDrive appears as a folder on your computer. All the files stored in the OneDrive folder are backed up into cloud servers and can be accessible by others, based on sharing rules.

Google Drive is the online cloud file storage system from Google and iCloud is the equivalent from Apple. Like Dropbox, Box, and OneDrive, these systems also offer cloud back up, versioning, and sharing capabilities.

A tradeoff for the ease of using a cloud-based file management are the expenses associated with these services. Once you are out of the free-trial period or use more storage than offered for free, you will have to sign up for the service and pay a subscription fee. This model of using software services for a fee is referred to as SaaS (Software as a Service). SaaS is becoming increasingly popular among companies as it saves companies the headache of buying and maintaining software and hardware. For a suitable rental fee, SaaS services can be valuable for a wide range of organizations.⁷⁸

Task or Activity Manager

You are likely to run into many situations where you'd want to know how your computer is performing—which applications are consuming too much power, memory, CPU, processing, or network bandwidth. Operating systems have utilities that help users manage, monitor, and troubleshoot the applications running on computers. On Windows, the utility is called **Task Manager** and on Mac, the utility is called **Activity Monitor**.

⁷⁸ For an alternate view of the economics of SaaS and cloud-based file management, particularly when companies grow big, you may like to read this article about DropBox and their use of Amazon Web Service. Sarah Wang and Martin Casado, "the Cost of Cloud, a Trillion Dollar Paradox," <https://a16z.com/2021/05/27/cost-of-cloud-paradox-market-cap-cloud-lifecycle-scale-growth-repatriation-optimization/> (accessed June 2023).

To open the Task Manager on Windows, you can press the Windows key (Windows logo key) and type “Task Manager.” Alternately, use the keyboard shortcut, “Ctrl+Shift+Esc.”

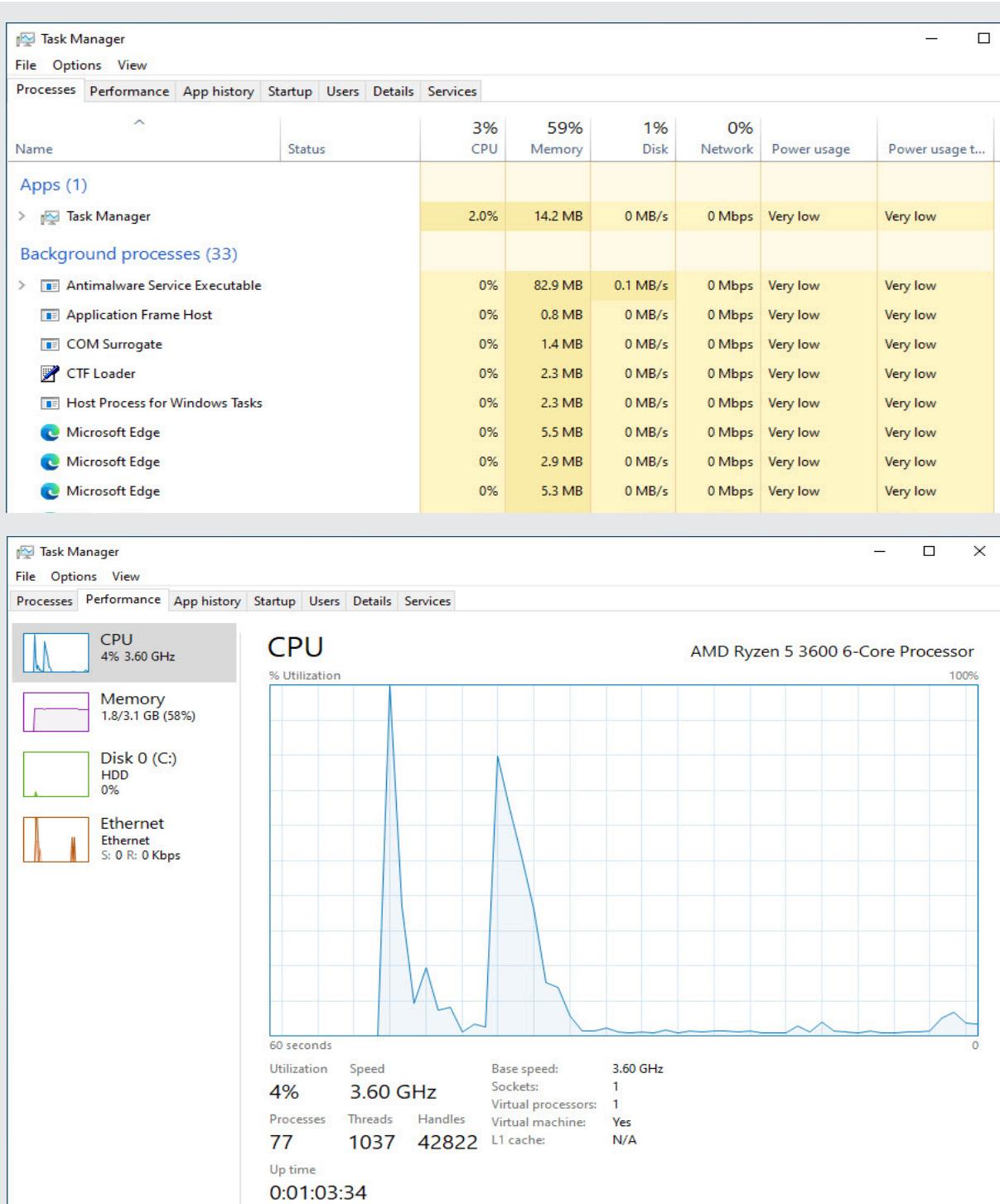
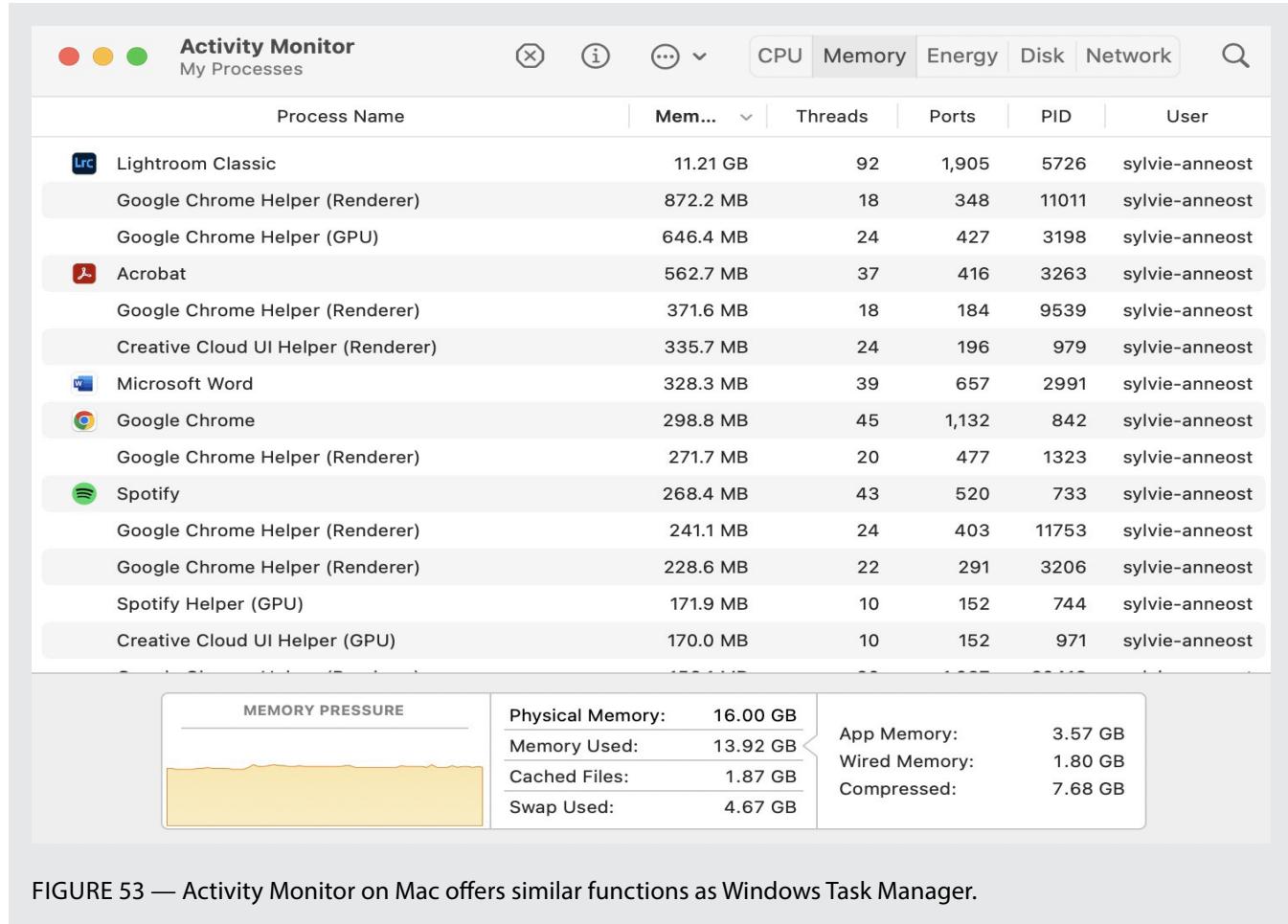


FIGURE 52 — Windows Task Manager offers a different view of the applications running on the computer.

As you can see in [Figure 52](#), the Task Manager provides great visibility into all applications running and the resources consumed on the computer. Like in File Explorer, you can right-click any process to pull up the context menu. A useful operation in the context menu of the Task Manager is the option to “End Process.” If you have an application that is not responding to user input, this is the most straightforward mechanism to end that application, and if needed, to restart it. [Figure 53](#) shows Mac’s Activity Monitor, which performs similar functions.⁷⁹



79 “Activity Monitor User Guide,” <https://support.apple.com/guide/activity-monitor/welcome/mac> (accessed June 2023).



Chapter Terms and Definitions

Activity Monitor: A utility provided by the Macintosh operating system that is designed to report how your Macintosh computer is distributing and processing disks, memory, or network communication

Cloud-Based File Management: The process of storing data with a cloud service provider while working with the data as if it were stored on the local computer

Copy and Paste: To transfer text or some other type of content, such as an image to another location in the same or different document; for example, in Microsoft Windows this can be done with “Control + C” to copy and “Control + V” to paste content

Cut and Paste: Similar to copy and paste, but instead of leaving the original text or content intact, the original content is removed and transferred to a new location

Drag and Drop: Using a mouse button to click and hold onto a software object such as an image or file, drag it across the screen, and then release the button to relocate the object

File Backup: The process of creating and storing a copy of data in such a way that the copy may be used to restore the original in case of data loss

File Compression: A process that reduces the space a file takes up in storage and increases the speed in which it can be transferred from one computer to another; for example, a ZIP file contains one or more files from a folder that has been compressed

File Decompression: The process of restoring a compressed file, such as a ZIP, to its original content form

File Extension: After the name of a file, followed by a period is a sequence of letters that indicate the format of the file; operating systems use the file extension to locate a default program that will be used to open and execute the file

File Management: Creating an organized structure to store information on your computer for easy retrieval and use

File Manager: The User Interface (UI) in which you can interact with the files and store them

File Operations: A computer operating system allows for the manipulation of files; such as create, edit, and delete

File Path: The absolute directory on a computer where a file is located; for example, the absolute file path for a file named hello_world.docx located in the Documents folder of a Microsoft Windows computer could be: C:\Users\Clinton\Documents\hello_world.docx

Mac Finder: The file manager UI used by the Macintosh operating system

Recycle Bin: Where Microsoft Windows stores the files deleted by a user before they are permanently removed; it offers an opportunity for a user to recover files before they are permanently deleted

Task Manager: A utility provided by the Microsoft Windows operating system that is designed to report how your PC is distributing memory, disk space, and processing applications

Trash: Where Macintosh stores the files deleted by a user before they are permanently removed; it offers an opportunity for a user to recover files before they are permanently deleted

User Interface (UI): Any medium that allows users to interact with computers

Windows File Explorer: The file manager UI used by the Microsoft Windows operating system



Chapter Case

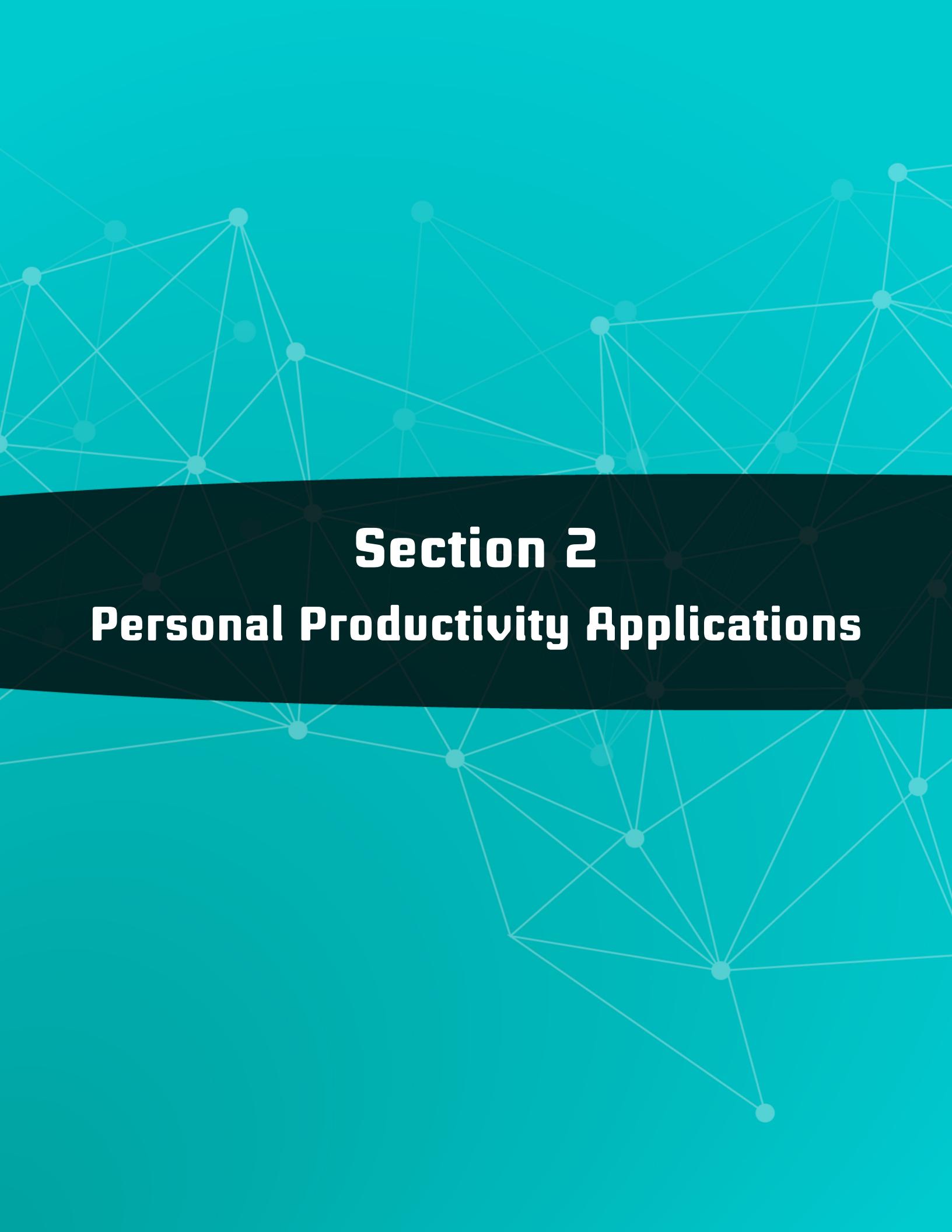
Ian's Research Paper File

It was a Saturday morning and Ian's sister needed to borrow his laptop for one day. Ian's laptop had an application program installed that his sister needed in order to complete her 10th grade science project. This meant Ian had to start writing his research paper using Microsoft Word on his mom's laptop. He knew he wouldn't be able to finalize it on Saturday and wanted to finish it using his personal laptop on Sunday, after his sister was done with her project. Once he finished writing his research paper, he had to submit the final version to receive his grade. It had to be on the cloud-based storage system before his writing class started on Monday at 9:00 A.M.

Based on the above scenario, what recommendations do you have for Ian given the following questions:

.....

- Question 1:** What possible file extensions would be used to write Ian's research paper?
- Question 2:** What should Ian do to save the work he partially completed on his research paper file after using his mom's laptop on Saturday?
- Question 3:** What should Ian do to save his research paper after completing it using his personal laptop on Sunday?
- Question 4:** What cloud-based storage should Ian use to submit the final version of his research paper for his Monday class and how will his teacher access the file?



Section 2

Personal Productivity Applications

Productivity Applications

7

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If we want America to stay on the cutting edge, we need young Americans to master the tools and technology that will change the way we do just about everything.

—Barack Obama, former President of the United States

Overview

In the chapters so far, we have talked about different types of computers and the important components of computers. We are now ready to introduce how these computers are used. Though computers were created to perform complex calculations, such as the correct angle to position a gun to hit a specific target and to find the correct trajectory to return safely to Earth from the moon, most users do not have such exotic uses for computers. Most folks own computers to work on assignments, prepare reports, calculate business profits, communicate with collaborators, or even just for entertainment, such as listening to music, watching videos, or playing games. In the next set of chapters, we will provide an overview of the most common categories of computer applications used in business. These applications help you create and process information and are called **productivity applications**. They include **word processors**, **spreadsheets**, **presentations**, and communication utilities such as **email**.

What Are Productivity Applications?

If you have ever watched plumbers, carpenters, or electricians at work, you might have noticed one common thing about all of them: their collections of tools. They must be extremely familiar with their tools to be good at what they do. They often reach for the right tool in their pocket without even looking. When they see a problem, they know exactly which tool to reach for and how to use it. They are so dependent on their toolset they carry backups of their core tools in their trucks. The best carpenter is useless without a saw, hammer, and drill. The best plumber in the world can't fix a leak without a wrench at hand.

Productivity applications play a similar role in the world of information. Productivity applications on computers enable users to create, process, and distribute information across the world. The Internet, computers, and productivity applications enable groups of widely dispersed individuals to share information seamlessly. You could have team members spread across the globe in different time zones, working on different parts of the same document simultaneously.

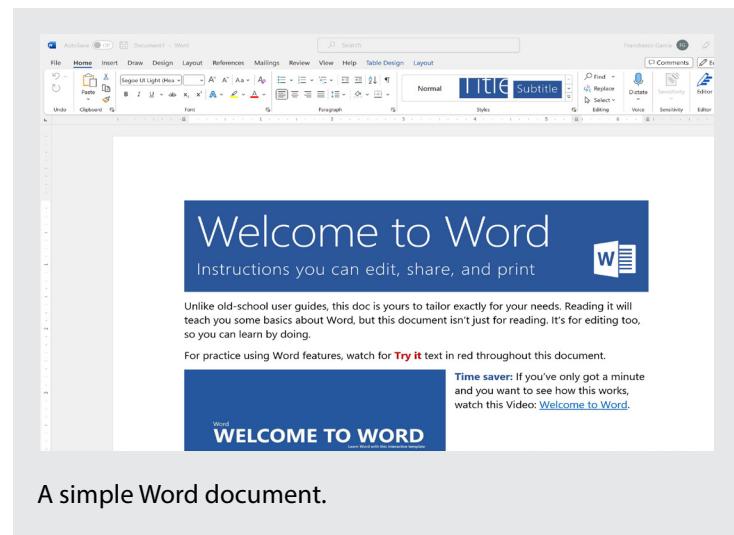
Productivity applications have enabled the globally connected world we live in. The car you are driving today was probably designed in California, manufactured in Japan, shipped to a port in Mexico, and delivered to a dealership in Florida. This distributed design, manufacturing, shipping, retail, and sales were made possible because of productivity applications that let different companies and teams seamlessly share information. Every aspect of our lives, including healthcare, banking, housing, food, and entertainment, is possible because millions of people around the world can work with each other using documents, spreadsheets, databases, emails, calendars, and chat applications. To participate in this ecosystem, create a document, build a database of expenses, make a presentation, send an invoice to a vendor, meet a customer, or quickly ask a colleague a question, you need to know which tool to reach for and how to use it. The next few chapters will introduce you to all the commonly used tools in the business workplace.

Documents

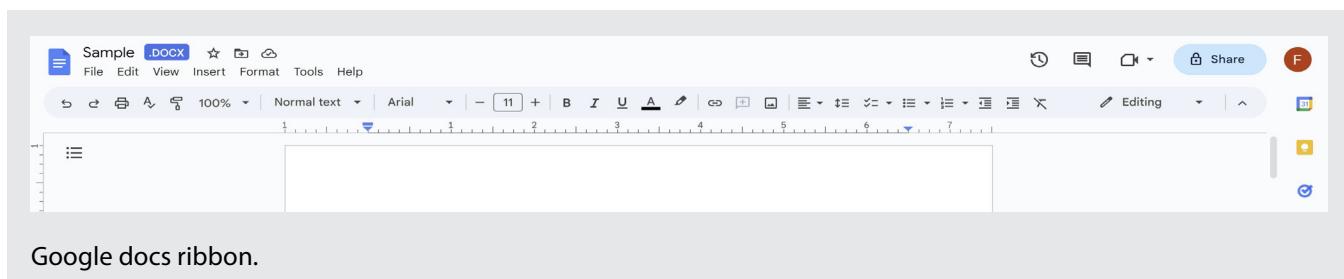
The basic information product is a **digital document**. A digital document is a collection of text and images organized meaningfully. Whether you receive a college admission letter, your semester report card, or the sale deed of a car regardless of whether you receive it in printed form in the mail or electronic form online, it was likely generated and stored as a digital document using one of the productivity applications we will discuss. This textbook also exists as a digital document, albeit a very large one, and is broken into many parts.

Working with digital documents is probably the simplest use of computers. Productivity applications that are used to create digital documents are called word processors. The two most popular word processing productivity applications are Microsoft Word⁸⁰ and Google Docs.⁸¹ Microsoft Word, or just Word, is the more traditional word processing software and is typically used by enterprises. Word documents are identified by the .doc or .docx extension. Any computer that has Microsoft Word (MS Word) or a compatible application will let you open and work on Word documents.

Google Docs on the other hand is browser based and designed with a focus on collaboration. Multiple team members can work on different sections of a Google Docs document at the same time. In recent years, MS Word has also become available in a browser-based version with comparable collaboration capabilities as part of the Office 365 set of productivity applications.



A simple Word document.



Google docs ribbon.

Word processors are simple to use, but most users only use the most basic capabilities. With just a little bit of effort and instruction, you can leverage the powerful capabilities of word processors such as fonts, paragraphs, lists, numbering, styles, sections, layouts, tables, pictures, colors, headers, footers, and templates. These are built into all modern word processors to easily create beautiful documents with a consistent look and feel. You can highlight critical bits of information and improve readability by formatting paragraphs and sections with ease.

⁸⁰ Microsoft 365 home page, <https://www.microsoft.com/en-us/microsoft-365/word> (accessed June 2023).

⁸¹ Google Docs home page, <https://www.google.com/docs/about/> (accessed June 2023).

Documents and Microsoft

In 2021, Microsoft's operating income was \$83 billion.⁸² Of these profits, \$29.7 billion came from the "Productivity and Business Processes" segment, which includes Office 365. Microsoft got its start in productivity applications with word processing when Charles Simonyi joined Microsoft in 1981. Simonyi had developed the Bravo WYSIWYG (What You See Is What You Get) editor at Xerox PARC labs. Simonyi started the productivity applications group at Microsoft, which has remained one of the most successful software groups of all time. In an interview in 2020, the 70-year-old billionaire said that he is currently working on the Microsoft Whiteboard productivity application and goes to work every day.

In the programming world, Simonyi is known for developing the Hungarian notation⁸³ for naming computer program elements such as variables and functions.⁸⁴

Portable Document Format (PDF)

The ease of editing is one of the primary motivations to use digital documents. However, there are times when you want to send a document to others who are not authorized to modify it. For example, when you return a purchased item to Amazon, they give you a shipping label with a special barcode. Amazon doesn't want you to modify the shipping label because it has a special barcode that helps Amazon identify the item and correctly process the return to issue a refund. Therefore, shipping labels are read-only documents. For correct handling, these documents should have the same form regardless of the printer and the operating system used. To accomplish the above task, you can save documents in a format known as the "Portable Document Format," or PDF.

Most forms including college applications, loan forms, tax forms, and club membership forms are distributed in PDF format. Word processors such as Microsoft Word and Google Documents can save documents in PDF format. In most applications, the simplest way to create a PDF version of the document is to print the document and select Adobe PDF as the printer.

The most popular application to view PDF documents is Adobe's Acrobat Reader software,⁸⁵ which is available for most operating systems.

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- 82 Trended Historical Financials, <https://www.microsoft.com/en-us/Investor/earnings/trended/yearly-income-statements.aspx> (accessed June 2023).
 - 83 A great article for the motivation of the Hungarian notation, with generalizable ideas for many life contexts. Joel Spolsky, "Making Wrong Code Look Wrong," <https://www.joelonsoftware.com/2005/05/11/making-wrong-code-look-wrong/> (accessed June 2023).
 - 84 Charles Simonyi, "Hungarian Notation," [https://learn.microsoft.com/en-us/previous-versions/visualstudio/visual-studio-6.0/aa260976\(v=vs.60\)?redirectedfrom=MSDN](https://learn.microsoft.com/en-us/previous-versions/visualstudio/visual-studio-6.0/aa260976(v=vs.60)?redirectedfrom=MSDN) (accessed June 2023).
 - 85 Adobe Acrobat Reader can be downloaded from here, <https://www.adobe.com/acrobat/pdf-reader.html> (accessed June 2023).

"View and Print Anywhere" Motivation for PDF⁸⁶

The portable document format was created in 1993 by a team led by John Warnock, a co-founder of Adobe, one of the world's leading software companies. The challenge at the time was to create a simple format that would look the same on any display, printer, etc., and demand minimal computer processing power. In 2008, Adobe opened up the specifications to the International Organization for Standards (ISO). Since then, most computer applications have introduced the option to save their output as PDFs.

Spreadsheets

A spreadsheet is a specialized digital document in which data is arranged in rows and columns for use in business calculations. Imagine if you maintain your expenses in a notebook on pen and paper. If you accidentally entered the wrong number, you would have to redo all calculations to find your current balance. If you wanted to find the value of expenses in a different currency, you would have to change every number in the list individually. Every time the currency rate changed; you would have to redo the calculations.

Spreadsheets simplify and even automate these and similar tasks, so users can focus on their business problem, not on the calculations. Spreadsheets not only give you predefined formulas to use for calculations but also allow you to create your own formulas. If you change the input values, the output is recalculated automatically. Similarly, the output data will change if you change the formulas.

As an example of the convenience of using spreadsheets, [Figure 54](#) is a home mortgage calculator. You just input your initial loan amount, interest rate, and the loan start and end dates. The spreadsheet automatically calculates your monthly payments based on predefined formulas. As you change your input values, all the output values (monthly payments in this case) change automatically. This allows you to focus on your home purchase options based on your budget, without worrying about the calculations or their accuracy.

86 John Warnock (founder of Adobe), "Camelot," https://web.archive.org/web/20090304134754/http://www.planetpdf.com/planetpdf/pdfs/warnock_camelot.pdf (accessed June 2023).

A	B	C	D	E	F		
1	MORTGAGE LOAN CALCULATOR				MONTHLY LOAN PAYMENT		
2					\$1,074		
3	LOAN DETAILS	VALUES	KEY STATISTICS	TOTALS			
4	Purchase price	\$300,000	Monthly loan payments	\$1,074			
5	Interest rate	5.0%	Total monthly payments*	\$520,679			
6	Duration of loan (in months)	360	Total loan payments	\$385,679			
7	Loan amount	\$200,000	Total interest paid	\$185,679			
8	Loan start date	7/25/2023	Monthly property tax amount	\$375			
9	<i>* Total monthly payments = loan payments plus property tax payments</i>						
10							
11							
	To amortization table						

FIGURE 54 — Home Mortgage calculator.⁸⁷

While spreadsheets are as simple to use as word processors, for proficient users they can also be the most technical of productivity applications to use. Advanced features such as Pivot Tables can help you aggregate your data by different parameters and identify patterns. For example, would you like to know whether the donations you collect for your school band come in on Sundays or from a particular zip code? Pivot Tables can help you aggregate the data by days or locations and show you totals for each category.

Spreadsheets are also great at filtering, sorting, and visualizing⁸⁸ data. A common workflow you can employ to present your business to stakeholders is to first capture your data in a spreadsheet, use the spreadsheet software to create appropriate graphs to describe the data, and then use these graphs in your documentation and presentations. Figure 55 shows an example.

-
- ⁸⁷ The spreadsheet can be downloaded from <https://templates.office.com/en-us/mortgage-loan-calculator-tm02802352> (accessed June 2023).
- ⁸⁸ For an overview of common chart types, please see <https://support.microsoft.com/en-us/office/available-chart-types-in-office-a6187218-807e-4103-9e0a-27cdb19afb90> (accessed June 2023).

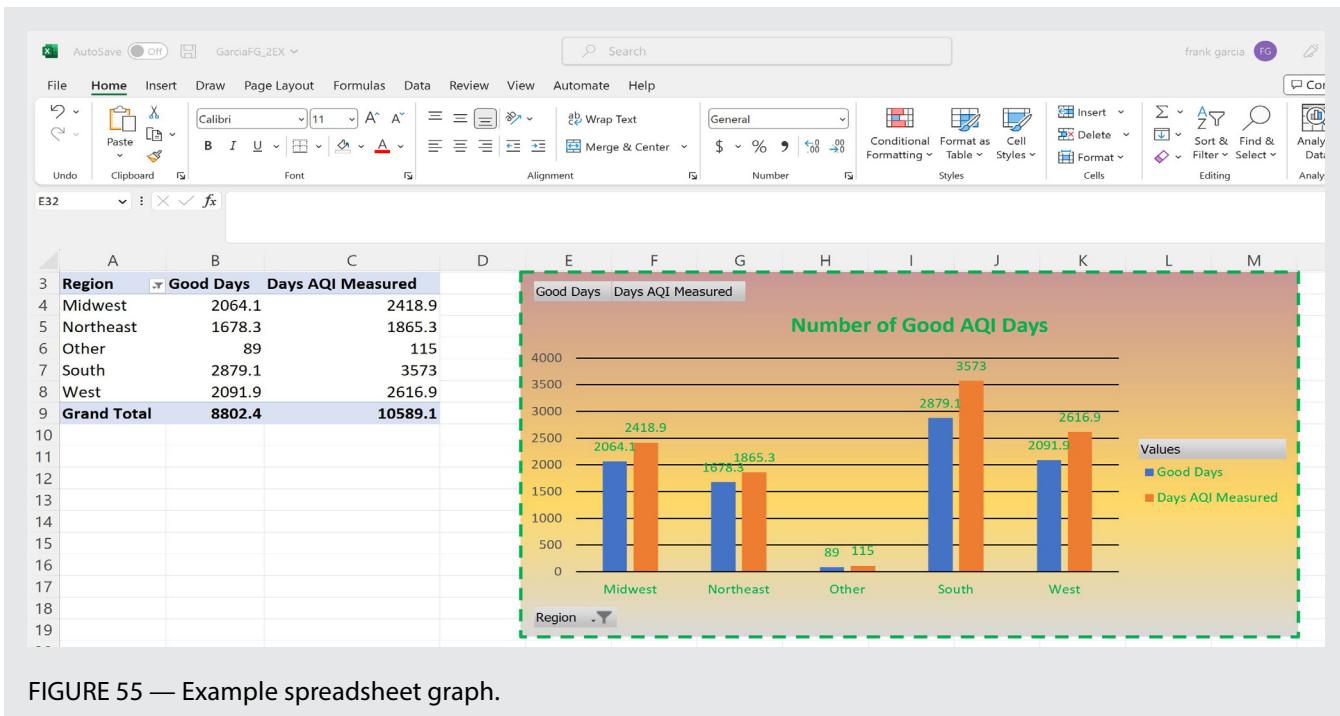


FIGURE 55 — Example spreadsheet graph.

Excel from Microsoft and Sheets from Google are the two leading spreadsheet productivity applications used today. Almost every business uses spreadsheets. Likely, your school uses several spreadsheets to keep track of students and their activities. It may not be an exaggeration to say that while “America runs on Dunkin,”⁸⁹ businesses run on spreadsheets. It is estimated that almost a billion people use spreadsheets to manage data. Any time you are working with data at school, whether for an assignment or personal management, we highly recommend using spreadsheets and exploring one new capability each time. This will help you not only manage your data more efficiently but also improve your own skills in one of the most important productivity applications.

VisiCalc and the Killer App⁹⁰

A killer app (application) is a computer application that is so desirable that it drives purchases of much more expensive technology.⁹¹ VisiCalc, the first popular spreadsheet software, is widely considered the world’s first killer app. It was created in 1979 by Dan Bricklin and Bob Frankston for Apple Computers and sold for \$100. However, it was so useful that users bought Apple Computers costing over \$2,000 just so they could use VisiCalc. Eventually, Lotus 1-2-3 from IBM and then Excel from Microsoft became the dominant spreadsheets.

-
- 89 “Dunkin’ Donuts Launches New Advertising Campaign ‘America Runs on Dunkin’(sm),” <https://news.dunkindonuts.com/news/dunkin-donuts-launches-new-advertising-campaign-america-runs-on-dunkin-sm> (accessed June 2023).
- 90 Luke Dormehl, “Today in Apple history: Apple II gets its first ‘killer app,’” <https://www.cultofmac.com/460680/apple-ii-killer-app-visicalc/> (accessed June 2023).
- 91 “Killer application,” https://en.wikipedia.org/wiki/Killer_application (accessed June 2023).

Presentations

Presentations are digital documents that combine text, graphics, and media (audio and video) for display to an audience. While documents are great at organizing detailed textual information and spreadsheets are great at analyzing numerical data, neither of them is suited for presenting to a large gathering. Documents and spreadsheets are largely designed to be viewed by individuals on their own personal devices, at their own personal pace.

Presentations, on the other hand, are designed to be viewed by a large audience at a pace set by the speaker. Typically, a presenter provides additional details about each slide during the presentation. Therefore, presentations focus on holding the viewer's attention through visual appeal, consistency, visual contrast, and other story-telling elements.

Whether you want to present to management, customers, or colleagues, you want to hold their attention and get your message across. Microsoft PowerPoint⁹² and Google Slides⁹³ are the two most popular presentation software applications today and can help you quickly put together slides that look professional and convey information. Prezi⁹⁴ is another popular presentation application, with some unique presentation formats. A slide is a single page of a presentation. Presentations are also sometimes called slide decks because a stack of printed slides looks like a deck of large cards, and the action of going through the slides in a presentation is like going through cards in a deck. In a typical presentation, one or more adjacent slides convey one point to the audience. You can embed summarized information from your analysis into slides, including images, graphs, and charts. As you move from one slide to the next while presenting to an audience, you tell a story that explains what's on the slides. Slides transition seamlessly from one to the next, and you can make content pop up on the screen to highlight important bits.⁹⁵



A slide presentation.



A standard presentation slide template that can be customized to your needs.

92 PowerPoint home page, <https://www.microsoft.com/en-us/microsoft-365/powerpoint> (accessed June 2023).

93 Google Slides home page, <https://www.google.com/slides/about/> (accessed June 2023).

94 Prezi home page, <https://prezi.com/> (accessed June 2023).

95 For a humorous take on common presentation mistakes, check out <https://www.youtube.com/watch?v=MjcO2ExtHso> (accessed June 2023).

One great feature of PowerPoint is its ability to serve as an outline of ideas. When working on a complex document for the first time, you can begin by organizing ideas in a presentation. The presentation can then be saved in outline format (rtf), which can be opened in a word processor. Next, content can be populated within each outlined section and you can be assured that the ideas will flow smoothly since they have already been organized in a logical sequence.

Modern presentation software creates beautiful slides by default. However, when presenters do not make the effort to deliver an engaging presentation, it can get monotonous and tedious for the audience. In business, this is seen as being subjected to a form of torture, particularly when successive speakers deliver weak presentations. “Death by PowerPoint” is a colloquial term used to criticize presentations that are so poorly planned or executed that they fail to effectively communicate their ideas to the audience.⁹⁶

PowerPoint Origins

Robert Gaskins and Dennis Austin created PowerPoint for Apple computers in 1987.⁹⁷ Microsoft bought their company within months of the software’s release. Robert Gaskins maintains an excellent website describing PowerPoint’s origin story,⁹⁸ with several original design documents. Some documents are great reads, including the first two-page concept proposal,⁹⁹ and a more detailed description.¹⁰⁰

Email

Messages distributed electronically from one computer user to one or more recipients and stored on a central server are called electronic mail, or email for short. Email was introduced in the 1970s and soon became popular in universities and businesses. Until email became widely available, documents were saved in paper form and stored in locked cabinets. Most large offices had systems like this. To find a document and get it approved by others, you had to go to the cabinet room, locate the file in the correct cabinet, and walk with the file to the



A physical filing repository.

96 This definition comes from chatGPT, <https://chat.openai.com/chat> (accessed June 2023).

97 “Microsoft PowerPoint,” https://en.wikipedia.org/wiki/Microsoft_PowerPoint (accessed June 2023).

98 Robert Gaskins Home Page, <https://www.robertgaskins.com/> (accessed June 2023).

99 Robert Gaskins, “Sample Product Proposal,” <https://www.robertgaskins.com/powerpoint-history/documents/gaskins-powerpoint-original-proposal-1984-aug-14.pdf> (accessed June 2023).

100 Robert Gaskins, “Presenter,” <https://www.robertgaskins.com/powerpoint-history/documents/gaskins-powerpoint-summary-and-review-1986-jul-15.pdf> (accessed June 2023).

approvers to get them to sign on it. Email and related technologies have greatly simplified this process now. In fact, it is often said that most forms now reside in users' emails.

Email enables you to put a message together easily, attach a file or two along with the message for review or approval, and send the message to as many people as you like with the click of a button. The people who receive your email can make changes to the document, if it is not read-only, and send the document back to you as an attachment. In a matter of minutes, you can get your document approved even if your approvers are thousands of miles away. Email helps you disseminate information in an instant, magically overcome the limitations of the physical workspace, and allows us to work as a worldwide team.

Good [email etiquette](#) is simple to learn and a very useful skill to develop. There are several articles online¹⁰¹ and most of them share similar ideas about email etiquette.¹⁰² Most people will form their first impression of you from your introductory email. Being polite, using correct spelling and grammar, using a pithy subject line, and staying brief are all likely to help people form the best impression about you and make it more likely that they will take your requests seriously.

Microsoft's Outlook and Google's Gmail are two popular email services.

Email as the Internet's Killer App

We introduced spreadsheets as the killer app for personal computers. Email has proven to be the killer app for the Internet.¹⁰³ Email services are generally free for personal users and relatively inexpensive for business users. However, most users buy computers primarily to communicate using email. Though a lot of personal information exchange has moved to instant messaging in recent years, email continues to be the preferred mode of communication outside close family and social circles.

Calendar

Calendars are charts that show how your time is organized by hours, days, weeks, and larger units such as months and years. [Digital calendars](#) leverage the capabilities of computers to simplify managing your time and collaborating with people ([Figure 56](#)). If you want to meet friends for a movie, you typically reach out to them and ask them if they are free to meet on a particular evening at a particular location. This is an easy problem to solve if there are just a few people involved and there is no rush or urgency to the task. Now imagine trying to meet groups of coworkers several times a day and multiple days of the week to complete a critical project. Even if all your colleagues were right in front of you, it would take a bit of time to find a slot that might work for everyone. You could spend all your

101 A good example is David Fallarme, "How to Write an Effective Email," <https://blog.hubspot.com/marketing/email-writing-for-international-teams> (accessed June 2023).

102 Jeff Su, "How to Write Better Emails at Work," <https://hbr.org/2021/08/how-to-write-better-emails-at-work> (accessed June 2023).

103 A nice article describing this phenomenon is Chris Preimesberger, "30 Years Ago: How Email Rose to Become the No. 1 Killer App," <https://www.ewEEK.com/enterprise-apps/30-years-ago-how-email-rose-to-become-the-no.-1-killer-app/> (accessed June 2023).

time coordinating the meetings if you did not have calendaring software to solve the problem for you.

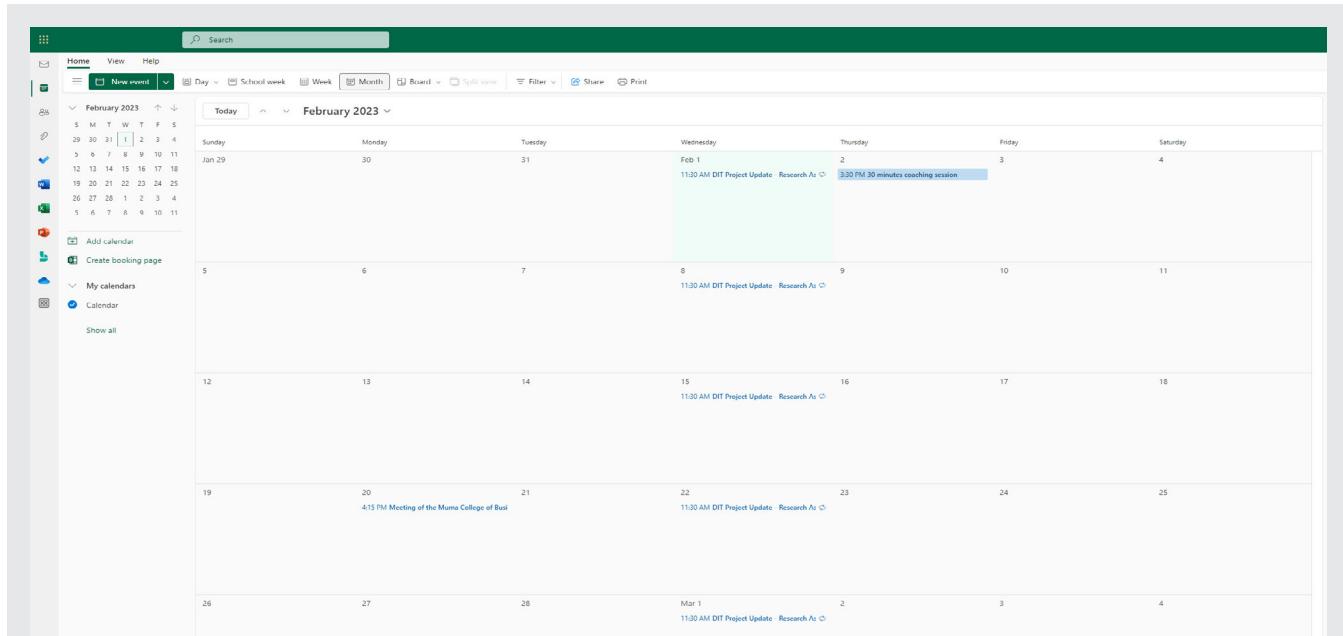


FIGURE 56 — A user's Outlook calendar showing free and busy periods.

Calendaring software helps you schedule meetings for specific times, create agendas for meetings, and add the people you want to include from your list of contacts or the organization's directory. You can even book resources like rooms and projectors and clarify which attendees are required and which ones are optional. As the software allows you to check when your colleagues are busy with other meetings and when their calendar is free, folks are likely to accept your invitation if you find a good time when everyone is free.

After you send the meeting invitation, the software will let you see who has accepted or rejected the meeting invitation. The software also sends reminders of upcoming meetings, so people don't accidentally miss meetings.

Though the most popular calendars are Microsoft's Outlook and Google's Calendar, smartphones also have fully functional calendar applications natively built into the operating system. These are increasingly popular, particularly for personal use.

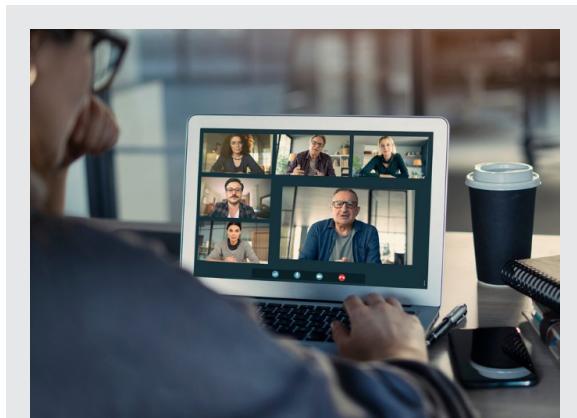
Web Conferencing

Web conferencing refers to any online interaction that approximates the information-sharing experience of an in-person meeting. The use of web conferencing was limited in business, until the Covid pandemic. As we emerge from the Covid pandemic, web conferencing is the hero of the moment, along with vaccines. Holed up in their homes, office workers were able to retain their jobs, take care of their families, and meet family and friends, all thanks to web conferencing tools.

Web conferencing has been around in some form since the introduction of webcams in the 1990s.¹⁰⁴ However, the covid pandemic and the resulting isolation forced everyone to become familiar with and rapidly adopt this technology. The major vendors in this technology—Zoom, Webex, BlueJeans, GoTo Meeting, Teams, and Google Hangouts—offer similar features including the ability to schedule meetings, invite others, launch meetings, and allow others to join using a URL. You can join the meeting on your phone or use your computer’s microphone and speakers. If you turn on your camera, you will be visible to other meeting participants and be able to have face-to-face conversations. Participants can share their screens and present information, just the way they would in a conference room.

A very useful feature added recently to popular web conferencing software is the ability to record meetings and share the recording with participants and those who may have missed the meeting. Recordings can also be used to go over discussions that were not clear when presented at the meeting.

In the post-Covid world, most calendaring software is also integrated with web conferencing software such as Zoom and Teams to allow you to schedule meetings. In most offices, it has become business as usual (BAU) to “Schedule a Meeting” in calendaring software such as Outlook and add Zoom or Teams meeting details, including phone numbers, meeting times, and meeting participants. The software sends the meeting invite automatically, including a meeting link and the agenda of the meeting (Figure 57).



A web conference in progress.

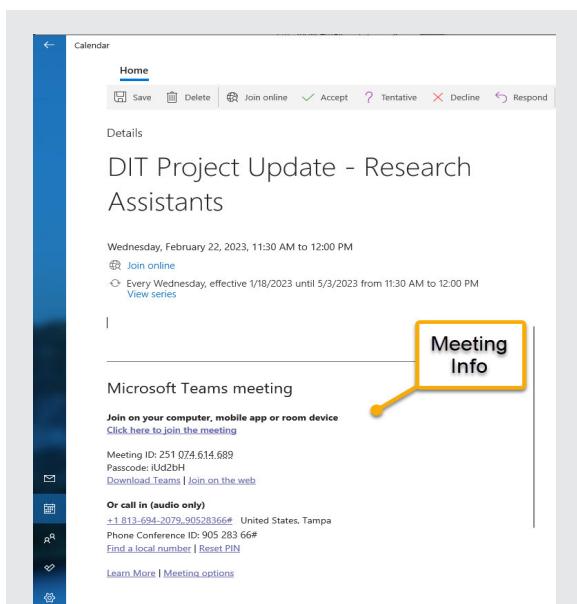


FIGURE 57 — A typical meeting invitation in Calendar.

104 For the origin story and its association to laziness, please see “The First Webcam Was Invented to Check Coffee Levels Without Getting Up,” <https://petapixel.com/2013/04/03/the-first-webcam-was-invented-to-check-coffee-levels-without-getting-up/> (accessed June 2023).

As an invitee, you can choose to “Accept/Reject” any invitation. You could also mark the invitation “Tentative” if you are uncertain (Figure 58).

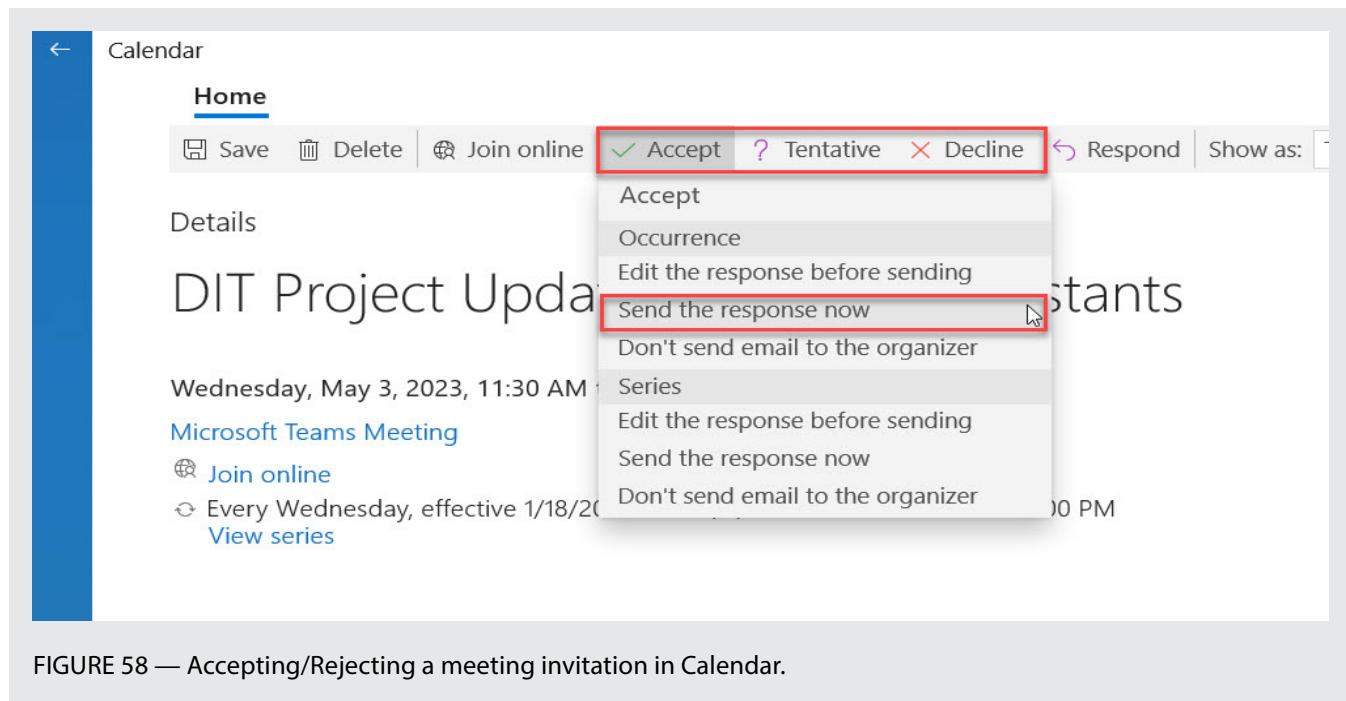


FIGURE 58 — Accepting/Rejecting a meeting invitation in Calendar.

Chat

Chat refers to real-time online communication. **Online chat** is very popular among family, friends, and social circles and has even gained popularity within business environments. If you use Facebook Messenger, WhatsApp, Snapchat, Signal, or Telegram to stay in touch with family and friends, then office chat apps will not be difficult to use. Chat capabilities are built into most web conferencing applications. Slack and Microsoft Teams are the two most popular office chat apps that organizations use to facilitate informal conversations between employees (Figure 59). A common feature of business chat apps is building channels of communication with select teammates on a topic or a common project. Through the channel, all team members interested in a topic or working on a project share files, screenshots, and messages.

As the chat history is preserved, you and your team members can search through the history to find something you discussed in the past or links you shared with each other. The generous use of emojis and gifs makes chat a fun way to stay in touch with your team. Not surprisingly, for many businesses, chat is increasingly popular, while email is increasingly used for more formal communications.

All popular chat apps now also offer mobile phone versions of their software, so you can seamlessly jump from your computer to your phone and continue the conversation.

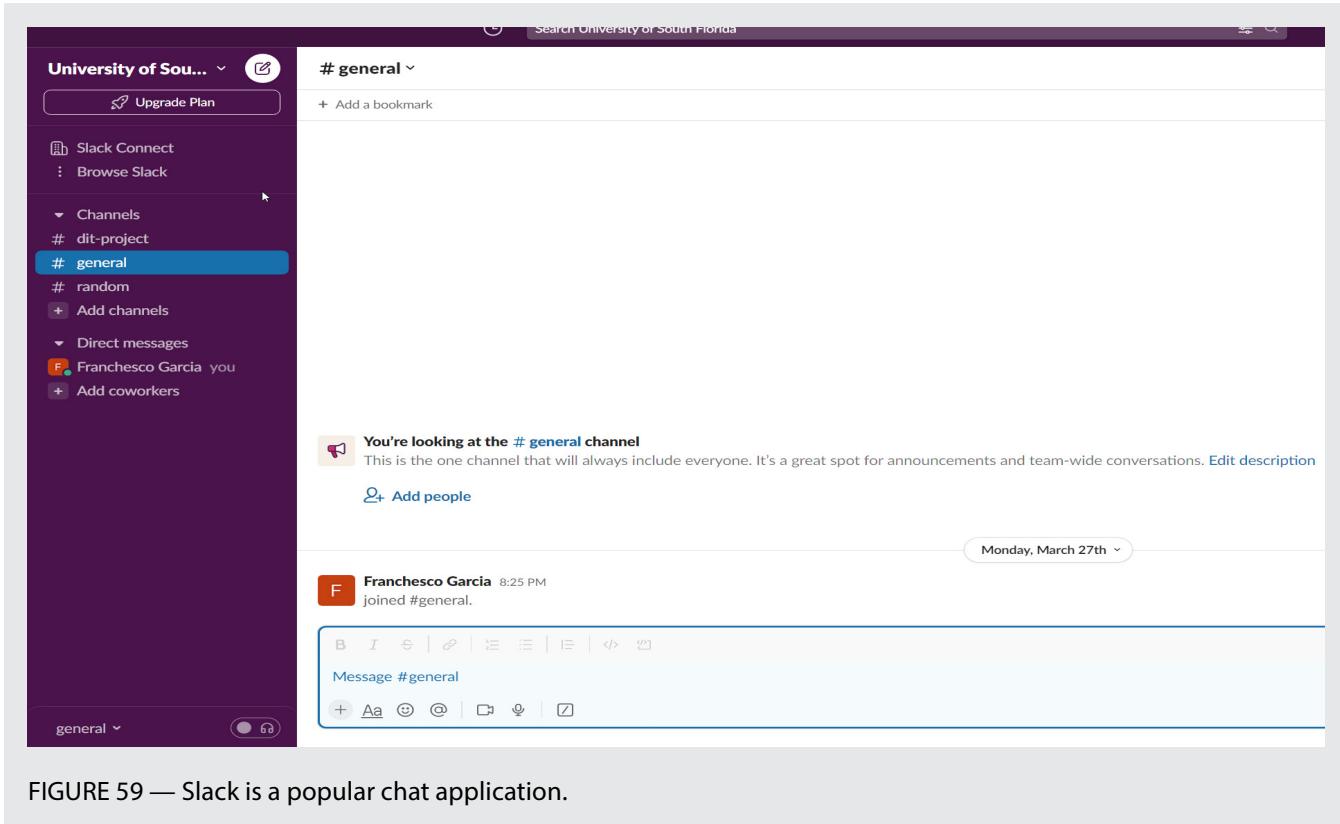


FIGURE 59 — Slack is a popular chat application.

Office 365 and Google Suite

In the next few chapters, we will look at each of the productivity applications in more detail. Most users typically pick one of the two sets of productivity applications—the Microsoft Office 365 Suite¹⁰⁵ or the Google Workspace Suite.¹⁰⁶ Apple also has a comparable set of productivity applications (Pages for word processing, Numbers for spreadsheets, and Keynote for presentations). Each of these sets of productivity applications has comparable capabilities for most users. The individual applications (e.g., Word, Excel, PowerPoint) within a suite tightly integrate with each other, so users can copy and paste information seamlessly from one application to the other, preserving formatting and other details for ease of use. Often, the choice of office suite is made by the organization based on several factors including pricing, features, etc.

Bundling

The distribution of productivity applications as a set of separate but tightly integrated applications is called **bundling**. Applications within a bundle typically have similar user interfaces and mouse actions, making it easy for users to transfer what they have learned from one application in the bundle to another. Vendors offer strong discounts to customers who buy office suites as a bundle because it

105 Microsoft Office 365 home page, <https://www.office.com/> (accessed June 2023).

106 Google Workspace home page, <https://workspace.google.com/> (accessed June 2023).

reduces competition for their products. Once a user pays for a bundle, they are less likely to pay for another bundle or another individual application. This has, therefore, become a common practice in the industry.



Chapter Terms and Definitions

Bundling: The distribution of productivity applications as a set of separate but tightly integrated applications

Digital Calendar: A calendar accessed through a computing device such as a PC or smartphone

Digital Document: A collection of text and images organized meaningfully using a digital medium

Email: Messages distributed electronically from one computer user to one or more recipients and stored on a central server

Email Etiquette: The utilization of accepted standards and practices when communicating through email

Killer Application: A computer application that is so desirable that it drives purchases of a much more expensive technology

Online Chat: Real-time online communication using an interface designed to send and receive text

Portable Document Format (PDF): A digital document format created for easy and reliable sharing of digital documents

Presentation: Digital documents that combine text, graphics, and media (audio and video) for display to an audience

Productivity Application: Software applications that help users create and process relevant information

Spreadsheet: A specialized digital document in which data is arranged in rows and columns for use in business calculations

Web Conference: A meeting facilitated by productivity applications that provide video collaboration

Word Processor: Software application designed to aid the user in creating digital documents focused on language and formatting



Chapter Case

A Teacher's Work is Never Done

Teachers must manage a wide variety of tasks during their daily work lives to stay productive at school. They are responsible for many different activities to ensure students from various backgrounds and levels of literacy are educated in a safe and productive environment. Teachers are very busy people and work hard to help students succeed. Here is a list of some of the daily work activities your teachers are responsible for:

- Develop, assign, and grade instructional content such as homework and tests.
- Supervise students in the classroom to ensure they are learning in a safe and productive environment.
- Organize the supplies and resources necessary for class lectures and presentations.
- Plan educational activities and events.
- Ensure a clean and orderly classroom.
- Prepare and distribute progress reports and report cards.
- Schedule parent-teacher meetings.

A teacher's work is never done....

.....

Question 1: Take a close look at the list of daily work activities your teachers are responsible for. List three types of applications that will help your teachers be more productive. Explain why each application will help your teachers be more productive with their daily work activities.

Question 2: If **you** were a school teacher, what type of work activity do **you** think would be the most difficult? Now, describe how and what type of application could help **you** improve the productivity of that difficult task.

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Lesson From MS Word: Either “Be Bold” OR “Be Italic.” Because the world doesn’t notice the “Regular ones”!!!

—Akhil Tiwari, software engineer

Overview

A word processing application is a software program that lets you create new digital documents and open and update existing digital documents. Google Docs and Microsoft Word (part of Office 365) are the most popular [word processors](#). If the document was created by Microsoft Word, it will have an extension of either .doc (older versions) or .docx (newer versions). Since Word documents are so ubiquitous, most productivity applications are able to open documents created in Word. You can also change document formats, for example, by uploading a Word document to Google Docs and downloading a Google Docs file as a .docx document.

When you think of a document with information on it, you generally imagine long lines of text, separated by paragraphs. Any simple text editor, like Notepad, could create that. However, there are times you want your document to be attractive with colors, line spacing, special fonts, hyperlinks, and references. For business documents, you may like to have the document reviewed by your peers before you send it out. You may want to do a spell check, fix awkward grammatical errors, and improve the vocabulary in the document. If your colleagues review and make changes to your document, you want to track the changes and comments and be able to compare different versions to make the collaborative work more manageable.

If you are building a pamphlet for your garage sale on paper, you may have to spend a lot of time drawing lines, creating images, adding captions, and highlighting and underlining text. However, if you have a word processor, you might be able to use a preexisting [template](#), saving a ton of time and energy while also creating a more attention-grabbing pamphlet. Templates can also help you to not miss any of the important elements such as the time and place of the sale.

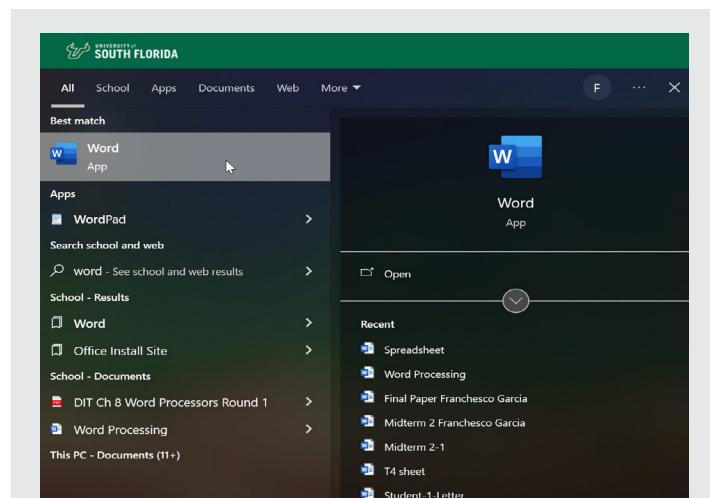
If the document is especially long, say you are writing a novel or a thesis using a word processor, you can number your pages, add [header](#) and [footer](#) information, and have chapter headings. An automatically created [table of contents](#) at the beginning of the document will enable readers to jump easily between chapters. When you are ready to print your document, you might want to adjust the layout, orientation, and margin size. The print-preview feature of your word processor will allow you to see how the printed sheets will look before you begin printing, hopefully saving printer ink and paper.

The two most popular word processing software applications in the market are Word from Microsoft and Docs from Google. Microsoft Word, a paid software program, is found in most offices. On the other hand, Google Docs is free and browser-based. If you have Gmail, you already have access to Google Docs.

In this chapter, we will introduce you to the core capabilities of word processors. We encourage you to explore these and other more sophisticated capabilities of word processors as you complete your school and college assignments.

Getting Started

To use Word, you can either launch the word processing software first and then open a document. Or you could double-click on an existing document with a .doc or .docx extension. The operating system will use its file associations to open Word and the document within the software application's window. To launch Word, you can click on the Microsoft Start button, then type "Word" in the search box. This should bring up the icon with the Word application logo. If you select the icon, the Word application opens. This is the standard procedure to open any application.



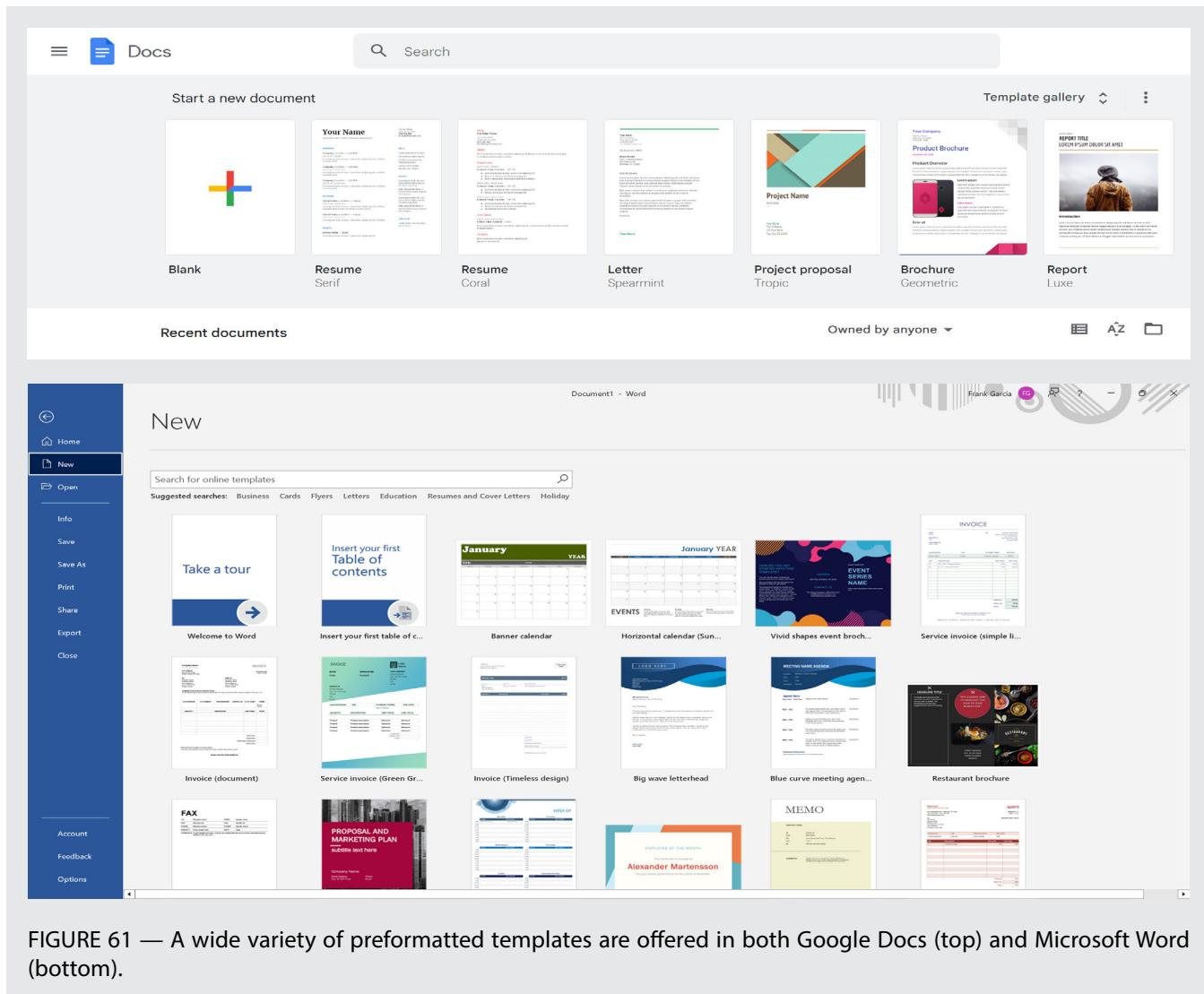
Windows users can search for the Word application by typing "Word" in the search box.

Typing the URL <https://docs.google.com> in the location bar of your browser will bring up all your Google documents (Figure 60). Alternatively, go to Gmail, then click on the dots next to your name in the top right corner to see all the apps, including Docs.

A screenshot of the Google Docs interface. At the top left is the "Docs" logo. Next to it is a search bar with the placeholder "Search". Below the search bar is a section titled "Start a new document" containing thumbnails for various document templates: "Blank", "Letter Spearmint", "Resume Serif", "Resume Coral", "Project proposal Tropic", "Brochure Geometric", and "Report Luxe". Below this is a section titled "Recent documents" displaying a grid of document thumbnails. One document, "Letter", is highlighted with a blue border and shows the status "Opened May 16, 2023". Other documents include "Welcome to Word", "Sample.docx", "Recommendation Report ...", "Draft of Recommendation ...", and "M4.3 Evaluating Recomm...". Each document thumbnail includes a timestamp and a three-dot menu icon.

FIGURE 60 — Recent Google documents.

Most Word processing applications offer preformatted templates for common documents such as invitations, resumes, certificates, and brochures. Using these can save a lot of time. So, before you start a new document, make sure to check out all the existing templates and save yourself the effort of formatting a blank document all by yourself. (Figure 61)



Essential File Operations

A few essential operations are common to all productivity applications. These involve saving the data you have worked on while using the application and exchanging the data with other users. Printing is another common operation as some readers may want printouts (also called hard copies) of your documents to read at leisure. We begin by introducing these operations.

Save

When you begin working on a digital document, it is useful to first save the file in a suitable location with a useful name. Once you do that, both Microsoft Word and Google Docs can integrate with their cloud services (OneDrive and Google Docs) and automatically save (Auto Save) documents as you work on them. So, if you did a bunch of work and closed your laptop without saving your document, your unsaved work will still be safe. If you save your work to a cloud service folder, the document is typically saved to the cloud to avoid using local space. You can mark the file to also be saved locally, which is useful if you plan to work on your documents even when you are not connected to

the Internet (for example, on a flight or at a camp). The latest version of the document will then get uploaded to the cloud once you connect to the Internet.

As old-time users of productivity applications, who have lost a considerable amount of work from power outages and other computer mishaps, the authors of this book reflexively use the “Ctrl+S” keyboard shortcut after almost every sentence to save their document, not relying on any automated saving features.

Print

Quite often, we need to make physical copies of documents. We may want to distribute documents as flyers, share them with friends, or simply wish to highlight, annotate, and take notes on them. Word processing software offers integrated print functionality. When you choose to print the document, you will get the print options based on the printer connected to your computer.

The standard print dialog gives you options to choose how many pages to print, which pages to print, and how many copies to make. You can select the paper size, margins, and whether to have single- or double-sided output. The print dialog also typically gives you a preview of the final output so you can confirm that the document looks exactly as you expect before you begin the printout. (Figure 62)

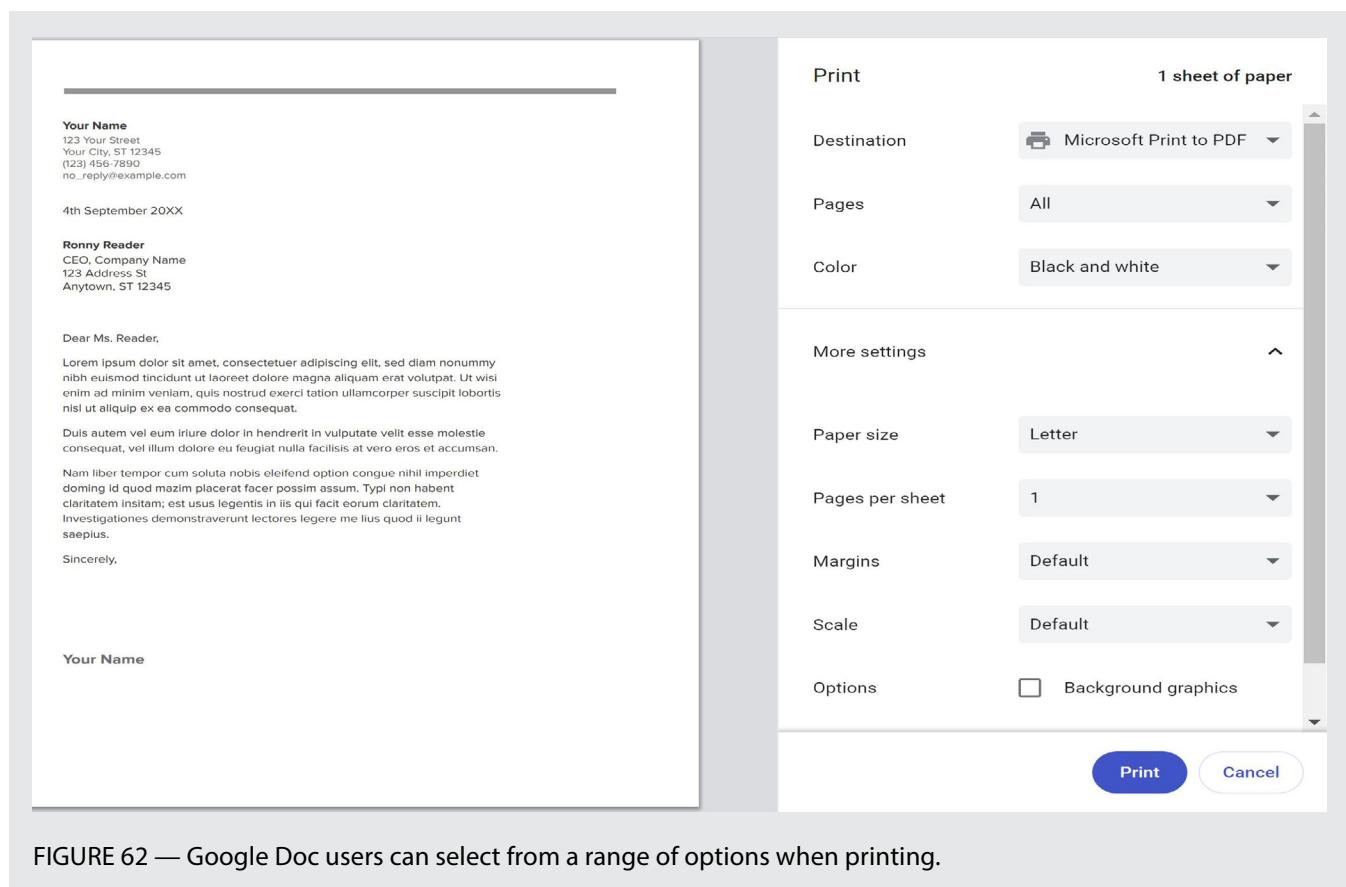


FIGURE 62 — Google Doc users can select from a range of options when printing.

Export

Productivity software, including word processing software, also gives you the ability to export your files to other useful formats. Portable Document Format (PDF) is a popular and free document format

maintained by International Organization for Standardization (ISO). When you save your Word or Google Doc in this format, it becomes a Read-Only version of your document that can be shared with others. Other popular output formats include webpages (.html) and plain text (.txt). The .html export option allows you to use word processors to save brochures and similar projects as webpages.

Google Docs also allows you to download your document as a .docx (Microsoft Word compatible) file, .pdf (Adobe Acrobat compatible) file, or as a .html (a webpage). You can even download your document as an Electronic Book (.epub) that can be opened by electronic book readers like Kindle or Nook. (Figure 63)

These basic file operations allow you to create digital documents and save and distribute them. We now introduce some basic features of word processors that are designed to make it easy for you to create content.

Creating Content

Have you tried to read a document that has nothing but plain printed text, page after page? Reading such a document can be a tortuous task! Even when you go to buy a car, sign papers for a home mortgage, or apply for a student loan, the sheer amount of text on paper can be intimidating. Word processors offer numerous capabilities to create content that is easy to read. We introduce these capabilities in this chapter, starting with the ability to affect individual characters, and ending with the ability to affect the entire document.

Fonts

Fonts refer to text of a particular shape, style, and size (Figure 64). For example, the style of the famous Coca-Cola logo comes from a font called the Spencerian font. This font was created in 1840 by Platt Rogers Spencer and was the standard writing style in American business until the typewriter replaced hand-

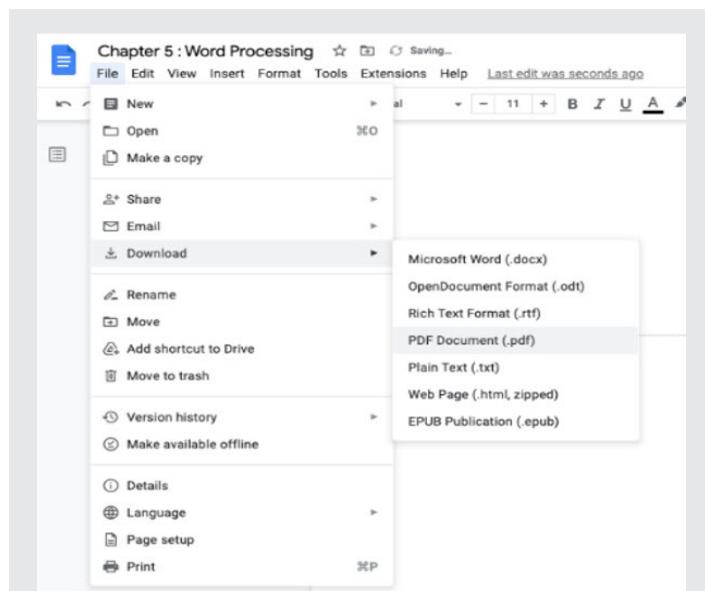


FIGURE 63 — Google Docs allows users to download multiple file formats increasing the compatibility of files when sharing.

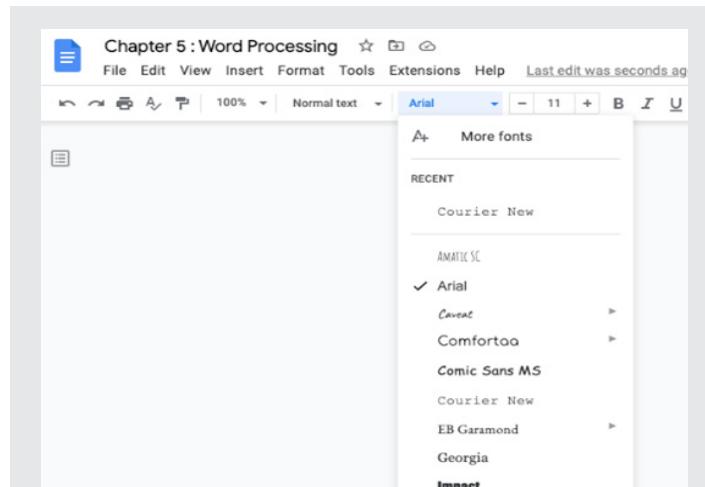


FIGURE 64 — Google Doc users can select from a wide range of fonts depending on the type of document they are creating.

written documents for business writing.¹⁰⁷ Perhaps due to the popularity of the font at the time of the company's founding, the early Ford logo also used the Spencerian font. Using the right font can improve readability and also convey emotions. For example, Apple created a custom font for use in its Apple Watch to improve the readability of text on small screens.¹⁰⁸

When choosing a font, knowing the basic categories is useful. This will help you decide which font is best for your document.¹⁰⁹ You can combine fonts to make your information stand out. Default choices in most word processors will serve you well.¹¹⁰

Serif Fonts

Serifs are small decorative tapers added to the beginning and end of letters. Serif comes from the Dutch word "shreef," which refers to a line or stroke of a pen.¹¹¹ Letters in serif fonts include serifs in their style. Since serifs take effort to create if written by hand, serif fonts appear formal and are perceived to indicate maturity and authority. Serif fonts are popular for print publications of magazines and novels.¹¹² It is considered accepted wisdom that serif fonts are easier to read on paper since the serifs guide the eye as it navigates blocks of text. Look at the letter T closely in different serif fonts (Times New Roman, Georgia, and Courier) to see the serif embellishments.

This text is in Times New Roman

This text is in Georgia

This text is in Courier

Popular serif fonts.

Sans-Serif Fonts

Sans is French for "without." Sans-serif fonts are fonts that don't have serif embellishments. Sans-serif fonts are considered more modern and are often used in digital publications. The default font for

This text is in Arial

This text is in Calibri

This text is in Verdana

Popular sans-serif fonts.

107 "Spencerian script," https://en.wikipedia.org/wiki/Spencerian_script (accessed June 2023).

108 Alissa Walker, "Apple Debuted a Brand-New Custom Typeface With Its Watch," <https://gizmodo.com/apple-debuted-a-brand-new-custom-typeface-with-the-appl-1632606916> (accessed June 2023).

109 You can read more online, for example see, "The Fundamentals of Font Psychology," <https://99designs.com/blog/tips/font-psychology> (accessed June 2023).

110 An article with some recommendations is, "Best Practices of Combining Typefaces," <https://www.smashingmagazine.com/2010/11/best-practices-of-combining-typefaces/> (accessed June 2023).

111 "Font Readability Research: Key Differences Between Serif Vs Sans Serif Font," <https://geniusee.com/single-blog/font-readability-research-famous-designers-vs-scientists> (accessed June 2023).

112 For a few example fonts, please see "The Best Fonts for Magazine Design: Editorial, Crisp & Memorable," <https://creativemarket.com/blog/best-magazine-fonts> (accessed June 2023).

Google Docs is Arial, a sans-serif style, as Docs, are typically used online. On the other hand, Microsoft defaulted until recently to Times New Roman, a serif font, probably because Microsoft evolved at a time when it was more common to print documents. In recent years, the default font in Microsoft Word has been Calibri, a sans-serif font.

Script Fonts

Script or cursive fonts mimic handwritten text. You will typically see them in invitations, such as a wedding invitation, an invitation to the opening of a golf course, or other documents intended to appear highly personalized.

The US Constitution was written by hand¹¹³ in a distinctive style. The cursive font capturing the style is called “Gouverneur Morris of Pennsylvania’s hand,” after Gouverneur Morris, who is considered the penman of the Constitution.¹¹⁴

Modern operating systems include many fonts by default. You can apply any available font to any written text by highlighting the text and selecting the font from the “Home” menu of most productivity applications. You can also add fonts to your computer by downloading them from online font libraries.¹¹⁵ Font files typically have the “.ttf” file extension, indicating a “true-type” font.¹¹⁶ True-type fonts use technology that makes them look sharp at any size. These files can be dropped to the fonts panel in settings (Figure 65) to be added to the computer, so they are available to all applications.

You're invited to a party — Segoe Script
You're invited to a party — Lucinda Handwriting
You're invited to a party — French Script
You're invited to a party — Brush Script

Script fonts.

Fonts

Add fonts



Drag and drop to install

Drag font files from File Explorer or your desktop and drop them here to install fonts on your device.

Get more fonts in Microsoft Store

Available fonts

Type here to search.



Filter by: All languages ▾

The starry night
brightens our
dreams.

Adobe Devanagari
4 font faces

A gentle moon lulls the
child to sleep.

Agency FB
2 font faces

SPLENDID
FIREWORKS
ERUPTED OV...

Algerian
1 font face

FIGURE 65 — Additional fonts can be added to the Windows operating system via font libraries.

¹¹³ For some font analysis, please see <https://www.dafont.com/we-the-people.font> (accessed June 2023).

¹¹⁴ “Gouverneur Morris,” https://en.wikipedia.org/wiki/Gouverneur_Morris (accessed June 2023).

¹¹⁵ Microsoft’s font library is at <https://learn.microsoft.com/en-us/typography/>. Google maintains a popular font library at <https://fonts.google.com/> (accessed June 2023).

¹¹⁶ True-type was a technology developed by Apple and licensed to Microsoft, <https://en.wikipedia.org/wiki/TrueType> (accessed June 2023).

Points and Pixels

Points were the unit of measurement for printing on paper. When computer displays became popular, measurement units needed to adapt to the limitations of screen resolutions. A unit of measure called pixel was developed that defined font sizes in terms of screen resolution. "Pixel" is an abbreviation for "picture element." It is the smallest dimension that can be manipulated through software on the monitor. This means that if the monitor capabilities change, the actual size of a pixel on the screen will change.

To display fonts at the same size regardless of display or page size—for most word processing or printing—one pixel typically refers to a fixed size of 1/96 inch. Since one point = 1/72 inch, a standard conversion between pixels and points is 12 points = 16 pixels.¹¹⁷

When using a font, you can fine-tune several properties including weight (bold or not), italics, as well as size. Font sizes are typically specified in points. 1 point is 1/72 inch. Most users find a font size of 11–12 points to be the most convenient to read. Figure 66 shows the font panel in Word (you can reach it from “Home” → “Font”), showing several other variants including strikethrough and superscript. A general rule for font use is to select a readable font for the document and use bold, italics, colors, and other variations selectively to draw attention to the text. Too much variation becomes very confusing to the reader.

Spacing

Spacing is the distance between lines and paragraphs of text. Appropriate spacing makes it easier for the reader to consume information. Less spacing makes the text difficult to read, but more spacing can waste paper or simply require unnecessary scrolling. The right spacing balances these conflicting needs. Spacing is a paragraph-level property. Figure 67 shows the spacing options in Google Docs and Word.

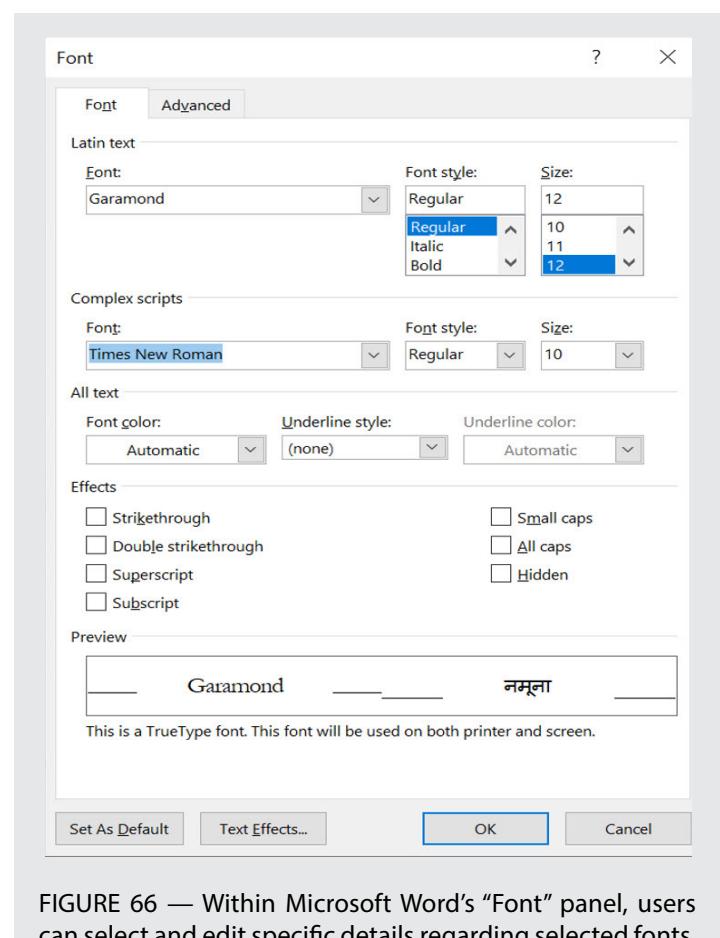


FIGURE 66 — Within Microsoft Word’s “Font” panel, users can select and edit specific details regarding selected fonts.

¹¹⁷ A nice article explaining these units and their origins is Gordan Banjac, “Difference Between Pixel (Px) and Point (Pt) Font Sizes in Email Signatures,” <https://blog.gimm.io/difference-between-pixel-px-and-point-pt-font-sizes-in-email-signatures/> (accessed June 2023).

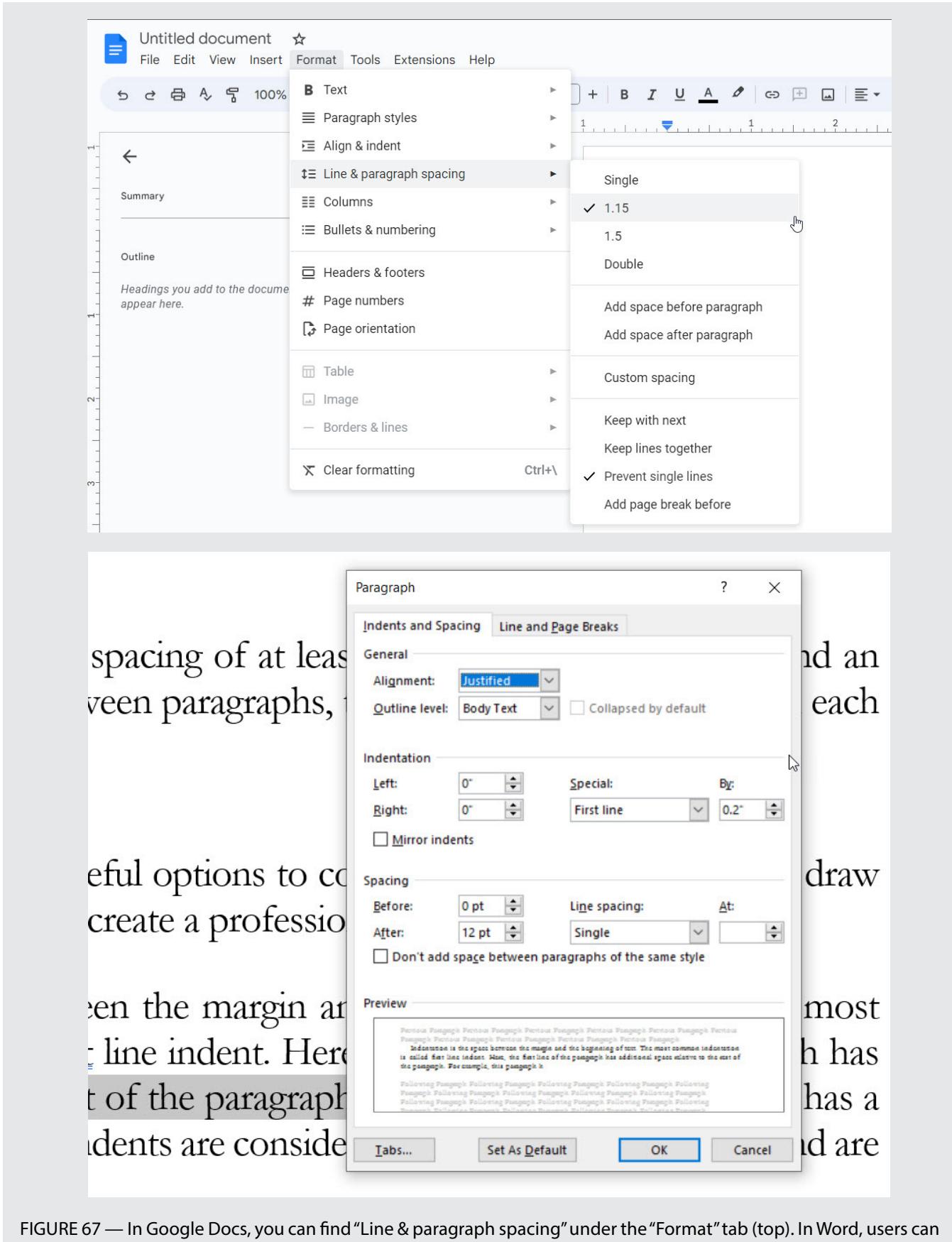


FIGURE 67 — In Google Docs, you can find “Line & paragraph spacing” under the “Format” tab (top). In Word, users can edit spacing in the “Paragraph” submenu (bottom).

To change spacing in Microsoft Word, select any text, then right-click, and choose the paragraph option. You will see a toolbox that has the option to adjust the spacing between lines and paragraphs.

For readability, we recommend a spacing of at least 1 line (called single-space) and an additional spacing of 6 points between paragraphs, to distinguish paragraphs from each other.

Indentation and Alignment

Indentation and alignment are useful options to consider to improve readability, draw attention to content, and generally create a professional document. (Figure 68)

Indentation is the space between the margin and the beginning of the text. The most common indentation is called first line indent where the first line of the paragraph has additional space relative to the rest of the paragraph. For example, this paragraph has a first-line indent of 0.25". First-line indents are considered indications of continuity and are typically used to indicate to the reader that the idea in the paragraph is related to the idea in the previous paragraph.¹¹⁸

Another common indentation is called hanging indent. The hanging indent is the inverse of a first-line indent, whereby all lines except the first line are indented. For example, this paragraph has a hanging indent of 0.25". Hanging indents are commonly used in references and allow the eye to easily skim through a list of references to quickly find articles by an author since the hanging indent offsets the author's name from the rest of the text.¹¹⁹

You can also indent both the left and right sides of a paragraph. This can be a powerful visual cue, for example, to indicate that the text is reproduced verbatim from a source, or is a quote from a source, etc. This paragraph has an indentation on both sides of .5".

Alignment is the orientation of the edges of paragraphs. Text can be left-aligned (the left edge of the paragraph is flush with the left margin), right-aligned, centered, or justified (both the edges of paragraphs are flush with the respective margins as in this paragraph). Different languages have their own indentation and alignment rules. In Arabic, the text is aligned right, and in English, it is aligned left.

118 A good description is written by Louise Harnby, "When to indent text: Laying out narrative and dialogue in fiction," <https://www.louiseharnbyproofreader.com/blog/when-to-indent-text-laying-out-narrative-and-dialogue-in-fiction> (accessed June 2023).

119 This article, "When Do You Indent a Paragraph?" has some recommendations from the style manuals, <https://www.grammarly.com/blog/great-indentation-debate> (accessed June 2023).

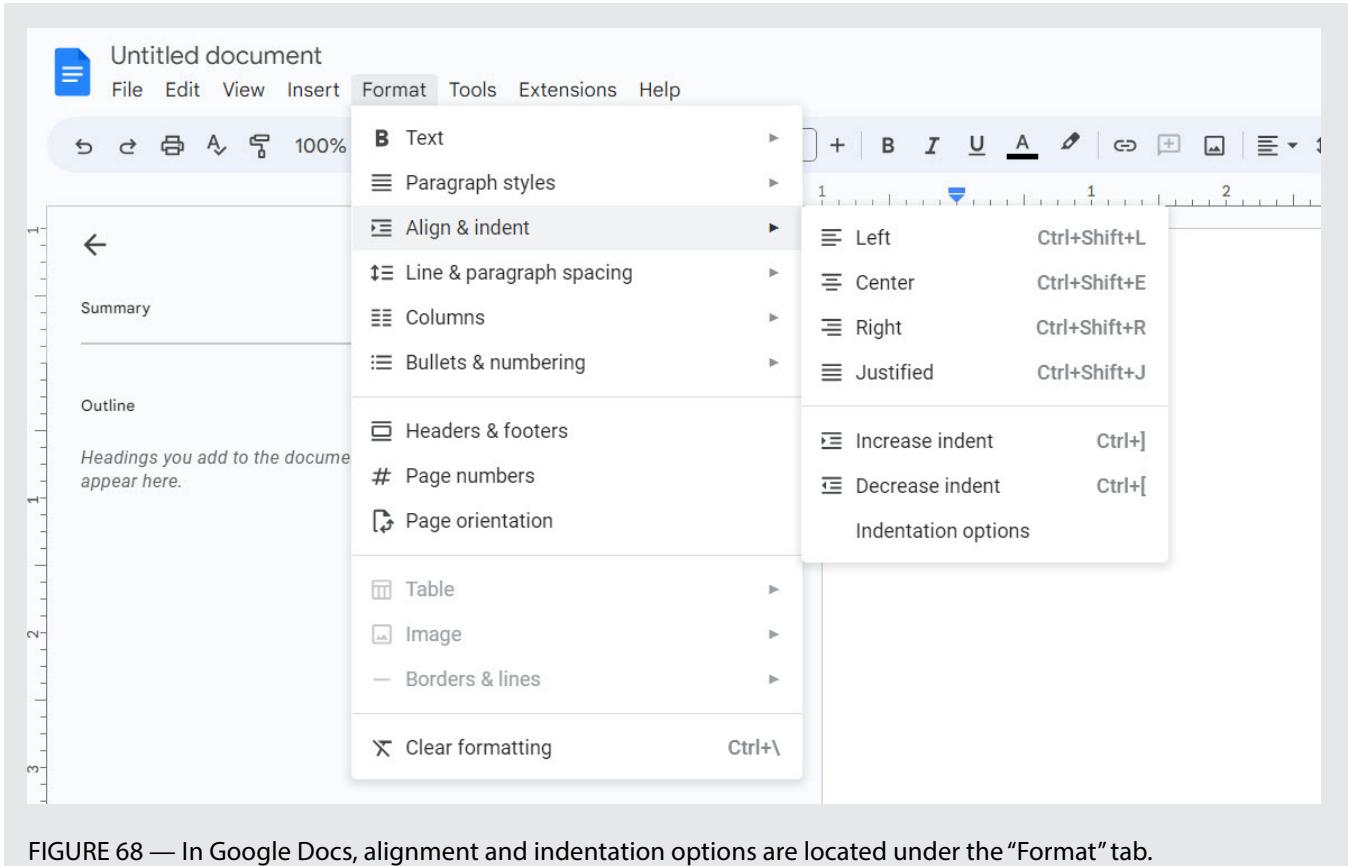


FIGURE 68 — In Google Docs, alignment and indentation options are located under the “Format” tab.

Justified text looks neat in print; therefore, most newspapers use justified text. However, the justified text also creates additional spaces between words, which can hurt readability. Therefore, the left-aligned text is often considered a good choice.¹²⁰

Lists

You may need to create a list if you go shopping, want to jot down the names of invitees, or need to have the supplies for the chemistry lab handy in one place. Word processing software helps you quickly create bulleted or numbered lists with automatic renumbering in case you change your mind and want to remove or reorder items. Bulleted list items are not numbered and should be used if the items are not in any specific order. On the other hand, numbered lists work well if you want to jot down instructions that are in a sequence. For example, it will make sense to use a numbered list to write down the lab instructions for a chemical reaction. Each list item can have its own list, creating a list within a list, called nested lists. In most word processors, lists are accessible from the “Home” menu.

- Animals
 - Cat
 - Dog
 - Horse
 - Birds
 - Eagle
 - Sparrow
 - Fish
 - Shark
 - Salmon
- An example of a nested list.

120 Justification is explained in, Aaron White, “Justify vs Align: Getting Started with Type Layout in InDesign,” <https://www.shutterstock.com/blog/justify-vs-align-guide-to-type-alignment> (accessed June 2023).

Styles

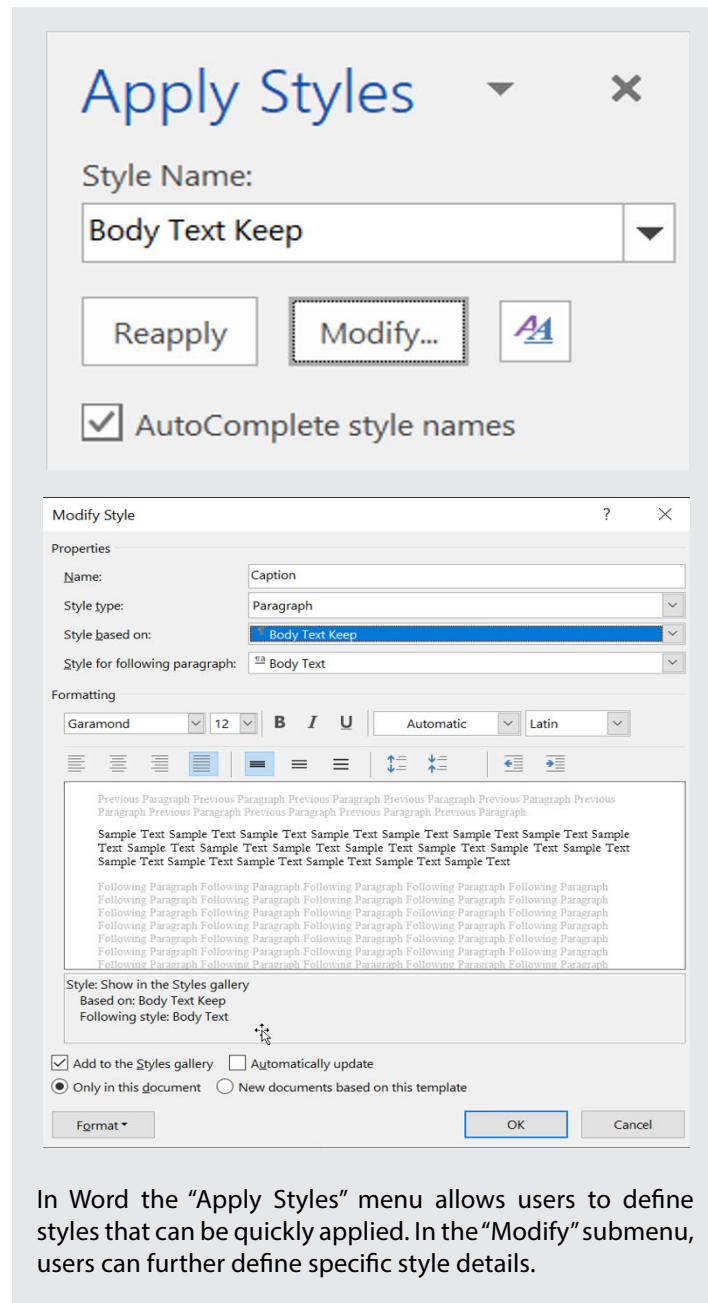
Creating digital documents with a consistent look and feel requires selecting combinations of the parameters we have discussed so far—fonts, spacing, indents, alignment—as well as several other parameters we have not discussed and which you will discover as you use word processors. The use of [styles](#) can really help you if, for instance, you would like one combination for text, another for headings, another for quotes, and another to emphasize certain sentences. Most users simply select words, sentences, or paragraphs and use the word processor interface to apply the appropriate fonts, spaces, etc. This works, but is a very inefficient way to create documents, and does not leverage a powerful feature of word processors—styles.

Styles are combinations of formatting features that can be applied to text to instantly change its appearance. By learning about styles and using them consistently, you will greatly improve your productivity in creating digital documents. For example, in creating this text, we defined a style we named “Body Text Keep,” which used Garamond font, size 12pt, single-spaced with 12pt space between paragraphs. By defining this style, we could simply apply the style to any paragraph to make it look identical to every other paragraph using this style. Later, we decided to use a different font for the text, so all we needed to do was change the font in the style definition and it was applied to the entire book.

Another advantage of styles is that they are hierarchical. For example, if we define a style for “Captions,” and the style is based on “Body Text Keep,” any changes to “Body Text Keep” will propagate to the “Caption” style. If we change the font of “Body Text Keep” from Garamond to Helvetica, the font for “Captions” will also change to Helvetica. This becomes a powerful feature for documents to remain consistent even with substantial changes to individual parameters.

We have used styles throughout this text, and it has greatly simplified our work.

Styles serve another meaningful purpose. There is a special class of styles called “Headings.” Word processors can build a table of contents easily from a document that has been correctly styled with



In Word the “Apply Styles” menu allows users to define styles that can be quickly applied. In the “Modify” submenu, users can further define specific style details.

headings. The software goes through the document to pull headings and subheadings that will show up as links in the table of contents. [Figure 69](#) shows a list of styles defined in Google Docs.

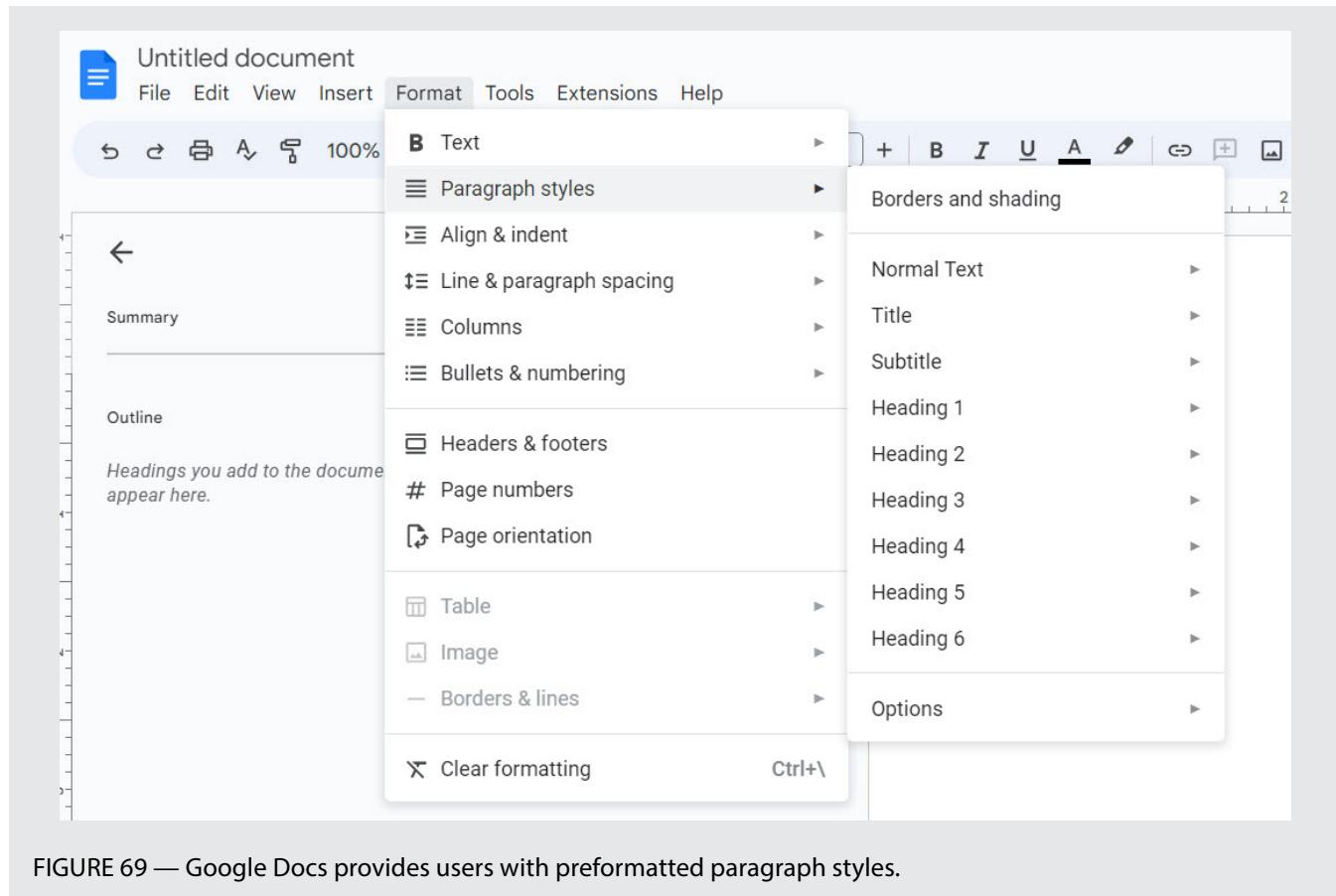


FIGURE 69 — Google Docs provides users with preformatted paragraph styles.

Check out the comprehensive list of styles Microsoft offers in the “Styles Gallery” on the “Home” tab of Word ([Figure 70](#)).

Tables

Readers can grasp complex data far more easily if it is presented in a tabular form as opposed to plain text. Tables are also useful to highlight trends and sudden increases or decreases in values. Below is an example of a partial roster of players of high school football teams playing a game. The table elegantly captures the roles of each team member, which would be very difficult to capture in plain text.

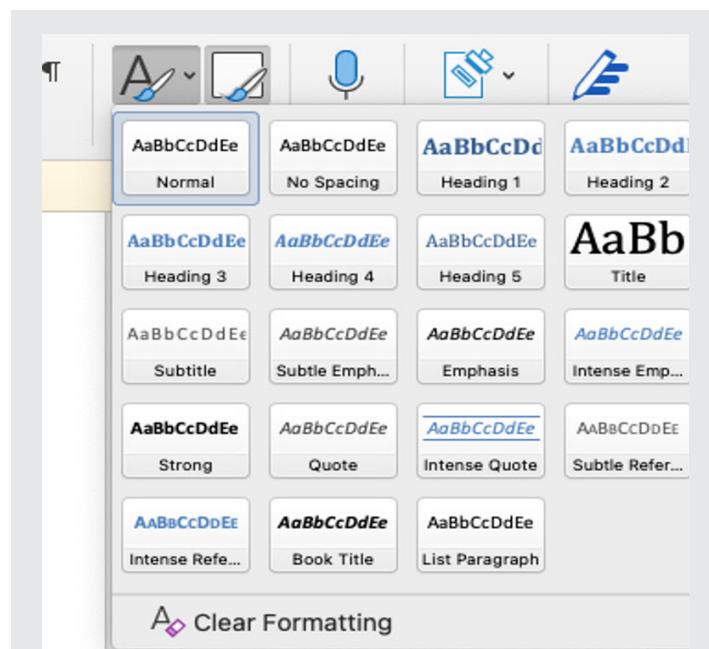


FIGURE 70 — Word has many preformatted styles users can choose from, each with a specific purpose detailed under the style.

Role	Coastside High	Bayside High
Quarterback	Alex Johnston	Conan Morrison
Left tackle	Angel Howard	Daryl Gilliam
Left guard	Arthur Smith	Edmund Day
Center	Ben Knight	Harold Sloan
Quarterback	Ryan Carter	Jack Walker

All word processors make it easy to work with tables. You can format tables and add and remove columns in no time. They also give you the ability to create tables from predefined templates (e.g., [Figure 71](#)).

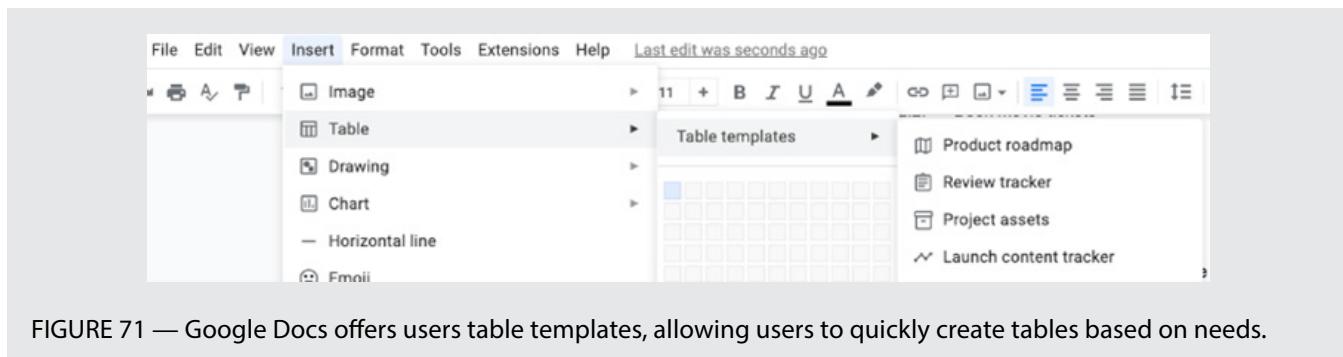


FIGURE 71 — Google Docs offers users table templates, allowing users to quickly create tables based on needs.

To format a table in Word or Google Docs, just right-click on the table to bring up a context-sensitive menu that lets you add/remove rows and columns and change the look and feel of the borders.

Captions

A convenient feature that further improves the usefulness of tables and other objects inserted into documents is captions. A caption is a title or brief explanation that is added to tables, figures, and other objects. For example, “[Figure 72](#) — Word processing applications allow users to format specific details of tables, increasing customizability.” is the caption to the next figure. Captions have three special features that make them very useful: 1) word processors add a sequence number to captions by default; 2) word processors add the caption style to captions by default to give them a distinctive appearance; 3) captions can be referenced later in the document. We show how to do this in the next section.

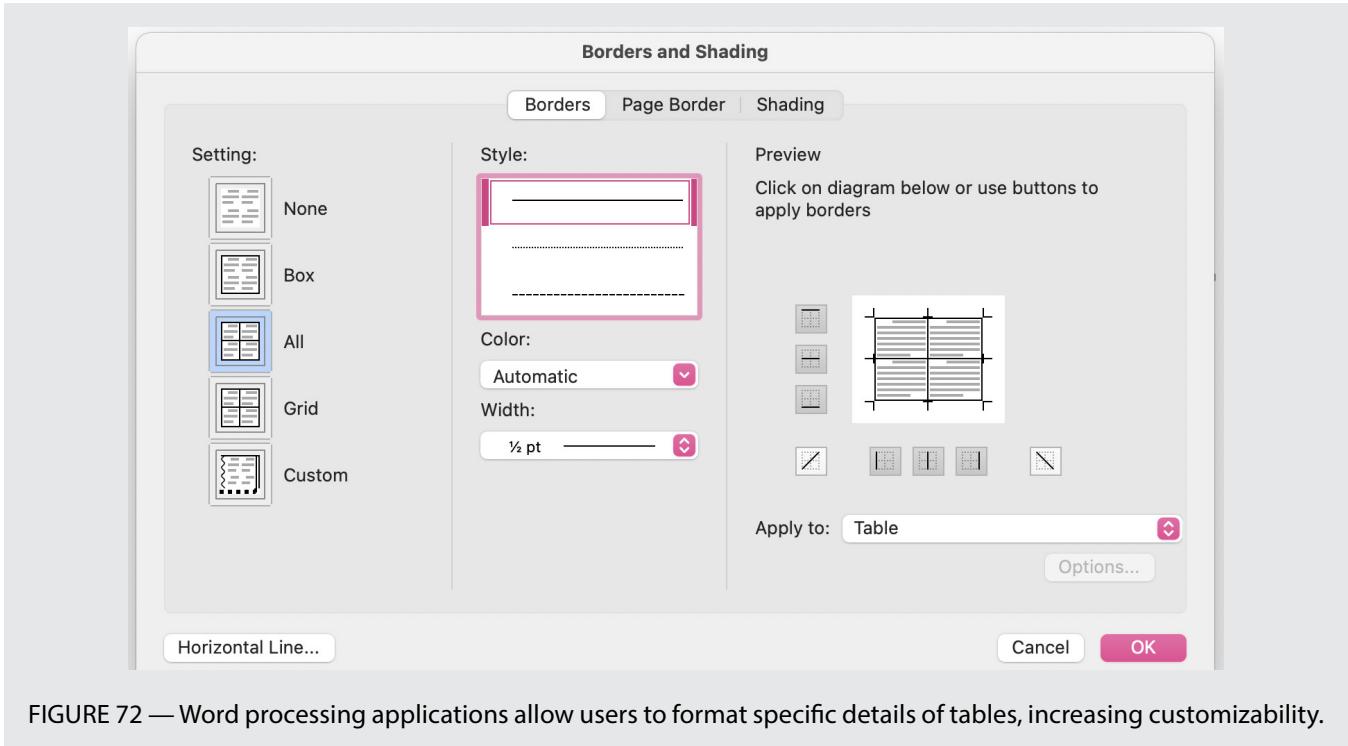


FIGURE 72 — Word processing applications allow users to format specific details of tables, increasing customizability.

To add a caption to a table or figure in Word, select “References” → “Insert Caption.” This brings up the dialog in [Figure 73](#). You can select one of the existing labels or add a new label. Each label has its own series of sequence numbers.

References

A powerful, but very underused capability in word processors is to insert references to captions. When you insert a table or figure in a document, you almost always want to refer to it in the document. Most users type in the caption label and sequence number into the document. But this is fragile. If you add, remove, or modify captions, the sequence numbers will get updated and the references will be incorrect. Word processors offer a powerful and convenient way to leverage your computer’s capabilities to refer to captions correctly using the “insert references” feature.

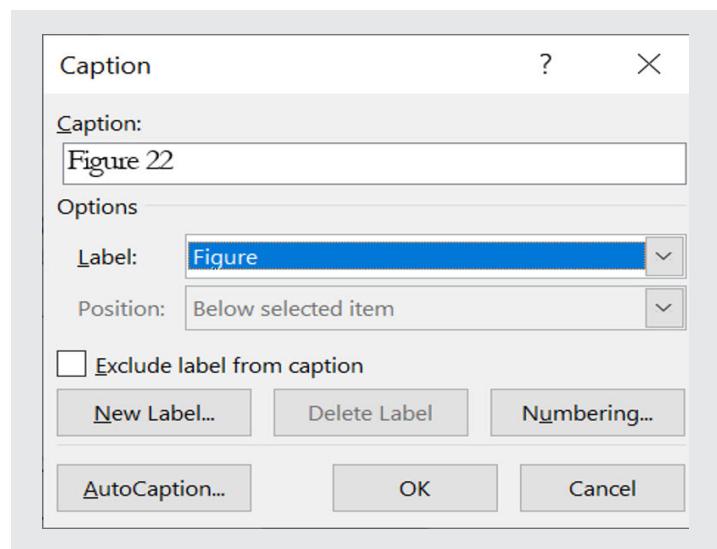


FIGURE 73 — Users can add captions to tables and figures to help explain their work.

To insert a reference, select “Insert” → “Cross-reference” to bring up the dialog in [Figure 74](#). In the reference type selector, select the caption, e.g., figure or table, and select the information to refer to in the “Insert Reference to” selector. Selecting “label and number” adds the right reference such as “figure 23” to the caption selected in the “For which caption” selector. Now, the word processor will ensure that the caption numbering is automatically updated even when you move captions around.

Insert Menu

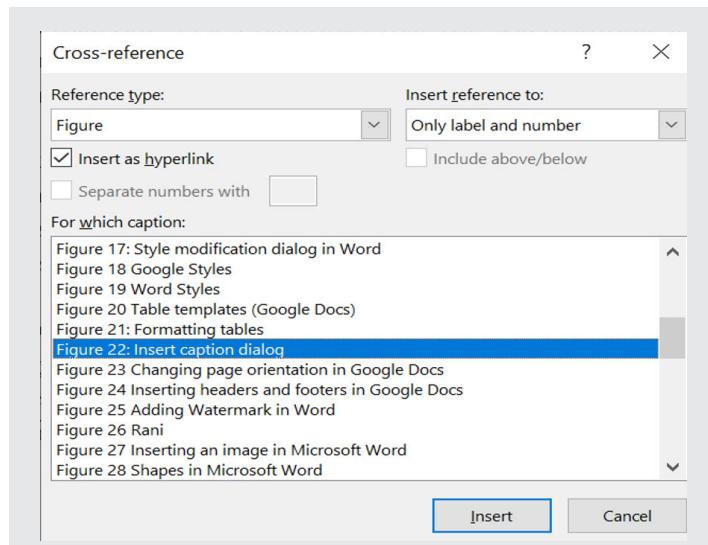
Captions and references are examples of specialized information that can be inserted into documents. You can explore the different options in the “Insert” menu such as pictures (images), shapes (arrows, triangles), bookmarks, text boxes, fields, and symbols.

One interesting option in the insert menu is symbols (“Insert” → “Symbol” → “More symbols”). This brings up the dialog in [Figure 75](#). You can insert almost any non-alphabetic character into the document from this dialog. We have used this dialog a lot in this book, for symbols such as   and .

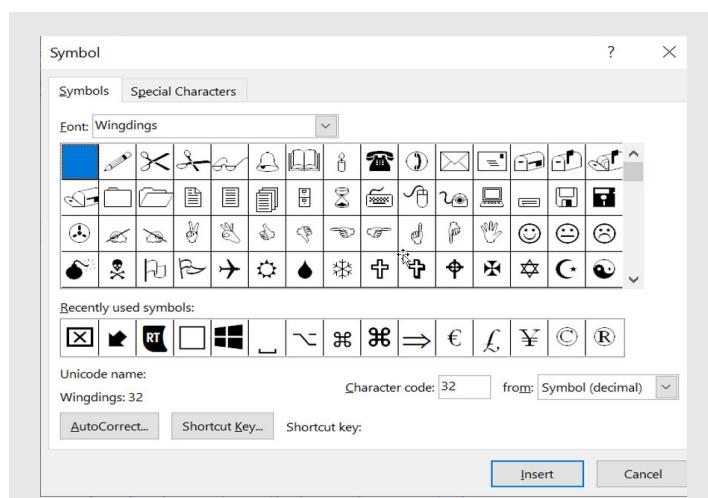
Keyboard Shortcuts

One very useful capability of word processors that greatly improves productivity is [keyboard shortcuts](#). Keyboard shortcuts are key combinations that give immediate access to specific functions in a computer program. Here are some keyboard combinations we have used extensively in this book.

- | | |
|----------------|---------------------------|
| Alt+I+N+C | Insert caption |
| Alt+I+N+R | Insert reference |
| Alt+I+S | Insert symbol |
| Ctrl+Alt+1/2/3 | Apply heading style 1/2/3 |



[FIGURE 74](#) — The “Cross-reference” menu allows users to add references to figures, tables, or paragraphs.



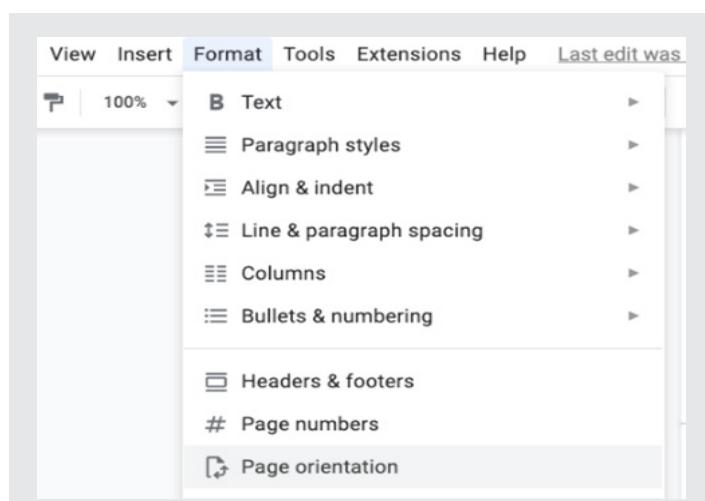
[FIGURE 75](#) — Word allows users to add symbols to documents via the “Symbols” menu.

Page Layout

We now introduce page-level features of word processors. The basic page-level property is the **page layout**. The page layout of digital documents is the arrangement of margins, content, and orientation of the page. As you create your document, it is useful to pay attention to how it will be consumed, so you can specify the layout for best readability. Is it a letter that you will print and mail out? If so, the layout should have a margin at the top to accommodate the organization's logo and the dimensions of a standard letter-sized sheet of paper. Is it a pamphlet that you will distribute at the mall? If so, you might want the layout to support folding the page into three sections. Is it a documentation manual that will be printed and made into a spiral-bound book? If so, the layout should support a wide internal margin where the spiral binding will go. Or will it be your magnum opus debut novel that will be read by millions of fans? If so, the layout should reflect the trim size recommended by the publisher.¹²¹ Thankfully, word processing software makes it easy to specify the layout of the document and modify it as needed, so you can quickly get the outcome you desire.

Orientation

Page orientation is how the rectangular dimensions of the page are placed for normal viewing. Whether the page should be horizontally or vertically oriented is important to consider. There are two possible orientations—portrait and landscape. In portrait orientation, the height of the page is greater than the width. This nomenclature comes from the standard appearance of a portrait where the height is greater than the width to capture the face and upper body in the picture. On the other hand, a page with a landscape orientation has a greater width than height. This nomenclature also comes from the visual arts where landscape photographs are typically wider than they are tall.¹²² If you are making a coffee-table book with wonderful, wide photos, you may want to use the landscape format. Any word processing software will allow you to change the orientation of a document easily.



Users can change a document's orientation in Google Docs to suit the purpose.

Other Page Layout Properties

Other than orientation, you should also consider the page size, margins, headers, footers, indentation, and spacing of your pages. If you want to print your pages on standard printer paper, you may want to choose 8.5 inches by 11 inches as your page size (if you are in the U.S.) or A4 in some other parts of the world.

121 "How to Choose a Trim Size: A Guide to Standard Book Sizes," <https://www.masterclass.com/articles/a-guide-to-standard-book-sizes> (accessed June 2023).

122 "Page Orientation," https://en.wikipedia.org/wiki/Page_orientation (accessed June 2023).

Headers and Footers

Headers and footers are informational text that is separated from the main content and appears at the top or bottom margins of a page. It is common to have headers and footers in long documents, like textbooks, novels, company quarterly reports, and product documentation. You may have noticed headers and footers as page numbers at the bottom of the page or as chapter titles at the top of the page. Headers and footers are typically unchanged throughout sections of a piece of work and help guide readers through large documents. Headers and footers are also commonly used to promote organizational branding by including the company name, author name, or company logo. Headers and footers not only give the document a professional and consistent look but also make it easy to identify and restore missing pages.

Headers and footers are accessible from the “Insert” menu in most word processors. [Figure 76](#) shows the “Insert” menu in Google Docs showing the “Headers and Footers” option.

As with all other word processing features that leverage the computer’s capabilities, headers and footers are updated as you update your document. For example, as you write, word processing software will automatically update page numbers when you add or remove pages.

Image Editing

No doubt, images make your document more readable and convey information far more intuitively than words. If you are writing a school essay about your cute pet, Alma, it makes sense to include a picture of Alma along with a description of how she looks. Both Google Docs and Microsoft Word make it easy to insert photos, either from the web or from your computer’s hard drive (“Insert” → “Pictures” as in [Figure 77](#)). If you right-click the image, you will get a context menu that lets you format the image to adjust its border, colors, and transparency. You can crop the image to a size you like and adjust other properties like brightness, contrast, and aspect ratio (the ratio of its width to height). Experiment with these properties to develop a personal style you like. Once you insert images, they become part of your document and will be there on the printed pages.

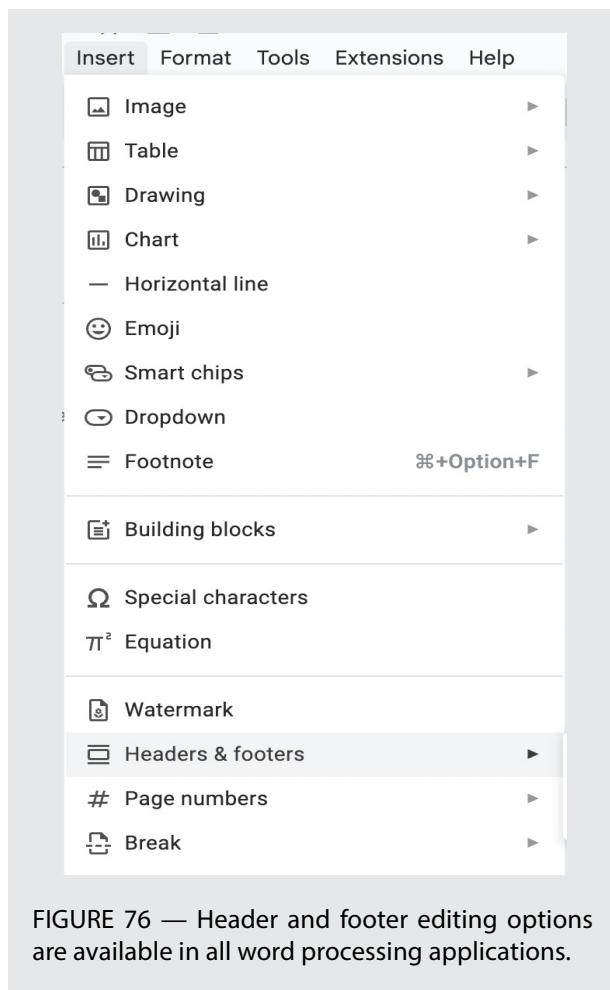


FIGURE 76 — Header and footer editing options are available in all word processing applications.



Word processing applications allow users to integrate images in their documents to support text.

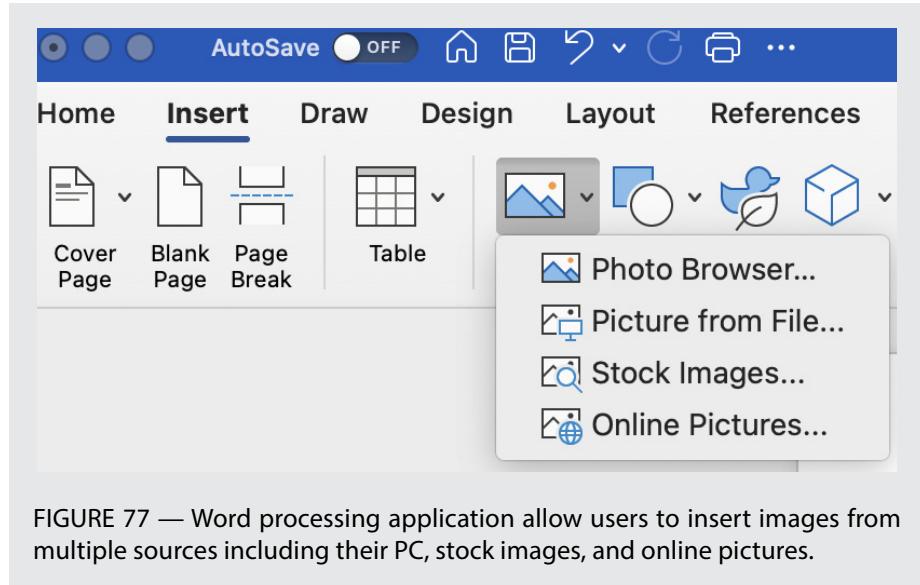


FIGURE 77 — Word processing application allow users to insert images from multiple sources including their PC, stock images, and online pictures.

As we will discuss in [Chapter 17](#) on ethics, if you insert pictures from the web, make sure to not use any copyrighted content without the owner's permission. If you choose to create your own image, you can take advantage of drawing tools available in Docs and Word, including shapes, arrows, text boxes, flowcharts, and banners.

Shapes

To create your own drawing in Google Docs, go to the "Insert" tab and select "Drawing" and "New." In Word, use "Insert" → "Shapes" ([Figure 78](#)). After you are done adding shapes and images to the new palette, the drawing gets inserted into your document the moment you save and close the palette. Both Google Docs and Word offer a wide range of shapes to let you create your own drawing.

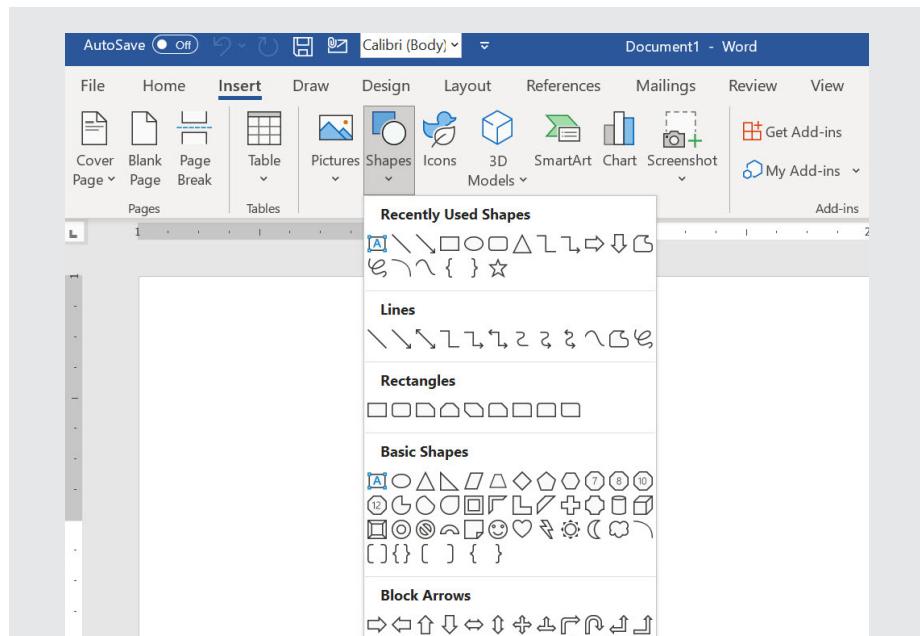


FIGURE 78 — Word allows users to add shapes to documents, which can improve clarity.

Revision and Proofreading

Whether you are writing high school essays, emailing a colleague, or working on your thesis, your work will improve tremendously through revision. Your first draft is likely to contain spelling mistakes, grammatical errors, and poorly structured ideas and sentences. As you revise the document and have your colleagues review your work, it will get consistently better. For example, this textbook went through several rounds of revision as the authors and teachers revised the contents. Word processing software provides several powerful tools to help with the revision and proofreading process. We introduce some of the commonly used tools in this section.

Track Changes

Track changes is the ability of word processors to keep track of any changes to a document. Tracking changes allows you to share your updates with reviewers and view their comments and updates. Word processors clearly indicate any changes and make it easy for authors and reviewers to accept or reject the suggested changes.

In Word, under the “Review” tab, there is “Track Changes” that can be enabled by clicking on it (Figure 79). Once track changes is on, Word will highlight any changes made to the document, so editors of the document can view, accept, or reject changes. When track changes is enabled, Word processors use different colors to highlight the text inserted by different authors. The keyboard shortcut to toggle track changes on or off is “Ctrl+Shift+E.”

The screenshot shows the Microsoft Word ribbon with the "Review" tab selected. In the main document area, there is a note about inserting headers and footers in Google Docs. On the right side, there is a sidebar titled "M (Personal) Agrawal" showing two comments. The first comment says, "I deleted watermarks as it is less common. If we wish to retain it, can undelete it." and is dated "December 25, 2022, 5:06 PM". The second comment says, "I used a Spanish name since probably resonate more with readers." Both comments have a "Reply" button below them. The status bar at the bottom shows the number "19".

FIGURE 79 — Word allows users to track their changes throughout their document. This is especially useful when collaborating with others.

When you are ready to accept/reject the changes made by your reviewers, you can see the comments and changes by selecting “All Markup” from the dropdown next to “Track Changes.” To see your original document, just select “Original.” You can also see the final clean document with all the changes made by your reviewers by selecting “No Markup.” When you have accepted or rejected the changes and no longer want to track changes, turn it off by clicking the “Track Change” button again.

Google Docs offers a slightly different mechanism to track changes. The “Editing” dropdown in the top right side of the ribbon has “Editing,” “Suggesting,” and “Viewing” modes. (Figure 80)

The “Viewing” mode is “Read-only,” so you cannot accidentally make changes. In the “Editing” mode, make sure to undo changes if you insert words you don’t want. The suggesting mode is analogous to track changes in Word. In the “Suggesting” mode, any text you type is highlighted in a green box and your suggestions show up in a comment box next to the document. You or any other editor of the document has the option to “Accept” or “Reject” the change. If you click “Accept,” the text will get inserted into the body of the document, and it will get removed if you click “Reject.”

Using track changes will greatly simplify your ability to work with friends on collaborative projects.

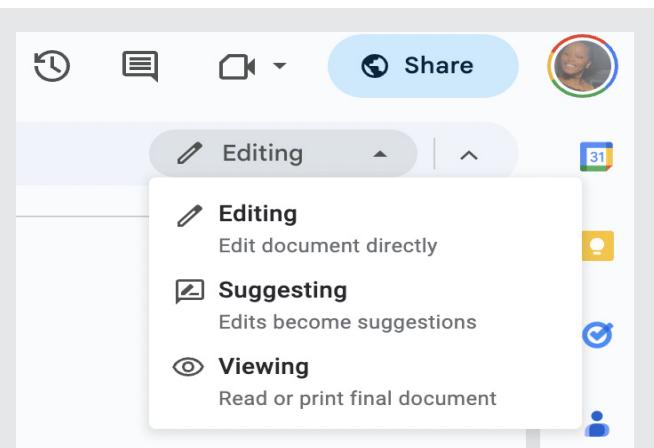


FIGURE 80 — Google Docs offers users three different editing modes, each with their unique rules and limitations.

Comments

A comment is a remark or observation. Adding comments to a document is like scribbling notes on the side of a physical book. Word processors support comments to allow reviewers to comment on a document in a non-intrusive way. While comments in physical books are typically reminders you make to yourself about something you noticed on the page, comments in word processors are typically used by reviewers to exchange observations with each other to improve the document. Typical comments may include suggestions to add examples, simplify language, reduce length, etc.

To comment, just go to the spot where you want to add a comment and choose the “Comment” option under the “Insert” menu in both Word and Docs. Alternatively, you could highlight any text and right-click to comment (Figure 81). The keyboard shortcut to add a comment is “Ctrl+Alt+M.”

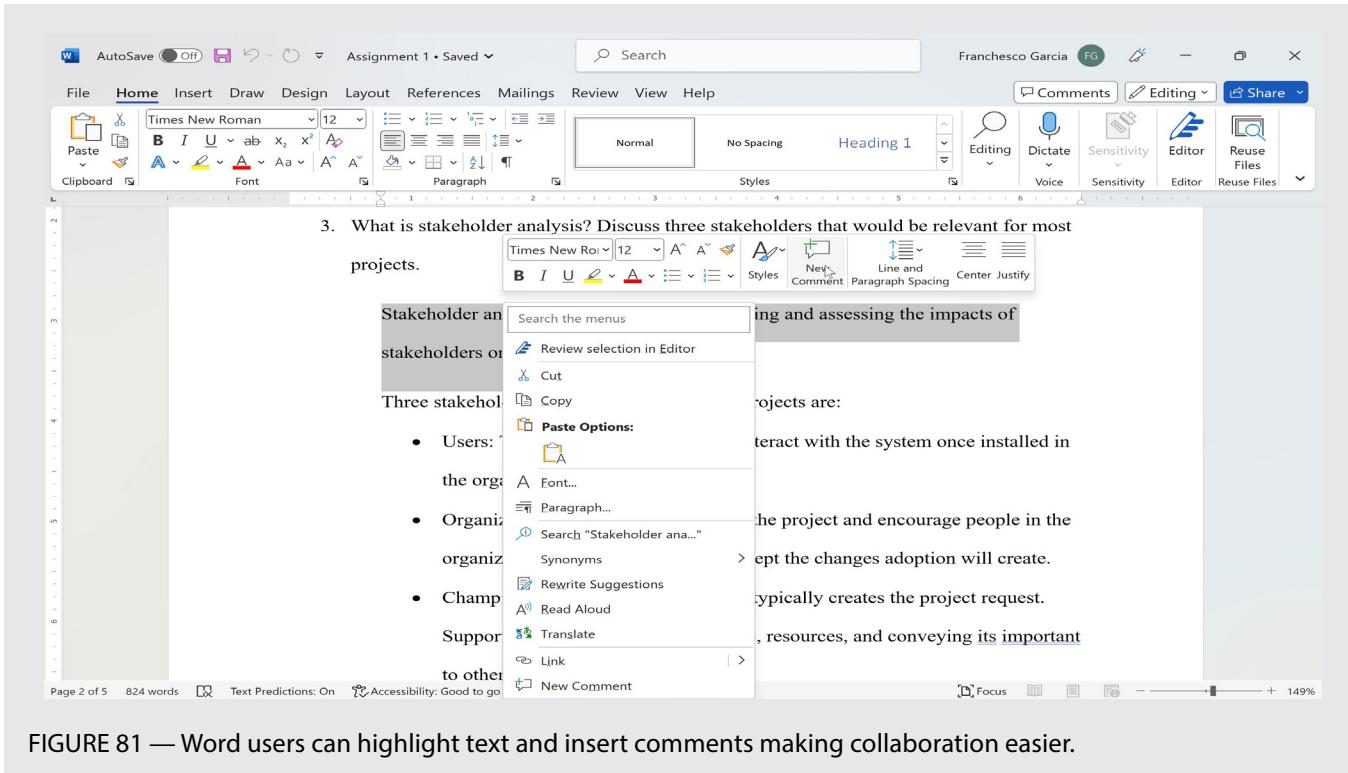


FIGURE 81 — Word users can highlight text and insert comments making collaboration easier.

Find and Replace

Find and replace is a pair of powerful features that lets you find and highlight all occurrences of a particular word or phrase. In Google Docs, you can launch these features by going to “Edit” and selecting “Find and Replace.” (Figure 82) You can replace words or phrases one at a time or all occurrences at once. This feature is useful when trying to avoid overusing the same word many times. For example, if you discover that you have misspelled a name, you can fix the spelling throughout your document with the click of a button. “Advanced Find & Replace” also allows you to find all forms of a word. So, if you look for “dance,” the software will highlight all occurrences of dance, danced, dances, and dancing. If you choose to match the case of a word you want to find, the tool will do a case-sensitive find. For example, if you look for “print,” it will ignore Print, PRINT, and prinT.

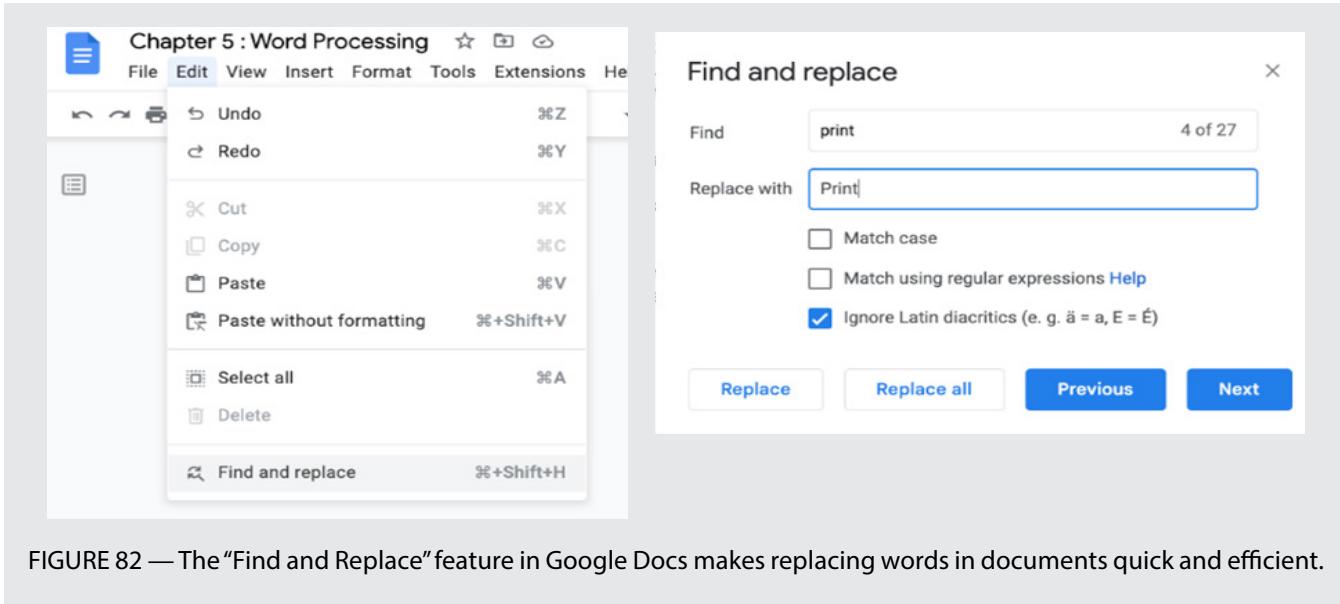


FIGURE 82 — The “Find and Replace” feature in Google Docs makes replacing words in documents quick and efficient.

In Word, you have the search icon (a magnifying glass) on the top right-hand side of the “Home” ribbon. Once you click on the icon, you get an option to type the word/phrase you want to find. (Figure 83)

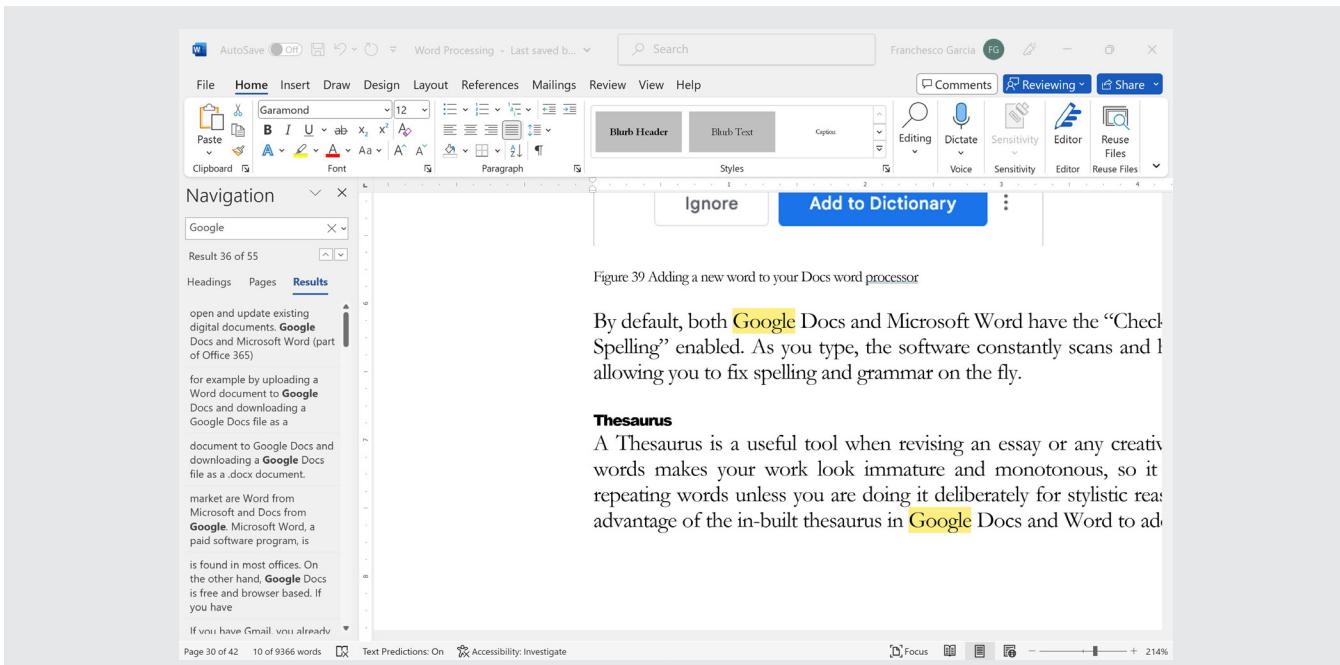


FIGURE 83 — The “Search” feature in Word allows users to quickly find key words in documents and highlights all occurrences of the key word.

Of course, the keyboard shortcut “Ctrl+F” works in almost every application to open the find dialog. In Word, “Ctrl+H” opens the find and replace dialog.

Spelling and Grammar

As you become comfortable with word processors, you can begin focusing on using their more sophisticated capabilities to improve your writing and remove common errors. [Spelling and grammar](#) tools use AI techniques to catch spelling and grammar errors and suggest potential fixes. Both Google Docs and Microsoft Word provide comprehensive spelling and grammar checkers, inbuilt thesaurus, and word-count monitors. In Google Docs, select “Spelling and grammar” under the “Tools” tab. ([Figure 84](#))

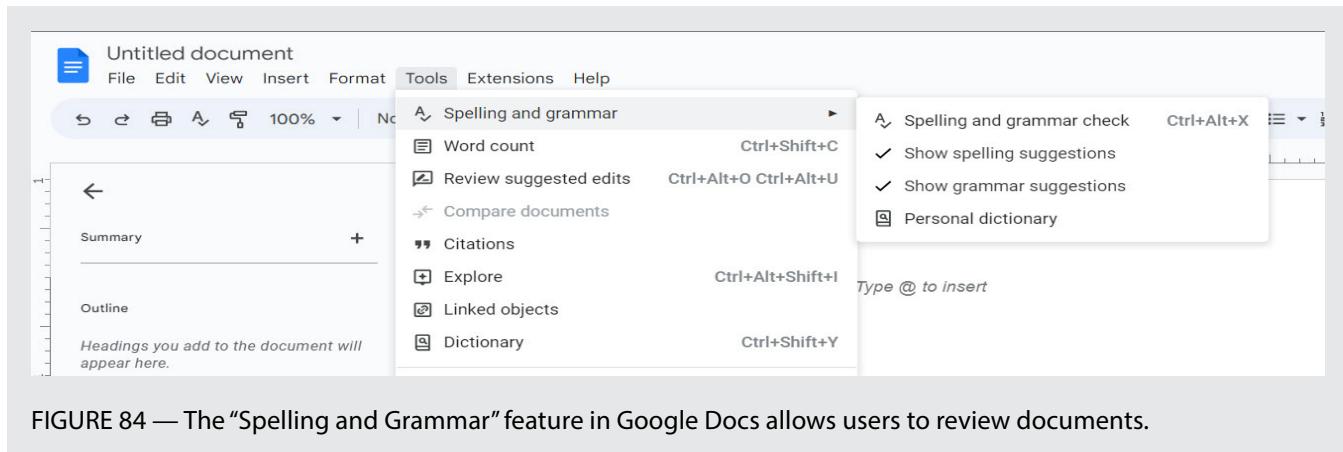


FIGURE 84 — The “Spelling and Grammar” feature in Google Docs allows users to review documents.

Once you run the “Spelling and grammar” checker by selecting it, the system will pop a suggestion box with recommendations, and you have the option to “Ignore” or “Accept” recommendations. If you accept any suggestions, the changes are applied immediately.

Not surprisingly, word processing software has difficulty with names of people, places, and things. But you have the option to add new words to your “Dictionary” to ensure the software remembers the words as acceptable words (nouns) and ignores future occurrences of these spellings. ([Figure 85](#))

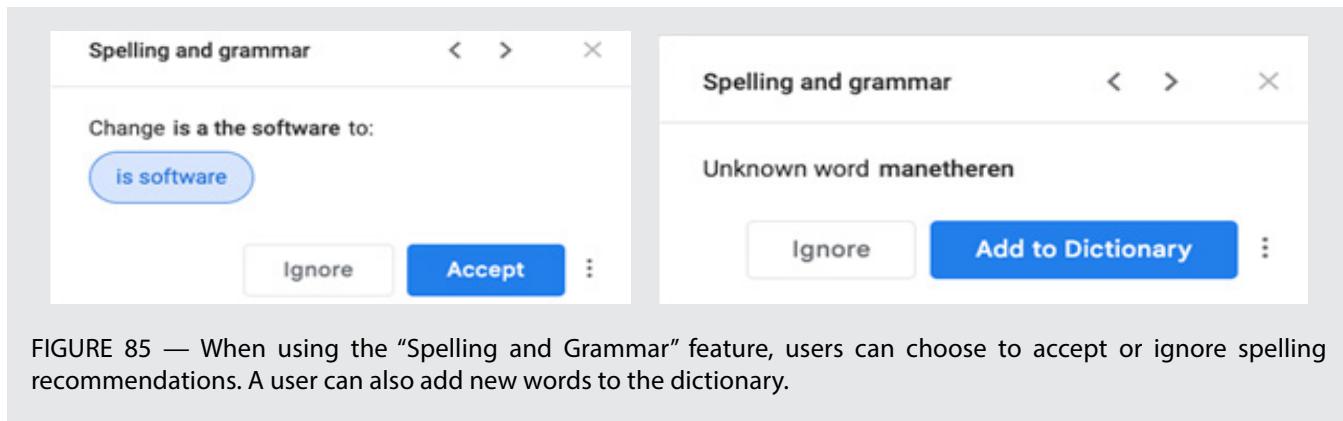


FIGURE 85 — When using the “Spelling and Grammar” feature, users can choose to accept or ignore spelling recommendations. A user can also add new words to the dictionary.

By default, both Google Docs and Microsoft Word have the “Check for Grammar and Spelling” enabled. As you type, the software constantly scans and highlights mistakes, allowing you to fix spelling and grammar on the fly.

Thesaurus

A thesaurus is a useful tool when revising an essay or any creative work. Repeating words makes your work look immature and monotonous, so it is useful to avoid repeating words unless you are doing it deliberately for stylistic reasons. You can take advantage of the in-built thesaurus in Google Docs and Word to add variety and color. In Google Docs, highlight any word and select “Tools” → “Dictionary” to find the meaning and synonyms. Results appear as shown in Figure 86.

In Microsoft Word, you can achieve the same effect by selecting a word and then choosing the “Thesaurus” option under the “Review” tab (Figure 87).

These tools to check spelling, grammar, and find-and-replace words are tremendously useful to polish up your work, remove redundancy, and make the text more enjoyable for readers.

References

Most documents are created to convey an idea to the reader. In addition to appearance and general readability, references to prior work can further enhance the credibility of the information presented. References also help readers locate related information to learn more about the topic if needed. Now we introduce the essential capabilities of word processors to help you enhance your documents with references.

Citations and Bibliography

A citation is a reference to a source of information. A bibliography is a list of information sources (books and articles) used in the document. For almost any writing, and particularly for books, theses, or other detailed documents, you will need to reference and build upon the work already done in the field. If you refer to research, news sites, or books that are accepted as reputable sources, the ethical thing to do is

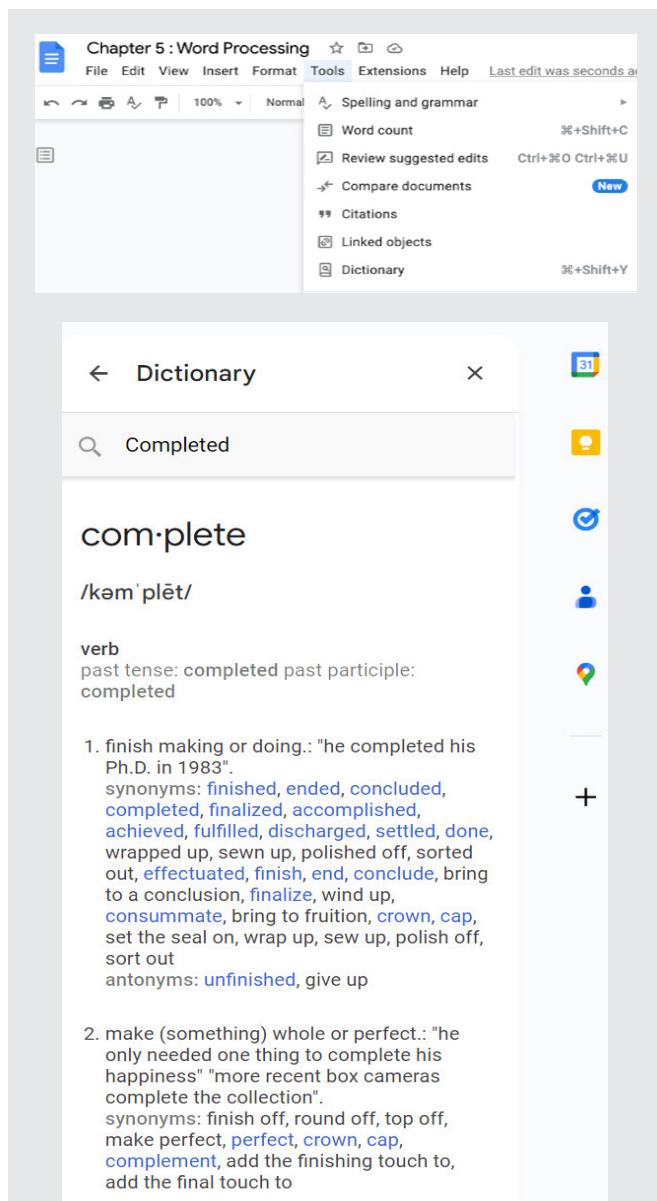


FIGURE 86 — The dictionary in Google Docs can be found under the “Tools” tab and will show the results of your chosen word making it easy to reference.

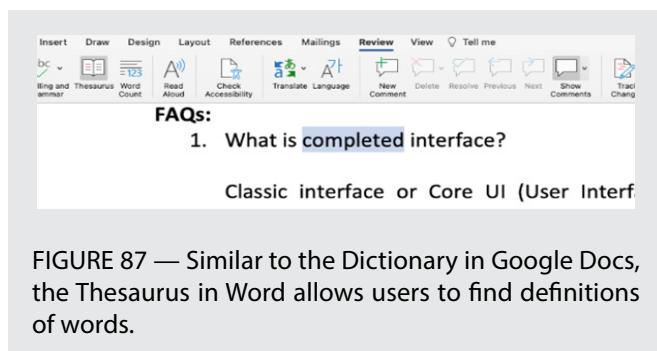


FIGURE 87 — Similar to the Dictionary in Google Docs, the Thesaurus in Word allows users to find definitions of words.

add citations to prior work to give credit to the original creator of the content. This will also allow your readers to go deeper into that topic by reading the original source.

Both Google Docs and Microsoft Word provide ways to add citations in an industry-standard format and to refer to them throughout your document. In Google Docs, you can start creating your collection of citations by launching “Citations” under the “Tools” tab. Once you select the style (MLA, APA, or Chicago), you can select “Source type” and “Accessed by” (how to access the source). You can give the ISBN of a printed book or the link to the online copy of the article. Once you have your library of citations, you can go to the place where you want to make a citation and insert the citation in your document. To create a bibliography at the end of your document, move your cursor to the end and insert all the cited works with a click. (Figure 88)

Microsoft Word also offers a similar framework to create citations under the “References” tab. The “Citations” tool here offers many styles and is feature rich and comprehensive. You can even cite films, interviews, patents, and articles presented at conferences.

Hyperlinks

Hyperlinks are shortcuts in a document to other parts of the Internet. If you embed hyperlinks in your documents, any reader clicking on that link will go to the target location. For example, to put a hyperlink pointing to the University of South Florida, select any text, then right-click to bring up the context-sensitive menu, and select “Link” (Figure 89).

In Microsoft Word, a new screen opens

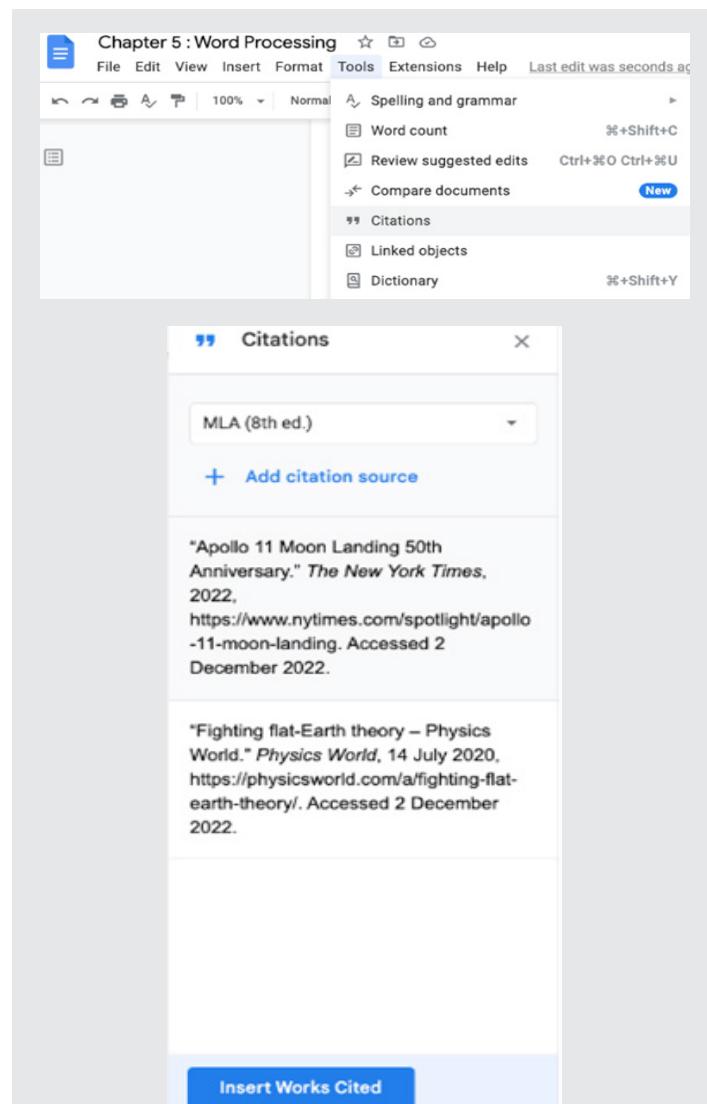


FIGURE 88 — In Google Docs, “Citations” can be found under the “Tools” tab. Your citations are organized in a library and gives users the option to insert a works cited section to the document.

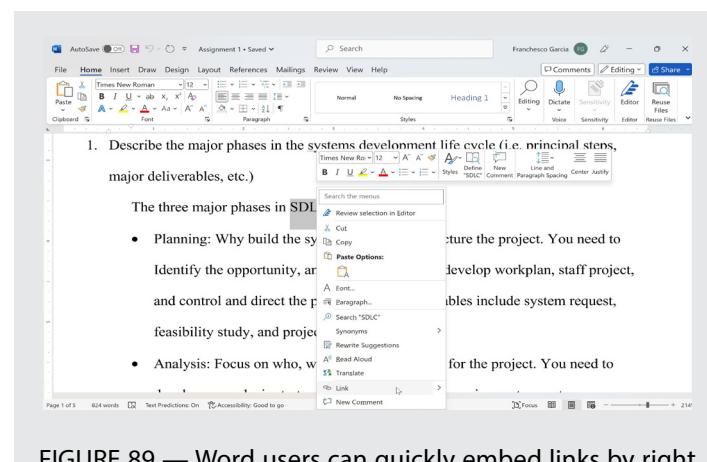


FIGURE 89 — Word users can quickly embed links by right clicking words.

(Figure 90). Once you enter the location address and click “Ok,” the selected text will get highlighted. Make sure the link works by clicking on the highlighted address.

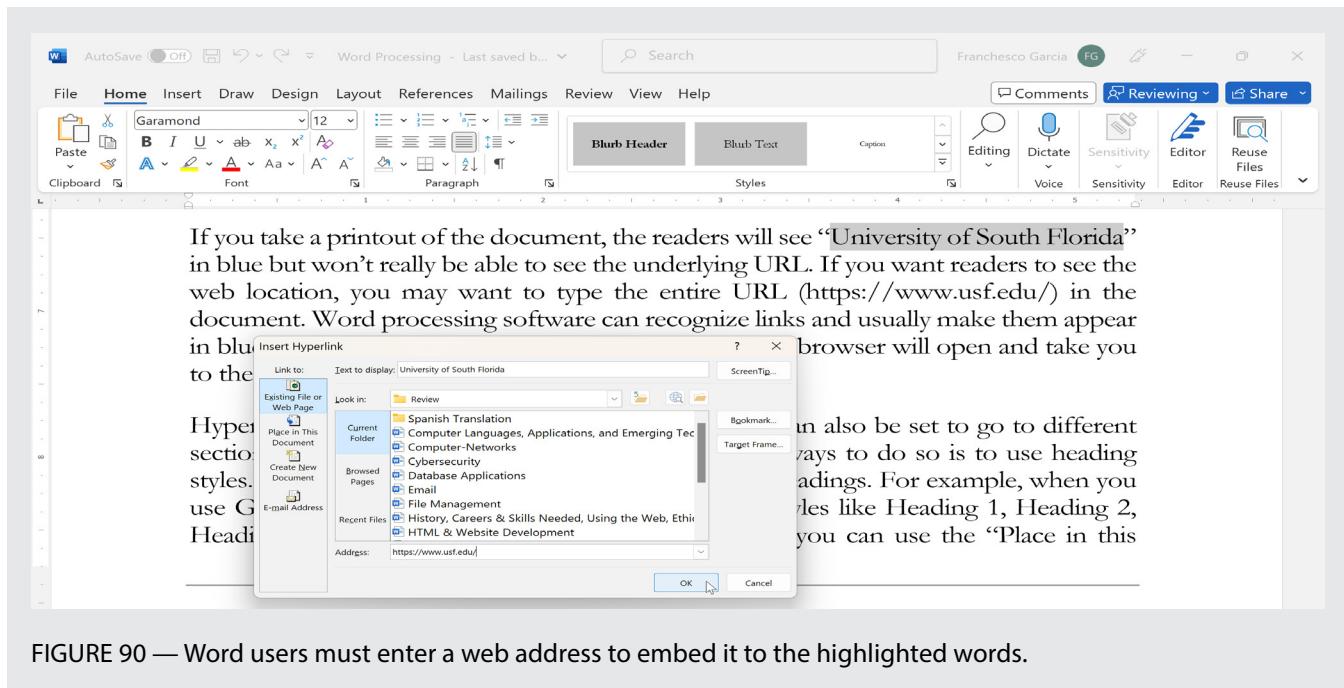


FIGURE 90 — Word users must enter a web address to embed it to the highlighted words.

If you take a printout of the document, the readers will see “University of South Florida” in blue but won’t really be able to see the underlying URL. If you want readers to see the web location, you may want to type the entire URL (<https://www.usf.edu/>) as part of the text of the document. Word processing software can recognize links and usually make them appear in blue font to indicate hyperlinks. When clicked, a new browser will open and take you to the address.

Hyperlinks are not limited to external websites. They can also be set to go to different sections of the same document. One of the simplest ways to do so is to use heading styles. Word processors greatly simplify navigating to headings. For example, when you use Google Docs or Word, you can use formatting styles like Heading 1, Heading 2, Heading 3, and others for sections of interest. Now, you can use the “Place in this document” option as shown in the left menu of Figure 91 to bring up a list of headings in the document and link to any of these headings. This is particularly useful if your document is large and requires a lot of scrolling to get from one section to another. Links from one part of the document to another can simplify navigating the document. For example, if your document is about different car models, you can organize the information about each car in one place with a heading for each car. For example, you can use the Heading 1 style for the headings of Land Rover, Jaguar, Mercedes, and Audi. Now, wherever you wish to help readers navigate to information about a car, you can add a link to the car. For example, if you are writing the section on Audi and want to have a link to Jaguar so readers can look up competing models, simply right-click on the text, and choose “Insert Link” to bring up the dialog in Figure 91 (which is the same as the dialog in Figure 90).

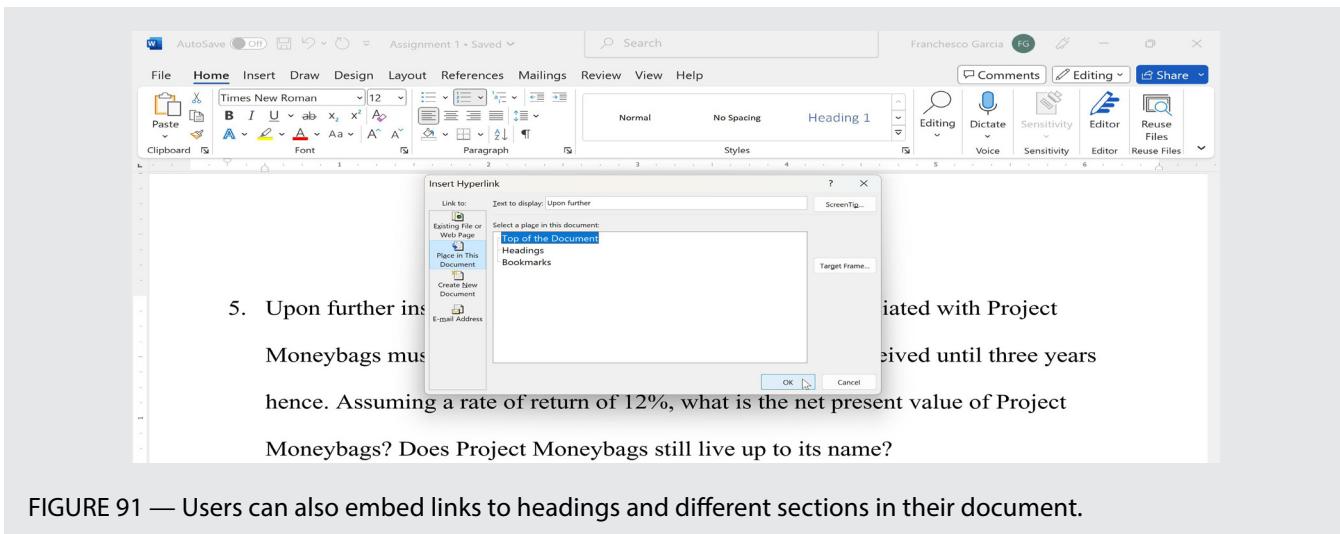


FIGURE 91 — Users can also embed links to headings and different sections in their document.

In the popup screen, choose “Place in This Document” and then select the “Jaguar” under headings. This will insert a link to “Jaguar.” If you “Ctrl-Click” the newly created link, you will go to the section that has information on Jaguar cars.

Bookmarks

Bookmarks are locations in your document that you want to identify for future reference. Bookmarks in digital documents serve the same purpose as physical bookmarks. They are an alternate mechanism to headings to refer to locations elsewhere in the document. An advantage is that they do not force you to adopt predefined heading styles.

Linking to another section of the same document is always a two-step process—first, identify the targets using heading styles or bookmarks, and next, link to the target from anywhere in the document. Using our previous example on cars, which used headings, if we wanted to use bookmarks, we could bookmark some cars, e.g., Fiat, Honda, Kia, and Toyota. Then to link to Toyota from somewhere in the section on Honda, select the text you wanted to be linked, then right-click, and choose “Link” to bring up the same popup screen as before. This time, choose “Place in This Document” and select “Toyota” under “Bookmarks” (Figure 92).

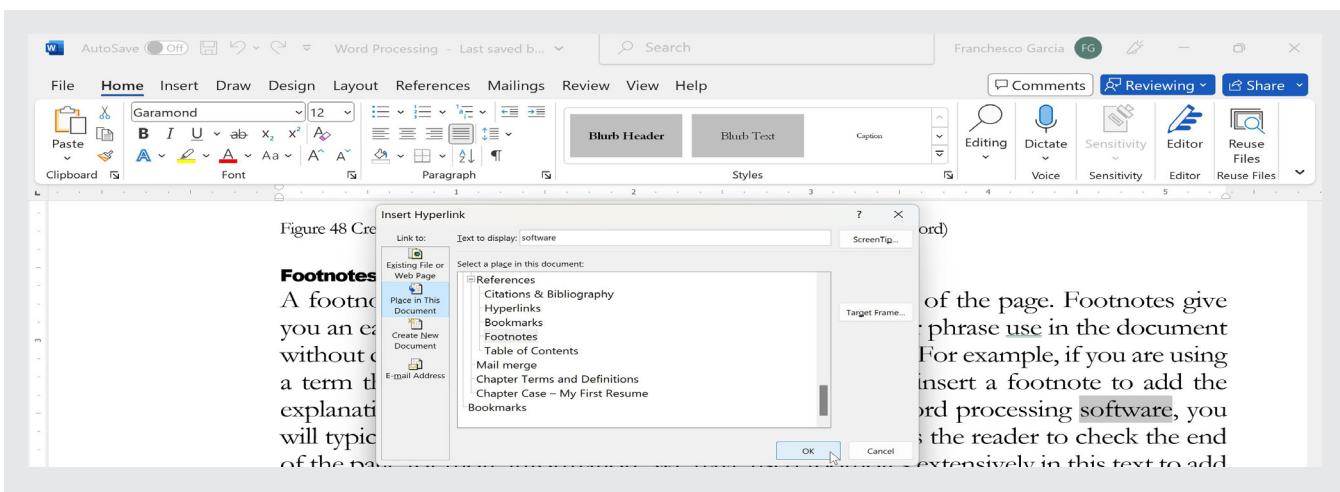


FIGURE 92 — Bookmarks allow Word users to link web addresses to different sections in the same document.

Footnotes

A **footnote** is additional information found at the bottom of the page. Footnotes give you an easy way to share more information about a term or phrase used in the document without distracting readers from the flow of the document. For example, if you are using a term that may be unfamiliar to some readers, you can insert a footnote to add an explanation. If you insert a footnote using any popular word processing software, you will typically see a superscript next to the term that informs the reader to check the end of the page for more information. We have used footnotes extensively in this text to add context or to point readers to related articles online.

To insert a footnote in Google Docs, go to the “Insert” tab and choose the “Footnote” menu. That will insert a superscript next to the term and take you to the bottom of the page, where you can type your explanation. Footnotes are sequenced to guide the readers to the correct explanation, in case you have more than one footnote for a page.

If you are using Microsoft Word, you can insert a footnote by going to the “References” tab and selecting “Insert Footnote” (Figure 93). This adds the footnote as shown in Figure 94. One variant of footnotes is endnotes. Endnotes show up collectively at the end of the document, unlike footnotes that show up separately on each page.

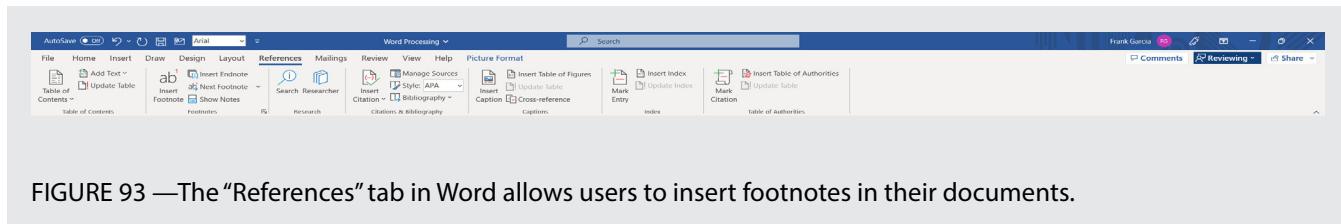


FIGURE 93 —The “References” tab in Word allows users to insert footnotes in their documents.

¹ An Artificial Intelligence based chat and search system accessible at <https://openai.com/blog/chatgpt/>

FIGURE 94 — Footnotes appear at the bottom of a page.

Table of Contents

A table of contents is usually found in the beginning of a document and lists all the chapters and subsections and the page numbers where they are found. You must have seen these in every textbook, novel, or magazine you have read. The table of contents serves two purposes even in physical books. It not only lets the readers easily find the page number of a chapter so they can quickly go to it, but it also gives them a high-level overview of the book.

When using a word processor, tables of content are “live.” You do not have to physically flip pages to go to the beginning of a chapter. You can simply “Ctrl-click” any heading in the table of contents to jump directly to that location. Word processing applications also allow you to build a table of contents easily. Their only requirement is that you use heading styles consistently in your document.

AC CATALOGUE
of the several Comedies, Histories, and Tragedies contained in this Volume.

COMEDIES.	
The Taming of the Shrew.	46
The Two Gentlemen of Verona.	49
The Merchant of Venice.	50
Midsummer Night's Dream.	51
The Comedy for Mankind.	52
The Winter's Tale.	53
Measure for Measure.	54
All's Well that Ends Well.	55
Twelfth Night, or what you will.	56
Lover's Labour's Lost.	57
Midsummer Night's Dream.	58
The Merchant of Venice.	59
As you Like it.	60
The Taming of the Shrew.	61
All's Well that Ends Well.	62
Twelfth Night, or what you will.	63
The Winter's Tale.	64
TRAGEDIES.	
Romeus and Juliet.	65
The Merchant of Venice.	66
Hamlet.	67
Othello, or the Moor of Venice.	68
King Lear.	69
Antony and Cleopatra.	70
Cymbeline King of Britain.	71
HISTORIES.	
The Life and Death of King John.	72
The Life and Death of Richard the Second.	73

A table of contents allows readers to identify key sections of a document or book.

Once you mark all your chapter titles as headings, you can go to the beginning of your manuscript and insert a table of contents. In Google Docs, the process is as simple as going to the “Insert” tab and selecting the “Table of Contents” menu. In Word, you can find “Table of Contents” under the “References” tab. In both cases, you get several options for the look and feel, each with a different way of organizing your chapters and subheadings. Once you select the look and feel you want, the software automatically identifies all the headings and creates a table of contents, reflecting the heading hierarchy, complete with page numbers ([Figure 95](#)).

Word Processors	2
Save, Print and Export documents	6
Entering and Formatting text content	10
Font	11
Text Styles	14
Spacing	18
Indentation and Alignment.	20
Lists	21
Tables	22
Page Layout	24
Image editing	27
Revision and Proof reading	30
Spell Checking	31
Find and Replace	32
Thesaurus	34
Revision / Collaboration	36
Collaborative Real Time Editing	37
Tracking Changes and Suggestions	38
Comments	40
Citation, Hyperlinks, Footnotes, Table of Contents	41
Citations & Bibliography	41
Hyperlinks	47
Footnotes	47
Table of Contents	47
Advanced - Mail merge, Macros, Tracking revisions	47
Business Communications	47

FIGURE 95 — Word processing applications allow users to create tables of content by indexing headers and page numbers.

As you add, move, and remove sections in your document, you can update the table of contents by right-clicking on the table and getting the context-sensitive menu. In Google Docs, choose the “Update table of contents” menu ([Figure 96](#)). In Word, you can select “Update Field” to see the popup screen with options to update the “Table of Contents.” Any time you update the table of contents (sometimes abbreviated as a TOC), it will refresh to show the latest chapter titles, subheadings, and page numbers of your manuscript.

Word Processors		2
Save, Print and Export documents 		6
Entering and Formatting text content		10
Font		11
Text Styles		14
Spacing		18
Indentation and Alignment.		20
Lists		21
Tables		22
Page Layout		24
Image editing		27
Revision and Proof reading		30
Spell Checking		31
Find and Replace		32
Thesaurus		34
Revision / Collaboration		36
Collaborative Real Time Editing		37
Tracking Changes and Suggestion:		38
Comments		40
Citation, Hyperlinks, Footnotes, Table o		41
Citations & Bibliography		41
Hyperlinks		47
Footnotes		47
Table of Contents		47
Advanced - Mail merge, Macros, Trackin		47
Business Communications		47

FIGURE 96 — Word processing applications allow users to quickly update the table of contents.

Keyboard Shortcut to Update Fields and Tables of Content

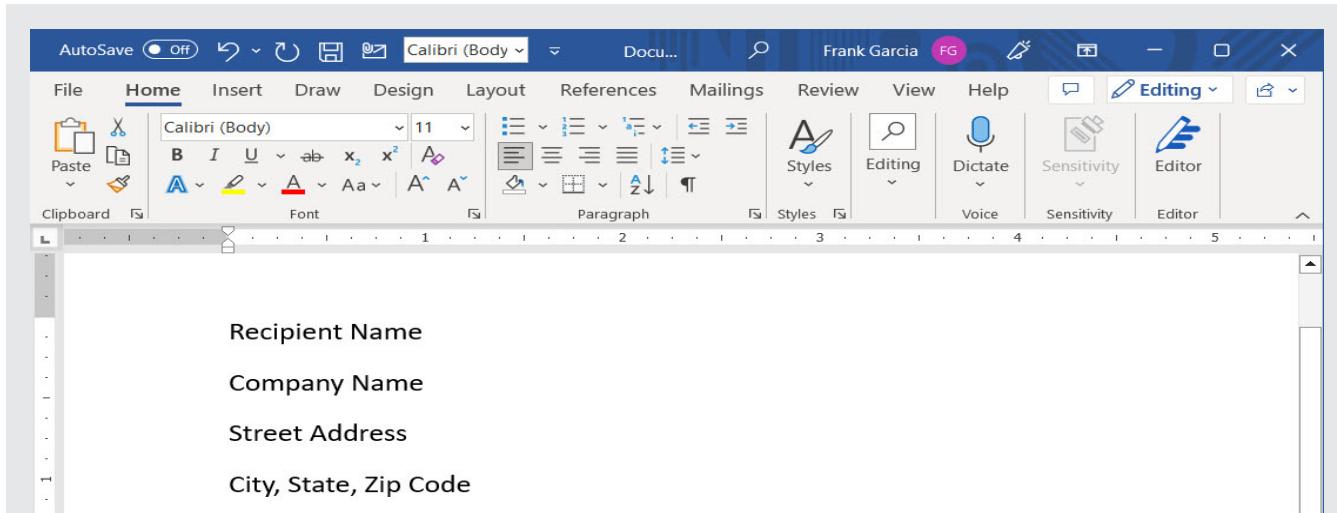
One favorite keyboard shortcut of the authors is to easily update all fields and the table of contents. We first use “Ctrl+A” to select the entire document. Then use “F9” to update all fields including the table of contents.

Mail Merge

Mail merge is the ability of word processors to create identical documents personalized for each recipient, and to automatically email them to each recipient if needed. For example, a teacher may want to send the same letter to each student or their parents. A small business owner may want to mail holiday greetings and promotional letters to a thousand customers with their addresses printed on envelopes. Or, a teacher may like to use the same format to email individual grade letters to students. If you did the job manually, you would spend many hours writing letters and you would also need to be very careful to not make mistakes.

The “Mail Merge” feature of word processing software makes the job easier and cleaner. It combines the formatting abilities of word processors with the organizing abilities of spreadsheets to give you a one-click method to create thousands of personalized letters or emails. You create the letter-template in Word ([Figure 97 top](#)) and the list of recipients in Excel ([Figure 97 bottom](#)). Then, follow a few easy steps under the “Mailings” tab in Word to connect the two and create the documents or emails. Here are the steps to use the mail merge feature in Microsoft Word.

- 1) Write the letter you want to mail to everybody in a Word document.



	A	B	C	D	E	F	G
1	Last Name	First Name	Company Name	Business Address	City	State	Zip Code
2	Smith	Martin	SynthPoint Music	47 Aspen Avenue	Gibsonia	PA	15044 (
3	Thomas	Adrienne	SoundModern	494 Columbia Ave.	Salem	MA	01970 (
4	Magill	Lena	Cyberphonic Music	221 Dogwood Avenue	Corpus Christi	TX	78418 (
5	Arrevalo	Ellis	Electronic Rebel	944 Foxrun St.	Bethpage	NY	11714 (
6	Anderson	Douglas	Virtuosity Music	45 Atlantic Ave.	Owosso	MI	48867 (
7	Nelson	Lola	Electronic Core Music	30 Sheffield Court	Chandler	AZ	85224 (
8	Jimenez	Patricia	Cool Tunes	846 Wild Horse Dr.	Goose Creek	SC	29445 (

FIGURE 97 — In Word, users must first create a template of the letter or email they wish to send (top). Then in Excel, a list of recipients must be created (bottom).

- 2) Prepare the list of people you want to mail. If you have a thousand business contacts, you should have an Excel sheet with a thousand rows of data. Just make sure to create a header row that describes the data in that column (First Name, Last Name, Company Name, Business Address, City, State, Zip Code, etc.).

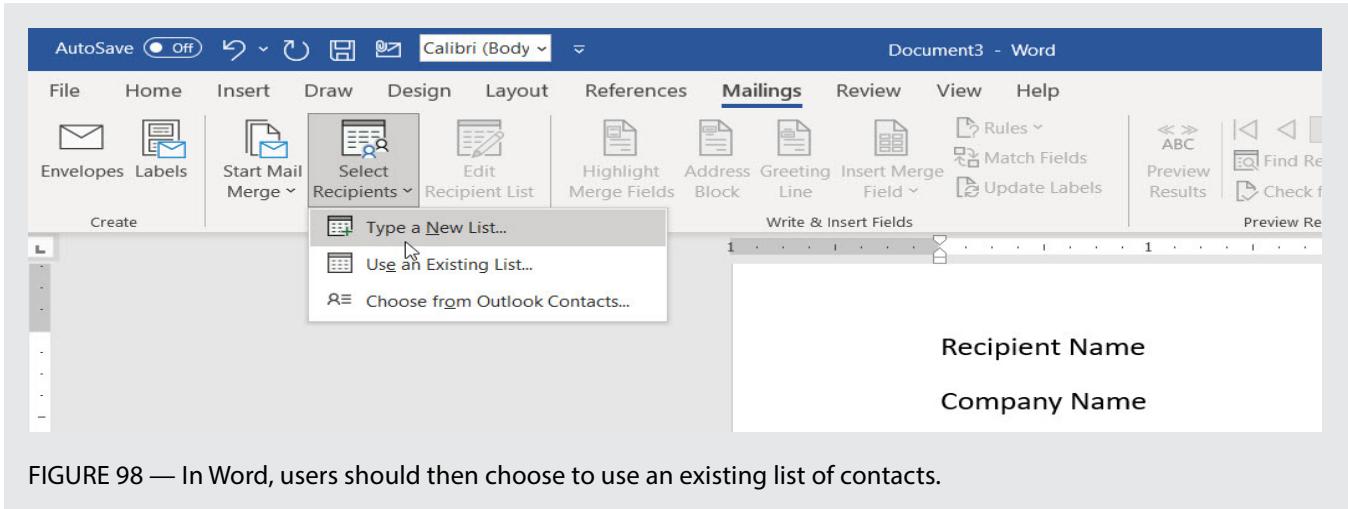


FIGURE 98 — In Word, users should then choose to use an existing list of contacts.

- 3) Go to the Word document that has your letter. Pick “Select Recipients” under the “Mailings” tab and choose the existing Excel file that has the recipients (Figure 98). You could also type a new list of people if you wanted. Now all the recipients of the letter are accessible in your Word document. Use “Insert Merge Field” to insert the name of your recipient and any other fields in appropriate places to personalize the letter (Figure 99).

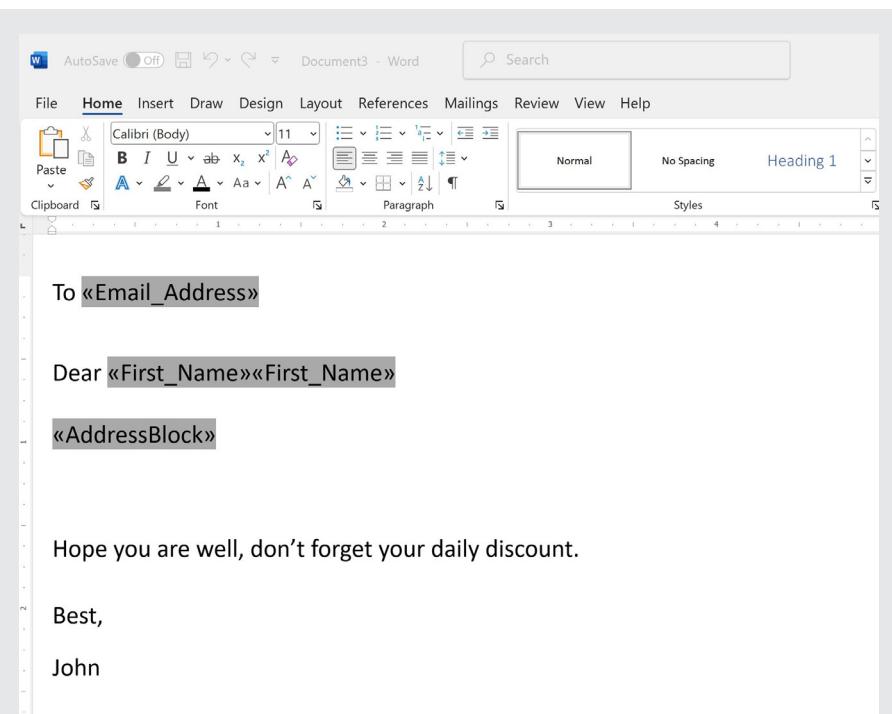


FIGURE 99 — Use the “Insert Merge Field” to set up the template. Any fields required to complete the letter can be inserted.

- 4) Once you are done inserting fields into the Word document, you can use “Preview Results” to see the output. Clicking on “Preview Results” again will take you back to the original document.
- 5) You are now ready to go. When you are ready to print or email the documents, choose either “Print Documents” or “Send Email Messages” under “Finish & Merge.” The word processor will connect to your printer and print the documents, or connect to your email and send the emails.



Chapter Terms and Definitions

Find and Replace: A pair of powerful features that lets you find and highlight all occurrences of a particular word or phrase within a document

Font: Text characters of a particular shape, style, and size

Footer: A text region at the bottom of the page that is reserved for content such as the name of the document, chapter heading, or page number

Footnote: A small text reference that appears at the bottom of a page; it usually references specific content on a page and is labeled with a number

Header: A text region at the top of the page that is reserved for content such as the name of the document, chapter heading, or page number

Indentation: The space between the margin and the beginning of the text

Keyboard Shortcut: Key combinations that give immediate access to specific functions in a computer program

Mail Merge: The ability of word processors to create identical documents personalized for each recipient, and to automatically email them to each recipient if needed

Page Layout: The arrangement of margins, content, and orientation of the page in a digital document

Spelling and Grammar: This feature analyzes your document and gives suggestions for spelling, grammar, and stylistic issues

Styles: Styles are combinations of formatting features that can be applied to text to instantly change its appearance

Table of Contents: A list of chapters or another type of content sections included within a document; it typically appears near the beginning of a document and can be based on the headings listed throughout the document

Template: A document that has preconfigured styles and other content elements; these elements can include formatting, styles, text, and graphics for specialized purposes such as a job resume or business letter

Word Processor: An application program that can create, open, print, and update documents; the application contains text editing features that are designed to enhance text or other supported media within the document; examples include Microsoft Word and Google Docs



Chapter Case

My First Resume

Matthew was finally old enough to get a job and make some money to save or buy the things he wanted. Finding a part-time job while he was still in school was a lot harder than he thought. He searched the Internet for job opportunities and asked all his friends where they worked. No matter where he searched or who he talked to, one thing was in common. Matthew needed to write a resume that he could hand to anyone who may want to hire him. It seemed like such a simple task, but Matthew wasn't sure where to start. He needs some advice on how to create his first resume.

.....

Question 1: Locate the templates available for a word processing application that you have access to. Search the templates for a "Resume." Review the "Resume" template of your choice. List and describe all the word processing features used in the "Resume" template.

Question 2: Use the "Resume" template in your word processor application to create your own resume. As you fill out the template, be sure to use the application to check your spelling and grammar. Verify the print layout of your resume. Save the resume and print a copy. After you complete your resume, write a short narrative describing what you would recommend Matthew do to create his first resume.

Introduction to Spreadsheets

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Data visualization transforms data into powerful visualizations and provides tactical, operational, and strategic insights. No longer merely a spreadsheet, business intelligence visualizations can be used for everything from providing analysis of cybersecurity patterns, to managing workplace efficiency for global companies.

—Jason Beres, Sr. VP of Developer Tools at Infragistics

Overview

Spreadsheets are electronic documents that help users to manipulate **data**. While word processors and email are probably the most used productivity applications, much of the world's business runs on spreadsheets. This is because spreadsheets are productivity applications designed to store numbers. Spreadsheets make it easy to visualize data and identify trends in that data. Any teacher tracking student grades will find it easiest to do so using spreadsheets. Student clubs will find it easiest to track contributions and expenses if they use spreadsheets. You may not use spreadsheets every day of your life, but your most valuable information is likely to be stored on spreadsheets.

For precisely this reason, spreadsheets were the killer app for computers in business. Just as email encouraged consumers to buy computers and get Internet connectivity, spreadsheets made it worthwhile for businesses to buy computers to track how they were doing. Steve Jobs credits the first spreadsheet program, VisiCalc, as being the driver for early Apple sales.

Dan Bricklin came up with the idea of a visual calculator in 1978 while doing his MBA at Harvard.¹²³ He initially visualized the user interface of spreadsheets as the cockpit display in aircraft but settled on the current **row-column** format to enable human-friendly names to be applied to data elements. Dan first called his program "Calcu-ledger" but eventually changed it to VisiCalc for Visual Calculator. Dan's business partner, Dan Fylstra, also an MBA from Harvard, and one of the earliest software publishers, demonstrated the VisiCalc program to Steve Jobs.¹²⁴ Almost a million copies of VisiCalc were sold at about \$100 each, driving sales for Apple, as well as the adoption of computers in business. Subsequently, Mitch Kapor and Jonathan Sachs created Lotus 1-2-3,¹²⁵ which was bought by IBM, and Microsoft came out with Excel. VisiCalc eventually lost its lead in the market.

Of all the applications and technologies discussed in this book, the ability to use spreadsheets productively is perhaps the most marketable skill. No one will hire you strictly because you can write emails or documents. But there is a good chance your expertise in spreadsheets may make you extremely valuable for some organizations.

123 See Dan's website for his own detailed account of how he came up with the idea of a spreadsheet, <http://www.bricklin.com/> and <http://www.bricklin.com/history/saiidea.htm> for the initial idea (accessed June 2023).

124 Steve Jobs' recollection of the story, "The History of Spreadsheets, from VisiCalc to Causal & beyond," <https://callmefred.com/the-history-of-spreadsheets/> (accessed June 2023).

125 Computer History Museum profile of Mitch Kapor, creator of Lotus 1-2-3, <https://computerhistory.org/profile/mitchell-kapor/> (accessed June 2023).

What is a Spreadsheet?

A spreadsheet is a computer program that represents information in rows and columns and makes it easy to perform calculations with the data.¹²⁶ In a typical spreadsheet, each column represents a different category of data and each row represents a record. For example, a spreadsheet for a sports club membership would have one row per student, and one column each for data such as first name, last name, sport of preference, email address, phone number, etc.

Spreadsheets are further divided into **cells**, organized in rows and columns. Rows are numbered and columns are named by alphabets, so any unique cell is defined by its row number and column letter. For example, in **Figure 100**, the cell outlined in white is B6, which indicates column B and row 6. The column letter always comes first in a cell reference.

The screenshot shows a Microsoft Excel spreadsheet titled 'Unemployment Rates'. The table has 13 rows and 6 columns. Row 1 contains column headers: A (State), B (2021 Unemployment Rate), C (2020 Unemployment Rate), D (2019 Unemployment Rate), E (2018 Unemployment Rate), and F (2017 Unemployment Rate). Rows 2 through 13 list US states with their corresponding unemployment rates for each year. The cells are color-coded: light blue for the header row, green for Wyoming, Wisconsin, and South Dakota, and red for all other states. The cell B6 (Wisconsin's 2020 rate) is highlighted with a white border.

	A	B	C	D	E	F
1	State	2021 Unemployment Rate	2020 Unemployment Rate	2019 Unemployment Rate	2018 Unemployment Rate	2017 Unemployment Rate
2	Average	4.8	7.4	3.6	3.8	4.2
3	Wyoming	4.5	5.8	3.7	4.1	4.3
4	Wisconsin	3.8	6.3	3.2	3.0	3.3
5	West Virginia	5.0	8.2	4.9	5.2	5.2
6	Washington	5.2	8.5	4.3	4.4	4.6
7	Virginia	3.9	6.2	2.8	3.0	3.7
8	Vermont	3.4	5.6	2.3	2.6	3.0
9	Utah	2.7	4.7	2.6	2.9	3.1
10	Texas	5.7	7.7	3.5	3.9	4.3
11	Tennessee	4.3	7.4	3.4	3.5	3.7
12	South Dakota	3.1	4.3	2.8	2.8	3.1
13	South Carolina	4.0	6.0	2.8	3.4	4.2

FIGURE 100 — Spreadsheets allow users to organize data efficiently, making it a crucial aspect of businesses.

Spreadsheets are the workhorses in business for a wide range of tasks, such as budgeting, financial forecasting, and data analysis. Spreadsheets include built-in **formulas** for all the data processing tasks common in business. For example, the formula $\text{PMT}(0.05/12, 60, 3000)$ will calculate the monthly payment for a car costing \$3,000 to be paid off in 5 years (60 months) at an annual interest rate of 5% (monthly interest rate of 5%/12).¹²⁷

When working with data, spreadsheets have capabilities that make them far more powerful compared to tables in word processing documents. Whereas word processor tables require you to do manual calculations on cells of data, spreadsheets allow you to type in a formula to process data from other parts of the same spreadsheet or even other spreadsheets. An added advantage of spreadsheets is that the results of the formulas will change automatically if any of the input data changes.

Let's check out a couple of example spreadsheets. Say you are a real estate investor renting out multiple properties. To help you focus on your customers and properties instead of your financials, you can create a spreadsheet and enter your rental income and maintenance expenses, using formulas

126 Spreadsheet definition, adapted from <https://www.britannica.com/technology/spreadsheet> (accessed June 2023).

127 The payment will be \$56.61 per month, for a total payment of \$3,396.82. In other words, the spreadsheet calculation shows that the buyer will pay almost \$400 in interest as the cost of the car loan.

to have the spreadsheet automatically calculate the profit/loss from each property as well as the overall profit/loss of your company. The spreadsheet will also easily highlight any unusual expenses or revenues (Figure 101).

A	B	C
1 Property Name	Condo	House
2		
3 Annual Rental Income	\$5,000.00	\$10,000.00
4		
5 Expense Categories		
6 Advertising	\$0.00	\$120.00
7 Auto and Travel	\$0.00	\$0.00
8 Cleaning & Maintenance	\$50.00	\$100.00
9 Insurance	\$1,000.00	\$3,000.00
10		
11 Total Expenses	\$1,050.00	\$3,220.00
12		
13 Total Profit/ Loss	\$3,950.00	\$6,780.00

FIGURE 101 — Spreadsheets can benefit a wide range of industries and be customized depending on user needs.

As another common example, say you are a stock market investor. You can track your portfolios by entering the names of companies in your portfolio, the number of shares in each company, the purchase price of each share, and today's market price. Formulas in your spreadsheet can calculate your profit/loss for each group of shares, the total profit/loss, and the percent weight of each stock by purchase price and by the current market price. This can help you identify winners and losers in your portfolio and manage your investments accordingly. Figure 102 shows an example adapted from a popular investment management spreadsheet (DR 179).¹²⁸

G	H	I	J	K	L
Ticker	Name	Category	Shares	Price	Value
MSFT	Microsoft	Technology	100	\$308.02	\$30,802.00
DOLE	Dole PLC	Agribusiness	300	\$12.11	\$3,633.00
APPL	Apple	Technology	100	\$172.23	\$17,223.00
XOM	Exxon	Energy	250	\$109.40	\$27,350.00
DAL	Delta Air Li	Travel	80	\$34.14	\$2,731.20
HD	Home Dep	Consumer	120	\$289.14	\$34,696.80

FIGURE 102 — Users can track investments using spreadsheets.

128 DR 179 refers to episode 179 of the Dough Roller podcast. The spreadsheet was introduced by the podcast host, Rob Berger, on his podcast in May 2015, <https://www.doughroller.net/podcast/> (accessed June 2023).

In addition to convenient formulas, spreadsheets also offer a variety of visualization tools like [charts](#) and graphs that can be used to represent and analyze data in intuitive and user-friendly ways. Additionally, just like word processing software, spreadsheets also support collaboration and sharing to allow multiple users to work simultaneously on the same spreadsheet. [Figure 103](#) shows the portfolio distribution (column J) of the spreadsheet in [Figure 102](#) as a pie chart. Appropriate visualizations can help users get a sense of the data.

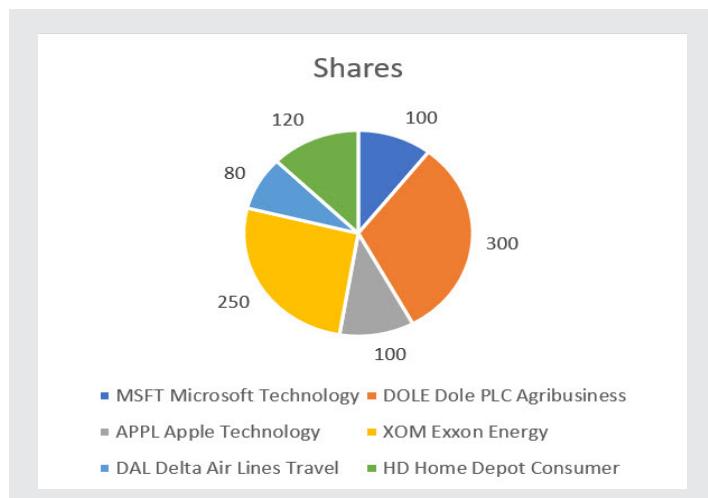


FIGURE 103 — Users can visualize data in spreadsheets.

Managing Spreadsheets

Managing spreadsheets is much like managing word processing documents. To create a new spreadsheet using Google Sheets, go to [sheets.google.com](#) and click on “Blank” to open a new sheet. To open an existing worksheet, you click on the sheet among your files. Once you have a spreadsheet open, you could also create a new one by using the “File” → “New” → “Spreadsheet” menu option. You can save any open worksheet the same way you save any electronic document, by clicking on the “File” menu and then selecting “Save.” If you would like to change the name of the spreadsheet while saving, give the saved spreadsheet the preferred name and choose where you want to save it in your Google Drive.

You can share the spreadsheet with colleagues by clicking on the “Share” button and entering the email addresses of your colleagues. This will allow your colleagues and friends to access and edit the spreadsheet from their own Google accounts.

Spreadsheets typically provide templates for common tasks like managing a monthly budget, a team roster, or weekly time sheets. These templates have a predefined look and feel and appropriate formulas. Generally, these templates are available from the “File” → “New” dialog as a “Template Gallery.” [Figure 104](#) shows the user interface for Google Sheets (top) and Microsoft Excel (bottom).

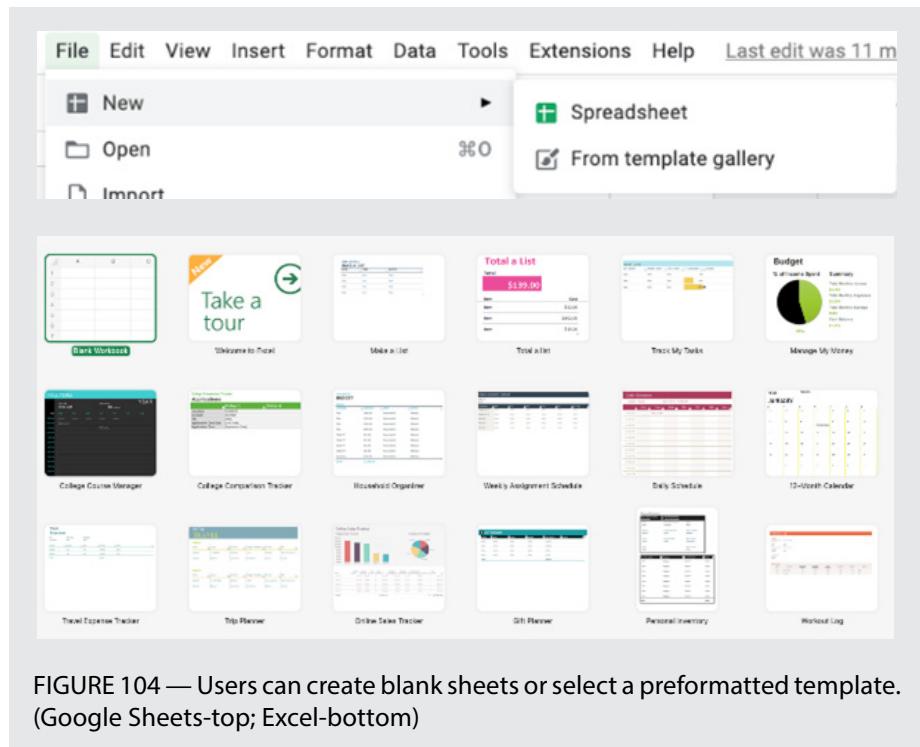


FIGURE 104 — Users can create blank sheets or select a preformatted template. (Google Sheets-top; Excel-bottom)

Menu Options

Both Excel and Google Sheets provide many menu options to simplify complex operations to organize and manage data and generate output. For example, Google Sheets has a standard toolbar to format cell contents, including font size, currency signs, indentation, and background color. The “File” menu in Google Sheets is used to perform file management operations, like creating new files or opening existing files (Figure 105).

The “Edit” menu in Google Sheets is used to copy, paste, and find and replace. “View,” as the name suggests, is used to manage the visible content on the screen. “Insert” has options to insert rows, cells, columns, charts, pivot tables, images, and drawings in documents. A

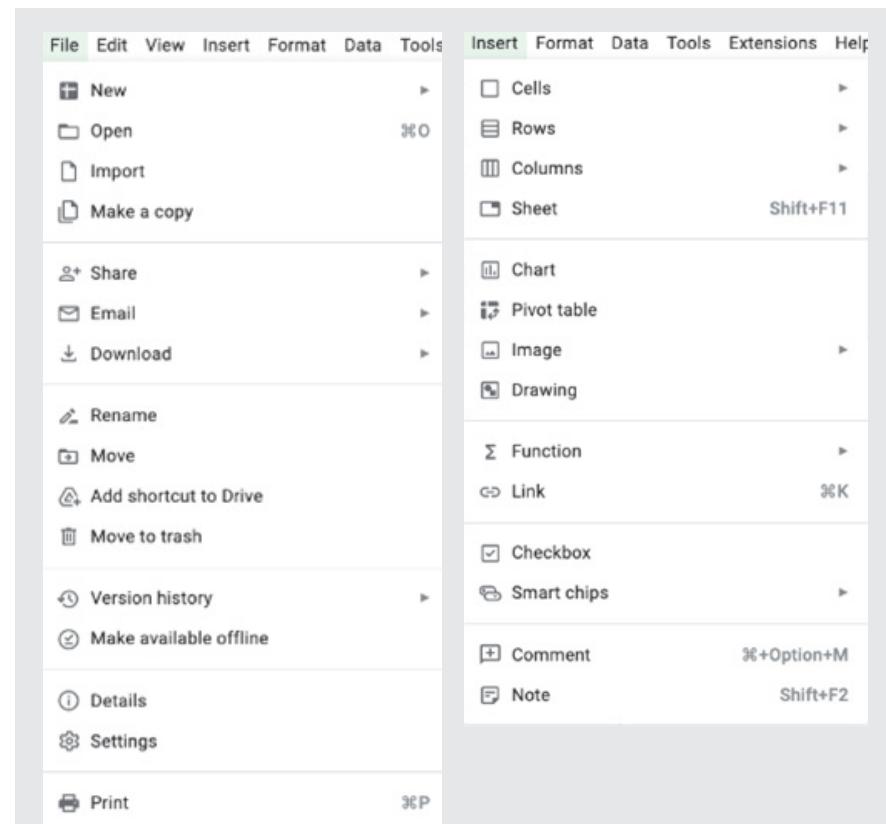


FIGURE 105 — The “File” tab (left) in Google Sheets has a wide variety of options and stores many commonly used ones. The “Insert” menu (right) in Google Sheets allows users to edit rows and columns.

common use of the insert menu is to insert charts. If you go to the “Data” menu in Google Sheets, you can sort and [filter](#) data, set up data validation, cleanup, and perform other operations with the data in the spreadsheet.

As in Google Sheets, Microsoft Excel is feature-rich, allowing you to manipulate data in complex ways ([Figure 106](#)). The “Insert” tab is also used in Excel to insert images, charts, rows, columns, shapes, and pivot tables.

The “Formula” tab in Excel has many predefined formulas that you can use to perform mathematical, financial, and other calculations. You can use the features under the “Data” tab in Excel to import data, sort and filter data, remove duplicate values, and set up data validation rules. Under the “View” tab, you have options to change the grid layout and freeze different sections of the document. If your document has macros (programs to automate spreadsheet tasks), you can view your macros from the view menu, and also record new macros.

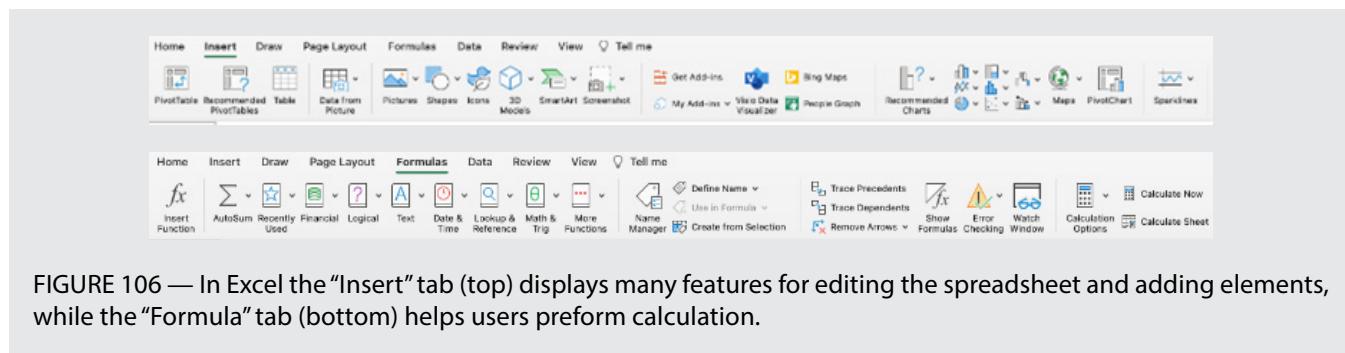
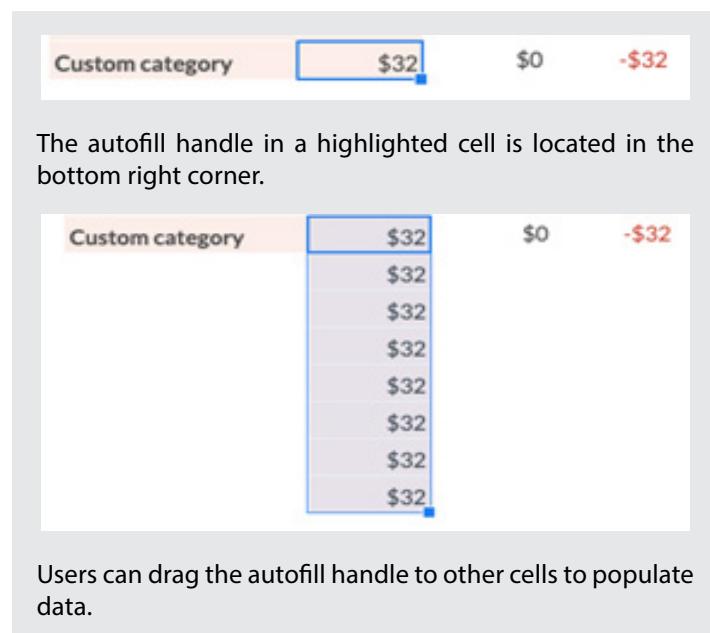


FIGURE 106 — In Excel the “Insert” tab (top) displays many features for editing the spreadsheet and adding elements, while the “Formula” tab (bottom) helps users perform calculation.

Entering Cell Data

While word processing documents are freeform, spreadsheets are structured and divided into cells. Once you click on a cell, the text you type will stay within the boundaries of that cell.

Spreadsheets are smart and do their best to understand what you are entering and give appropriate suggestions. One nifty feature that helps you copy data or generate a series is called autofill. Autofill is the ability of spreadsheets to extend a data series (e.g., numbers, dates, or text) to neighboring cells. Autofill is accessed from the autofill handle. If you click on a cell, you will see a tiny square box in the lower right corner. This is the autofill handle. If you put your mouse on the autofill handle, the mouse pointer will turn into a cross sign indicating that it is ready to autofill. You can drag the cross sign to autofill data in neighboring cells.



The autofill handle in a highlighted cell is located in the bottom right corner.



Users can drag the autofill handle to other cells to populate data.

The autofill concept works across rows too. You can even autofill series across rows and columns at the same time (Figure 107). To create an initial series, just enter the first few numbers of the series, select the cells, then drag the autofill handle to extend the series.

A	B	C	D	E	F	G	H	I	J	K
1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	9
10	10	10	10	10	10	10	10	10	10	10

FIGURE 107 — Users can autofill multiple rows and columns at the same time by creating an initial copy.

Autofill can also help you enter a series of dates (Figure 108).

Copy/Paste is another great way to enter data in spreadsheets. You can copy from any location on the web, another spreadsheet, or another section of the same spreadsheet and paste the data into your spreadsheet. When you paste data into a spreadsheet, the software will convert the data appropriately into cells and rows. If you copy data from another spreadsheet, just highlight the cells to copy and right-click to bring up the context-sensitive menu. You can then either cut or copy the selected data and paste it into the desired location in your spreadsheet.

When you paste data in a spreadsheet, you have the option to paste just the data values or bring along the associated formulas, references, and formatting from the source spreadsheet. To take advantage of the various pasting options, right-click on your spreadsheet and choose “Paste Special” (Figure 109).

If your data is in the CSV format, you can import it into spreadsheets by choosing the import option, generally accessed from “File” → “Import” (Figure 110). Excel offers a dedicated “From Text/CSV” button in the “Data” tab to import CSV. The spreadsheet software will let you select any existing data source and then walk you through a step-by-step import process. Data import is useful when you collect data from different sources

January 2022	February 2022				
January 2022	February 2022	March 2022	April 2022	May 2022	

FIGURE 108 — Users must create an initial template with dates that the autofill feature will use (top). Then the user can highlight the cells and auto fill (bottom).

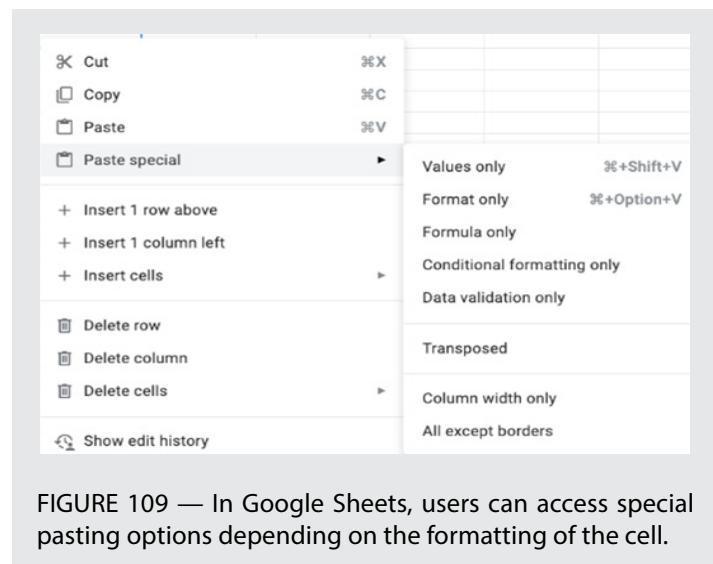


FIGURE 109 — In Google Sheets, users can access special pasting options depending on the formatting of the cell.

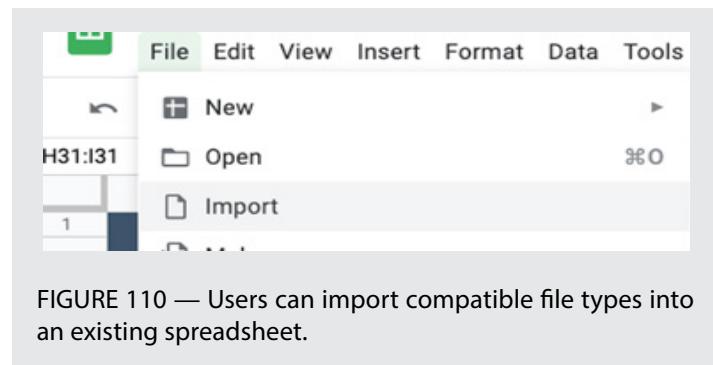


FIGURE 110 — Users can import compatible file types into an existing spreadsheet.

to create your own unified spreadsheet. For example, to create a spreadsheet to plan club meetings, you may import club member names from your membership directory and import meeting locations from the county's parks listing.

Row and Column Titles

Row and column titles, also known as labels, are the names/headers that appear at the beginning of each column/row in a spreadsheet. These labels are very useful and you should be deliberate about their values. Not only do labels make spreadsheets easy to understand, but they are also used to identify and describe the rows and columns of data in charts, tables, and other outputs. For example, in a spreadsheet containing sales data, the column titles might be different time periods, such as "Month," "Year," or "Region," or categories, such as "Sales," "Profit," or "Cost."

Expenses	Planned	Actual	Diff
Totals	\$950.00	\$1,000.00	-\$50.00
Food			
Gifts			
Health/Medical			
Home	\$950.00	\$1,000.00	-\$50.00
Transportation			
Personal			

FIGURE 111—When creating labels, users should be concise and clear to ensure values are properly represented and the spreadsheet is easy to understand.

The table in [Figure 111](#) shows Planned and Actual expenses and the column titles are Planned, Actual, and Diff. The items for which the cost is tracked, such as Food, Gifts, and Health/medical, are the row titles. Column titles are used in conjunction with row titles to provide a complete picture of the data in a spreadsheet. Titles can be especially useful when working with complex data sets to help readers make sense of the information.

Formatting Cells and Worksheets

To make data easy to comprehend, spreadsheet software provides extensive formatting options. As spreadsheets grow large, these formatting options become increasingly critical to understand the data. [Figure 112](#) shows some data without formatting. Even though it is a very simple spreadsheet, it is difficult to understand what the data says without any formatting.

Expenses	Planned	Actual	Diff
Totals			0
Food	0	0	0
Gifts	0	0	0
Health/medical	0	0	0
Home	950	1000	-50
Transportation	0	0	0
Pets	0	0	0
Utilities	0	0	0
Travel	0	0	0
Debt	0	0	0
Other	0	0	0
Custom category 1	0	0	0
Custom category 2	0	0	0
Custom category 3	0	0	0

FIGURE 112 — While the data is understandable, formatting helps improve clarity and usability.

1 Expenses	Planned	Actual	Diff
2 Totals	\$950.00	\$1,000.00	-\$50.00
3 Food	\$0.00	\$0.00	\$0.00
4 Gifts	\$0.00	\$0.00	\$0.00
5 Health/Medical	\$0.00	\$0.00	\$0.00
6 Home	\$950.00	\$1,000.00	-\$50.00
7 Transportation	\$0.00	\$0.00	\$0.00
8 Personal	\$0.00	\$0.00	\$0.00
9 Pets	\$0.00	\$0.00	\$0.00
10 Utility	\$0.00	\$0.00	\$0.00
11 Travel	\$0.00	\$0.00	\$0.00
12 Debt	\$0.00	\$0.00	\$0.00
13 Other	\$0.00	\$0.00	\$0.00
14 Customer Category 1	\$0.00	\$0.00	\$0.00
15 Customer Category 2	\$0.00	\$0.00	\$0.00
16 Customer Category 3	\$0.00	\$0.00	\$0.00
17 Customer Category 3	\$0.00	\$0.00	\$0.00

FIGURE 113 — When data in a spreadsheet application is formatted, it becomes easy to identify the key features.

Now let's use some formatting options and update the same table by adjusting the font size, text color, background color, and header elements. You can also include currency symbols and comma separators and have the negative numbers show up in a different color. Suddenly, the same data set not only looks pretty but also becomes easier to digest (Figure 113).

To format cells in Google Sheets, select the cells you want to format and choose the "Format" menu option. If your cells have numbers, you can choose the "Number" option and select any one of the available formatting options for numeric, financial, and date values. You can also set the font size, alignment, and how data should wrap in a cell.

In Microsoft Excel, you can select the cells you want to format, right-click to open the context menu, and select the "Format Cells" menu option. A window opens where you can specify several formatting options including number display and the look and feel of the cells—alignment, font, border, or fill (Figure 114).

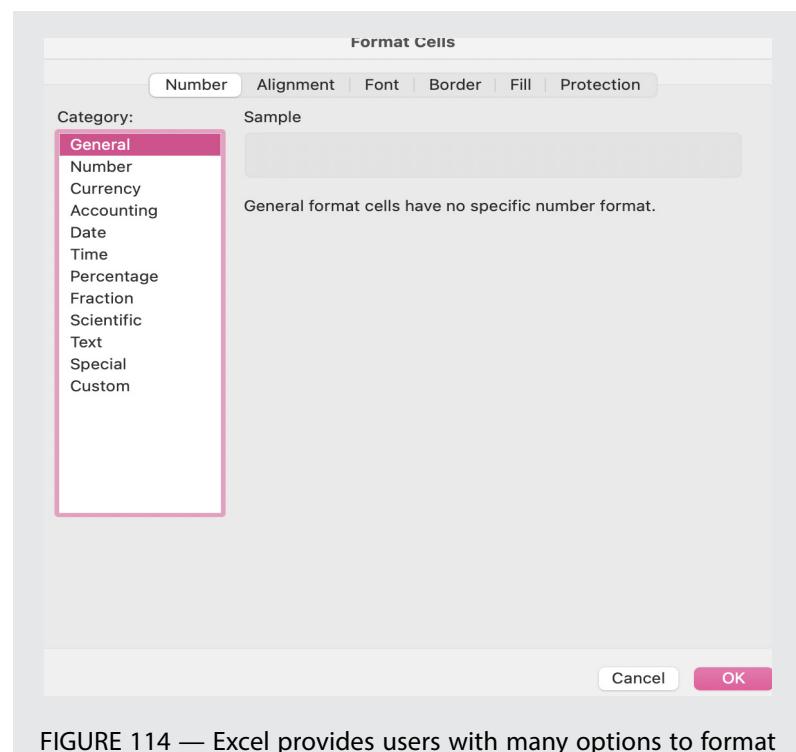


FIGURE 114 — Excel provides users with many options to format cells.

Styles

Just as in word processing software, styles in spreadsheets are a collection of predefined formats that give your document a consistent look and feel. If you want all your numbers to have a currency symbol, two decimal places of accuracy, and appear in red if negative, you could apply the formatting features one at a time, which might turn out to be cumbersome and error-prone. Alternatively, if you are using Excel, you could pick an existing “Cell/Table” style from the “Styles” group under the “Home” tab and apply the selected style to cells and tables (Figure 115).

If the existing styles don’t meet your needs, you can create a new style by clicking on “New Cell Style” or “New Table Style” (Figure 116). Once you format the new style by opening the formatting window and selecting all the features you want, you can give the style a new name and reuse the style to format any cell or table in your sheet.

If you like the formatting of a cell and want to copy it, click on that cell, then go to the styles dropdown and select “New Cell Style” (Figure 117). All the styling features of the cell are preselected for you. Just give the style a name and use it wherever you want unless it is copyrighted material.

Themes

Spreadsheets offer themes to let you have a consistent look and feel with respect to the choice of colors, fonts, cell borders, and background colors. Changing a spreadsheet’s theme will change the fonts, colors, and effects across the entire spreadsheet. In Excel,

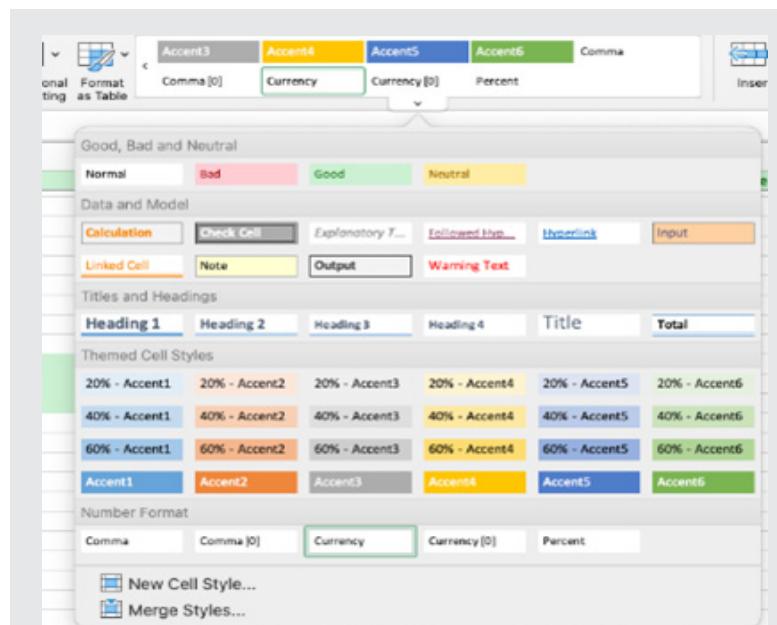


FIGURE 115 — Excel offers a wide variety of cell styles.

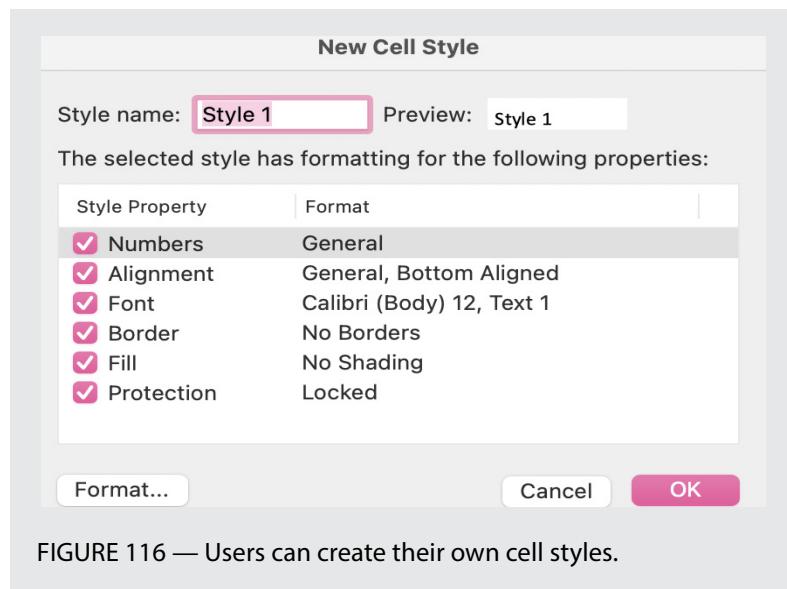


FIGURE 116 — Users can create their own cell styles.

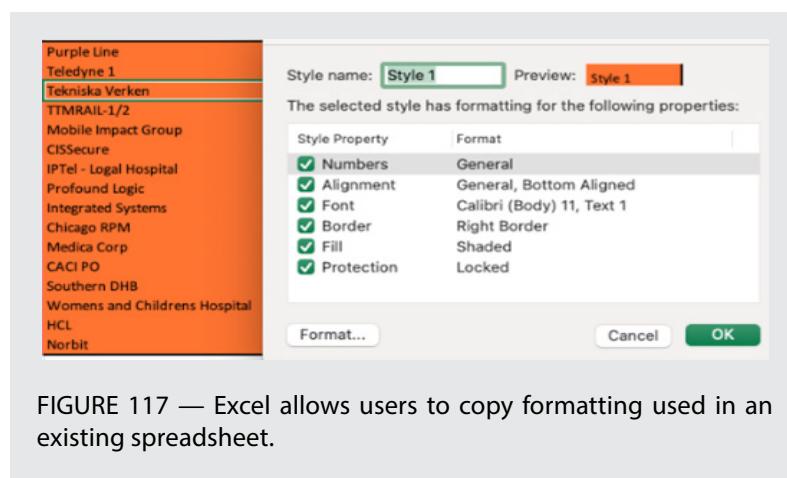


FIGURE 117 — Excel allows users to copy formatting used in an existing spreadsheet.

the “Page Layout” tab has a themes menu with many predefined themes (Figure 118). Google Sheets has “Themes” under the “Format” menu with a range of themes and the ability to customize existing ones. As with other properties of spreadsheets, you can also change existing themes and create new ones.

Merging and Splitting Cells

Merging cells allows you to combine multiple adjacent cells into one cell. This technique is particularly useful when creating a header row for a table in a spreadsheet (Figure 119).

In the “Expenses Table,” even though all the rows have the same number of cells, the title row appears to be a single cell because several cells have been merged to create one cell for the title. To merge cells in a spreadsheet, you can select the cells that you want to merge and then use the “Merge Cells” command. This will combine the cells into a single cell and adjust the formatting of the merged cell to match the formatting of the first cell in the selection. In Google Sheets, you find “Merge cells” under the “Format” menu and Microsoft Excel has various options to merge and unmerge cells on the ribbon under the “Home” tab (Figure 120).

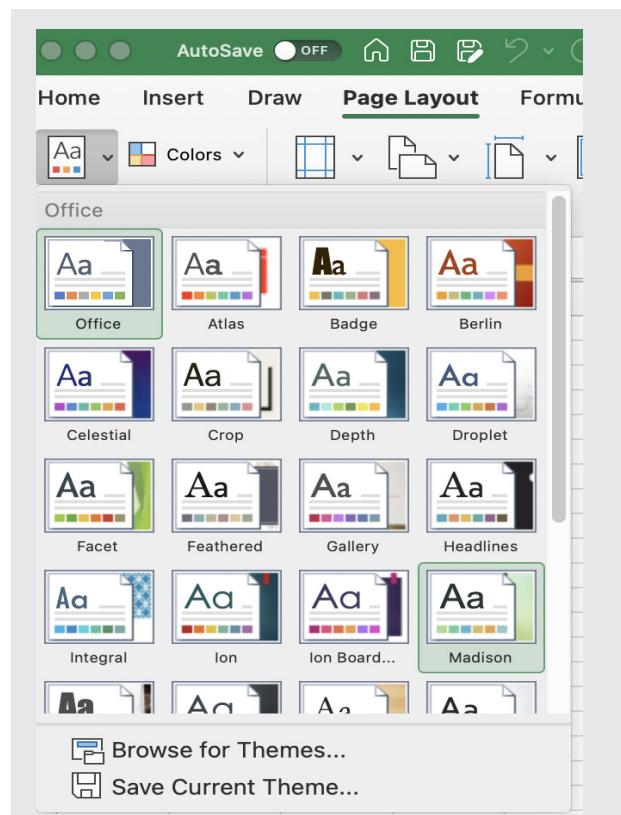


FIGURE 118 — Excel offers users a wide range of themes that can be quickly applied.

Expenses Table			
	Planned	Actual	Diff
Totals	\$1,000	\$1,050	-\$50
Food	\$350	\$375	\$25
Gifts	\$300	\$300	\$0
Health/Medical	\$350	\$375	\$25

FIGURE 119 — Headers can be created by merging cells.

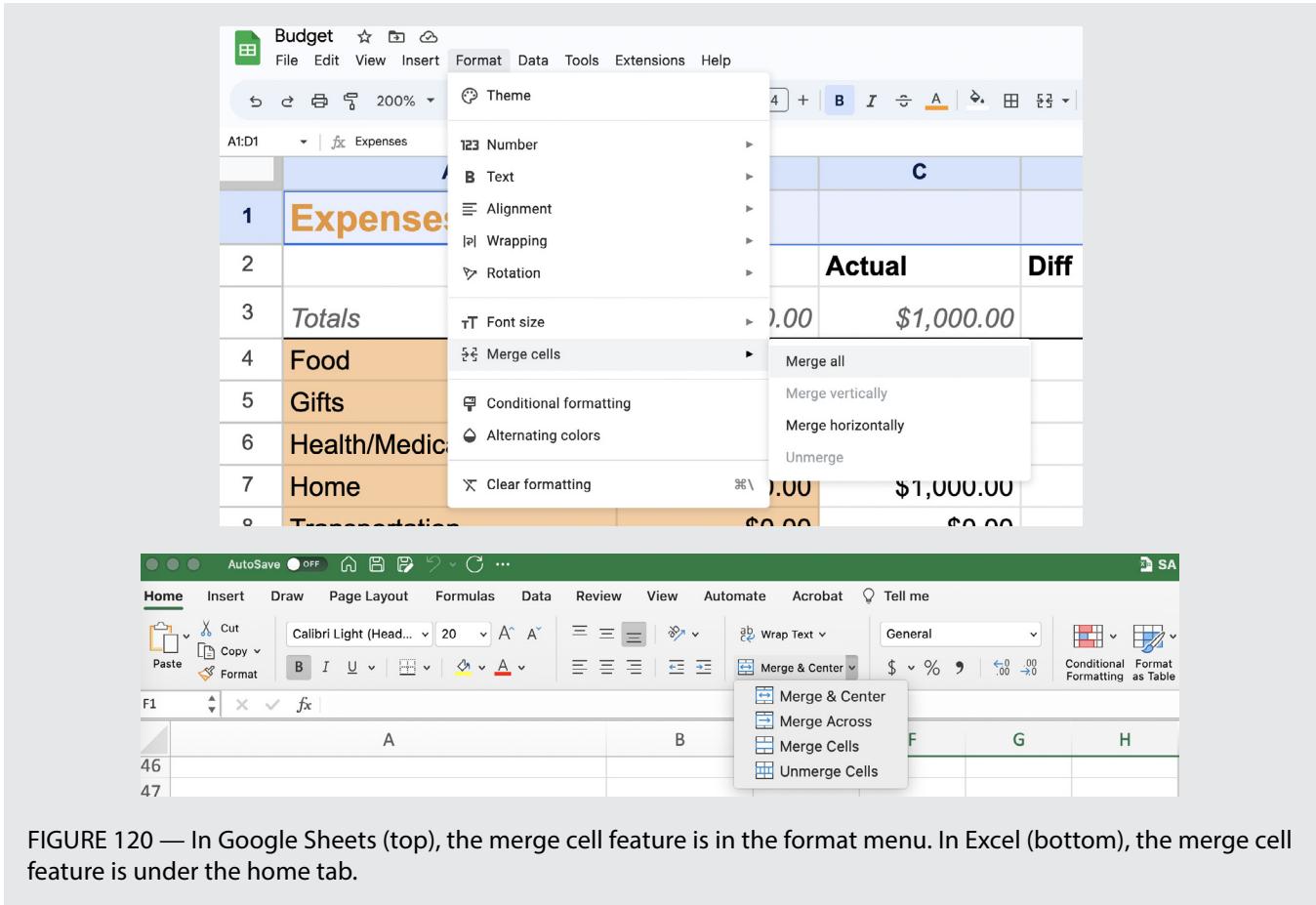


FIGURE 120 — In Google Sheets (top), the merge cell feature is in the format menu. In Excel (bottom), the merge cell feature is under the home tab.

Keep in mind though that you can't merge cells that don't form a proper rectangle, as in [Figure 121](#).

If things change, you can use the “Split Cells” command to split a merged cell back into its original cells. This can be useful if you want to make changes to the individual cells within the merged cell.

Hide and Unhide Columns and Rows

Spreadsheets can easily expand to fill many columns and rows. But your monitor typically only allows a few rows and columns to be visible at a time. Spreadsheets have an interesting capability to hide rows and columns to allow you to focus on the columns and rows of interest. To hide a column in Google Sheets, simply click on the column letter at the top of the spreadsheet and choose “Hide” ([Figure 122](#)). If you are using Excel, go to the “Cells” group under the “Home” tab and click “Format.” In the “Visibility” section, you will see “Hide” and

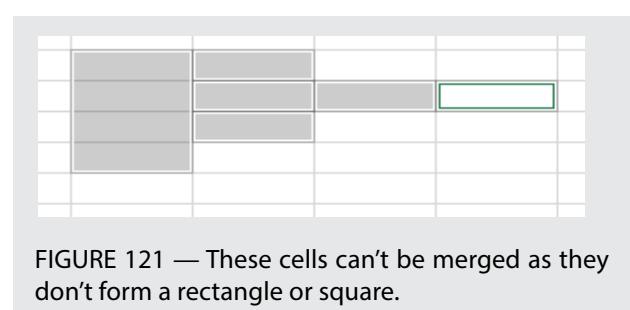


FIGURE 121 — These cells can't be merged as they don't form a rectangle or square.

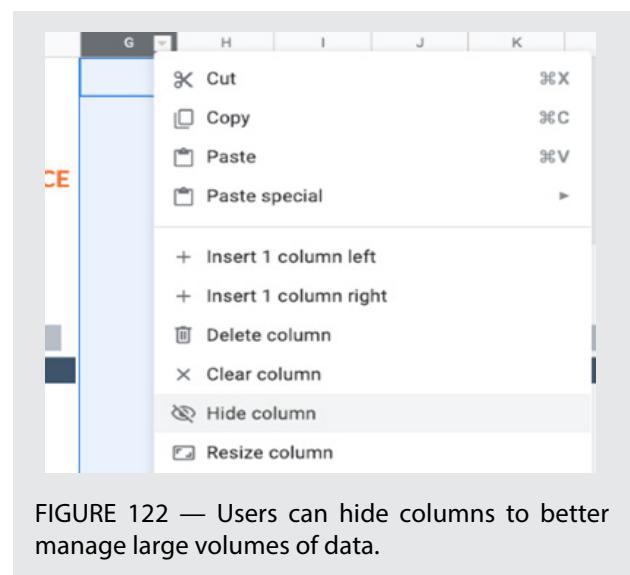


FIGURE 122 — Users can hide columns to better manage large volumes of data.

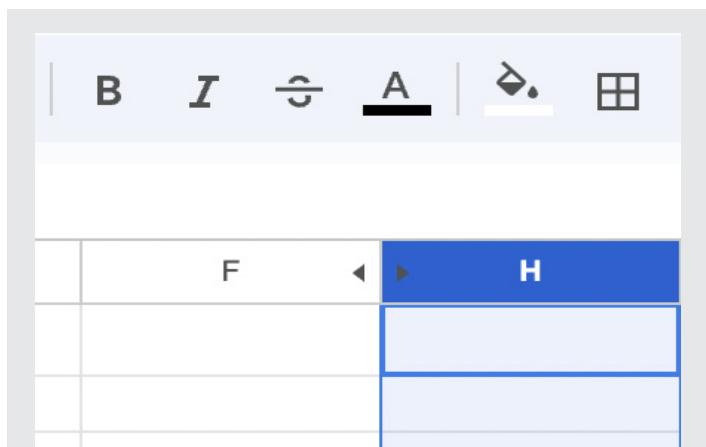
"Unhide." You can also click on the column or the row header to select a column or row, then right-click to bring the context menu and select "Hide" or "Unhide."

When columns or rows are hidden, you will see a break in the sequence of column headers or row numbers. In [Figure 123](#), column G is missing. Clicking on the gap will unhide the column. In our experience, it is far more common to need to hide columns than to hide rows.

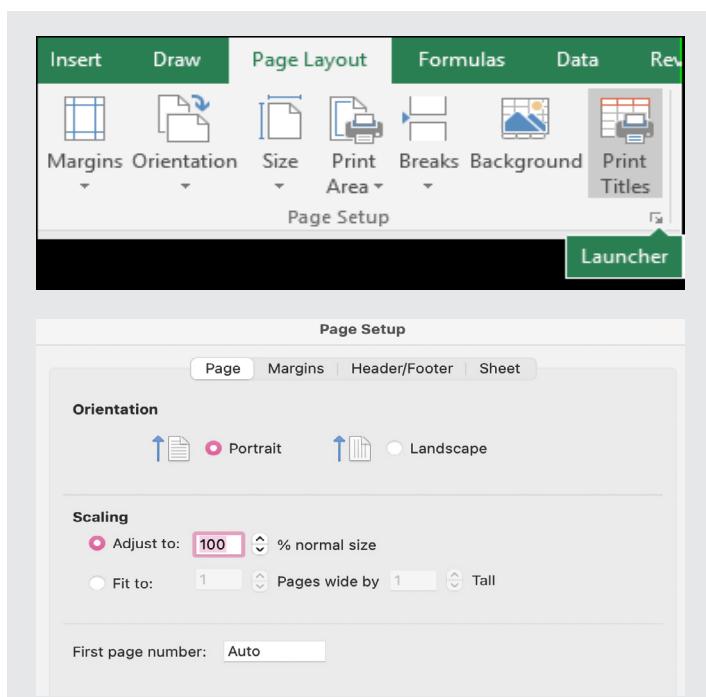
Page Layout Options

Users often want to print out spreadsheets to present to managers or other decision-makers. Spreadsheets allow you to format and preview the spreadsheet for printing. The page layout determines how a spreadsheet will look when printed. As a spreadsheet is a collection of cells organized into large numbers of rows and columns, printing it can be a challenge unless you set it up well. To solve the problem, spreadsheet software gives you page layout options that will allow you to have a presentable look when you print it on paper or view it as a PDF. There are many ways to get to the "Page Layout" option and many features to consider. In Excel, click on the "Page Layout" tab, then in the "Page Setup" group, click the "Dialog Box Launcher" in the bottom right corner to bring up the page setup dialog ([Figure 124](#)).

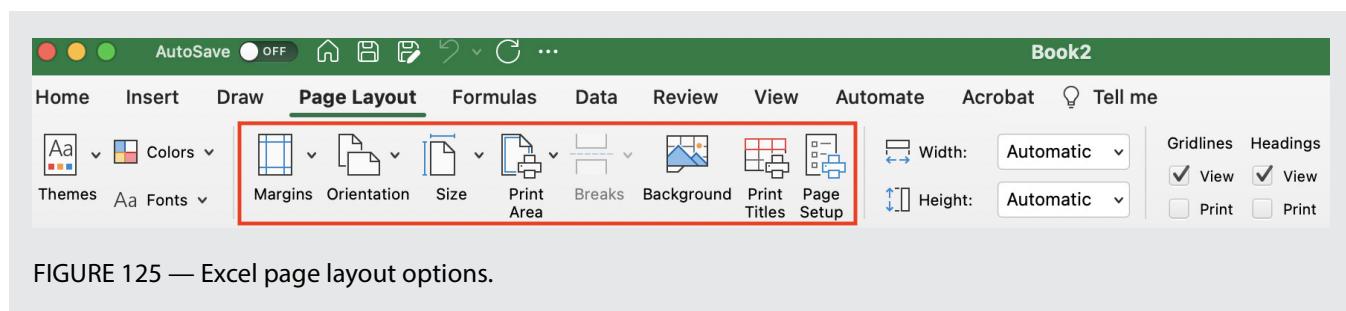
You can also make a few quick choices directly from the "Page Layout" menu options ([Figure 125](#)).



[FIGURE 123](#) — Users can hide columns to better manage large volumes of data.



[FIGURE 124](#) — In Excel users can change the page layout to make their data easier to print or export. Opening the "Print Titles" launcher (top) allows users to specify "Page Setup" requirements (bottom).



[FIGURE 125](#) — Excel page layout options.

Here are a few things to consider to make your spreadsheet visually appealing.

Page orientation: Just like word processing software, spreadsheets can have either portrait (vertical) or landscape (horizontal) orientation. In Excel, the “Page Layout” tab has menu options to set the orientation. In Google Sheets, when you select “File” → “Print,” you see a “Print Preview” of the pages and have the option to adjust the paper size, orientation, headers and footers, grid visibility, alignment, and other properties.

Page size: You can specify whether you want to print/export your spreadsheet to PDF as a letter sized, A4 sized, or any of the other standard or customized paper sizes.

Margins: You can adjust the size of the margins to have the look you want.

Headers and footers: You can add headers and footers to the top and bottom of each page. In Excel, go to the “Insert” tab and click on the “Header & Footer” menu to insert headers and footers. As mentioned earlier, in Google Sheets you can add headers and footers, page numbers, workbook tiles, and other information when you try to print the document.

Page breaks: You can insert page breaks to control where the spreadsheet gets divided across multiple pages when it is printed/exported.

Gridlines: If you want, you can choose to display gridlines on the printed/exported version of the spreadsheet.

Scaling: You can adjust the scaling of the spreadsheet to fit it on a specified number of pages by making it a percentage of its original size.

Formulas and Functions

You can supercharge your spreadsheet by employing formulas and **functions** to calculate values using the data in cells. Formulas are simple. When you write a formula in a cell, you begin with the equals (=) sign and specify the cells to use for the calculation and what operations to perform on the data. For example, if you want to add the values in cells A1 and B1, you could type the following formula in any cell “=A1+B1.” The result will get displayed in the cell where you type the formula.

If you have a table with your daily expenses, you can use a formula to calculate the sum of all your expenses. The total cell in [Figure 126](#) has the sum of expenses (=B13+B14+B15+B16). As you enter the formula and press “Enter,” you will get the total. As you change the data in cells, the calculations change automatically, which makes spreadsheets a very powerful tool. If you want to calculate the average daily expense over a month, you can add the daily total expense for a month and divide it by the number of days in the month. As soon as you enter a new set of values for the next month, you will immediately get the new daily average.

Spreadsheets also have powerful functions ranging from simple functions like Sum, Average, Count, Max, and Min to complex engineering, statistical, math, and financial

Daily Expenses	
Coffee	\$2.00
Breakfast	\$4.00
Lunch	\$5.00
Bus Fare	\$1.00
Total	\$12.00 × =B13+B14+B15+B16

FIGURE 126 — Spreadsheets allow users to quickly perform calculations with the help of visual aids.

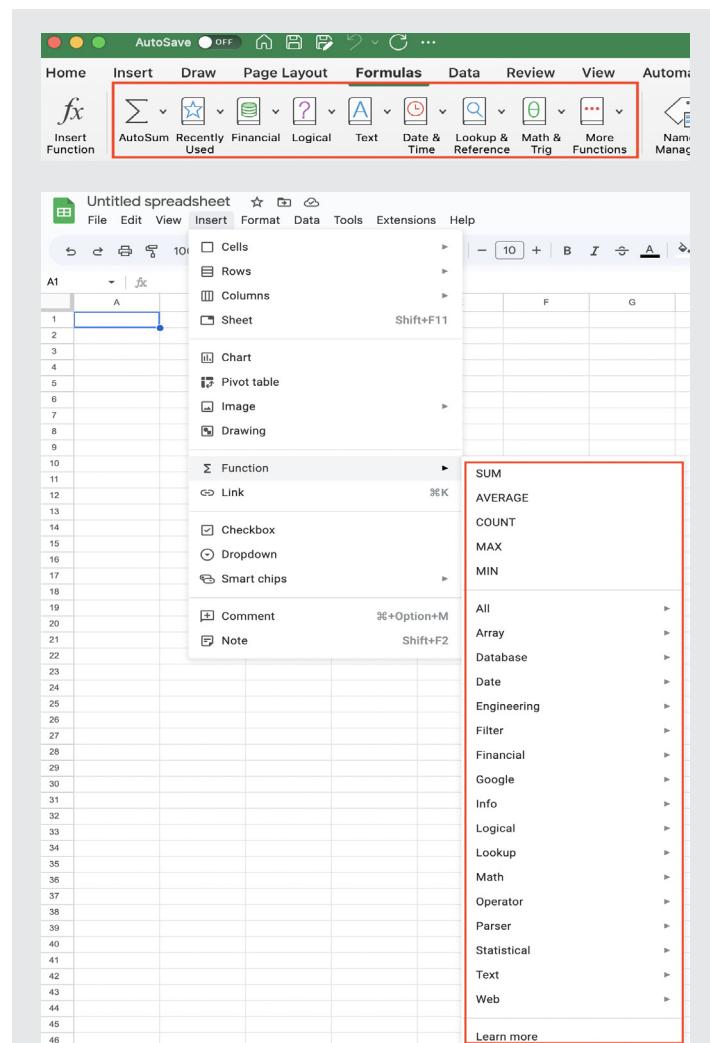
functions. To use the sum function to add your expenses in [Figure 126](#), just type =SUM(B13:B16). To access the “SUM” functions in Google Sheets, select a range of cells and click “Insert” → “Functions” → “SUM.” In Excel, functions are located under the “Formulas” tab and are further organized by financial, logical, text, date & time, math & trig, and other menu options ([Figure 127](#)).

Charts and Images

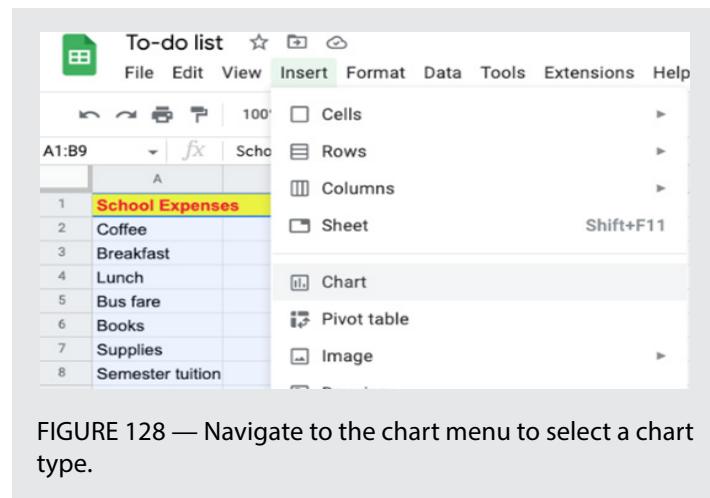
Charts offer a graphical representation of data and can help analyze data in a more meaningful and visually appealing way. You might not see a pattern or discrepancy by staring at 1000s of numbers, but a chart can bring out anomalies to the forefront quickly. In the language of British journalist and author David MacCandless, charts allow you to use the language of the eyes (pictures) along with the language of the mind (numbers), greatly speeding up data comprehension.¹²⁹

To create a chart, select the data that you want to include—a range of cells or a table—then use the charting tools in the spreadsheet software. In Google Sheets, you can use the “Insert” → “Charts” option to bring up an interactive tool that lets you pick the chart type you want ([Figure 128](#)). Bar charts, line charts, pie charts, and scatter plots are each suited for different types of data and can help you visualize information in different ways.

It is important to identify the chart type that will be most useful for a given task. For example, if you are trying to chart your school expense in [Figure 128](#), let’s consider some options.

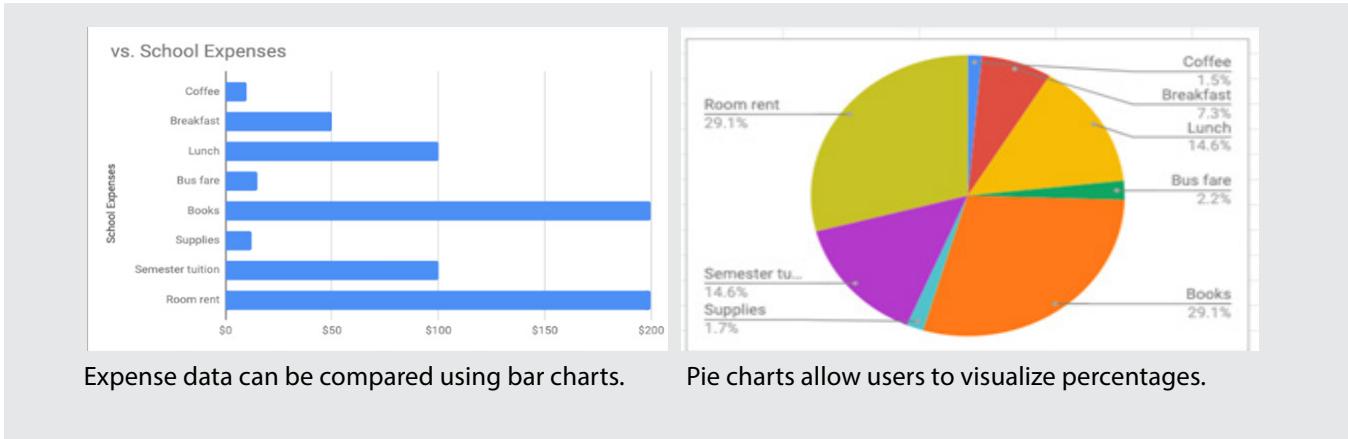


[FIGURE 127](#) — Both Excel (top) and Google Sheets (bottom) offer a range of formulas to perform calculations.

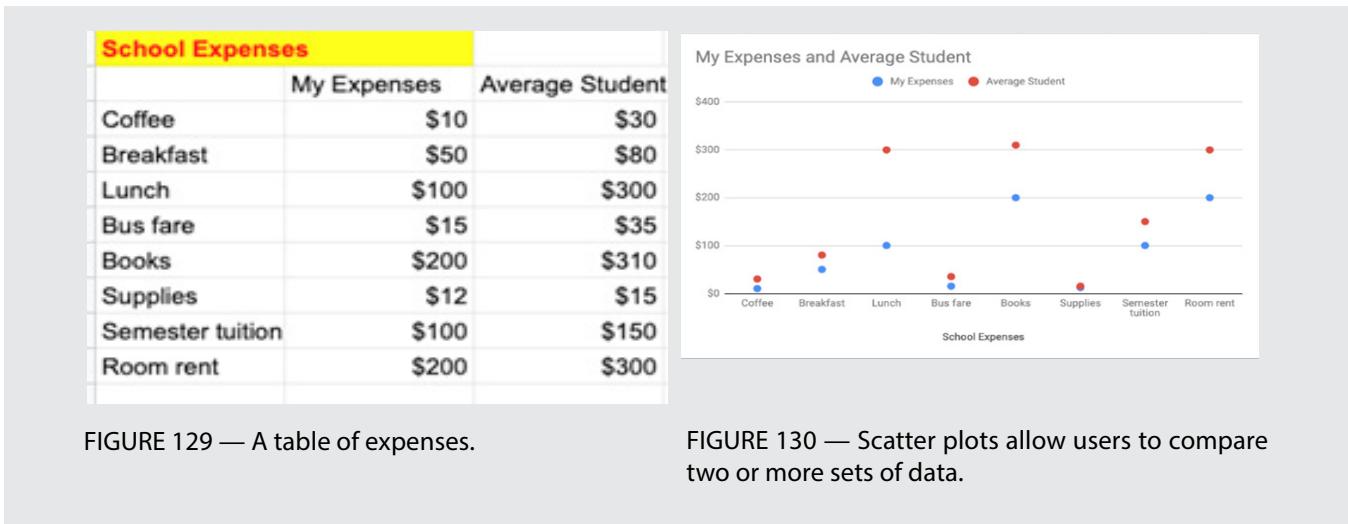


[FIGURE 128](#) — Navigate to the chart menu to select a chart type.

¹²⁹ The beauty of data visualization, TED talk by David MacCandless in 2010, https://www.ted.com/talks/david_mccandless_the_beauty_of_data_visualization. David also maintains a website with novel visualizations at <https://informationisbeautiful.net/> (accessed June 2023).



A line chart is a good choice for showing trends over time, and a scatter plot is good at showing the relationship between two variables. So, if you wanted to compare your expenses against an average student's expenses, you may consider a scatter plot (Figure 129 and Figure 130).



Once you create a chart, you can customize it by changing the appearance and layout of the chart and adding labels, titles, and data markers.

Benefits of Charts

Charts can give users a quick visual summary of large volumes of data. A well-known example to demonstrate the utility of charts was published in 1973 by Yale statistician Francis Anscombe and is popular as Anscombe's Quartet.¹³⁰ The quartet consists of 4 sets of 11 numbers each, with very different distributions but almost identical statistical properties. While the differences are not readily apparent from the data, the differences are immediately apparent from a chart. The data and their charts are shown below. The mean and variance of y for each series are 7.5 and 4.125. The example is meant to show that though numerical data is considered precise, and charts are considered approximate, charts help with analysis and detecting the underlying phenomena.

¹³⁰ Anscombe, F.J. (1973). "Graphs in Statistical Analysis," American Statistician. 27 (1): 17–21. See also the Wikipedia page on "Anscombe's Quartet" at https://en.wikipedia.org/wiki/Anscombe%27s_quartet (accessed June 2023).

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89

Anscombe's Quartet data series

The series is plotted in [Figure 131](#). It becomes immediately clear that the series is describing different phenomena and that there are outliers in some data series that merit further investigation.

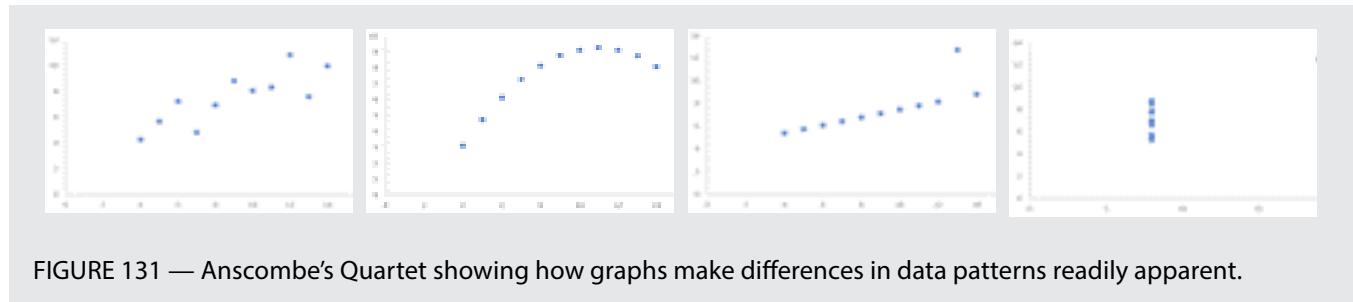
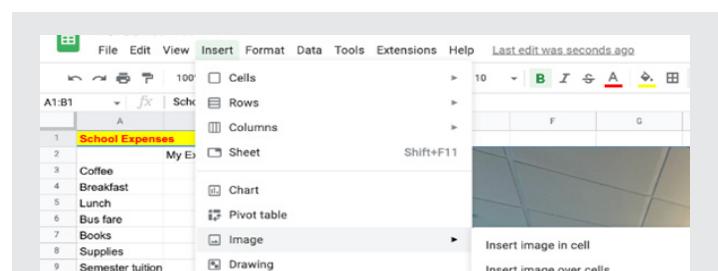


FIGURE 131 — Anscombe's Quartet showing how graphs make differences in data patterns readily apparent.

Images

While charts are graphs created based on the data in your spreadsheet, images are pictures you can directly insert into your spreadsheet. In Google Sheets, you can click on any cell and then choose “Insert” → “Image.” If you choose to insert the image in a cell, then it is constrained by the dimensions of the cell. If you choose to insert it over cells, then the picture floats on top of cells and can be sized independently of the underlying cells. In Excel, you can go to the “Insert” tab and click on the pictures menu to insert pictures in your spreadsheet. Inserting images adds organizational branding to spreadsheets.



Google Sheets offer users the ability to insert images over cells or in cells.

Share and Collaborate

Just like word processing documents, you can share spreadsheets with others in your team, so more

than one person can view and edit the spreadsheet in real-time. In Google Sheets, you will see the “Share” button on the top right side of your screen.

Clicking “Share” will open a window where you can enter your team members’ email addresses and make them viewers, commenters, or editors.

As the names imply, editors can edit the content, commenters can add comments, and viewers can see the changes.

If you use an online version of Excel (OneDrive, SharePoint, or Excel for the web), you can share it with teams, and the changes made by each member will be visible to others.

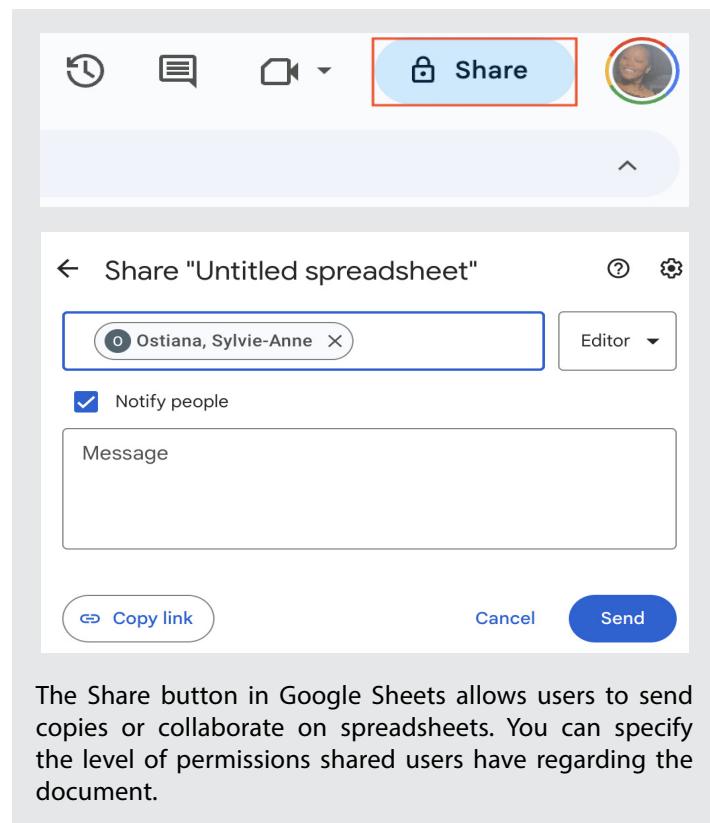
Analyzing and Organizing Data

Filters

If you have a humongous spreadsheet, you may find it useful to look at a narrower set of data to focus your attention on one or two aspects of the data. By applying a filter, you can choose which rows are visible and which ones are hidden. Keep in mind, filtering doesn’t change the underlying data. Only the data set that matches the filtering criteria gets displayed. When you remove the filters, you will have the original spreadsheet with all the rows, just as before.

For example, you may have your company’s sales data for every Division, Sub-Division, and product (Figure 132). If you want to focus only on the data for your Division, Sub-Division, or product, setting up a filter may be a great idea.

In Google Sheets, click on the filter icon and select “Create new filter” view. Then click on the column header of any column to filter data (Figure 133).



The Share button in Google Sheets allows users to send copies or collaborate on spreadsheets. You can specify the level of permissions shared users have regarding the document.

Division	Sub-Division	Product Number	Number of Units	Price per unit
east	1	1111	140	\$10
west	2	1111	21	\$9
west	3	1111	18	\$12
east	3	1111	16	\$8
west	1	1111	11	\$10
east	4	1111	11	\$9
west	3	2222	16	\$12
west	2	2222	15	\$10
east	2	2222	15	\$11
west	1	2222	12	\$10
east	3	2222	12	\$9
east	4	2222	12	\$9
east	1	2222	10	\$9
east	2	2222	9	\$13

FIGURE 132 — When working with large sets of data, users may choose to filter specific columns.

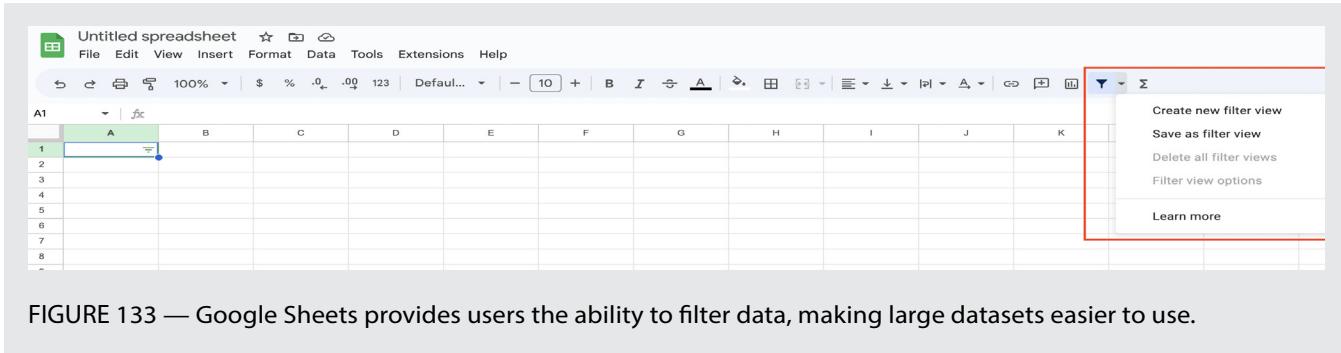


FIGURE 133 — Google Sheets provides users the ability to filter data, making large datasets easier to use.

To create a filter on the division column, click on the column header “Division.” If you only want to see sales data for the West Division, you should deselect “East” and click “Ok” (Figure 134). When you create filters in Google Sheets, the sidebars change in color to indicate that a filter is in place (Figure 135).

You could create additional filters on top of an existing one. For example, if you wanted to only see a particular Sub-Division within your Division, you can create a filter on the “Sub-Division” column (Figure 136). Removing the filters will bring the original data and the color changes back to normal.

To filter in Excel, select any cell within the range of data. Then go to the “Data” tab and click on the “Filter” menu. On the column headers, you will see the option to filter.

Sorting

Sorting organizes data in an ascending or descending order and facilitates searching for data. Some spreadsheet operations such as VLOOKUP and Remove Duplicates also expect data to be sorted. For example, if you have a list of students with First Name, Last Name, City, and GPA in a spreadsheet, it may be useful to group all the students in a city together. Just sort the data by City to reorganize the underlying data and see all the students from one city in one place. If mayors want to award the top-performing students in their cities, they can sort by City and then by GPA to figure out which students will receive awards. If you choose to sort from the largest to the smallest (descending

A screenshot of a Google Sheets spreadsheet titled "Divisions". The spreadsheet has columns A through E and rows 1 through 27. Column A is labeled "Divisions" and contains values like "West", "West", "West", etc. A filter sidebar is open on the left, showing the current filter applied to column A: "West". The sidebar includes buttons for "Select all" and "Clear", and "OK" and "Cancel" buttons at the bottom.

FIGURE 134 — Once in the “Create new filter” view of Google Sheets, users can filter columns of data.

A screenshot of a Google Sheets spreadsheet titled "Divisions". The spreadsheet has columns A through E and rows 1 through 10. Column A is labeled "Divisions" and contains values like "West", "West", "West", etc. The data is filtered to show only the "West" entries. The sidebar shows the filter applied to column A.

FIGURE 135 — Once a filter has been established, you only see the data you are interested in.

A screenshot of a Google Sheets spreadsheet titled "Sub-Division". The spreadsheet has columns A through E and rows 1 through 8. Column A is labeled "Divisions" and contains values like "West", "West", "West", etc. The data is filtered to show only the "West" entries across multiple columns. The sidebar shows the filter applied to column A.

FIGURE 136 — Users can filter multiple columns at the same time.

order), the student with the highest GPA will be at the top.

Just like Filtering, Sorting doesn't alter the underlying data. What you change is how rows get ordered compared to the other rows in the data set.

To sort by Division in Google Sheets, we simply select the column and then do "Data" → "Sort" (Figure 137).

If you want to do more complex sorting (first by one column, then by another), in Google Sheets simply select the cells that comprise your data set and choose "Data" → "Sort Range" option. "Advanced range sorting options" will let you sort by as many columns as you like (Figure 138).

In Excel, go to the "Data" tab and click "Sort" to open the "Sort" window and sort by as many columns as you like. Don't forget to select the checkbox "My data has headers," if your top row has headers. This will make sure only the data gets sorted, not the headers.

Conditional Formatting

Conditional formatting allows you to apply formatting, such as cell shading and text color, to cells based on conditions. This can be useful in highlighting important information or for making data easier to read and understand. You can use a formula or a set of rules to determine which cells should be formatted.

Going back to our company sales data, let's say we want to highlight any sales of more than 15 units in green and those with less than 10 units in red. In Google Sheets, select the cells you want to format, then choose "Format" → "Conditional Formatting" (Figure 139). In the conditional formatting window, make sure the cells you want to format are selected, then create rules to see the formatting results (Figure 140).

In Excel, the "Conditional Formatting" menu is under the "Home" tab. Just select "Highlight Cells Rules" and create the conditional formatting rules you want.

Division	Sub-Division	Product Number	Number of Units	Price per unit
east	1	1111	140	\$10
west	2	1111	21	\$9
west	3	1111	18	\$12
east	3	1111	16	\$8
west	1	1111	11	\$10
east	4	1111	11	\$9
west	3	2222	16	\$12
west	2	2222	15	\$10
east	2	2222	15	\$11
west	1	2222	12	\$10
east	3	2222	12	\$9
east	4	2222	12	\$9
east	1	2222	10	\$9
east	2	2222	9	\$13

Division	Sub-Division	Product Number	Number of Units	Price per Unit
east	1	1111	140	\$10
east	2	1111	21	\$9
east	3	1111	18	\$12
east	3	1111	16	\$8
east	1	1111	11	\$10
east	4	1111	11	\$9
east	3	2222	16	\$12
east	2	2222	15	\$10
west	2	2222	15	\$11
west	1	2222	12	\$10
west	3	2222	12	\$9
west	4	2222	12	\$9
west	1	2222	10	\$9
west	2	2222	9	\$13

FIGURE 137 — Unsorted sales data of a company (top); Data sorted by Division (bottom).

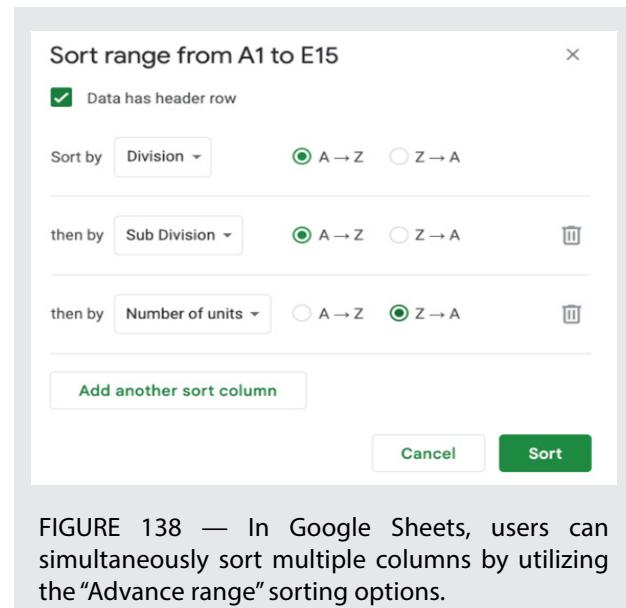


FIGURE 138 — In Google Sheets, users can simultaneously sort multiple columns by utilizing the "Advanced range" sorting options.

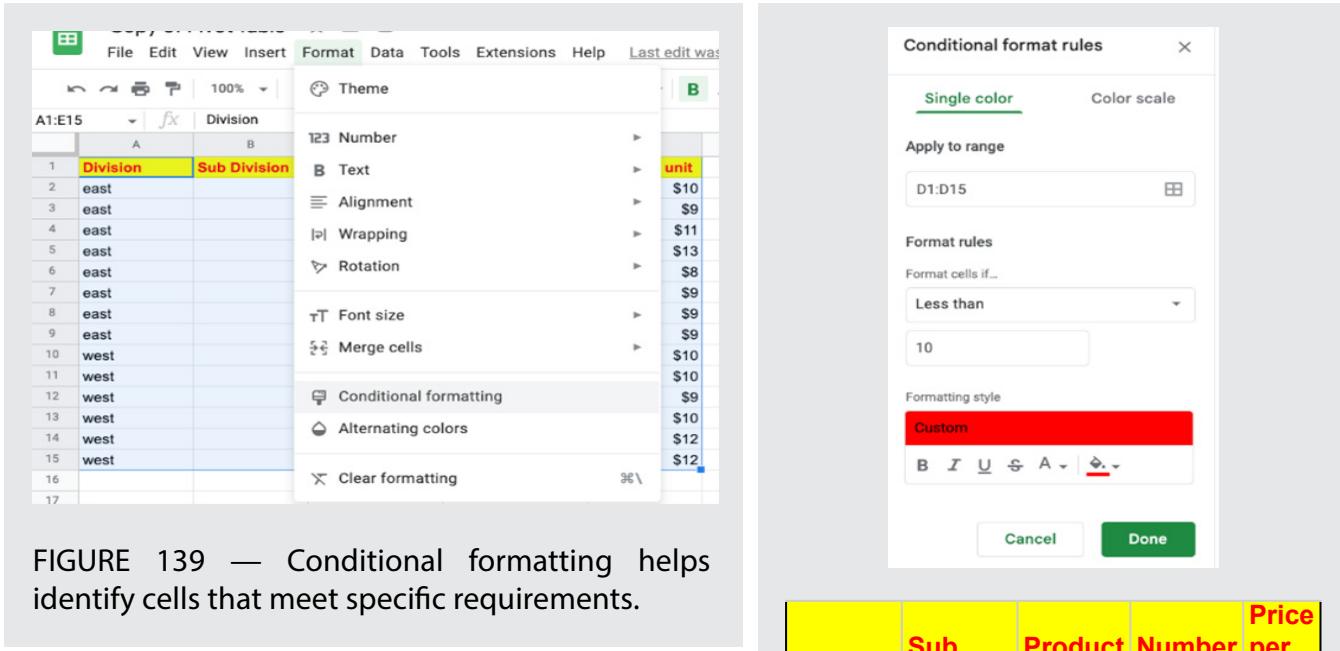


FIGURE 139 — Conditional formatting helps identify cells that meet specific requirements.

Pivot Tables

A pivot table is a useful tool to quickly summarize and analyze large amounts of data to see patterns and trends. Manually analyzing the data in a spreadsheet with 1000s of rows spread across tens of columns can be a daunting task. If you want to see patterns, compare the impact of different columns, or group data in categories, you may need to put in months of painstaking work. Using pivot tables, you can simply select all your data, transpose it to a pivot table, select columns to categorize on, filters to apply, and choose the summarizations you want. The software will do the calculations and give you a pivot table summary report. If you don't like the outcome or if you want to change your filtering, grouping, or summarization parameters, you can do so and immediately see the outcome.

Additional Resources

Spreadsheets have a wide range of capabilities for a wide array of applications. To become proficient at using spreadsheets, consider using them anytime you are working with numbers. Like any skill, practice will improve your ability to leverage this highly valuable technology.

Several influencers share valuable Excel tips on social media sites, including Twitter. Some threads the authors can recommend are below:

15 Excel tips: <https://twitter.com/FluentInFinance/status/1611807041399705600>

Search by hashtag for Excel: <https://twitter.com/hashtag/excel>.

Division	Sub Division	Product Number	Number of units	Price per unit
west	2	1111	21	\$9
west	3	1111	18	\$12
west	3	2222	16	\$12
west	2	2222	15	\$10
west	1	2222	12	\$10
west	1	1111	11	\$10
east	1	1111	140	\$10
east	3	1111	16	\$8
east	2	2222	15	\$11
east	3	2222	12	\$9
east	4	2222	12	\$9
east	4	1111	11	\$9
east	1	2222	10	\$9
east	2	2222	9	\$13

FIGURE 140 — Users can specify colors to represent cells that meet specific criteria.



Chapter Terms and Definitions

Cell: A cell is a single element in the worksheet that has a value, some text, or a formula

Chart: A type of visualization shaped like a pie and used to analyze data in an intuitive and user-friendly way

Column: Represents categories of data and the cells are named by alphabet vertically

Conditional Formatting: A spreadsheet feature that allows you to apply formatting options, such as cell shading and text color, to cells based on conditions

Data: Information used for reasoning, discussion, or calculation

Filter: A spreadsheet feature designed to narrow a set of data based on specific criteria so that you can choose which rows are visible and which ones are hidden

Formula: A feature that performs specific calculations or other actions on the data in the spreadsheet

Function: A set piece of code built into a spreadsheet that performs certain predefined actions; examples include SUM, AVERAGE, COUNT, MIN, and MAX

Pivot Table: A useful tool to quickly summarize and analyze large amounts of data to see patterns and trends

Row: Represents a record of data and the cells are numbered horizontally

Sorting: A spreadsheet feature that organizes data in an ascending or descending order and facilitates searching for specific data

Spreadsheet: A computer program that represents information in rows and columns, and makes it easy to perform calculations with the data



Chapter Case

Sports Tracking Spreadsheet

Kenny needed to take on a volunteer project to help with his future chances of getting a college scholarship. Most of the college scholarships he was interested in applying for required that he have a minimum number of documented volunteer hours. Thankfully, a local non-profit youth sports management organization needed to create a spreadsheet that would help track students who sign up for various youth sports.

Kenny offered to help the organization create the spreadsheet in exchange for documented volunteer hours. The manager of the organization agreed to the project and Kenny was ready to apply his spreadsheet skills.

The spreadsheet required the tracking of the following data:

- Student First Name
 - Student Last Name
 - Student Age
 - Student Grade
 - Student School
 - Telephone Number
 - Sport (Volleyball, Basketball, Softball, Baseball, Soccer, or Football)
-

Question 1: Considering the data required in the list above, create a spreadsheet in a spreadsheet application you have access to. Add at least 10 rows of data to your spreadsheet. Once you add all the data to the spreadsheet, what is the average age for all the students? What formula did you use to calculate the average age?

Question 2: Add a chart to the spreadsheet that illustrates the total number of students for each sport. Which sport has the highest number of students? What formula did you use to count the total number of students for each sport?

Introduction to Presentation Applications

10

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Presentations aren't about the presenter; they're about the audience and what the audience needs.

—Simon Raybould, author of “Presentation Genius: 40 Insights from the Science of Presenting”

Overview

A **presentation** is an electronic document that conveys information to an audience. Robert Gaskins got the idea¹³¹ of software to create “*slides of text and graphics in a graphical, WYSIWYG environment, then outputting them to 35-mm slides, overhead transparencies, or video displays and projectors... [t]he presentation would spring directly from the mind of the business user, without having to first transit through the corporate art department.*”¹³² Before working on PowerPoint, as a student, Gaskins had worked in the computer lab at Berkeley as a graphics consultant. Gaskins began working on the software, initially called Presenter, in July 1984, and continued working on it with two colleagues, Dennis Austin and Tom Rudkin, and released PowerPoint on April 20, 1987, for Mac computers. Three months later, in July 1987, Microsoft bought their company, Forethought Inc, for \$14 million. 5 years later in 1992, Microsoft released PowerPoint 3.0, which in Gaskins’ words, realized his initial vision for the product.¹³³ The first public presentation from a laptop to project video from PowerPoint took place on February 25, 1992, in Paris. Since then, presentation software is used at virtually all business meetings to improve communication.¹³⁴ Students use presentation software in a variety of creative ways to create flyers, brochures, and other electronic documents.

What is a Presentation Application?

A presentation application allows users to create and display presentations. Presentations are usually made up of a series of **slides** or pages, each containing text, charts, images, and videos. Both word processors and presentation applications create electronic documents with unstructured content. The difference is in the goals and intended audience. Word processors create self-contained documents that have all the detail necessary for a single reader to understand the information without any external aids. This book is an example of a document created with a word processor. Presentation

-
- 131 The 2-page original concept for PowerPoint is at <https://www.robertgaskins.com/powerpoint-history/documents/gaskins-powerpoint-original-proposal-1984-aug-14.pdf> (accessed June 2023).
 - 132 How PowerPoint was created, David Pescovitz, <https://boingboing.net/2017/11/01/how-powerpoint-was-created.html>, accessed from David Gaskins’ website at <https://www.robertgaskins.com/> (accessed June 2023).
 - 133 A highly recommended site that describes the PowerPoint origin story is Robert Gaskins’ website at <https://www.robertgaskins.com/> (accessed June 2023).
 - 134 For an important counterpoint to the use of presentations to facilitate business meetings, read why Bezos banned the use of presentations at Amazon, and what they do instead at <https://twitter.com/JonErlichman/status/1573096127389474816?lang=en>. This is business legend and there are several articles online describing this approach. An example is <https://www.foleon.com/blog/why-jeff-bezos-banned-powerpoint-from-meetings> (accessed June 2023).

applications are used to create electronic documents that support a talk given by a presenter to a large audience, by making it easy to display visual information. The slide decks your teacher will use in class to present the information in this textbook are created using a presentation application.

Typically, when a speaker presents information or teaches in front of an audience, they use slides to display graphics, statistics, and other related information that adds context to the talk. Often this information is difficult to describe verbally, but easy to present visually. Popular presentation applications include Microsoft PowerPoint, Google Slides, and Apple Keynote. These applications are feature-rich, providing tools to create and format text, images, and other media, to design a consistent look and [layout](#) of the presentation.

Slides

A presentation slide is a single page of a presentation. The term “slide” originated from the days of overhead projectors, when an enhanced image was projected onto a screen that the audience could see from a distance. Even with the advent of computers, the term slide remains popular. Presentations are sometimes called slide decks. Unlike a page in a document, which is typically intended to be read by someone in a personal setting, a slide is intended to be used in a shared setting, either on a conference call such as Zoom or in a conference room in front of an audience.

Adding, Deleting, and Reordering Slides

If you have Microsoft software, you can click on any existing presentation or open PowerPoint to create a new presentation. If you use Google Slides, just go to slides.google.com. You can either open a blank presentation or pick a template from the wide selection of templates available in both PowerPoint and Google Slides (Figure 141 shows an example).

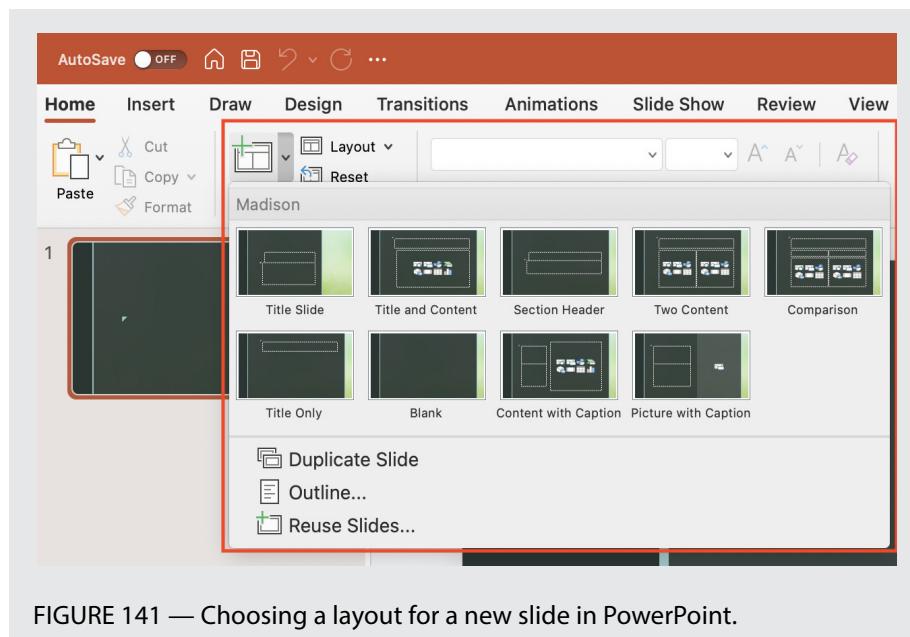


FIGURE 141 — Choosing a layout for a new slide in PowerPoint.

To add new slides to your presentation in PowerPoint, go to the “Home” tab, click “New Slide,” and then pick any layout you want. In Google Slides, go to the “Insert” menu and select “New slide” (Figure 142). You will notice new slides inherit the same color scheme as the existing slides. We will discuss later in this chapter how you can change the layout and **theme** of your slides.

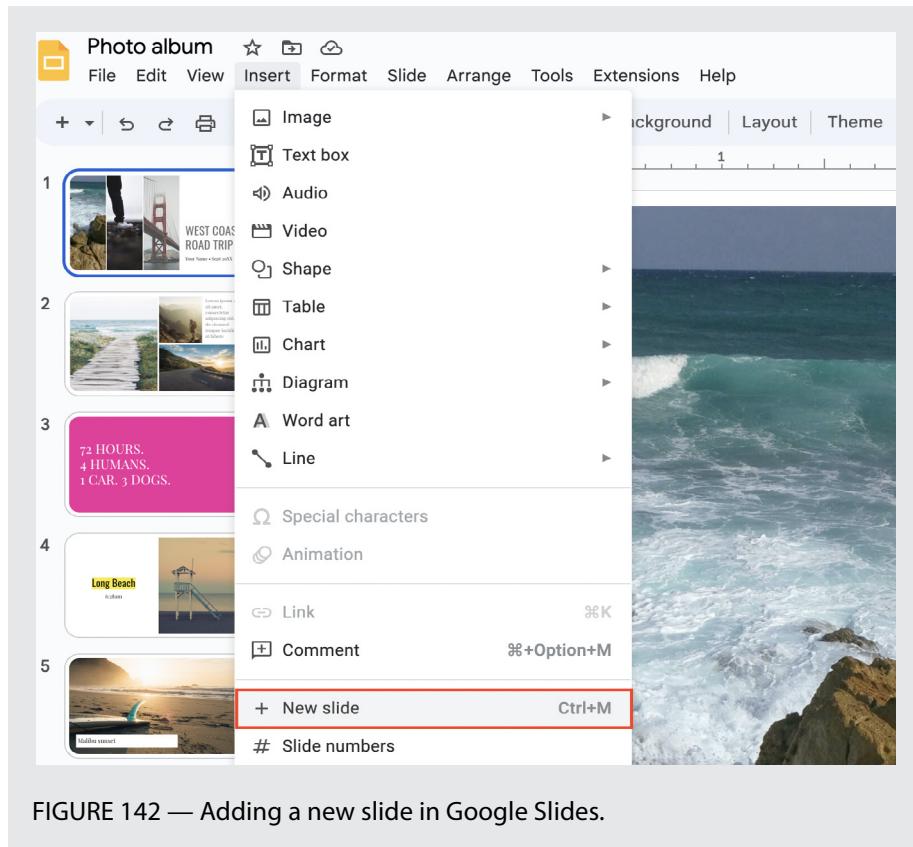


FIGURE 142 — Adding a new slide in Google Slides.

To delete any slide in PowerPoint or Google Slides, select the slide, then right-click on your mouse to bring the context menu, and then select “Delete Slide” (Figure 143). Once you have finished creating your slides, you may want to rearrange the slides based on inputs from colleagues and friends. In the pane on the left (called the slide thumbnail pane), you can see thumbnails of all your existing slides. To move slides around, just click the thumbnail of the slide you want to move, then drag it to the new location. You can also select multiple slides by holding “Ctrl” while you click the slides you want to move, and then drag them as a group to a new location. The slide thumbnail pane is very useful to organize your slides.

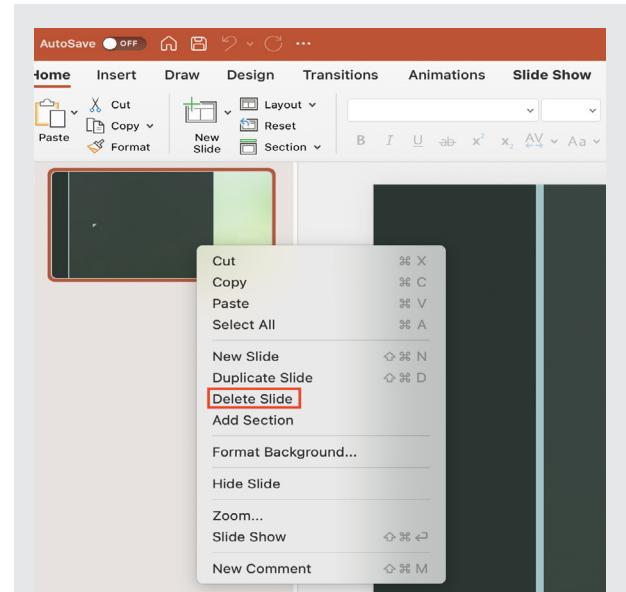


FIGURE 143 — Users can delete a slide by right-clicking on the slide to bring up the menu that has “Delete Slide.”

Formatting Slides

You can customize how your presentation looks by changing the theme, layout, and background of your slides.

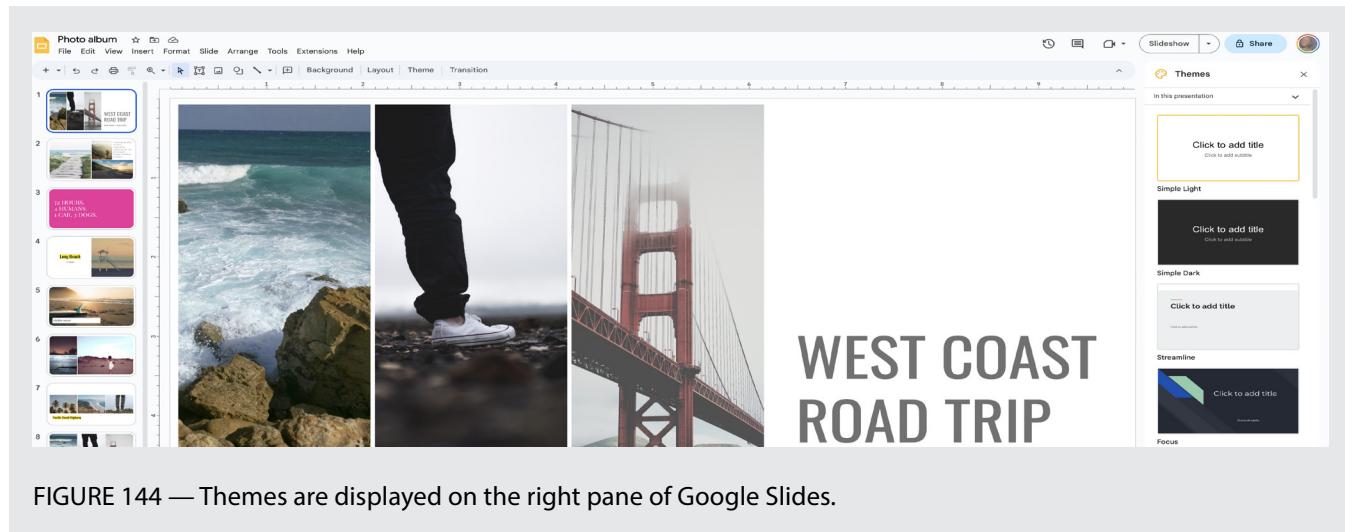


FIGURE 144 — Themes are displayed on the right pane of Google Slides.

Themes offer a predefined set of colors, fonts, and visual effects for the presentation. Themes give your presentation a unified, professional look. For most presentations, one of these predefined themes will work very well. To change the theme in Google Slides, go to the “Slide” menu, then select “Change theme.” The right pane will show a variety of themes you can choose from (Figure 144). Selecting any theme will change the theme of all your existing slides (Figure 145). In PowerPoint, go to the “Design” tab to select from the list of available design themes.

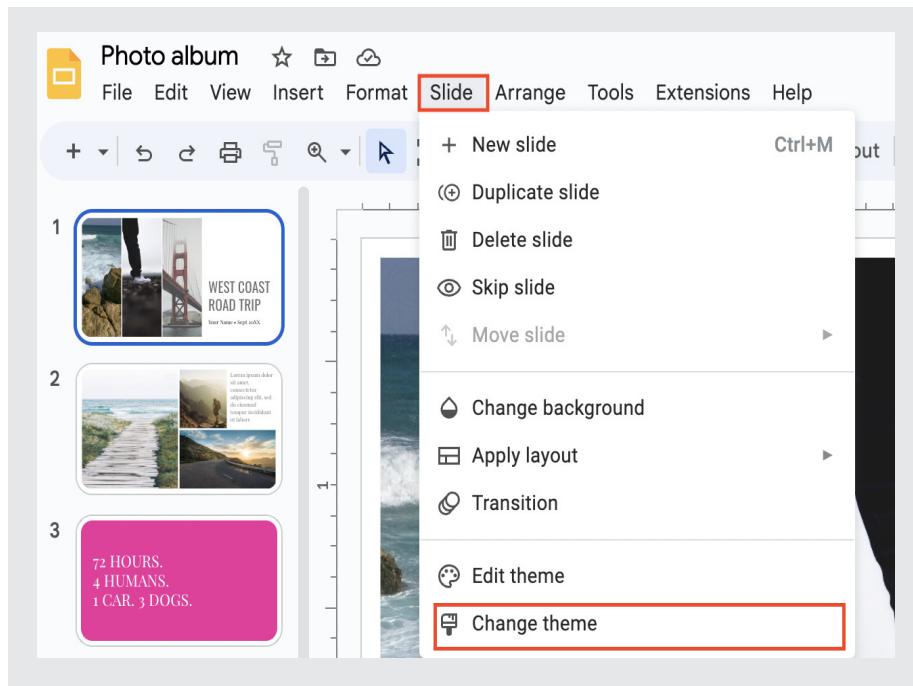
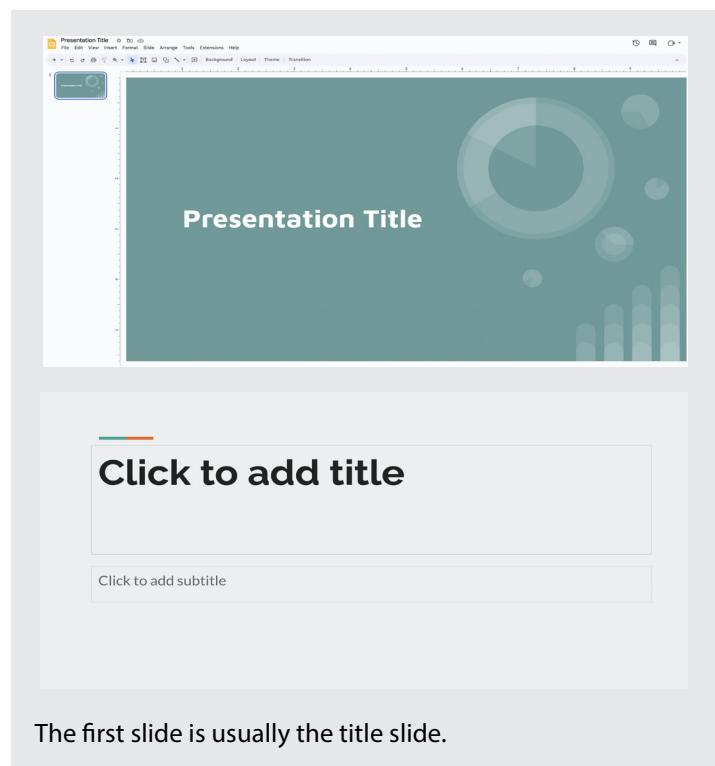


FIGURE 145 — Google Slides users can change their themes using the toolbar.

Layout determines how information is arranged on a slide. Typically, there is a single theme for the entire presentation, but the layout changes from slide to slide based on the type of information you want to present. For example, in a typical presentation, the first slide has a layout appropriate for a title slide to introduce the presentation to the audience. By default, this first slide has a place to enter the title and subtitle of the presentation, along with the name of the presenter. Most themes offer multiple layout options for the same task. You can use any of these layouts to communicate your message.

The slides following the title slide have different kinds of content and there are various layouts to choose from to present this content. In the simplest case, you may just have a text box in your slide if you are planning to write a paragraph. You may want to use a two-column layout if you plan to compare the performance of two different products. In PowerPoint, you have the option to select a layout when you add a new slide. You can also change the layout of any slide by clicking the slide and then right-clicking on the mouse to bring the context menu. Select “Layout” to get all the available layout options (Figure 146). In Google Slides, you have the option to “Apply layout” under the “Slide” menu (Figure 147). Of course, you can change the layout of the slide manually, too. For example, if you want to remove a text box or an image from your slide, just select the text box or image and click delete.



The first slide is usually the title slide.

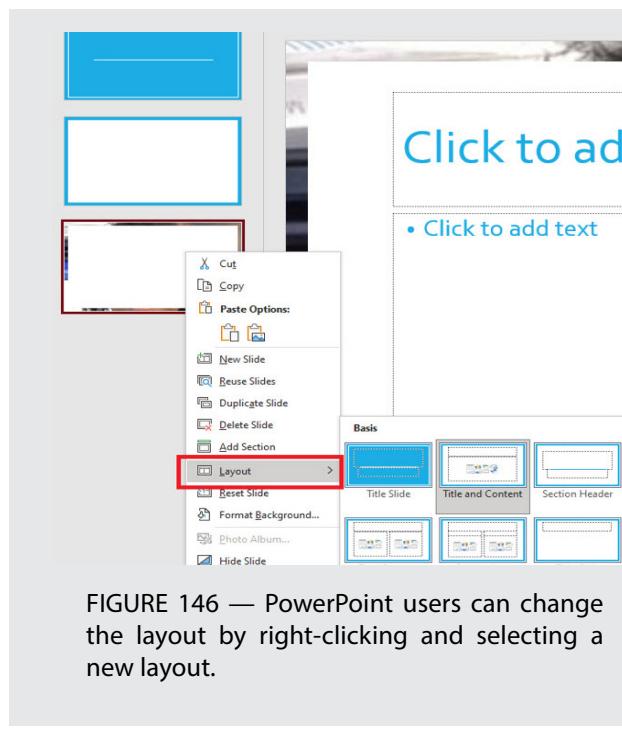


FIGURE 146 — PowerPoint users can change the layout by right-clicking and selecting a new layout.

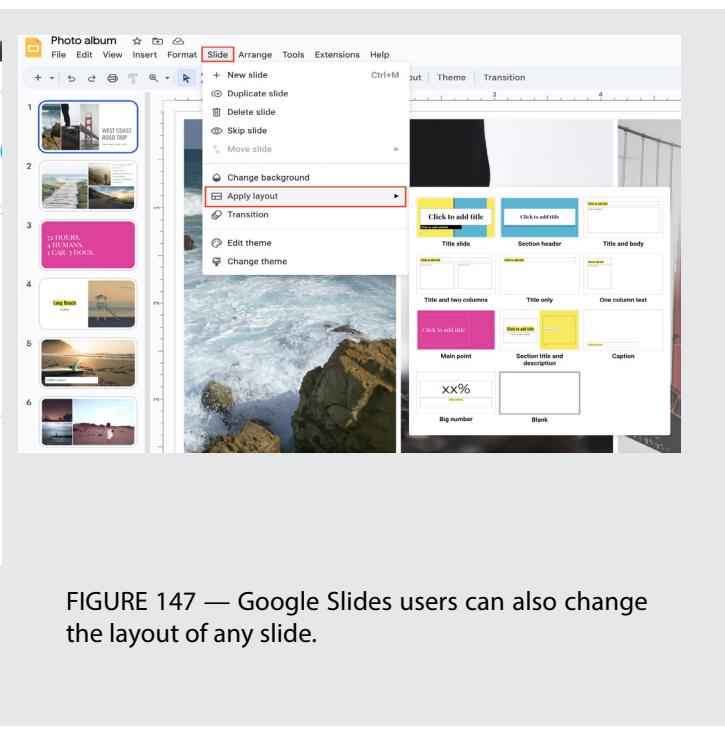


FIGURE 147 — Google Slides users can also change the layout of any slide.

The background refers to the area behind the slides. It can be a solid color, a pattern, or a picture. The purpose of the background is to set the tone and style of the presentation and to help create a cohesive look. You can use the background to reinforce your presentation's theme or to support your overall message. You can customize the background for a single slide or all the slides in your presentation.

To change the background in Google Slides, just select the slide you want to change, right-click on your mouse to bring the context menu, and then select "Change background" (Figure 148). You can also go to the "Slide" menu and select "Change background." The process to change the background is similar in PowerPoint. You can select the slide, bring up the context menu, and select "Format Background" (Figure 149). Once you select the kind of background you want, you could apply it to the selected slide or to all the slides in your presentation. The "Design" tab in PowerPoint also offers you the option to "Format Background" and apply it to the selected slide or all the slides in your presentation.

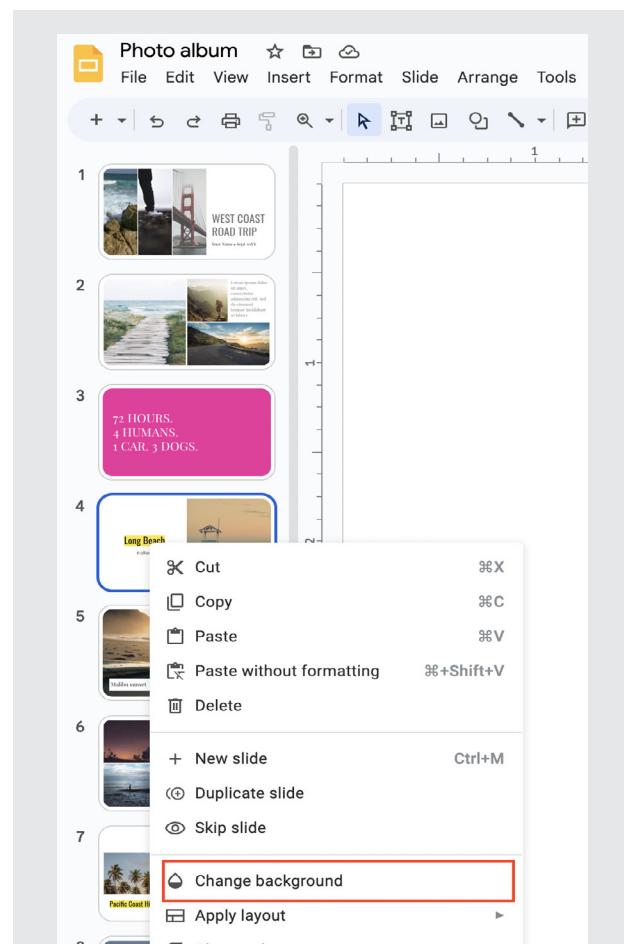


FIGURE 148 — Editing the background of a slide allows users to insert pictures.

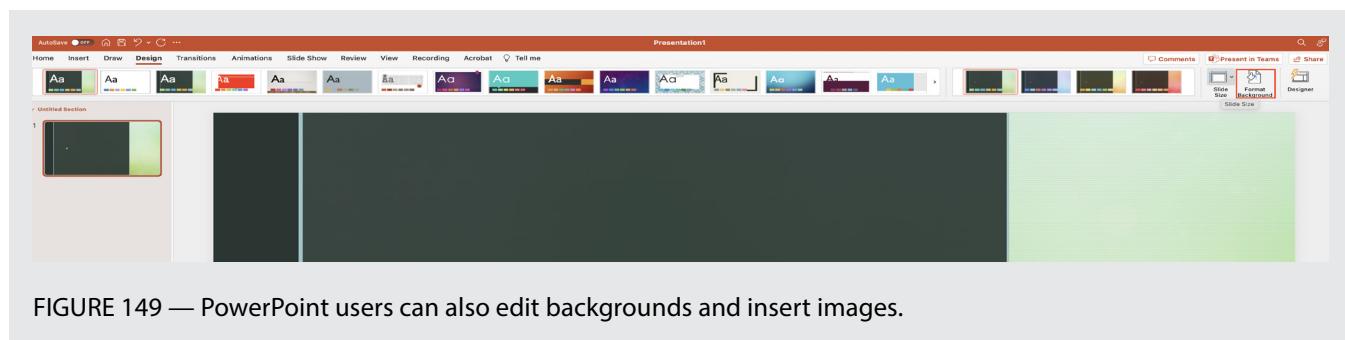


FIGURE 149 — PowerPoint users can also edit backgrounds and insert images.

Presentation Design Tip

As you discover presentation software features such as backgrounds and layouts, it is very tempting to use them indiscriminately across your presentation. However, too many changes in visual design can quickly become jarring and draw viewers' attention away from the core message you are trying to convey. Use your judgment so your design elements enhance your message, not distract from the message you want to convey.

Adding Content

Once you insert a slide, you can add content to the slide by listing your ideas and inserting charts and videos to illustrate your point. Charts and videos serve the additional purpose of ensuring folks don't fall asleep in the middle of your presentation. Keep in mind, you do not want to create verbose slides with paragraphs of text. These slides become unreadable to most. You should have just enough words to convey your core message, without boring your audience with details. For additional information, you can refer audience members to websites or other documents that have the necessary context. For example, your slide can say that "club membership grew by 16% this year" and present all necessary details in your talk or supporting documents.

Adding text is easy. Most slide layouts have text boxes where you can enter text. How many text boxes are there depends on the layout of the slide. In the slide in [Figure 150](#), there are two rectangular text boxes, one small box that serves as the header of the slide and the other large one for the main content. This is perhaps the most common layout used in presentations.



FIGURE 150 — Text boxes allow users to customize the location of text in individual slides.

Sometimes you may want to add additional text boxes to your slide. In Google Slides, go to the "Insert" tab and then click on the "Text box" ([Figure 151](#)). Click and drag on the slide to create a text box. Similarly, in PowerPoint, go to the "Insert" tab and click on the "Text Box" icon in the "Text" group. You can then click and drag on the slide to create a text box.

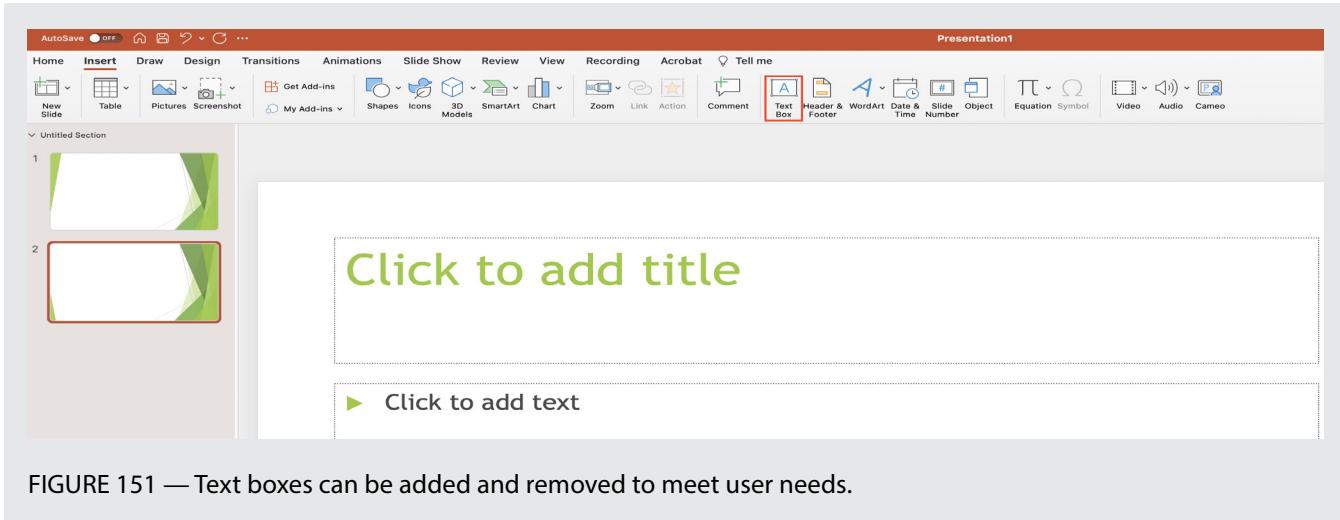


FIGURE 151 — Text boxes can be added and removed to meet user needs.

You may want to create bulleted and numbered lists in text boxes to make your point succinctly. To create a list in PowerPoint, just go to the “Home” tab and click on the “Bulleted List” or “Numbered List” in the “Paragraph” group. Similarly, in Google Slides, just click on the bulleted or the numbered list icon in the ribbon and select the format you want (Figure 152). A bullet point or number will appear on the slide. Press “Enter” to create a new bullet point or number.

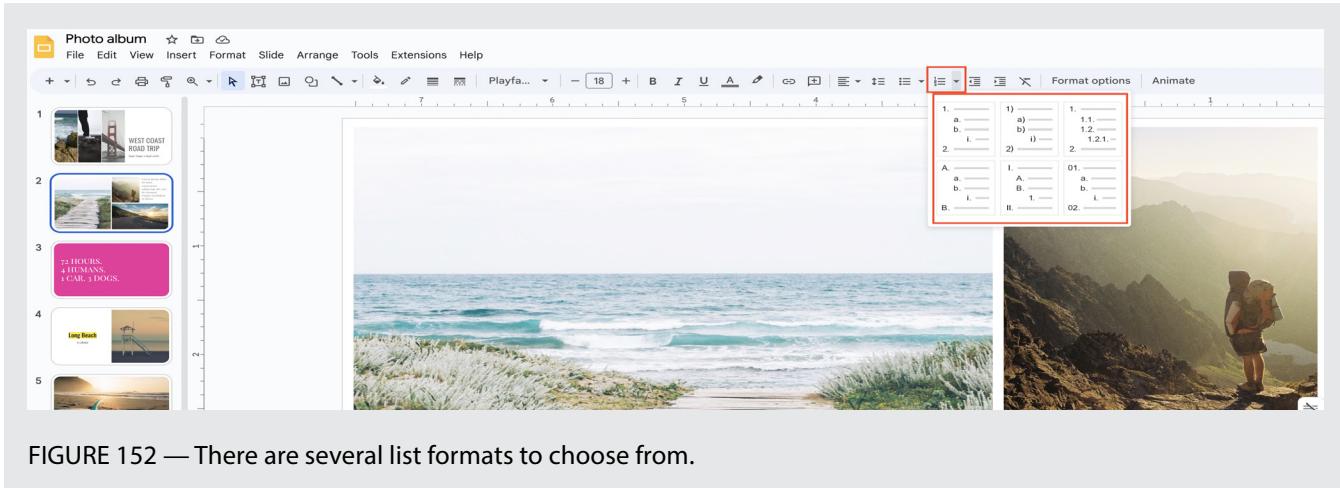


FIGURE 152 — There are several list formats to choose from.

Both Google Slides and PowerPoint allow you to insert shapes, images, tables, charts, headers, and footers. In PowerPoint, the ribbon of the “Home” tab has many different shapes in the “Drawing” group (Figure 153). You can choose to fill the shapes if you want with color and add texture and gradients. In PowerPoint, under the “Insert” tab, you have the option to add tables, charts, slide numbers, headers, and footers.

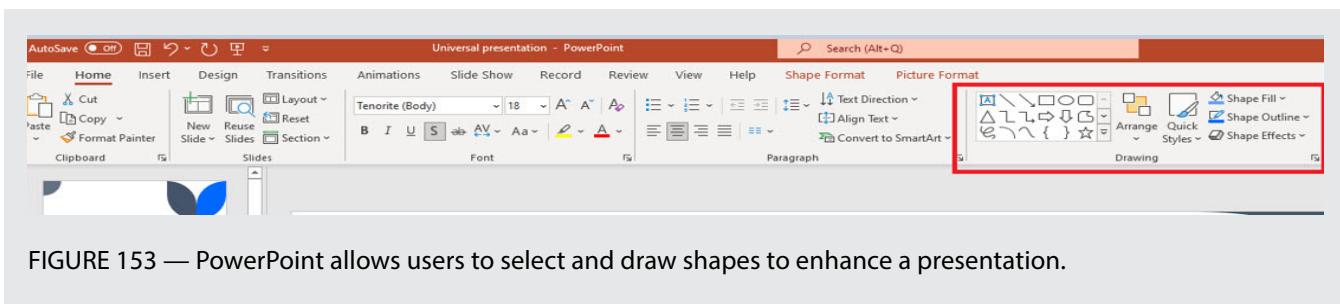


FIGURE 153 — PowerPoint allows users to select and draw shapes to enhance a presentation.

When you add shapes and text boxes to your slide, it is useful to ensure that the shapes on the slide don't go out of sync with each other. The simplest way to do this is to group shapes. Grouping preserves the individual shapes but treats the group as one object while rearranging. To group shapes, select the shapes by clicking on the shapes while holding the "Ctrl" button, then right-click to bring the context menu, and choose "Group" (Figure 154). A very common group is a shape object and the associated text box label.

In Google Slides, you have the shapes icon on the ribbon, which offers a variety of shapes, arrows, callouts, and equations (Figure 155). You can also go to the "Insert" tab to add shapes, tables, charts, diagrams, and images. Text boxes can also be added over shapes to create a narrative. You can group and align several shapes to create a consistent look.

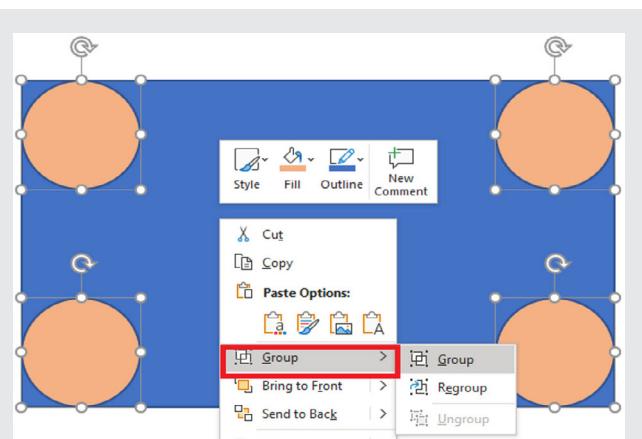


FIGURE 154 — Grouping shapes helps create complex images that can be reused later

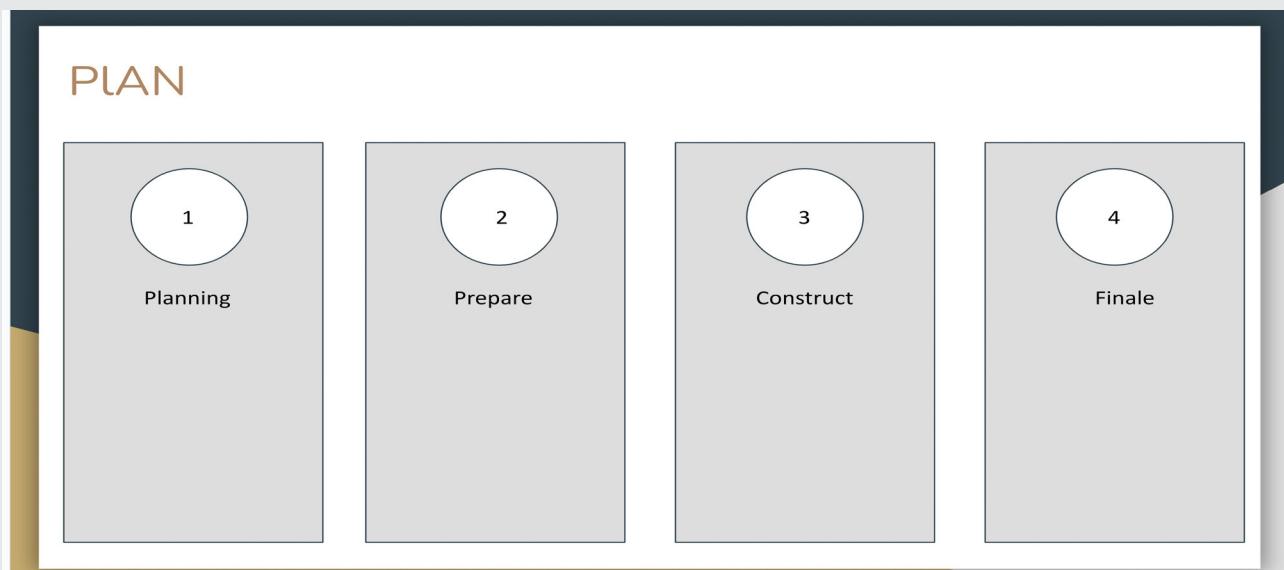
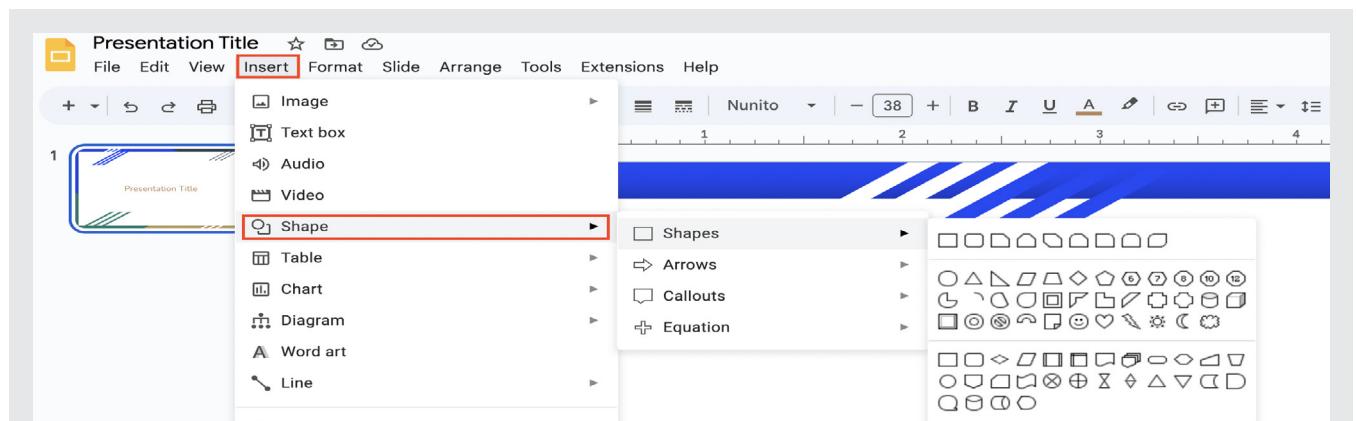


FIGURE 155 — Google Slides also allows users to insert and create shapes (top). By layering shapes and combining with text boxes, users can create unique layouts (bottom).

Inserting media content is also easy in Google Slides and PowerPoint. In Google Slides, go to the “Insert” tab and search for any video on YouTube, the Internet, or your local drives. Once you find the video you want, selecting it will insert it into your slide. Similarly, in PowerPoint, under the “Insert” tab, you can use the “Video” button in the “Media” group to select videos from your device, YouTube, or other online sources.

Presentation Applications as Drawing Tools

Presentation applications are one of the best drawing tools available, though unfortunately, their drawing abilities are highly underrated. Between shapes, connectors, alignment tools, grouping, and related capabilities, you can create almost any kind of drawing using presentation tools.

Business Elements: Charts, Graphs, Tables, and Spreadsheets

You can make the data in your presentation stand out by adding tables, charts, graphs, and spreadsheets. There are many ways to add tables to slides. In PowerPoint, just go to the “Insert” tab, click on the “Table” button, and find several options to create a table (Figure 156). You can select boxes representing columns and rows to tell the software how many columns and rows you want. Otherwise, you can select the “Insert Table” option and input the number of rows and tables you want.

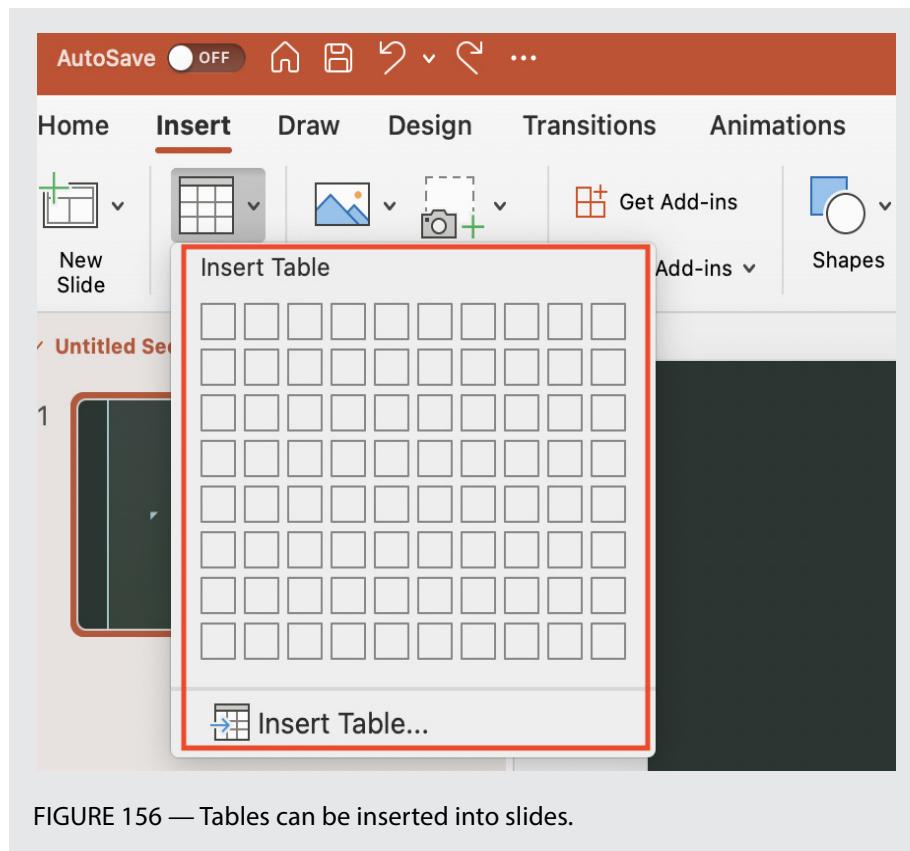


FIGURE 156 — Tables can be inserted into slides.

Once you have your table, you can go to the “Table Design” tab and select any of the available Table Styles. You can change the border style to either highlight or minimize the table borders. The “Effects” button allows you to add special effects, including Cell Bevel, Shadow, and Reflection (Figure 157).

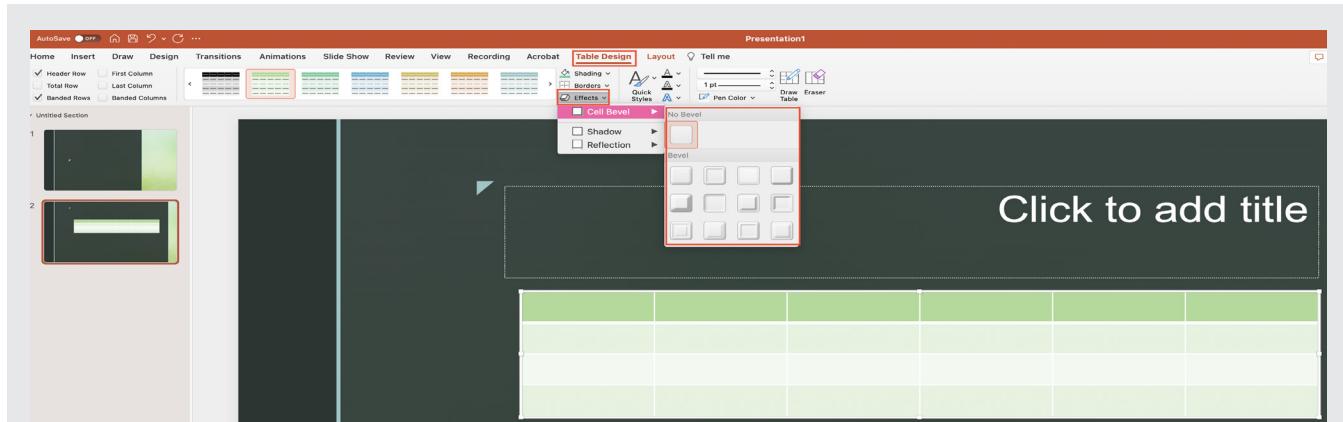


FIGURE 157 — Table effects personalize how data is displayed and can be attention grabbing.

You can also link an Excel spreadsheet to your PowerPoint slide to make sure that the data in your slide gets updated every time you change your spreadsheet. To do this, go to the “Insert” tab and then click on “Object” in the “Text” group. In the “Insert Object” window, select “Create from file” and make sure to select the checkbox (“Link”) to link the two objects (Figure 158). Once you click “Ok,” the spreadsheet will get inserted into your slide. Anytime you change your Excel file, the data in your presentation will also get updated. This is particularly useful when working with rapidly changing data and ensures the data and charts are up to date.

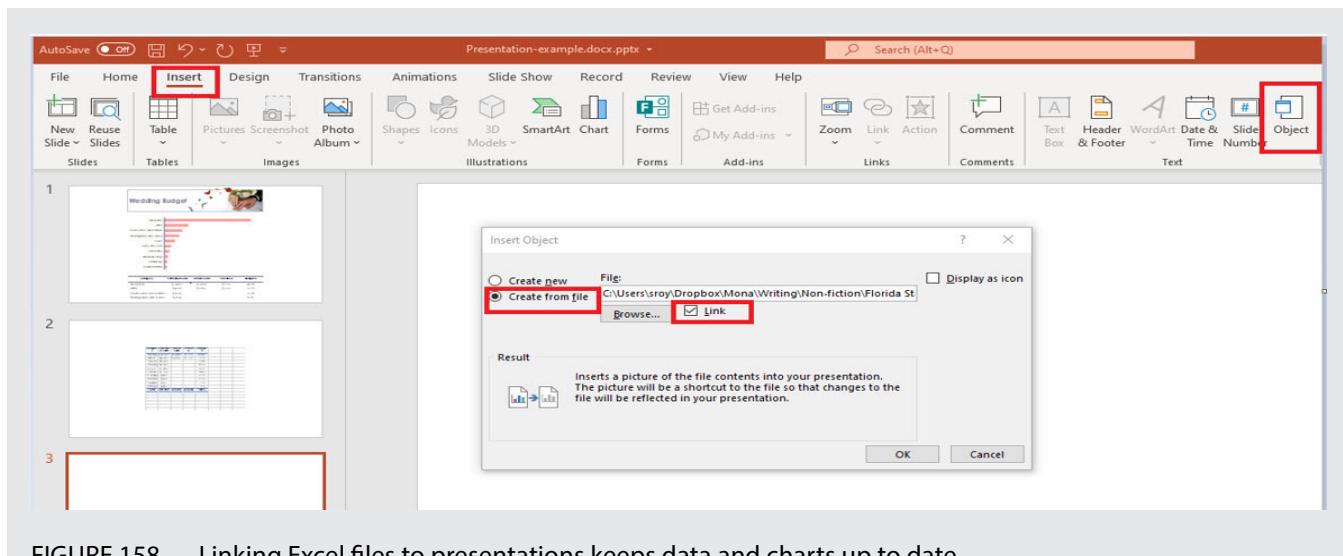


FIGURE 158 — Linking Excel files to presentations keeps data and charts up to date.

Working with tables in Google Slides is also relatively simple. You can create a table in Google Slides by choosing the “Table” option under the “Insert” tab. To link an existing spreadsheet to a slide, just open both the slide and the spreadsheet. Copy the data in the spreadsheet and make sure to select “Link to spreadsheet” before you paste it on your slide (Figure 159).

Adding charts and graphs is important to make your presentation stand out. Presentation applications have basic charting capabilities to help you create charts without first plotting them in spreadsheets.

If you are using PowerPoint, simply go to the “Insert” tab and select the type of chart you want. A sample chart, as well as the data associated with the chart, will get added to the slide (Figure 160). To replace the sample data with your own, paste your data or change the sample data manually.

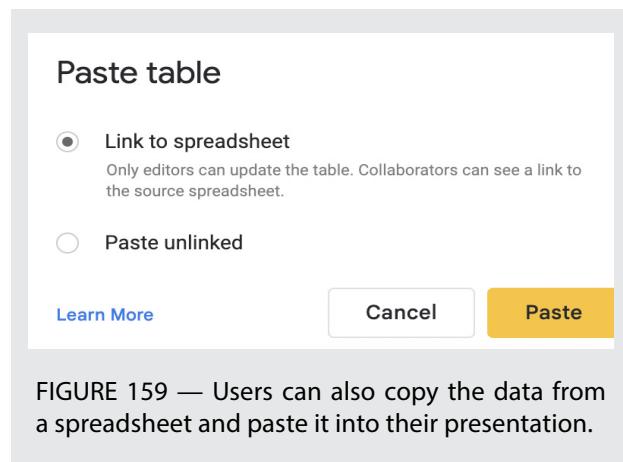


FIGURE 159 — Users can also copy the data from a spreadsheet and paste it into their presentation.

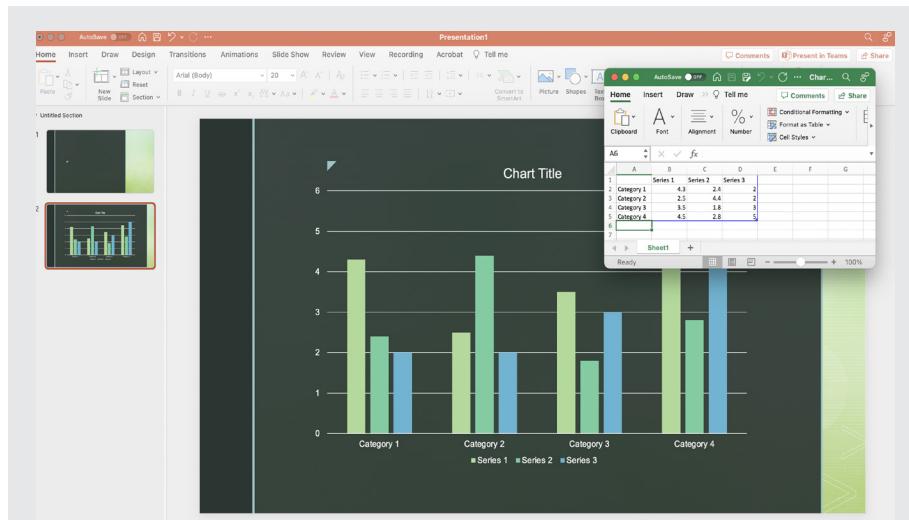
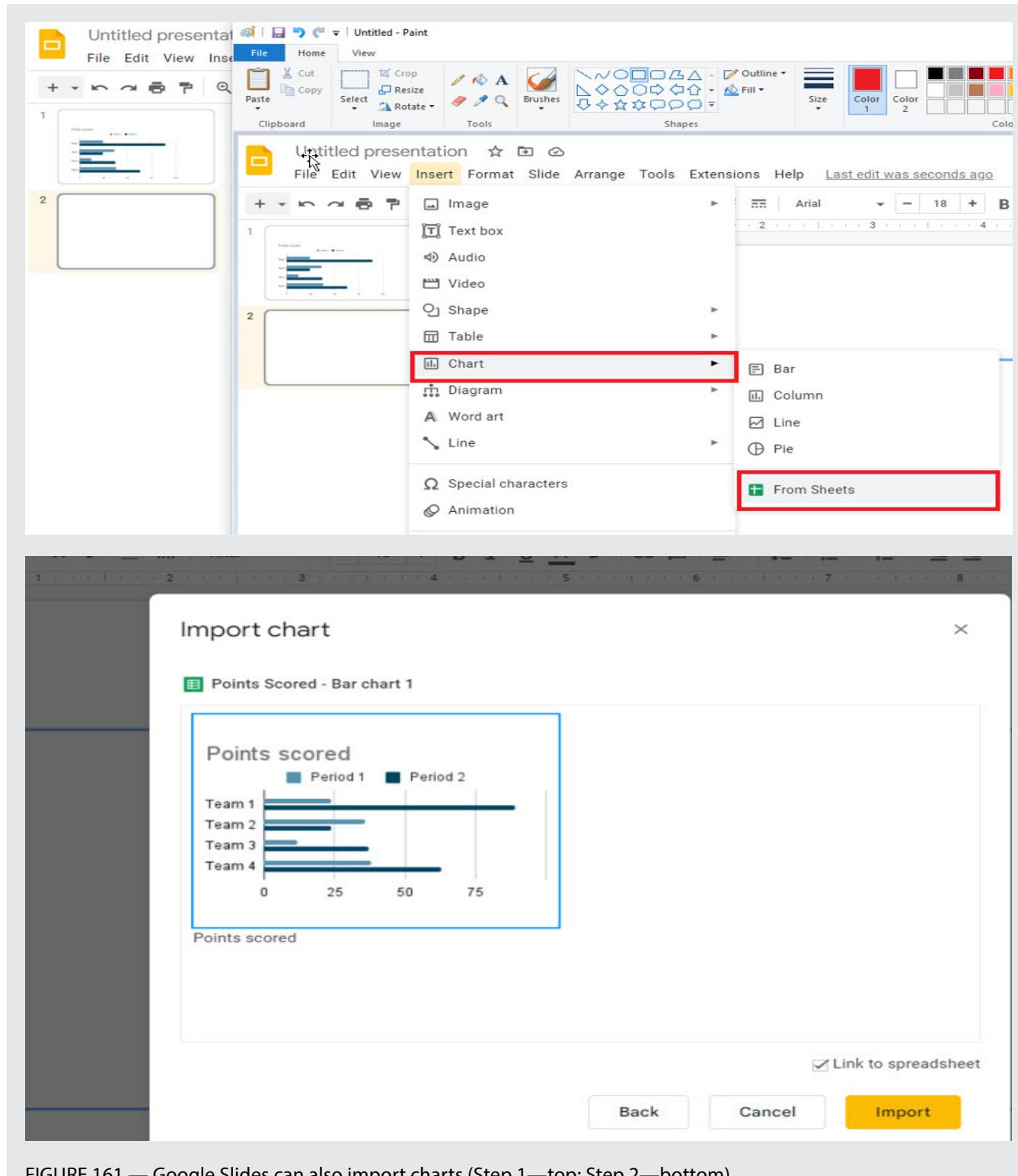


FIGURE 160 — Users can create graphs and visualizations in the presentation application.

Right-clicking on the chart will bring up the context menu to let you change labels, chart type, and data. For more extensive controls and to work with large quantities of data, you could copy charts created in Excel and paste them in PowerPoint. You will have the option to link the PowerPoint chart to Excel, which can be great if you want the chart in PowerPoint to change every time you change the data in Excel. Otherwise, you could choose to embed an Excel chart into a slide, which makes the chart a part of the presentation and disconnects it from the original source data. You can edit the data associated with the chart in PowerPoint, and it will be saved with the presentation.

You can insert a chart just as easily in Google Slides by going to the “Insert” tab and selecting the “Chart” menu option and the chart type you want. Both the chart and the sample data will get inserted into your slide. You can change the data and labels to customize your chart. For more extensive capabilities, you can also insert a chart from an existing Google Sheets file and link the two, so the chart in Google Slides gets updated whenever you update the data in the spreadsheet (Figure 161).



Linking and Embedding¹³⁵

Linking and embedding are two different ways of displaying information that has been created in a different program (often a spreadsheet). Embedding creates a copy of the original data in the document and removes any association between the document and the data source. Linking retains the data in the original spreadsheet and uses the document or presentation just for display.

In practice, linking requires great care since the links can get broken if either the document or spreadsheet is moved from their locations.

Sharing, and Printing Slides

Sometimes you may need to share your slides with your colleagues to get their feedback before your slides are ready to be presented to customers or stakeholders. If you want to share Google Slides, you can do that by clicking on the “Share” button in the top-right corner of your screen. You can also use the “Share” option under the “File” tab and set up your colleagues and friends as editors, commenters, or viewers. Once your presentation is final, you may want to make it available to everyone by choosing to “Publish to the web” (Figure 162). If you choose the “Publish to the web” option, you can select the “Auto-advance” option to make sure the slides move forward automatically.

To share PowerPoint slides with others, you could send the slides as an email attachment. Otherwise, you could also upload the file to a cloud storage service such as OneDrive, Google Drive, or Dropbox and share the link with your audience. The third option is to upload the file to an online presentation platform such as Slideshare, Prezi, or PowerPoint Online and share the link with others.

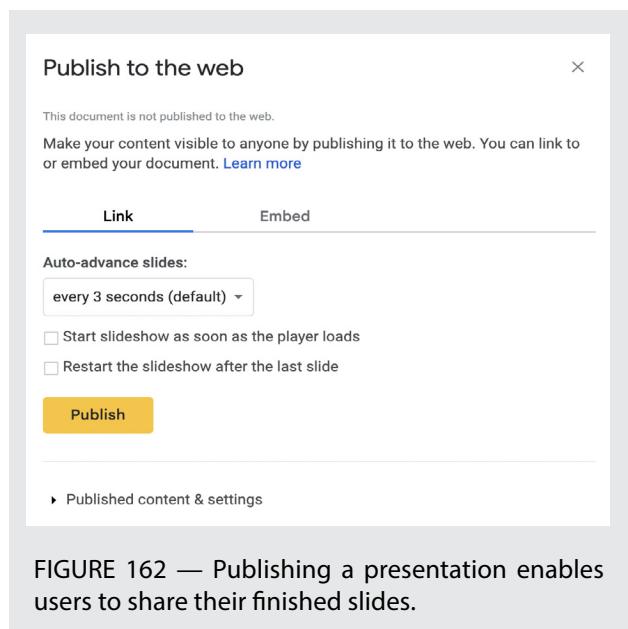


FIGURE 162 — Publishing a presentation enables users to share their finished slides.

¹³⁵ For more information on linking and embedding, please lookup related articles online. One such article is from 2010 at Microsoft’s website <https://support.microsoft.com/en-us/office/linked-objects-and-embedded-objects-0bf81db2-8aa3-4148-be4a-c8b6e55e0d7c> (accessed June 2023).

Often, while delivering in-person presentations, speakers like to distribute printed copies of their slides to everyone in the audience, to help them make notes while the presentation is going on or to refer to the slides at their leisure. When you print your slides, you could choose to print your slides as handouts or outlines (Figure 163). Handouts let you print multiple slides per page, usually in a format that is easy for people to take notes on. In PowerPoint, you can choose to print anywhere from one to nine slides per page. You can also include space for notes or include speaker notes. Outlines are a way to print the text from your slides in a document format. This is useful for people who want to follow along with the presentation or for people who want to read through the presentation before or after it is given.

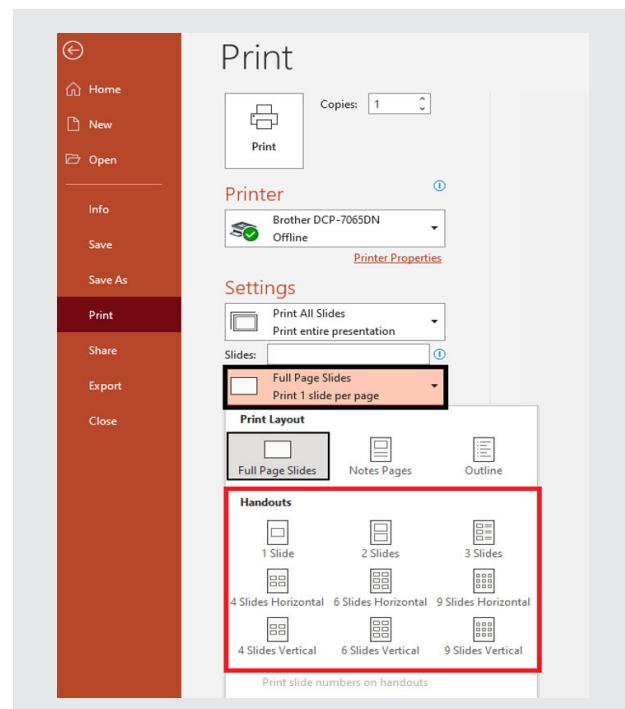
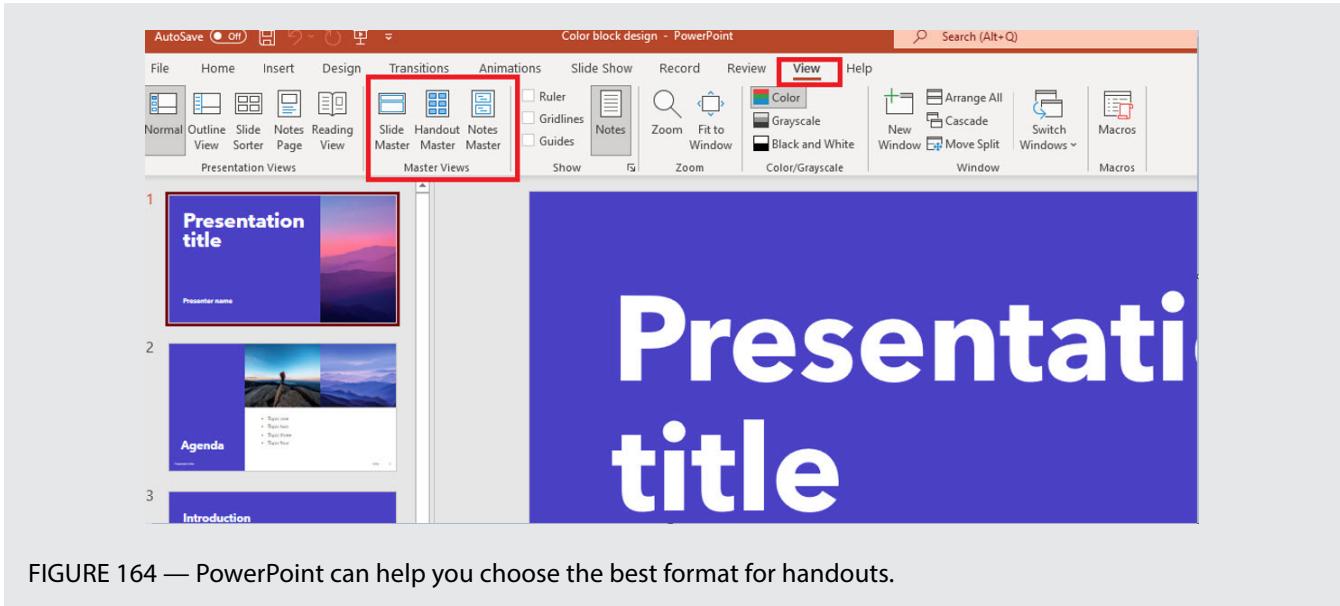


FIGURE 163 — Users can print slides to create handouts.

Outlines as a Power Tool for New Document Creation

One very powerful but underrated use of presentation applications is creating document outlines. In the normal workflow, users create documents describing a plan in the greatest possible detail, then create a presentation to describe the plan to an audience. This sequence can also be reversed. You can start with the presentation and use the bullet lists and slide rearranging features to create your presentation as an outline of your document. The outline exported from the presentation application will be an electronic document with slide titles and bullets. You can now fill in each section to create the complete document. This is a very effective way to create a new document when you are still trying to develop the structure of the document.

To see all the formatting options for handouts (to decide the layout, the number of slides per page, page numbers, headers, footers, and background styles) go to the "View" tab and check out the "Handout Master" (Figure 164). "Notes Master" will let you customize how your presentation will look when printed with notes.



When you are ready to print or export a PowerPoint presentation, just go to the “File” menu and select “Print.”

Google Slides also has similar options to print or export your presentation in the form of handouts and outlines. You can download Google Slides as PowerPoint slides or as a PDF document. Once you have the slides in PowerPoint or PDF, you can use the print option to create handouts or outlines. The “Print” option in Google Slides lets you choose the number of slides per page and whether to include notes or not.

Delivering the Presentation

When you are done creating and ordering your slides and have prepared them for sharing with others, you may have the opportunity to deliver the presentation to an audience. One of the first things you may want to add is speaker notes for your slides. Speaker notes are a list of important talking points. Speaker notes can be added to slides in Google Slides as well as in PowerPoint to help you remember things you want to talk about during the presentation. In PowerPoint, click on “Notes” in the bottom-right corner to add notes. In Google Slides, clicking on the three dots at the bottom of the page will bring a box to enter speaker notes. Otherwise, you could go to the “View” tab and select “Show speaker notes.”

You can add a few elements to make features in your presentations interesting. One such feature is **transitions** between slides (Figure 165). To add transitions in PowerPoint, go to the “Transitions” tab and select the type of transition you want. If you are presenting at a children’s birthday party, your transitions may have sound effects. But formal presentations in business contexts tend to be more sober affairs. Flashy visuals are seen as lacking in seriousness. Once you select the type of transition you want, you can choose to apply it to all slides by clicking “Apply To All.” If you are at a trade show and want to run slides continuously, you may choose to advance slides automatically after a certain time rather than move slides manually with “On Mouse Click.” In Google Slides, add transitions by clicking on the “Transition” button on the ribbon.

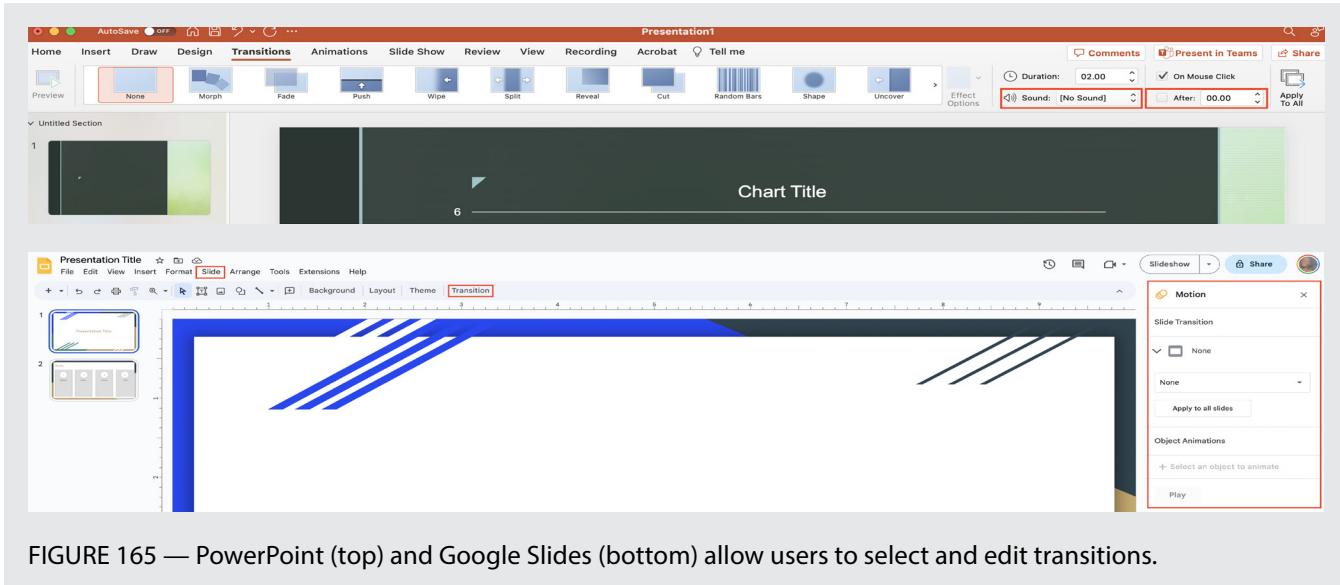


FIGURE 165 — PowerPoint (top) and Google Slides (bottom) allow users to select and edit transitions.

Not all presentations are in-person. With many organizations switching to remote work due to the changes and adaptations required as a result of the Covid pandemic, many meetings and presentations are now delivered on Zoom, Google Meet, or Skype. Whether online or live, when you present in front of a large audience, you may want to ensure that your laptop or mobile device can successfully connect to the projector, display, or meeting software. Make sure to practice a few times to avoid a panicky, stressful situation on the day of the presentation.

Once you are ready to present, you will need to switch to the presentation mode in the presentation application. The presentation mode removes all editing controls and uses the entire viewing area to display the slides. In presentation mode, you can move slides manually or automatically. In PowerPoint, you have the “Slide Show” tab with many different options to present. To start the presentation, go to the “Start Slide Show” group and select “From Beginning” or “From Current Slide.” If you select “Use Presenter View,” you will see the notes and several other presentation options on a second display connected to your computer while you present. This can be very useful since you may want to have access to your notes while presenting but don’t want to show them to others. The presenter view also gives you access to the taskbar while you are presenting. In Google Slides, begin presenting by clicking on the “Slideshow/Presenter” button in the top-right corner ([Figure 166 top](#)). You have the option to give the URL of the presentation to your audience so they can ask questions that will show up on your screen as they are typed in ([Figure 166 bottom](#)). You can address the questions at the end or immediately as they appear on your screen.

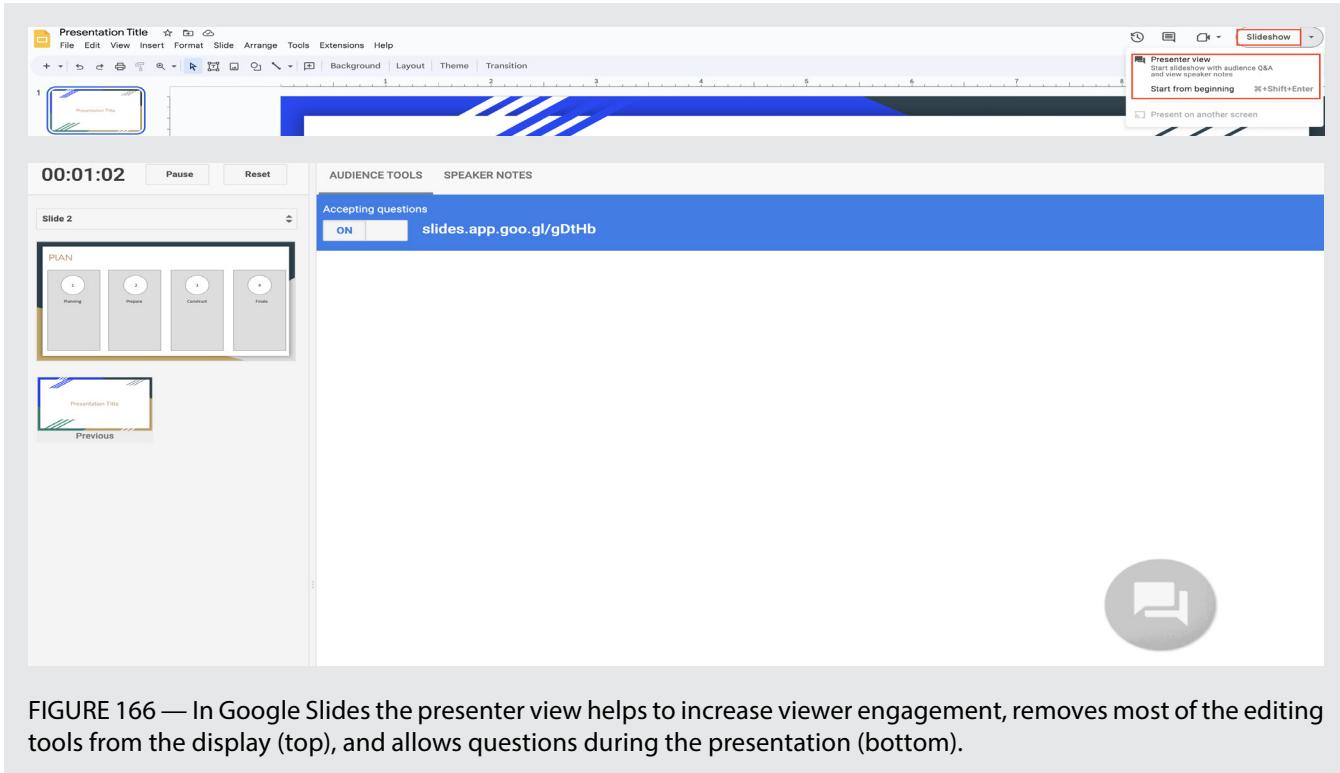


FIGURE 166 — In Google Slides the presenter view helps to increase viewer engagement, removes most of the editing tools from the display (top), and allows questions during the presentation (bottom).

Learning to Deliver Great Presentations

Thus far, we have described the important elements of creating and delivering a presentation. As you create your own presentations, it is useful to pay attention to what makes presentations successful. Since the primary purpose of presentations is to communicate with an audience, it is important to use consistent font sizes, styles, and colors throughout your presentation. Bullet points and numbered lists help organize and present information clearly and concisely. Headings and subheadings help structure your content and make it easier for your audience to follow along. Also, images, charts, and other types of graphics help illustrate your points and make your presentations more engaging.

Experts have shared several tips online for creating and delivering great presentations. A very good starting point is the TED talks playlist on how to create great presentations. It is available at https://www.ted.com/playlists/574/how_to_make_a_great_presentation.

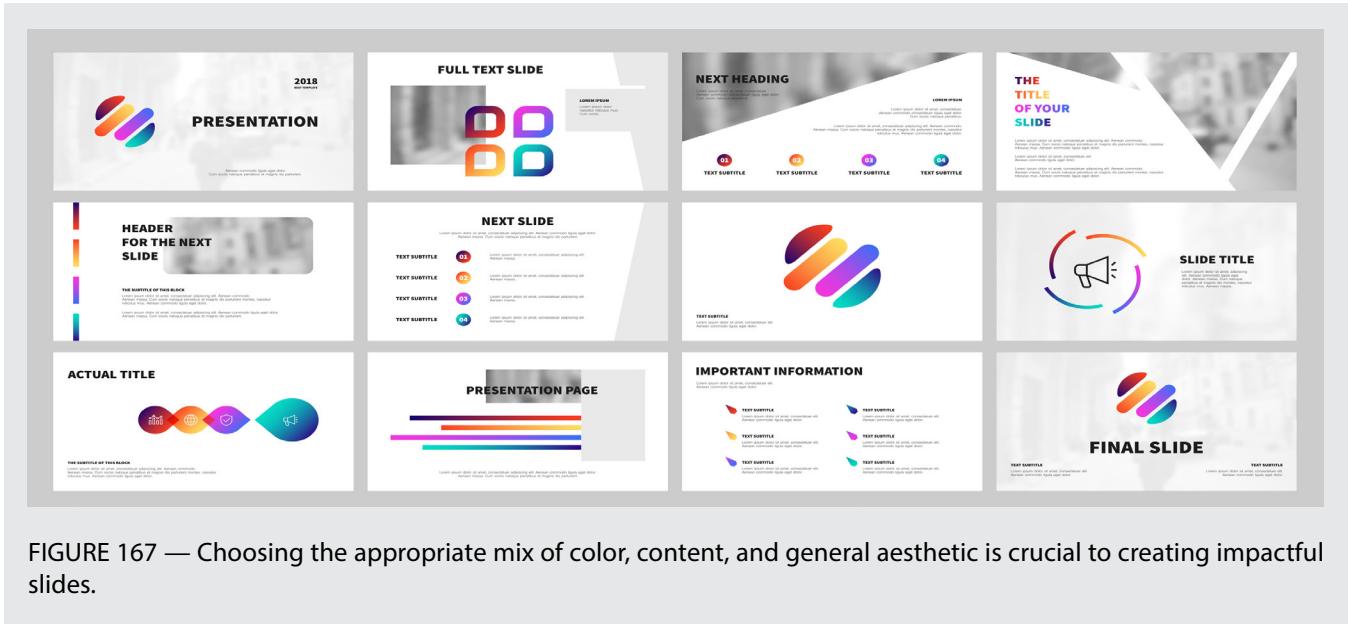


FIGURE 167 — Choosing the appropriate mix of color, content, and general aesthetic is crucial to creating impactful slides.

Here are a few suggestions to create impactful slides ([Figure 167](#)):

1. Add data and remarks to make your point clearly and briefly
2. Explain complex concepts or ideas by providing visual aids—images, charts, graphs, and videos—to help your audience understand and retain information.
3. Create an appealing presentation that captures and holds the audience's attention and helps them stay engaged.



Chapter Terms and Definitions

Background: Refers to the area behind the slides

Embedding: Creates a copy of the original data in the document and removes any association between the document and the data source

Layout: Determines how information is arranged on a slide

Linking: Retains the data in the original spreadsheet and uses the document or presentation just for display

Presentation: An electronic document that conveys information to an audience

Slide: A single page of a presentation used to visually display content intended to be used in a shared setting

Slide show: A presentation mode in the presentation application that removes all editing controls and uses the entire viewing area to display the contents of the slides

Theme: A predefined set of colors, fonts, and visual effects that can be used for the presentation

Transition: A feature is used in presentations to apply special visual or audio effects when advancing one slide to another



Chapter Case

Amber's Business Presentation

Amber was preparing for a Future Business Leaders of America (FBLA¹³⁶) high school competition. FBLA is the largest business Career and Technical Student Organization in the world. Each year, FBLA helps over 230,000 members prepare for careers in business. Its mission is to inspire and prepare students to become community-minded business leaders in a global society through relevant career preparation and leadership experiences.¹³⁷

Amber was competing in the category, "Introduction to Business Presentation." Her task was the following:

You are trying to raise money to attend a business leadership training program in New York City. This would be a week-long summer program that will cost \$2,000. You will prepare a presentation that can be used in front of potential sponsors from your community. Be sure to include why you should attend, and the benefit you will receive and bring back to your school.¹³⁸

.....

Question 1: Maybe you aspire to be a future leader or perhaps you may not. However, consider for a moment that you will be participating in this competition with Amber. Create a presentation using a presentation application you have access to that meets the requirements described above. Be sure to apply a theme, background, and professional layout.

Question 2: Considering that you are petitioning your community to sponsor the funding needed to pay for the summer program, add at least one "business element" to your presentation. Describe the "business element" and why you added it to your presentation.

136 Future Business Leaders of America, FBLA, High School, <https://www.fbla-pbl.org/divisions/fbla/> (accessed June 2023).

137 Future Business Leaders of America, FBLA, Mission, <https://www.fbla-pbl.org/about-fbla-pbl/> (accessed June 2023).

138 This sample scenario was taken from FBLA website, which describes the "Introduction to Business Presentation" competition category.

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To not have an email address is the digital equivalent of being homeless. Without it you can't shop online, bank online or engage with social media.

—Dela Quist, email marketing leader and founder of Alchemy Worx

Overview

Email is the method of sending, receiving, and organizing messages using a computer. Barely a few decades ago, the only way to [send](#) messages and documents was to mail them physically at the post office (or use courier services like FedEx and UPS). Email transformed the way we communicate. It allowed us to send and receive messages and documents instantaneously, regardless of the physical location of the sender or the receiver. Along with services like instant messaging and video calling, email spurred global e-commerce by breaking geographical barriers and allowing friends and family to stay in touch on a day-to-day basis for little to no cost. To mail a letter through the postal service, you needed to write the letter or take a printout of the letter, put it in an envelope, attach stamps, and write the mailing address on the envelope. If you have access to a smartphone or computer, emailing is much easier. You only need to know the [email address](#) of the person you want to email, then type the message, and include any documents you want to attach to the message. Clicking the “Send” button will instantly transfer the email from your [inbox](#) to the receiver’s inbox, while you continue to work on your computer.

Email is critical for students and adults in the modern world. As a high schooler, you probably receive important notifications from your school and are required to submit assignments through email. These days, most job applications are sent and received through email because email not only helps deliver information and documents but also serves as a permanent record of your interactions. When you shop online for clothes or use food delivery services, you may get an email or a text message that you can refer to for details or in case of a disagreement with the other party. A critical feature of email, compared to instant messaging, is that emails are stored in virtual mailboxes, and have the advantage of never getting lost, unless deleted deliberately. In most cases, depending on your email provider,¹³⁹ you will be able to restore even deleted messages from the Trash folder for a while.

Email Origins

Message passing was one of the first uses of computers. The earliest electronic communication systems were like leaving a note on a user’s desk. Users could leave a message in a specific folder on another user’s computer, who would then open the message at their convenience.¹⁴⁰ When the Internet became available, users wanted to send messages to anyone connected to a computer. This introduced the need for consistent ways of doing several things, such as identifying computers, identifying users on computers, and packaging messages. In 1972, Ray Tomlinson used the “@” symbol already available on computer keyboards to create the simple “user@computer” convention

139 Even after you delete an email, service providers go through a detailed process to ensure the email is deleted from all their servers. Google’s policies are described at, “How Google Retains Data We Collect,” <https://policies.google.com/technologies/retention> (accessed June 2023).

140 Ian Peter, “The History of Email,” Net History, <http://www.nethistory.info/History%20of%20the%20Internet/email.html> (accessed June 2023).

for identifying users and computers, a convention that lives on to this day.¹⁴¹ In 1973, Tomlinson¹⁴² co-authored RFC 561,¹⁴³ a simple three-page document that standardized the email fields we still use today, such as "FROM""SUBJECT." In 2011, on the occasion of MIT's 150th anniversary, *The Boston Globe* rated Tomlinson the fourth most significant inventor from MIT.¹⁴⁴

As email gained popularity, accounting for as much as 75% of all Internet traffic in the early days, protocols and applications emerged to make it easier for users to send and receive email. This chapter describes these applications in detail.

The Impact of Email

The popularity of email is based on its unique ability to meet the human need to communicate.¹⁴⁵ Email has even had a significant impact on the business world. The dot-com boom of 2000, one of the greatest financial manias of all time, can be associated with email. In one of the best-known books on market manias,¹⁴⁶ author Charles Kindleberger has attributed the dot-com bubble to email and related technologies. The book states that "events that lead to a [financial] crisis start with a 'displacement,' some exogenous, outside shock to the macroeconomic system." In other words, a financial mania begins with some unanticipated event that has a great economic impact. Further, to describe the dot-com mania, the book states that "the shock in the United States in the 1990's was the revolution in information technology and new and lower-cost forms of communication and control that involved the computer, wireless communication and email." The popular adoption of email led to an entire financial bubble!

Email Technologies

Emails use a combination of technologies to work. End users have software called **mail clients** to read and write emails and manage their mailboxes. Service providers use software called **mail servers** to store and deliver emails on behalf of end users. We discuss email clients and their use in this chapter.

141 Google paid homage to this creative use of the "@" symbol on Oct 29, 2021 in "As Email Turns 50, the @ Symbol Continues to Fuel Collaboration," <https://workspace.google.com/blog/productivity-collaboration/celebrating-50-years-of-email> (accessed June 2023).

142 Internet Hall of Fame on Ray Tomlinson, <https://www.internethalloffame.org/inductee/raymond-tomlinson/>. The four-minute video on the page is worth watching, <https://youtu.be/kJp0NHkBIAY> (both accessed June 2023).

143 Abhay Bhushan, Ken Pogran, Ray Tomlinson and Jim White, RFC 561, "Standardizing Network Mail Headers," <https://www.rfc-editor.org/rfc/rfc561> (accessed June 2023).

144 "MIT 150," Wikipedia, <https://en.wikipedia.org/wiki/MIT150> (accessed June 2023).

145 As an example, most of the gadgets shown in Star Trek focused on communication, Sarah Kessler, "8 Star Trek Gadgets That Are No Longer Fiction," <https://mashable.com/archive/star-trek-gadgets> (accessed June 2023).

146 C.P. Kindleberger and R. Aliber, *Manias, Panics, and Crashes: A History of Financial Crises*, 5th ed. (Wiley, 2005).

Mail Clients

A mail client is a software program that allows you to send, receive, and manage electronic messages ([emails](#)). Mail clients get messages from a mail server and display them to the user, allowing users to read, compose, send emails, and move emails between folders. All operating systems now include an email client. New users can set up their email accounts during initial setup.

Most modern mail clients are integrated with personal productivity applications including tools for calendaring, contact management, and task management. For example, when you use Outlook (a [desktop mail client](#)), it will have a tab for managing mail, another for managing calendar events, and another for managing contacts ([Figure 168](#)). Similarly, if you use Gmail (Google's browser-based mail client), you will also have access to Google Calendar and Google Contacts.

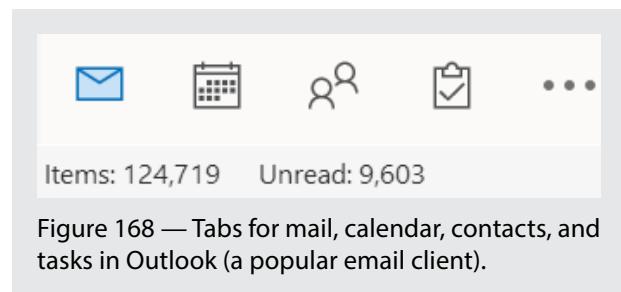


Figure 168 — Tabs for mail, calendar, contacts, and tasks in Outlook (a popular email client).

The mail client typically communicates with the mail server using a protocol called [Internet Message Access Protocol \(IMAP\)](#). A protocol is a precise specification of the interactions between communicators. Protocols govern every aspect of communication between computers. The IMAP protocol is used by mail clients to synchronize messages between your local computer and the server. When you delete an email on your email client, IMAP ensures that the email is also deleted from your mailbox on the server, operated by your Internet service provider or mail service. If you have multiple computers connected to the same email account on the server (for example, on your phone, and your desktop), IMAP ensures that an email deleted on one device is also deleted from all other devices. Similarly, an email read on one device is also marked as read on all devices connected to the same email account because IMAP helps the server inform all connected devices about the state of every message on the server.

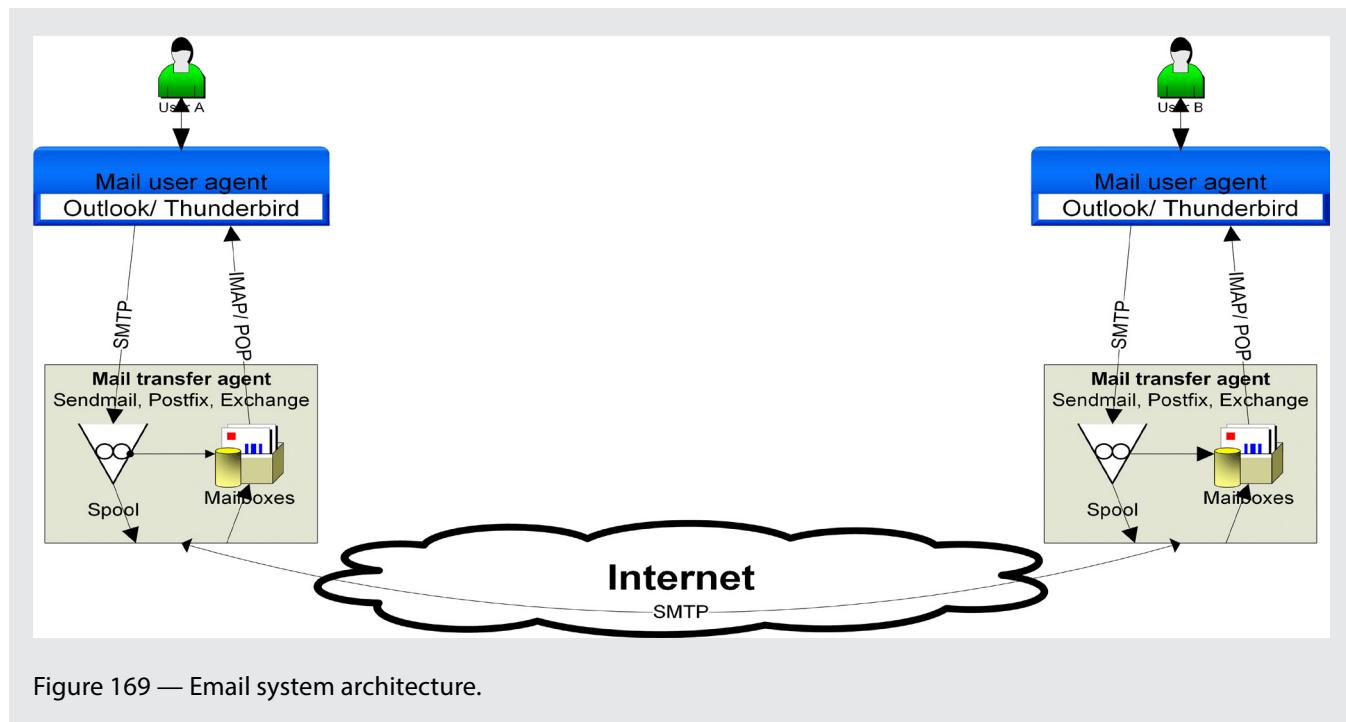
Protocols Create Efficiency and Precision

In TV shows or movies, you may have heard cryptic conversations between police officers over the radio, or between members of a medical team before a procedure. These conversations are generally very different from typical social conversations. Most of the time, you don't understand the conversation. Yet you may also have noticed that these cryptic conversations obey well-defined rules, with well-defined meanings for every word used in the conversations, and are relatively quick and error-free. These cryptic conversations are an example of protocols.¹⁴⁷

When you compose an email and hit “Send,” your mail client sends the message to your mail server, which then forwards it to the recipient’s mail server. When the recipient logs into their mail client,

147 This example to explain protocols is from L. Pouzin and H. Zimmermann, “A tutorial on protocols,” Proceedings of the IEEE, 1978. 66(11): pp. 1346–1370

their mail client requests their mail server for all new messages and their mail server delivers your message along with all other new emails to the recipient's mail client for display ([Figure 169](#)).



Desktop Mail Clients

Some of the most popular desktop mail clients are:

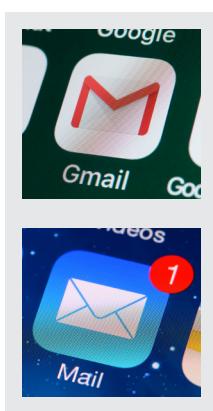
1. Microsoft Outlook—A widely used email client part of the Microsoft Office suite.
2. Mozilla Thunderbird—This open-source email client is from the Mozilla Foundation.
3. Apple Mail—The default email client for Apple's macOS operating system.
4. Gmail—Google's web-based email service can be used as a desktop client through the use of a web browser.

These desktop mail clients work by connecting to the mail server using the appropriate protocol and downloading the email messages to the desktop. The client provides a user-friendly interface for managing email accounts and messages, as well as tools for composing and sending new messages.

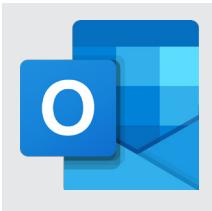
Mobile Mail Clients

As smartphones are handy and easy to use, some people end up using [mobile mail clients](#) as frequently, if not more frequently, than desktop mail clients.

1. Gmail—Google's email service allows users to access Gmail accounts and manage emails directly from mobile devices.
2. Apple Mail—The default email client for Apple's iOS devices, it allows users to manage email accounts from iPhones and iPads and serves as the default email client for Apple's iOS devices.



3. Outlook—Microsoft’s email client is available on both iOS and Android devices. It allows users to manage multiple email accounts, including Microsoft Exchange, Gmail, and others.
4. Yahoo Mail—Yahoo’s email service is available as a mobile app for iOS and Android devices. It allows you to access and manage your Yahoo email account directly from mobile devices.



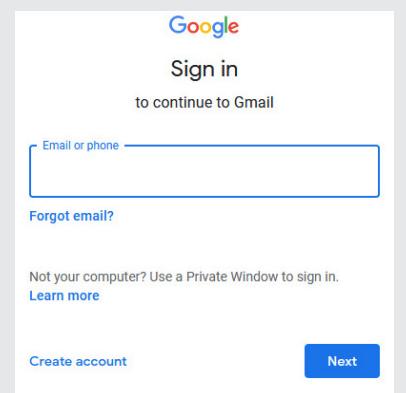
Receiving, Creating, and Forwarding Mails

The most popular email services—Gmail, Office 365, Yahoo Mail, and Apple Mail—are all free and easy to use. If a recruiter you met a few days ago told you to check your email for their response, you may be inclined to check your email every few minutes, whether you are at the mall or a park and have no access to computers. Isn’t it great that you can check your email using your smartphone? As with most other features, there are multiple ways to check and receive messages. Some email clients, like Outlook, have both desktop and web versions. Once your desktop Outlook is set up, you just need to open Outlook to receive all the latest messages. However, if the desktop Outlook application is giving you trouble for some reason or you do not have your own machine with you, you could go to outlook.com using any computer and log in with your user-id and password to receive and send messages.

If you use Gmail, you probably already know that you can access it from anywhere if you have a phone or a computer with an Internet connection.¹⁴⁸ To access your Gmail using a computer, just type Gmail.com in the location bar of your browser and enter your user-id and password as directed.

Once you log in to Gmail, all your received emails will be visible in the Inbox. The other important folders you may need to access frequently are **Sent**, **Drafts**, **Trash**, and **Spam**. All email clients have some version of these folders with the same or similar names (Figure 170). As the names suggest, the Sent folder will have all your sent messages; Drafts will have the messages you composed but did not send; Trash will have all the messages you deleted; and Spam will have all the emails that the system has determined to be unwanted or unsolicited. Whenever you want, you can go back to a draft message, reword it, and send it out. Emails in the Trash folder will remain there for a period of time that depends on your email provider. If an email was mistakenly moved to the Trash folder, you can easily restore the message to your Inbox.

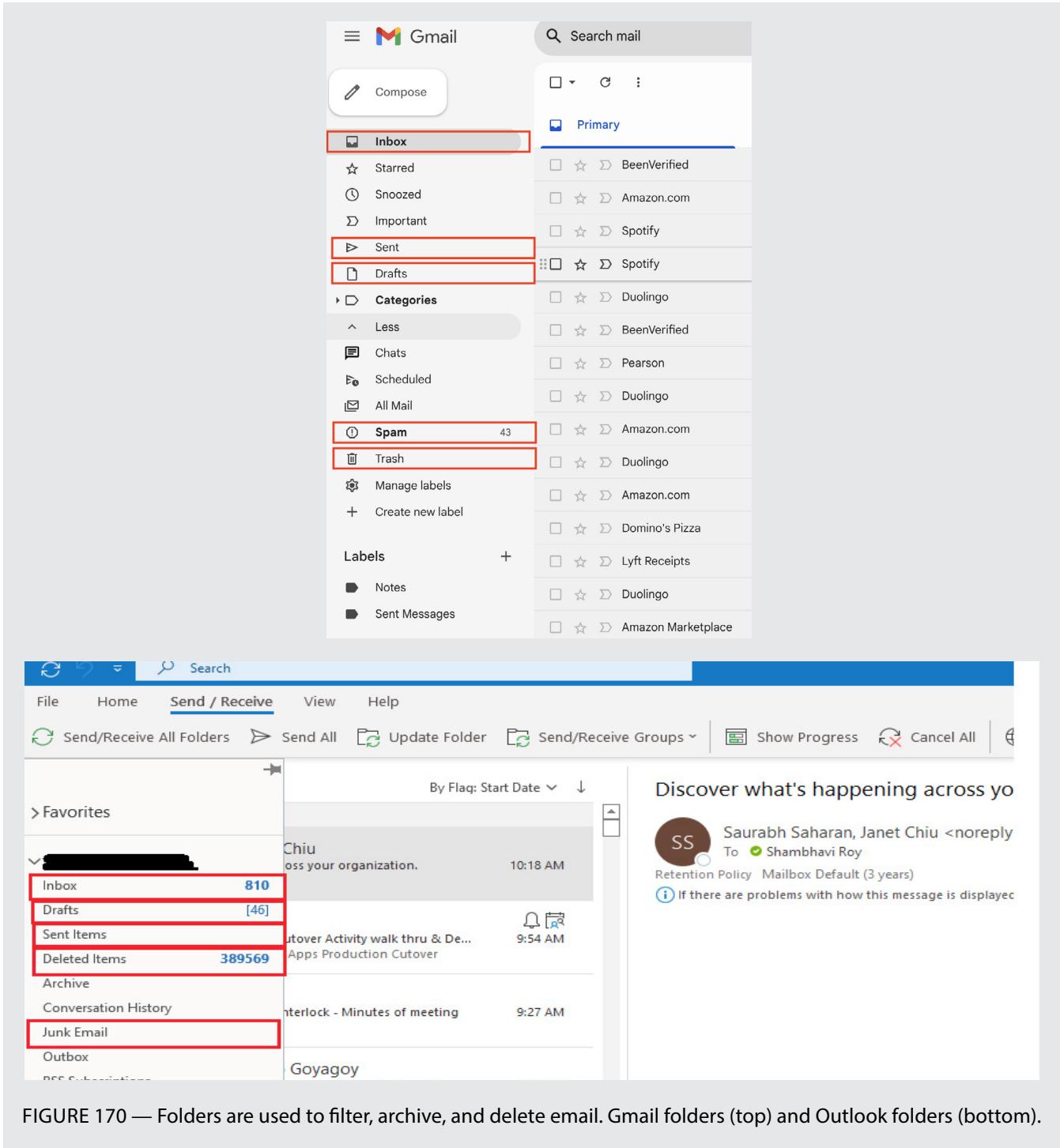
It’s useful to regularly check your Spam folder, particularly if you’re expecting an important email, to make sure that your legitimate emails have not ended up there by mistake. Email providers use machine learning algorithms to determine which emails are unwanted and unsolicited—phishing scams, messages from unknown senders, or messages containing malicious content. These algorithms can mistakenly label useful emails as spam.



The image shows the Google Sign-in page for Gmail. At the top, it says "Sign in" and "to continue to Gmail". Below that is a large input field labeled "Email or phone" with a placeholder "Email or phone". Underneath the input field is a "Forgot email?" link. Further down, it says "Not your computer? Use a Private Window to sign in." with a "Learn more" link. At the bottom left is a "Create account" link, and at the bottom right is a blue "Next" button.

In order to access or use Gmail, you must first create an account or sign in.

148 To hear about Gmail’s origin story, particularly how Gmail was released by its creator Paul Buchheit in one day, visit Aarthi and Sriram’s podcast episode page, <https://www.aarthiandsriram.com/p/the-man-who-created-gmail> (accessed June 2023).



To send an email to friends or colleagues, you only need their email addresses. In Gmail, clicking on the large “Compose” button in the top-left corner will open a new email window where you can enter the email addresses of your friends/colleagues in the list of recipients, write a subject, which is a summary of your email, and type your message in the body of the email. If you want to send a copy of your email to others, enter their addresses in Cc (carbon copy) field. The Bcc (blind carbon copy) field lets you send a copy of your email to people without other recipients being able to see the Bcc recipients' email addresses. This is a very useful feature if you want to send an email to a group of people without revealing their email addresses to each other.

You can also [attach files](#) and photos to your email by clicking on the “Attach File” icon (a paperclip at the bottom) and then selecting files and photos ([Figure 171](#)). Finally, you just need to click the “Send” button to send the email to your recipients. Outlook and other email clients work similarly. Clicking on the “New Email” button ([Figure 172](#)) opens a window where you can enter the email addresses of recipients, add attachments ([Figure 173](#)), type your message and subject, and send the email by clicking on the “Send” button.

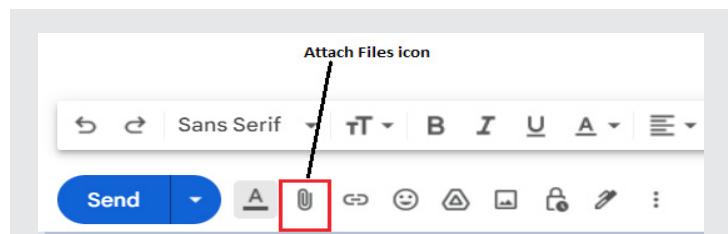


FIGURE 171 — When composing an email in Gmail, you can also attach files.

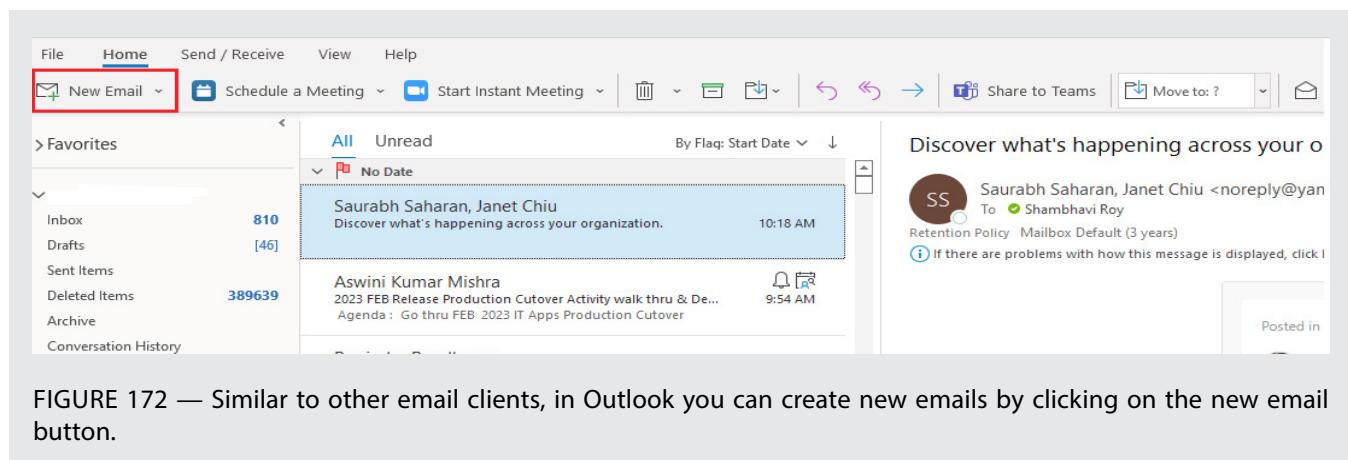


FIGURE 172 — Similar to other email clients, in Outlook you can create new emails by clicking on the new email button.

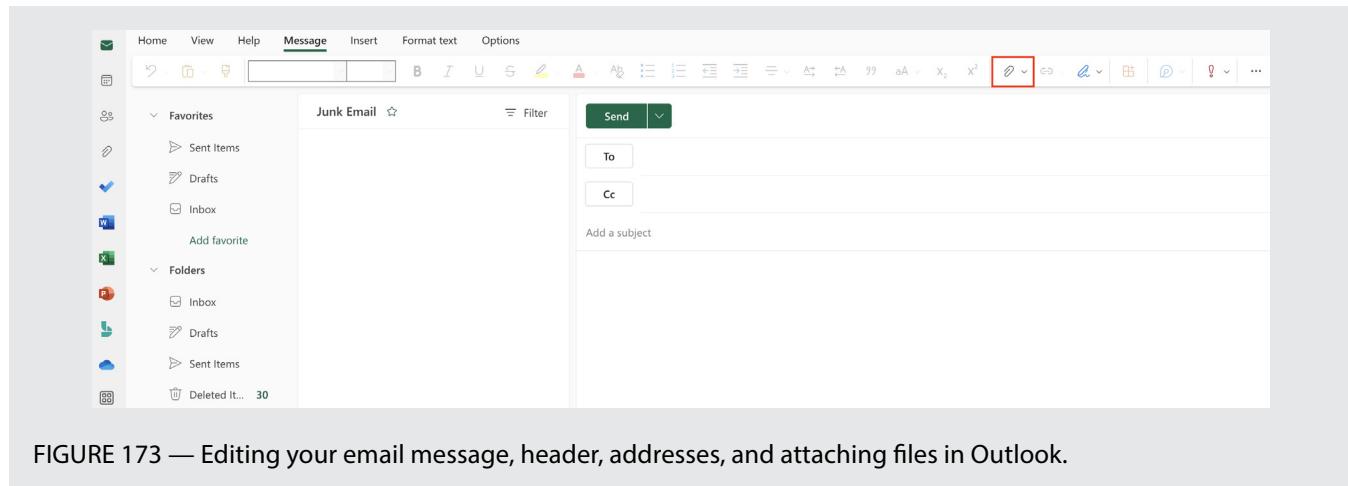


FIGURE 173 — Editing your email message, header, addresses, and attaching files in Outlook.

Reading an email is as easy as clicking on the email in your Inbox ([Figure 174](#)). If you have any attachments in the email you have received, you can click on the attached file to view the attachment. Keep in mind, clicking on attachments from unknown senders can be dangerous as they may have malicious content. Though modern mail clients perform various checks to identify malicious attachments, you are the victim if your computer gets damaged or your information gets stolen. We will discuss this further [later in this chapter](#). Once you have opened an attachment, you can download and save or print ([Figure 175](#)).

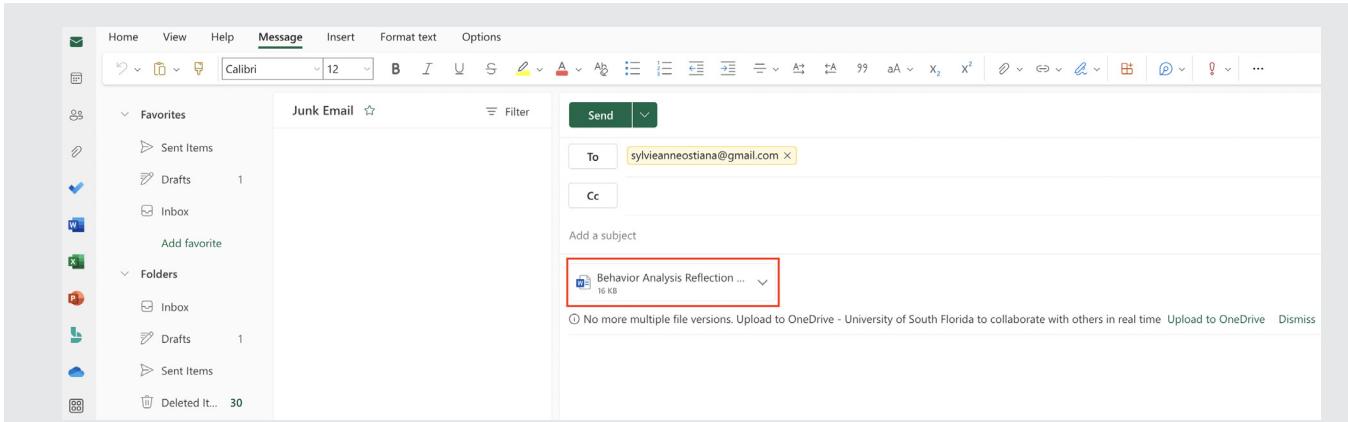


FIGURE 174 — Attachments sent or received in Outlook are highlighted.

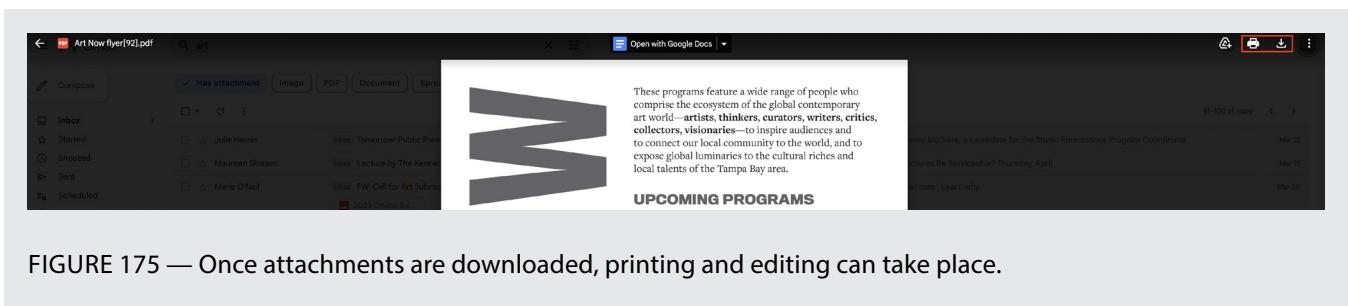


FIGURE 175 — Once attachments are downloaded, printing and editing can take place.

To make sure you don't miss attachments sent with an email, both Outlook and Gmail prominently highlight the name and the document type of the attachments (Figure 176).

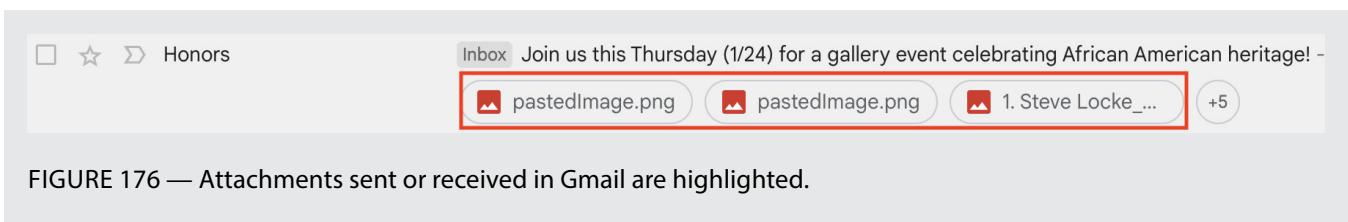


FIGURE 176 — Attachments sent or received in Gmail are highlighted.

After you finish reading the email, you can reply to the sender of the email by clicking on the “Reply” button. When you open any email, you have received in Gmail, you will see the option to “Reply,” “Reply all,” and “Forward” at the bottom of your message (Figure 177). You can also click on the dots in the top-right corner to open a context-sensitive window that will let you “Reply,” “Reply to all,” and “Forward.” As the names suggest, clicking on “Reply” (this is also represented with an arrow pointing to the left) will open a new email that has the email address of the sender in the “To” field and the original message from the sender quoted in the body of the message. You can also add additional recipients. Then type your reply and click the “Send” button. Clicking on “Reply to all” opens a new email with the sender’s email address and the email addresses of all other recipients of the original email in the “To” field. You must use “Reply to all” only when your reply is relevant to everyone on the email to avoid bombarding and annoying people with unnecessary emails.

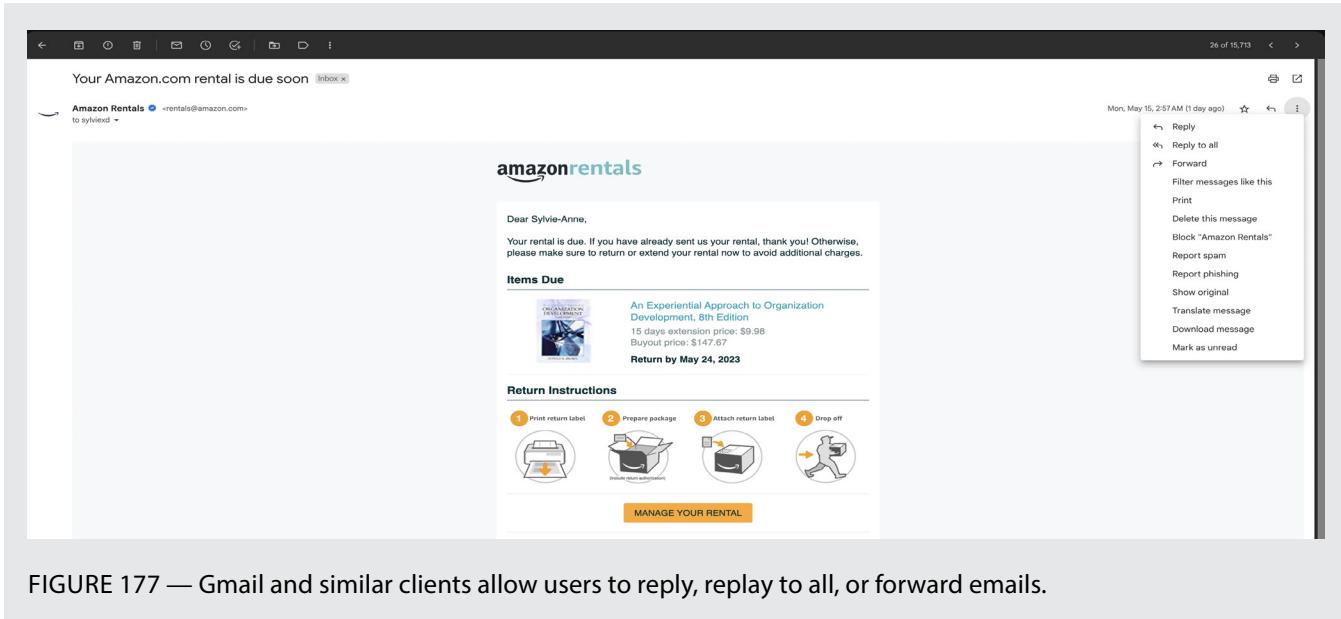


FIGURE 177 — Gmail and similar clients allow users to reply, replay to all, or forward emails.

Sometimes you may need to print an email. Thankfully, printing any message in your Inbox is easily achieved by clicking on the printer icon or using the print option in the context-sensitive window. In Outlook, right-clicking on your mouse will open a context-sensitive window that has the print option (Figure 178). You can also use the "File" tab at the top to print email messages.

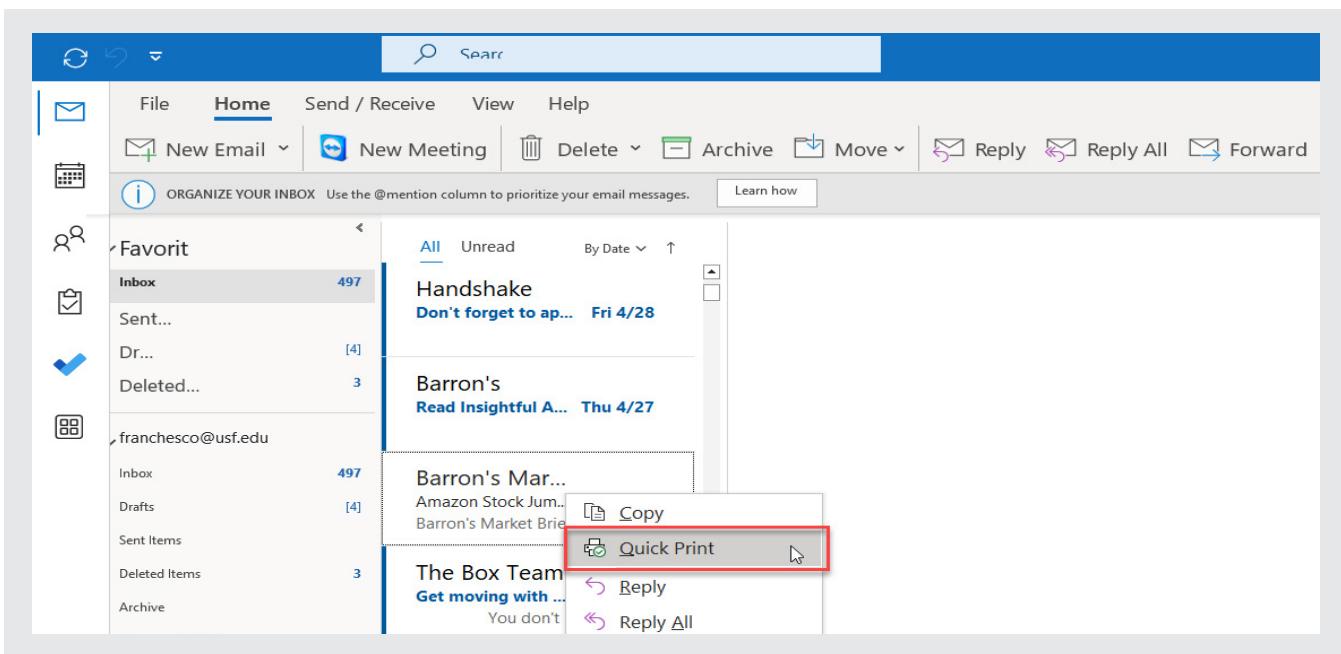


FIGURE 178 — Outlook and similar clients allow users to print emails by right-clicking on messages.

The option to "Forward" message lets you send an email message you have received in your Inbox to others. Clicking on the "Forward" button (sometimes it is an arrow pointing to the right), will open a new email with the original message quoted in the body of the mail. You just need to add the list of recipients, type your message, and click the "Send" button to forward the email.

Organizing Email into Folders

We saw in the “File Management” chapter that folders are the essential mechanism to organize information on computers. Email also supports folders to organize email. By default, most mail services include an Inbox folder for all received mail; a Sent folder for all emails you send; and a Deleted or Trash folder for emails we delete. In addition to these folders provided by the email system, you can create folders to meet your needs. To create a new folder, right-click on a folder to bring up the context menu to create a new subfolder (see Figure 179).

To move email between folders, click the email in the inbox and drag and drop it into the folder of your choice. With a judicious choice of email folders, messages can be easily located.

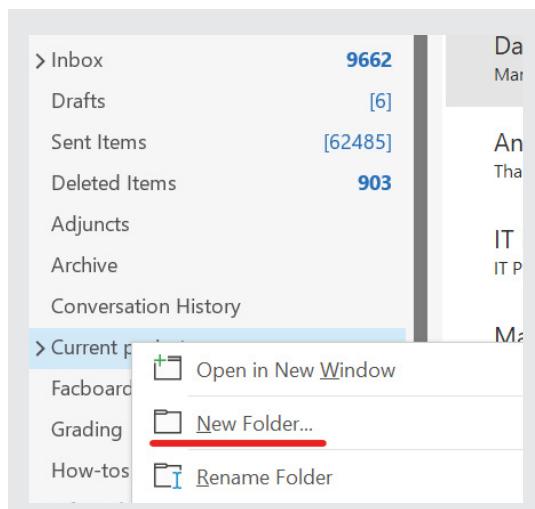


FIGURE 179 — Creating new folders and subfolders in Outlook can aid in file management.

Mail Labels

Motivated by its search heritage and leveraging its superior search abilities, Google adopted the principle of “search over structure” to organize email. Google adopted the concept of using labels to organize email.¹⁴⁹ Labels are tags that can be added to any email message.¹⁵⁰ In Gmail’s approach, all messages remain in their default folders—inbox for incoming email, sent for outgoing messages, spam for undesired mail. Users can search messages by text, date, attachments, etc. To organize email, users can attach labels to a message by right-clicking the email and selecting one or more labels to attach to the message.

Though folders probably feel intuitive, arguments in favor of labels include the ability to attach more than one label to a message, and ease of locating messages using search compared to navigating folders to locate a message.

Gmail already gives you a few folders like Spam and labels such as Promotions and Social where emails are directed automatically. You can also easily create new labels depending upon your needs, such as Sales, Utilities, or Action Required. These can be added using the “create new label” menu item (Figure 180). The new labels will appear in the menu on the left. Once you create the label, you can right-click on any email to

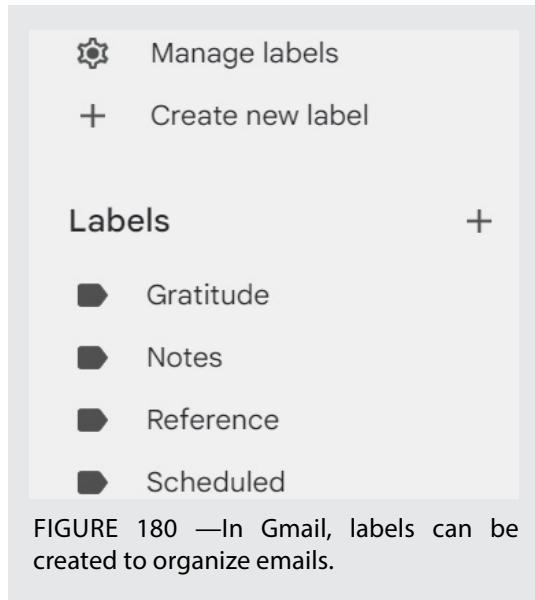


FIGURE 180 —In Gmail, labels can be created to organize emails.

149 Google Workspace Learning Center’s page for “Organize and Find Emails,” <https://support.google.com/a/users/answer/9260550> (accessed June 2023).

150 A useful page about labels, “Gmail Labels; Everything You Need to Know,” <https://hiverhq.com/blog/gmail-labels> (accessed June 2023).

bring up the context-sensitive menu and attach the label to the message. The message can now be found in the inbox as well as by selecting the label in the menu on the left.

As always, creating too many labels can also make it difficult for you to remember and categorize emails. A small set of well-selected labels is more than sufficient in most cases.

Mailing Lists

A mailing list is a feature used in email systems that allows messages sent to one email address to be delivered to another email address or a group of addresses. For example, you can create a list called “students@example.edu” that forwards emails to all students in the school, without having to include individual email addresses in the message. Your teacher may use a mailing list to inform all students and parents in the class about an upcoming activity. Your school principal may use a mailing list to inform all students in the entire school about an issue. Universities routinely use mailing lists for announcements to students, faculty, and staff. Mailing lists make email an extremely powerful service.

However, the convenience of mailing lists also results in everyone receiving tens of emails—personal, official, advertisements, and others—every day. This can make your inbox unmanageable and important emails difficult to find amidst the clutter.

Mail Filters and Rules

Fortunately, some email clients, like Outlook, help you deal with email clutter by allowing you to create email filters to automatically move emails matching specific criteria to a folder and some, like Gmail, let you apply labels. This way, those emails don’t clutter your Inbox.

To create a filter in Gmail, go to “Settings” (the gear icon in the top-right corner) and select the “Filters and Blocked Addresses” tab ([Figure 181](#)). Clicking on “Create a new filter” brings up a window where you can enter the filtering criteria. Once you select your criteria, click on Search to see the emails that will get filtered by the criteria. When you are happy with your filtering criteria, you can click “Create Filter” and decide what you want to do with the filtered emails—for example, move them to the “deleted items” or some other folder automatically.

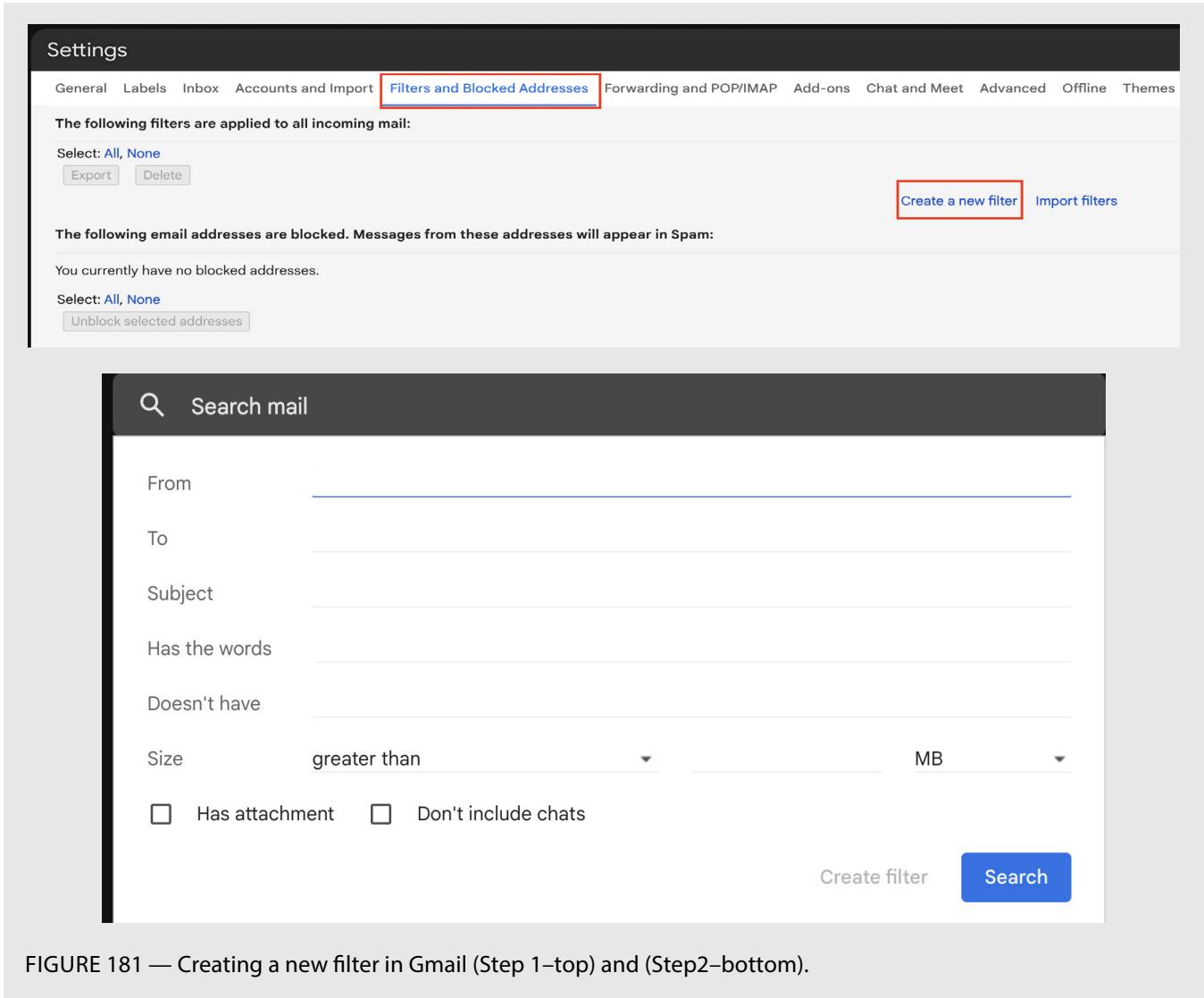


FIGURE 181 — Creating a new filter in Gmail (Step 1-top) and (Step2-bottom).

Outlook and other email providers also offer similar features to allow you to filter emails. In Outlook, right-click on any email to categorize it into any of the available categories.

Filters are called rules in mail clients such as Outlook. To create a rule in Outlook, just go to the “File” tab and click on “Manage Rules and Alerts.” A popup window opens allowing you to create new rules and modify existing ones ([Figure 182](#)).

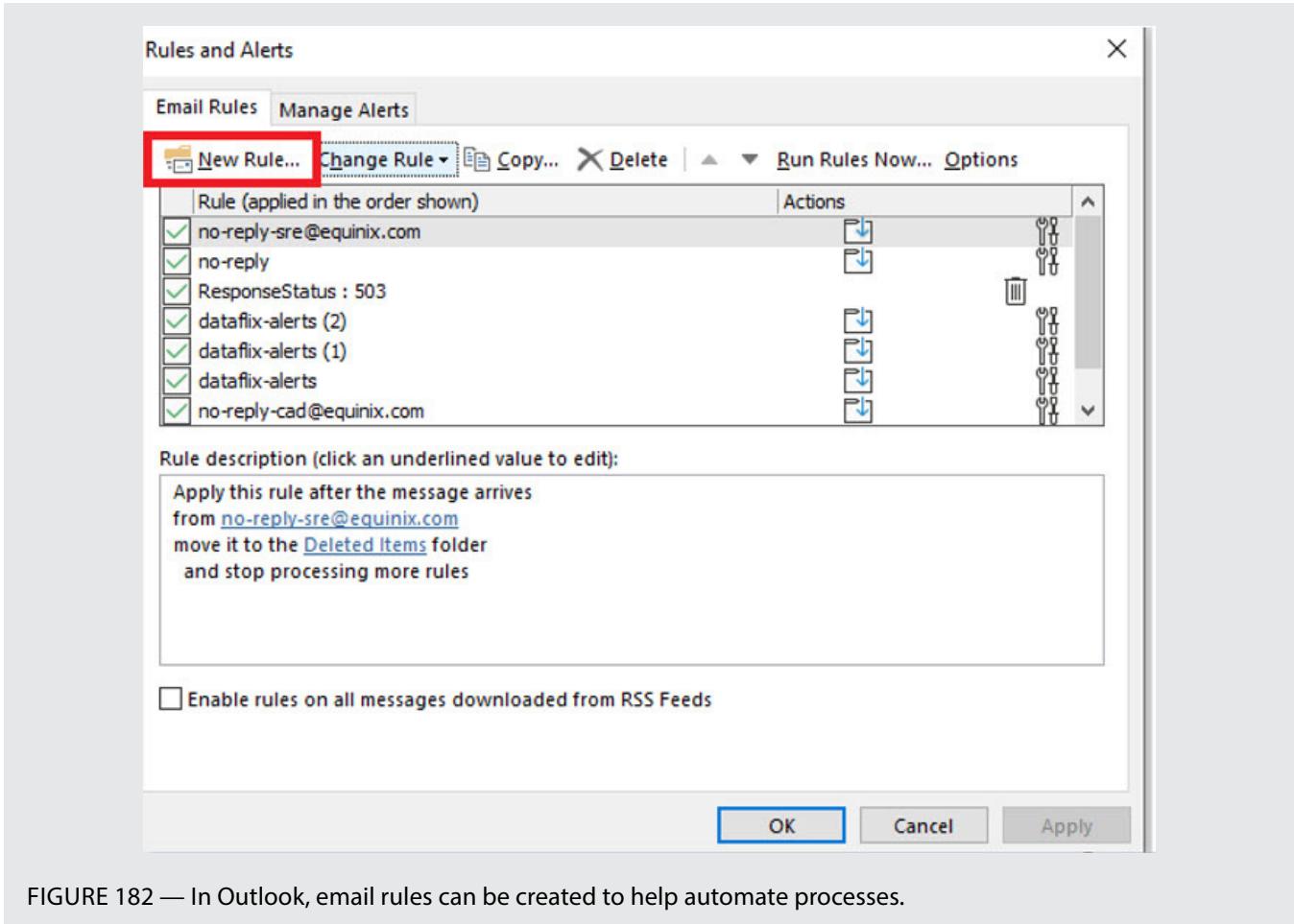


FIGURE 182 — In Outlook, email rules can be created to help automate processes.

For example, you could automatically divert emails from mailing lists to a folder called “Lists” that you open once a week. This way, emails from your teachers that require your immediate attention will not get buried under promotional emails.

Managing Signatures

An email **signature** is information that is automatically added at the end of an email. Signatures typically include contact information or personal touches such as a favorite quote. Creating signatures for your emails saves you the effort of typing basic details every time you send an email. This is particularly useful if you send emails to customers and would like to have your name, address, phone number, email, and company logo in the emails you send.

To create signatures in Outlook, go to the “File” menu and select options. In the Outlook “Options” window, select “Mail” from the left-hand menu and scroll down to the “Signatures” section. In the “Signatures” dialogue box, you can click on “New” to create a new signature (Figure 183).

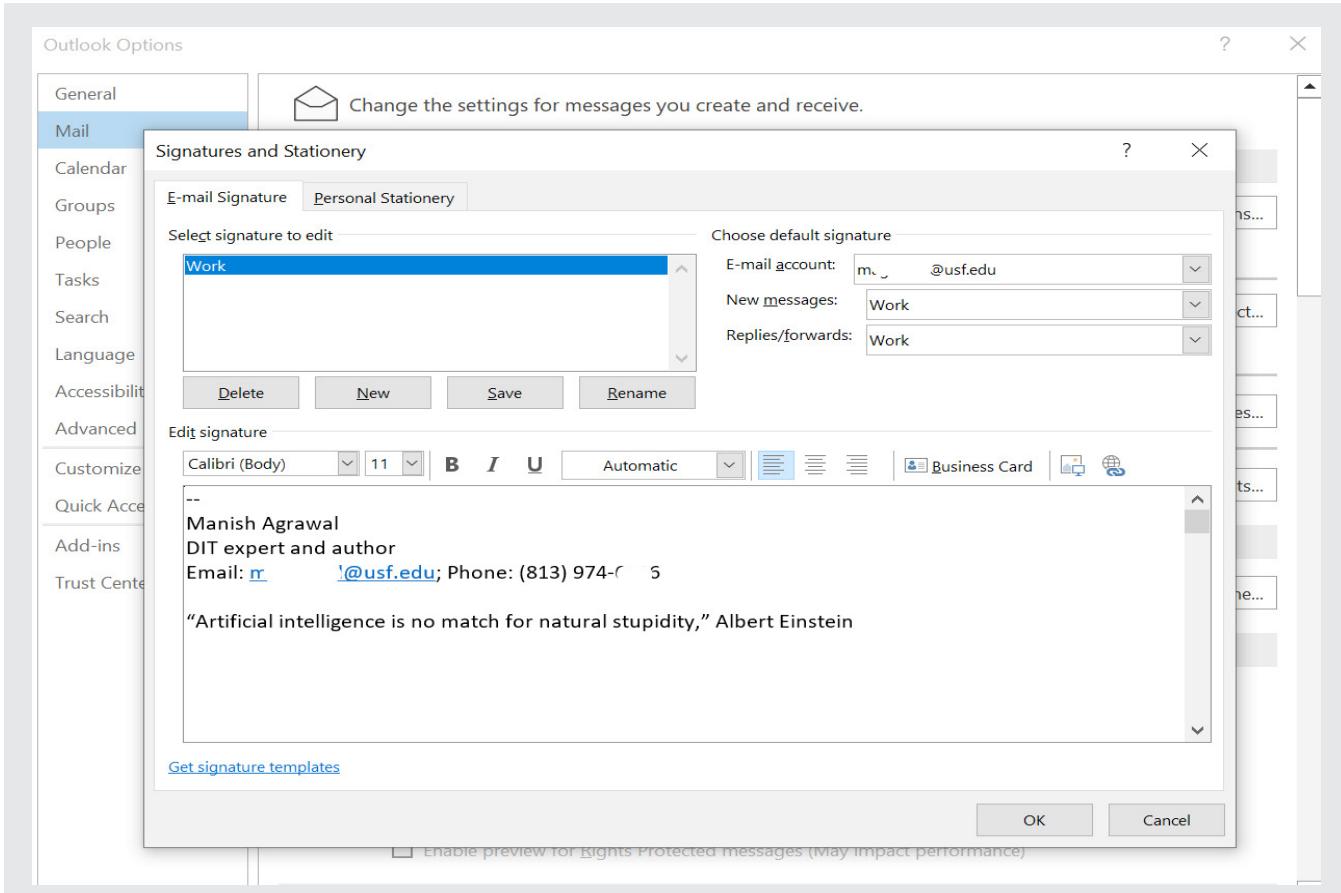


FIGURE 183 — The Outlook Signature and Stationery menu window allows users to create and edit signatures.

You can have a different signature for new messages compared to replies and forwards. To add a signature or change the signature of an email, go to the “Insert” tab at the top and click on “Signature.” Choose the signature you want to insert in your email (Figure 184).

To create signatures in Gmail, go to your account and click on the gear icon in the top-right corner of the page. Select “See all settings.” This brings up the familiar settings menu that we saw in Figure 181 when creating email filters. In the “General” tab, go down to “Signature” and create a signature by giving a name to your signature and adding the signature text (Figure 185). As in Outlook, Gmail also allows you to create separate signatures for new emails compared to replies/forwards. You must save the signatures by clicking on “Save Changes” at the bottom of the page to activate the signatures.

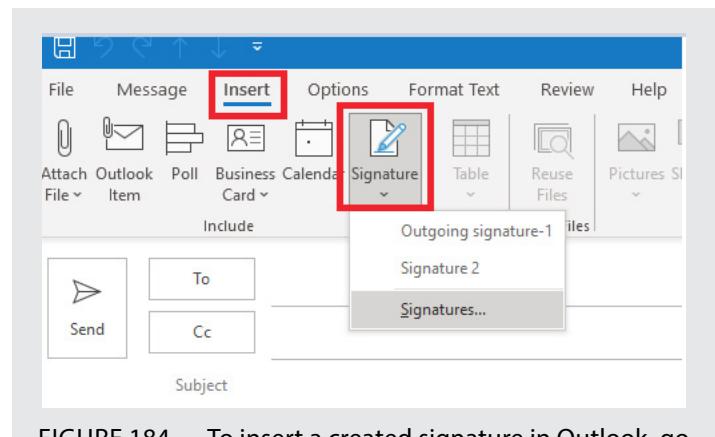


FIGURE 184 — To insert a created signature in Outlook, go to the signature function under the Insert tab.

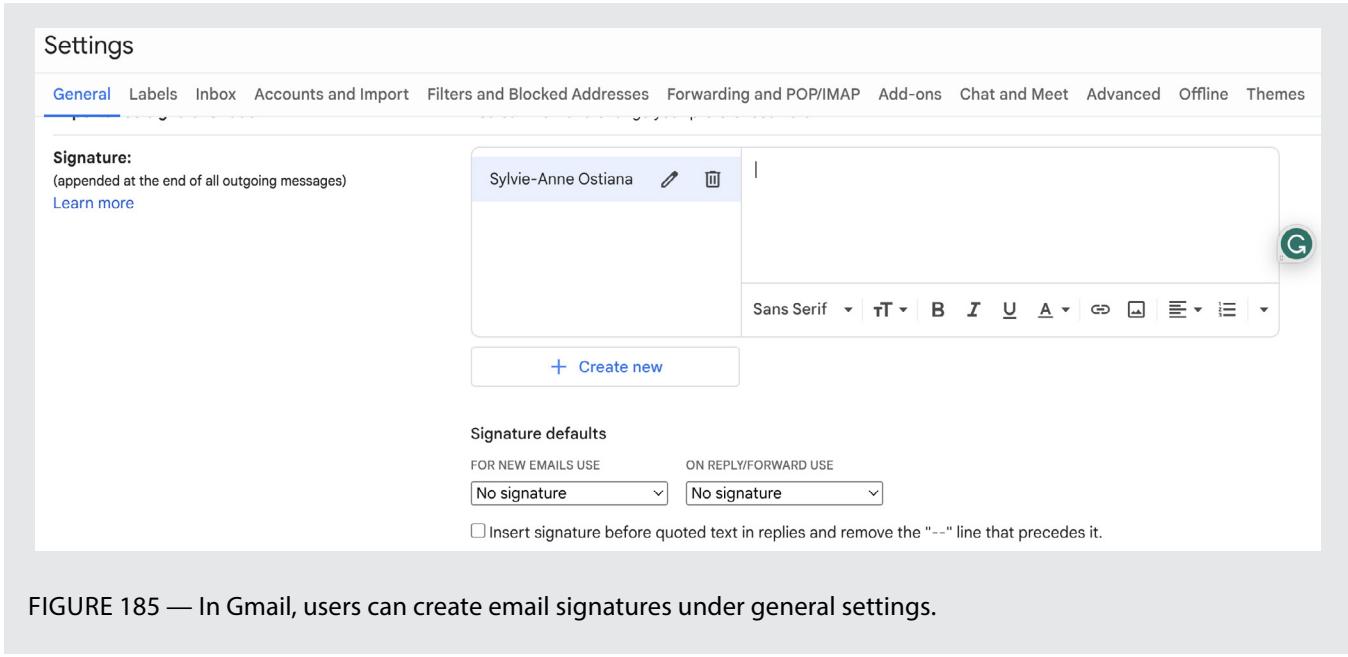


FIGURE 185 — In Gmail, users can create email signatures under general settings.

Email Sensitivity, Security, and Delivery Options

At times, you may want to send an email that is personal or confidential. Email clients can help maintain some level of privacy by disabling the common methods used to distribute messages, such as forwarding and printing. Users can still take screenshots of your messages and send those out if they choose, but only with additional effort.¹⁵¹

In Gmail, you can use the confidential mode to protect sensitive information, so the recipients cannot forward, copy, print, or download messages. You can also require your recipients to receive a passcode from Google to see the message and set an expiration date for the message. To invoke these options, in the "Compose" email window, click on the "lock" icon at the bottom (Figure 186) to open the "Confidential mode" window (Figure 187).

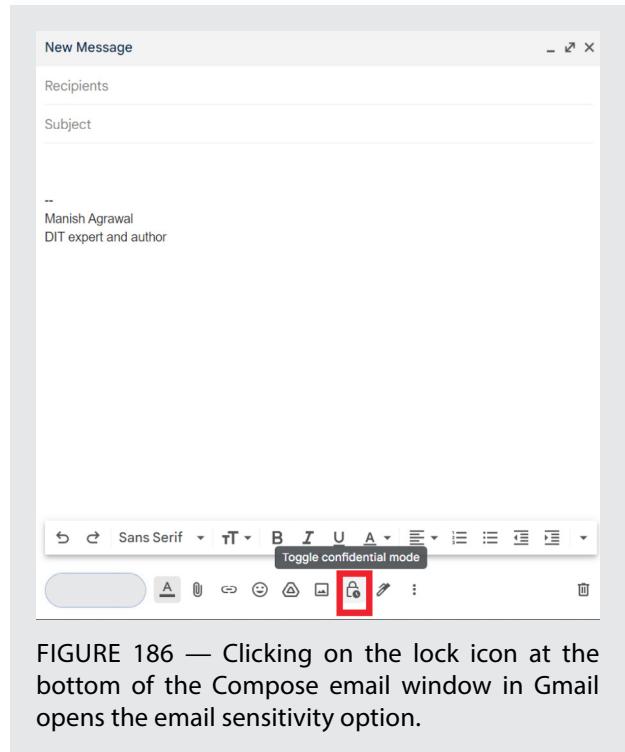


FIGURE 186 — Clicking on the lock icon at the bottom of the Compose email window in Gmail opens the email sensitivity option.

151 For more information about Gmail's confidential mode, see "Protect Gmail Messages With Confidential Mode," <https://support.google.com/a/answer/7684332?hl=en> (accessed June 2023).

Similar options exist in Outlook. You can change the importance and sensitivity of an email—mark it “Personal,” “Private,” or “Confidential.” To access these options, when you open a new email window, go to the “Options” tab. Clicking on “More Options” will open the “Properties” window that has a range of security settings and delivery options (Figure 188). You can also make sure the email is not delivered before a certain date and set an expiration date for the message.

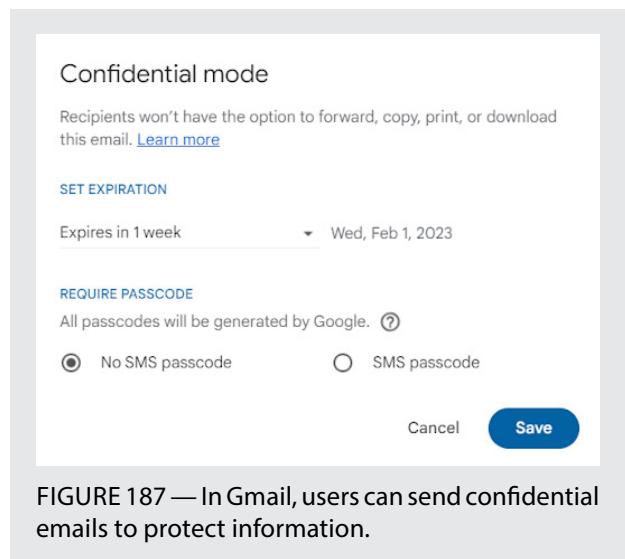


FIGURE 187 — In Gmail, users can send confidential emails to protect information.

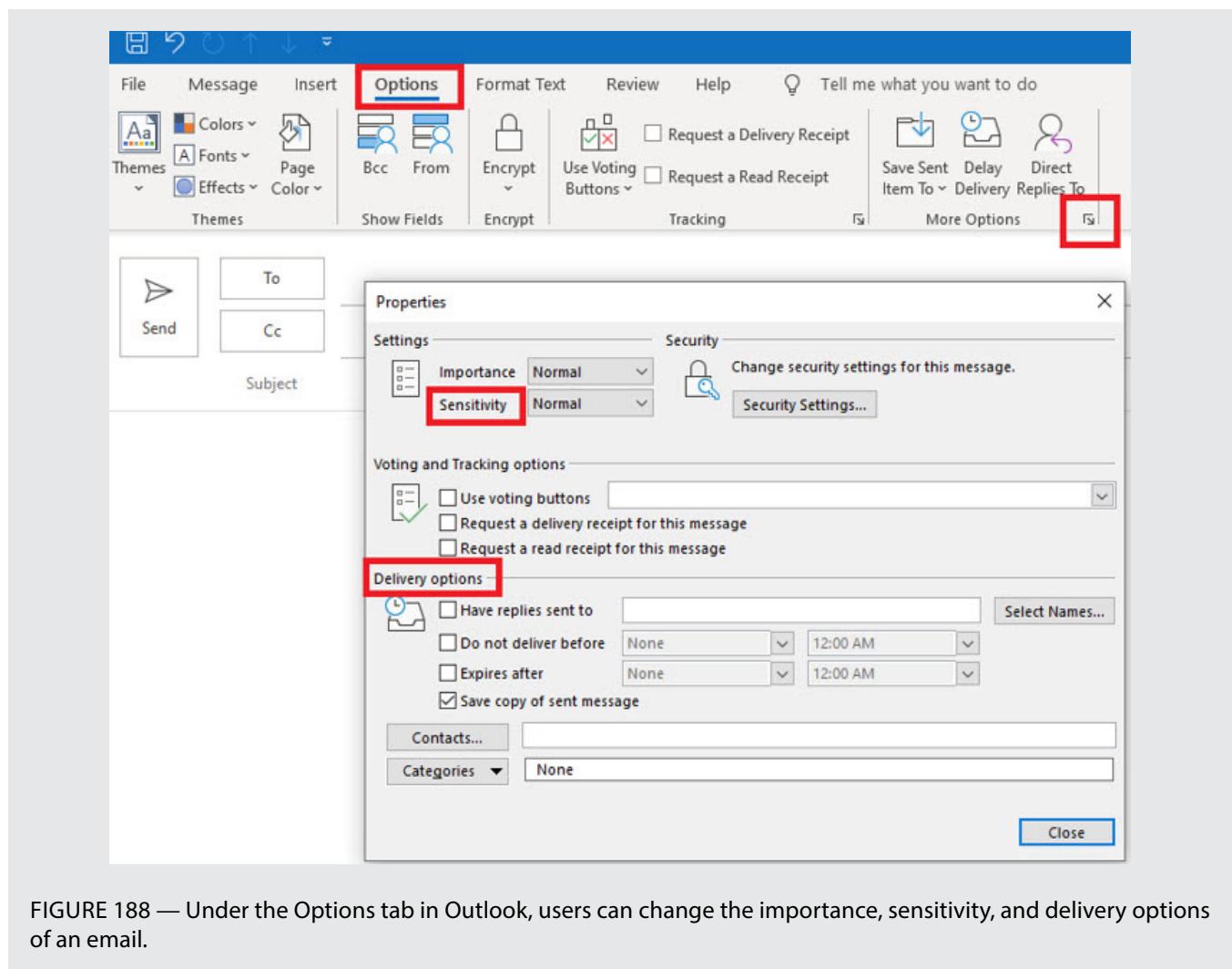


FIGURE 188 — Under the Options tab in Outlook, users can change the importance, sensitivity, and delivery options of an email.

Email Contacts

Contacts are people you communicate with. They are usually family, friends, and business associates. Contact management features of productivity applications allow you to save phone numbers, email addresses, mailing addresses, and other relevant information about your contacts for ready access. Most email services and clients let you save contacts and create groups of contacts to make it easy to send emails to your colleagues or friends. In Gmail, you can access contacts by clicking on the “Google Apps” icon in the top-right corner of the screen (it looks like a square made of nine smaller squares¹⁵²) **Figure 189**. Click on “Contacts” to open the contacts manager. You can add and delete contacts. You can also group contacts by labeling them. You can create a label called Friends and add all your friends to it (**Figure 190**). When you want to send an email to your friends, just type “Friends” in the To or Cc field to send an email to all your friends. This feature is tremendously useful when you send emails to contact groups frequently.

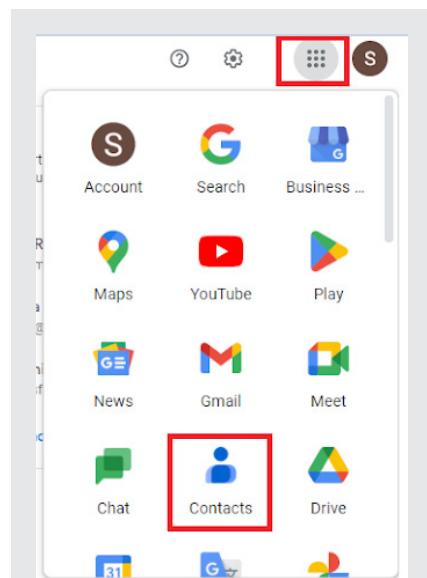


FIGURE 189 — The contacts feature in Gmail helps to increase your efficiency when sending emails to colleagues.

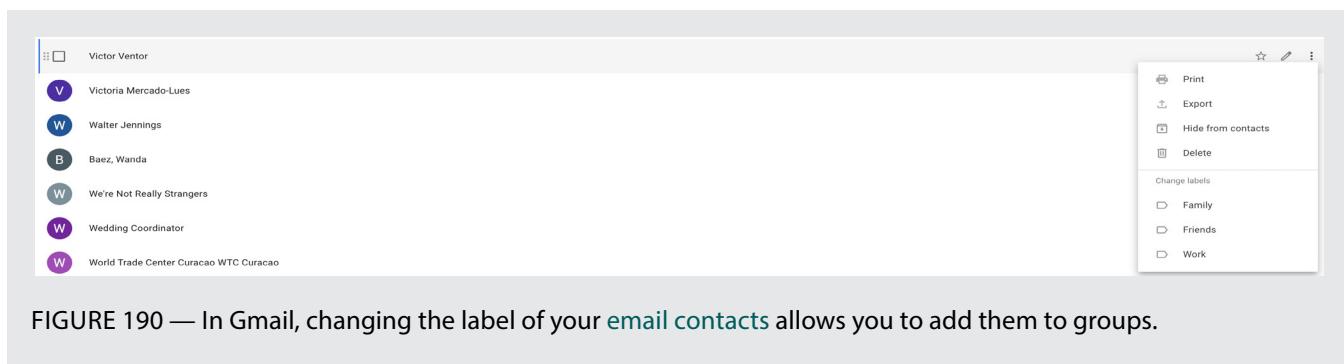


FIGURE 190 — In Gmail, changing the label of your email contacts allows you to add them to groups.

Automated Messages

A frequent need in work environments is to know when a recipient is busy or out of the office and unable to respond promptly to emails. This allows email senders to take alternate measures to complete their tasks. Email services allow you to send automated replies in these situations. Automated messages are preconfigured responses to all incoming messages. Automated messages tell folks emailing you that you are unable to reply—for example when you are on vacation or outside of the reach of the Internet. A best practice for automated messages is to share the contact information of your colleagues who cover for you while you are unable to respond to messages. This allows senders to reach out to your colleagues for any assistance to complete their tasks.

Since automated messages are commonly used when users are on vacation, they have come to be

152 This is called a waffle. For some context on the use of food icons on websites, see “How Did Food Get In My Website and Digital App?” <https://bluezoocreative.com/2013/10/navigation-trends-hamburgers-waffles-and-breadcrumbs/> (accessed June 2023).

known as vacation responders, vacation messages, or simply out of office messages. To turn your vacation responder on in Gmail, click on the “gear” icon in the top-right corner and access settings. Under the “General” tab, scroll down to the “Vacation responder” and turn it on. You can set the start and the end dates of the vacation response and type your Subject and Message (Figure 191).

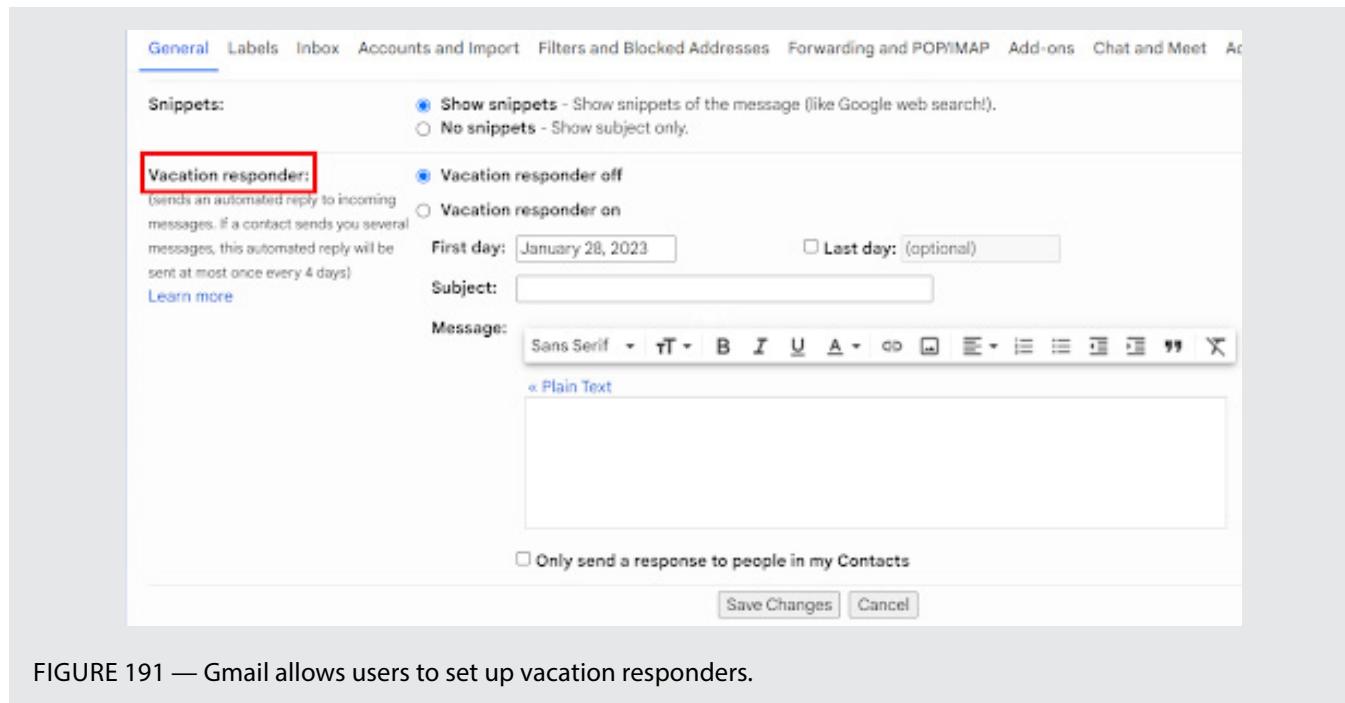


FIGURE 191 — Gmail allows users to set up vacation responders.

Outlook and other email clients also have similar capabilities. To set your vacation response in Outlook, go to the “Files” tab and then click on the “Automatic Replies” tile to access the window that allows you to set automatic replies (Figure 192).

This completes our discussion of email. Email is one of the core technologies enabling our digital world, particularly at work. Email’s convenience and efficiency help professionals exchange information and speed up decision-making. Email’s archiving capabilities make it a valuable record-keeping tool in organizations. Effective email use can greatly improve your productivity.

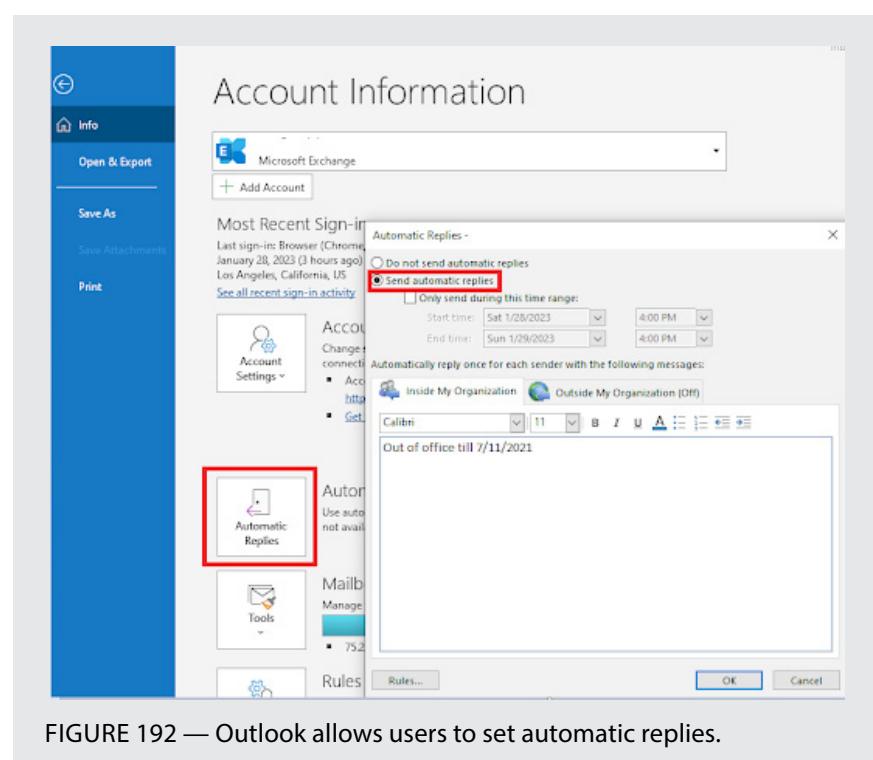


FIGURE 192 — Outlook allows users to set automatic replies.

Using Calendars to Schedule Meetings and Tasks

We now introduce calendars. Calendars are productivity applications that help individuals and teams manage their schedules, appointments, and tasks. Calendars allow users to create and manage events; view schedules in various formats, daily, weekly, or monthly; schedule meetings; and share their calendars with colleagues or clients. Calendars are typically integrated with email, so we will discuss calendars alongside email.

To access Gmail's calendar, open your Gmail and click on the "calendar" icon on the right pane (Figure 193). If the calendar opens as a pane to the right of the Gmail Inbox, you should click on the "Open in new" tab icon to make it easier to see your entire weekly calendar.

If you want to schedule a meeting with others, click on the "Create" button and select "Event" (Figure 194). Since

the Covid pandemic, videoconferencing capabilities have become tightly integrated with calendars. Google Calendar allows you to add Google Meet video conferencing to any meeting with up to a hundred attendees. You can click on "More options" to open a detailed window where you can enter the message you want to send to your attendees, specify the meeting and notification time, and add the location. When you click on "Save," the meeting is added to your calendar and an email with the event information is sent to all invitees. This email is called a meeting invite. The email has options for the receiver to add the event to their calendar.

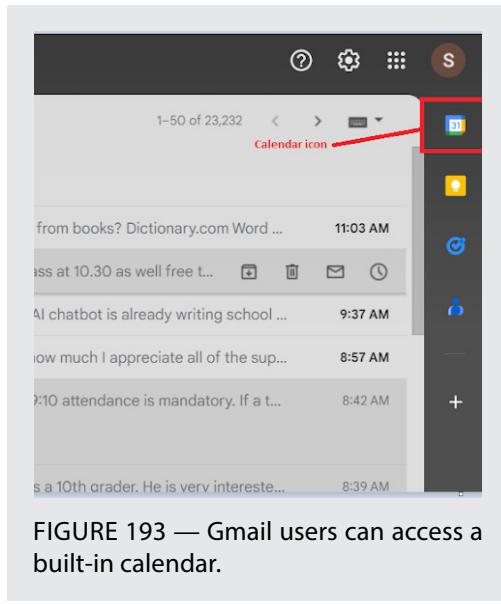


FIGURE 193 — Gmail users can access a built-in calendar.

The screenshot shows the Google Calendar interface. On the left, there's a sidebar with a 'Create' button highlighted by a red box. Below it is a calendar for May 2023, with May 16 circled. The main area shows the day view for May 16, 2023, from 12:30pm to 1:30pm. A modal window titled 'Add title' is open, also highlighted with a red box. It contains tabs for 'Event' (which is selected), 'Task', and 'Appointment schedule'. The event details show 'Tuesday, May 16 12:30pm – 1:30pm' and 'Time zone · Does not repeat'. Other options include 'Add guests' (highlighted with a red box), 'Add Google Meet video conferencing' (highlighted with a red box), 'Add location', 'Add description or attachments', and guest information for 'Sylvie-Anne Ostiana'. At the bottom of the modal are 'More options' and 'Save' buttons. Below the main calendar area, another smaller modal window titled 'Add title' is partially visible, showing time selection, event details, and guest settings.

FIGURE 194 — Creating an event in Google Calendar. Step 1(top)—create the event. Step 2 (bottom)—add details about the event.

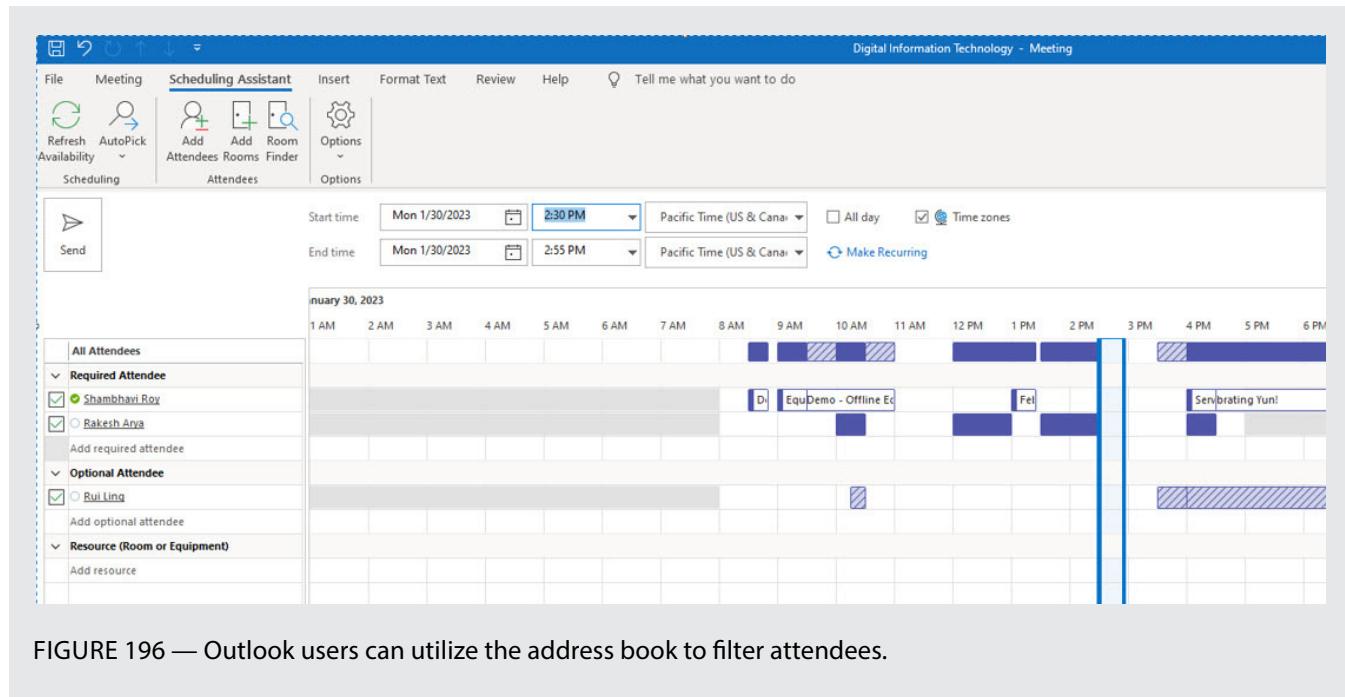
As you see in [Figure 194](#), you can make the meeting recurring or non-recurring. Setting up a recurring meeting is useful if you plan to meet the same group of people regularly. For example, if your student club meets at the same time and place each week, setting up the club meetings as a recurring appointment can easily put all the club meetings for the year on every club member's calendar with just one click.

Microsoft's Outlook software is also integrated with calendaring software that allows you to schedule audio and video meetings and create appointments to remind yourself of specific tasks. Click on "New Meeting" to open a window where you can specify all the details about the meeting, including the date and time of the meeting, recurrence, required attendees, optional attendees, location, and the message your attendees will receive ([Figure 195](#)). In businesses, Outlook is typically integrated with Zoom or Teams to allow you to create video meetings with ease as part of the event creation.

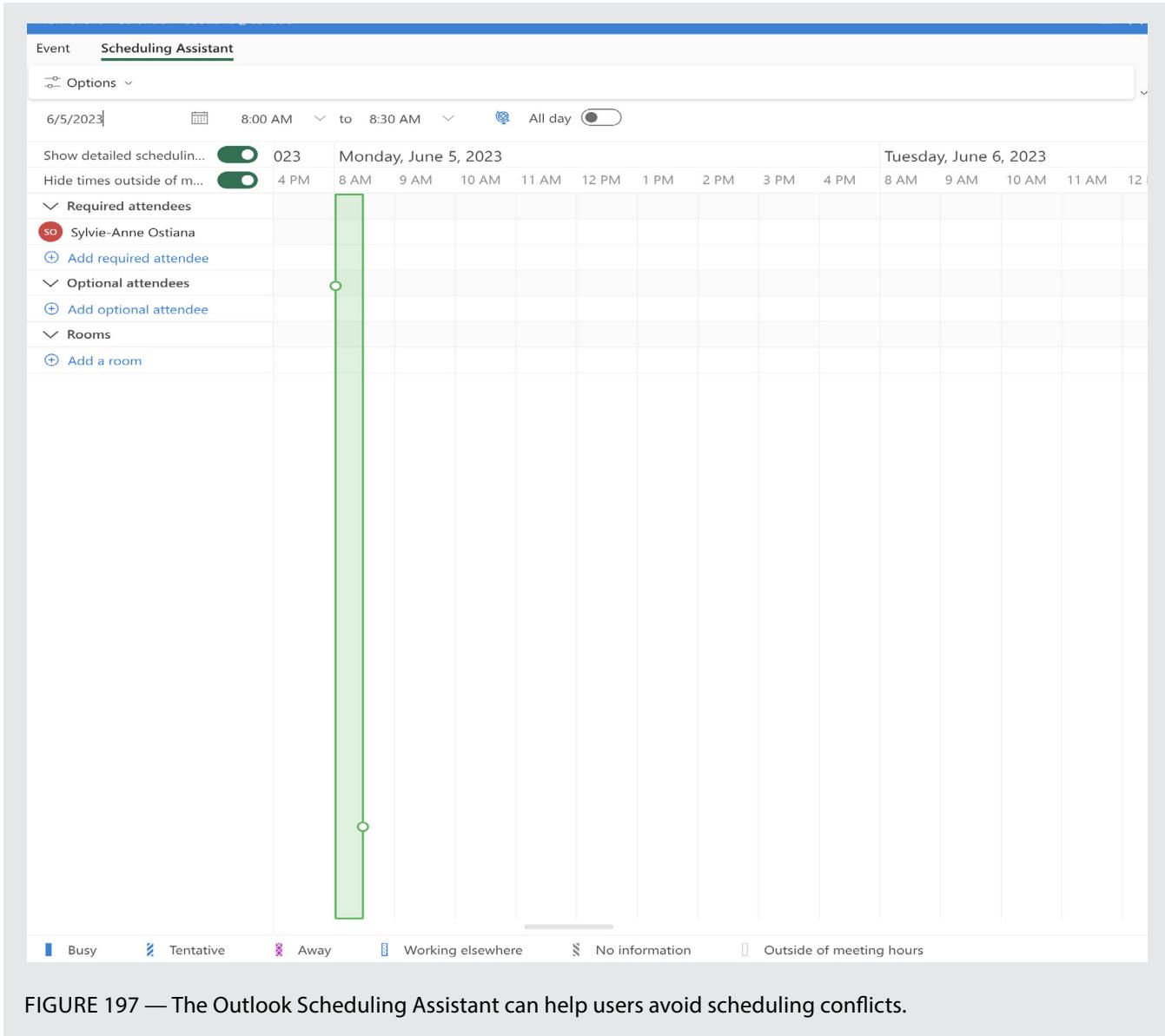
The screenshot shows the Microsoft Outlook interface. At the top, the ribbon menu is visible with tabs like File, Home, Send / Receive, Folder, View, and Help. Under the Home tab, there are several buttons: 'New Appointment' (highlighted with a red box), 'New Meeting' (highlighted with a red box), 'New Items', 'Schedule a Start Instant Meeting', 'Meeting Now', 'Meet Now', 'New Teams Meeting', 'Zoom', 'Teams Meeting', 'Today', 'Next 7 Days', 'Go To', 'Day', 'Work Week', 'Week', 'Month', 'Schedule View', 'Arrange', 'Add Calendar', 'Share', and 'Manage Calendars'. Below the ribbon, the calendar view shows the month from January 28 to February 3, 2023. A specific meeting is selected for January 28, 2023, from 9 AM to 10:00 PM. A tooltip for this meeting displays the title 'Dev Rel Monday Social; Alice Sowerby' and the location 'Equinix Edge Infra'. The tooltip also includes a link: 'EZ Demo - Offline Equinix Internet Access https://equinix.zoom.us/j/92601633753?pwd=DhrubajyotiChakrab'. At the bottom, a modal window titled 'Add title' is open, showing the meeting details: 'Jan 28, 2023 9:00pm to 10:00pm Jan 28, 2023 Time zone'. The 'Does not repeat' checkbox is checked. The 'Event Details' tab is selected, showing options like 'Add Google Meet video conferencing' (highlighted with a red box), 'Add location', 'Email', 'Notification', 'Shambhavi Roy' (busy status), and 'Add description'. The 'Guests' tab shows guest permissions: 'Modify event' (unchecked), 'Invite others' (checked), and 'See guest list' (checked). The 'Save' button is at the top right of the modal.

FIGURE 195 — Creating a new meeting in the Outlook calendar. Step 1 (top)—create the New Meeting. Step 2 (bottom)—add details about the meeting.

Clicking on the “Required” or “Optional” button of the meeting window opens another window—the address book—where you can pick the email addresses of your attendees and even book a location for your meeting (Figure 196).



If you are scheduling a meeting with your colleagues, you may have partial access to their calendars to be able to see when they are free. This allows you to schedule a meeting at a time that works for everyone. Click on the “**Scheduling Assistant**” tab to see when your attendees are free or busy in a grid format (Figure 197). Bold colors indicate times when a person is busy and gridlines indicate times when they may be free. You can change the time of your meeting or the day of your meeting to make it easy for others to attend. In Figure 196, both the required and optional attendees are free at 2:30 P.M. on Monday (January 30th). Once you pick a time that works for everyone, you can go to the “Meeting” tab and send the invitation.



Email Security

Before we close the chapter, it is useful to draw your attention to a few security concerns related to email. Most cybersecurity issues arise from individuals trying to reach your computer to steal information. Since email is a mechanism for users (including malicious users) to reach you, email has emerged as an important cybersecurity vulnerability. According to the data breach investigations report published by Verizon, over 80% of all computer breaches involve the human element.¹⁵³ We highlight a few important cybersecurity considerations below.

¹⁵³ The 2022 Verizon data breach investigations report can be accessed at <https://www.verizon.com/business/resources/reports/dbir/> (accessed June 2023).

Phishing Attacks

Since we keep a lot of valuable personal information and company secrets digitally, cybercriminals have much to gain by tricking you into allowing them to use your credentials to steal information. Perhaps the most common method to do so is phishing. Phishing is the use of emails that appear to be from reputable companies but are designed to get users to reveal personal information, such as passwords and credit card numbers. A common method is to send emails that appear to be from a bank or ecommerce site asking you to refresh your credentials. When you click on the link and log into the site, the operators get your credentials, which they can use to make purchases using your account.

Phishing attacks come in the form of deceptive emails or text messages that may ask you to install software or divulge personal information. The attacks are increasing in frequency and getting more sophisticated and dangerous, so it is important to be watchful when you receive a suspicious email or text from an unknown person. Don't be fooled by shopping and tax deals or shipments you are about to receive unless you are sure about the senders. Sometimes, you may also receive a phone message that lends credibility to the email or text message, adding to the urgency of the request. To get your personal information, criminals also create fake websites that look exactly like well-known and reputable government or business websites. The result of a successful attack can be disastrous.

In a notable case, Facebook and Google lost over \$100 million in a phishing scam where a person in Lithuania tricked employees into wiring money to his bank account.¹⁵⁴ This just goes to show that nobody is above these scams, not even people working in tech companies themselves.

Spear Phishing

A spear phishing attack is more sinister and malicious because it is targeted at a particular individual. The cybercriminals often do their homework on social media; they know who you are—may know the names of your family members, managers, and friends. They may use your manager's social media posts to make the attack even more directed. Let's say you work in the purchasing department of a company and receive an email from your boss directing you to buy supplies in a hurry—to create a temporary invoice, approve it, and send \$1000 to an account. The attacker may even customize the message and say, "I talked to our director, Jane, who is at her daughter's wedding. She's good with it and will sign off when she comes back to work next week." In this example, the hacker knows that your manager is traveling, and his boss is at her daughter's wedding and won't be back at work for some time. The criminals might even have hacked your boss's email account and were just waiting for the perfect moment (when he is traveling, and his boss is at an important event) to send the email from his address.

Targeted attacks can be particularly difficult to detect, so it is important to spend some time and pay attention to small details, like the tone of the request. Have you ever received a request like that

¹⁵⁴ This is the case of Evaldas Rimasauskas, who was prosecuted in 2019. You can read about it at <https://www.reuters.com/article/us-cyber-fraud-tech/lithuanian-pleads-guilty-in-u-s-to-massive-fraud-against-google-facebook-idUSKCN1R12FB> (accessed June 2023).

from your manager/friend in the past? Run the request by your manager or someone similar. Just like banks and other institutions that use multiple ways to authenticate users, even you should employ relevant means to validate unusual requests by talking to others or running the request by specialists who deal with cybercriminals regularly.¹⁵⁵

Emails Don't Go Away

Your email communication serves as a system of record from a legal perspective. When you send a mail, a copy of it is retained on your provider's email servers as well as at the receiving end. Even if you delete sent emails, they remain on the servers and in the inboxes of your recipients. As only you are expected to be able to send emails from your address, any message you send is a written record of your intent and is admissible as digital evidence in most courts. Therefore, before you send out an email, always remember the permanence and system of record aspect of emails. Also, it is important to re-read important emails a few times for tone, intent, and accuracy. The written word generally appears less polite than the spoken word. When in doubt, be extra polite when writing emails.

Because of the ease with which we can send emails, we sometimes end up writing things we may regret later. Emails do not communicate your facial expressions. You may call your boss "a tough boss" jokingly in his presence. However, writing the same thing in an email may take on a serious note and may be construed as rude or even threatening. Many people make a rule of never sending an email in anger. If you do type an angry email, let it sit there for a day or two before you hit the "Send" button.

¹⁵⁵ A colleague of one of the authors of this book, a professor at a university, became a victim of a phishing attack and lost \$500. He was asked to buy iTunes in a hurry as a birthday gift. These attacks are all around us.



Chapter Terms and Definitions

Attach File: A feature in the email client that allows users to share files through email messages

Desktop Mail Client: Desktop mail clients connect to mail servers, download email messages, and display them to the user on desktop computers

Draft (Email Folder): A folder within the email client where messages that are created but not sent are stored

Email Address: Email addresses are uniquely assigned or created by users, and are used to send emails to specific users or parties

Email Contact: A list of colleagues, friends, or other users, found within the email client, that have previously interacted with your email address, are saved as email contacts

Forward: To send an email to someone else or a different address after you have received it; forward allows you to type in a whole new set of recipients

Internet Message Access Protocol (IMAP): Provides ease of access to emails from any location or device without the need of downloading it to your hard drive

Inbox: A repository, within the email client, for all received emails

Mail Client: A software program that allows you to manage and send electronic messages (emails)

Mail Server: Servers tasked with handling the data and traffic of email client users; these servers handle the backend operation of email clients

Messages (Emails): Electronic forms of correspondence that allow users to communicate and share files through the Internet

Mobile Mail Client: Mobile mail clients offer portable connection to mail servers and the ability to download and display email messages by utilizing mobile computing devices

Phishing Attack: An attempt to steal information from victims through the use of social engineering techniques and various communication channels

Reply: To answer; reply only sends the new message to the original sender

Reply All: To answer; reply all sends the new message to the original sender and all other recipients on the To and Cc lines

Scheduling Assistant: Email scheduling assistants help users identify availability for meetings, this allows users to schedule in advance while increasing attendance

Send: The action of an email client sending a message to the mail server, which then forwards it to the recipient's server

Sent (Email Folder): After you send an email message, you might want to find that email; your email service stores those messages in the Sent Items folder

Signature: Email signatures allow users to customize personalized messages that are appended to the end of emails, and typically contain the user's name and contact information

Spam (Email Folder): A folder, within the email client, where messages that are deemed unwanted or unsolicited are sent

Trash (Email Folder): Items that you delete are moved to the Trash folders, but aren't permanently deleted until those folders are emptied

Spear Phishing: An attack used to steal the personal information of a specific target or person; the defining characteristic of spear phishing is that the attack is targeted for a specific purpose; named after a phishing method



Chapter Case

I'm Admitted to USF!

Carl is ready to graduate high school and has applied for admission to the University of South Florida. He has waited weeks to hear from the admissions office and today he finally received an email in the inbox of his high school account. Take a close look at the following email:

From: Clinton Daniel <clinton.daniel_usf_admissions@gmail.com>
Date: Monday, April 10, 2023 at 8:59 AM
To: Carl Student <carl_student@hcps.net>
Subject: Congratulations! - You've Been Admitted to USF for Fall 2023



Welcome to the Herd

Hi Carl,

On behalf of the USF President, we welcome you to the University of South Florida!

Congratulations!

As part of our admissions process, you must fill out a Federal Student Aid packet.

Go here to apply for Federal Student Aid: [Click here](#)

Dr. Clinton Daniel

Associate Professor of Instruction, School of Information Systems and Management

Academic Director, BS in Business Analytics & Information Systems

University of South Florida, Muma College of Business

Office: (813) 974-6765

<https://www.usf.edu/business/about/bios/daniel-clinton.aspx>



Question 1: What information in this email is unusual and what kind of attack is this? Why is the information unusual?

Question 2: Why do you think there is a link in the email asking Carl to fill out a Federal Student Aid application?



Section 3

Enterprise Productivity Applications

Introduction to HTML and Website Development

12

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It may not always be profitable at first for businesses to be online, but it is certainly going to be unprofitable not to be online.

—Esther Dyson, investor, philanthropist

Overview

The Internet has been around since the early 1970s. In the early years, the Internet only supported plain text and using the Internet required users to learn the precise syntax of several computer commands. For example, to send an email to user `jane@example.com` required users to type the command: `mail -s "mail subject" jane@example.com <<< "Mail body."` Most users found this too challenging and the only users on the early Internet were computer science researchers at universities.

This changed in 1989 when Sir Tim Berners Lee proposed and demonstrated an information management system in 1989 based on hyperlinks.¹⁵⁶ Users could click on links to navigate to other pages.¹⁵⁷ By 1993, Tim Berners Lee¹⁵⁸ had specified the first version of HTML, which made information sharing as easy as clicking a link on a page. During December 1992–March 1993, Marc Andreesen (a student) and Eric Bina (a graduate) of the University of Illinois at Urbana-Champaign (UIUC), both working at the National Center for Supercomputing Applications (NCSA) at Urbana-Champaign, built the Mosaic web browser.¹⁵⁹ They also added the “img” tag to html to handle images¹⁶⁰ and released the web browser to the Internet. The browser soon became immensely popular and acquired the status of a killer application that popularized the Internet.¹⁶¹ Sites like Yahoo offered directories for users to find content on the emerging World Wide Web.

Since then, the Internet has become increasingly user friendly as HTML has improved,¹⁶² adding support for images and videos. This has made the Internet and World Wide Web a powerful force

156 This overview is from CERN, the birthplace of HTML and HTTP <https://home.cern/science/computing/birth-web/short-history-web> (accessed June 2023).

157 The first webpage, created by Sir Tim Berners Lee is at <http://info.cern.ch/hypertext/WWW/TheProject.html> (accessed June 2023).

158 Wikipedia’s page on Tim Berners Lee is at https://en.wikipedia.org/wiki/Tim_Berners-Lee (accessed June 2023).

159 NCSA also published one of the first HTML tutorials. It is a simple document, perhaps the best introductory documents to learn HTML. An entire generation of enthusiasts, including the authors of this book learned HTML from this document. It is archived at <http://seismo.berkeley.edu/~rallen/resources/html/HTMLPrimerAll.html> (accessed June 2023).

160 Marc Andreesen’s message of Feb 25, 1993, proposing the img tag is at, <http://1997.webhistory.org/www.lists/www-talk.1993q1/0182.html> (accessed June 2023). An interesting feature of this thread is that Time Berners Lee responds to the proposal by suggesting that the tag is unnecessary

161 You can read about Eric Bina on Wikipedia at https://en.wikipedia.org/wiki/Eric_Bina (accessed June 2023). and on MIT at <https://lemelson.mit.edu/resources/marc-andreesen-and-eric-bina> (accessed June 2023).

162 A quick overview of the evolution of HTML is at https://www.washington.edu/accesscomputing/webd2/student/unit1/module3/html_history.html (accessed June 2023).

for information sharing and commerce, no longer limited to specialized users familiar with exotic computer commands. Today over 5 billion people, over 60% of the world's population, use the Internet, primarily because HTML and related technologies have made it easy, inexpensive, and meaningful for anyone anywhere in the world to access the web.

This chapter introduces HTML, the primary end-user technology used on the web.

What is HTML?

HTML (Hypertext Markup Language) is the standard markup language used for creating webpages and web applications. A markup language is a computer language that is used to apply layout and formatting conventions to a text document. The HTML markup language makes text on webpages more interactive and dynamic. HTML allows us to specify the placement of images, tables, links, etc. on webpages using simple text descriptions. HTML provides the structure and content of a webpage, specifying how text, images, hyperlinks, tables, and other media should be displayed on a browser. When you visit a website, say <http://www.google.com>, returned is an HTML page (Figure 198). Your browser can understand the page specifications defined in HTML and is able to render it as a webpage that you can see and interact with.

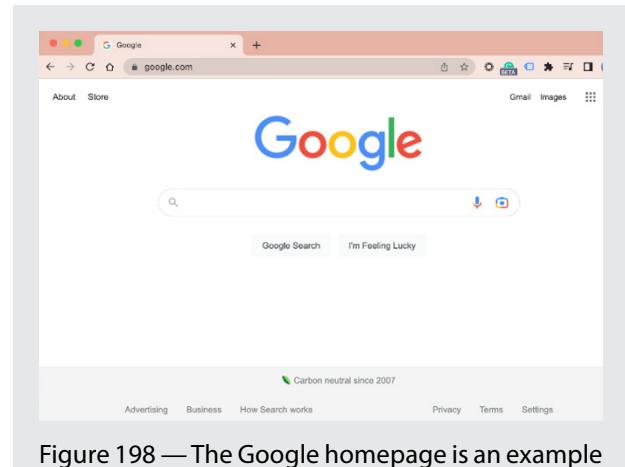


Figure 198 — The Google homepage is an example of an HTML page.

Hypertext^{163, 164} means “text within text.” In the context of the World Wide Web, hypertext refers to text with a link to another page within it. Hypertext is the Internet’s way to link two or more webpages (HTML documents) with each other.

163 The term “hypertext” has a Florida association. It was coined by Ted Nelson in 1965. In 1963, when he got the idea, Nelson was documenting research at the John C. Lilly Dolphin lab in Miami (<https://web.archive.org/web/20150506080854/http://hyperland.com/TNvita>) (accessed June 2023). Hypertext was defined as “*A body of written or pictorial material interconnected in such a complex way that it could not conveniently be presented or represented on paper.*” Nelson could foresee that “[hypertext] could grow indefinitely, gradually including more and more of the world’s written knowledge.” Hypertext was seen as a file system that, unlike file systems such as those used in Windows and Macs, “[allowed] file contents to be arranged any-which-way, and in any number of ways at once.” Unfortunately, Nelson’s lack of technical expertise prevented him from implementing the idea. Modern hyperlinks are seen as one-sided versions of Nelson’s proposed two-sided links. Ted Nelson’s hypertext idea may have greatly influenced the design of modern personal computers, <https://archive.nytimes.com/bits.blogs.nytimes.com/2007/12/11/when-big-blue-got-a-glimpse-of-the-future/> (accessed June 2023).

164 Nelson, Theodor Holm (August 1965). “Complex information processing: a file structure for the complex, the changing and the indeterminate.” ACM ‘65: Proceedings of the 1965 20th National Conference. ACM: 84–100. doi:10.1145/800197.806036, <https://dl.acm.org/doi/10.1145/800197.806036> (accessed June 2023).

To see the HTML code that defines the page, you can right click on your webpage (on most browsers such as Google Chrome or Mozilla's Firefox) and choose "View Page Source." This will bring up text specification of that webpage. (Figure 199).

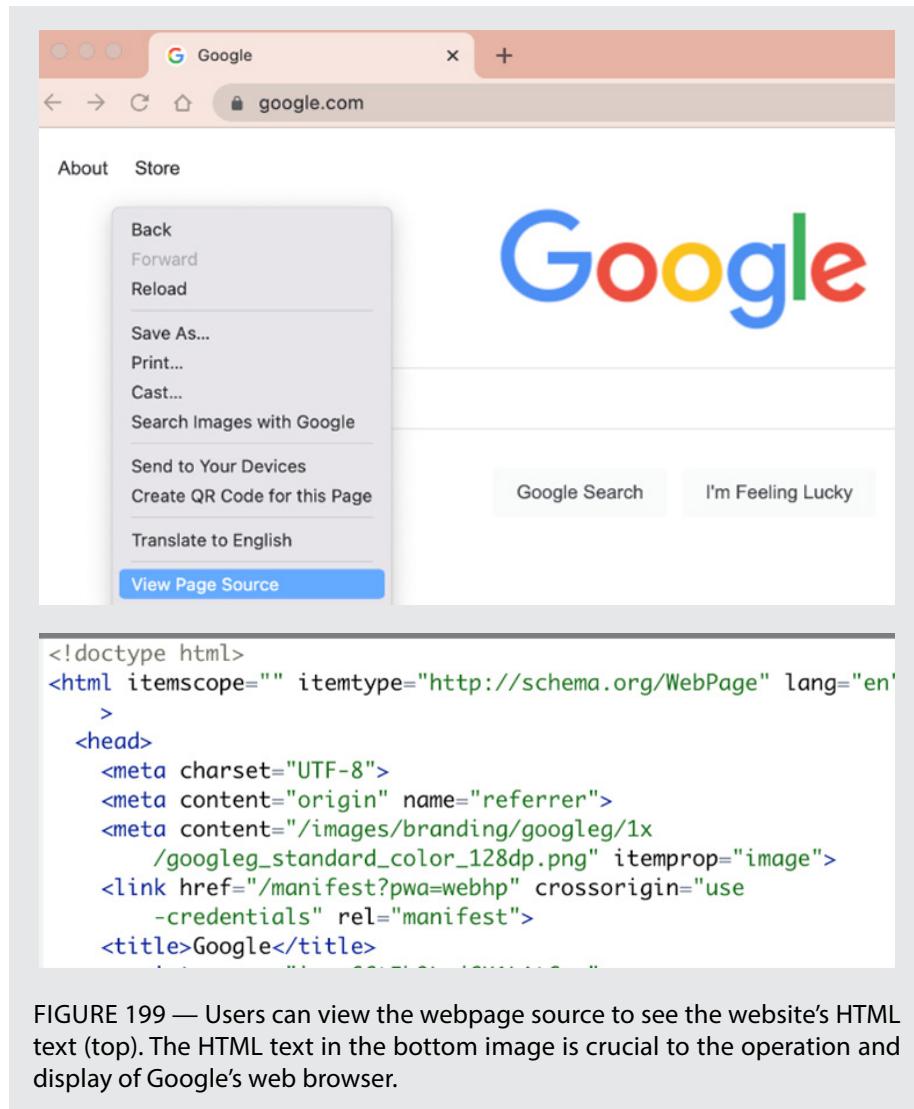


FIGURE 199 — Users can view the webpage source to see the website's HTML text (top). The HTML text in the bottom image is crucial to the operation and display of Google's web browser.

HTML has been an Internet standard since 1993, and all common browsers (e.g., Google Chrome, Apple Safari, Microsoft Internet Explorer, and Mozilla's Firefox) understand HTML. So, when you visit any page written in HTML, say <http://www.google.com>, on any browser, they all receive the same text, and the page looks the same on all these browsers. For example, the Google home page looks the same on all browsers.¹⁶⁵

HTML is a crucial part of the web and forms the foundation of all webpages. HTML uses tags to define elements. Tags can have attributes to further describe elements. These tags and attributes are used to create the visual and semantic structure of a webpage. Though HTML is primarily designed for machines to interpret, as you will see in this chapter, its simplicity makes it easy even for humans to understand the content.

¹⁶⁵ Browsers introduce minor individual tweaks, for example in their choice of default fonts. Commercial websites are tested for performance on all browsers to account for these tweaks. But for the purposes of this book, we treat all browsers as identical.

Virtually all information and tools are presented to end users as webpages. You access your school resources on the web, check email on the web, track bank accounts on the web, your teachers enter your grades on the web, and so on. All these webpages are created using HTML. Therefore, HTML is a foundational technology that all modern professionals will find useful.

In this chapter, we will review the basic elements you need to know to create HTML pages and review the editors that make it easy to build webpages. If you find this chapter interesting and would like to learn more about HTML and creating webpages, you should also take advantage of free online tutorials like W3Schools to learn HTML in more detail,¹⁶⁶ as it is not possible to cover all tags and attributes in a chapter.

Structure of an HTML Page

HTML is a simple language. It essentially encloses text within tags to tell the browser how to render the enclosed text. For example, the browser will render **this is bold text** as **this is bold text**. *<i>this is italicized text</i>* will be rendered as *this is italicized text*. You don't need fancy editors to create an HTML page. You could create an HTML page by typing HTML commands on a notepad and saving the file as .html (a file with an html extension). All HTML pages follow the same basic structure. They contain a **DOCTYPE declaration** at the top, followed by an HTML section. The HTML section comprises of a HEAD and BODY. Figure 200 shows a basic example.

```
<!DOCTYPE html>
<html>
  <head>
    <title>Page Title</title>
  </head>
  <body>
    <h1>This is a Heading</h1>
    <p>This is a paragraph.</p>
  </body>
</html>
```

Figure 200 — The basic structure of an HTML page includes the DOCTYPE, HEAD, and BODY.

The contents of Figure 200 are interpreted by the browser as follows:

DOCTYPE Declaration: This is the first line of an HTML page, and it tells the browser what kind of document to expect, particularly, which version of HTML.

HTML tag: All code in HTML is declared using tags. A tag is a special keyword that is enclosed by <>. The **HTML tag** defines the start and end of an HTML document. Everything in the HTML document is nested within the opening and closing HTML tags, i.e., between **<html>** and **</html>**. Tags are closed with the "/" symbol in the tag. Thus, **</html>** indicates the end of the section that began with the **<html>** tag.

Head tag: The **head tag** contains information about the HTML document that is mostly not displayed to the user. This section includes the title of the page, any information about the page such as author information and version history (this is often called meta information), information about the look and feel (called stylesheets), and information about user interactions (specified using a language called **JavaScript**). You can also include additional description and relevant keywords about your webpage within the head tag, so search engines can more easily identify your page. The only content within the head that is displayed to the user is information within the title tag, which is displayed as the title of your browser tab.

¹⁶⁶ The W3Schools HTML tutorial is at <https://www.w3schools.com/html/default.asp> (accessed June 2023).

Body tag: The body tag contains all the content that is displayed to the user. This includes text, images, links, and other HTML elements. When you build your HTML page, you will spend most of your time within the body. This is also the section we discuss the most in this chapter.

Elements in HTML

Like most electronic documents, webpages have text, images, tables, and links to other pages. The text may be bold, italicized, and use different font sizes. You might see ideas listed as bullet points or numbered lists. You may also see forms, with different input elements for you to fill in. You can represent each of these elements with HTML tags and build a complex HTML page that asks users to enter data and then sends the inputted data to a server for further action.

Here are a few essential tags to get you started.

- The **paragraph** < p > tag is used to define a block of text as a paragraph. The text within the < p > tag is displayed as a separate paragraph, with a line break before and after it (Figure 201). The text within the paragraph tag can include any type of content, such as text, images, links, or other HTML elements.

The screenshot shows a code editor with a single HTML file. The code is as follows:

```
<!DOCTYPE html>
<html>
<body>

<p>
    This is my new paragraph.<br>
    It is a collection of text that can be styled
</p>

</body>
</html>
```

To the right of the code, there is a preview window showing the rendered HTML. It displays a single paragraph with the text "This is my new paragraph." and "It is a collection of text that can be styled".

FIGURE 201 — Using the <p> tag creates a paragraph.

When creating a paragraph, you could use attributes to further specify the kind of paragraph you want. To create a paragraph with text in red color, try this:

```
<p style="color:red;">This is a red paragraph.</p>
```

- **Heading tags:** Headings are the essential mechanism to create structure within pages. HTML supports headings with six levels of headings, ranging from < h1 > to < h6 >. ¹⁶⁷ The < h1 > tag represents the main heading on a page and is typically used for the page title, while the other headings < h2 > to < h6 > are used for subheadings. It is best practice to not skip heading levels, i.e., subsections of < h1 > should use < h2 >, not < h3 > or < h4 > etc. Figure 202 shows an example.

¹⁶⁷ Headings have another use, they indicate the organization of the page to assistive technologies. You can read about this at <https://www.w3.org/WAI/tutorials/page-structure/headings/> (accessed June 2023).

```
<!DOCTYPE html>
<html>
<body>

<p>
  <h1>This is a Main Heading</h1>
  <h2>This is a Secondary Heading</h2>
  <h3>This is a Tertiary Heading</h3>
</p>

</body>
</html>
```

This is a Main Heading

This is a Secondary Heading

This is a Tertiary Heading

FIGURE 202 — Heading tags are useful for separating titles and subheadings.

- **Bold** **** tag is used to bold text.
- The **underline** **<u>** tag is used to underline text.
- The delete **** or **<strike>** tag is used to visually strikethrough text (Figure 203).

```
<!DOCTYPE html>
<html>
<body>

<h1>The delete element</h1>

<p>My favorite color is <strike>green</strike> <u>orange</u>!</p>

</body>
</html>
```

The delete element

My favorite color is ~~green~~ orange!

FIGURE 203 — Strikethrough tags are useful for visualizing text that is no longer relevant.

- The **subscript** **<sub>** and **superscript** **<sup>** tags are used to display text as subscript or superscript (Figure 204). These tags can be helpful to display scientific formulas.

```
<!DOCTYPE html>
<html>
<body>

<p>
  <p>This is text with a subscript: H<sub>2</sub>O</p>
</p>

</body>
</html>
```

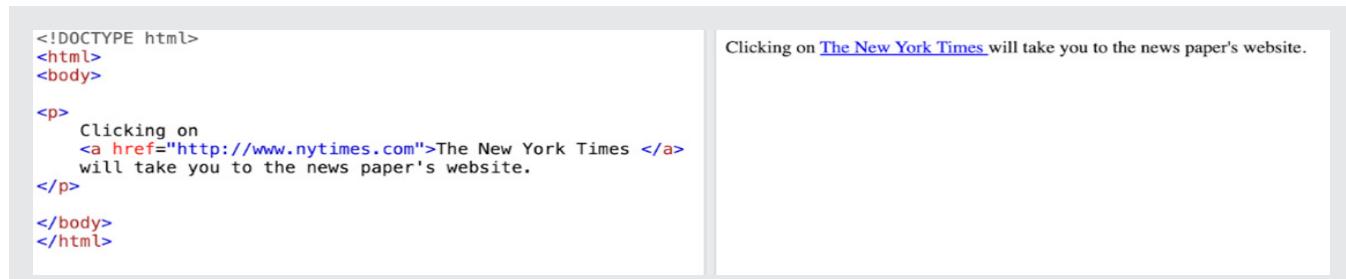
This is text with a subscript: H₂O

FIGURE 204 — Subscript tags are useful when displaying chemical formulas.

Adding Links

Hyperlinks are the unique distinguishing feature of HTML. Hyperlinks allow you to click on a link on a page and immediately navigate to another page that could be hosted anywhere in the world. The **<a>** tag stands for “anchor” and allows you to add hyperlinks to an HTML page.

The `<a>` tag has a required attribute to specify the target page. The target page is specified using the `href` attribute, giving the URL of the page or the resource you want to link. For example, to create a link to the homepage of the New York Times website, you can use the code shown in [Figure 205](#):



```
<!DOCTYPE html>
<html>
<body>
<p>
    Clicking on
    <a href="http://www.nytimes.com">The New York Times </a>
    will take you to the news paper's website.
</p>
</body>
</html>
```

Clicking on [The New York Times](http://www.nytimes.com) will take you to the news paper's website.

FIGURE 205 — An anchor tag allows users to link web addresses.

When this code is rendered on a web browser, the user can click on “The New York Times” to go to the website.

Adding Images

You can add images to your HTML page with an `` tag. Like the `<a>` tag, the `` tag also has a required attribute, `src`, that specifies the image file to be displayed. You need to have the source (`src`) attribute to give the location of the image, so the browser can get the image and display it on the webpage. Optionally, you can also have other attributes like `width` and `height` parameters to tell the browser how large the image should be on the page ([Figure 206](#)).

Images draw the attention of visitors. So, not surprisingly, company logos, background images, and advertisements are carefully and tastefully designed to draw the attention of visitors and convey the right message about the site to them.

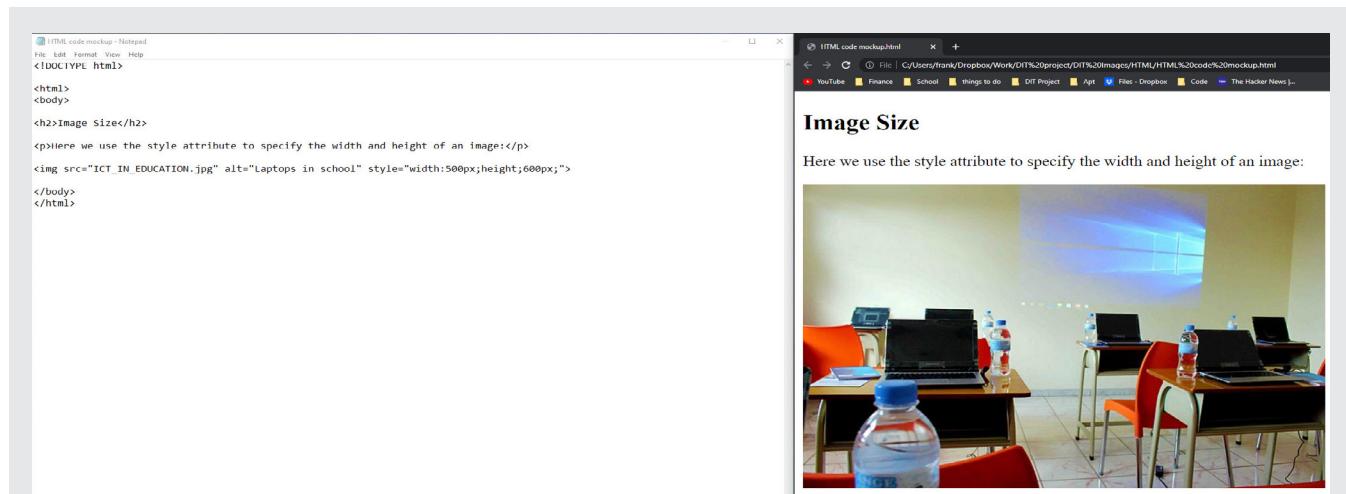


FIGURE 206 — Users can add images and adjust the image size in HTML.

Creating Lists

To create lists in HTML, such as a list of things to buy, places to visit, or people to invite, HTML offers two options—bulleted lists and numbered lists. You have the `` tag for unordered (bulleted) lists and the `` tag for ordered (numbered) lists. You can indicate the list items with the `` tag and nest lists within lists (Figure 207).

```
<!DOCTYPE html>
<html>
<body>

<h2>A Nested List</h2>
<p>Movies to watch with family</p>

<ul>

<li>Watch with Family
    <ul>
        <li>Gray Hound</li>
        <li>Saving Private Ryan</li>
    </ul>
</li>
<li>Watch with Friends
    <ul>
        <li>Lord of the rings</li>
        <li>Game of Thrones</li>
    </ul>
</li>
<li>Watch with Friends
    <ul>
        <li>13 Assassins</li>
        <li>Zombieland</li>
    </ul>
</li>

</ul>

</body>
</html>
```

A Nested List

Movies to watch with family

- Watch with Family
 - Gray Hound
 - Saving Private Ryan
- Watch with Friends
 - Lord of the rings
 - Game of Thrones
- Watch with Friends
 - 13 Assassins
 - Zombieland

FIGURE 207 — Nested lists using bulleted or numbered lists in HTML make it easy for users to identify sections.

Creating Tables

To display structured data, such as price lists, club memberships, class enrollments etc., HTML supports tables. Tables are created using the `<table>` tag. Tables have some additional necessary elements to specify rows and cells. The `<tr>` and `<td>` tags define the rows and cells of the table, respectively. You can also use the `<th>` tag to define table headers, which are typically bolded and centered. A `<table>` will have one or many `<tr>` tags, indicating the rows in the table. Each `<tr>` in turn encloses many `<td>` tags, indicating the cells within the row. The `<td>` tag represents a cell and encloses the contents of the cell (Figure 208).

```

<!DOCTYPE html>
<html>
<style>
table, th, td {
    border:1px solid black;
}
</style>
<body>
<table style="width:100%">
<tr>
<th>Rank</th>
<th>Name</th>
<th>Points</th>
<th>Team</th>
</tr>
<tr>
<td>1</td>
<td>Domestic</td>
<td>88,110</td>
<td>dcode</td>
</tr>
<tr>
<td>2</td>
<td>Sally</td>
<td>72,400</td>
<td>Students</td>
</tr>
<tr>
<td>3</td>
<td>Nick</td>
<td>52,300</td>
<td>amped</td>
</tr>
</table>
</body>
</html>

```

Rank	Name	Points	Team
1	Domestic	88,110	dcode
2	Sally	72,400	Students
3	Nick	52,300	amped

```

<!DOCTYPE html>
<html>
<head>
</head>
<body>
<table>
<tr>
<th>Rank</th>
<th>Name</th>
<th>Points</th>
<th>Team</th>
</tr>
<tr>
<td>1</td>
<td>Sally</td>
<td>72,400</td>
<td>dcode</td>
</tr>
<tr>
<td>2</td>
<td>Nick</td>
<td>52,300</td>
<td>amped</td>
</tr>
</table>
</body>
</html>

```

Rank	Name	Points	Team
1	Sally	72,400	dcode
2	Nick	52,300	amped

FIGURE 208 — Users can create tables in HTML to help organize data.

Creating Forms

Forms are the principal mechanism to get user inputs on webpages. Creating forms on webpages is exciting because it allows your users to interact with the webpage and submit information for processing. Almost all your favorite webpages have forms where data can be entered. Through forms,

users can enter text, numbers, dates, and upload files. Users can also press buttons, tick checkboxes, and choose radio buttons. The Google.com homepage, probably the most famous webpage in the world, is just a simple form with an input field where you can enter your search query. The page is essentially a form with a text input element and two buttons (Figure 209).¹⁶⁸

Forms are created using HTML code. Later in this chapter, we will see how they can be styled and customized using CSS stylesheets. When a user submits a form on an HTML page, the data is sent to a server for processing or storage in a database. For example, when you search for “Movies to watch” on Google.com, your input into the form is taken and sent to a Google server. The server then responds with the answer to your search query.

Forms are used in a variety of contexts. Common forms include login and registration forms, search forms, contact forms, feedback forms, and e-commerce checkout forms. They are an essential part of web development and enable webpages to collect data, provide a personalized user experience, and perform various actions based on user input.

Forms are created using the `<form>` tag. Every form also has multiple `<input>` tags to specify the kind of input you want from the user. These `<input>` elements can be text, number, file, or image. Each of these can be specified by choosing the right value for the “type” attribute of the `<input>` tag. The data collected in a form is sent to the server for processing using the `action` attribute of the `form tag`.¹⁶⁹

In the example in Figure 210, we have a simple form to collect the first name and last name of the user. When the “Submit” button is pressed after entering the first and last names, the form data will be sent to the processor located at `server_submit.php`. The processor will respond after processing the name, for example by saving it in the database, and customizing the response with the name, etc.¹⁷⁰

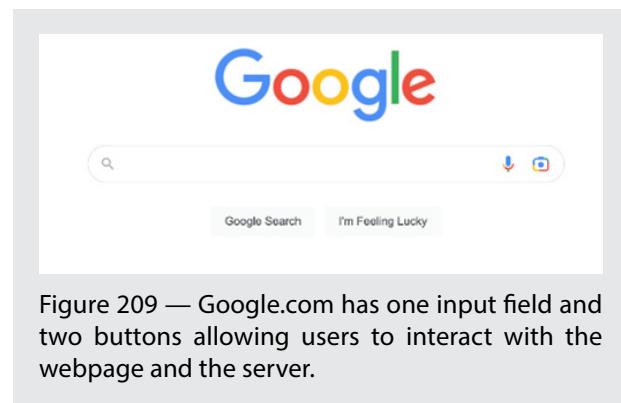


Figure 209 — Google.com has one input field and two buttons allowing users to interact with the webpage and the server.

¹⁶⁸ The ‘I’m feeling lucky’ button on Google’s home page has an interesting history. Most users do not use it, but it is a founder favorite. You can read about it at <https://www.howtogeek.com/847170/googles-im-feeling-lucky-explained/> (accessed June 2023) and <https://content.time.com/time/business/article/0,8599,685801,00.html> (accessed June 2023).

¹⁶⁹ Forms generally use the capability of HTTP (hypertext transfer protocol) to upload data from the browser to the server. This is specified using the `POST` method attribute of the FORM tag. We ignore this detail in this book.

¹⁷⁰ The ids (unique Id) of elements you see in the form help the processor associate inputs with the fields. These ids should, therefore, be unique for forms to work as expected.

```

<!DOCTYPE html>
<html>
<body>

<h2>HTML Forms</h2>

<form action="/server_submit.php">
  <label for="firstname">First name:</label><br>
  <input type="text" id="firstname" name="firstname" value="John"><br>
  <label for="lname">Last name:</label><br>
  <input type="text" id="lname" name="lastname" value="Doe"><br><br>
  <input type="submit" value="Submit">
</form>

<p>If you click the "Submit" button, the form-data will be sent to a page called "/server_submit.php".</p>

</body>
</html>

```

HTML Forms

First name:

 Last name:

If you click the "Submit" button, the form-data will be sent to a page called "/server_submit.php"

FIGURE 210 — Users can create multiple forms in HTML to collect different types of input.

To create a multi-line input element, use the tag "textarea." You can also specify how wide and tall this text box should be using "rows" and "cols" attributes.

To create a dropdown that allows users to select from a list of things, you can use the select tag (Figure 211).

```

<!DOCTYPE html>
<html>
<body>

<h2>The Select (Dropdown) Element</h2>
<p>The select elemnt defines a drop-down list:</p>
<form action="/action_page.php">
  <label for="cars">Choose a car:</label>
  <select id="cars" name="cars">
    <option value="gm">GM</option>
    <option value="chevy">Chevy</option>
    <option value="ford">Ford</option>
    <option value="chrysler">Chrysler</option>
  </select> <br><br>
  <input type="submit">
</form>

```

The Select (Dropdown) Element

The select elemnt defines a drop-down list:

Choose a car: ▼

FIGURE 211 — Using the select tag, users can create dropdown menus in HTML.

There are additional form input types to handle common input scenarios. A radio button is a great choice if you want to give users multiple choices, but you want them to pick only one option. The concept of a radio button dates to radios that had mechanical buttons to select a station. You could only select one button at a time. If you pressed another button, then the previously pressed button would pop out automatically. This concept has carried over to HTML forms and such selectors are called radio buttons, tracing their lineage. So, even though you may see many options, selecting a new option will deselect your previous choice. Figure 212 shows an example.



HTML forms are similar to car radios. Both can have multiple buttons/fields to receive input.

```

<!DOCTYPE html>
<html>
<body>

<h2>Radio Buttons</h2>

<p>The <strong><input type="radio"></strong> defines a radio button:</p>
<form action="/action_page.php"
      <input type="radio" id="html" name="fav_language" value="HTML">
      <label for="html">HTML</label><br>
      <input type="radio" id="css" name="fav_language" value="CSS">
      <label for="css">CSS</label><br>
      <input type="radio" id="javascript" name="fav_language" value="JavaScript">
      <label for="javascript">JavaScript</label><br>
      <input type="submit" value="Submit">
    </form>

</body>
</html>

```

Radio Buttons

The **input type="radio"** defines a radio button

Choose your favorite web language:

HTML

- HTML
- HTML

Submit

FIGURE 212 — Similar to actual radio buttons, even HTML radio buttons can only allow one input at a time, clearing the previous options.

The “Checkbox” element in HTML derives its name from paper forms with checkboxes. You can select one or many checkboxes. Similarly, creating a “Checkbox” element in HTML will allow your users to select one or more choices (Figure 213).



Checklists make receiving user input simple while recording the data.

```

<!DOCTYPE html>
<html>
<body>

<h2>Checkboxes</h2>

<p>The <strong><input type="checkbox"></strong> defines a checkbox:</p>
<form action="/action_page.php"
      <input type="checkbox" id="vehicle1" name="vehicle1" value="Bike">
      <label for="vehicle1">I have a bike</label><br>
      <input type="checkbox" id="vehicle2" name="vehicle2" value="Car">
      <label for="vehicle2">I have a car</label><br>
      <input type="checkbox" id="vehicle3" name="vehicle3" value="Boat">
      <label for="vehicle3">I have a boat</label><br>
      <input type="submit" value="Submit">
    </form>

</body>
</html>

```

Checkboxes

The **input type="checkbox"** defines a checkbox:

I have a bike

- I have a car
- I have a boat

Submit

FIGURE 213 — Users can create checklists in HTML by using the checkbox element.

If you want users to enter a date, you may want to use the “Date” element. Your browser will recognize this element and display a calendar (Figure 214). Once a date is selected, the browser updates the field with the selected date.

```

<!DOCTYPE html>
<html>
<body>

<h2>Date Field</h2>

<p>The <strong>input type="Date"</strong> is used for input fields that should contain a date.</p>
<form action="action_page.php">
<label for="Birthday">Birthday:</label><br>
<input type="date" id="birthday" name="birthday">
<input type="submit" value="Submit">
</form>

<p>Note: <strong>input type="date"</strong> is not supported in Internet Explorer 11 or prior,  
Safari 14.1</p>
</body>
</html>

```

Date Field

The **input type="Date"** is used for input fields that should contain a date.

Birthday:

mm/dd/yyyy

Note: **input type="date"** is not supported in Internet Explorer 11 or prior, Safari 14.1

FIGURE 214 — Date fields include inputs for the day, month, and year.

Cascading Style Sheets (CSS)

The HTML we have created thus far is functional, but bland. We now look at **CSS**, which is the standard way to make webpages stand out with color and design. CSS stands for **Cascading Style Sheets** and is used to describe how HTML elements are to be displayed on screen, paper, phones, iPads, or in other media. The design of CSS saves the developer time by allowing the layout of multiple webpages to be controlled all at once. In a few examples we have specified the height and width of the image. See [Figure 206](#). While this was convenient for the example, imagine trying to decide how every element should look across multiple pages on your website. When you add tags like `` and `<color>` attributes to HTML, you will have a nightmarish experience trying to remember the color and other attributes of other similar elements on your page. Your webpage may end up looking inconsistent if you are not careful. Besides, the HTML file will be huge and messy. It gets worse. If you decide to change the colors or font styles on your site, you would have to update the look and feel of every such element on your page.

To avoid these problems, the best practice is for developers to define all their styles in a CSS file that they then link to their HTML documents. In this way, every “Submit” button on all webpages across your site will use the same size and color and every header will be of the same font size and style.

To see how CSS works, let’s begin by trying to add some basic styling effects to our HTML document within the style tag as shown in [Figure 215](#).

```

<!DOCTYPE html>
<html>
<head>
<style>
body {
    background-color: lightblue;
}

h1 {
    color: white;
    text-align: center;
}

p {
    font-family: verdana;
    font-size: 20px;
}
</style>
</head>
<body>

<h1>My First CSS Example</h1>
<p>This is a paragraph.</p>

</body>
</html>

```

My First CSS Example

This is a paragraph.

Figure 215 — Utilizing style in HTML allows users to personalize webpages. Here is the HTML (top) and its result (bottom).

W3Schools is a great resource to learn about styles.¹⁷¹ You can tweak more aspects about the look and feel of your webpage than you can imagine. Once you develop some comfort with CSS, the next step to improve your productivity as a web developer is to create a separate CSS file (Figure 216) and then link it to your HTML file as shown in line 4 of Figure 217.

```
body {  
    background-color: lightblue;  
}  
  
h1 {  
    color: navy;  
    margin-left: 20px;  
}
```

```
<!DOCTYPE html>  
<html>  
<head>  
<link rel="stylesheet" href="mystyle.css">  
</head>  
<body>  
  
<h1>This is a heading</h1>  
<p>This is a paragraph.</p>  
  
</body>  
</html>
```

FIGURE 216 — CSS files include styles and attributes that affect normal HTML elements.

FIGURE 217 — Users can link stylesheets to HTML to reduce clutter in the HTML text.

Website Design and Storyboarding

Websites are collections of individual webpages that accomplish a specific purpose. For example, the website of your school district, say <https://www.hillsboroughschools.org/> or your school, say <https://kingib.org/> has several pages that provide all the information and interaction students and parents expect from the school or school district.

When you visit a website (say, www.google.com), there are servers (owned and managed by a service provider) waiting for you to reach out to them. To support all their users and their requests, websites have a collection of webpages that are connected to one another through weblinks. This way, when you go from one Google webpage to another, you have a seamless experience.

For example, when you search for a book on Google, you see a collection of results. If you click on a Google sponsored ad after reviewing the results, another result page opens. The entire flow is managed by multiple Google webpages and application programs that handle these user requests.

To accomplish this, websites should be coherent, easy to navigate, and accomplish what you set out to do. The same need for coherence and ease of use applies to much larger sites where you write your blog, sell your products, or promote your company. Building a website is a resource-intensive exercise. You must plan, build, and deploy your website. Just like you wouldn't start constructing a house without having a plan, you don't want to build a website on the fly. Therefore, once you learn the elements of webpages including HTML and CSS and are ready to build a website, it is a good idea to start with [storyboards](#).

¹⁷¹ The W3Schools CSS tutorial is at <https://www.w3schools.com/css/default.asp> (accessed June 2023).

Storyboards are visual representations of creative projects.¹⁷² When used with websites, storyboards help all members of the development team identify all the users of a website and their expected interactions.¹⁷³ Once storyboards are developed, they are usually communicated using [wireframes](#). Wireframes are illustrations of the webpage that focus on space allocation for the elements of the page and their intended behaviors.¹⁷⁴ Wireframes are intended to be simple and disposable and typically do not include any styling, color, or graphics.

Storyboards and wireframes are both important tools in the design and development process of a website, but they serve different purposes and are used in different contexts. Storyboards are about the storytelling and visual components and wireframes focus on the user interface and interaction aspects of a website. For large scale projects, you should first do storyboarding before moving on to wireframing tools.

While storyboarding evolved from film and drama, the concept has found a home in website development. It is useful to understand the high-level overview and flow of the webpages and visualize the user experience. Once you and your team agree about the flow, you can then move to wireframing the design.

A wireframe outlines the structure and content of a website without including design elements such as colors, typography, or images. Wireframes are created during the planning phase to help designers and developers identify and address potential design and usability issues.

Wireframes typically include boxes and lines to represent the placement of different elements on the page, such as headers, navigation menus, content sections, and calls to action. Balsamiq¹⁷⁵ is a popular wireframing software that lets you quickly wireframe your webpages and then share it with your team and customers to get their feedback before investing development effort to create the website ([Figure 218](#)). Wireframing tools such as Balsamiq offer templates to pick, drag, and drop different webpage elements and put them on the screen to quickly develop wireframes. You can use wireframes to design browser-based webpages or for mobile apps like iOS or Android. Building wireframes to refine application concepts is an excellent, low-effort, no-cost way to test new application ideas.

172 You can read about the origins of storyboards, and how Walt Disney and his team originated the concept in 1933 to convey the story of "Three Little Pigs" at <https://www.instructionaldesign.org/concepts/storyboarding/> (accessed June 2023).

173 A good description of storyboards and their use is at <https://www.capterra.com/resources/what-is-a-storyboard-in-web-design/> (accessed June 2023).

174 The US federal government's usability website has a nice introduction to wireframing at <https://www.usability.gov/how-to-and-tools/methods/wireframing.html> (accessed June 2023).

175 <https://balsamiq.com/> has an excellent tutorial on wireframing and user interface design at <https://balsamiq.com/learn/courses/intro-to-ui-design/> (accessed June 2023).

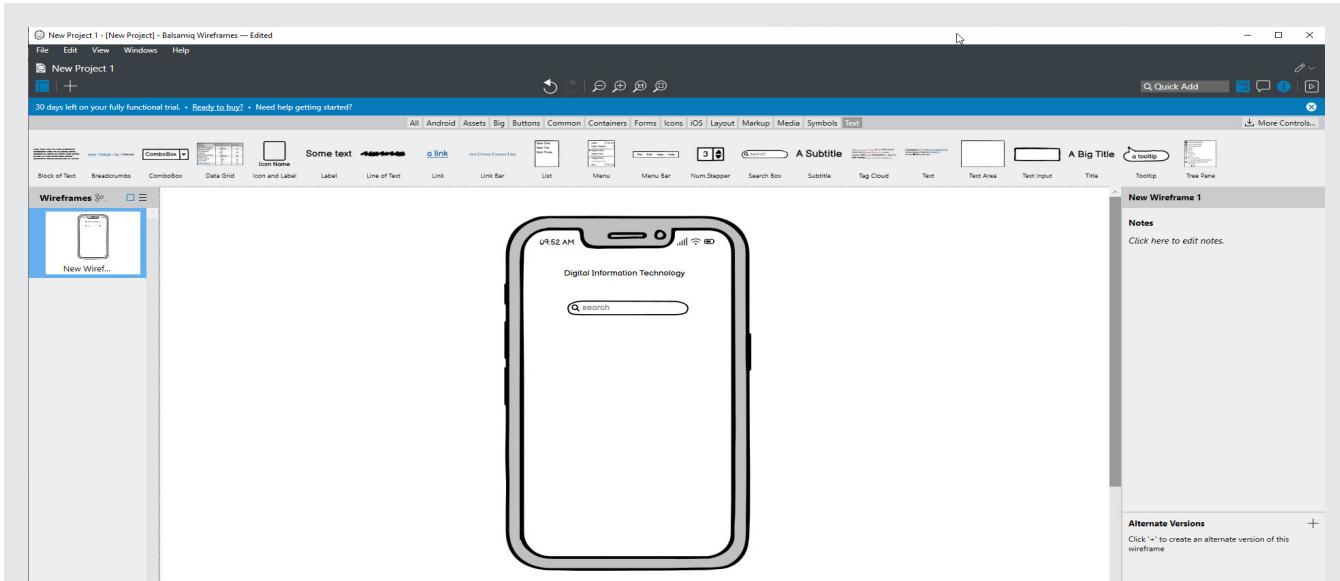


FIGURE 218 — Software, like Balsamiq, allows users to design outlines of webpages without committing to code.

Another popular wireframing tool, Figma, was acquired by Adobe in September 2022 for \$20 billion.¹⁷⁶ Figma not only lets you wireframe and collaborate with colleagues but also automatically converts your wireframe design into a working HTML website that you can later deploy to your webhost.

Structure of a Website

Once you learn HTML to build webpages and create storyboards and wireframes for your idea, you may be interested in creating your website so it can be viewed by anyone in the world. We now provide an overview of the elements of a working website.

If you want to create a website, your website admin (or you) will need to have a [webserver](#) (e.g., Apache webserver¹⁷⁷) to host the website.¹⁷⁸ You will need to save your HTML pages and other supporting files in an organized folder structure on the webserver. We will now discuss the basic structure of a website so you can understand how all the elements of a site are integrated together.

It is a good idea to include the folder structure of your website in your wireframe, so it is easy to see how it is organized on your webserver. [Figure 219](#) shows an example of the folder hierarchy of a website and how it ties to the different sections of the site together.

¹⁷⁶ You can read the announcement at <https://news.adobe.com/news/news-details/2022/Adobe-to-Acquire-Figma/default.aspx> (accessed June 2023).

¹⁷⁷ The Apache webserver, which traces its origins to the first webserver built by Tim Berners Lee at CERN, is extremely robust and easy to install. If you have access to a personal computer, installing the Apache webserver and becoming familiar with its use is delightful learning. You can learn more and download Apache from <https://httpd.apache.org/> (accessed June 2023).

¹⁷⁸ You can read more details online, including at GoDaddy's page, <https://www.godaddy.com/garage/how-to-build-a-website-with-html-and-css/> (accessed June 2023).

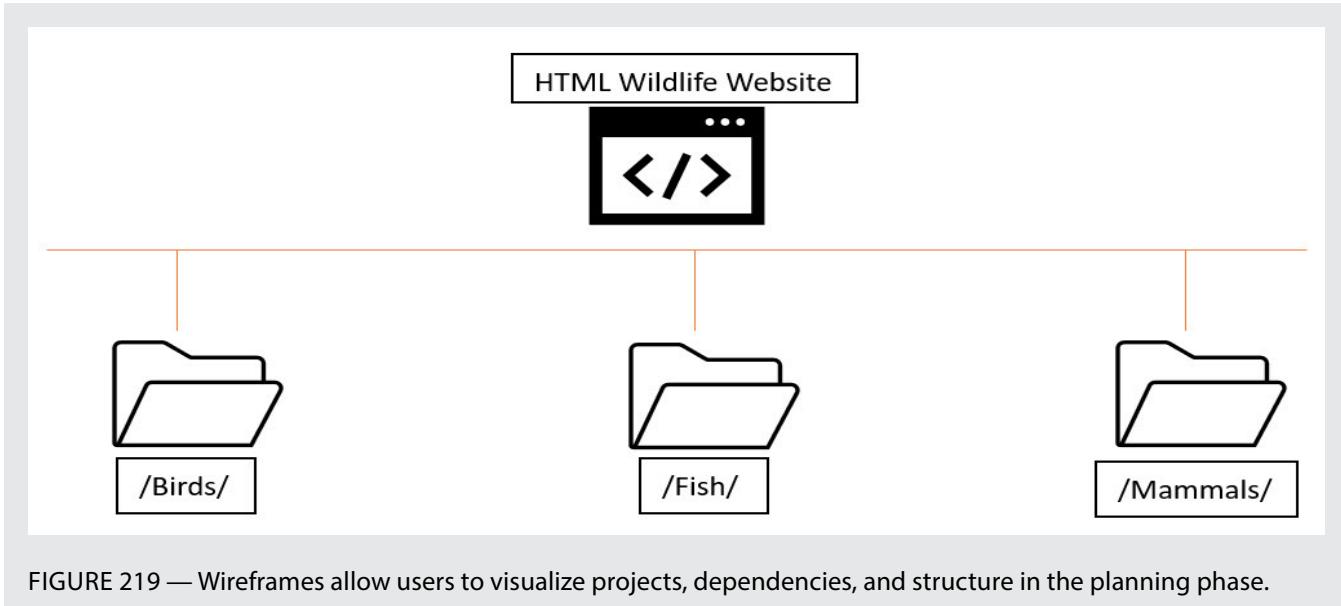


FIGURE 219 — Wireframes allow users to visualize projects, dependencies, and structure in the planning phase.

It is useful to maintain a consistent organization for the files within each folder. Figure 220 shows a popular organization structure for the files in a folder. The starting point of your application or website is typically called the “Root” folder of your site. A file called “index.html” is displayed by default if someone visits your website and does not specify a specific file name.¹⁷⁹

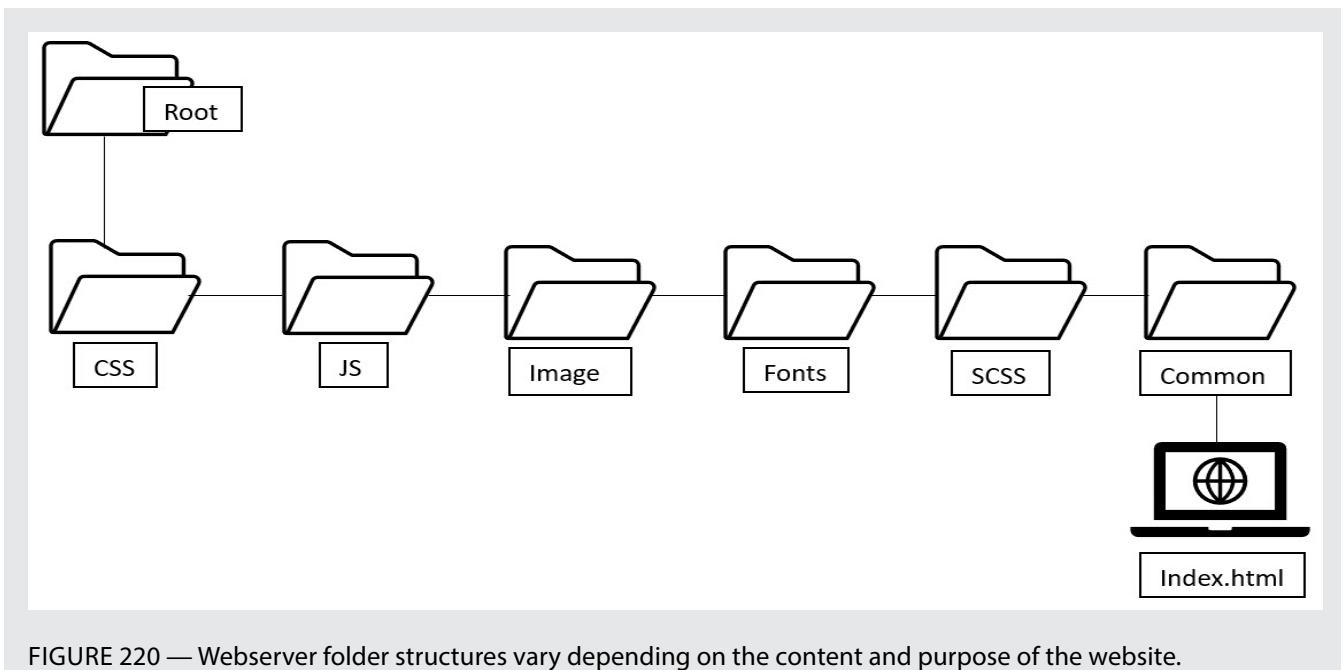


FIGURE 220 — Webserver folder structures vary depending on the content and purpose of the website.

Organizing folders for Images, Fonts, Common libraries, JavaScript, and Stylesheets (Figure 220) makes it easier to manage and maintain files. Search engines and users will also be able to navigate the website easily. Additionally, many websites also use a Content Management System (CMS) that provides a graphical interface to organize and manage the files and contents of websites.

¹⁷⁹ A question thread at StackOverflow on this file name convention is at <https://stackoverflow.com/questions/32408259/why-do-people-name-their-files-index-html> (accessed June 2023).

You can have all your HTML pages in a separate folder, or you can choose to divide your website into different functional areas and have a separate webpage for each topic within it. In [Figure 221](#), you can see how the submenus of a website correspond to similarly named folders on the server. For example, if a user visits your home page, the server will show the root-level index.html file. However, if the user clicks Submenu 1, then the Index.html within the Submenu 1 folder will be displayed.

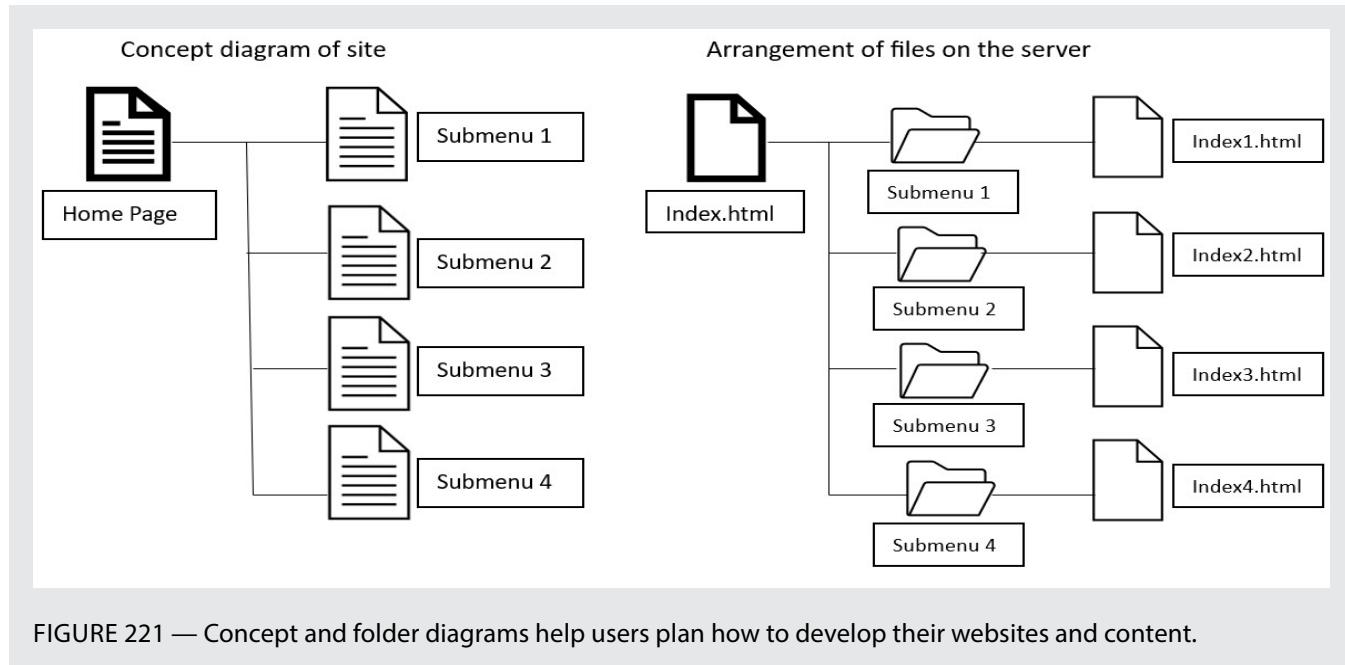
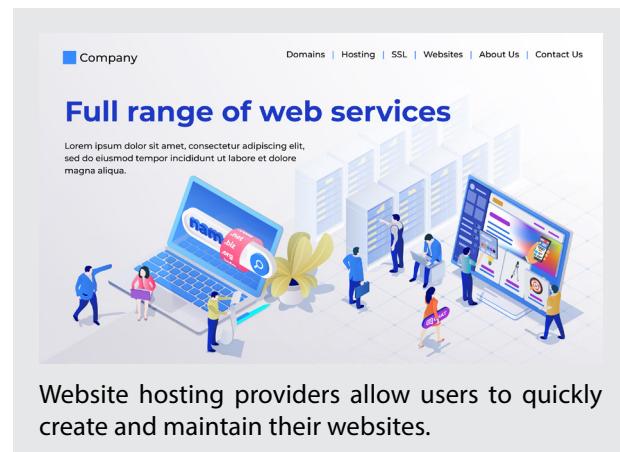


FIGURE 221 — Concept and folder diagrams help users plan how to develop their websites and content.

Hosting a Website

Hosting a website means making it accessible to the public over the Internet by storing the website's files and data on a webserver. A webserver is a computer that is connected to the Internet and is designed to store and deliver webpages to users who request them through their browsers.

When you host a website, you essentially rent space on a webserver from a hosting company or provider. This allows your website to be stored on the webserver and made available for access over the Internet. The web hosting company also provides a range of services, such as server maintenance, security, and technical support, to ensure that your website is always accessible and runs smoothly. You'll need to upload your files to the webserver and configure your website settings so users can find your site on the web.¹⁸⁰



Website hosting providers allow users to quickly create and maintain their websites.

¹⁸⁰ The primary configuration is to acquire a domain name (such as www.example.com) and point it to your website. Hosting service providers take care of this detail, so we do not discuss this in more detail in this book. For details, please see <https://www.hivelocity.net/kb/dns-configuration-everything-you-need-to-know/> (accessed June 2023). To see what the setup at a hosting service provider looks like, please see GoDaddy's details at <https://www.godaddy.com/garage/configuring-and-working-with-domains-dns/> (accessed June 2023).

Once your website is hosted, users can access it by typing your domain name (e.g., www.cyberflorida.org) into their web browsers. This sends a request to the webserver hosting your website. The webserver then responds by sending the requested webpages back to the user's web browser, which displays them on their screen.

Hosting from Your Home Computer

You can actually host your site from your own home computer. You'll have to get a permanent IP address from your Internet service provider, purchase a domain name (website name) from a DNS registry, and connect the website name to your computer's IP address. You'll also need to ensure your computer can handle the load, is protected, is always turned on, and is being backed up regularly.

As you can see, this adds a lot of complexity and responsibility. Therefore, the alternative of taking advantage of web-hosting providers is very popular.

There are many popular web hosting sites available, each with its own features, pricing, and capabilities. Some of the most popular web hosting sites are GoDaddy,¹⁸¹ Bluehost, SiteGround, HostGator,¹⁸² DreamHost, A2 Hosting, InMotion Hosting, and Wix.¹⁸³ It's important to research and compare different options to find the one that best meets your needs and budget.¹⁸⁴

Website Editors

There are multiple ways to build HTML pages. One way is to code it from scratch using the HTML elements like <table>, <text>, , and others. Another way is to use a wireframe tool like Figma and then use the tool's conversion feature to convert the wireframe into HTML code.

Another popular way is to use a WYSIWYG (Pronounced WIZ-EEE-WIG) editor. WYSIWYG is a popular industry acronym for "What You See Is What You Get." In the context of HTML editors, a WYSIWYG editor is a software program that allows users to create and edit HTML documents without having to know the HTML code. With a WYSIWYG editor, users drag and drop website elements such as images and tables on a drawing canvas, and see the webpage they are creating as it will appear in a browser without having to manually code the HTML.¹⁸⁵

WYSIWYG HTML editors make web technologies accessible to everyone. They are popular among non-technical users, such as bloggers, content creators, and small business owners, who may not have the technical expertise to create webpages using HTML code. Some popular free WYSIWYG

¹⁸¹ GoDaddy's plans are at <https://www.godaddy.com/hosting/web-hosting> (accessed June 2023).

¹⁸² You can check out plans at <https://www.hostgator.com/web-hosting> (accessed June 2023). HostGator started in a dorm room at Florida Atlantic University, so we are biased towards them.

¹⁸³ You can check out their services at <https://www.wix.com/> (accessed June 2023).

¹⁸⁴ You can find several resources and comparisons online, e.g., <https://geekflare.com/best-static-site-hosting-platform/> (accessed June 2023).

¹⁸⁵ Wikipedia's WYSIWYG page has a nice history of WYSIWYG editors at <https://en.wikipedia.org/wiki/WYSIWYG> (accessed June 2023).

HTML editors¹⁸⁶ include Brackets from Adobe,¹⁸⁷ Phoenix code editor from the Brackets developer community,¹⁸⁸ and SeaMonkey from the Mozilla community.¹⁸⁹ There are also commercial WYSIWYG editors, including Adobe's Dreamweaver.¹⁹⁰

Website hosting providers like Wix.com can also give you access to website builders and editors. The website builder is typically a WYSIWYG platform, where you can drag and drop elements on to the page. When you are ready, you can click the "Publish" button to deploy your website without writing or editing a line of code.

Google Sites (www.sites.google.com) is another website hosting provider that has its own WYSIWYG webpage builder (Figure 222).

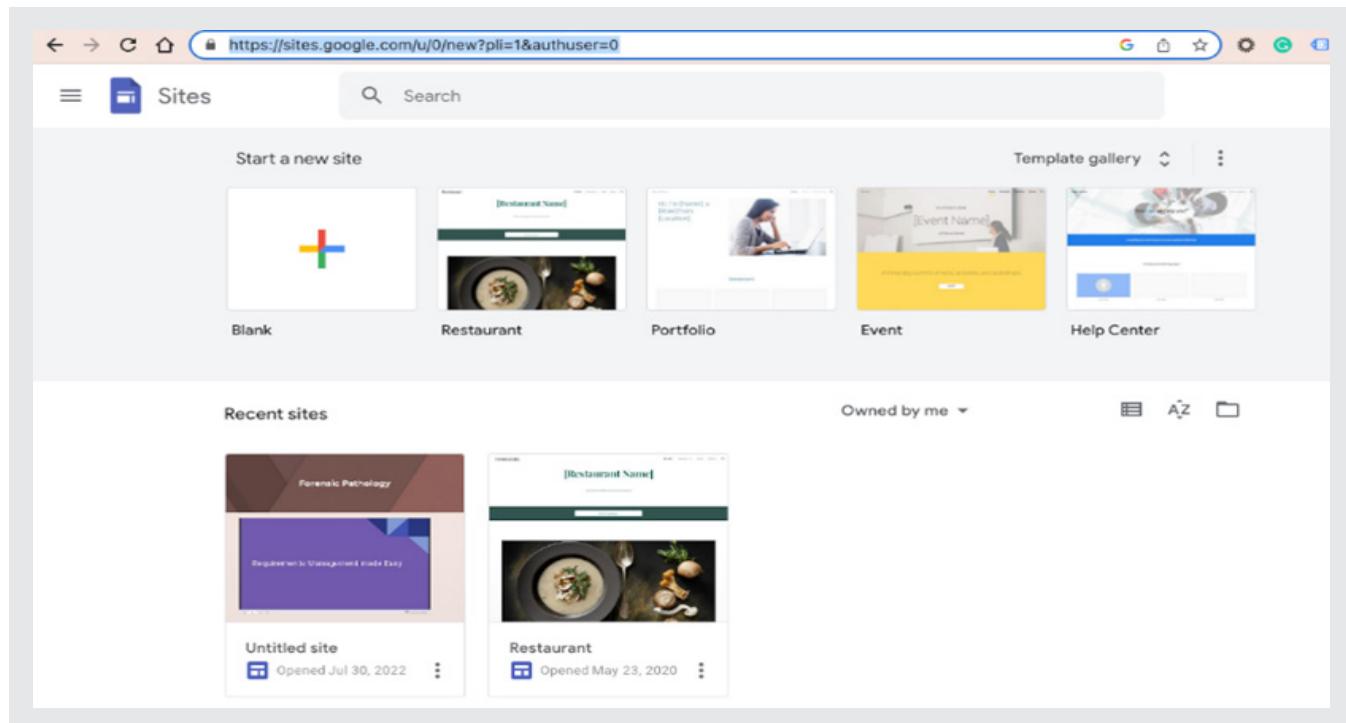


FIGURE 222 — Similar to Wix and other providers, Google Sites allows users to host and build websites.

The capabilities of HTML editors are evolving rapidly. While the editors share most of the same basic capabilities, they can also offer additional capabilities depending upon the needs of their target audience, pricing structure, etc. For example, commercial editors may offer advanced features like a library to maintain your common themes, icons, a collaboration framework (so you can get your work

¹⁸⁶ There are other choices and reviews available online, including for example in the article at <https://www.thoughtco.com/best-windows-wysiwyg-editors-3471324> (accessed June 2023).

¹⁸⁷ You can download Brackets from <https://brackets.io/> (accessed June 2023).

¹⁸⁸ The Phoenix editor is entirely online and can be accessed at <https://phcode.dev/> (accessed June 2023).

¹⁸⁹ You can download SeaMonkey from <https://www.seamonkey-project.org/> (accessed June 2023). SeaMonkey continues the all-in-one Internet application suite concept popularized by the Netscape browser, which all authors of this book used in the early days of the Internet.

¹⁹⁰ Available at <https://www.adobe.com/products/dreamweaver.html> (accessed June 2023).

approved before it gets published), and a built-in version control system (so you can go back to any previous version). Check out the capabilities and pricing models of the different editors to find one that best fits your needs.

Learning to build webpages and websites is a great way to enter the fascinating world of modern information technologies. You can continue your journey by following tutorials available online freely. The Mozilla Developer Network (MDN) is a great resource to learn the technologies introduced in this chapter.¹⁹¹ W3Schools is also a great resource.

HTML Extensions

We close this chapter by introducing some popular related technologies that power the web and commerce today. The popularity of the web has led to several innovations in web design, collectively called DHTML. The concept of tags has also been extended to XML, which generalizes publishing and even allows machines to directly exchange information with each other.

Dynamic HTML (DHTML)

As you begin developing your own webpages, you will notice that popular websites have capabilities beyond those introduced in this chapter. A static HTML page can look attractive with text in different fonts, shapes and sizes, and colorful images sprinkled all over. However, in the world of mobile phones, we expect our webpages to also be interactive. We want to click and see things change. When we go to a site such as Amazon, we like to see items added immediately to the shopping cart when we click the buy button. Developers use multiple web technologies to enable this interactivity. The collection of web technologies including HTML, CSS, and JavaScript to create interactive websites is called Dynamic HTML, or DHTML.¹⁹²

One way to look at the DHTML technologies is to think of HTML code as answering the question “What to display” CSS code as answering the question “How the display should look” and JavaScript code answering the question “How the webpage should interact with the user.”

Using DHTML, you can create webpages that respond to user actions such as mouse clicks and hover events, without requiring the page to reload or requiring server-side processing.

Another recent development, popularized by social media websites such as Facebook and Twitter, is called the Single Page Architecture (SPA). Single Page Architecture (SPA) is a development approach in which the content and functionality of a web application is contained within a single HTML page. Instead of navigating to separate pages when clicking on links, the user remains on the same page while sections of the page get dynamically updated based on the user’s interaction with the website. The initial HTML page is loaded from the server, and then subsequent interactions with the application are handled through JavaScript. The JavaScript code updates sections of the page based on user

¹⁹¹ Tutorials for HTML, CSS and related technologies including JavaScript for developers at different levels of expertise can be accessed at <https://developer.mozilla.org/en-US/docs/Web/Tutorials> (accessed June 2023).

¹⁹² We consider JavaScript to be beyond the scope of this introductory book. But interested students can follow the JavaScript tutorial at the Mozilla Developer Network (MDN) link in the previous footnote.

interactions without requiring a full page reload, offering a seamless experience to visitors.¹⁹³

SPAs offer several advantages to page visitors, including a smoother user experience, faster page load times, and easier development and maintenance due to the separation of client-side and server-side code.¹⁹⁴ Popular examples of SPAs include Gmail, Facebook, and Twitter. Their convenience is also a source of criticism of single page applications—users keep scrolling SPAs, anticipating interesting news, a phenomenon popularly labeled doom-scrolling.¹⁹⁵

Extensible Markup Language (XML)

HTML is designed specifically for publishing webpages. The popularity of HTML to publish information for the World Wide Web led to interest in generalizing this idea to standardize all forms of electronic publishing, including electronic documents, and electronic records. The core idea was that if information elements could be standardized, computers could easily modify the information for different purposes at the click of a button. For example, the same information could be formatted with stylesheets for web and print publication with the click of a button, saved as structured information into a relational database for archival storage at the click of another button, and relevant information extracted and reported to the government for tax purposes with another click.

Extensible Markup Language (XML) is the generalization of tags for electronic publishing.¹⁹⁶ Several electronic publishing technologies use XML behind the scenes for their operation. Almost all electronic documents are saved behind the scenes as XML. For example, Figure 223 shows the XML created by Microsoft Word for the title and opening sentence of this section.^{197, 198} You can see the styles and content for the title and paragraph in the figure.

As you can see in Figure 223, XML encodes documents in a format that is both human-readable as well as machine-readable. XML can specify how every element of an electronic document should be interpreted. With this detail, computers can precisely and easily transform information for different uses such as recordkeeping and publishing.

-
- 193 The technology to load sections of the page is called AJAX (Asynchronous JavaScript and XML). AJAX requests pieces of data from the server and updates small sections on the page with the data without disturbing the user's flow. An example of the use of AJAX is how the Gmail just moves the entire view up one row when you delete an email, without reloading the entire page. You can learn more at the W3Schools AJAX tutorial at https://www.w3schools.com/xml/ajax_intro.asp (accessed June 2023).
- 194 However, SPA also present some challenges, such as search engine optimization (SEO) difficulties and the need for careful management of memory and performance.
- 195 Doomscrolling can not only be a time sink, but also a health hazard, please read about it, a starting point is <https://www.webmd.com/balance/what-is-doomscrolling> (accessed June 2023).
- 196 The homepage of the technology working group is at <https://www.w3.org/XML/> (accessed June 2023).
- 197 To view the XML for a Microsoft Word document, first change the extension of the file from ".docx" to ".zip". Then unzip the file and view the "document.xml" file within the Word folder.
- 198 The XML specification for Microsoft Office documents is called Office Open XML. You can read about it at https://en.wikipedia.org/wiki/Office_Open_XML (accessed June 2023).

```

▼<w:p w14:paraId="3DE2CE7B" w14:textId="068E7512" w:rsidR="00880F3C" w:rsidRDefault="00E2563A" w:rsidP="003105C2">
  ▼<w:pPr>
    <w:pStyle w:val="Heading2"/>
  </w:pPr>
  <w:bookmarkStart w:id="1081" w:name="_Toc132104541"/>
  ▼<w:r>
    <w:t>Extensible markup language (</w:t>
  </w:r>
  ▼<w:r w:rsidR="00880F3C">
    <w:t>XML</w:t>
  </w:r>
  ▼<w:r>
    <w:t>) </w:t>
  </w:r>
  <w:bookmarkEnd w:id="1081"/>
</w:p>
▼<w:p w14:paraId="6DD9495F" w14:textId="60E7BD61" w:rsidR="00E2563A" w:rsidRDefault="005D6A3C" w:rsidP="00880F3C">
  ▼<w:pPr>
    <w:pStyle w:val="BodyText"/>
  </w:pPr>
  ▼<w:r>
    <w:t>HTML is designed for the specific case of publishing web pages.</w:t>
  </w:r>
  ▼<w:r w:rsidR="00B9518F">
    <w:t xml:space="preserve"> The popularity of HTML </w:t>
  </w:r>

```

FIGURE 223 — XML tags format text into a language that humans and computers can interpret.

XML is very useful if the organization you work for does data exchange, for example with buyers, sellers, credit card companies, banks, and other organizations. Data exchange between companies and customers is a critical aspect of online commerce, which makes XML a key language you should know about.

A unique feature of XML is that it allows users to create their own custom tags to represent specific data structures and identify elements within a document. This flexibility makes it suitable for a wide range of applications, including web services, data storage and retrieval, and configuration files for computer applications.

XML standards, which specify tags for specific uses, have been developed for most of the important information exchange contexts. For example, the XML Business Reporting Language (XBRL) helps organizations report financial performance in a universal format.¹⁹⁹ Since 2018, the U.S. Securities and Exchange Commission, the principal regulator of publicly traded companies in the United States, has required that companies submit their annual reports using XBRL.²⁰⁰ An example is shown in Figure 224.²⁰¹ A critical feature you can see in the example is that the numbers are clearly associated with their corresponding meanings specified by the International Financial Reporting Standards (IFRS).²⁰² For example, the underlying XML conveys to every financial publishing technology anywhere in the world that the highlighted number of \$3,404,031 represents salary expenses for the organization. This makes it easy and precise for investors to compare the performance of different organizations,

199 You can read about XBRL at <https://www.xbrl.org/> (accessed June 2023).

200 You can read about this at <https://www.sec.gov/structureddata/osd-inline-xbrl.html> (accessed June 2023).

201 The example is from <https://www.xbrl.org/ixbrl-samples/gleif-annual-report-2017/gleif-annual-report-2017-viewer.html#f-f6> (accessed June 2023) (you can find this example by searching for “inline xbrl example”)

202 The home page for the standards is at <https://www.ifrs.org/> (accessed June 2023).

and for regulators to ensure that the numbers are correctly reported. Finally, XML viewers can format documents for easy human readability, as you see in [Figure 224](#).

The screenshot shows a financial statement from GLEIF's annual report. The statement is titled "Statement of Comprehensive Income for the Period from January 1 to December 31, 2017". The table includes columns for Notes, Jan. to Dec. 2017, and Jan. to Dec. 2016. A blue box highlights the value "-3,404,031" in the 2017 column under "Wages and salaries". To the right of the table is a sidebar titled "Fact Properties" which provides details about the selected item: Concept (ifrs) Wages and salaries, Date (31 Dec 2016 to 30 Dec 2017), Fact Value (US \$ 3,404,031), Accuracy (0 (ones)), Change (26.0% increase on 31 Dec 2015 to 30 Dec 2016), Entity ([LEI] 506700GE1G29325QX363), and Concept (ifrs.WagesAndSalaries). There is also a search bar at the bottom.

FIGURE 224 — XBRL aids business users in organizing financial data.

One of the key features of XML for recordkeeping, electronic commerce, healthcare, and other industrial applications is that computers can validate data against a defined schema or document type definition (DTD). Computers can review every element of a document and ensure that the data is properly formatted and satisfies all necessary properties. For example, a DTD can specify that profits or losses must be numbers, or, as in the example of [Figure 225](#), a person must have a name. This helps avoid errors and inconsistencies in electronic documents.

[Figure 225](#) introduces the structure of XML documents. In this example, the XML document starts with a declaration that specifies the version of XML being used ("1.0") and the character encoding used to encode the document ("UTF-8").²⁰³

The main content of the document is contained within the `<person>` element, which has several child elements representing different aspects of the person's information. The `<name>` element contains the person's name, the `<age>` element contains the age, and the `<address>` element contains the street, city, state, and ZIP code. The DTD can specify the properties of each of these tags, including whether they are required or optional.

Note that each element has a corresponding closing tag (e.g., `</name>`) marking the end of the element's content, just like HTML. Also note that elements can be nested inside other elements to create a hierarchical structure, as with the `<address>` element in this example.

```
<?xml version="1.0" encoding="UTF-8"?>
<person>
  <name>John Smith</name>
  <age>35</age>
  <address>
    <street>123 Main St</street>
    <city>Anytown</city>
    <state>CA</state>
    <zip>12345</zip>
  </address>
</person>
```

FIGURE 225 — XML tags allow users to transfer and validate data efficiently.

203 You can read about Unicode Transformation Format (UTF) and UTF-8 at <https://blog.hubspot.com/website/what-is-utf-8> (accessed June 2023).

There are several reasons why the essential concept of XML is widely used:

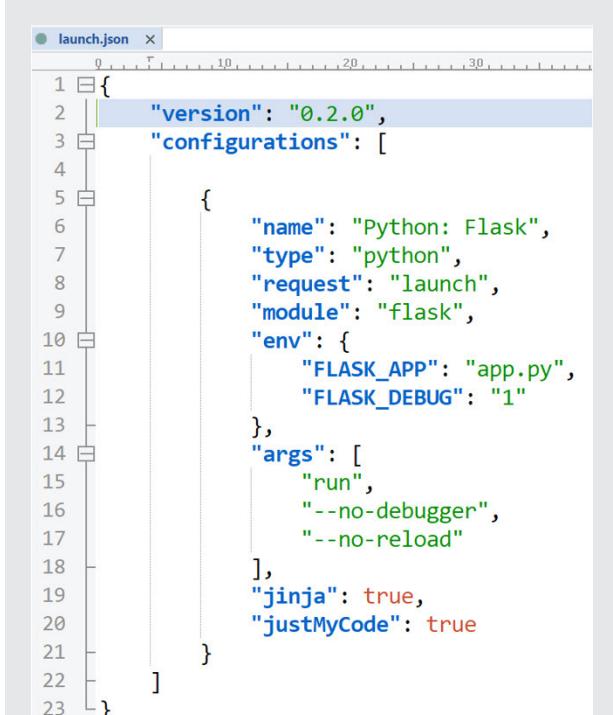
- XML can be easily read by humans and parsed and processed by computers.
- XML is not tied to any specific platform or programming language, which makes it very flexible for data exchanges on the Internet.
- XML is designed to be extensible. Users can define their own tags to describe data in a way that is specific to their needs. This allows for the creation of custom data structures that can be tailored to particular use cases.
- XML documents can be validated against a defined schema or document type definition (DTD). You can easily ensure that data is properly formatted and structured to avoid errors and inconsistencies.
- XML is used for data exchanges between systems and applications. This is due in part to its flexibility, extensibility, and its ability to represent a wide range of data types and structures.
- XML is used for representing data, not formatting or styling. This allows for a clear separation between content and presentation, making it easier to reuse data in different contexts or formats.

If you receive data in an XML format, you may need an XML reader to read and parse the XML documents. An XML reader reads an XML document and extracts the information contained within it, making it available for use in applications. XML readers can also be used to validate XML documents against a schema or document type definition (DTD) and to transform XML documents into other formats.

XML and JSON

XML's core idea of generalizable tags is extremely useful. However, the fast-moving technology industry has improved upon the idea to address one key limitation of XML technology—its verbosity. Of the 28 words in [Figure 225](#), only 9 words (~33%) convey unique information. The remaining 19 words (67%) are just protocol tags, not conveying unique information about John Smith. This is inefficient, particularly when an important use is to exchange information.

Therefore, developers have increasingly replaced XML with JavaScript Object Notation (JSON). JSON replaces tags with key-value pairs, thereby eliminating closing tags and greatly reducing the number of words needed to convey the same information. [Figure 226](#) shows an example of a JSON file that specifies how a web application written using Python's Flask framework should be run. You can see that JSON eliminates closing tags such as </configurations>, </name> etc.



```
1 {  
2     "version": "0.2.0",  
3     "configurations": [  
4         {  
5             "name": "Python: Flask",  
6             "type": "python",  
7             "request": "launch",  
8             "module": "flask",  
9             "env": {  
10                 "FLASK_APP": "app.py",  
11                 "FLASK_DEBUG": "1"  
12             },  
13             "args": [  
14                 "run",  
15                 "--no-debugger",  
16                 "--no-reload"  
17             ],  
18             "jinja": true,  
19             "justMyCode": true  
20         }  
21     ]  
22 }  
23 }
```

FIGURE 226 — JSON files differ from XML by the use of key-value pairs.

For the foreseeable future, in all likelihood, XML will continue to be popular in highly regulated environments such as financial reporting where the focus is on precisely specifying the document types and their properties. For most other contexts, where the focus is on simplified information exchange, XML is likely to be seen as a legacy technology, increasingly replaced by JSON.



Chapter Terms and Definitions

Anchor Tag: The `<a>` tag allows you to add links to an HTML page, also known as hyperlinks

Bold Tag: The `` tag is used to bold text

Cascading Style Sheets (CSS): A web markup standard that allows web designers to define the appearance and position of a webpage using special dynamic effects

DOCTYPE Declaration: The first line of an HTML page that tells the browser the kind of document to expect, specifically the version of HTML

Form Tag: Created using the `<form>` tag; every form also has multiple `<input>` tags to specify the kind of input you want from the user

Head Tag: The head tag contains information about the HTML document; it is mostly not visible to the user

Heading Tag: The `<h1>` tag represents the main heading on a page and is typically used for the page title, while the other headings `<h2>` to `<h6>` are used for subheadings

HTML Tag: A tag is a special keyword that is enclosed by `<>`; the HTML tag defines the start and end of an HTML document

Hypertext Markup Language (HTML): The standard markup language used for creating webpages and web applications

Image Tag: The `` tag is used to add images to your HTML page; it requires the source (`src`) attribute to give the location of the image so the browser can get the image and display it on the webpage

JavaScript: A programming language that lets you supercharge your HTML with animation, interactivity, and dynamic visual effects

Paragraph Tag: The `<p>` tag is used to define a block of text as a paragraph

POST: An HTML method that allows users to submit data to a server

Storyboard: A process used in the development of a website that involves the designer and colleagues simulating a particular set of visits to the site in order to gain ideas about how the site should be structured

Strike Tag: The `<strike>` tag is used to visually strikethrough text

Subscript Tag: The `<sub>` tag is used to display text as subscript

Superscript Tag: The `<sup>` tag is used to display text as superscript

Tables: Created using the `<table>` tag, and `<tr>` and `<td>` tags to define the rows and cells of the table

Underline Tag: The `<u>` tag is used to underline text

Wireframe: A rough visual outline of a proposed application and is a specific kind of prototype generated during the user-centered design process to collect input and feedback from target users before designs are finalized

Webserver: Computer servers specifically designed and programmed to host websites and facilitate the communication between other computers across Internet networks

Website Host: Typically, a company or provider that allows users to maintain, secure, and support website domains on webservers



Chapter Case

Wrenley Saves the Pets!

Wrenley was recently given an opportunity to develop a website for a local non-profit company dedicated to helping animals housed in an animal shelter. The focus of the website was to help the pets find permanent homes through adoption. Wrenley really had a passion for pets and wanted to help find them new homes anyway she could.

It is your job to help Wrenley plan out the new website.

.....

Question 1: Write out a detailed list of all the webpages Wrenley should include in her website (examples: "About Us", "Contact Us", "Donate"). As you list each webpage, include a small sample of content you think would be helpful on the webpage.

Question 2: What webpage development languages would you recommend on Wrenley's website and explain why those languages are necessary?

Question 3: Research a good website host provider that could potentially host Wrenley's website. List the URL and provide a description of the website host provider.

Bonus: Develop an HTML prototype of your proposed website for Wrenley. You can learn more about how to develop a website using HTML at W3Schools (<https://www.w3schools.com/html/default.asp>).

Computer Languages, Applications, and Emerging Technologies

13

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“Computer language design is just like a stroll in the park. Jurassic Park, that is.”

—Larry Wall, creator of the Perl programming language

Overview

Computer languages are the rules for writing computer programs. Just as we need languages such as English to communicate ideas and information with each other, we need computer languages to tell computers what to do. Computer languages are popularly called programming languages. The important difference between human languages and computer languages originates from the human ability to handle ambiguity and fill context. For example, in most contexts people would understand the phrase “let’s meet tomorrow.” But computers would not be able to figure out who is meeting, the place of the meeting, the time of the meeting, any prior preparation for the meeting, etc. Therefore, computer languages use specific syntax and grammar to precisely communicate with machines to avoid miscommunication. Once you develop some familiarity with computer languages and comfort with giving precise instructions in computer languages to get the job done, you can create increasingly complex computer applications that make life easier. Computer applications are a set of instructions written in a programming language. Computers read these instructions and perform the corresponding set of actions.

Types of Computer Languages

Computer languages (programming languages) can be divided into a few broad categories for easier understanding: **procedural programming languages**, **object-oriented programming languages**, **scripting languages**, **markup languages**, **domain-specific languages**, and **low-level languages**. Here's an overview of these categories:

- **Procedural programming languages** are computer languages that use precise steps to compose programs. In a way, all programming languages are procedural languages, but the term typically refers to languages with a limited set of data types such as numbers and strings. C, Fortran, and Pascal are examples of procedural languages and allow programmers to create procedures or subroutines to perform specific tasks. Today, procedural languages are primarily used for introductory programming classes. Historically, they were used to write the earliest scientific and engineering applications.
- **Object-oriented programming languages** are computer languages that allow developers to create their own data types by organizing data and related functions into objects. Object-oriented (OO) languages greatly simplify representing the real world in computer programs and are widely used in software development. Examples of object-oriented languages include Java, C#, and C++.
- **Scripting languages** are computer languages used to automate tasks using the capabilities of existing applications. Scripting languages are typically aimed at end users and are considered easier to learn than procedural or object-oriented languages. AppleScript²⁰⁴ is an example

²⁰⁴ “AppleScript,” Wikipedia, <https://en.wikipedia.org/wiki/AppleScript> (accessed June 2023).

of a scripting language for MacOS, and AutoHotKey²⁰⁵ is an example of a scripting language for Windows. JavaScript and Python are scripting languages that have evolved into powerful languages to create computer applications. Scripting languages are typically not used to create software for commercial distribution, since scripts are not compiled, and the programs can be read by all users.²⁰⁶

- **Markup languages** are computer languages used to specify how information should be displayed or interpreted. HTML, Markdown and XML are well-known markup languages. Markup languages define markup tags, which are used to create webpages and other content that can be displayed on a variety of devices.
- **Domain-specific languages** are computer languages optimized for specific application domains. SQL is an example of a domain-specific example. Other domain-specific languages include R for statistical applications and MATLAB for engineering applications. Domain-specific languages greatly simplify application development for complex domains such as data retrieval (SQL) and statistical data analysis (R).
- **Low-level languages** are programming languages that are close to the processor's native instruction set. They are sometimes called assembly language. Programs in all other languages (e.g., procedural, object-oriented, and domain-specific languages) are converted by compilers into low-level language programs for each type of processor.

Binary Code

Eventually, all computer programs are stored as instructions in binary code. Computers can only read binary code, which is a collection of 1s and 0s. Binary code is the native language of computers and is necessary for communication and storage of data. For example, files and data are stored in binary format on hard drives and other storage media.

Specialized software programs called compilers convert software code, written in any of the above languages, into binary code that can then be executed directly by the computers. Compilers allow developers to write computer programs in languages that resemble plain English (called high-level languages) and convert these programs into binary code customized for each processor.

Computer Programming

Each type of programming language has its own strengths and weaknesses. The choice of language often depends on the specific needs of the application being developed. It is common to use a combination of languages to build a software application.²⁰⁷ You may use HTML and JavaScript to

205 AutoHotkey homepage, <https://www.autohotkey.com/> (accessed June 2023).

206 A developer perspective, "How to Distribute Commercial Python Applications," can be read at <https://hackerboss.com/how-to-distribute-commercial-python-applications/> (accessed June 2023).

207 A good thread with examples of languages used in different popular applications is at <https://www.quora.com/In-what-programming-language-s-is-Gmail-implemented> (accessed June 2023).

manage the look and feel (frontend) of the application, and Java or C++ to create the middleware that handles the business logic and responds to requests from the frontend. You may use SQL to create your backend code that helps your middleware interact with the database to store and retrieve information.

Programming languages and frameworks are evolving rapidly to handle emerging business needs. These days, it is becoming increasingly common to use JavaScript to build the frontend as well as backend, so you just need to learn one language to build entire applications. This greatly improves developer productivity. Frameworks like React Native let you use JavaScript to build mobile applications. These frameworks also do the heavy lifting to convert your JavaScript code into the required low-level language components necessary to work with Apple iOS and Google Android phone systems.

We begin our introduction of programming languages with block-based programming. Block-based programming is a way to use graphical interfaces to write simple programs. If you have never tried computer programming before or if programming languages appear complicated, you could try block-based coding till you get comfortable enough to use regular programming languages.

If you would like to learn programming, we have some recommended resources at the end of the chapter.

Block Based Coding

Block coding is a visual programming language that uses blocks or graphical elements to represent programming concepts instead of traditional text-based coding. These blocks can be dragged and dropped to create a sequence of commands or instructions.

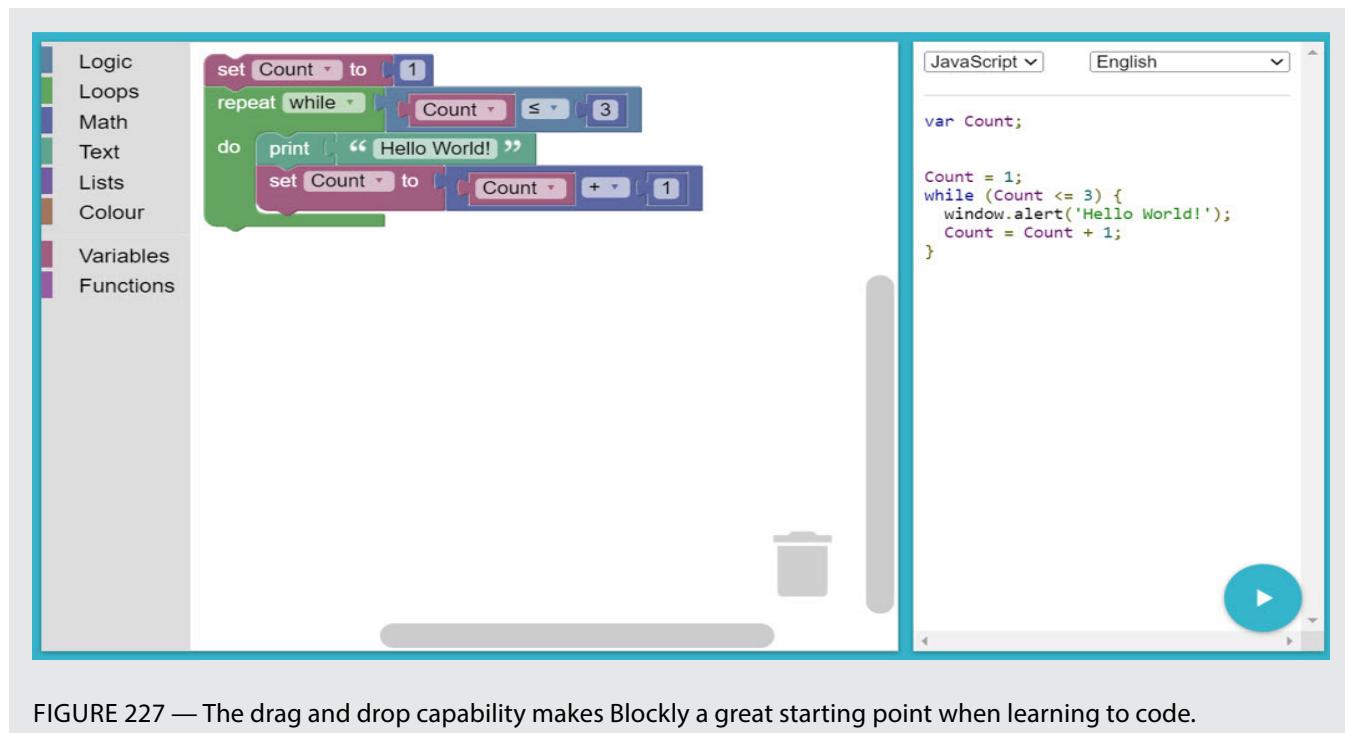


FIGURE 227 — The drag and drop capability makes Blockly a great starting point when learning to code.

Blockly²⁰⁸ from Google is an example of a block-based computer language. Scratch from MIT labs is another block-based computer language that allows developers to create animations and stories. As shown in [Figure 227](#), Blockly allows you to use simple graphical interfaces to specify instructions, and it converts these instructions into well-formed programs in different languages.

Block coding is a fun and interactive way to learn programming, ideal for beginners and even children. It allows you to focus on the logical structures of programming, without worrying about the syntax and details of text-based coding.

Block coding can give you a taste of the power of programming. It can also help you build foundational skills to assist in the move to text-based programming.

Programming Basics

While there are many popular programming languages (e.g., Java, C#, C, C++, JavaScript, Python), they all share most of the underlying concepts. Once you learn the basic programming concepts and use them in a few languages, learning new programming languages will be easy and fun. Here are a few concepts you will need to learn no matter which language you choose. If you would like to practice the examples in this chapter, and create your own programs, you can use the jdoodle online code editor. Most students find Python to be their favorite introductory language. The Python editor is at <https://www.jdoodle.com/python3-programming-online/>.

Variables

A **variable** is a named storage location in a computer's memory that holds a value. Variables are the basic mechanism used to store and manipulate data in code. A variable is one of the first things you will learn when you begin to write software programs.

Let's say you are creating a program that calculates the area of rectangles. Since the area is computed from the length and width of the rectangle, you would need to store the width and height of the rectangle as variables. You would need to create one variable for each dimension, maybe one called width and the other called height. For simplicity in this example, let's assume all numbers are integers. Every language has its own way of declaring a variable. Once you declare the variables to hold the dimensions of the rectangle, you would assign values to the variables when a user inputs the width and height values of the rectangle.

Variable declaration of the type int (integer):

```
int width;  
int height;
```

Variable assignment:

```
width = 10;  
height = 5;
```

208 Blockly, <https://developers.google.com/blockly> (accessed June 2023).

In programming, the equals operator (=) is typically used to assign values to variables. Once we have the values assigned to variables, we can perform calculations to get the area of the rectangle. If we wish to save this value for future use, we will need a third variable (Area) to store the value of the area:

```
int area;
```

We can now compute the area as the product of the width and height as:

```
area = width * height;
```

In the above statement, we ask the computer to fetch the values stored in width and height and multiply the two. The final output or the area is stored in area. As you see in the example above, computer programs written in modern programming languages read much like the same commands written in plain English.

To be useful to end users, just doing the calculations is often not enough. Users likely also want to see the results. You can print the output to the display using the print function available in most programming languages:

```
print ("The area of the rectangle is:", area);
```

When users run your program and enter the height and the width values, they will see the following message:

The area of the rectangle is: 50.

Functions/Methods

A function (aka method in some programming languages) is a block of code that performs a specific task. A function is defined with a name and can be called or invoked repeatedly from other parts of a program.

Functions provide a way to modularize code and make it easier to read, understand, and reuse. Instead of writing the same code multiple times in different parts of a program, a function can be defined once and called whenever it is needed. Functions also improve program correctness since program errors only need to be fixed in one place (the method), instead of all the places where the methods are used.

Functions typically have inputs and outputs. The inputs are called parameters or arguments. They represent the data that the function will receive and work on. The outputs are the result of the function's computation and can be returned to the calling code.

Here is an example function in JavaScript that adds two numbers together and returns the result:

```
function AddNumbers (x, y) {  
    let sum = x + y;  
    return sum;  
}
```

In this example, the function AddNumbers takes two parameters x and y. The function adds x and y together and stores the result in a variable named sum. Finally, the function returns the value of sum to the calling code.

You can call this function from other programs by passing two numbers. Here's how you could call the function AddNumbers.

```
let result = AddNumbers (5, 7);
```

There are several ways to view the result. Developers typically print the values to the console to test their code. JavaScript has the "console.log" function to print results to the console. We can use the console.log function to print the value of the result variable as shown below (// is used to add a comment. Comments are meant for developer reference and are ignored by the computer processor. // 12 in the line below is a comment, indicating that the output is expected to be 12.):

```
console.log (result); //Output: 12
```

Figure 228 shows the complete example. On the left is the html page with the JavaScript method defined in lines 6–9. Clicking the "Add" button on the page calls the AddNumbers method and passes the values 5 and 7 as arguments to the method. The result is saved as the value of the variable, "result." Finally, the result is printed to the console. To view the console, we open the Inspector (right-click anywhere in the browser and select "Inspect," and go to the console tab. We see the result in the console (bottom half on the right). You can type this example in a file, save it with an html extension, open the file in a browser, and use the Inspector to observe how the program is executed. A convenient way to do that is to set breakpoints in the JavaScript method. The browser will stop execution when it reaches the breakpoint and show you the value of every variable. You can then step through the function line by line, observing how the variables change values as the code is edited.

The screenshot shows a browser window with the title "Ch13AddNumbersExample.html". The left pane displays the HTML code:

```
1 <!DOCTYPE html>
2 <html>
3   <head>
4     <title>Add Two Numbers</title>
5     <script>
6       function AddNumbers(x, y) {
7         let sum = x + y;
8         return sum;
9       }
10      </script>
11    </head>
12    <body>
13      <h1>Add Two Numbers</h1>
14      <button onclick="let result = AddNumbers (5, 7); console.log (result);">
15        Add
16      </button>
17    </body>
18  </html>
```

The right pane shows the browser's developer tools with the "Console" tab selected. It displays the output "12".

FIGURE 228 — An example of the AddNumbers method.

Functions are an important part of programming languages and are used extensively in both frontend and backend development. They allow us to write reusable code that can be called from anywhere in our program, making our code more modular and easier to maintain.

Algorithm

An **algorithm** is a set of instructions for solving a problem. While any computer program that does the job can be considered an algorithm, in computer science and computer programming, algorithms typically refer to the most efficient methods to perform a task. There are well-known algorithms to efficiently perform specific operations such as sorting and searching for data. Advances in algorithms are one of the most important ways that Digital Information Technologies have improved lives across the globe.

Your algorithm could be just an idea shown as a flowchart or it could be pseudocode—a detailed set of instructions to write a program in the language of choice. Algorithms are language independent and programmers can implement them in any language they choose.

For example, here's an algorithm for a student to sign up for a class at the University of South Florida:

- begin by logging into the online registration system for the school;
- browse the course catalog to find the desired class;
- check for any prerequisites or restrictions on the class;
- select the desired class and verify the course details, including course number, schedule, location, and instructor;
- add the class to the student's schedule;
- check for any conflicts with the student's existing schedule or other classes;
- if there are no conflicts, confirm the enrollment in the class, else remove the class from the schedule;
- pay any associated fees or tuition for the class;
- confirm the enrollment and payment and review any important deadlines or course requirements;
- if there are conflicts or other issues preventing enrollment, contact the school's registration office for assistance;
- end the enrollment process.

Here are a few popular algorithms you may want to learn about or implement if you are interested in computer science.

- **Sorting algorithms** are used to sort collections of data. Sorted data is much easier to search than unsorted data, therefore, sorting is an essential task for any data-intensive application. Depending on the type of data you have, you may choose from one of the many available sorting algorithms: bubble sort, quick sort, merge sort, heap sort, and others.²⁰⁹
- **Search algorithms** are used to find a specific piece of information within a collection of data. Once again, depending on the type of data and other constraints, you could try out the various

²⁰⁹ "Sorting Algorithms," Wikipedia, https://en.wikipedia.org/wiki/Sorting_algorithm (accessed June 2023).

search algorithms—linear search, binary search, jump search, exponential search, Fibonacci search, and others—to find the one that works best.²¹⁰

- **Encryption algorithms** are used to encrypt data to protect it from unauthorized access. AES, RSA, and DES are all examples of popular encryption algorithms.²¹¹
- **Machine learning algorithms** have gained in importance and may change the way we analyze data or make predictions and decisions based on data. Neural networks are a **machine learning** algorithm modeled on our brains and designed to make decisions. Recommendation algorithms are popular and used by big businesses like YouTube and Netflix to predict what you like based on your previous choices.²¹²

Once you develop comfort with the syntax and structure of computer programming, algorithms will offer you a framework to solve complex problems and perform tasks efficiently.

Object Oriented Programming

Object-oriented programming (aka OOP) is a programming model that is based on the concept of classes and objects. A “class” in OOP represents the properties and behaviors of entities relevant to the program. Every time you create an instance of a class, you have an object with values attached to the predefined characteristics of the class. For example, if you are building a software to record student progress at a school, then Students and Teachers could be objects relevant to the program. Student objects would have properties such as names and addresses and behaviors such as course registration. Every time a new student or a teacher joins, you could create an instance of the class with the appropriate properties such as name and age.

OOP allows you to organize your code in a modular and reusable way by encapsulating data and behavior into objects. In OOP, objects have attributes (data) and methods (functions) to operate on that data. For example, a car object might have attributes such as color, make, and model, and methods such as accelerate, brake, and turn.

OOP provides several advantages over simpler programming paradigms such as procedural programming.

- **Simplicity:** OOP allows you to define **variables** that closely resemble the properties and behaviors of the real world.
- **Modularity:** OOP allows you to break your code into small, reusable modules (objects).
- **Encapsulation:** OOP allows you to hide the internal details of an object and expose only the necessary methods and attributes.
- **Inheritance:** OOP allows you to create new classes that are based on existing classes (parent

210 “Search Algorithms,” Wikipedia, https://en.wikipedia.org/wiki/Search_algorithm (accessed June 2023).

211 “Category: Cryptographic Algorithms,” Wikipedia, https://en.wikipedia.org/wiki/Category:Cryptographic_algorithms (accessed June 2023).

212 “Outline of Machine Learning,” Wikipedia, https://en.wikipedia.org/wiki/Outline_of_machine_learning (accessed June 2023).

classes). The children inherit attributes and methods of the parent classes. For example, “Transfer Students” and “International Students” may inherit all the properties of regular “Students,” but may also have extra traits specific to Transfer and International students. This greatly simplifies application development.

Objects

As described above, an object is an instance of a class. An object consists of one or more properties that are key-value pairs defining the characteristics of the object, and methods, which are functions that define the behavior of the object.

Objects are a core feature of most programming languages used today, including JavaScript, Python, and Java. They allow us to encapsulate related data and functionality into a single unit, which can be more convenient and easier to work with than using separate variables and functions.

Here is an example of an object in JavaScript that represents a recipe:

```
let recipe = {  
    recipeName: "Lemon Orange Cake",  
    recipeSource: "Taste of Home",  
    recipeDetails: function () {  
        return recipeName + " from " + recipeSource;  
    }  
};
```

In this example, we have defined an object named `recipe` that has three properties: `recipeName`, `recipeSource`, and `recipeDetails`. The `recipeName` and `recipeSource` have basic information about the recipe, while the `recipeDetails` property is a method that returns a string with the recipe name concatenated to the recipe source.

We can access the properties and methods of an object using dot notation or bracket notation. For example, to access the `recipeName` property of the `recipe` object, we can use the following code:

```
console.log(recipe.recipeName); //Output: Lemon Orange Cake
```

To call the `recipeDetails` of the `recipe` object, we can use the following code:

```
console.log(recipe.recipeDetails()); //Output: Lemon Orange Cake from Taste of Home
```

Objects are a powerful tool in programming and make it easy to organize and manipulate complex data structures. They are used extensively in all types of programming.

Popular OOP Languages

Here are a few examples of programming languages that support object-oriented programming.

- **Java** is the first object-oriented language that gained commercial popularity. Java continues

to be a popular OOP language that is used for building mobile apps, web apps, and enterprise systems. It is known for its platform independence, robustness, enterprise support, and extensive libraries. Online learning resources, inbuilt functions, and libraries make Java easy to learn and use.

- **Python** is a versatile general-purpose OOP language that is used for a wide range of applications, including data analysis, machine learning, and web development. It is known for its simplicity, readability, and versatility.
- **C++** is a powerful OOP language created by the notable computer scientist Bjarne Stroustrup. It is known for its efficiency and ability to interact with hardware and is used to build high-performance applications, including operating systems, game engines, and embedded systems. Almost all widely used applications on desktops such as web browsers, email clients, and office suites are built using C++. C++ requires greater developer knowledge about the internal workings of computers and, therefore, is considered to have a steeper learning curve than other languages.
- **C#** is a modern OOP language that supports emerging design practices. It is used to build mobile apps, web applications, cloud-based services, and games. It is known for its simplicity, type safety, and extensive libraries.
- **Ruby** is a flexible, dynamic OOP language that is used for building web applications, scripting, and automation. It is known for its readability, expressiveness, and the Ruby on Rails web framework.²¹³ Rails introduced the concept of Model-View-Controller to develop web applications, which is now the basis for almost all web applications written in any language.²¹⁴
- **Swift** is a modern, fast OOP language that is used for building iOS, macOS, and watchOS applications. It is known for its safety, speed, and ease of use.
- **JavaScript** did not start out as an OOP language, but it has acquired a lot of OOP characteristics. It is a versatile language that can be used for both OOP and procedural programming styles. It supports OOP concepts such as encapsulation and abstraction and offers built-in objects and methods that can be used for OOP.

Applications

Computer applications created by developers can typically be used in three different versions; (1) downloaded to desktops, (2) downloaded to mobile devices, or (3) accessed through browsers. This has evolved over time. Personal computers (desktops and laptops) running Microsoft Windows and Apple MacOS were the first computing platforms used to run applications. These became common in offices in the 1980s and homes in the 1990s. In the 2000s, the Internet and World Wide Web allowed desktops to connect to the web and exchange information. People began using web-based applications to file taxes and pay their bills. Then in 2007, Apple introduced the iPhone and the IOS mobile platform and launched the era of mobile applications.

213 Ruby on Rails home page, <https://rubyonrails.org/> (accessed June 2023).

214 For a comparison of Ruby and Microsoft's MVC.NET, see Yana Bonderchuk, "ASP.NET MVC vs Ruby on Rails: Choosing the Right Framework for Your Web Development Needs," <https://marketsplash.com/tutorials/ruby-on-rails/asp-net-mvc-vs-ruby-on-rails/> (accessed June 2023).

Each of these shifts in technology changed how we humans conduct our day-to-day lives and connect with others for fun and work. These shifts also changed how we access applications and the type and variety of available applications.

Desktop Applications

Desktop applications are computer programs that are installed and run on a personal computer or a local network. Word processors, spreadsheets, graphics editors, and audio and video editors are desktop applications. Typically, desktop applications are faster, more powerful, and offer more features than web applications. Desktop applications can also be used offline, without an Internet connection. Here are just a few examples of desktop applications:

- Word, Excel, PowerPoint, and Outlook from Microsoft are desktop applications widely used for business and personal productivity. Chrome, Safari, Edge, Firefox, and Opera are popular web browsers.
- Photoshop, Illustrator, InDesign, and other applications are part of the Adobe Creative Suite and are used for graphic designing and photo and video editing.
- QuickBooks accounting software is used by businesses to manage financial transactions and generate reports.
- AutoCAD is a computer-aided design (CAD) software used by architects, engineers, and designers to create 2D and 3D drawings and models.
- Visual Studio is an integrated development environment (IDE) used by developers to create software applications for Windows, Mac, and other platforms.

Web Applications

Web applications run on remote servers and are accessed through a web browser. Facebook, Amazon, Gmail, Instacart, and Netflix are all web applications we use in our daily lives. Typically, web applications are relatively simpler in design and functions compared to desktop applications, as they are unable to use all the capabilities of desktops such as notifications. Popular web applications include:

- Gmail is used for emailing. Google Drive and Google Docs are used for storing information, editing, and collaboration.
- Amazon, Instacart, and other online shopping platforms allow users to buy and sell products and services, browse reviews and ratings, and compare prices.
- Yelp, TripAdvisor, and other rating platforms let users review products and services before making a major purchase or committing to a hiring decision.
- Monday.com, Trello, and Asana are web-based tools that allow users to manage projects with the help of online boards, calendars, approval workflows, and reports.

Web applications are available 24*7 from any device that has a reliable Internet connection. Not surprisingly, they have become an essential part of our daily lives—we cannot imagine going back to the time when we didn't have web applications.

Mobile Applications

Mobile applications run on mobile devices such as smartphones and tablets. In addition to the standard pre-installed apps that come with smartphones, you can buy and install mobile apps from mobile stores such as Microsoft Store, Google Play, and the App Store.

Mobile apps are currently designed for the two major mobile platforms in the market: Android and iOS. These apps enable much of social networking, gaming, entertainment, communication, and even productivity, particularly since remote work became popular after Covid.

- WhatsApp is a popular mobile app that transformed the world of voice and video calling by offering the services for free.
- Instagram, a photo and video sharing app, allows users to upload, edit, and share photos and videos.
- Spotify changed the world of music streaming by allowing users to listen to songs and to create playlists using their mobile phones.
- Google Maps not only provides directions but also real-time traffic updates and information on nearby businesses.

The ease of use of mobile apps has led to a rapid growth in the app development industry, with new apps being released every day. If programming is what you do for fun, you should consider building a mobile app and putting it for sale on online stores.

The Interplay Between Desktop, Web, and Mobile

As you spend more time in the technology world, you will notice an interplay between desktop, web, and mobile apps. In the morning, you may open a word document on your laptop and edit it using Word. As a copy of the document is saved to Microsoft's servers, you may later log into a library computer to access the same document through the browser. On the train ride back home, you may open the same doc on your mobile app and forward it to a friend. Although you are interacting with the same document, you are using different interfaces based on your needs. Most popular applications such as Gmail, Google Maps, and Discord have desktop, mobile, and browser-based versions.

Providers that sell both computers and mobile phones are increasingly developing end-to-end ecosystems, so your phone calls, meetings, alerts, and chat messages interact with you seamlessly through your desktop and phone.

Computer Program Design

When you first decide to write a software program, you should spend a bit of time designing the program first. Above all, the program should be safe and should not expose internal company information or customers' personal information to the outside world. The program should also be designed so it does not consume more database or server resources than necessary. The UI of the program must be attractive and easy to use if you do not want your program to fall in the huge garbage bin of discarded, unused programs.

Only after you are completely satisfied with the design, you should begin writing code in a language

best suited for the purpose. Most organizations have adopted an iterative programming model, so you will write small modules of the program, test it, and show it to potential users before going back to write more code.

The language you choose for your program will depend on the needs of the program, the resources available to you, and the platform where you want to deploy your program.

Emerging Technologies

There is an adage in the technology industry that technology helps us build better technology. If you observe how computer chips are made, you will notice that the most powerful chips we have were made possible because of technology. It would have been impossible to build today's computer chips in the 1980s or 1990s. The pace of development of several other technologies has increased in recent decades. The power of the mobile phone, your ability to connect to a GPS satellite and ask for navigation, the cost/speed of sending money to a friend, or the cost of messaging your friends are all examples of this trend. Being aware of emerging technologies can help us anticipate how our future is likely to shape over the next few decades. We provide a brief overview of some emerging technologies that we believe will have the greatest impact in our lifetimes.

Artificial Intelligence (AI) and Machine Learning (ML)

Artificial Intelligence is technology that enables computers to perform tasks normally associated with human intelligence. Intelligent systems tend to mimic the human ability to interact with each other to solve problems using capabilities such as image recognition, speech recognition, and language comprehension. If you have interacted with Apple's Siri or Amazon's Alexa, you must have noticed that they can understand your verbal commands and respond with an answer in an audio form. Similarly, you can direct questions or commands at ChatGPT, which may seem like a back-and-forth conversation with another human. This ability of software programs and devices to simulate human intelligence is Artificial Intelligence (AI). Self-driving cars, Facebook programs that tag photos with names, and automated fraud detection by credit card companies are all applications of AI software.

Machine Learning is a subset of Artificial Intelligence that focuses on using large datasets to train models that can then predict outcome for new data sets. For example, you can use the data of all recently sold homes in a neighborhood to train a pricing model to figure out how homes are priced. Then, the model can be used to price new homes coming up on the market. Popular real estate pricing tools like Redfin and Zillow use Machine Learning to suggest possible rent and sale prices of apartments and homes. Machine Learning software can assist radiologists in reading X-rays, MRIs, CT scans, and Mammograms. ML is also widely used in voice recognition, email filtering, malware detection, fraud identification, and preference analysis.

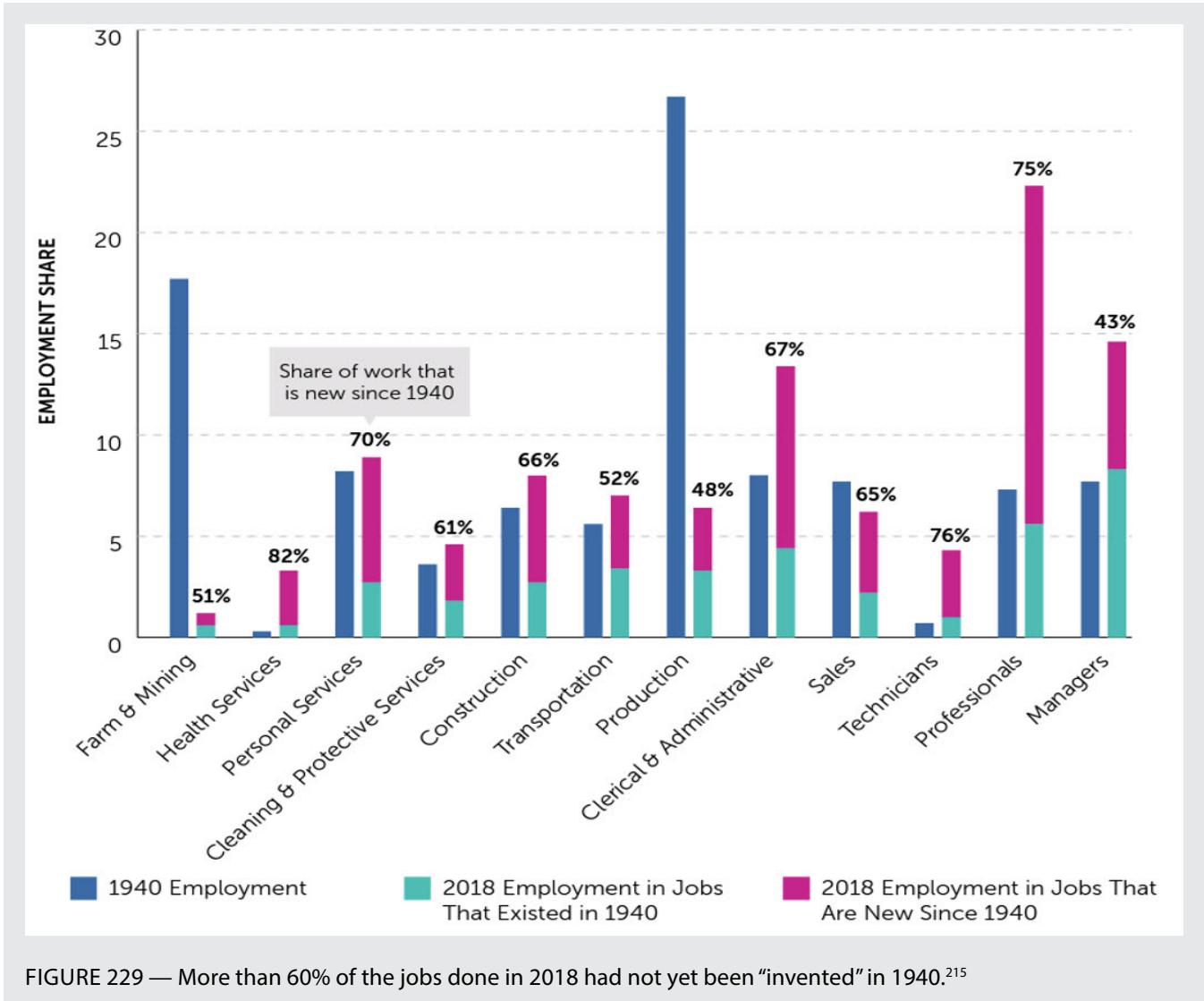


FIGURE 229 — More than 60% of the jobs done in 2018 had not yet been “invented” in 1940.²¹⁵

Machine Learning and Artificial Intelligence are highly likely to change our lives. While there is great fear that these technologies may make some jobs redundant, they will also create new job categories that we don’t even know about. For example, Figure 229 shows that a large percent of jobs done today are new, and this trend is likely to continue.

However, we must exercise caution when adopting AI and ML models because the long-term impact on humans is difficult to predict and the regulatory framework around these technologies, to guide software makers is still in its infancy.

²¹⁵ Source: “The Work of the Future: Building Better Jobs in an Age of Intelligent Machines,” by David Autor, David Mindell and Elisabeth Reynolds, Figure 2, <https://workofthefuture.mit.edu/wp-content/uploads/2021/01/2020-Final-Report4.pdf> (accessed June 2023).

Blockchain and Cryptocurrencies

Bitcoin and other cryptocurrencies are based on an underlying technology called Blockchain. It is a decentralized digital ledger that records transactions in a secure and transparent manner. A collection of computers, owned by individuals all over the world, can run a blockchain software that enables them to interact with one another, review transactions, and add to the common ledger. Because no single computer controls the ledger, and all computers must agree before a ledger can be updated, the transactions are considered reliable and secure.

While cryptocurrencies are the most prominent use of blockchains, the underlying technology can be used in other areas, too. Supply chain management, voting record management, and digital identity management are a few such fields.

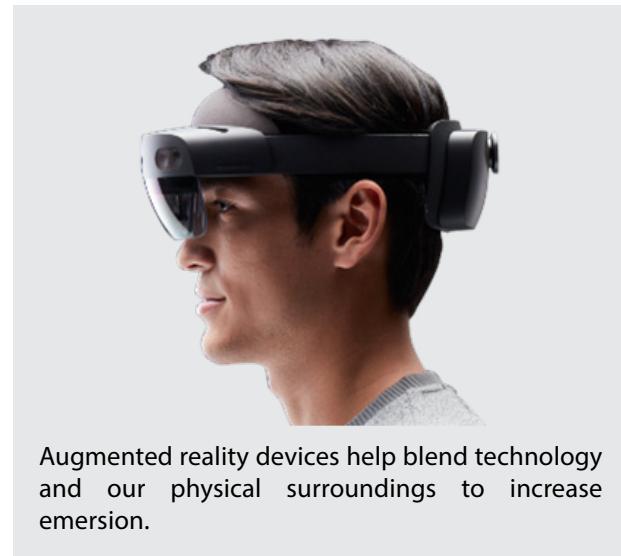
Ethereum, a variation of the Bitcoin block chain, enables you to not only track data in a distributed ledger but also execute code. This lets developers build distributed apps on the Ethereum blockchain where “smart contracts” can be written into the code. The contracts execute automatically when conditions are met. For example, if you implement a supply chain system on the Ethereum blockchain, your supply chain app could be written with smart contracts to automate payment to the vendor when the shipment has reached its destination. When the ledger is updated with the “shipment received” event, the money is automatically moved from the buyer’s wallet to the seller’s wallet, without any human intervention. This greatly reduces the transaction cost, improves transparency, and avoids risk.

Augmented Reality and Virtual Reality

Augmented Reality (AR) combines digital information and real-world information in one place. If you are a surgeon with AR glasses, you would have vital information about the patient as you look at the patient on your operating table. A warehouse worker can wear glasses that show him directions to the precise location of an item in the warehouse. If you are a student reading a textbook, you may want additional information about the topic visible to you as you read. If you are looking at a toy in Walmart, AR can display special offers and user reviews about that product.

AR uses cameras, computers, displays, computer vision, and context-aware software to project information that appears to overlay the real world. Microsoft’s HoloLens is an example of an AR device.²¹⁶

Virtual Reality (VR) focuses on simulating new reality. The real world is blotted out, and users are immersed in a computationally generated world.



Augmented reality devices help blend technology and our physical surroundings to increase immersion.

²¹⁶ Microsoft HoloLens 2, <https://www.microsoft.com/en-us/hololens> (accessed June 2023).

In the military, VR is used to train soldiers by simulating flight and battlefield scenarios. In medicine, students use VR to study the human body and surgical procedures. Vision Pro VR headset from Apple provides an immersive gaming and movie watching experience.

VR generally uses a headset as it needs to immerse users in a simulated world. You don't need headsets to experience AR. Cars with AR can display directions and local traffic information overlaid on the screen display or windshield. This means that as you navigate your car, you have information in front of your eyes to help you make judicious decisions without taking your eyes off the road.



Apple's Vision Pro VR headset allows users to be fully immersed in content.

Internet of Things

Devices connected to the Internet form the **Internet of Things (IOT)**. Your old doorbell did a good enough job of notifying you when someone rang the bell. However, if you attach a camera and a microprocessor to it and connect it to the Internet, it can notify you on your mobile device when someone is at your doorstep. It is not only a doorbell but also a security and communication device that lets you interact with the person at the door (even if you are not at home) to receive a package or let a family member in. Ring and Nest have become popular by selling smart doorbells. If you own a fleet of trucks, you can connect smart sensors to your trucks to notify you ahead of time about any required maintenance. Your smart fridge may determine that you are short on milk, eggs, and vegetables and place an order on your behalf for online delivery.

The Internet of Things and devices connected to the Internet can lead to savings of time and energy. The world as we know it will change as a result because many of the manual chores that we have been doing for ages will be done automatically by Internet connected devices.

Autonomous Vehicles (Self-Driving Cars, EVTOL, Drone Delivery)

If you live in San Francisco, Phoenix, LA, Beijing, or Las Vegas, you can hail a self-driving car. A recent McKinsey article estimates that a sizeable chunk of new cars will have autonomous driving features by 2035.²¹⁷ The report predicts that self-driving cars will lead to fewer accidents, increase in productivity, and improve mobility for senior drivers.

The flying car has been promised by many science fiction writers, but it is not here yet. However, don't be surprised if, within a decade, you look up at the sky and see streams of flying vehicles autonomously

²¹⁷ "Autonomous Driving's Future: Convenient and Connected," January 6, 2023, <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/autonomous-drivings-future-convenient-and-connected> (accessed June 2023).

delivering people and goods from point A to B. Companies like Joby aviation,²¹⁸ Lilium,²¹⁹ and Archer Aviation²²⁰ have prototype aircrafts that are already going through FAA certification to deliver that dream.

Developments in battery technologies, computer vision, electric motors, and robotics have made it possible to design drones that are whisper quiet, safe, and cheap. It is expected that by 2030, for about what you pay for an uber ride, you can catch an EVTOL (Electric Vertical Take Off and Landing) drone from New York JFK airport to downtown Manhattan or from Chicago O'Hare to downtown Chicago.

Advanced Robotics

Imagine a world where a robot follows you around carrying your coffee and your laptop. A robotic dog walks around your property guarding your perimeter, looking for trespassers, broken fences, navigating difficult terrain, and using its camera like eyes. It can identify security risks and let you know if anything is amiss. Imagine a robotic exo-skeleton that lets a soldier carry 100s of pounds with ease over difficult terrain. A robotic surgeon that can do surgery with precision. A drone that can act as a refueling gas station in the sky for military aircraft. Robots that can run into a fiery building and rescue people.

All these science-fiction sounding robots are available today. And they are continually getting better as their underlying computers, batteries, motors, and machine learning improve.

Biotechnology

Emerging biotechnology trends have the potential to impact our health and happiness in a big way. Here are a few:

- Gene editing techniques such as CRISPR have revolutionized the field of genetics and have the potential to cure genetic diseases. In the future, gene editing could become more precise, efficient, and accessible, opening new possibilities for genetic therapies.
- Personalized medicine is becoming a reality with advances in genomics and data analytics. Healthcare providers can use genetic data to develop targeted therapies for individual patients, reducing the need for trial and error in treatment and improving patient outcomes.
- Synthetic biology involves the design and engineering of biological systems for specific purposes. This field has the potential to create new biologically inspired materials, improve food production, and develop novel treatments for diseases.
- Cell therapies involve using living cells to treat diseases. Stem cell therapies are already being used to treat some diseases, but researchers are exploring the potential of other cell types, such as immune cells, to treat cancer and other conditions.

218 "Electric Aerial Ridesharing," <https://www.jobyaviation.com/> (accessed June 2023).

219 Lilium homepage, <https://lilium.com/> (accessed June 2023).

220 Archer homepage, <https://www.archer.com/> (accessed June 2023).

- Microbiome research involves the human microbiome, which consists of trillions of microorganisms living in and on the body, and is increasingly recognized as playing a crucial role in human health. Researchers are studying the microbiome to better understand its impact on various diseases and to develop new therapies.

Overall, biotechnology is a rapidly evolving field, and new breakthroughs are likely to continue to emerge in the coming years. These advances have the potential to revolutionize not just medicine but also agriculture and other industries, improving our overall quality of life.

Learning to Program: Getting Started

Making programming easy for newcomers is a priority for the industry. We provide some recommendations here to get you started. As you develop comfort, continue to search online for additional or superior resources to grow your skills.

Most experts agree that Python is the best language to start learning programming. For this reason, most college courses, even at the most selective colleges, use Python for the introductory programming class.

The simplest way to get started is to use an online environment. Jdoodle lets you get started without creating an account. By clicking a button, you can run the basic addition program. You can access it at: <https://www.jdoodle.com/python3-programming-online/>.

If you are willing to create an online account, you can also use repl.it. REPL stands for Read-Eval-Print-Loop, which is any interactive interface that can accept a user program as input, execute (evaluate) it, print the result for the user to check, and be ready for the next program (loop). Repl.it is a popular modern commercial implementation. You can access the Python interpreter at Repl.it—<https://replit.com/languages/python3>.

Once you settle on an environment, you need a lesson plan. The official Python tutorial is at: <https://docs.python.org/3/tutorial/>.

The official Python tutorial is text-heavy. For a more visual experience, YouTube has a few extremely popular introductory Python tutorials. “Learn Python—Full Course for Beginners” by Mike Dane is one of the most popular.²²¹ You can get started by practicing these exercises on either JDoodle or Repl.it. Once you get comfortable and if you have access to a computer on which you can install software, you can install Python on your computer and write your programs locally.

In 2023, we also have an excellent resource to learn programming—ChatGPT. You can ask ChatGPT to write programs to meet your specifications as shown in Figure 230 (top). After you complete a few initial lessons in the tutorial of your choice, we encourage you to explore other similar examples from ChatGPT. To use ChatGPT, go to the website <https://chat.openai.com> and sign up for an account. After that, the site is as intuitive to use as a search engine.

²²¹ “Python—Full Course for Beginners,” on YouTube at <https://www.youtube.com/watch?v=rfscVS0vtbw> (accessed June 2023).

MA write me a simple python program with numbers. Keep the explanation brief

Certainly! Here's a simple Python program that performs basic arithmetic operations with numbers:

```
python
# Perform arithmetic operations
result1 = 10 + 5
result2 = 10 - 5
result3 = 10 * 5
result4 = 10 / 5

# Display results
print("Result 1:", result1)
print("Result 2:", result2)
print("Result 3:", result3)
print("Result 4:", result4)
```

In this program, we perform addition, subtraction, multiplication, and division operations using numbers directly in the arithmetic expressions.

The results of these operations are stored in separate variables: `result1`, `result2`, `result3`, and `result4`.

Finally, we use the `print()` function to display the values of the results.

When you run this program, it will output the results of the arithmetic operations.

MA What is the error in this Python program?

```
result4 = 10 /+ 5
print("Result 1:", result1)
```

The error in the given Python program is a syntax error in the line `result4 = 10 /+ 5`. The `/+` operator combination is not a valid operator in Python. To perform addition and division, you need to separate the operators and use them individually.

To fix the error and perform division, you should use the `/` operator alone, without the `+` symbol. Here's the corrected version of the program:

```
python
# Perform arithmetic operations
result4 = 10 / 5

# Display result
print("Result 4:", result4)
```

In this corrected version, the program correctly calculates the division of 10 by 5 using the `/` operator and assigns the result to `result4`. Finally, it prints the value of `result4`.

FIGURE 230 — ChatGPT can be used to learn and write code (top). Then Chat GPT can be asked to evaluate and help debug code (bottom).

You can also use ChatGPT to identify errors in your programs as shown in [Figure 230 \(bottom\)](#). ChatGPT will not just fix errors but also explain them. ChatGPT can, therefore, serve as your personal tutor and debugger as you write programs.

Once you get comfortable with basic programs and are curious to see how these programs work, Python Tutor is an excellent resource to show you exactly what happens inside the computer as it processes each line of the program. Many of the top computer science programs use Python Tutor in introductory programming classes. You can access Python Tutor at <https://pythontutor.com/>.

Writing programs is thrilling ,and the 2020s are a great time to learn computer programming. Between the online REPL environments, structured tutorials, and ChatGPT, all of which are available for free, you have everything to develop proficiency in computer programming at your own pace.



Chapter Terms and Definitions

Algorithm: A set of instructions for solving a problem

Augmented Reality (AR): Combines digital information and real-world information in one place

Compiler: A specialized software program that can convert software code written from specific languages into binary code, which can then be executed directly by the computers

Domain-Specific Languages: Computer languages optimized for specific application domains; examples include SQL, R, and MATLAB

Internet of Things (IOT): Devices that serve a specific purpose and are connected to the Internet

Low-Level Languages: Programming languages that are close to the processor's native instruction set; these languages are sometimes called assembly language

Machine Learning: A subset of Artificial Intelligence that focuses on using large datasets to train models that can then predict outcome for new data sets

Markup Languages: Computer languages used to specify how information should be displayed or interpreted; examples include HTML, Markdown, and XML

Object-Oriented Programming Languages: Computer languages that allow developers to create their own data types by organizing data and related functions into objects; examples include Java, C#, and C++

Procedural Programming Languages: Computer languages that use precise steps to compose programs; examples include C, Fortran, and Pascal

Scripting Languages: Computer languages used to automate tasks using the capabilities of existing applications; examples include AppleScript, JavaScript, and Python

Variable: A named storage location in a computer's memory that holds a value



Chapter Case

Vivian's Raspberry Pi

Vivian had a hard time with volleyball practice today. She couldn't get her mind off of her science fair project idea. She wasn't sure exactly what she wanted to do. All she knew is that she wanted to use a Raspberry Pi. Suddenly...BOOM! Here comes the volleyball straight at her head! And then...she got an idea!



A Raspberry Pi is a small low-cost computer that enables people of all ages to explore technology and learn how to program. There are lots of projects students can explore such as building a robot or creating wearable technology. Here is a list of projects: <https://projects.raspberrypi.org/en>. The projects are designed for people all over the world who speak different languages. For instance, here is the link for projects with the instructions in Spanish: <https://projects.raspberrypi.org/es-ES>. The whole world can have fun with Raspberry Pi!

.....

Question 1: Look through the projects on the Raspberry Pi website. Find a project that interests you. Describe at least 2 things about the project that interests you to include: What will you make and what will you learn?

Question 2: Each Raspberry Pi project includes a detailed set of Instructions. Look through all the steps included in the instructions of your project. What do you think would be the most difficult task for you to complete and why do you think it would be so difficult? Now, describe what you think you would need to learn in order to complete this most difficult task.

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Once the business data have been centralized and integrated, the value of the database is greater than the sum of the preexisting parts

—Larry Ellison, co-founder of Oracle

Overview

Databases are structured collections of data that can be efficiently searched and manipulated by computers.²²² Databases are the underlying information store powering our modern technology-driven world. These databases are like digital vaults where you can keep data safely, and authorized users can read or update the data as needed. While you may not yet know what databases are, they touch your life daily. Your student records, your score history in online video games, your checkout history at the library are all stored in databases somewhere. In all likelihood, your personal information, including your home address, your phone number, and your school grades are stored in multiple databases.

Database applications typically refer to software programs that help users interact with the data stored in databases. They fall into categories such as customer relationship management (CRM), enterprise resource planning (ERP), learning management system (LMS), etc. For example, enterprise resource planning applications help retailers update their stock information when you checkout items at the store. Learning management systems help schools tracks the performance of all students at the school. When you buy something online, inventory management applications update the stock information on the site and create the shipping label for the items to be delivered to your home. We have discussed these applications throughout this book.

In this chapter, we focus on databases and introduce the technologies and concepts used to build databases. While there are several types of databases including object-oriented databases, hierarchical databases, and relational databases, most modern applications use relational databases. We, therefore, introduce relational database technology in this chapter.

Evolution of Database Technologies²²³

Commercial databases trace their origins to the Apollo moon program. The Saturn V rocket used to land Neil Armstrong on the moon used more than 3 million parts.²²⁴ Rockwell International, the company building the rocket, asked IBM if it could build a computer system to track the status of all these parts. A team of about 25 engineers from IBM, Rockwell, and Caterpillar, led by IBM engineer Vern Watts, created IMS (Information Management System), the world's first commercial database in 1968. Since then, IMS has become the backbone of banking, hotel, and airline applications around

²²² This definition is adapted from Oracle's site at <https://www.oracle.com/database/what-is-database/> (accessed June 2023).

²²³ This section draws heavily on Sinclair Target's blog post at <https://twobithistory.org/2017/12/29/codd-relational-model.html>. All posts on his blog are relevant to DIT, check them out at <https://twobithistory.org/> (accessed June 2023).

²²⁴ An overview of the Saturn V is at <https://airandspace.si.edu/exhibitions/space-race/online/sec300/sec384.htm> (accessed June 2023).

the world. Any time you use your credit card or make an airline reservation, chances are that the transaction involves IMS at some point.²²⁵

IMS is considered a hierarchical database. Hierarchical databases are very efficient, but also very inflexible. Searches in hierarchical databases require traversing the data store.²²⁶ They are designed to respond to specific queries and can be very slow in responding to other queries.²²⁷ Relational databases improve upon this limitation.²²⁸

The relational model to store data was introduced by Edgar F. Codd of IBM in 1970.²²⁹ Codd used concepts from set theory to organize data. He used the term “relation” to refer to a **table** in the database based on set theory, and this reference to relations gives the technology its name.

Following the publication of his landmark paper in 1970, which introduced the relational model, Codd²³⁰ described how data storage could be optimized in the relational model (called normalization).²³¹ He also demonstrated that a small set of operations could extract any information from the database.²³²

²³³ This language is now called **Structured Query Language (SQL)**.²³⁴

225 This is from IBM’s page on IMS at <https://www.ibm.com/ibm/history/ibm100/us/en/icons/ibmims/> (accessed June 2023).

226 One of the leaders of hierarchical databases, Charles Bachman, provides an overview in his 1973 Turing award lecture, “Programmer as Navigator,” at <http://people.csail.mit.edu/tdanford/6830papers/bachman-programmer-as-navigator.pdf>. Wikipedia has a page on Bachman at https://en.wikipedia.org/wiki/Charles_Bachman (accessed June 2023).

227 An overview of hierarchical databases can be seen at <https://dataintegrationinfo.com/hierarchical-vs-relational-database/> and https://en.wikipedia.org/wiki/Hierarchical_database_model (accessed June 2023).

228 The Wikipedia page on relational databases provides a nice overview of the technology at https://en.wikipedia.org/wiki/Relational_database (accessed June 2023).

229 The paper is considered a landmark paper in the commercialization of computing technologies. You can download it from <https://www.seas.upenn.edu/~zives/03f/cis550/codd.pdf> (accessed June 2023).

230 E. F. Codd, Wikipedia https://en.wikipedia.org/wiki/Edgar_F._Codd (accessed June 2023). Codd has a Florida connection—he retired to Aventura, Florida, where he died in 2003.

231 E. F. Codd, Normalized database structure: A brief tutorial, available at <https://dl.acm.org/doi/pdf/10.1145/1734714.1734716> (accessed June 2023). Proceedings of the 1971 ACM SIGFIDET (now SIGMOD) Workshop on Data Description, Access and Control, November 1971, Pages 1–17

232 E. F. Codd, A database sublanguage founded on the relational calculus, <https://dl.acm.org/doi/pdf/10.1145/1734714.1734718> (accessed June 2023). Proceedings of the 1971 ACM SIGFIDET (now SIGMOD) Workshop on Data Description, Access and Control, November 1971, Pgs 35–68

233 E. F. Codd, “Relational Completeness of Data Base Sublanguages,” Computer Science Research Report, 1972, available at <http://www.geology.cz/personal/j/jan.sedlacek/codd2.pdf> (accessed June 2023).

234 For those interested in more detail on Codd’s relational model, his colleague C. J. Date has published a critique of the model, “Codd’s First Relational Papers: A Critical Analysis,” available at <https://www.dcs.warwick.ac.uk/~hugh/TTM/CJD-on-EFC%27s-First-Two-Papers.pdf> (accessed June 2023).

While the relational model was conceptually sound, the success of IMS prevented commercial investments from creating a working technology based on the relational model. IBM had a small team working on a project called System R to build a relational database, and Professor Michael Stonebraker²³⁵ at UC Berkeley obtained funding from NSF as well as Army, Navy, and Air Force to start a project called INGRES to create a database using the relational model.^{236, 237} The viability of INGRES and wide distribution of its open-source code facilitated the commercialization of the relational model. Today, the relational model is taught as the standard database model in all relevant academic programs.

A few popular relational databases include:

- Oracle Database, offered by Oracle corporation, is probably the most popular relational database system in the world.
- MySQL is a widely used open-source relational database management system. MySQL is also owned by Oracle since its purchase of Sun Microsystems.
- Microsoft SQL Server is provided by Microsoft and common in Microsoft-based ecosystems.
- PostgreSQL is another popular open-source relational database management system that is known for its advanced features and reliability. It is the successor to the INGRES project.
- IBM DB2 is provided by IBM and is widely used in enterprise applications.
- SQLite is a lightweight relational database management system that is often used in embedded systems and mobile applications. For example, your browser uses SQLite to manage bookmarks.

Why Study Databases

Compared to the technologies covered in other chapters in this book, database technologies have a unique feature—they are a core enterprise technology, there is an entire class of highly paid professionals—database administrators—who maintain databases. We introduce the relational database technology in this book because of its importance as well as because the basic concepts of relational databases should be very interesting to high school students. If you find the contents in

235 A summary of Stonebraker's work can be seen in his award citation for the John von Neumann medal at <https://par.nsf.gov/servlets/purl/10219488> (accessed June 2023).

236 This paragraph draws from the excellent story in "The rise of relational databases," Chapter 6 in Funding a revolution: Government support for computing research, available at <http://worrydream.com/refs/National%20Research%20Council%20-%20Funding%20a%20Revolution.pdf>, pgs 159–168 (accessed June 2023).

237 For a report on INGRES, please see Michael Stonebraker, Eugene Wong, Peter Kreps and Gerald Held, "The Design and Implementation of INGRES Tandem Computers, Inc.," available at <https://dl.acm.org/doi/pdf/10.1145/320473.320476>. It goes into the details of INGRES' working.

this chapter interesting, you can learn more online at your own pace at sites such as Khan Academy,²³⁸ W3Schools,²³⁹ Coursera,²⁴⁰ EdX,²⁴¹ etc.

Relational Databases

Relational databases are databases that organize data as tables linked to each other. Each row in a table represents one item in the database. A single database can have any number of tables, with each table representing all stored items of a type.

Each table (or relation) in a relational database represents an entity or a concept. Each table consists of rows, also known as records or tuples, and columns, also known as attributes or fields. Each row in a table represents a specific instance of the entity, and each column represents a specific characteristic or data related to that entity.

In a relational database, tables are related to each other using **keys**. Following set theory, every row in the database is unique. Keys uniquely identify data in each row and also allow data from different tables to be joined together. Let's go over these ideas with an example of students enrolled in courses.

Figure 231 shows a relational database model storing information about courses taken by students. There is a table called Students, which stores information about students such as names (other information could also be added). A separate table called Courses has information about courses such as the title of the course. Finally, a table unique to the relational database model, called StudentCourses, identifies all the courses taken by each student.

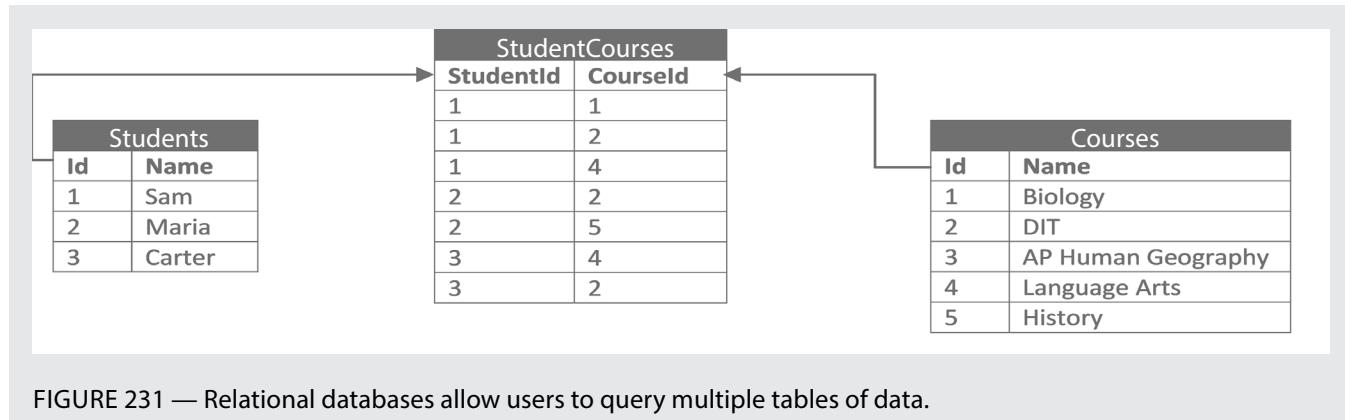


FIGURE 231 — Relational databases allow users to query multiple tables of data.

The tables for students and courses are intuitive, but the way the tables are linked to each other to list all the courses taken by all the students gives the relational database model its power. First note that the Students and Courses tables have a column labeled **Id**, which assigns a unique label (called identifier, or **Id** for short) to each row. In the StudentCourses table, both students and courses are

238 "Intro to SQL: Querying and Managing Data," <https://www.khanacademy.org/computing/computer-programming/sql> (accessed June 2023).

239 "SQL Tutorial," <https://www.w3schools.com/sql/> (accessed June 2023).

240 "SQL for Data Science," <https://www.coursera.org/learn/sql-for-data-science> (accessed June 2023).

241 "Databases: Relational Databases and SQL," <https://www.edx.org/course/databases-5-sql> (accessed June 2023).

represented by the respective unique identifiers (Ids). We can see from the StudentCourses table that only Maria (studentId 2) has taken History (courseId 5), but Sam, Maria, and Carter have all taken DIT (course Id 2).

In the relational model, a column (or combination of columns) that is guaranteed to be unique in a table can serve as the primary key for the table. For example, your license number is a primary key that uniquely identifies you in the Department of Motor Vehicles (DMV)'s database. Your student Id is a primary key that uniquely identifies you in your school's database. Usually, the unique identifiers serve as the primary key column(s) of tables. For example, in the Students table, the "Id" column is the primary key of the Students table. Similarly, even in the Courses table, the "Id" column is the primary key. Typically, the database software generates a unique value for the primary key in a row.

When a primary key is defined on a table, the relational database management system ensures that no two rows in the table have the same primary key values. In addition, the primary key column(s) cannot have null (empty) values since a null value cannot uniquely identify a row.

Organizing data as shown in [Figure 231](#) allows for efficient storage and retrieval of data using various relational operations and Structured Query Language (SQL) commands. For example, if you regularly buy goods from Amazon, they can maintain a record of all your purchases and returns made in the recent past by looking you up using your primary key and pulling all the purchase records associated with your primary key. Each purchase is a database record, and so is every return. Each record of purchase has many details, including the item name, the name of the seller, the time of transaction, the amount, and the location of the transaction. Once you have a way to input your data into a database, you can track, update, delete, and report on that data easily. In Amazon's database, a collection of all the purchases and returns of all their customers comprises the transactions table. Can you imagine how huge the table must be, how many bytes of data it must have?

In the relational database model of [Figure 231](#), you will only need to interact with the Students table if you want to get the basic information related to students. Similarly, if you just want to get information about all the courses offered, you will only need to [query](#) the Courses table. However, to get the course information of every student, you will need to use the StudentCourses table, which joins all the Students and Courses tables by Ids. Retrieving records by Ids is much faster than that by names, which makes well-designed relational databases extremely efficient.

In relational databases, the process of keeping data spread across multiple tables is called normalization. Normalization ensures that no single table becomes too unmanageable in size. Not surprisingly, the relational database model is widely used across industries for its flexibility, scalability, and robustness.

Introduction to SQL

Storing data in a database is just the first step. Once you have your data in a database, you need to interact with the database management system (the software that manages the database) to see or change the data. Structured Query Language (SQL) is a programming language used to interact with relational databases.

SQL commands can be used to create new databases and tables. There are also SQL commands to insert, update, and delete data in existing tables. SQL can also be used to search for and retrieve specific data using queries, which are statements that specify the criteria for selecting data. Most

college programs in computing have a course on databases, which goes into all the details of SQL. In this chapter, we only provide an overview of SQL.²⁴²

SQL Commands Types

There are four main types of SQL commands you should know about:

Data Manipulation Language (DML) commands are used to manipulate the data stored in databases. The most commonly used DML commands are SELECT, INSERT, UPDATE, and DELETE. SELECT is used to retrieve data from databases; INSERT is used to add new data; UPDATE is used to modify existing data; and DELETE is used to remove data from databases.

Data Definition Language (DDL) commands are used to define the structure (schema) of databases. When you are creating a new database, you will need to create tables, specify the relationship between tables, and add constraints on the data to make sure the integrity of the data is maintained. CREATE, ALTER, and DROP are the most common DDL commands you will need. CREATE is used to create new tables and other database objects; ALTER is used to modify the structure of existing tables; and DROP is used to delete tables and other database objects.

Transaction Control Language (TCL) commands serve as gatekeepers of changes. COMMIT, ROLLBACK, and SAVEPOINT are the most common TCL commands. If you COMMIT a transaction, you make the changes permanent; ROLLBACK undoes the changes you made earlier; and SAVEPOINT creates a bookmark in a transaction to which you can rollback later.

Data Control Language (DCL) commands are used to control who can access your database. GRANT and REVOKE are the most common commands. GRANT is used to grant permission to users to access and modify the database; and REVOKE is used to revoke permissions.

Querying a Database Using DML Commands

If you are a database developer, you will use DML commands very frequently to change previously added data, delete existing records, or insert new data. Luckily, SQL is easy to learn because it has English-like commands to select, insert, update, and delete. SELECT allows you to fetch data; INSERT is used to add data; UPDATE is used to change previously added data; and DELETE is used to remove records.

Querying data—The first operation you will most likely want to do is view data stored in your database. Here's an example of a basic SELECT statement:

```
SELECT *
FROM Students
WHERE Id= 56745;
```

²⁴² You can practice SQL at several sites online. A popular site for code practice is jdoodle, <https://www.jdoodle.com/execute-sql-online/> (accessed June 2023).

This statement tells the RDBS to fetch all the details (*) from the Students table about the student whose Id is 56745. If you wanted to fetch just a few specific columns about the student, you could alter the query to specify the names of columns as:

```
SELECT StudentName, StudentAge, StudentAddress  
FROM Students  
WHERE Id= 56745;
```

The WHERE command is powerful, offering many possibilities, and can be used to select exactly what you want to fetch.

Suppose you want to get all the students who are either from California or Florida, you could change the WHERE clause in the following way:

```
SELECT *  
FROM Students  
WHERE State = 'California' OR State = 'Florida';
```

This statement will only return those students who have the values California or Florida in the column "State." Just like the equals (=) and the OR operations, you can also employ > (greater than), < (less than), BETWEEN, LIKE, and IN.

```
SELECT *  
FROM Students  
WHERE State = 'California' AND GPA >= 3.5;
```

This command only returns the rows where the "state" column is equal to "California" and the "GPA" column is greater than or equal to "3.5."

You can also use both "AND" and "OR" operators in the same query and even group conditions using parentheses. For example:

```
SELECT *  
FROM Students  
WHERE (State = 'California' AND GPA >= 3.5)  
OR (State = 'Florida' AND GPA >=3.5);
```

Querying from Multiple Tables

In relational databases, data is stored in many tables to eliminate data duplication. However, you will frequently need to join tables to get the data you want. In SQL, JOIN is a special command that links tables based on shared columns.

Let's consider two tables "customers" and "orders" (Figure 232) to see how JOIN works:

Schema refers to the way a database is structured. To relate the orders to the customers who placed those orders, the Orders table has the Id of the customer as the customer_id column. This allows us to link the two tables (Customers and Orders). For example, to get the orders placed by customers, we can link the two tables, as shown below, and get all orders from all customers:

```
SELECT customers.first_name, customers.last_name, orders.order_date, orders.total  
FROM customers, orders  
WHERE customers.id = orders.customer_id;
```

With this query, you are fetching the first name and last names of your customers from the Customers table and the order_date and total from your Orders table. We can join the two tables because the id column of the Customer table and the customer_id column of the Orders table contain the same data: the id of the customers. The relational model gives us this convenient method to retrieve the data we need from databases. SQL queries read like plain English sentences. (Figure 233.)

Updating Data

Databases need to be updated with the latest information all the time. For example, at the DMV, drivers will come in to register new cars, update their license plates, or change their current residential addresses. With the help of SQL, you can identify the record in the database that needs to be updated and set the new values.

The UPDATE command allows you to change the values of one or more columns in one or more rows of a table. The basic syntax of the SQL UPDATE command is as follows:

```
UPDATE table_name  
SET column1 = new_value1, column2 = new_value2, ...  
WHERE some_condition;
```

In this syntax:

- table_name is the name of the table you want to update.
- column1, column2, etc. are the names of the columns you want to update.

Table 1: customers		
id first_name last_name		
1 John Smith		
2 Jane Doe		
3 Bob Johnson		

Table 2: orders				
id order_date total customer_id				
1 2022-01-01 10.00 1				
2 2022-02-01 20.00 2				
3 2022-03-01 30.00 1				

FIGURE 232 — Data is structured in tables with rows and columns, similar to spreadsheet files.

first_name last_name order_date total
John Smith 2022-01-01 10.00
Jane Doe 2022-02-01 20.00
John Smith 2022-03-01 30.00

FIGURE 233 — Separate tables can be joined by using matching columns or "keys."

- new_value1, new_value2, etc. are the new values you want to set for the corresponding columns.
- some_condition is a condition that specifies the rows to update. Only the rows that satisfy the condition will be updated.

Here's an example that demonstrates how to use the UPDATE command to change the email address of a customer:

```
UPDATE customers  
SET email = 'newemail@example.com'  
WHERE customer_id = 123;
```

This command will update the email address of the customer with ID 123 to "newemail@example.com."

You must be very careful when using the UPDATE command and not change data you don't want to change. Always doublecheck your WHERE clause to make sure you are correctly specifying the rows to update. For example, the command below will update the email addresses of ALL the customers in the database to "newemail@example.com." If your database has information about a million users, the email addresses of all million users will be updated instantly. Unless all your customers have the same email address, you don't ever want to run a command like the one below:

```
Update customers  
SET email ='newemail@example.com';
```

Deleting Data

If a student drops out of a class, you'll need to remove the student from the Class table. If a customer requests you to remove them from your monthly mailers, you'll need to delete the customer from your Subscriptions table.

The DELETE statement deletes one or more rows from a table based on the selection criteria in the WHERE clause. The basic syntax of the DELETE statement is as follows:

```
DELETE FROM table_name  
WHERE condition;
```

In this syntax:

- table_name is the name of the table from which you want to delete data;
- condition specifies which rows to delete and only the rows that satisfy the condition will be deleted.

Here's an example that shows how to use the DELETE statement to remove a particular customer record:

```
DELETE FROM customers  
WHERE customer_id = 123;
```

This command will delete the customer record with Id 123 from the “customers” table.

It’s important to be careful when using the DELETE statement to avoid removing data you don’t want to delete. Always make sure that you have a backup of your data before performing deletions. Additionally, as mentioned earlier for the UPDATE command, double-check your WHERE clause to ensure that you are deleting only the data you want to remove.

If you forget to include a WHERE clause, as in the example below, you may end up deleting ALL the rows in the customers table:

Delete FROM customers;

Defensive Updates and Deletes

Before you run a DELETE command, you may want to test the WHERE clause in a SELECT statement to confirm you are deleting the right set.

For example, to DELETE all customers who live in a particular zip code, run this SELECT command first.

Select * from CUSTOMERS where zipcode='95070';

If the output has all the rows you want to delete, then use the same WHERE clause in your delete command to delete records.

Delete FROM customers WHERE zipcode='95070';

Advanced Querying Options

Databases can quickly get large and may require special reporting, sorting, and grouping to make sense of the stored data. If you have a database to keep track of exam results for your school, the “Students” table may have 1000s of rows. If you assume each student takes 50 courses over their high school career, the “StudentCourses” table will be 50 times as large as the “Students” table. Now if each course has 100 grading events, you can imagine how large the “Grading” table will be.

When you report on this data, you need to know how to sort, group, and limit the amount of output to quickly get to the information you need. For example, your teacher may be interested in identifying the two students who have not submitted a deliverable, or the four or five students who have excelled on tests. It is not helpful in these cases to simply print out the 5 million rows for all grading events at the school. It is much more useful to use the capabilities of the database to list just the four or five rows with the needed information.

Sorting

The ORDER BY command sorts the result set in ascending or descending order based on one or more columns in the SELECT statement. The basic syntax of the ORDER BY clause is as follows:

SELECT column1, column2, ...

FROM table_name

ORDER BY column1 [ASC|DESC], column2 [ASC|DESC];

You can specify the column or columns you want to sort by, followed by either “ASC” for ascending order or “DESC” for descending order. If you want, you could sort by multiple columns, separated by commas.

Let's consider a table of employees with the following data: id, name, age, and salary (Figure 234).

To sort this table by salary in descending order, you can use the following SQL query:

```
SELECT * FROM employees  
ORDER BY salary DESC;
```

This will return the following output (Figure 235):

To sort the same table by age and then by salary, try the following SQL query:

```
SELECT * FROM employees  
ORDER BY age ASC, salary DESC;
```

This will return the following output (Figure 236).

Grouping

The GROUP BY command helps you get a summary of data. If you have a database of students, you may want to group students by their courses to see how well the students are doing in different courses. Or, you may want to group students by their classes (freshman, sophomore, junior, senior) to see the average grade across different cohorts.

The GROUP BY command in SQL is used to group rows that have the same values in one or more columns. It is typically used with aggregate functions like AVERAGE, MAX, MIN, and COUNT. The result set will contain only one row for every value of the column in the GROUP BY clause. For example, if you GROUP BY the department field in a table that has employee_name, salary, and department, then the result set will have one row for every department.

As another example, if you want to count the number of employees and the average salary of employees in every department, you can use GROUP BY, COUNT, and AVG commands.

id	name	age	salary
1	John	25	50000
2	Jane	30	60000
3	Bob	28	55000
4	Alice	35	65000

FIGURE 234 — The ORDER BY command allows users to efficiently sort data in a table.

id	name	age	salary
4	Alice	35	65000
2	Jane	30	60000
3	Bob	28	55000
1	John	25	50000

FIGURE 235 — Users can choose to sort a table by column name in ascending or descending order. This table is sorted by salary in ascending order.

id	name	age	salary
1	John	25	50000
3	Bob	28	55000
2	Jane	30	60000
4	Alice	35	65000

FIGURE 236 — ORDER BY commands are not limited to one condition. A user can combine conditions to further refine their request.

```

SELECT department, COUNT(*) as num_employees, AVG(salary) as avg_salary
FROM employees
GROUP BY department;

```

In this example, the query counts the number of employees in each department (COUNT(*)) and gives you the average salary of those employees. In the original table, we did not have the count of employees or the average salary of employees. So, in the output, we have two new fields that did not exist before. You can use the “as” operator to give these fields meaningful names in the output as shown in [Figure 237](#).

department	num_employees	avg_salary
Sales	10	50000
Marketing	8	45000
Engineering	15	70000
Finance	5	55000

FIGURE 237 — A variety of commands, including GROUP BY, allow users to count sets in data.

The general syntax for using the GROUP BY command, is as follows:

```

SELECT column1, column2, ..., aggregate_function(column)
FROM table_name
GROUP BY column1, column2, ...;

```

In the above syntax, column1 and column2 are the columns you wish to GROUP BY. The aggregate_function(column) is the function that you want to apply to the grouped data, such as COUNT, AVG, SUM, MAX, MIN, etc.

You can use multiple columns in the GROUP BY clause if you want to group data by more than one column.

As you can see, the GROUP BY command is a powerful tool in SQL that allows you to summarize data based on specific criteria, making it easy to extract useful information from large datasets.

* in SQL

The symbol “*” as used in the GROUP BY example above indicates “all.” In the example, it tells the database to count all rows in each group.²⁴³

Calculated Fields

There are times when you don’t want to simply present the data in the database but would like to apply some calculations before printing the output. For example, if you are looking at a database of students with their scores, you may also like to calculate and print their letter grades (A, B, C). Or, if you have a database of employees, you may want to calculate their bonuses as a percentage of their salaries. SQL lets you do these calculations easily without impacting the underlying data.

A calculated field is a column in a query result set that is created by applying an expression or formula to one or more columns in a table. The expression can be a combination of arithmetic operators,

²⁴³ You can check out this Stackoverflow post for some additional information, <https://stackoverflow.com/questions/38662318/what-does-mean-in-sql> (accessed June 2023).

functions, and constants. This can be especially helpful when you need to perform complex calculations on columns in the table or create custom metrics that are not available in the original dataset. Consider this query:

```
SELECT first_name, last_name, salary, salary * 0.1 AS bonus  
FROM employees;
```

In this example, the query calculates a 10% bonus for all employees.

The result set of this query has four columns: first_name, last_name, salary, and bonus (Figure 238). The bonus column is a calculated field that contains the bonus of employees based on their salaries. As the field does not exist in the original table, you can give it a meaningful name with the help of the "AS" operator.

first_name	last_name	salary	bonus
John	Smith	50000	5000.00
Jane	Doe	60000	6000.00
Bob	Johnson	70000	7000.00
Alice	Williams	80000	8000.00

FIGURE 238 — SQL queries can also perform calculations and output new fields, which is crucial in data analysis.

Creating and Managing Tables Using DDL Commands

To create a table in SQL, you can use the CREATE statement.

```
CREATE TABLE table_name (  
    column1 datatype,  
    column2 datatype,  
    column3 datatype,  
    ...  
);
```

In the above DDL command, the datatype specifies the type of data that can be stored in the column. Common datatypes are VARCHAR for text, INT for integers, DECIMAL for decimal numbers, and DATE for dates. An interesting feature of relational databases is that most data in databases is numbers or strings.

Here's an example of a CREATE TABLE statement that creates a table Customers with columns for three items of information (name, email and rent) and an id:

```
CREATE TABLE boarders (  
    id INT PRIMARY KEY,  
    name VARCHAR(50),  
    email VARCHAR(100),  
    rent INT  
);
```

If you run this SQL command, you will create a table called boarders with four columns: id, name, email, and rent. The id column is an integer and is set as the primary key of the table.

There are occasions when you no longer need a table, either because you want to create a new table or because you have the same data in another table. You can use the DROP command to permanently delete tables.

```
DROP TABLE table_name;
```

For example, to delete the boarders table, run the following DDL command:

```
DROP TABLE boarders;
```

Sometimes you may need to change a table to add new columns, change the column name, or change the data type of a column. You can use the ALTER TABLE command to add, remove, and rename columns. You can even change the type or the size of data stored in columns. Here are examples for each of these commands:

```
ALTER TABLE table_name ADD COLUMN column_name data_type;
```

```
ALTER TABLE table_name MODIFY COLUMN column_name new_data_type;
```

```
ALTER TABLE table_name  
RENAME COLUMN old_column_name TO new_column_name;
```

```
ALTER TABLE table_name DROP COLUMN column_name;
```

The DROP COLUMN command removes an existing column from the table.

Storing Images, Documents, and Other Information in Relational Databases

Relational databases typically store simple data types such as numbers and strings. However, we often need to store information such as images and documents. How can you store such information in relational databases?

Most modern relational databases have a datatype called blob (binary large object) that can be used to store images, documents, videos, and any other information. However, a better alternative is to store these images, documents, videos, etc., as files in the file system and just save the name and location of the file in the database. This keeps the database compact, speeding up searches.

Inserting Data

To add data to tables in your database, you can use the INSERT INTO command.

The INSERT command expects you to know the column names and the type of data the columns can

hold; therefore, you will need to know the structure of the table before you can insert data into it. To check the structure of a table, use the DESCRIBE command.

```
DESCRIBE Users;
```

When you run the above command, you will see the structure of Users, a result set that lists all the columns in Users, along with their data types and any constraints applied to them.

As you can see in [Figure 239](#), the Users table has three columns: id, name, and email. The id column is an integer with a maximum length of 11 digits and is marked as the primary key. The type of both the name and email columns is varchar with a maximum length of 50 characters. They are also marked as nullable, which means that they can contain Null values. In a relational database, a Null value means that the data is unknown or missing.

While this table looks okay in theory, a record that has just an id, but no name or email won't make sense. So, ideally, you should change the table to make sure either the name or the email contains a value—cannot be Null.

Once you know what a table expects, you can use the INSERT INTO statement to begin adding data. Here's an example.

```
INSERT INTO Users (id, name, email) VALUES (1, 'Cecilia Flores', 'cecilia.flores@example.com');
```

```
INSERT INTO Users (id, name, email) VALUES (2, 'Ratna Devi', 'ratna.devi@writers.com');
```

INSERT INTO Variants

The examples shown are the typical ways the INSERT command is used. We listed three column names next to the table name (Users (id, name, email)) and gave the values to be inserted for each of these columns. There is another way to use the INSERT command by skipping the column names. However, you can only skip the column names if the data being passed has the same columns in the same order as the existing columns of the table. For this reason, the usage shown in the example is more typical.

Importing Data

There are times you already have data that you would like to insert into a table in a file. For example, you may want to move the data in an Excel file into a database. The general concept to import data is similar across all relational database systems and uses some common methods including the following:

- We've already used the INSERT INTO command to add data to a table in a database. You can also use the LOAD DATA INFILE command to insert data from a file into a database table. Ideally, the file should be a text file with well formatted input data, so you can map the data to the columns in your target table.

- Many database management systems provide command-line utilities to import data from different sources. For example, MySQL provides the mysqlimport utility that can be used to import data from CSV or TSV files.
- Some database management systems provide GUI tools that allow you to import data. For example, Microsoft SQL Server Management Studio provides the Import Wizard that can be used to import data from different file formats such as Excel, CSV, and Access.
- You can write a script (software program) in a programming language such as Python or Java to read data from a file and insert it into a database table using the INSERT INTO command.

In general, here are the steps developers follow to import data into an SQL database:

- Connect to the database using a database client or a programming language.
- Create a table or select an existing table to import data into.
- Prepare the data by cleaning it up and ensuring it is in the correct format.
- Use SQL commands, command-line utilities, or a programming language to import the data into the table.
- Verify that the imported data is accurate by querying the table.

Transactions Using TCL Commands

As stores of information, databases have stringent requirements for correctness. Therefore, if a database activity fails for any reason, you typically want to restore the data to its original state. Let's demonstrate this by example.

Suppose you manage the database of Expedia.com and need to transfer a few passengers to a new flight because the original flight is inconvenient. Since the passengers want to be transferred only if the new flight has seats available, you want to make sure that both the transactions (booking seats on the new flight and cancelling seats on the original flight) are successful. If you remove the passengers from their original flight, you must be able to allocate seats for them in the new flight. If your operation completes the first step but fails the second, you will have some very angry passengers with no flight. Without the assurance that transactions complete as a set or do not occur at all, databases would not be very useful.

Banking transactions also need to fail or succeed as a set. If you remove money from one account but fail to add it to the target account (say if the network connection fails), then you end up in an inconsistent state as far as the database is concerned. The unfortunate account owners may wonder what happened to their money, and the bank may receive some frantic calls.

To avoid these problems, databases support the concept of a transaction. You can make sure that database operations in a transaction are executed as a single unit of work or a single transaction, or not at all. The Transaction Control Language (TCL) commands—BEGIN TRANSACTION, SAVEPOINT, ROLLBACK, and COMMIT are useful in ensuring a set of transactions fail or succeed as a set.

The BEGIN TRANSACTION statement starts a transaction and the COMMIT statement commits or saves the transaction to the database permanently. If any part of the transaction fails, the ROLLBACK statement is used to undo the changes made by the transaction and to return the database to its original state. Consider the example:

```
BEGIN TRANSACTION;  
  
UPDATE accounts SET balance = balance - 250 WHERE account_id = 786543;  
  
UPDATE accounts SET balance = balance + 250 WHERE account_id = 90643;  
  
COMMIT;
```

In this example, the transaction has two UPDATE statements. One subtracts \$250 from account_id 786543 and the other adds \$250 to a different account. If either of the UPDATE statements fails, a ROLLBACK statement would undo the changes made by the transaction to return the database to its original state. Anytime you are unsure of the changes you are about to do; you may want to create a Savepoint to be able to Rollback the database changes to the Savepoint. Consider the following set of transactions:

```
SAVEPOINT Mark1;  
  
UPDATE accounts SET balance = balance - 250 WHERE account_id = 786543;  
  
SAVEPOINT Mark2;  
  
UPDATE accounts SET balance = balance + 250 WHERE account_id = 90643;  
  
ROLLBACK TO Mark2;
```

At the end of the set of above transactions, the database will have just one change (the first update) since we have rolled back the second change.

Transactions implement a few concepts unique to databases: atomicity, consistency, isolation, and durability (these are popular in the industry as the ACID properties of transactions).

- **Atomicity:** a transaction is atomic, meaning that it is executed as a single unit of work. Either all the operations in the transaction are completed successfully, or none of them are. If any part of the transaction fails, the entire transaction is rolled back, and the database is left in its original state. In our example, when you transfer money between accounts, both activities (removing from one account and depositing in another) complete as a single transaction.
- **Consistency:** a transaction must keep the database in a valid state both before and after the transaction. Any constraints or rules that apply to the data must not be violated by the transaction. In our example, the total amount of money in accounts must be the same before and after the transfer of money between accounts.
- **Isolation:** the data accessed by one transaction must be isolated and not affect other transactions running in parallel. A transfer of money from one account to another must not impact other banking activity between other users and their accounts.
- **Durability:** once a transaction is committed or saved to the database, the changes are permanent and must survive any subsequent failures or crashes. Even if the database crashes once a transaction has completed, the data must be recoverable.

Controlling Database Privileges Using DCL Commands

Database administrators manage databases using DCL commands. These commands help database administrators create roles and users, grant privileges to roles, assign roles to users, and alter and revoke privileges. Granting specific privileges prevents accidental errors. Removing users when they leave or change organizations prevent unauthorized access.

The CREATE USER command creates a new user account in the database.

Example: CREATE USER jose_robelo IDENTIFIED BY 'password';

The ALTER USER command modifies the properties or privileges of an existing user.

Example: ALTER USER jose_robelo PASSWORD 'new_password';

THE CREATE ROLE command is used to create a new role. Once you have a role, you can assign privileges to the role. You may have roles like developer, marketing, sales, and admin, each with a specific set of privileges. When Jose Robelo joins the organization, granting the right role to him will make sure he has all the necessary privileges.

CREATE ROLE marketing;

Once you have a role, you can grant privileges to the role; and then assign the roles to users.

GRANT select, update ON customers TO marketing;

GRANT marketing TO jose_robelo;

Later, if Jose Robelo leaves the marketing organization, you can revoke all his privileges with the following command:

REVOKE marketing FROM jose_robelo;

Conclusion

There is no modern organization or government that doesn't own and rely on its huge databases of information about their people, industries, education, banking systems, and hospitals, among others. Modern databases are typically built using the relational model. A simple English-like language allows you to work with the data in databases.

Although relational databases are popular and widely used across industries and governments, newer technologies such as NoSQL databases and graph databases are also useful in certain scenarios. Every database has its own unique strengths and weaknesses. So, you should learn about them before you decide to pick one to store your data. Most computing programs in colleges discuss the development and maintenance of databases in more detail.



Chapter Terms and Definitions

Data Control Language (DCL): SQL commands that serve as gatekeepers to changes in the data within the database; examples include COMMIT, ROLLBACK, and SAVEPOINT

Data Definition Language (DDL): SQL commands used to define the structure of databases; examples include CREATE, ALTER, and DROP

Data Manipulation Language (DML): SQL commands used to manipulate data stored in databases; examples include SELECT, INSERT, UPDATE, and DELETE

Database: A structured collection of data that can be efficiently search and manipulated by computers

Database Management System: The software that manages the database

Key: Uniquely identified data in each row that can be used to join different tables together

Query: SQL written to search for and retrieve specific data from a database based specific criteria

Relational Database: A database that organizes data as tables linked to each other

Structured Query Language (SQL): A programming language designed to execute a small set of operations that could extract any information from databases

Table: An entity within a relational database that consists of rows and columns

Transaction Control Language (TCL): SQL commands that serve as gatekeepers of changes to the database. Examples include: COMMIT, ROLLBACK, and SAVEPOINT.



Chapter Case

Dionne's Grade Tracking Database

Dionne is planning to attend the University of South Florida (USF) when he graduates from High School. USF has a Grade Point Average (GPA) requirement for admissions and Dionne wants to make sure he keeps a close eye on his grades. Now that he knows a lot more about the power of databases, he wants to design a database that will help him keep track of his grades. But he's not sure which database to choose and what features the database offers. He's also not sure if the database is free or if he will have to pay to use it. He doesn't have a lot of money, so a cheap price or free is the best. Dionne also isn't sure if he should pick a database that he will have to install on his laptop or if he can just login to a website online and use it. There are so many questions that Dionne needs to answer before he can design his database.



Question 1: Use the Internet to research the World Wide Web for at least one database management system that Dionne could use to design his database. If you have trouble finding any database management systems, review the “[Evolution of Database Technologies](#)” section in this chapter where you will see a list of popular relational database management systems. List the database management systems you have found for Dionne and describe the following: What are some key features of the database management system? How much does it cost?

Question 2: Describe in detail what Dionne will have to do to use the database management system. In other words, will he have to install it on his laptop, login to a website, or use some other method?

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There were 5 exabytes of information created between the dawn of civilization through 2003, but that much information is now created every two days.

—Eric Schmidt, Executive Chairman at Google

Overview

The interconnection of information systems is an extremely important function in today's personal, consumer, and business world. Many people stay connected with information available on the [Internet](#) by using virtual assistant technologies such as Amazon's Alexa to purchase items online with their Amazon Prime account. Similarly, businesses are motivated to use interconnected devices to conduct daily tasks such as virtual meetings and email communication. In all these cases, computer networks are required to move information from one application operating on a computer to another. *Computer networks can be defined as the interconnection of information systems through the use of components designed to communicate using standardized technologies.*

Computers interact with networks by using specialized hardware components designed to communicate data in a very consistent way. In fact, today's modern computer networks are the result of over 100 years of innovations engineered to communicate data. One of the earliest examples of using a network to communicate data from one device to another was the telegraph. Patented in 1840, the telegraph was a communications device used by Samuel Morse to send information to locations across great distances. To do this, the telegraph would connect and release a switch from a sender device that was designed to energize an electromagnet on a receiver device. Once the receiver's electromagnet was energized, it would pull a marker to one side. The marker would then scratch a line on a paper at the receiver device. Morse then developed an encoding of the marks in the form of dots and dashes that today is known as Morse code. Morse code could be used to fully encode a message generated by energy that people can understand. For instance, the letter *a* is coded as a dot and a dash.



Samuel Morse's electromagnet inker machine.

Since the invention of the telegraph, communication technologies have evolved considerably and eventually motivated the standardization of network architecture. In particular, when computers from different manufacturers in different countries needed to be networked together, the components had difficulty interoperating between the different networking equipment from the various vendors. It, therefore, became necessary to standardize computer networking technology. This problem motivated the standards organizations to develop models that could be adopted by the entire computer networking industry. The computer network industry could now innovate while complying with the standard model. For example, by developing components that offered standard interoperable functionality while consuming less power. We will learn more about these models and standards later in this chapter.

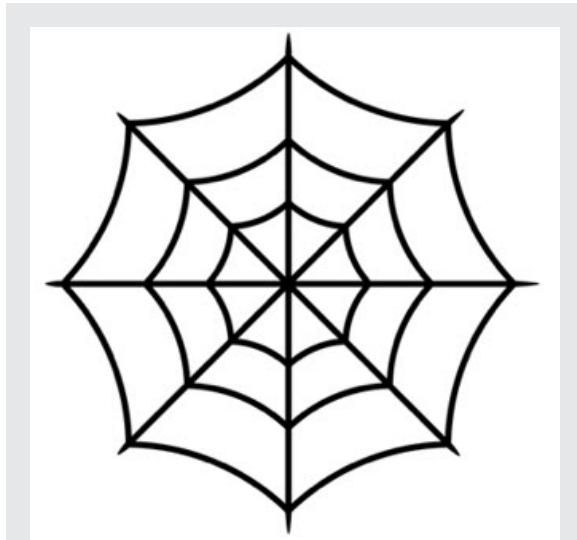
The Internet

Typically, when we talk about computer networks, we cannot escape a historical conversation about the Internet. What is the Internet and how did we get it? How does it help us today?

Put simply, the *Internet can be defined as an interconnection of individual computers across the world through an interconnection of networks using a standardized set of communication protocols.* The Internet allows people and systems to communicate in a consistent way as data moves across the multiple networks that are interconnected across the globe.

Consider a spiderweb, which has been spun by a spider. Each time the spider constructs a new direction in the web it is continuously connected to another portion of the web. You can trace multiple directions from any point within the spiderweb. The spiderweb design is similar to the concept of the Internet where computers are connected by specialized hardware, and you can trace their communication in multiple directions creating a web-like design.

When we think of the Internet, it's easy to relate it to what we know about the [World Wide Web](#). The World Wide Web is what people use every day to do things like shop online, ask "Siri" (Apple's digital assistant²⁴⁴) a question, or post videos to social media platforms such as Instagram.²⁴⁵ Historically, the World Wide Web grew in popularity through the use of web browser applications designed to enable people to navigate content in the form of webpages stored as documents on computers around the world. To navigate content and display it in a consistent way requires a standardized set of protocols. For instance, the [Hypertext Transfer Protocol \(HTTP\)](#) is an Internet protocol used by the World Wide Web that standardizes how documents such as webpages are transferred across systems.²⁴⁶ You can observe a secure version of HTTP called HTTPS if you type www.google.com in your Internet browser ([Figure 240](#)).



The spiderweb design can represent the concept of the Internet, where computers are connected by specialized hardware and you can trace their communication in multiple directions.

²⁴⁴ Siri, Apple's digital assistant, <https://www.apple.com/siri/> (accessed June 2023).

²⁴⁵ Instagram home page, <https://www.instagram.com/> (accessed June 2023).

²⁴⁶ Hypertext Transfer Protocol—HTTP/1.1, <https://www.ietf.org/rfc/rfc2616.txt> (accessed June 2023).

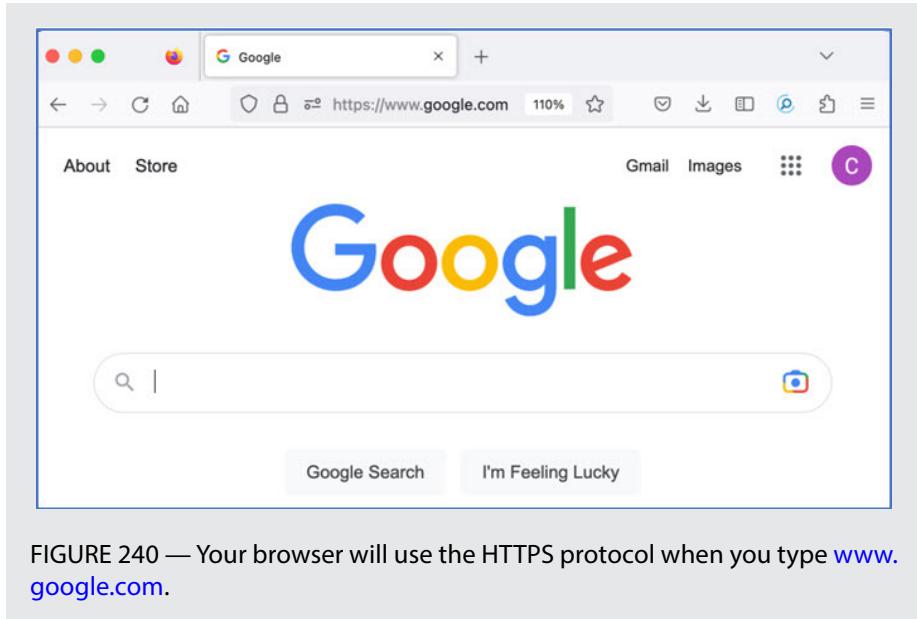


FIGURE 240 — Your browser will use the HTTPS protocol when you type www.google.com.

As seen in [Figure 240](#), the browser navigation bar has applied the secure HTTPS protocol to communicate the Google home page document content to the screen. Internet browser applications, such as Google Chrome or Firefox, help keep us compliant with the HTTP protocol requirements of the Internet. This allows us to access content and documents across the World Wide Web without worrying about the complexities of the standardized communication.

TCP/IP Stack

As Internet technologies were standardized, they were eventually constructed as a stacked layer of technologies, specified as the [Open Standards Interconnection \(OSI\) Model](#). Today, the OSI Model has been simplified using a core set of standardized technologies, which are described as the TCP/IP stack.

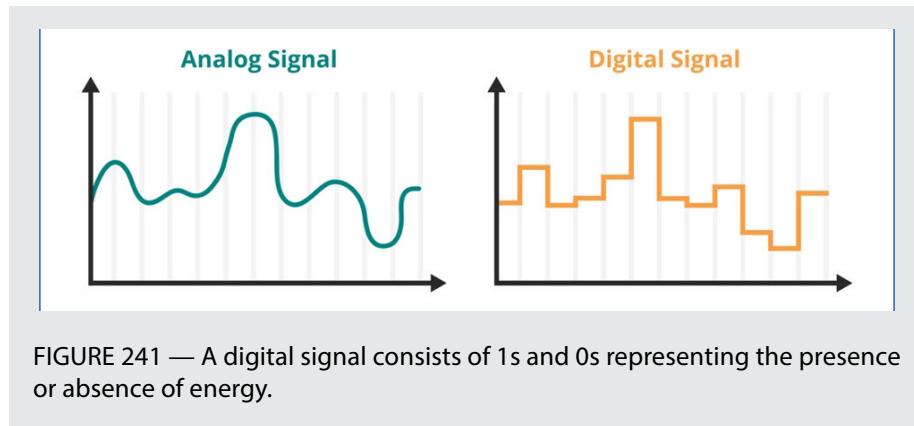
Layer Number	Layer Name	Networking task
5	Application	Specify the needs of users
4	Transport	Organize data for network transmission
3	Network	Identify and locate the destination network
2	Data Link	Remove errors during transmission and label devices
1	Physical	Signals transmitted across a wire

The TCP/IP stack is a five-layered network architecture. The TCP/IP stack layers and their described functional networking tasks are described above, but includes some unfamiliar terms and technologies. Therefore, it makes sense to describe each layer in detail so that you can fully understand how the stack is used to support computer networks.

Physical Layer

The first thing needed for communication is the transmission of information over a distance. The physical layer of the TCP/IP stack does this and requires technology that can transmit signals across a physical medium. Different types of media include copper wire, optical fiber, or various forms of wireless communication (e.g., cellular and Wi-Fi). The signals are generated by capturing energy from an energy source and encoding the data using this energy for transmission over the physical medium.

Depending on the physical medium, signals are commonly transmitted as digital or analog. A digital signal is typically generated when an energy source transmitting the signal turns on and off. If the energy is present, we can measure the data as a 1. If the energy is absent, we can measure the data as a 0. Analog signals are generated by an energy source that applies continuous energy to the medium. This continuous signal changes in amplitude and frequency forming a sine wave as energy varies in intensity and time. Since an analog signal can be measured by amplitude and frequency, data can be encoded by varying the amplitude or frequency of the signal or both. [Figure 241](#) illustrates the difference in how an analog versus a digital signal can be visualized.



The 1s and 0s data generated by signals traveling through a physical medium is commonly referred to as binary data. Binary data captured from signals can be encoded to represent characters that humans can understand. For instance, the American Standard Code for Information Interexchange (ASCII) includes numerical representations (decimals) that can be used to convert letters in the English language to binary data.²⁴⁷

Hello

The word “hello” can be represented as a binary number using the ASCII code.

Character	ASCII Decimal	Binary
h	104	01101000
e	101	01100101
l	108	01101100
l	108	01101100
o	111	01101111

247 ASCII Table, <https://www.asciitable.com/> (accessed June 2023).

Early physical media used in networks were made of copper wiring. In fact, today, copper wire exists in many office buildings and schools. You may have seen network plug outlets in your school walls with a cable plugged into it and attached on the other end to a teacher's PC, laptop, or printer. Copper is an excellent conductor of electricity and can be used to carry signals across great distances. The most common type of network copper cable used today is called Cat5e, and it has a connector on its end called RJ45 (Figure 242).

As seen in Figure 242, Cat5e cable has four pairs of wires that are color coded. From left to right the pairs include White-Orange + Orange, White-Blue + Blue, White-Green + Green, and White-Brown + Brown. Each wire within the cable is carrying a different type of signal. Therefore, the color code sequence is important because it must match the signal sequence of receiving devices such as PCs, laptops, or printers.

Additionally, each of these colored wires is tightly twisted. The tight twisting of the copper wire improves the rate at which a signal can be transmitted through the cable. This also improves the speed of the data transfer on the network that the cable is connected to. Data transfer rate is measured in bits per second. For example, a Cat5e cable is capable of supporting network speeds up to 1000 Mbps (megabits per second). A bit is a small unit of data. A megabit represents a million bits. Therefore, Cat5e cable has tightly twisted copper wires capable of moving up to 1 million bits of data per second!

Another common physical medium used in networks is optical fiber. Optical fiber is typically bundled inside of fiber optic cable. Fiber optic cable is made up of a set of protected layers to prevent any damage to the inner glass fibers (Figure 243).

The inner glass fibers are typically the width of a human hair and designed to allow laser light to travel through the medium. Once an energy source generates a laser light it travels through the glass tube to its destination.

As the energized light signal is pulsed, or turned on and off, by a sending device (described in the "Data Link Layer" section below) it can be measured as data. Therefore, a light-sensitive receiver (also described in the "Data Link Layer" section) on the other end of the fiber optic cable can convert the pulses of light into a 1 or a 0. If light is present, the receiver can measure a 1 as data. If the light is absent, the receiver can measure a 0 as data.

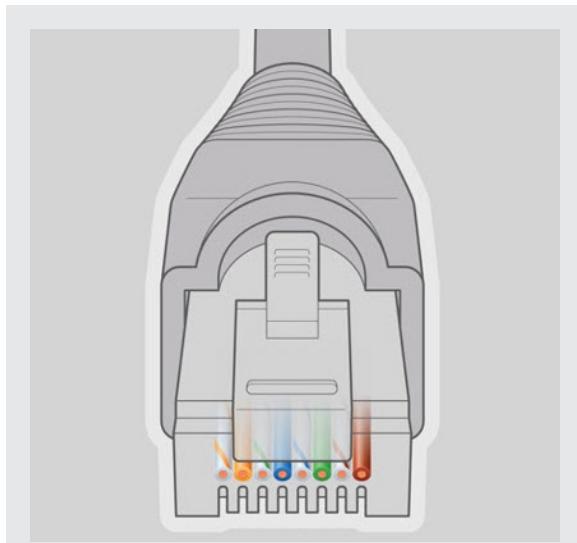


FIGURE 242 — Cat5e network cables are crucial to accessing the internet.

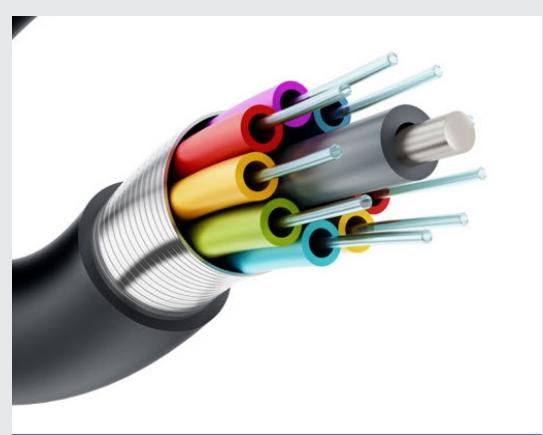


FIGURE 243 — Fiber optic cables allow digital signals to travel. These cables play a key role in network configurations.

Data Link Layer

Signals can get damaged while traveling through a medium. It is also necessary for devices to know if a signal is directed at them. Therefore, it is necessary to include a layer of technology that supports getting the signal to the desired destination without errors. The Data Link layer functions to provide both addressing and error detection.

Think about your home networks for a moment. You probably have devices such as PCs, smartphones, laptops, tablets, smart televisions, and network storage connected to the Internet on your home network. To make this network connection work, you will need a Router (described in the “[Network Layer](#)” section) between the devices, which is designed to connect to the Internet. We will talk more about what makes this possible later in this chapter.

We can use [Figure 244](#) to imagine a scenario where you are using your laptop at home to complete a homework assignment that must be submitted online. I’m sure you would want your homework to find its way through the Internet to its final destination and arrive there in the exact state as you completed it, with no errors. This is where the Data Link layer is necessary.

Whether it is wireless or wired, you will have a connection between your home device and your home router. This connection is considered an instance of the Data Link layer. For example, your home laptop contains hardware that has a wireless network [interface](#) card (WNIC) built inside. The word *interface* is referenced in the WNIC hardware name because it describes the technology used to make the connection between the laptop and the home router or other networking device. Interface is a commonly used term in networking to describe the connection between devices.

Each WNIC, or any other type of network interface card (NIC), has what is called a [Media Access Control \(MAC\) address](#), also called a physical address. The MAC address is a unique identifier assigned by the manufacturer of the hardware. If you were to open your laptop or other device, you may see the MAC address labeled on the hardware. But when you are connected to the Internet there are easier ways of discovering the MAC address you are currently using on a device. For instance, if you own a laptop with Microsoft Windows installed you can run a command within a command prompt that will output the MAC address actively being used by your WNIC. Here is an example of what some of the output would look like if you typed the command “ipconfig / all” from a Microsoft Windows command prompt from a laptop that is actively connected to a wireless network:

```
C:\Users\clinton> ipconfig /all
```

Example of partial output from the above command (Note: your output will have different information than this one):

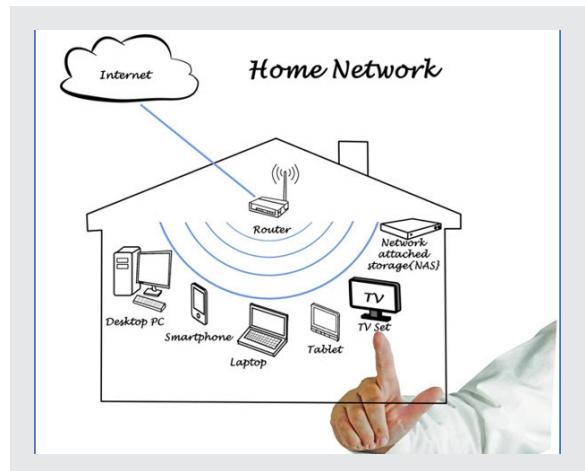


FIGURE 244 — Home networks allow multiple devices to connect to the internet.

Wireless LAN adapter Wi-Fi:

Description.....: Intel® Wi-Fi AX200 160Hz

Physical Address.....: 6D-B1-00-5U-03-9R

DHCP Enabled.....: Yes

IPv4 Address.....: 192.168.1.26

In the above example of output from the “ipconfig /all” command, you can see that the Microsoft Windows operating system has identified that the active interface connection is using a WNIC described as “Intel Wi-Fi AX200 160Hz” with the physical address, or MAC address, of 6D-B1-00-5U-03-9R. In this case, the Data Link layer is implemented within the WNIC where the physical address can be used to uniquely identify a device connected to a network. Circling back to the homework example we mentioned earlier, the physical address plays an important role in making sure that your homework finds its way toward its final destination. Other technologies that support the Data Link layer and your homework finding its way also work similarly, as we will describe in detail later.

The Data Link layer not only functions to provide addressing, it also serves the function of error detection. There must be a technology within a layer of the TCP/IP stack that can detect if any errors were introduced during the transmission of a signal. Errors can occur when a signal is disrupted by events such as power outages or power spikes. When events like this occur, there must be a technology capable of detecting errors to improve the reliability of the network.

Errors are typically detected on a network using specialized algorithms. This is where mathematicians really get to use their skills. The algorithm used by networks to detect errors is known as a cyclic redundancy check (CRC). CRC uses Modulo 2 arithmetic to reliably calculate bit-level errors on binary (1s and 0s) data that may occur during network communication. These algorithms are always getting better and will keep mathematicians in business for many years to come.

Let's look at a simple error-detection algorithm example that's easy to understand, though not robust enough for industrial use. Recall that an algorithm is a set of steps used to accomplish a desired output. In this case we are constructing an algorithm designed to detect an error in the transmitted data.

Let's say we want to send HELLO in a text message. We could code the letters in integer format as 8 5 12 12 15 based on their integer position in the English alphabet. In other words, the letter H is in the 8th position of the English alphabet while E is in the 5th position and so on. A simple algorithm first step would be to add all integers together to get the single integer value of 52.

$$8 + 5 + 12 + 12 + 15 = 52$$

Now add 5 and 2.

$$5 + 2 = 7$$

Now, the technology would send a text with the integer values of the letters HELLO as:

8 5 12 12 15 7

Where 7 is appended to the integer encoded version of HELLO.

Now, let's try to detect an error when our technology receives the text message.

The receiver technology will get 8 5 12 12 15 **7**

The receiver knows that the 7 is extra data, so it calculates:

$$8 + 5 + 12 + 12 + 15 = 52$$

Then it calculates: $5 + 2 = 7$

Now the receiver technology can interpret the HELLO text message, represented by integers in the data received, as having no errors because the calculated result 7 matches the extra data labeled as **7** on the end of the text message.

This simple algorithm is easy to understand but it certainly has flaws. For instance, what if the receiver technology received 8 5 11 13 15 **7** or 10 5 11 11 15 **7**. Both integer combinations will sum to 52. But they are messages with errors. The first one would translate to HEKMO while the second one would translate to JEKKO. These text messages are certainly not HELLO, but our simple algorithm would not detect the error. If you can imagine the power of this simple algorithm example, you can then understand how mathematicians can improve the accuracy of the algorithm so that it can detect all possible errors. This is just one example of why math plays a critical role in technology.

Network Layer

While the Data Link layer is responsible for the connections between devices on a single network, the Network layer's function is to transfer **packets** of data from a source computer, such as a laptop on your home network, to a destination computer through one or more networks. This task is also called routing and is performed by networking devices called routers. You may have a router in your home, that was supplied by your Internet service provider, which allows you to connect your home devices to resources across the global Internet ([Figure 245](#)).



FIGURE 245 — A home router. A Cat5e cable with an RJ45 connector allows access between your home devices and the Internet.

As previously mentioned, the Network layer functions to transfer packets across multiple networks. A packet of data is a small segment of a larger piece of data sent over a network. For example, consider a scenario where you are using the Internet to research a topic on the World Wide Web for your homework assignment. As you open a webpage (described later in the “[Application Layer](#)” section of this chapter) with your browser, packets of data are being sent across the Internet from a webserver somewhere in the world to your laptop. All the content included on the website is not being sent as one large file. Instead, the website data would be broken into small packets of data prior to being transmitted over the Internet. Once the packets reach their destination, they will be reassembled into their original form so that the complete webpage can be viewed in your browser. This reassembly process is handled by the “[Transport Layer](#),” which we will cover later in this chapter.

Communicating signals and data over networks involves the use of standard protocols. The most common protocol used at the Network layer is the [Internet Protocol \(IP\)](#). You may have noticed that this protocol is part of the name included in TCP/IP stack. This is because IP plays an essential role in the Network layer and is the standard responsible for routing packets across interconnected networks. IP is managed on networks by professionals who configure routers and facilitate routing by assigning IP

addresses to devices. An IP address is a unique identifier that has been assigned to devices accessing a network. Unlike a MAC address, which is uniquely assigned by a hardware manufacturer, an IP address is automatically or manually assigned by technology designed to manage devices connecting to a local network or the Internet.

For example, in the “[Data Link Layer](#)” section of this chapter we reviewed the output of a Microsoft Windows command “ipconfig /all.” In the output of this command, you may have noticed:

IPv4 Address.: 192.168.1.26.

The 192.168.1.26 is the unique IP address assigned to the device connected to the Internet.

Additionally, you will notice in the output of the command “IPv4.” This indicates IP version 4. This version contains 4 sections of integer values ranging from 0 to 255 and separated by periods. So, IP addresses range from 0.0.0.0 to 255.255.255.255. This version of the IP address was created in an early period where most experts thought that at most, the world would have one computer-connected device per person on the planet. IPv4 could support 2^{32} or about 4.29 billion devices. This was enough to assign one IP address per person at the time IPv4 was created. But today, many users have multiple devices, and we began running out of IPv4 addresses. So IPv6 was created that allows up to 2^{128} or approximately 340,282,366,920,938,463,463,374,607,431,768,211,456 devices! The IPv6 address is significantly longer and consists of integers and letters. Here is a sample of what an IPv6 address looks like:

2603:9000:f700:6347:1492:8241:c756:3812

Each of the four characters are separated by a colon. As you can see, it contains more information than can be used to support a lot more IP address combinations than IPv4.

Transport Layer

The Transport layer functions to ensure that data is reliably delivered to its destination over a network. To do this the Transport layer includes technology designed to track data as it is broken down into small segments. Segmentation is the process of breaking data down into smaller units to allow for a more compact transmission over a network using IP. This is useful because IP has a limitation on the size of packets it can transfer over a network. Once a receiving technology receives all the segmented data, the Transport layer is then responsible for reassembling these segmented packets of data back into their original form so that they can be used by an application such as a web browser.

The most common Transport layer protocol is the [Transmission Control Protocol \(TCP\)](#). Notice that TCP, just like IP, is part of the TCP/IP stack name. Applications like email can transfer data, such as an email message, to TCP so that the data can be broken into small segments before being transmitted to a destination on the Internet. These segments are assigned sequence numbers so that the receiving technology at the Internet destination knows how to logically reorder and reassemble the email message data back into its original format before handing it off to the receiving email application.

Application Layer

Since the Transport layer handles all details of transmitting data over a network, this opens tremendous potential for the development of applications. The Application layer functions to support the needs of technology users. If you want to send an email from your laptop or text a message to your friends

from your smartphone, you will need to use an application specialized for the task. TCP will make sure that the data is reliably sent across the Internet to your friends. This functional relationship between layers that support the Internet is why we call the technology stack TCP/IP.

With the support of the Application layer, the technology industry has invented many functional uses for the Internet to fit our daily lives. This table summarizes five common application protocols that have been developed to support a variety of applications.

Common Application Layer Protocols

Application Protocol	Functional Description
HTTP (Hyper Text Transfer Protocol)	Used in the World Wide Web to communicate data from webpages
SMTP (Simple Mail Transfer Protocol)	Used to send and receive email
FTP (File Transfer Protocol)	Used to communicate and transfer files between computers
SSH (Secure Shell)	Used to send commands between computers
IM (Instant Messaging)	Used to exchange text-based messages using computers or mobile devices

As you can see, the Application layer is the most practical layer that Internet users can relate to. These application protocols support many of our daily personal, professional, and academic uses for the Internet. So, whether you are using an app on your smartphone or working on an assignment using your school device, you are being supported by the Application layer of the TCP/IP stack.

Networking Support Services

Services have been developed over time to support the use of Internet applications communicating on the TCP/IP stack. For instance, in order for an application to communicate on a network it needs to operate on a device that has been assigned an IP address. The Dynamic Host Configuration Protocol (DHCP) service was developed to manage the assignment of IP addresses on a network. This service is commonly used in places such as schools or businesses where people need to connect to the Internet.

Consider a scenario where you are at school, and you turn on your device to join the network so you can use the Internet. As soon as your device is turned on, the operating system is seeking an available network to connect to. If the network allows you to connect to it, a DHCP service assigns your device an IP address on the network. This assigned IP address is then used by your device so that you can operate applications capable of communicating on the Internet.

Another common service used on computer networks is the Domain Name Service (DNS). This service is used by the Domain Name System, which includes a set of databases responsible for translating IP addresses into domain names. To see DNS in action, you can execute a WHOIS query. A WHOIS query is used to check publicly available databases to identify who owns a domain. Additionally, you can check the DNS records to determine what IP addresses are owned and associated with the domain name.

To conduct a WHOIS query, open your browser and navigate to <https://who.is/>. Note, you can Google WHOIS and the search results will recommend many WHOIS query tools. Any of these will work just as well. Once you are on the who.is site, type usf.edu in the search bar and click the search button (Figure 246).

Your WHOIS query will result in lots of contact and other information about usf.edu. For instance, usf.edu was activated on September 29, 1986, and is registered by the University of South Florida Information Technology at 4202 E. Fowler Avenue, SVC 4010 Tampa, Florida 33620 USA. This information may be useful for anyone who is trying to investigate the owner and support for any specific domain.

Next, click on the “DNS Records” button to view a report on the records documented over time with the usf.edu domain. Make a special note of the entry next to www.usf.edu under the “Hostname” column (Figure 247).

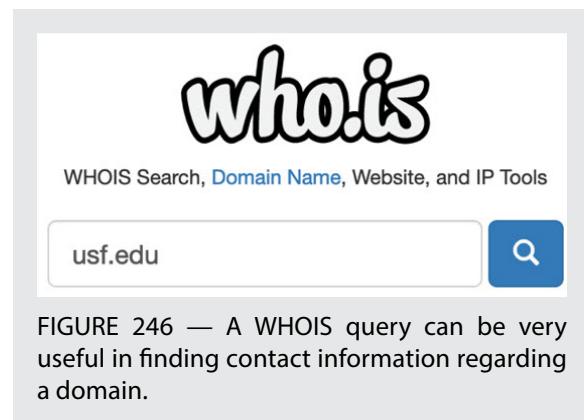


FIGURE 246 — A WHOIS query can be very useful in finding contact information regarding a domain.

The screenshot shows the DNS information for the usf.edu domain. At the top, there are three tabs: "Whois" (disabled), "DNS Records" (selected and highlighted in blue), and "Diagnostics". Below the tabs, the title "DNS Records for usf.edu" is displayed. A table follows, listing various DNS records:

Hostname	Type	TTL	Priority	Content
usf.edu	SOA	21600		mother.usf.edu postmaster@mother.usf.edu 3050181717 7200 1200 864000 7200
usf.edu	NS	21424		azure-dr-bns1.usf.edu
usf.edu	NS	21424		mother.usf.edu
usf.edu	NS	21424		ziggy.usf.edu
usf.edu	A	21600		52.141.216.229
usf.edu	A	21600		131.247.100.1
usf.edu	A	21600		131.247.1.40
usf.edu	MX	3090	1	usf-edu.mail.protection.outlook.com
www.usf.edu	A	10		52.149.184.58
www.usf.edu	CNAME	465		usfcms.mscloud.usf.edu

FIGURE 247 — A WHOIS query will return a lot of information regarding the searched domain.

As seen in Figure 247, www.usf.edu is used to respond to any Internet requests on the World Wide Web and it is assigned the IP address 52.149.184.58. If you were to navigate to www.usf.edu with your Internet browser, you would actually be navigating to the IP address 52.149.184.58. However, DNS translates this IP address into a domain name that humans can easily remember and understand.

Overall, many networking support services exist to promote the use of networks and their technologies. Information technology professionals make a career out of supporting, managing, and implementing these services in an enterprise business environment that supports people and business processes.

College degree programs and industry certifications have developed entire curriculums to support the knowledge and expertise needed to support the technologies of today and tomorrow. Therefore, it is a worthy investment to learn more about these services, if you are interested in a future career in technology.

Computer Network Security

Networks were originally motivated and designed around the concept of communication through technology. As you may have noticed throughout this chapter, these technologies were not designed to consider the risks of intentional harm to the systems or data as a result of a cyber-attack. You will learn more about cybersecurity in the “[Cybersecurity](#)” chapter of this textbook. For now, let’s consider a cyber-attack as an attempt by a malicious person or program to damage or destroy a computer network and the systems that support it. There are daily attacks on computer networks in our homes, schools, and business. Protecting networks using security technology is a necessity in today’s world.

One specific and important security technology that is designed to protect networks is a firewall. A firewall is a computer that is positioned on the network between the devices used inside a network and the outside world. The firewall computer keeps a careful eye on all the incoming network traffic and applies filters that can block any unwanted or malicious packets. The filters are configured by IT professionals who can assign a set of rules that are designed to identify known harmful network traffic.

Firewalls keep us all safe when we use our devices to communicate on the Internet. However, malicious people are always trying to get past these protective firewalls to cause harm to our systems. This is why for years to come cybersecurity professionals will continue to be in high demand.

There are some simple things that we can do to protect the security of our networks. Two such easy security practices include patching our systems and making sure that we communicate on our networks using secure methods. Patching systems basically involves keeping our software and operating systems up to date with the latest security updates. It is common among software and hardware vendors to discover weaknesses in their products that may expose vulnerabilities to a cyber-attack. To prevent these attacks from occurring, the vendors recommend that we update our systems by downloading and installing these patches.

Communicating on a network securely typically involves the use of [encryption](#) technologies. Put simply, encryption is the process where you use an algorithm to scramble data into a secret encoded message that can only be unlocked with a unique and guarded key. One such type of encryption uses a digital certificate. Digital certificates are issued by certificate authorities. You can use these digital certificates to encrypt data being transmitted over a network such as an email, text, or instant message.

To understand how encryption technologies work, consider the following simple example. You have a text message consisting of the word “hello” that you are about to send to your friend using your smartphone app.

Swap each letter with the one that holds its opposite position in the alphabet. For example, “a” would be swapped with “z” and “b” would be swapped with “y” and so on.

So, the encrypted version of “hello” would be “svool.”

The receiving technology would then need to have a key to unlock the algorithm. In other words, the receiver knows the algorithm used to scramble the letters and can execute the swap in reverse to translate “svool” back into “hello.”

This simple encryption example is useful to understand the concept. However, in practice the method to this algorithm could be leaked somewhere on the Internet and malicious people could write a simple program to decrypt all your network communication. This is why it is important to use strong algorithms that are so complex that it would be impractical for anyone to decrypt. You will learn more about the complexities of cybersecurity in the “[Cybersecurity](#)” chapter of the textbook.



Chapter Terms and Definitions

Encryption: The use of an algorithm to scramble data into a secret encoded message that can only be unlocked with a unique and guarded key

Hypertext Transfer Protocol (HTTP): An Internet protocol used by the World Wide Web that standardizes how documents such as webpages are transferred across systems

Interface: A networking term that describes the interconnection between a computing device, such as a laptop or smartphone, to a network

Internet: An interconnection of individual computers across the world through an interconnection of networks using a standardized set of communication protocols

Internet Protocol (IP): A network layer protocol responsible for routing packets across interconnected networks

Media Access Control (MAC) Address: Commonly known as a physical address; a unique identifier consisting of numbers and letters assigned to network interface hardware and used as the identity of a network address

Open Standards Interconnection (OSI) Model: A conceptual stack of technologies that could be used to describe the various functions of a networked system

Packet: A small segment of a larger piece of data sent over a network

Transmission Control Protocol (TCP): A reliable transport layer protocol that enables applications to exchange data over a network

World Wide Web: An information system designed to display content in the form of documents, such as webpages, which are stored on computers across the world



Chapter Case

WHOIS Arianna's Domain

Arianna has just learned about the World Wide Web and how it works. She was given an assignment by her teacher to come up with an online business idea. The online business should include a website that is available for her customers to use from any network across the world. Arianna knew this meant she had to purchase a domain and have it registered so that it is available to Domain Name Systems throughout the globe. To do this, Arianna needs to think of a unique domain name and complete a WHOIS query to see if its available. Basically, she must pick a domain name that nobody in the world has actively registered.



Question 1: Think of an online business idea. Now describe your online business in one or two sentences. Think of a unique domain name to use with your business and conduct a WHOIS query on the Internet to see if it's available. If the domain name is already registered by someone else, think of another name. Continue to conduct WHOIS queries until you have identified a domain name that has not been registered by someone else. Write your domain name here.

Question 2: Now that you have explained your online business idea, use the Internet to conduct multiple WHOIS queries to identify at least one other company who has registered a domain name with a similar online business model idea. In other words, another company who may be a potential competitor. List all the information reported in that companies WHOIS query.

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If security were all that mattered, computers would never be turned on, let alone hooked into a network with literally millions of potential intruders.

— Dan Farmer, computer security researcher and programmer

Overview—What is Cybersecurity?

The National Institute of Standards and Technology (NIST), founded in 1901, is part of the U.S. Department of Commerce and supports the U.S. mission to promote today's innovations and industrial competitiveness. This mission is accomplished by advancing measurements and standards in science and technologies that enhance economic security and quality of life. NIST, defines **cybersecurity** as:

*Prevention of damage to, protection of, and restoration of computers, electronic communicationssystems,electroniccommunicationsservices,wirecommunication, and electronic communication, including information contained therein, to ensure its availability, integrity, authentication, confidentiality, and nonrepudiation.*²⁴⁸

At the core of cybersecurity is the motivation to protect information and the systems that manage it. In fact, the U.S. law, 44 USC 3552, defines **information security** as “*protecting information and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction in order to provide—integrity..., confidentiality..., and availability....*²⁴⁹

In cybersecurity practice, this is commonly known as the **CIA triad** where **C** stands for confidentiality, **I** for integrity, and **A** for availability. What's notable here is that cybersecurity is all about information and the systems that support its management. Our information and systems are increasingly under attack from powerful adversaries who would like to steal our information for profit. Therefore, having an understanding of cybersecurity is important to protecting the future of people, resources, and societies. Our journey to this understanding starts with exploring the past so we know how we have arrived to the present. Then, it demands we turn our attention toward studying where we are going in the future.

Before we begin to understand how we got to today's climate of cybersecurity, let's first establish some context with the CIA triad. This will help us understand what motivates the actors of cybersecurity in the past, present, and future.

Confidentiality

According to 44 USC 3552(b)(3)(B):

Confidentiality...means preserving authorized restrictions on access and disclosure, including means for protecting personal privacy and proprietary information.

The law recognizes the right of individuals to privacy, and such right extends to information that, if made public, could cause harm to the person. It is the responsibility of the custodians of the information to

²⁴⁸ NIST, Computer Security Resource Center (CSRC), Information Technology Laboratory, <https://csrc.nist.gov/glossary/term/cybersecurity> (accessed June 2023).

²⁴⁹ 44 USC 3552(b)(3), <https://www.law.cornell.edu/uscode/text/44/3552> (accessed June 2023).

provide that privacy to the individuals whose information they have in their possession. For instance, people rely on banks to protect the privacy of their credit card information. The expectation is that banks (the custodian of the information) should not allow their customer account information to be exposed to those who do not require its access.

Modern cybersecurity services have been put in place by banks to protect the privacy of their customers' information. Such practices include services such as fraud alerts to customers when credit cards are used in unusual ways. These services provide an opportunity for customers to freeze their credit card so that it cannot be used by someone who has violated their confidential information. This response is typically followed up with changing the compromised credit card information so that the stolen information is no longer useful, and disputing all unwanted charges to the credit card.

Integrity

The law under 44 USC 3552(b)(3)(A) defines integrity as:

Integrity...means guarding against improper information modification or destruction, and includes ensuring information non-repudiation and authenticity.

When you pull information from an information system, for example, your grades from school, or the monthly statement from your bank account, you trust that the information provided is reliable and actionable. For example, when the bank reports the balance in your checking account, you do not think it necessary to calculate the totals of credits, debits, and interest income yourself to verify the amount. Rather, you trust that the bank has made the right calculations. Imagine how complex life would be if the information you received from IT systems could not be trusted to be accurate. Integrity is the aspect of information security that prevents that from happening.

Consider the following example: you have worked really hard throughout the semester to keep up with the grades in all of your classes. Now it's time for report cards and you expect to see straight A's in all of your classes. You open your report card, and it shows that you have failed all of your classes. This could be devastating and perhaps ruin your chances of getting into the college of your choice. This is the impact of integrity. Your expectation is that the system that manages your grades in school should maintain its integrity so that you can be rewarded for your hard work. Now that you realize the information has somehow been modified, you will need to dispute the grades and the school will need to investigate how the integrity of its grade information has been violated. An information system without integrity is not useful for any serious work.

Availability

Availability as defined by 44 USC 3552(b)(3)(C):

Availability...means ensuring timely and reliable access to and use of information.

When you log into an online class, you expect it to be online. That in essence is availability. The relevance of availability to information security is self-explanatory. An information system that is unavailable is an information system that is not useful. Most **viruses** impact availability—they typically delete important files, causing a loss of availability. Even if the files can ultimately be recovered from backup systems or other sources, the time lost in recovering those files represents time not spent doing useful work, i.e., lack of availability.

A famous example of lack of availability occurred on October 4, 2021. Facebook, Instagram, WhatsApp, and Oculus were unavailable globally for a period of time (Figure 248). This availability problem caused a global disruption of information services, which affected many different people and businesses who relied on the Facebook infrastructure for business.

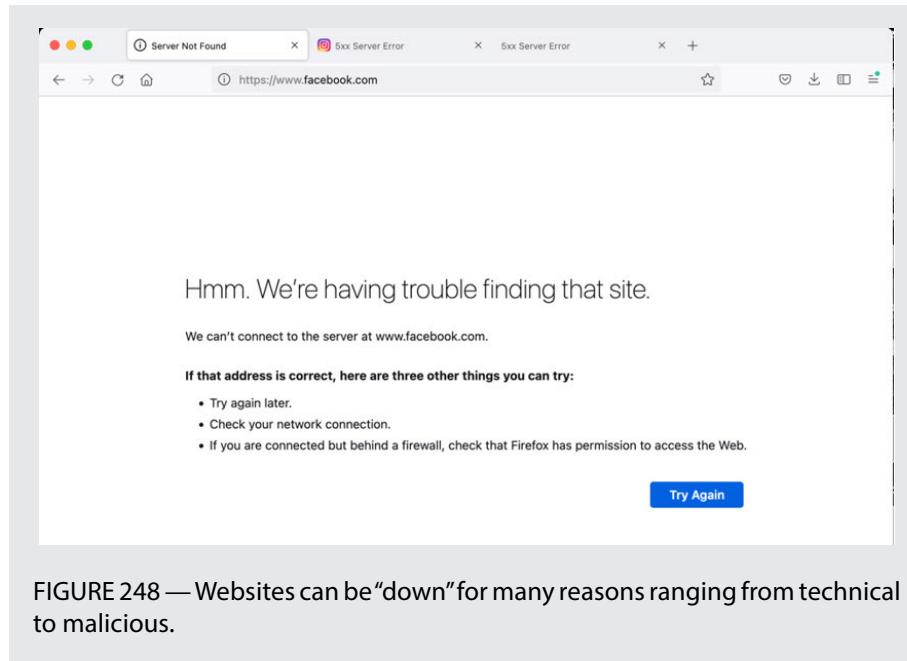


FIGURE 248—Websites can be “down” for many reasons ranging from technical to malicious.

Although the unavailability of Facebook and its services was not confirmed to be a cybersecurity attack, it demonstrated the impact of how the availability of Internet resources can quickly cause disruption in global information dependent societies. Figure 249 is a screenshot taken by this author on October 4, 2021, which demonstrates how quickly information availability cyber events such as this can become disruptive and cause fear and panic among people.

A screenshot of a Twitter post titled 'Tweet'. The tweet content is:

This is not just a DNS failure, seems like a planned cyber attack. I tried pinging [Facebook.com](#) and DNS is still not found. If a company like Facebook can not recover their DNS server, then its something beyond #Facebook. Data leaks news are old, nothing fresh.

Below the tweet are two screenshots of a ping tool interface. Both screenshots show results for 'Ping server facebook.com' and 'DNS facebook.com'. The left screenshot shows numerous 'Unknown host' entries from various countries. The right screenshot shows similar results with some additional details. At the bottom of the tweet, it says '4:08 PM · Oct 4, 2021 · Twitter for Android' and shows '11 Retweets 31 Likes'.

FIGURE 249—The global access to information allows for real-time discussions of occurrences.

Update About the October 4, 2021, Outage by Meta²⁵⁰

What happened

The October 4 outage occurred due to a command issued by an engineer during routine maintenance that unintentionally took down all the connections in our backbone network, effectively disconnecting Facebook data centers from the Internet globally. Our Facebook Engineering blog provides a more detailed explanation about what caused this outage and why it took time to restore our services. Ads did not deliver during the time our systems were offline, and advertisers were not and will not be billed for ads during the outage. However, we've heard from customers that their campaigns experienced volatility as our services came back online.

Separately, on October 8, a configuration change caused some people and businesses to have trouble accessing some of our apps and products for a shorter period of time. Following discovery of the issue, our teams were able to quickly resolve it and restore access to our services.

Brief History of Cybersecurity Events

To better understand how the domain of cybersecurity functions in today's businesses, it is useful to know about specific incidents that have happened in the past and how they have significantly influenced our business environment. The list of incidents that follow is not intended to be comprehensive. But they do serve as excellent examples of information security concerns at the time of their occurrences. These incidents also played a significant role in establishing some of the important laws and organizations related to cybersecurity. As you read through these various events in history, you will notice how new cybersecurity or technology terms and concepts are gradually introduced into our daily lexicon.

1981—*Development of the core Internet technologies (TCP and IP)*: The core technologies of the Internet were finalized in 1981. There was no mention of security in these technologies, indicating that at that time the technology world was not concerned about cybersecurity. Since TCP and IP were available for free, they became the preferred networking technology for UNIX systems, widely used at universities and various intensive organizations such as hospitals and banks. Without TCP/IP, there would probably be no networking, and without networking, there would probably be little cybersecurity risk.

1982–1983—*Gang of 414's*: Computer intrusions began soon after TCP and IP were integrated into industrial equipment. The most highly publicized incident of this time was the gang of 414's, a group of six teenagers from Milwaukee, who got their name from the telephone area code for Milwaukee. These teenagers found it exciting to get into systems that were supposed to be out of their reach.

250 The information in this section is from "Update About the October 4 Outage" by Meta, <https://www.facebook.com/business/news/update-about-the-october-4th-outage> (accessed June 2023).

Using home computers, phone lines, and default passwords, this group was able to break into approximately 60 high-profile computer systems, including those at the Los Alamos Laboratories and the Memorial Sloan-Kettering Cancer Center in New York. The incident received wide coverage, including a *Newsweek* cover story titled “Beware: Hackers at play.” This is believed to be the first use of the term “hacker” in the mainstream media in the context of computer security. While the teenagers themselves did no harm, it was easy for the industry to see that the simple techniques used by the kids could easily be replicated by others. As a result, the US Congress held hearings on computer security. After more such incidents, Congress passed the Computer Fraud and Abuse Act of 1986, which made it a crime to break into federal or commercial computer systems.

1988—*Morris worm*: Robert Morris, then a graduate student at Cornell, and now a Professor of Computer Science and Artificial Intelligence at MIT, released a 99-line self-replicating program on November 2, 1988, to measure the size of the then nascent Internet. As a result of a design feature of the program, it brought down many systems it infected, and achieved several landmarks in the process. It is considered the first Internet *worm*. In percentage terms, it is estimated to have brought down the largest fraction of the Internet ever (10%). It also resulted in the first conviction under the 1986 Computer Fraud and Abuse Act. Robert Morris was sentenced to probation, community service, and a fine. The Morris worm prompted the US government to establish the CERT/CC (CERT coordination center)²⁵¹ at Carnegie Mellon University as a single point to coordinate industry–government response to Internet emergencies. Prof. Morris was also a co-founder of Viaweb, an e-commerce firm bought by Yahoo and renamed “Yahoo! Store.”

Father and Son

As an interesting anecdote, Robert Morris’ father, Bob Morris, designed the password encryption system for the UNIX operating system that is still used today. Even more interestingly, at the time of this incident, the senior Bob Morris was the chief scientist for the National Computer Security Center (NCSC) of the National Security Agency (NSA),^{252, 253} the federal agency responsible for designing secure computers.

1995–1998—*Windows 95/98*: Microsoft released Windows 95 on August 24, 1995. The operating system had a graphical interface and was designed to run on relatively inexpensive computers. The release was supported with a heavy marketing push, and within a very short time, it became the most successful operating system ever produced. Windows 95 was designed primarily as a stand-alone single user desktop operating system and, therefore, had almost no security precautions. Most users ran Windows 95 without passwords and most applications ran on Windows 95 with administrative privileges for convenience. However, Windows 95 supported TCP/IP, thereby bringing TCP/IP into mainstream businesses. This combination of a security-agnostic networking technology (TCP/IP)

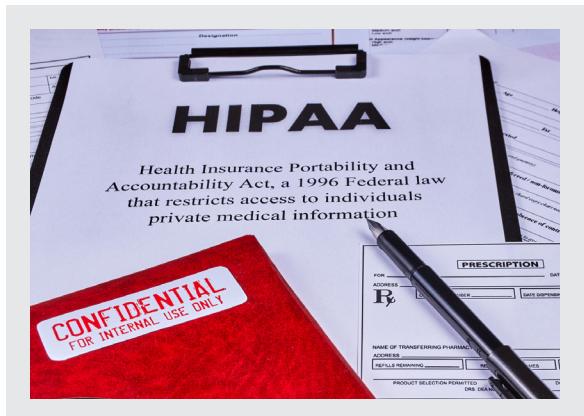
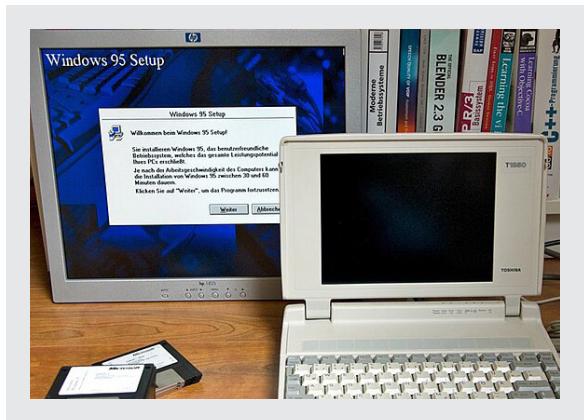
251 While CERT typically stands for Computer Emergency Response Team, CMU has registered the name as a service mark with the US Patents and Trademark Office.

252 Robert Morris (cryptographer), [https://en.wikipedia.org/wiki/Robert_Morris_\(cryptographer\)](https://en.wikipedia.org/wiki/Robert_Morris_(cryptographer)) (accessed June 2023).

253 For another very interesting account of Bob Morris, read the amazingly humorous book by Cliff Stoll, “The Cuckoo’s Egg,” ISBN 0671726889.

combined with an equally security-agnostic business desktop created a fertile environment for information security compromises to flourish. In talks, security experts sometimes refer to this TCP/IP–Windows 95 environment as the birthplace of the information security profession.²⁵⁴

1996—Health Insurance Portability and Accountability Act (HIPAA): This act, which primarily focused on protecting health insurance for US workers when they change or lose jobs, also had important information security implications. Many government leaders believed at the time that electronic health records (EHR) were an important instrument to lower rising health care costs in America. The act, therefore, also pushed for electronic health records. Since information security was getting recognized as an important concern, the law had provisions to make organizations responsible for maintaining the confidentiality of patient records in the health-care industry. The health-care industry has now moved over completely to EHR, creating significant demand for information security within the healthcare industry.



2000—ILOVEYOU virus: On May 5, 2000, this virus was released by a student in the Philippines. The virus deleted images on infected computers and automatically sent itself as an email attachment to all of the Outlook contacts of the infected computers. The virus infected millions of computers worldwide, and caused billions of dollars in damage. The creators of the virus, Reomel Ramores and Onel de Guzman, were traced within hours of the release of the virus. However, investigators realized very quickly that Philippines had no law against writing computer viruses, and had to drop all charges against the students.²⁵⁵ This incident led to the realization that information security was a global phenomenon and led to a push from developed countries to encourage developing countries to revamp their information security laws. However, even today there are significant differences between countries regarding information security laws. For example, while writing a virus can lead to fines of up to \$250,000 and 10 years of imprisonment in the United States, the punishment in the Philippines can range from 100,000 Pesos (about \$2,500) and up to an amount commensurate to the damage and up to three years in prison. These international differences are an ongoing challenge to cybersecurity in technology-intensive societies.

2002—Sarbanes–Oxley Act: During 2000–2002, America witnessed many unpleasant incidents of corporate fraud involving such legendary companies as Enron, Tyco, and WorldCom. For example, Enron claimed revenues of over \$100 billion in 2000 and declared bankruptcy the next year. MCI–WorldCom revealed in 2002 that it had overstated its earnings by over \$72 billion in the past five quarters. These

²⁵⁴ For example, Dan Geer (chief information security officer for In-Q-Tel, the venture capital arm of CIA) referred to this in his talk at the ISSA meeting in Tampa, December 2011.

²⁵⁵ Arnold, W. "TECHNOLOGY: Philippines to drop charges on e-mail virus," New York Times, August 22, 2000.

frauds were enabled by fraudulent manipulation of accounting systems, believed to be at the behest of firm leadership. However, during trials the CEOs consistently tried to escape blame by pleading ignorance of accounting procedures and claiming blind trust in their highly paid and well-educated lieutenants. Since the retirements of most Americans are invested in large publicly traded firms, their downfall affects most American families. Compelled to act by these devastating corporate frauds and to ensure correctness in financial reporting, Congress enacted the Sarbanes–Oxley Act in 2002. The act focused on making the key executives personally accountable for the correctness of financial reports filed by publicly traded companies. The act had three major provisions. Section 302 of the act requires the CEO and CFO of firms to sign a declaration of personal knowledge of all the information in annual filings. Section 906 of the act imposes criminal penalties including imprisonment of up to 20 years for incorrect certification. Section 404 of the act required that the certification in Section 302 be based on formal internal controls. Section 404 has had a major impact on the information security profession because it required publicly traded companies to establish formal information security processes in place. This has led to significant investments in internal controls over financial reporting in publicly traded firms, and corresponding growth in the demand for cybersecurity professionals.

2005–2007—*Retailer attacks*: In December 2006, T.J.Maxx reported that its computer systems, which processed credit card payments, had been breached. On investigation, it was found that the breach had started in July 2005, a year and a half prior to its discovery, and over 45 million credit card and debit card numbers had been stolen. It turned out that the leader of the group involved in the breach was Albert Gonzalez,²⁵⁶ an informer for the US Secret Service and in fact Albert was cooperating with the Secret Service in connection with another case at the time of these attacks. Investigations also revealed that the group had also hacked into the systems at other retailers such as BJ's Wholesale Club, DSW, Office Max, Boston Market, Barnes & Noble, and Sports Authority. The modus operandi of the group was to drive along US Route 1 in Miami and seek out an insecure store with wireless networks to enter the corporate networks. Later the group improved its methodology and used SQL injection attacks to enter the networks at Hannaford Brothers and Heartland Payment Systems, a credit card payment processing company. Over 125 million credit card numbers were estimated to have been stolen from Heartland, and the company estimated damages at over \$12 million. In March 2010, Albert Gonzalez was sentenced to 20 years in prison. He also forfeited over \$1.65 million that he had earned from selling fake credit cards based on the stolen information. These incidents highlighted that even large firms had glaring information security weaknesses that could lead to serious embarrassment and losses. The SQL injection attacks, in particular, created an awareness of the need to pay attention to information security during software development, and introduced the term “secure SDLC” to the IT lexicon.

2008—*Denial of service attacks in Georgia*: Coinciding with the military war between Georgia and Russia in 2008, Georgia was the victim of massive distributed **denial of service attacks**. The attacks defaced the websites of many media and government organizations, limiting their ability to communicate their viewpoints about the war to their citizens. Many experts believe that the cyber-attacks were caused by Russia as part of a war strategy. If so, these were the first known incidents of cyber-attacks being used as an instrument of warfare.

²⁵⁶ The New York Times magazine published a detailed profile of Albert Gonzales, highlighting the intensely personal side of cybersecurity. James Verini, The great cyberheist, The New York Times magazine, Nov 10, 2010, accessible at <https://www.nytimes.com/2010/11/14/magazine/14Hacker-t.html> (accessed June 2023).

June 2009—Establishment of the US Cyber Command: In April 2009, the Wall Street Journal reported that intruders had broken into the computer networks of defense contractors developing the Joint Strike Fighter, also called the F-35 Lightning II. The \$300 billion project was the Defense Department's costliest weapons program ever, and used 7.5 million lines of computer code. Intruders had stolen terabytes of data related to the aircraft's design and electronics. It was believed that the theft would help enemies plan their defenses against the fighter. The contractors involved in the project include Lockheed Martin, Northrop Grumman, and BAE Systems. Also, in April the Wall Street Journal reported that the US electricity grid had been penetrated by spies from China, Russia, and other countries. The spies also inserted computer software into the grid, which could be used to cause damage by remote control.²⁵⁷ Soon thereafter, on June 23, 2009, the US Cyber Command was created to defend US military computer networks against attacks from adversaries. The US Cyber Command is also responsible for responding in cyberspace as necessary.



2010—Operation Aurora and Google-China: On January 12, 2010, a blog post by Google's Chief Legal Officer reported that Google had detected an attempt, originating from China, to steal its intellectual property. The attacks were also aimed at accessing the emails of Chinese human-rights activists. The US government soon escalated the incident with Congress announcing its intention to investigate the allegations. The Secretary of State compared the Chinese censorship of the Internet to an information-age Berlin Wall. Further investigations traced the attacks to two educational institutions in China—Shanghai Jiaotong University and the Lanxiang Vocational School. Jiaotong is home to one of China's elite computer science programs, and Lanxiang is involved in training computer scientists for the Chinese military.²⁵⁸ China has, however, denied formal government involvement and called the attacks simply an attempt by students to refine their computer skills. This was one of the earliest suspected state-sponsored cybersecurity incidents.

April 17, 2011—Sony PlayStation Network (PSN): Just before summer break of 2011, Sony announced that an external intrusion had compromised its PlayStation Network and Qriocity service, and that hackers had obtained personal information on the 70 million subscribers of the network. In response, the company took the network offline while it tried to ensure that all traces of the offending software had been removed from the network. During that time, millions of kids all over the world who had planned their summer breaks around catching up with online gaming on PSN had to find alternate ways to pass their time. While the intrusion affected a relatively innocuous network, the impact on families around the world was huge and almost every family with kids followed the daily developments around the attacks. Imagine losing out on an entire summer break because of a cybersecurity incident. This actually happened in the summer of 2011.



²⁵⁷ Gorman, S. "Electricity grid in US penetrated by spies," Wall Street Journal, April 8, 2009.

²⁵⁸ Markoff, J. and Barboza, D. "2 China schools said to be tied to online attacks," New York Times, February 18, 2010, <http://www.nytimes.com/2010/02/19/technology/19china.html> (accessed June 2023).

February 1, 2013—*Mandiant APT 1 report*:²⁵⁹ Cybersecurity firm Mandiant released a report alleging that a suspected Chinese military unit, 61398, was engaged in a novel form of state-sponsored cybersecurity attack—advanced persistent threat. An advanced persistent threat is a sophisticated and well-resourced adversary that uses multiple attack methods over an extended period to execute its objectives. Mandiant called this adversary APT1. The report attracted considerable attention among business and government leaders who realized that cyber-attacks were no longer limited to individuals for private gain. The stakes were raised when organizations realized that states could invest military-scale resources to compromise cybersecurity.

2014—*Cyber-attack on Yahoo*: 500 million accounts were stolen²⁶⁰ by what was believed to be a state-sponsored actor. Email addresses, passwords, telephone numbers, dates of birth, and names were stolen by cybercriminals hired by Russian agents who targeted Yahoo employees via a **phishing** campaign. Phishing is a form of **social engineering**. In this case, a Yahoo employee with network access clicked on a malicious link in an email. This allowed hackers to gain continuous access to the network to obtain confidential data such as security questions and answers that were stored unencrypted by Yahoo. Social engineering attacks have been getting progressively sophisticated since the early 2000s. This cyber-attack on Yahoo is one of the most significant attacks recorded to date. Today, the US Cybersecurity & Infrastructure Security Agency (CISA) publishes security tips on how to avoid social engineering and phishing attacks.²⁶¹

2021—*RockYou2021*: In 2021, a hacker whose identity has not been disclosed harvested billions of user passwords. To date, this is the largest collection of passwords ever leaked online.²⁶² The anonymous hacker uploaded a 100GB TXT (text) file to a popular hacker forum that contained approximately 8.4 billion entries of passwords. Some would argue that this number of passwords exposed could cover the entire global online population several times over. Today, the rockyou.txt file is commonly used by cybersecurity researchers and professionals as a wordlist to study or recreate **brute force attacks** on user passwords. A brute force attack is a programming scripts designed to repeatedly execute its code while attempting to log into a system with a user account. These types of wordlists are managed within software packages found in today's open-source distributions of Linux, such as Kali Linux, which are designed for cybersecurity professionals to assess the security of their systems.²⁶³

This brief chronology highlights how information security attacks have evolved from technical proofs-of-concept to commercially driven attacks to steal credit card information. Of late even governments are being suspected of pursuing their agendas through cybercrime. In Europe, a remote Romanian

259 Mandiant, "APT1, Exposing One of China's Cyber Espionage Units," <https://www.mandiant.com/sites/default/files/2021-09/mandiant-apt1-report.pdf> (accessed June 2023).

260 Yahoo says hackers stole data from 500 million accounts in 2014. Reuters by Dustin Volz. Article access via the website on 2/21/2023: <https://www.reuters.com/article/us-yahoo-cyber-idUSKCN11S16P> (accessed June 2023).

261 "Avoiding Social Engineering and Phishing Attacks," Security Tip (ST04-014), Cybersecurity & Infrastructure Security Agency, <https://www.cisa.gov/uscert/ncas/tips/ST04-014> (accessed June 2023).

262 "RockYou2021: largest password compilation of all time leaked online with 8.4 billion entries," cybernews.com, 27 July 2022, website accessed on 2/21/2023: <https://cybernews.com/security/rockyou2021-alltime-largest-password-compilation-leaked/> (accessed June 2023).

263 Kali Linux, website accessed on 2/21/2023: <https://www.kali.org/> (accessed June 2023).

town, Râmnicu Vâlcea, has emerged as the focal point in global cyber money laundering. In the middle of nowhere, this town has car dealerships selling Mercedes-Benz and other expensive cars.²⁶⁴ Social response has evolved as well, from judges merely warning intruders and laws making specific exceptions for juveniles, in spite of their known involvement in cyber-attacks (414's), to governments establishing entire military commands to deal with cybersecurity.

The Basic Information Security Model

Information security is a very broad subject area because most information security incidents exploit some new weakness in an organization. Maintaining information security, therefore, requires attention to almost every aspect of the organization. To provide structure to these efforts, it is useful to organize all the activities associated with maintaining information security into a unified model. A model is used to represent a concept that exists in the real world. This will make it easy for you to understand what motivates cybersecurity events. Let's start with examining the model diagrammed in Figure 250.

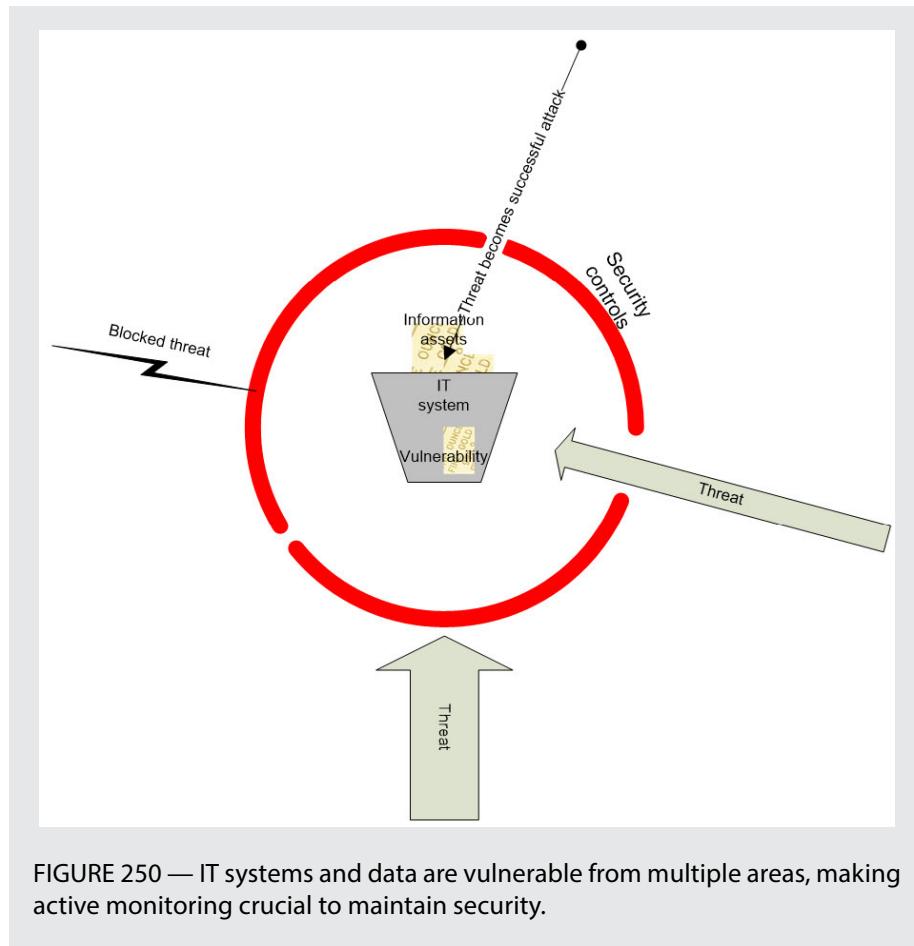


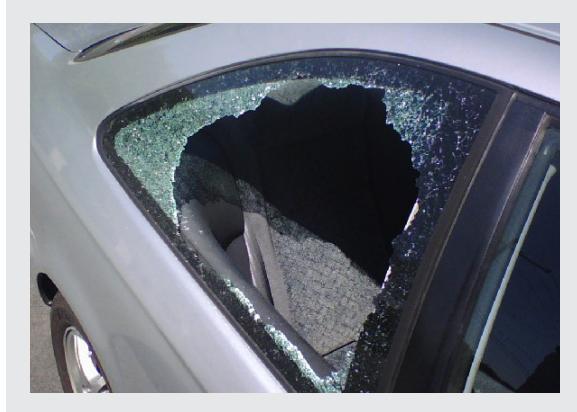
Figure 250 represents a framework for understanding information security. The core components of this model illustrate the relationship between **assets**, **vulnerabilities**, **threats**, and **controls**. These four components are extremely important to understand any cybersecurity event or case where information is the target.

²⁶⁴ Yudhijit Bhattacharjee, "How a Remote Town in Romania Has Become Cybercrime Central," *Wired*, Jan 31, 2011, <https://www.wired.com/2011/01/ff-hackerville-romania/> (accessed June 2023).

Assets

At the center of Figure 250 are assets. In the context of information security, *an asset is defined as a resource or information that is to be protected*. All security scenarios, whether related to information security or simply related to securing one's own property, start with an asset that is considered valuable enough for you to put forth special efforts on protecting it from harm. Information security is no different. If some information or related resource is valuable to the organization, the organization needs to put forth a special effort to secure it.

There are, however, two important differences between conventional assets and information assets—**invisibility** and **duplicability**. In most security scenarios that you are likely to be familiar with, the items to be protected can be seen and felt. For example, you lock your cars to prevent theft. You install home alarm systems to prevent home break-ins. In both cases, the assets are visible to the naked eye. The damage is also visible. If someone breaks into your car or home, the damage is immediately visible. If there are closed-circuit cameras in the vicinity, they will capture the act of vandalism.



But information security is different. The assets in information security are not tangible artifacts that can be seen and felt. Instead, they are data and information stored as 0s and 1s on computers, tapes, phones, and other devices. While the hard drives and other devices are themselves visible, the valuable data stored on these devices is invisible. If the data is stolen over the network, the transfer of data is not visible to cameras or other conventional security devices. The thieves may even operate from another country, thousands of miles away, safe from the scrutiny of conventional security agencies.

The second important difference between conventional assets and information assets is **duplicability**. Continuing with the car example, if your car is stolen, you will notice the missing car in the morning. This is because the car can only exist in one place at any given time. However, information can be duplicated. If your data is stolen, you will not notice the theft until it is brought to your attention. For example, if someone finds your laptop unattended, emails a copy of your assignment to himself and submits the copied assignment as his own work, you will have no idea of the act of plagiarism unless the instructor brings it to your attention.

These two differences between conventional assets and information assets—**invisibility** and **duplicability**—make information security a considerably different challenge than conventional security. Conventional security methods such as locks and guards are not very effective at maintaining information security. For example, conventional locks will do little to prevent the theft of data over the network. A stolen conventional asset such as gold can be recovered and restored to its owner. But stolen data may be copied to a hundred locations and even if a few of these copies are destroyed, it is almost impossible to deny the thief the benefit of having access to the data. Information security controls, therefore, must try to prevent theft in the first place and detect and block thefts as they occur through constant monitoring.

IT Assets

In the most common scenario you will encounter, the information assets are stored in an IT system. Paper-based systems simply cannot provide the density of information storage required by modern organizations. An IT system is defined as *an assembly of computer hardware, software, and firmware, configured for the purpose of processing, storing, or forwarding information*. In a small family-owned business, this IT system may be as simple as an Excel spreadsheet.

Threats

A threat is defined as *the capabilities, intentions, and attack methods of adversaries to exploit or cause harm to assets*. In the Excel example, a worker may want to exploit the lack of password protection on the file and modify their hourly rate. These threats are shown in the framework of [Figure 250](#) as arrows.

Today, it is common practice among cybersecurity professionals to use a framework created by Mitre called "MITRE ATT&CK."²⁶⁵ Mitre is a non-profit federally funded research and development organization. This framework from Mitre includes real-world observations through a globally accessible knowledge inventory of tactics and techniques used by cybercriminals to exploit vulnerabilities in IT systems. The MITRE ATT&CK knowledge inventory is a tremendous source for what is called threat intelligence. NIST (National Institute of Standards and Technology) defines threat intelligence as:

*Threat information that has been aggregated, transformed, analyzed, interpreted, or enriched to provide the necessary context for decision-making processes.*²⁶⁶

Basically, there are public and private threat intelligence resources available to cybersecurity professionals that provide a collection of information necessary to understand the global threats actively seeking to exploit the vulnerability of IT system assets. For instance, [Figure 251](#) illustrates a threat intelligence report published by the MITRE ATT&CK knowledge base that warns of three threats (Axiom, GOLD SOUTHFIELD, and Hikit), which have been used to execute phishing campaigns to gain access to victim IT systems.²⁶⁷



²⁶⁵ MITRE ATT&CK home page, <https://attack.mitre.org/> (accessed June 2023).

²⁶⁶ NIST, Computer Security Resource Center, https://csrc.nist.gov/glossary/term/threat_intelligence (accessed June 2023).

²⁶⁷ "Phishing, Sub-techniques," T1566, MITRE ATT&CK, <https://attack.mitre.org/techniques/T1566/> (accessed June 2023).

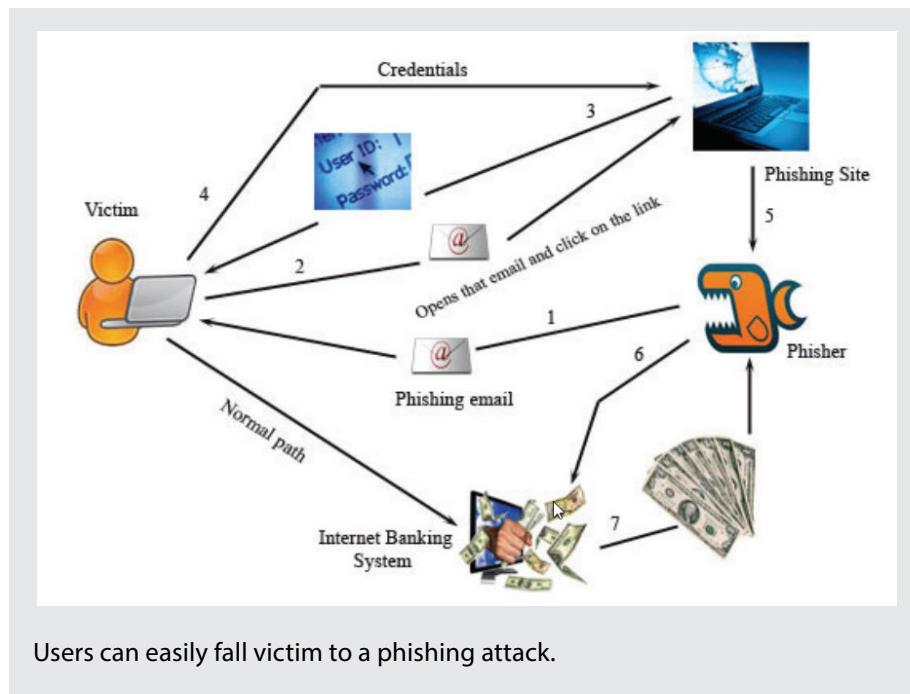
ID	Name	Description
G0001	Axiom	Axiom has used spear phishing to initially compromise victims. ^{[1][2]}
G0115	GOLD SOUTHFIELD	GOLD SOUTHFIELD has conducted malicious spam (malspam) campaigns to gain access to victim's machines. ^[3]
S0009	Hikit	Hikit has been spread through spear phishing. ^[2]

FIGURE 251—Threat intelligence resources make referencing and identifying malicious attacks easier for professionals.

As illustrated in Figure 251, Axiom is a suspected Chinese cyber espionage group while GOLD SOUTHFIELD is a group motivated for financial gain. Both groups are considered global threats to cybersecurity. The third name mentioned in Figure 251, Hikit, is classified as malware that can be used to remotely connect to an IT system for the purpose of creating a persistent threat. Persistent threats are used to cause damage to an IT system at any time a **malicious actor** chooses.

The most popular types of threats observed in cybersecurity include viruses, worms, phishing, and malware. Viruses and worms are *computer programs that adversely affect computers and propagate through the network without the user's consent*. The difference between a virus and a worm is that a virus uses other programs (e.g., the user's email client) to spread, whereas the worm can propagate all by itself. Since the authors of worms and viruses know that most users use antivirus software, modern-day worms and viruses are designed to cause all possible damage within minutes of release.

Phishing is *an attempt to compromise a user by masquerading as a trustworthy entity in electronic communication*. Early phishing attacks attempted to acquire information such as usernames, passwords, and credit card details. Most people receive at least one or two of these emails every week. The emails appear to originate from banks and lead users to visit a website that looks like the bank's website. At the website, users are asked to provide their username and password in order to make some correction at the bank. While the emails and target website appear to be legitimate, they really aren't. A careful look at the URL will show that the website has been hosted at a compromised server.



Malware (malicious software) is *a general term used to describe software or code specifically designed to exploit a computer, or the data it contains, without the user's consent*. A very common way for malware to reach computers is via free downloads where the malware author creates a computer software that appears to be very useful and distributes it for free. When unsuspecting users download and install this apparently useful software, the malware is installed along with it. This is called the Trojan horse technique.

Vulnerabilities

Information security becomes important because all systems have vulnerabilities. A vulnerability is *a weakness in an information system that gives a threat the opportunity to compromise an asset*. The vulnerability of an asset enables threats. In the case of the Excel-based IT system discussed above, such vulnerabilities include unauthorized access that may cause loss of confidentiality or integrity and hard drive failures that may cause loss of availability. If we reached some state of utopia where no vulnerabilities existed in IT systems, we would not have to study information security and would not need a cadre of professionals dedicated to information security. However, modern software products are large. For example, Microsoft Windows took millions of lines of code to create. It is difficult to anticipate and eliminate all possible vulnerabilities in such large products.

To deal with vulnerabilities, the software industry in collaboration with the federal government has invested considerable resources to create an inventory of known software vulnerabilities. This is the Common Vulnerabilities and Exposures (CVE) list.²⁶⁸ The CVE list aims to provide common names and identifiers for all publicly known software vulnerabilities. The list is also maintained by Mitre.

Vulnerabilities can be classified into specialized categories such as software vulnerabilities. A software vulnerability is *an error in the specification, development, or configuration of software such that its execution can violate the security policy*.²⁶⁹ For example, a software developer may create a website that requires user input within a textbox prior to submitting a form. However, if the developer does not write code to validate the input of the user on the web form it is possible for a malicious hacker to inject Structure Query Language (SQL) into the textbox when the form is submitted. This is also called a SQL Injection attack.

Figure 252 illustrates a SQL Injection attempt on ChatGPT.²⁷⁰ ChatGPT is a free Artificial Intelligence (AI) website by OpenAI that allows a user to enter text in a textbox. ChatGPT then analyzes the text and attempts to respond to the text using AI, similar to the way a human may answer a verbal query. Here, as seen in Figure 252, the user attempts to inject malicious SQL and ChatGPT does not allow the code to execute. This illustrates how the ChatGPT developers have written code that validates the user input to prevent any software vulnerabilities of the IT system.

268 The list can be accessed at <https://cve.mitre.org/> (accessed June 2023).

269 Krsul, I. "Software vulnerability analysis," unpublished PhD dissertation, Purdue University, 1988.

270 ChatGPT by OpenAI, <https://openai.com/blog/chatgpt/> (accessed June 2023).

C

or 1=1'--



This is a SQL injection attack attempt. It is trying to inject SQL code into a query in order to manipulate the database or retrieve unauthorized data. As an AI language model, I do not have the capability to perform or assist with such malicious activities. It is important to ensure that your systems are secured and updated to prevent SQL injection attacks.

FIGURE 252 — Some webpages are vulnerable to SQL injection attacks when characters are typed into the search bar.

Controls

All IT systems will be vulnerable for the foreseeable future. Also, in this timeframe there will be dedicated attackers threatening to exploit these vulnerabilities for personal gain or other motives. What does a system administrator do to defend the computers they are in charge of?

The role of information security is to minimize the impact of threats. This is done by deploying security controls around the vulnerable IT system. Security controls are *safeguards used to minimize the impact of threats*. Within the framework illustrated in [Figure 250](#), these controls are shown as the ring around the IT system. The width of the arrows in [Figure 250](#) indicates the relative frequencies of the different categories of threats seen by a typical organization. Most threats are blocked by the controls commonly adopted by organizations. For example, most operating systems now come with a firewall configured with some default settings and encourage users to use a strong password to secure the administrative user account on their computers. Commercially, even the smallest businesses backup their important files on external storage appliances or other Internet services and keep their computers locked to prevent unauthorized access.

Even rudimentary controls such as firewalls and passwords can successfully block a large majority of the threats facing organizations. However, as shown in [Figure 250](#), even the best security controls have holes. For example, users often prefer memorable passwords over secure passwords. They are also often irregular in backing up their data even if they have spent hundreds or thousands of dollars to purchase backup systems. Threats exploit these weaknesses in security controls to reach the vulnerable IT systems. These threats are shown by the arrow on the right, which has breached the controls and reached the IT system. Fortunately, many of these threats may yet do no harm, as shown by the inability of the arrow on the right of [Figure 250](#) to reach the IT system.

Cybersecurity controls can be classified as physical, procedural, and technical. Physical controls use traditional non-technical methods of preventing harm. Typically, they prevent unauthorized users from being able to enter technical facilities. Examples of such controls include locks, fire extinguishers, background checks, and doors. Procedural controls are prescribed plans of action that govern the use of computer resources. Examples of procedural controls include the procedures for obtaining computer accounts, procedures for escalating privileges, procedures for modifying programs, procedures for hiring, and requirements that users change their passwords periodically. Technical controls are the security measures built into the information system itself. Common examples include passwords, firewalls, intrusion detection systems, system updates, and antivirus software.

Cyber Hygiene

The US Cybersecurity & Infrastructure Security Agency (CISA) defines [cyber hygiene](#) as those practices that reduce the risk of a successful cyber-attack.²⁷¹ Today, it is important for people to understand how to use good cyber hygiene practices in order to safely use online IT systems and resources. Some intuitive practices of good cyber hygiene include simple measures of updating the security of your technical devices. For instance, if your mobile device has a software update, it will typically notify you by displaying an alert on your screen. A mobile device user can choose to ignore these updates or take the time to download and install them. Keeping your mobile device up to date is an excellent way to maintain good cyber hygiene and prevent cybercriminals from causing harm to your personal information.

Other types of good cyber hygiene practice include the use of end-point protection (formerly called antivirus) software and changing your passwords regularly. Antivirus software, such as McAfee,²⁷² are designed to protect your identity, privacy, and devices. This protection is accomplished through software products that are designed to monitor your devices for known viruses and other malicious technologies that have the intent of harming the user.

Password management is one of the most effective ways to practice good cyber hygiene. Keeping passwords safe and secure include practices such as:

- avoid using the same password for multiple accounts;
- change passwords on a regular basis;
- passwords should be at least 12 or more characters long;
- passwords should include a mixture of upper and lower-case letters plus symbols and letters;
- avoid obvious passwords such as sequential numbers like 1234 or personal information someone could acquire on your social media accounts such as your pet's name or your first car;
- avoid sharing passwords with others;
- use a password manager to help generate, store, and manage all your passwords in one security online account, for example: 1Password, <https://1password.com/>;
- use apps that require multi-factor authentication, for example, many social media accounts require a login username/password and a code sent as a text to your cell phone to complete the login process;
- back up your important files in a secure and protected location, for example, on an external hard drive or cloud storage;
- don't post private information such as your home address or phone number on social media accounts;

²⁷¹ Cybersecurity & Infrastructure Security Agency (CISA), "Cyber Hygiene Services," <https://www.cisa.gov/cyber-hygiene-services> (accessed June 2023).

²⁷² McAfee, <https://www.mcafee.com/> (accessed June 2023).

- check all your social media privacy settings because each social media account is slightly different and designed to protect its users when settings are appropriately applied;
- keep your devices locked with a password or PIN when not in use;
- do not use websites or apps that disclose private information on a public Wi-Fi;
- only make online transactions on websites that are secure (this requires a URL with https:// rather than just http://);
- change the default name of your home Wi-Fi router—in other words, don't leave your home router with the same name it has been given by the manufacturer when you took it out of the box;
- setup a guest network on your home Wi-Fi so that guests in your home use this network instead of the one setup for your personal use;
- use firewalls to prevent malicious software from accessing your home network;
- encrypt devices that contain sensitive data, for example, removable USB drives; and
- before selling or disposing of a device, it is a good practice to wipe the hard drive clean.

Overall, people are typically the weakest link to a cybersecurity attack. Many cyber-attacks are designed to exploit the vulnerabilities of people and their poor cyber hygiene. For instance, cyber-attack techniques such as social engineering are used by malicious actors with the intent of getting people to expose specific information they would otherwise be unwilling to share. This specific information, exposed by poor cyber hygiene, can be used against a person to do horrible things such as stealing their identity or emptying their bank accounts. Therefore, as technologies evolve over time it will continue to be a basic necessity for the general population to stay informed on what it takes to practice good cyber hygiene.

Teams in Cybersecurity

Professionals who work in cybersecurity often work in teams to respond to or investigate a cybersecurity event. These teams must be familiar with the tactics, techniques, and procedures (TTP) used by bad actors in a cybersecurity event. Tactics can be described as the basic methods used by the hacker to gain access to a system or information. A technique may include the tools or methods used by the hacker to gain access to the system or information. Finally, the procedure describes how a hacker carries out the techniques step-by-step.

Cybersecurity teams need to be familiar with the TTPs known by the cybersecurity intelligence community in order to understand the behavior of a hacker. This behavioral understanding is what teams need to better protect companies and systems from being attacked. One of the world's largest open-source repository of TTP knowledge used by cybersecurity teams is the MITRE ATT&CK framework. Cybersecurity teams can use this real-world threat intelligence to help make the world a safer place to live.

Although people may commonly call a bad actor a malicious hacker, not all hackers are bad. Cybersecurity teams have evolved over time to specialize in different areas of behavior commonly engaged by hackers. In fact, the members of these specialized teams could also be called hackers.

Essentially, hackers are classified by the intent of their behavior. Whether the actor has bad or good intentions, cybersecurity teams must understand all classifications of hacker behavior.

The following summarizes the two common types of cybersecurity teams that specialize in the TTPs used by actors involved in a cybersecurity event:

Red Teams: These cybersecurity teams consist of operators that use tools and techniques typically used by malicious actors to attack a system or the information it manages. If this were a sport, you could think of Red Teams as the “offense.” Cybersecurity attacks executed by Red Teams are often called campaigns. The intent of a Red Team operator (hacker) is to help companies understand how their security weaknesses (vulnerabilities) can be exploited by a malicious actor. This understanding can help the company put better business and technology practices in place to protect their systems from future attacks.

Blue Teams: These cybersecurity teams focus on the constant defense of systems and information managed by organizations. It is common for companies to work with Security Operation Centers (SOC), which consist of multiple Blue Teams dedicated to keeping a close watch on all the systems critical to conducting their daily business. Blue Teams are trained to use tools designed to protect, capture, analyze, and respond to a cybersecurity event. For instance, in the event a company’s system is attacked by a malicious actor or malware a Blue Team will work together to investigate what happened. Once they understand what happened, they will work to understand how it happened and recommend a mitigating response to prevent the event from happening again.

Overall, you can consider cybersecurity as a “team sport.” It requires teams of individuals working together to endlessly understand the offensive and defensive TTPs used by hackers across the globe. Ultimately, these “good” hackers are motivated with a passion to prevent the “bad” hackers from harming the security of information and the management of critical systems.



Chapter Terms and Definitions

Asset: A resource or information that is to be protected

Brute Force Attack: A programming script designed to repeatedly execute its code while attempting to log into a system with a user account

CIA Triad: The provision of confidentiality, integrity, and availability; by protecting information and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction

Control: Safeguards used to minimize the impact of threats

Cyber Hygiene: The practices that reduce the risk of a successful cyber-attack

Cybersecurity: Prevention of damage to, protection of, and restoration of computers, electronic communications systems, electronic communications services, wire communication, and electronic communication, including information contained therein, to make sure its availability, integrity, authentication, confidentiality, and nonrepudiation

Denial of Service Attack: The act of more than one networked computer overwhelming a network with fraudulent traffic

Hacker: A person who wishes to gain access to an identified target to learn more about the target and exploiting the target for an attack

Information Security: Protecting information and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction in order to provide integrity, confidentiality, and availability

Malicious Actor: Someone or something that causes harm in the digital domain

Phishing: Attempting to compromise a user by masquerading as a trustworthy entity in electronic communication

Social Engineering: When deception is used to make a person give up private information or provide unauthorized access to a computer system or network

Threat: The capabilities, intentions, and attack methods of adversaries to exploit or cause harm to assets

Virus: A computer program that uses other programs to spread and adversely affect computers and propagate through the network without the user's consent

Vulnerability: A weakness in an information system that contributes to a threat with the opportunity to compromise an asset

Worm: A computer program that can propagate all by itself and adversely affect computers and propagate through the network without the user's consent



Chapter Case

The Red Team Operators

NIST defines a “Red Team” as a group of people authorized and organized to emulate a potential adversary’s attack or exploitation capabilities against an enterprise’s security posture. The Red Team’s objective is to improve enterprise cybersecurity by demonstrating the impacts of successful attacks and by demonstrating what works for the defenders (i.e., the Blue Team) in an operational environment. Also known as Cyber Red Team.²⁷³ In the figure below, two Red Team operators are attempting to exploit any vulnerabilities by the Widget Inc. Human Resources (HR) department.

Damian Hatter, Red Team Operator 1, walked past the Widget Inc. HR department and looked through several of the windows to observe the general layout of the room prior to entering. He noticed that a single HR clerk was sitting behind a front desk and there were several workstations positioned across the room that were shielded by cubicle walls. Hatter then walked in the HR department and approached the HR clerk behind the front desk. He asked the clerk if he could fill out an application for a job opening. The clerk then directed him to sit down at a workstation and click the shortcut icon located on the PC desktop to begin the application process. Hatter then proceeded as instructed by sitting down at one of the workstations while the clerk remained sitting behind the front desk.

Shortly after Hatter sat down at a workstation, he began to evaluate the PC for vulnerabilities. His primary goal was to implant a backdoor²⁷⁴ and maintain network persistence²⁷⁵ through a remote command and control server (C2).²⁷⁶ To accomplish this, he first started with verifying that he could use one of the open USB ports located on the PC. He reached into his pocket, pulled out his USB flash drive, and inserted it into an open USB port. The Windows Operating System immediately responded with a notification confirming that the USB port access was enabled. Upon confirmation, Hatter proceeded with opening his USB flash drive and executed a malicious program he had installed earlier prior to leaving his office desk. The malicious program running on his USB flash drive then successfully communicated with his C2 instance running on a remote system located offsite

²⁷³ National Institute of Standards and Technology (NIST), Computer Security Resource Center, “Red Team,” https://csrc.nist.gov/glossary/term/red_team (accessed June 2023).

²⁷⁴ “Backdoor (computing),” TechTarget, August 2017, https://www.techtarget.com/searchsecurity/definition/back-door?Offer=abMeterCharCount_var3 (accessed June 2023).

²⁷⁵ Maloney, Sarah, “What is an advanced persistent threat (APT)?” Cybereason, 1/9/2018, <https://www.cybereason.com/blog/advanced-persistent-threat-apt> (accessed June 2023).

²⁷⁶ “Command and Control Server,” TechTarget, January 2017, <https://whatis.techtarget.com/definition/command-and-control-server-CC-server> (accessed June 2023).

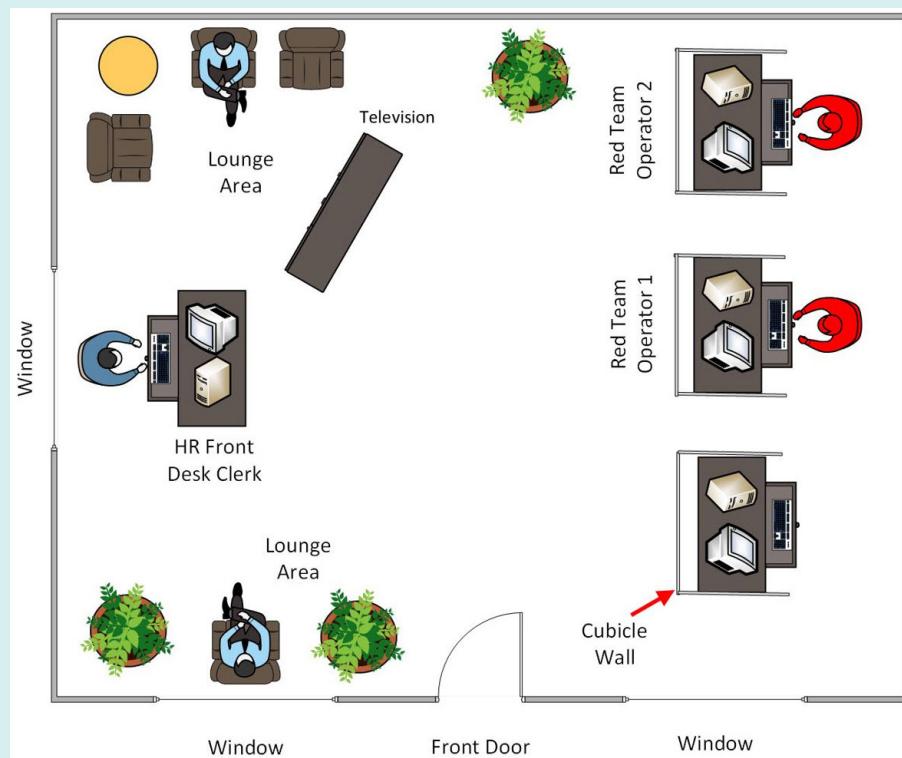


Chapter Case (continued)

from Widget Inc. Once he confirmed that his C2 instance could communicate with the malicious program executed from a networked PC located inside of the Widget Inc. network, his goal was complete. Hatter then ejected his USB flash drive, placed it in his pocket, and left the HR room.

As soon as Hatter left the HR room, Wanna Bee, Red Team Operator 2, walked in and went directly to a workstation without confronting the HR desk clerk. As soon as he sat down at the workstation, he immediately used a web browser to navigate to a website that he had previously setup on a remote webserver for the purpose of downloading malicious software. The user account setup on the PC had enough privileges to download and execute applications directly from the Internet. Upon successfully downloading and executing the malicious software, Bee was able to communicate with the remote C2 system.

Hatter and Bee had successfully gained unauthorized persistent access to the Widget Inc. network. This was accomplished through exploiting unsecure physical and technical entry points.



Illustrates a Red Team operation on a company's Human Resources (HR) department.

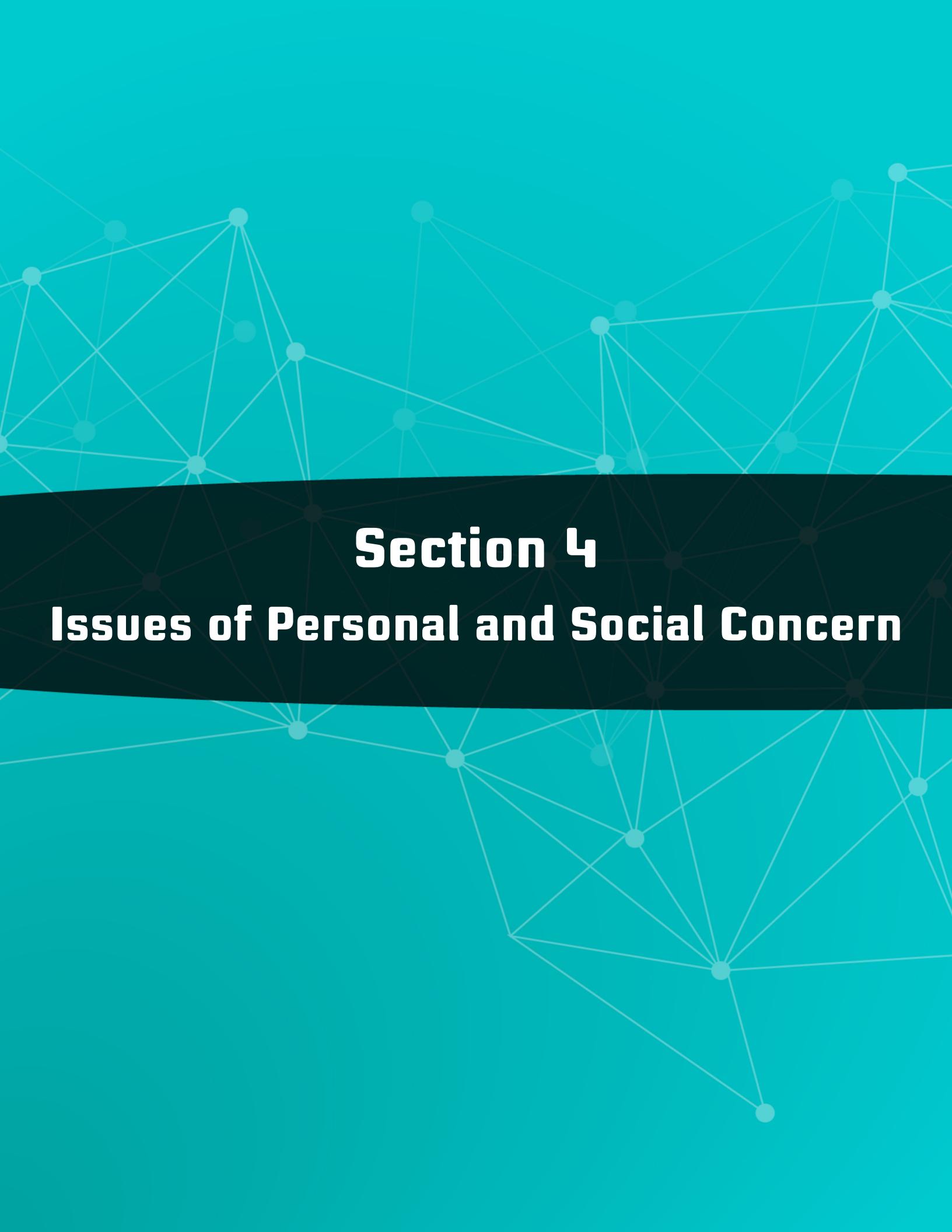


Chapter Case (continued)

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Question 1: What vulnerabilities do you think exist in the HR department?

Question 2: Identify as many cybersecurity controls as you can that you think should be added to the HR department based on this case scenario. Be sure to consider physical, procedural, or technical controls.



Section 4

Issues of Personal and Social Concern

Ethical Issues in Information Technology

17

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Ethics is knowing the difference between what you have a right to do and what is right to do.

—Potter Stewart, former Associate Justice of the US Supreme Court

Overview

Ethics are a community's shared beliefs about what is good for the individual and for society and the duties that people owe themselves and one another.²⁷⁷ The word "ethics" traces to the Greek word ἡθος (ethos), which describes the guiding ideals of a community. Though some ethical principles may be codified as law, ethics are more commonly enforced by disapproval among members of the community. For example, not breaking a promise to a friend is a common ethical principle. It is not prohibited by the law; however, strong disapprovals ensure that friends do not break promises among each other.

Today, we talk of ethics in most workplaces as the expectations of the membership in the organization or profession. These ethical principles help the organization, profession, and community to flourish and prosper. Much like the consequences of breaking promises among friends, failure to abide by these ethical principles can lead to dismissal from the organization or profession, even if the specific conduct does not violate the law. Ethics are a strong force that help communities prosper.

Ethics have evolved with time. One of the oldest and most influential texts in western thought is Aristotle's, *Nicomachean Ethics*.²⁷⁸ In the book, Aristotle (384–322 BC) aims to search for the highest good in life. He begins by asserting that the highest good in life has three characteristics: (1) it is desirable for itself, (2) it is not desirable for the sake of some other good, and (3) all other goods are desirable for its sake.²⁷⁹ He then identifies εὐδαιμονία (eudaimonia), translated as happiness/living well, as this highest good. These ideas have guided society since our earliest days, and ethics may be seen as our quest to use our own reasoning to act in ways that maximize happiness over a lifetime.

With regard to modern times, our use of networked computers has introduced several unique ethical concerns. Several common practices from earlier times raise ethical concerns when powerful computers and high-speed networks become available to everybody. Most of these contemporary ethical concerns are associated with the use of information, and we will highlight some of the most salient concerns in this chapter. As an example of how computers make a long-standing practice an ethical concern, consider music sharing. Artists spend long hours creating a song and invest considerable money packaging it into an album. In olden days when people listened to music on cassette tapes, it helped everybody if music-lovers made copies of songs they had purchased. For example, to create a collection of songs to listen to on the road. It was even considered acceptable for users to make copies of these personal collections for friends, because eventually many of those friends would buy their own copies of the original albums for their superior audio quality. These

277 Definition of Ethics, Cornell Law School, <https://www.law.cornell.edu/wex/ethics> (accessed June 2023).

278 *Nicomachean Ethics*, Aristotle <http://classics.mit.edu/Aristotle/nicomachaen.html> (accessed June 2023).

279 "Aristotle's Ethics," Stanford Encyclopedia of Philosophy, <https://plato.stanford.edu/entries/aristotle-ethics> (accessed June 2023).

copies, therefore, served a marketing purpose for the artists, and everyone benefited. This was even codified as the Fair Use Act, which we will discuss [later in this chapter](#).

However, with computers, it is now easy to make flawless copies of original music and distribute it widely to the entire world at no cost. This reduces revenues for artists, which reduces their incentives to create new music, which hurts everybody. There is, therefore, a need to develop appropriate ethical principles for music distribution in the digital era, which provide financial incentives for the artists as well as listening freedoms to consumers for the music they have purchased. Most ethical concerns with computers and networks can be traced to this general idea.

Ownership Rules

Most users believe everything available online is free to use as they please, because they can hop from one website to another and gather a ton of information without buying any tickets or paying any fees. In reality, everything you see on the World Wide Web is “owned” by someone, usually the creator or publisher of the information. Users are expected to recognize this ownership of images, text, media, or ideas they find on the Internet. The online world has ownership rules just like the real world, and you need to be aware of them to be a good [netizen](#) and avoid getting into legal trouble. In this chapter, we highlight a few terms that existed long before the Internet arrived but have gained special importance with the advent of computers and online resources.

Copyright

[Copyright](#) is a type of intellectual property that protects original works of authorship as soon as an author fixes the work in a tangible form of expression.²⁸⁰ The combination of originality and fixation gives the creator copyright over the work. Copyrights for “works made for hire” are owned by the employer and copyrights for work commissioned by a publisher are owned by the publisher. Copyright does not protect ideas or facts per se, but an original expression of an idea in a tangible form is protected by copyright. Thus, several people can own the copyright to the same idea or fact, each based on the originality the creator brings to the idea or fact. For example, multiple photographers can take pictures of the same sunrise from the same location, and each photographer will own the copyright to their own photographs, since they are the photographer’s original expression of the idea, expressed in tangible form as a photograph.

Since January 1, 1978, creators own the copyright until seventy years after the author’s death. Copyright protection for works made for hire is 95 years from publication or 120 years from creation, whichever is shorter. An interesting copyright case with particular reference to Florida is Disney’s copyright over several beloved characters, including Mickey Mouse.²⁸¹ The 95-year copyright deadline for Mickey Mouse is in October 2024.

If a content is copyrighted, the creator of the content has complete ownership of the work. Even if copyrighted material is publicly displayed online, you cannot use it personally without the explicit

280 “What is Copyright?,” <https://www.copyright.gov/what-is-copyright/> (accessed June 2023).

281 “Disney could soon lose exclusive rights to Mickey Mouse,” The Guardian, <https://www.theguardian.com/film/2022/jul/03/mickey-mouse-disney-copyright-expiry> (accessed June 2023).

permission of the creator. This test becomes even more stringent if you use copyrighted content in commercial work, where you anticipate some income. Search engines can help you find images with license terms that allow you to incorporate them in your own work.²⁸²

Beginning with the 1978 report of the National Commission on New Technological Uses of Copyrighted Works (CONTU), an author's original creation expressed as computer software can be copyrighted. Computer software is, therefore, also subject to copyright laws. In the early days of the computer industry, computer manufacturers bundled software at no additional cost to help buyers make the best use of their expensive computers. However, in January 1969 the US government filed a lawsuit against IBM, the dominant computer company of the time, calling this practice of bundling software with hardware as anti-competitive.²⁸³ Software became an independent marketable product, and as the cost of creating computer software rose, an independent computer software industry emerged. The copyright protections created further incentives to create and monetize computer software.

The ethical principle of copyright protection is well codified in law. Software companies take former employees to court for copying company code and offering it to competitors. However, the issues involved often become complicated for lawyers, judges, and juries to understand.²⁸⁴

However, several developers and even leading software vendors have continued to offer their computer code to the public for free for various reasons. Some individuals are motivated by the general good of humanity. A leader in this school of thought is Richard Stallman who created the Free Software Foundation²⁸⁵ in October 1985 to create software that users can run, edit, contribute to, and share freely.²⁸⁶ Other motivations include establishing standards in an area critical to a company's success. For example, Google has made the source code for its Chrome browser available for free²⁸⁷ and Microsoft has made the source code for its web application development technology (MVC Core) available for free.²⁸⁸

Open-Source Software (OSS) is software whose source code is designed to be publicly accessible. Open source is a popular term in the industry. Much critical Internet infrastructure runs on open-source software such as the Linux Operating System. Contributing to open-source projects can be a great learning and rewarding experience. However, using open-source code within the commercial

282 A good example can be found on Google's help page, "Find images you can share and use," <https://support.google.com/websearch/answer/29508> (accessed June 2023).

283 "Software Becomes a Product," Computer History Museum, <https://www.computerhistory.org/revolution/mainframe-computers/7/172> (accessed June 2023).

284 For example, in the case of Sergey Aleynikov found in the article, "Judge overturns conviction of Goldman Sachs programmer for stealing code," <https://nakedsecurity.sophos.com/2015/07/08/judge-overturns-conviction-of-goldman-sachs-programmer-for-stealing-code/> (accessed June 2023).

285 The Free Software Foundation homepage, <https://www.fsf.org/> (accessed June 2023).

286 The foundation defines freedom in "What is Free Software?" <https://www.gnu.org/philosophy/free-sw.en.html> (accessed June 2023).

287 The open-source browser project, Chromium, is described at <https://www.chromium.org/Home/> (accessed June 2023).

288 ASP.net Core, is described at <https://github.com/dotnet/aspnetcore> (accessed June 2023).

code of a company can create several risks to the commercial product.²⁸⁹ Therefore, if you work for a for-profit software company, you should talk to your legal department before taking advantage of any open-source software within the product. Software companies typically scrutinize their code to ensure that no open-source code has crept into their software.

Public Domain

The body of creative work to which no intellectual property rights apply is considered to be in the **public domain**. Creative work generally comes within the public domain either because the work is not eligible for copyright protection in the first place, or because copyright protection on the work has expired, for example, 70+ years after the death of the author.²⁹⁰ For example, the book *Nicomachean Ethics* is now in the public domain because it's been millennia since the death of its author(s). You can use material in the public domain extensively in your own creative works even though you cannot own it.

Project Gutenberg is an easily accessible library of most classic books that are in the public domain.²⁹¹ Books available at Project Gutenberg include *Alice in Wonderland*²⁹² and *The Adventures of Sherlock Holmes*.²⁹³

Fair Use

Fair use is any copying of copyrighted material done for a limited and “transformative” purpose, such as to comment upon, criticize, teach, research, or parody a copyrighted work.²⁹⁴ Fair use principles allow the use of copyrighted materials without permission from the copyright owner. Fair use balances the interests of the copyright owner and freedom of expression by allowing unlicensed use of copyright-protected works in certain circumstances.²⁹⁵

Fair use is a legal doctrine that promotes freedom of expression by permitting the unlicensed use of copyright-protected works in certain circumstances.

—Section 107 of the US Copyright Act

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- 289 “Risk Management of Free and Open Source Software”(FOSS) is explained by the Federal Financial Institutions Examination Council, <https://www.federalreserve.gov/boarddocs/srletters/2004/sr0417a1.pdf> (accessed June 2023).
- 290 “The Public Domain,” University of California, <https://copyright.universityofcalifornia.edu/use/public-domain.html> (accessed June 2023).
- 291 The Project Gutenberg homepage, <https://www.gutenberg.org/> (accessed June 2023).
- 292 Lewis Carroll, *Alice’s Adventures in Wonderland*, Project Gutenberg, <https://www.gutenberg.org/ebooks/11> (accessed June 2023).
- 293 Arthur Conan Doyle, *The Adventures of Sherlock Holmes*, Project Gutenberg, <https://www.gutenberg.org/ebooks/1661> (accessed June 2023).
- 294 “What is Fair Use?,” Stanford Libraries, <https://fairuse.stanford.edu/overview/fair-use/what-is-fair-use/> (accessed June 2023).
- 295 The US Copyright Office Fair Use Index, <https://www.copyright.gov/fair-use/> (accessed June 2023).

Section 107 of the Copyright Act specifies the framework for fair use.²⁹⁶ Generally, fair use guidelines in the US allow the use of brief excerpts of copyrighted material for teaching, research, criticism, commentary, or news reporting. If you have any doubts or concerns about fair use, you may want to contact the copyright owner. Most companies have information about fair use of their copyrighted material.²⁹⁷

Plagiarism

Plagiarism is the use of someone else's words or ideas in your own work without permission, attribution, or acknowledgment.²⁹⁸ The ethical principles around plagiarism protect intellectual creativity in a society and encourage creative expression of ideas in all possible forms. Since ideas build on each other, you can use the specific creative expression of another person or published material. However, when doing so, you are required to clearly demarcate the creative expression of the other person and cite the source of the borrowed expression. For short expressions, it is appropriate to use quotation marks around the borrowed words and cite the source. For more extensive content, it is appropriate to paraphrase or summarize the information, while citing the source. Citing the source gives the reader the opportunity to engage directly with the original creator's full expression. If these procedures appear unnecessarily tedious, consider how you'd feel if the content you created was used by others without attribution to you.

It is possible to plagiarize unintentionally without meaning to do so. For instance, when looking up information online, you must take special care not to plagiarize, as everything on the web seems to be publicly available for general consumption. In the academic world, technology such as TurnItIn²⁹⁹ checks submitted work against a database of all prior published and submitted work to detect potential plagiarism and instill the discipline of attribution among students.

Computer technologies can help businesses detect plagiarism to protect their patented/copyrighted material and also make sure they do not plagiarize content intentionally or unintentionally. In the publishing world, a plagiarism check is a critical step in the publishing process for books and magazines.

Plagiarism is an example of an ethical principle that is not illegal.³⁰⁰ However, plagiarism is considered a serious violation of ethical codes and can lead to significant disciplinary action, including dismissal from an organization. Copyright owners can also initiate legal action for plagiarism.

296 17 USC 107, <https://www.copyright.gov/title17/92chap1.html#107> (accessed June 2023).

297 For example, see <https://about.google/brand-resource-center/guidance/> for Google "Guidance," or <https://www.mcdonalds.com/us/en-us/contact-us/trademark-permission.html> for McDonald's "Trademark Permission" (accessed June 2023).

298 "What is Plagiarism?" Academic Integrity at MIT: A Handbook for Students, <https://integrity.mit.edu/handbook/what-plagiarism> (accessed June 2023).

299 Turnitin homepage, <https://www.turnitin.com/> (accessed June 2023).

300 Definition of Plagiarism, Cornell Law School, <https://www.law.cornell.edu/wex/plagiarism> (accessed June 2023).

Piracy

Piracy is the unauthorized copying, distribution, and selling of copyrighted content.³⁰¹ While plagiarism involves passing off another's creation as your own, piracy involves distributing another's creation without permission, without claiming it as your own. Piracy is typically relevant for creative expression with immediate monetary value, for example music, movies, TV shows, and software.

One of the best-known examples of piracy was the use of Napster to distribute music around 2000.³⁰² Napster claimed that its service was an example of fair use—helping customers sample music before buying. But the courts concluded that the Napster service was really commercial, given the volume of copying and distribution involved.

The media industry uses several measures to prevent piracy including encryption and user-friendly apps with reasonable pricing.

Ethics and Online Content

Ethical use of the web does not only involve the use of information consumers find on websites. Individuals, companies, and users responsible for maintaining, monitoring, tracking, and posting on sites also have an ethical responsibility to the site's consumers.

Online Privacy

Privacy is understood as the right to be left alone.³⁰³ In various judgments, the Supreme Court has found that the first, third, fourth, and fifth amendments give individuals a right to privacy. This right extends to privacy over one's information. In 1974, the Privacy Act established a code of fair information practice for the collection, use, and dissemination of personally identifiable information by federal agencies. These principles have guided personal privacy protections in various laws established for specific contexts such as healthcare (HIPAA) and education (FERPA).

The individual right to privacy creates responsibilities for anyone storing personal information about anyone else. This is where [online privacy](#) is important. Information you collect about others should be used only for the express purpose for which it is collected. You must be particularly careful about the privacy of your users if your work involves finding and storing personal information online. Fraud and online identity theft being big concerns, you need to have a safe way to handle the personal and copyrighted information of your customers and vendors. For example, if you create a website for a fast-food chain and take the credit card information of your patrons to process transactions, you are responsible for securing the information and ensuring it is not misused. Similarly, teachers are responsible for safeguarding in their computers the personal and academic information of students.

301 "About Piracy," RIAA, <https://www.riaa.com/resources-learning/about-piracy/> (accessed June 2023).

302 *A&M Records, Inc. v. Napster, Inc.*, 239 F.3d 1007 (9th Cir. 2001), <https://www.copyright.gov/fair-use/summaries/a&mrecords-napster-9thcir2001.pdf> (accessed June 2023).

303 "History of Privacy Timeline," Safe Computing, University of Michigan, <https://safecomputing.umich.edu/privacy/history-of-privacy-timeline> (accessed June 2023).

Healthcare workers in the US have the additional responsibility of complying with HIPAA, which dictates how to store, handle, and dispose of sensitive health data of patients. If you intern at a bank or in the financial industry, you may have to follow protocols specific to the industry for dealing with privacy issues.

Social Media Addiction

Evidence increasingly suggests that online content, particularly the content offered by social media, has created a new form of addiction for many adults and children, who are glued to their computers and phones, wasting away their days in the virtual world, playing games, and watching videos. One reason suggested for this addiction is the instant gratification offered by social media.³⁰⁴ Following friends on social media makes us feel good and release a chemical in the brain called Dopamine. A Dopamine release happens during experiences that increase our chances of survival, for example, upon finding food or shelter. This is nature's mechanism to direct us toward behaviors that help us flourish as a species. Unfortunately for the human species, particularly in developed nations, as scarcity has been replaced with plenty, this Dopamine-mediated survival mechanism has become an addiction mechanism. People crave pleasure and seek out pleasurable experiences, which are now within easy reach. For some, drugs offer these chemical mediators directly. For others, social media delivers these pleasurable and thereby addicting experiences. The term "Dopamine Nation" captures this phenomenon.³⁰⁵

There are also adverse effects from these addictions. Estimates suggest that when visual social media (e.g. Instagram) became dominant among teenagers and access to high-speed wireless Internet significantly increased, teen girls' mental health diagnoses increased by as much as 90% relative to teen boys.³⁰⁶ Possible mechanisms include reduced self-esteem and reduced body image, which affects both boys and girls, but has a greater impact on girls.³⁰⁷ Thus, widespread use of computers and networks can have significant adverse effects, with some demographic groups affected more than others. This is an important concern for national competitiveness and is likely to draw increasing attention from parents and lawmakers in the coming years.

Online Tracking

Search companies, ecommerce companies, and social media companies have a commercial interest in knowing about your personal interests. They use the vast computing power and algorithmic expertise at their disposal to analyze your browsing behaviors and store detailed information about your preferences in their databases. For example, you may have noticed that if you search for shoes

304 Bruce Goldman, "Addictive Potential of Social Media, Explained," Scope, Stanford Medicine, <https://scopeblog.stanford.edu/2021/10/29/addictive-potential-of-social-media-explained/> (accessed June 2023).

305 Anna Lembke, MD, *Dopamine Nation*, <https://www.annalembke.com/> (accessed June 2023).

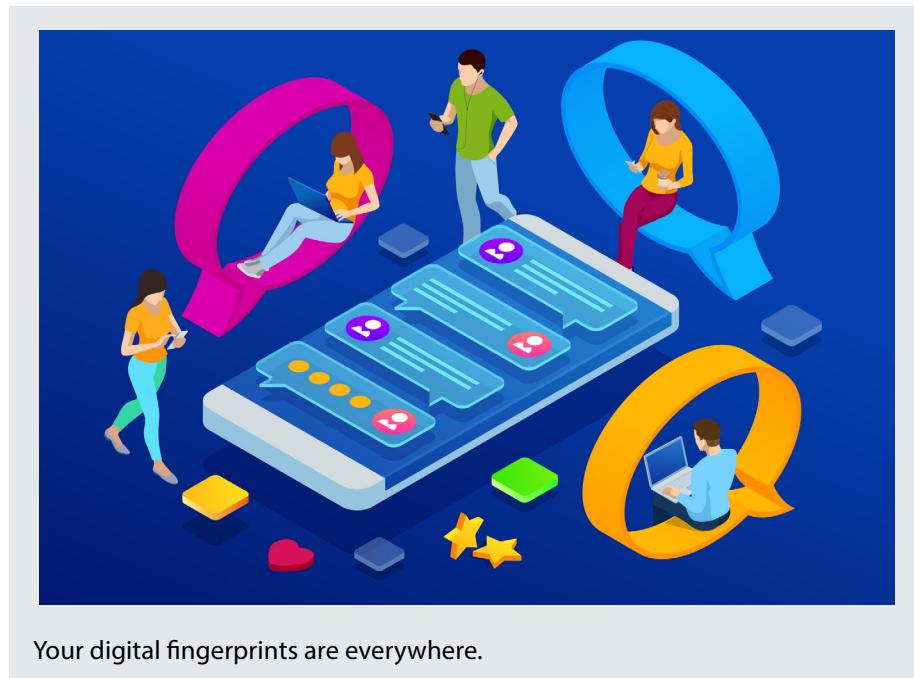
306 Elaine Guo, "Social Media and Teenage Mental Health: Quasi-Experimental Evidence," 2022, Working Paper.

307 Yvonne Kelly, "Social Media Use and Adolescent Mental Health: Findings From the UK Millennium Cohort Study," [https://www.thelancet.com/journals/eclim/article/PIIS2589-5370\(18\)30060-9/fulltext](https://www.thelancet.com/journals/eclim/article/PIIS2589-5370(18)30060-9/fulltext) (accessed June 2023).

on your browser, advertisements for shoes begin to show up in your TikTok feed, your Facebook and Instagram pages, and other websites you may visit. You may even see mailers for shoes show up at your home address.

Something as benign as lingering too long on a TikTok video, liking a post on Facebook, or searching for a device on Google is equivalent to standing in a public square and raising a flag to trumpet your personal interest.

While **tracking** customers to sell shoes may seem harmless, online trackers are capable of other practices that may not be as harmless.



Your digital fingerprints are everywhere.

Political Impacts

The Internet has also given a great new tool to governments eager to manipulate and/or monitor their citizens' opinions. Rogue regimes can now fight bloodless wars by influencing voter opinion in democracies, and disabling critical infrastructure such as the power grid.³⁰⁸ Digital authoritarianism is the term used to describe the actions of countries to influence and coerce private citizens and businesses in other countries to advance their own interests.³⁰⁹ These actions are considered unethical in most countries.

Additionally, in some authoritarian countries, the Internet is a highly monitored zone where behaviors and words are tightly controlled. The authorities can get notified if you search for certain phrases.

308 "Securing the US Electricity Grid from Cyberattacks," USGAO, <https://www.gao.gov/blog/securing-u.s.-electricity-grid-cyberattacks> (accessed June 2023).

309 "Cyber Operations Enabling Expansive Digital Authoritarianism," National Intelligence Council Assessment, <https://www.dni.gov/files/ODNI/documents/assessments/NICM-Declassified-Cyber-Operations-Enabling-Expansive-Digital-Authoritarianism-20200407--2022.pdf> (accessed June 2023).

If you criticize the government in a social media post, not just you but even your friends may be answerable and may need to justify your action. Even buying thermometers or fever reducers could trigger a visit by health officials and a lock down of your building in a post-Covid world.

The use of the Internet and computers has changed how we live and think. It has had broad implications on our society and has affected how groups with opposing ideas engage with each other. Technology has given social media firms the ability to understand your passions, interests, and political inclinations, and group you with others similarly inclined.

By diverting and holding your attention with their algorithms, companies can influence your opinions in unprecedented ways. While their motivation is simply to get you to spend more time on their platform and make more money, they end up emphasizing our differences. Their actions can have a pernicious effect that can threaten the very fabric of our social structure.

Biases in Artificial Intelligence (AI) Models

Artificial intelligence is the ability of computers to do tasks that require intelligence and training. With the help of AI, we can train software programs to analyze vast amounts of existing information to predict the outcome of an event. As examples, AI models can analyze X-rays to detect tuberculosis and examine mammograms to identify cancerous tissues. AI models also enable self-driving cars to interpret images captured by a car's cameras to determine safe driving paths.

Although these AI models save time and lives, we introduce new ethical risks when we increase our reliance on them in matters central to human lives, such as criminal justice, healthcare, and finance. We may inadvertently introduce biases related to race, gender, age, and other human attributes into AI models, by the way we collect data to train the models. This may result in individuals of certain backgrounds being denied loans, rental opportunities, and admittance into colleges. For example, in 2015, Amazon discovered that an AI model they had built to identify potential high-performing software developers was biased against women.³¹⁰ This happened because most developers at the company were men and Amazon's model learned to associate words more common on men's resumes with success. Similarly in 2016, a news organization claimed that an AI algorithm used by courts to predict whether a criminal was more likely to revert to crime (recidivism) was biased against black people.³¹¹ Similar biases can enter into



AI models without bias.

310 Roberto Iriondo, "Amazon Scraps Secret AI Recruiting Engine that Showed Biases Against Women," <https://www.ml.cmu.edu/news/news-archive/2016-2020/2018/october/amazon-scaps-secret-artificial-intelligence-recruiting-engine-that-showed-biases-against-women.html> (accessed June 2023).

311 Julia Angwin, Jeff Larson, Surya Mattu, and Lauren Kirchner, ProPublica, "Machine Bias," <https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing> (accessed June 2023).

AI models in other contexts, and as we delegate increasing responsibilities to AI, we should be aware of the ethical concerns raised by AI model bias.

AI models may detect too many false positives when analyzing the data of some ethnicities. A false positive happens when a model incorrectly identifies an individual as a fraudster, a criminal, or someone suffering from a disease or being at risk for certain medical conditions. False positives result in billions of dollars of unnecessary treatments, innocent individuals being tagged as offenders, and consumers being denied benefits. Since most of the data used to train and build the AI models is from the western world, these models also fail if we use them in other parts of the world without taking location into consideration.



Chapter Terms and Definitions

Artificial Intelligence: The science and engineering of creating intelligent computer programs

Copyright: A type of intellectual property that protects original works of authorship when an author fixes the work in a tangible form of expression

Fair Use: Ability to use material that is copyrighted for limited purposes and limited conditions (for example, we use the Apple logo in this textbook to depict what a technology company is)

Netizen: A user of the Internet

Online Privacy: Information on the Internet that shouldn't be accessible without permission

Online Tracking: Collecting, storing, and sharing information about visitors' activities on the web

Piracy: Unauthorized duplication and distribution of copyrighted material

Plagiarism: Claiming another entity's work as your own

Public Domain: Work exempt from copyright protection; also referred to as commons



Chapter Case

Allison's Report—To Plagiarize or Not To Plagiarize

Allison had just finished reading *Romeo and Juliet*, a tragedy written by William Shakespeare, as part of an assignment for her 4th period reading class. She was required to write a two-page report that summarized what she had learned from reading the novel and provide examples of how the story had been reproduced or adapted in modern films.

Allison opened up the Google search engine on her laptop and searched for, “*Romeo and Juliet* in modern films.” To her surprise, over five million results were estimated in the search results. As she read through many of the webpages, she realized that the topic was overwhelming. So many films had been adapted from themes written by Shakespeare in the classical novel version of *Romeo and Juliet*.

Allison thought to herself, “How do I write about all of these modern films without just copying some of what I’ve read on these webpages?” She was supposed to turn in an electronic version of her report because her teacher was going to check the paper using a software called **turnitin** (<https://www.turnitin.com/>). Software like turnitin was designed to verify the originality of student work by calculating the likelihood of plagiarism.

Allison understood what plagiarism was and wanted to do her best on this report.

.....

Question 1: What kinds of things can Allison do to avoid plagiarizing her report on *Romeo and Juliet*?

Question 2: *Romeo and Juliet* was written by Shakespeare hundreds of years ago. Therefore, the original work is now considered in the Public Domain. Today, there are many modern films that represent a recreation or adaptation of its original story. If you were to create your own modern version of *Romeo and Juliet*, how can copyright laws protect your work? Note: Review the U.S. Copyright Office website on this topic, <https://www.copyright.gov/what-is-copyright/>.

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The social-media landscape changes incredibly fast, so you have to be open-minded and nimble to keep up with it.

—Alexis Ohanian, co-founder of Reddit

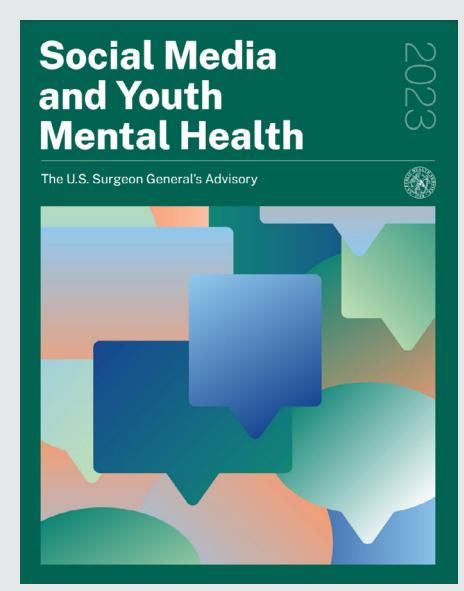
Overview

At the turn of the century, we were still at the beginning of our journey into this always-on, always-connected world. We still wrote physical letters and sent birthday cards by mail. Phone calls were expensive and video calling was like science fiction. Google and Facebook didn't exist.³¹² You couldn't download video games on your mobile phone because you didn't have access to an app store that sold software.

In contrast, just today you might have viewed TikTok videos, checked Instagram, sent a WhatsApp message, liked an author's tweet, and chatted with your friends on Discord. All before starting your school day. You may not realize it, but the smart-phone-always-on-hand lifestyle has turned us into **social media** creatures constantly dropping digital breadcrumbs about our lives on the Internet. Without being aware, you may have shared information about your friends, your boss at work, the books you like, your vacation plans, the products you use at home, and even revealed your eagerness to find a partner. These breadcrumbs help companies show you ads for the things you are most interested in. But they also have a dark side. Social media apps—the consumer-facing applications of the digital world—could potentially hurt your career and relationships. All these possibilities arise from social media apps—the consumer-facing applications of the digital world.

While the benefits of social media are well known, in recent years there is increasing awareness of its potential harms. Several states have passed laws to regulate social media use, and the US Surgeon General has issued an advisory summarizing results from research on social media's impact on mental health. The Surgeon General's advisory informs us on large sections of this chapter and is a great resource to augment the information in this chapter.³¹³ Particularly useful are the links in the advisory to the empirical studies that have looked at the issues we have brought up in this chapter.

Adapting from Carr and Hayes³¹⁴ and the advisory from the Surgeon General, we define social media as *Internet-based channels that allow users to interact and derive value from user-generated content*. The goal of this chapter is to make you



³¹² Television was the primary information source on 9/11.

³¹³ "Social Media and Youth Mental Health," The U.S. Surgeon General's advisory, <https://www.hhs.gov/sites/default/files/sg-youth-mental-health-social-media-advisory.pdf> (accessed June 2023).

³¹⁴ Carr, C. T., & Hayes, R. A., "Social Media: Defining, Developing, and Divining," *Atlantic Journal of Communication*, 23:1, 46-65, <https://doi.org/10.1080/15456870.2015.972282> (accessed June 2023).

more aware of the impact of social media, so you can make the best use of social media in your life and career, while avoiding the pitfalls. For both benefits and risks, we look at both professional and personal aspects.

Benefits of Social Media

Professional Benefits

When you want to watch a movie, you may check out movie ratings and user comments on IMDb before choosing a movie to buy. Before you purchase a product on Amazon, you often read reviews posted by previous buyers to confirm the product will work as expected. In college, students often review websites where students post comments about professors before picking classes.

You face similar situations when you enter the workforce. When you are looking for jobs, in many ways it is useful to think of yourself as a product on the market for potential employers to buy. Before people hire you for your next job, they are very likely to explore what others have to say about you in the digital world. They may go to LinkedIn to check if your previous employers and colleagues have great things to say about you. They may even check your social media activities and learn about your family and political inclinations. The stakes are high. Hence, it is important to carefully manage your presence in the digital world, so your digital presence helps you and does not adversely affect your chances of finding a new job or striking new alliances.

One great software tool you can take advantage of is LinkedIn. It was officially launched in 2003³¹⁵ to connect working professionals and now boasts over 930 million members in over 200 countries. Even as a high-school student, you may want to create your LinkedIn profile to list your accomplishments and work experiences and to connect with your classmates, students at other schools you meet at events, teachers, and employers. If you have done a great job as an intern, you may request your boss and your colleagues to leave a review about you on LinkedIn. This will not only help exhibit your experience and interest but also confirm your identity to your potential employers. Before you graduate high school, don't forget to connect with your friends on LinkedIn to start building your professional network and stay connected.

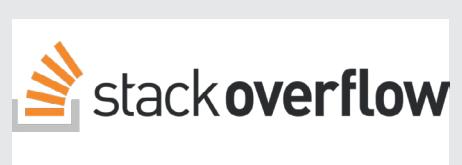


Good reviews and connections on LinkedIn may prove to be more valuable than what you list about yourself on your resume. An important challenge for both fresh graduates and employers is the high uncertainty about the work ethic and professionalism of fresh graduates. Do you show up on time? Are you a team player or do you create disruptions on the team? Do you show initiative, or do you have to be pushed to complete every task? A school or college transcript does not reveal these details. LinkedIn reviews from internship employers or team coaches can help close this gap and be a critical asset as you get started in your career.

³¹⁵ For a quick history of LinkedIn, please see, "Looking Back at the History of LinkedIn," <https://penningtoncreative.com/history-of-linkedin>. "The Complete History of LinkedIn: Everything You Need to Know," is a slightly more detailed version, <https://history-computer.com/the-complete-history-of-linkedin/> (accessed June 2023).

A basic LinkedIn account is free and allows you to send emails to your connections on LinkedIn. To send messages to members you don't know, you need to pay for a premium account. If you are interested in working at a company, you can check on LinkedIn to see if any of your friends are working there and message them politely to make them aware of your interest. If a suitable position opens, your friends may reach out to you and may even connect you with the hiring manager. In fact, if your LinkedIn profile looks strong, a new job is likely to find you rather than the other way around. Recruiters, particularly in fields such as Digital Information Technology, with demand for good talents constantly scour LinkedIn in search of candidates.

Other than LinkedIn, you may also want to establish your presence on sites frequented by other professionals in your field. If you are a programmer, you may want a GitHub profile³¹⁶ to showcase all the hobby programming work you have done. If you are technically proficient, you could answer questions on StackOverflow and build your online reputation. If you do gig work, sites like Upwork³¹⁷ and Fiverr³¹⁸ can help you create a repertoire of work and reviews.



Personal Benefits

People of all ages use social media for its benefits. The authors of this book stay connected with their friends from high school through social media, decades after graduation. The Surgeon General's advisory identifies several benefits, including a sense of community for people with shared values identities, abilities, and interests. Users get important information quickly and also use social media to express their opinions. Social media helps you sustain friendships online and organize social events easily. By giving you access to a wider community, social media can increase the diversity of your peer groups. If you need social support, social media increases the likelihood that you will find one close to your preferences. Most adolescents report that social media helps them feel more accepted, more supported, more creative, and more connected to what's going on in their friends' lives.

Risks of Social Media

Professional Risks

Unfortunately, the benefits of social media come with several risks that are not present in face-to-face interactions. Comments made during personal interactions stay limited to the memories of those present at the time of the interaction. But comments made on social media are persistent and available for review potentially forever. Many employers don't just look at professional websites like LinkedIn but also do a Google search of your name. Employers, particularly large employers, are

316 You can create a GitHub profile at <https://github.com/> (accessed June 2023).

317 Upwork home page, <https://www.upwork.com/> (accessed June 2023).

318 Fiverr home page, <https://www.fiverr.com/> (accessed June 2023).

very concerned about how their customers feel about them. Anything associated with you on social media that can be interpreted as being disagreeable, such as racist, homophobic, xenophobic, or misogynistic, even statements made as jokes, may come in the way of a great career opportunity. In contrast, a carefully curated online persona can have a positive and meaningful impact on both your career and life. Therefore, be careful before you share information online.

Another risk of social media relates to how you spend your time and attention. How you spend your time during your school years to learn skills relevant to a career can have a disproportionate impact on your professional outcomes. The earlier you enter a career, the longer you can benefit from the income earned from the career. Unfortunately, teenagers are also eager for social validation. They may end up spending their time and attention on trying to look like social-media influencers with excellent physiques. They do this without considering that having a certain body structure may be a job requirement for influencers, but few people can make a living by just relying on their great physique.

For most people, it would take far greater effort to maintain physique and acquire skills necessary to earn a living as models (social media influencers) than it would take to learn technology for a profitable career. Focusing your attention on learning skills (such as enterprise technologies introduced in this book) that can help you find a good job may be very valuable ultimately compared to maintaining influence on social media. Besides, it becomes increasingly difficult to create novelty and maintain influencer status. But careers in widely relevant skills such as Digital Information Technologies can easily last a lifetime.

Personal Risks

Tracking

Ever wondered how Spotify picks up songs aligned with your taste? How Netflix, YouTube, and TikTok can keep you glued for a long time with their recommendations? How the surprise loot box pops up just when you are about to wrap up video games for the day? How Amazon seems to know what you want to buy, as if it's reading your mind?

When you watch a TikTok video, not only do they know what you watched but also where you placed your finger when watching, how long you watched it, how many times you watched it, and how many similarly themed videos you watched. They know what time of the day you usually watch videos and how much time you spend on every session. They know whether you are stationary or driving when you watch videos. They know what you liked, disliked, followed, or commented on. They know who your friends are and what their viewing preferences are. This enables TikTok to build a profile about you, and it's safe to assume that TikTok knows more about you and your innermost thoughts, likes, and dislikes than your teachers, doctors, parents, friends, and colleagues. TikTok may even know more about you than you might be willing to acknowledge about yourself. This information gives TikTok, and other social media companies who are similarly [tracking](#) your information, enormous leverage over you.



You should not be surprised to see digital ads follow you around wherever you go on the Internet. Even if your partner searches for a new car on a laptop that is connected to your home router, you may soon begin to see car advertisements. It doesn't take long for a search engine to figure out that two people are closely associated if they use the same home router. If your friend is interested in a car, car companies are willing to spend their dollars to influence you, too.

Even if you use your browser in the incognito mode, all you can hope to achieve is not leave a trace on your computer of your activity. However, the websites you access still know that the request came from your computer. There is always a server log somewhere of your activity; and breadcrumbs have been dropped.

Addiction

Research in this area is nascent but according to the Surgeon General's advisory, it is possible that social media exposure affects the reward center in the brain in ways comparable to [addiction](#). There is evidence that frequent and inappropriate social media use may cause brain structures to change in ways similar to people with substance use or gambling addictions.

Not surprisingly, social medial companies are able to offer targeted advertisements to keep people glued to their platforms for hours. Teenagers and young adults are particularly susceptible to social media addiction. If you answer "Yes" to any behaviors such as those listed here, you may be suffering from this addiction.³¹⁹

- Do you become restless if you haven't checked your social media accounts in the past few minutes?
- Do you wake up in the middle of the night to see how many people have liked your post?
- Do you stalk people online?
- Do you spend your free time playing video games with strangers?
- Are your closest friends in the online world?
- Are you compelled to send snaps on Snapchat just to have a high Snapstreak count?

Social Media addiction can be as dangerous as Cocaine addiction, since it has the potential to come in the way of your life and career. The algorithms of social media apps are designed to make you feel good by giving you dopamine-induced highs. Snapchat encourages you to check the app constantly, so you don't lose your winning streak. Similarly, Facebook and YouTube can keep you on their platform by dangling content you like. Even LinkedIn sends notifications to entice you to hop on to their platform by notifying you of a colleague's promotion, someone's new job, and the names of people you can connect with to expand your network. However, once you go on LinkedIn, you may end up wasting hours doom-scrolling and checking on ex-colleagues and even people you are not likely to ever meet in your life.

³¹⁹ There are several scales developed to measure social media addiction, including the Bergen Scale, <https://pubmed.ncbi.nlm.nih.gov/29130330/> (accessed June 2023), and the social media addiction scale for adolescents <https://openaccess.marmara.edu.tr/entities/publication/258b3245-75d7-4a95-8f9c-d28a707e6da1> (accessed June 2023). The items presented here are our adaptations of the items in these scales.

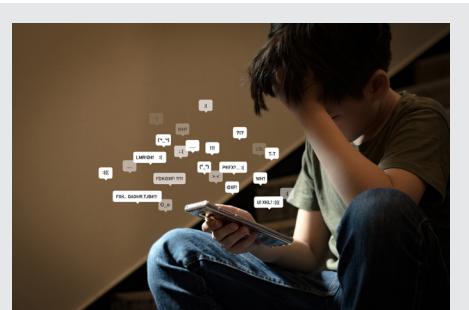
Heavy social media users end up being more isolated from others and are less physically active because they are static in one place with their phones and laptops. Studies have also shown that the indiscriminate use of social media can lead to anxiety, stress, poor work performance, and low self-esteem. Most people project a narrow view of themselves on social media—photos in which they are looking great, receiving an award, or smiling with their happy families. Even folks suffering from deadly, incurable diseases may post glamorous pictures of themselves on social media without offering a hint of the truth. And their friends who are unable to post great pictures may feel miserable in comparison. The pressure to be liked on social media can turn it into a village square where everyone is judged all the time based on the whims and fancies of the most vocal participants. Your online friends usually have no clue of your financial situation; they may have no clue that you are suffering from mental or physical disabilities or going through a breakup, while posting unflattering comments related to you.

The good news is that social media addiction can be cured. While research results are limited at this time, several experts have shared their personal experiences on how they cured their own social media addictions.³²⁰ Setting rules and boundaries is a common theme. Here are a few suggestions based on these experiences:

- Create a social media “happy hour.” Designate a happy hour dedicated to social media and use it for social media engagement but eliminate social media activity outside this window. This limits doom scrolling where you spend hours scrolling through your accounts. For example, you may decide to spend 30 minutes in the evenings or after accomplishing a major task.
- Avoid social media during lonely or low times. The apps are likely to make you feel worse as you will end up comparing yourself to others. Instead, find ways to create in-person interactions by visiting a library to borrow books or engage in other activities—e.g., yoga studio, cycling, dancing, or other team sports.
- Disable notifications. Most social media apps hook you by notifying you of some event that promises excitement. This interferes with any serious activity. If you get notified of your friends’ dating adventures every five minutes, you are not likely to focus on your upcoming exams. Focus on what is in your best interests, not on what is in the social media companies’ best interests.
- Practice technology hygiene. Keep laptops and phones way from your bedroom at night to avoid disrupting your sleep.
- Visit friends and family when you want company.

Cyberbullying

The mobile Internet connected us to people, but it also connected us to their darker sides. **Cyberbullying** is a pattern of threatening, mocking, or demeaning posts about someone on social media



³²⁰ For example, a Harvard Business Review blog article, “I Ran 4 Experiments to Break My Social Media Addiction. Here’s What Worked.” describes the experiences of Sarah Peck, an entrepreneur in NYC, <https://hbr.org/2018/10/i-ran-4-experiments-to-break-my-social-media-addiction-heres-what-worked> (accessed June 2023).

apps or messaging platforms. Once limited to physical interactions, bullying can now easily become a pervasive and permanent feature of our life, following us wherever we go. It is no longer confined to school playgrounds and toxic family gatherings.

Adolescents often minimize sharing their social media experiences with their loved ones, so it is possible for them to bully or get bullied without others finding out about it. Sometimes, it may not be clear if the jokes about you are unintentional, harmless, or a form of cyberbullying. However, if something happens repeatedly and ends up hurting you emotionally, then it is cyberbullying. Here are a few forms of cyberbullying, according to UNICEF:³²¹

- spreading lies about or posting embarrassing photos or videos of someone on social media;
- sending hurtful, abusive, or threatening messages, images, or videos via messaging platforms;
- impersonating someone and sending mean messages to others on their behalf or through fake accounts.

If you are experiencing cyberbullying, please act immediately to avoid impacting your physical and mental health. Here are a few options to consider:

- hide or delete offensive posts;
- bring the cyberbullying to the attention of a trusted adult;
- unfriend or block bullies;
- alert your school counselors since they deal with cyberbullies regularly;
- delete the social media app where you are being bullied until the issue is addressed (This may be a temporary measure since you are likely to depend upon social media apps and messaging platforms as a source of information and a networking tool.);
- contact the help center of the social media app or the messaging platform where you are being bullied. (Social media companies are far more aware of cyberbullying now than they were a decade ago and are constantly developing new technology and offering help to thwart cyberbullying. The UNICEF website to stop cyberbullying lists the help centers of social media apps at the bottom of the page.³²²)

Online Predators

Parents strongly discourage their children from getting close to strangers, but often give children access to the Internet, where strangers can contact them, talk to them, and share inappropriate content with them. Someone pretending to be a sixteen-year-old girl may be a fifty-year-old man convicted of pedophilia. Unfortunately, the Internet offers anonymity, which can be a blessing as well as a curse. Online predators hang around in social media sites that are popular with children, pose as

321 "Cyberbullying: What is it and how to stop it," <https://www.unicef.org/end-violence/how-to-stop-cyberbullying> (accessed June 2023).

322 "Cyberbullying: What is it and how to stop it," <https://www.unicef.org/end-violence/how-to-stop-cyberbullying> (accessed June 2023).

children to befriend them, and gain their trust over time before trying to take advantage of them in inappropriate ways. Here are a few things to keep in mind:

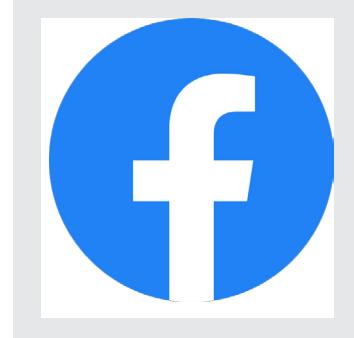
- never give your contact information (e.g., address or phone number) to people you meet online;
- never arrange to physically meet a person you have only met online;
- never share a picture or a video of yourself that has the potential to embarrass you publicly or to blackmail you;
- beware if someone uses excessive flattery;
- immediately alert trusted adults/school counselors/police if someone shares inappropriate content.

Online Scammers

In the physical world, we can avoid pickpockets and scammers by avoiding busy places and refusing to talk to strangers. However, in the online world, we could be in the comfort of our homes and be scammed by a sweettalking conman sitting thousands of miles away in another country.

By posting your real birthday on Facebook, you give away an important bit of personal information about yourself. If you click on an email from an organization that you don't completely trust, you may end up installing malware on your computer. If you follow the directions to update your credit card information sent in an email, scammers may end up withdrawing money from your account. If you tell people on Facebook that you are vacationing in Hawaii, then you may end up revealing to potential thieves that you are not at home. There are many types of scams going on in the online world, including job offer scams, lottery scams, hitman scams, romance scams, disaster relief scams, grandparent scams, and others. Scammers can pose as FBI agents, bank officials, IRS agents, or sheriffs. Sometimes, groups of individuals come together to scam and may play different roles to make it appear legitimate. With time, scammers are becoming so good at their jobs that it may be practically impossible to tell fake from real. So, what can you do to protect yourself? Here are a few tips:

- Be wary of revealing personal information. A favorite trick of scammers is to ask you for credentials to help fix a problem in your account. This is so common that being solicited for credentials is now a known security risk. Almost no legitimate service provider will ever solicit you for credentials or contact information. If there is a problem with your account, you will know it from your account page at the service provider's website. If you are threatened with disruption of service, call the help desk number of the service provider directly. It is almost never appropriate to share your SSN, driver's license, or other information in response to a cold outreach.
- Look for "https://" at the beginning of the URL, which indicates a secure connection. Additionally, check for a padlock symbol in the browser's address bar. People eager to secure U.S. visas are regularly scammed by look-alike websites.



- Automate updates on your machines so you always have the most current security updates.
- Use strong passwords and update them regularly.
- Don't click or hover on links in unsolicited emails or texts to avoid installing malware on your computer.
- Report scams to your local law enforcement agencies or to the appropriate platforms. This may mobilize action to end the scam and reduce the chances that others fall victim to it. You may also file a complaint with the Internet Crime Complaint Center (IC3) of the FBI.³²³

In general, be skeptical of unsolicited communication asking for your financial or personal information. If some offer looks too good to be true, then it probably is. You can get more information about the current recommendations to defend against scammers by visiting the Federal Trade Commission's website on scam defense.³²⁴

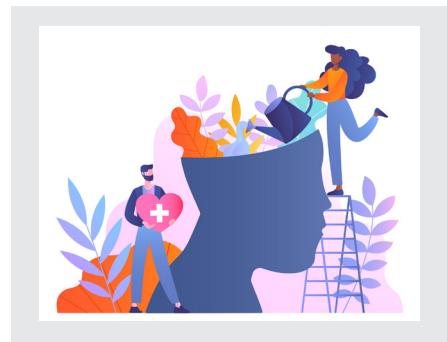
Echo Chambers or Confirming Your Biases

As human beings, we tend to seek information that reinforces our preexisting beliefs. **Echo chambers** refer to groups that promote information that fits their conclusions and ignore information that does not. If you spend time on social media apps, you are likely to gravitate towards information that you agree with. Social media algorithms will then flood you with similar information to keep you engaged. If you are not careful, social media apps can then become echo chambers and confirm and solidify your biases. Unfortunately, this can prevent you from learning counterpoints to your opinions. Potentially, you may accept untrue information that reinforces your opinions. The Internet is full of fringe groups spouting fake news and rumors. Over time, this leads people to move further away from the truth and reluctant to listen to opposing viewpoints. Social scientists believe that social media apps have contributed to the polarization we see in our world.

To avoid getting into this trap, try to consciously reach out to people and groups with opposing opinions and try to understand what might be behind their opinions. It is generally not useful to label those who disagree with you in adversarial terms.

Mental Health

The Surgeon General's advisory identifies several mental health concerns associated with social media use. Spending significant time on social media (three hours per day or more) greatly increased the risk of anxiety and depression among adolescents. Social media use increased depression even among college students. Evidence suggests that these concerns are greater for girls. Specific health concerns linked to social media use include cyberbullying-related depression, body image and disordered eating behaviors, and poor sleep quality.



³²³ Internet Crime Complaint Center (IC3), FBI, <https://www.ic3.gov/> (accessed June 2023).

³²⁴ "Avoiding and Reporting Scams," FTC, <https://consumer.ftc.gov/scams> (accessed June 2023).

Conclusion

Although social media apps connect us to each other and give us unlimited access to information, they also have the potential to isolate and divide us. It is important to carefully monitor what we say or do on social media apps to not just avoid scammers, bullies, and predators but also to build a good online reputation. Assume that anything you say or do on social media will be used against you at the most critical time in your life. Just the way a potential employer may ask you to do a drug test before hiring you, employers may also ask for your social media handles to review your online reputation.

As the Surgeon General's advisory states, social media platforms are designed for adults, but used extensively by adolescents, placing adolescents at high risk of harm. By the time we understand how social media affect our youth, the current generation of youth may experience long-lasting harm. Many of the concerns associated with social media may eventually be addressed by regulation, but until then, it has become the responsibility of children, adolescents, parents, and teachers to minimize harm from inappropriate social media use.



Chapter Terms and Definitions

Social Media: Internet-based channels that allow users to interact and derive value from user-generated content

LinkedIn: A global social network designed to connect working professionals

GitHub: A complete developer platform with communities across the world collaborating on software development

Cyberbullying: A pattern of threatening, mocking, or demeaning posts about someone on social media apps or messaging platforms

Echo Chambers: Groups that promote information that fits their conclusions and ignore information that does not

Social Media Tracking: The process of collecting social media data and saving it into a data store for analysis and use in algorithms

Social Media Addiction: Social media exposure that affects the reward center in the brain in ways comparable to addiction



Chapter Case

Ken's Social Media Safety Research

Ken just finished taking a class on Internet safety. He knew that social media was a place where lots of good and bad things can happen. Ken wanted to know more about social media and what their companies can do to protect the safety of their users. He remembered that when he joined several social media platforms, he would just ignore the terms of use. At that time, he just wanted to start using the social media platform and socialize with his friends. But now, he was concerned about safety and researched the terms of use for three popular social media platforms. Here is a sample of what Ken found from Instagram, Snapchat, and Twitter:

Instagram: Maintain our supportive environment by not glorifying self-injury.

The Instagram community cares for each other, and is often a place where people facing difficult issues such as eating disorders, cutting, or other kinds of self-injury come together to create awareness or find support. We try to do our part by providing education in the app and adding information in the Help Center so people can get the help they need.

Encouraging or urging people to embrace self-injury is counter to this environment of support, and we'll remove it or disable accounts if it's reported to us. We may also remove content identifying victims or survivors of self-injury if the content targets them for attack or humor.

Snapchat: Rights You Grant Us

Many of our Services let you create, upload, post, send, receive, and store content. When you do that, you retain whatever ownership rights in that content you had to begin with. But you grant us a license to use that content. How broad that license is depends on which Services you use and the Settings you have selected.

For all content you submit to the Services, you grant Snap and our affiliates a worldwide, royalty-free, sublicensable, and transferable license to host, store, cache, use, display, reproduce, modify, adapt, edit, publish, analyze, transmit, and distribute that content. This license is for the purpose of operating, developing, providing, promoting, and improving the Services and researching and developing new ones. This license includes a right for us to make your content available to, and pass these rights along to, service providers with whom we have contractual relationships related to the provision of the Services, solely for the purpose of providing such Services.



Chapter Case (continued)

Twitter: Targeted harassment

We consider targeted behavior as malicious, unreciprocated, and intended to humiliate or degrade an individual(s). We prohibit the following behavior on the platform:

- Posting multiple Tweets, over a short period of time, or continuously posting replies with malicious content, to target an individual. This includes accounts dedicated to harassing an individual or multiple individuals.
 - Mentioning or tagging users with malicious content.
-

Question 1: Review the terms of use samples from the three social media platforms listed above. Choose one and describe in your own words why you think the platform has listed this term of use and how it can keep its users safe.

Question 2: Think of a feature you could add to any social media platform of your choice that would help keep people safe. Describe the feature in detail and how you think it will keep the platform's users safe.

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