

# **How Computers Work and What to Do When They Don't: A Guide for Users like You!**

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# How Computers Work and What to Do When They Don't: A Guide for Users like You!

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## Preface

*“Give a man a fish, and you feed him for a day. Teach a man to fish, and you feed him for a lifetime.” — Chinese Proverb*

I’ve had my hands on technology since I was six years old. My family bought our first computer just after the turn of the millennium, a big beige box with a massive monitor. I distinctly remember telling my friends at school that I was going home that afternoon to “help” Dad put it together. He custom-ordered the build (this was back in the days of Gateway) and I think it cost about \$1,200—a pretty hefty investment for our young family. It came with the appropriately-titled Microsoft Windows Millennium Edition, ME for short. I first helped Dad assemble the computer table (as much as I could at six years old), and then watched as he hooked all the components together with colorful wires. Once finished, he powered it on and, magically, the screen brightened. We set up Windows and then dialed in to AOL, where I heard the memorable “You’ve got mail!” greeting—my welcome to the World Wide Web.

As great as those first moments were, that computer was often the bane of our existence. At least once every year, for as long as we owned it (too long), something broke. Windows ME corrupted itself. The video card burnt up. The hard drive crashed. The whole motherboard crashed, forcing an update to Windows XP, which performed marginally better than the disaster that was ME. I remember sitting on Dad’s knee before the beige beast while he troubleshooted these problems. He ran antivirus software in the hopes of curing the computer of a malady. He backed up our data to floppy diskettes. He reinstalled Windows again and again.

Over the years of computer crashes and burns, I learned how to diagnose, repair, and eventually prevent these and other problems. I learned that every problem has a solution, and most of the time that solution is easier than one first thinks.

The time when I, for better or worse, became my family's designated tech guy was when I was fourteen. That same desktop, a dinosaur at that point, still sat in the corner of our living room. Windows XP decided not to boot up, which prevented us from doing anything at all on the PC, including backing up our files. If we took our computer to the go-to repairman, he would have charged us to recover our files and, potentially, to replace the computer's hard drive.

At the time, I was experimenting with booting the Ubuntu Linux operating system from a USB drive on computers in my math class (in hindsight, something I probably wasn't supposed to be doing). This gave me an idea: I could try booting up our computer with a USB drive in order to back up the files and maybe, just maybe, repair Windows. Long story short, my idea worked and, with an external hard drive purchased by Dad, I backed up *all* of our data *and* reset Windows. Mom and Dad were fully expecting to spend a fair amount of money on another repair job, and I did it for free over a weekend.

From that point onward, I've never doubted my ability to solve a problem, at least when it comes to computers and technology. I think that attitude comes from my dad, who has that same gumption and grit. My reputation as the "computer genius" slowly spread among those who knew me and I became the go-to guy for all technical issues. As they say, the rest is history.

When I graduated high school, a good friend hired me to be the technical support person for his small business. When discussing what my job title should be, he made a witty suggestion: Client Support Guru. That title stuck, and eventually I became known as simply "The Guru." He and his clients embraced the title because, to them, I was the expert.

In my job, I just did what I was good at: I solved problems with technology for my boss and his clients. In doing this, I realized two things.

First, I was solving the same problems over and over again. The first time a certain problem presented itself, I did a lot of research and trial-and-error to find a solution. Every time after that, the solution was easy because I'd already solved the problem once.

Second, in many cases, I could not only solve someone's problem but also teach them *how* I solved it so that, the next time around, *they* had a way to solve it themselves. This made them happy because, if the issue cropped up again, they didn't have to contact me and wait until I could get around to solving their problem, which sometimes could be a full day.

I would never have called myself a guru, but I now realize how apt a title it is. A guru is not just an expert. A guru is also a teacher. A guru isn't just a wise man who sits alone on top of a mountain; a guru willingly imparts his wisdom to willing students.

These pages contain some of that wisdom, distilled down from my many experiences. To refer to the Chinese proverb quoted at the start of this Preface, it certainly gives you some fish, but it's my hope that it also helps you learn how to fish for yourself.



# Introduction

This book exists because computers exist and because you exist.

Computers are fantastic machines that do amazing things. They've connected the world and revolutionized the way we communicate with each other, do business, and live life. Consider this: The computer you likely carry in your pocket every day, your smartphone, is more powerful than the computer that put men on the moon in 1969. The computer in your home gives you the power to write and publish a book (like this one!), develop an app, or start your own business.

Yes, computers are pretty cool—when they work.

That's where you come in. You're a *user*, a very special someone who operates computers whether you want to or not. If you're like most people, you're probably not too familiar with the ins and outs of computers, or what to do when they aren't functioning correctly.

That's where this book comes in. This is my way of equipping you with the knowledge you need to understand how computers work and what to do when they don't. (Hey, sounds like a great title for a book!)

I've divided this book into five main chapters, and each chapter into sections and subsections. Chapter One covers the basics of computers, explaining their components and how they work in a way that I guarantee you will be able to understand. Chapter Two reveals what I call The Seven Principles of Solving Problems and how you can use them to fix your computer when something's not running right. In Chapter Three, I provide some best practices for computer maintenance—things you can do to prevent bad things from happening to your computer. Chapter Four addresses some common computer problems: slow performance and malware. Finally, Chapter Five is a guide to help you make smart computer purchases by identifying your computer needs and investigating the various options available to you.

In addition, I've included two appendices. Appendix A guides you through some common troubleshooting scenarios in a question-and-answer format. Appendix B provides some online resources that I've used when solving problems or researching information on computers.

Throughout the book, I've bolded and underlined some key terms that I think are important for you to know. The Glossary at the end of this book contains a full list of these terms.

I suggest you read this book from cover to cover, and then reread or reference specific sections as needed. As you read, you may encounter information that you already know or is irrelevant to you; for example, if you use a Mac, you may not care to know how to do something on a PC. Skimming or skipping past these portions is fine. (I'm not offended!)

I try to explain all the information in this book at a high level and stay away from the nitty-gritty details. Some sections are more technical than others, so if you find that you're lost in the details, come up for a breath of air and skip ahead. You don't have to understand everything right away. Grasp the basics and come back for the specifics when you need them.

Finally, if you have a computer nearby and you'd like to follow any directions as you read, do it! Learning by doing is a fantastic way to remember things. You never know what you might discover by clicking and tapping around, as you'll learn later.

All right, I hope you're ready for a learning adventure. Let's dive in!

# Chapter One:

## The Basics of Computers

*“The whole is greater than the sum of its parts.” — attributed to Aristotle*

Before we examine the basic components of computers and how they work, I need to clarify some terminology. When most of us hear the word **computer**, we think of a device with a screen and a keyboard, maybe connected to a big box (a **desktop**) or housed in a single unit that folds shut like a clamshell (a **laptop**). Technically, any device that *computes* something could be considered a computer (including a cellphone, smartphone, or tablet), but for the purposes of this book and for ease of understanding I refer collectively to desktops and laptops with this term. I’ll note that, while other devices such as smartphones and tablets are not the main focus of this book, many of the information and tips included herein apply to them as well.

There’s also the term **personal computer**, abbreviated as **PC** for short. By a strict definition, a PC is any computer designed for personal use (in contrast to, say, a supercomputer). However, if you remember the “I’m a Mac, I’m a PC” commercials that Apple ran for several years, you may think that the term PC solely refers to a Windows machine. Both Apple Macintosh (or **Mac**) and Microsoft Windows computers are indeed personal computers. However, for the sakes of clarity and common usage, I will use the term *PC* to refer explicitly to a Microsoft Windows computer, *Mac* to refer to an Apple Macintosh computer, and just *computer* to refer to them both collectively.

To summarize, a computer is a desktop or laptop (or hybrid), a PC is a Microsoft Windows computer, and a Mac is an Apple Macintosh computer. With these distinctions out of the way, let’s take a look at what makes your computer tick!

## The Difference Between Hardware and Software

Chances are, you've heard the terms hardware and software before. Understanding what these two are is critical to understanding how a computer works, so it is here that we begin.

**Hardware** is just what it sounds like. It's "hard," meaning that you can physically touch it. The word hardware is unitless, so always use it with a singular verb. ("Hardware is tangible," not "Hardware are tangible.") Hardware includes the keyboard I'm typing these words on, the screen that's displaying them as I type, and all the electrical components that interconnect inside the computer.

**Software** is the opposite. It is intangible, meaning it can't be touched. It is the instructions the computer needs to run. Computers are given instructions in **binary**, a number system consisting only of 0 and 1. 0 represents "off" and 1 represents "on." Each 0 or 1 is called a **bit**, and a string of 8 bits is called a **byte**. All software can be reduced to a series of 0s and 1s stored somewhere in the hardware. Most computers have at least one layer of software, and devices that run programs and apps usually have two or more. We'll explore this in more detail in a bit (no pun intended).

When distinguishing between the two, it may be helpful to remember what someone once told me in jest: "If it falls on your foot and doesn't hurt, it's software." Even simpler: if you can touch it, it's hardware; if you can't, it's software.

Computers would not work without both hardware and software. Think about it: software requires hardware on which to run, and hardware could do nothing but collect dust without software.

As you read about the various hardware and software components described in this chapter, the distinction between the two should become clearer, if it's not clear already. We'll start by taking a look at hardware.

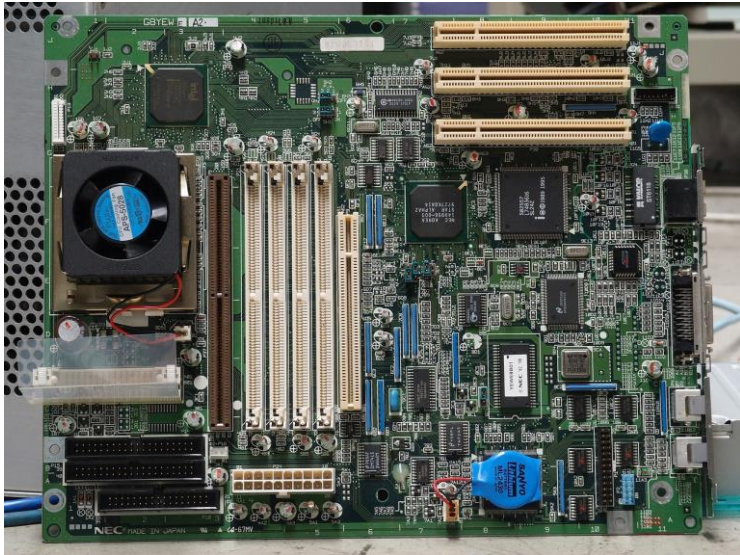
## Hardware Components

As just mentioned, hardware components are tangible. On desktops, hardware can often be replaced or upgraded very easily. On laptops, due to size and design, hardware is harder to replace and few components can be upgraded.

In this section, I'll take you through the basic hardware components of all computers and explain how they work. I've also included plenty of pictures so you can *see* what it is I'm describing.

## Motherboard

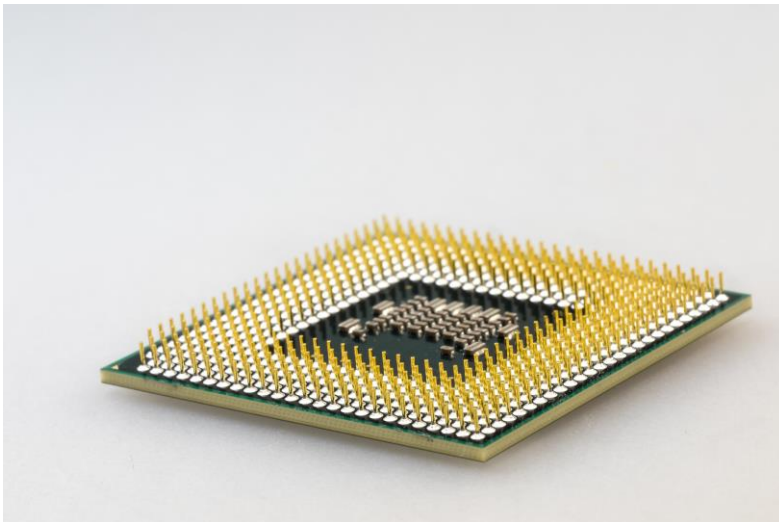
The Grand Central Station of your computer is the **motherboard**. It provides power to the other hardware components so they can function correctly, connects the individual pieces of hardware so they can communicate with each other, and serves as a hub for diagnosing hardware issues. You may see or hear a motherboard referred to as a “mobo” for short.



In the picture of the motherboard above, you can see many slots that other components plug into. Keep this in mind as we examine other hardware components on the following pages.

## CPU

If the motherboard is the heart of the computer, the **central processing unit (CPU)** is the brain. This is where the number-crunching and program-running occurs. The CPU deals with information in binary (see the discussion on software at the start of this chapter). When someone writes software code, it must be translated from the human-readable format to a computer-understandable format, which is ultimately binary.



The CPU doesn't look very exciting, and is very small. Modern CPUs are no larger than 2 inches (5 centimeters) in any dimension, and most are smaller than that. Despite their size, they are incredibly intricate and delicate, so if you ever find yourself handling one, be especially careful with it.

CPU speed is calculated in Hertz (Hz), which is a unit measuring cycles per second. For example, 1 Hz is one cycle per second, and 2 Hz is two cycles per second. Most modern processors have speeds measured in Gigahertz (GHz), equivalent to one-billion cycles per second. As you might expect, the higher the Hertz value, the faster the processor.

In addition, each processor has one or more **cores**, which are individual processing units. **Single-core processors** have a single core. **Multi-core processors** have two or more cores, the most common being dual-core (two cores) or quad-core (four cores). From a user's standpoint, multi-core processors are faster than single-core processors because they can better handle multiple running programs. Multi-core processors are more expensive than single-core processors, but are becoming more common on all computers.

The CPU puts out a lot of heat, so if you ever notice your computer getting really warm, it's because the CPU is processing a lot of data. This is usually the result of running several programs or apps at once, or a very resource-intensive one. For this reason, computers have **cooling fans** and **heatsinks** mounted on or near the CPU to keep the CPU from heating up too much and to keep other components cool.



You will likely never see a CPU on a motherboard because either a heatsink or a cooling fan sits on top of it. The blue object in the bottom-left of the picture above is a heatsink; the circular object in the top-right is a cooling fan.

## Memory and Storage

The term **memory** refers to hardware that allows for quick data retrieval, and there are two main types. The first is **RAM**, which stands for **random-access memory**. The CPU has direct access to RAM, and stores data it needs to process there. RAM is fast but relatively small in data capacity. It is also used only for temporary data because it is cleared out every time your computer reboots or loses power. The term for this is **volatile**.



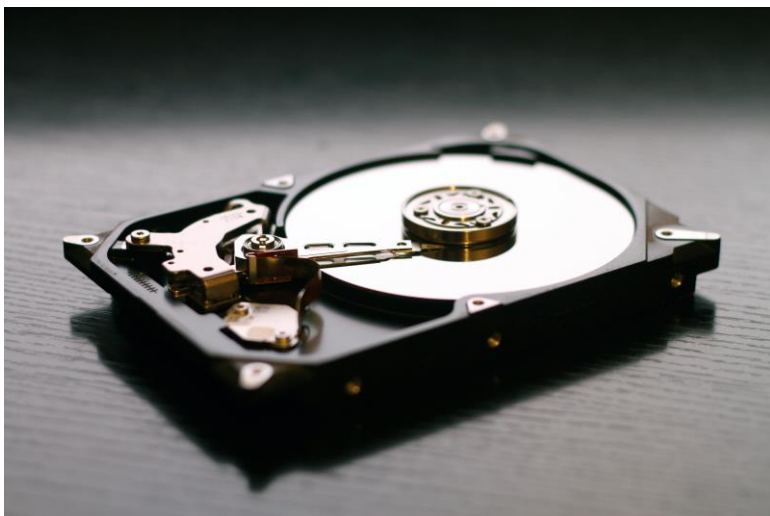
Above are two RAM modules, commonly called sticks. Each stick plugs into a slot on the motherboard (see the picture of the motherboard in the Motherboard section of this chapter), and they are usually simple to upgrade due to their ease of plug-and-play. The amount of RAM a computer contains is a good standard to use when judging the computer's speed because RAM is where the data from all running programs and open files is stored. The more RAM a computer has, the more programs that can be open at once without the computer slowing down.

There is also **read-only memory (ROM)**, which, as the name implies, can only be read from. No data can be written to it. ROM is built onto the motherboard and, when you first turn on your computer, is where the software to load your computer is loaded from. (We'll get more into this in the Software Components section of this chapter. For clarity in this book, I'll mostly use the specific terms *RAM* or *ROM* instead of the more ambiguous term *memory*.)

As a user, you don't directly interact with RAM, but you can feel its effects when the app you're running starts slowing down or your computer freezes up. This is typically an indication that the RAM is maxed out. To speed things up, you can close the culprit app or reboot the computer, though the only way to prevent it may be to forego using the app or not running as many apps at once.

In contrast to memory, **storage** is a slower means of saving data but is also larger in capacity. The CPU does not have direct access to it, as it is intended for long-term storing of data (as its name implies). Storage is **non-volatile**, meaning that it retains information regardless of whether it has power.

Traditionally, a **hard disk drive (HDD)** was the main form of storage for a computer. A hard drive is a hardware unit consisting of a spinning metal platter and an arm with a magnetic head, not too different in design from a record player. Data is stored on the platter and read by the head as the platter spins. The hard drive has been mostly supplanted by the **solid-state drive (SSD)**, which is more like RAM in that the data is stored in integrated circuits, making it faster to retrieve. The fact that SSDs have no moving parts also makes them more durable and far less likely to malfunction.



The hard drive pictured above has the outer case removed so you can see the platter and the spindle. You can also see how easy it would be to render the hard drive useless if any of the intricate parts are damaged.

Even though an SSD technically is not a hard drive, the term *hard drive* is often used generically to refer to a computer's storage. For the sake of clarity, I will refer to *storage* when discussing where your files are saved, regardless of whether that data is on a hard drive or a solid-state drive.

When you save a file to your computer, that file is saved to storage. When you open up that file, whether it's a photo or a document or something else, the contents are copied to RAM so that the processor can interact with the file. If you edit the photo or make changes to the document, those changes are recorded in RAM; when you save the file, the contents are copied back to storage. When you close the file, the space in RAM is freed. This is why, when working on files of any kind, it's important to save early and often! If you're working on a file and haven't saved in a while, a power outage or spontaneous crash will make your data irretrievable because the latest version is stored in RAM, not storage. *This bears repeating: Save early and often!*

As mentioned at the start of this chapter in *The Difference Between Hardware and Software*, digital data is stored in bits (0s and 1s). Eight bits make one byte, the unit of storage you will most often see or hear about in regards to computers. Just like how one-thousand meters make a kilometer, one-thousand bytes make a **kilobyte (KB)**. One-thousand kilobytes (that's one-million bytes) make a **megabyte (MB)**, and one-thousand megabytes (that's one-million kilobytes or one-billion bytes) make a **gigabyte (GB)**. One-thousand gigabytes make a **terabyte (TB)**, which is today the largest unit of storage for all personal-computing purposes.

To give those terms some relevance, let's look at common file sizes. A simple text document created in a program like Notepad on Windows or TextEdit on a Mac might only be a few bytes in size due to its simplicity. A document created in Microsoft Word is usually several kilobytes in size. Most pictures taken with digital cameras or smartphones are a few megabytes in size, while video can be several hundred megabytes. Video games and high-definition movies are often several gigabytes large. Finally, you could back all your files up to a one-terabyte hard drive and still have plenty of room. (A 1 TB hard drive could store over two-hundred high-definition movies.)

Typically, you will find computers with RAM somewhere between 4 GB and 16 GB and storage somewhere between 250 GB and 1 TB (1000 GB). More RAM means increased performance, and more storage space means more files you can save to your computer. USB flash drives are available in all capacities and external hard drives are, as of this writing, available up to 8 TB.

In case you were wondering, you're supposed to put a space between the value and the unit—so 8 TB is correct, but 8TB is not. And yes, most people and even most companies are doing this wrong.

RAM and storage are two important specs to consider when buying a computer. I cover more on buying computers in Chapter Five and in this book's bonus article, *Buying the Right Computer for Your Needs*, which you can access by signing up at my website, MatthewRBaker.com, in order to receive it via email.

## Video and Graphics Cards

Video cards, also known as graphics cards, are hardware components that process and output video and graphics. Some desktops and most laptops don't have dedicated video cards (the CPU takes care of all computer-generated graphics), but higher-end computers used for gaming, engineering, and data analysis require them in order to process the sheer amount of information that must be handled for these purposes. Video cards often come with their own built-in fans to keep cool, and are often upgradeable on desktop computers.

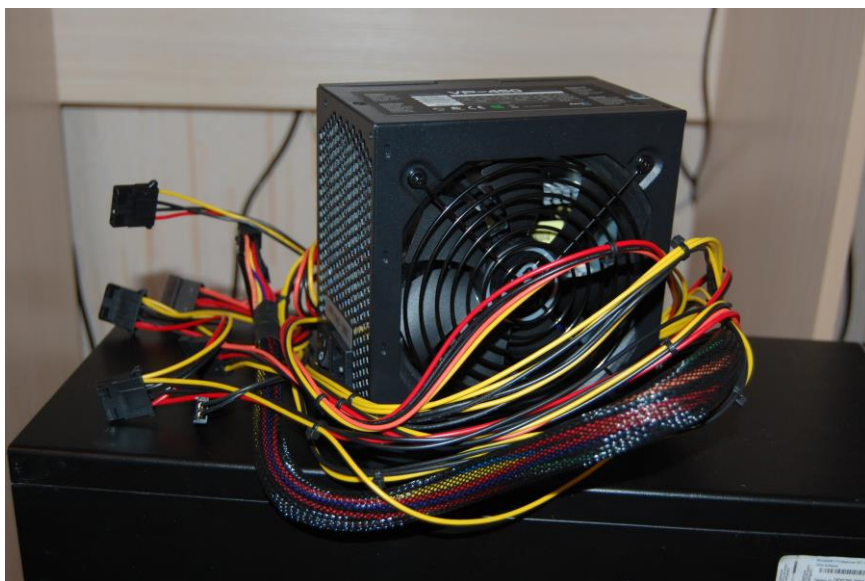


The video card pictured above plugs into the motherboard via the metal contacts extending out from the foreground edge. The ports on the left side are for connecting monitors for output. Also note the cooling fan placed prominently in the center of the card to keep the graphics processing unit (GPU) cool.

## Power Supply

The **power supply** is pretty self-explanatory: It supplies power. On desktop computers, the power supply is fairly large and usually contains a fan to keep the electrical components cool. On a laptop, the power supply is more or less part of the motherboard and you simply plug in a **power adapter**, or AC (alternating current) adapter, for charging.

Power supplies can go bad, but are easy and inexpensive to replace on desktop computers. If your desktop won't power on, chances are the power supply is dead. On laptops and other devices, a power supply failure could be indicated by a failure to charge when plugged in. Resolving this issue could be as simple as buying another power adapter, or indicative of a more critical motherboard failure that means you'll likely need to replace the computer altogether.



One end of the desktop power supply pictured above connects to a typical wall outlet. The multi-colored cables connect to various other hardware components, such as the motherboard, storage drive, and video card.

## Ports and Interfaces

Your computer likely has several different receptacles for attaching external devices. These receptacles are called **ports**. When the word *port* comes to mind, you might conjure up a mental image of shipping containers being loaded onto and off of large freighters—an exchange of goods. A computer port operates in a similar way because it facilitates the exchange of information (data) between your computer and another device.



There are four ports visible in the image of the laptop above. The leftmost one is an **Ethernet** port, which you plug an Ethernet cable into in order to establish a wired connection to the Internet.

Next to the Ethernet port is a **Video Graphics Array (VGA)** port for connecting an external display device. VGA ports allow you to connect your computer to external monitors or projectors. I explain more about monitors in the upcoming Output Devices section.

To the right of the VGA port is a **High Definition Media Interface (HDMI)** port, also used for connecting to an external display or audio device. The primary difference between VGA and HDMI is that HDMI transmits audio as well as video; VGA transmits video only. HDMI is the interface you would use to connect your computer to a high-definition television, while VGA is what you would likely use to connect your computer to a projector when giving a presentation.

On the far right is a standard **Universal Serial Bus (USB)** port. USB allows you to connect a wide variety of devices to your computer, including printers, speakers, and control devices such as joysticks and videogame controllers. It's truly universal in the sense that a wide variety of products from a wide variety of manufacturers all use the same USB interface to communicate. If your computer has a USB port (and I'm willing to bet it has *at least* one, though likely more), you can attach almost anything with a USB connector to it.

There are a few different varieties of USB. USB 2.0 has been the most common version for many years. USB 3.0 is a newer version that uses the same style of port but allows for faster data transfer with compatible devices. It's important to note that, for maximum speed, a USB 3.0 device must be connected to a USB 3.0 port. However, you can connect a USB 3.0 device to a USB 2.0 port, or a USB 2.0 device to a USB 3.0 port, but the data transfer speeds will be at the USB 2.0 rate, not the faster USB 3.0 rate.



There is also a new version of the USB connector known as USB-C, pictured above. The primary advantage USB-C has is that it provides a single charging interface for both laptops and smart devices (i.e., smartphones and tablets). Manufacturers are moving towards the USB-C interface in part because of a European Commission campaign to establish “one charger to rule them all,” so to speak. This benefits you because it means you can use the same cable to charge your phone and your laptop without worrying about plugging it in upside-down. You can also charge a less-powerful device, like a smartphone, from a more-powerful one, like a laptop.

While the legacy USB connector, called USB Type A, is far from obsolete at this point, there is a definite shift towards USB-C. If you’re considering buying a new laptop (see Chapter Five: A Guide to Buying Computers), look for ones that come with a USB-C port. You can also buy hubs or adapters that convert from USB Type A to USB-C, or vice versa. These will allow older and newer devices to interface with each other, with the caveat that they will be operating at the slower USB Type A speeds.

Your computer may also have other ports, but the ones described in this section are some of the most common. Ports are also evolving: What is widely-used today may be supplanted by something newer and faster in a few years. In the next sections, we'll take a look at some specific uses for ports and interfaces.

## Removable Media

**Removable or external media** are any data storage devices that can be plugged into your computer. The most common forms of removable media are discs and USB drives.

A **disc drive** is used to read data off a disc, like a **compact disc (CD)** or **digital versatile disc (DVD)**. On my family's first computer, we had three drives: CD, DVD, and 3.5" Floppy. Nowadays, most computers only include a DVD drive (which will also play CDs), and the trend with laptops is to eliminate DVD drives altogether in favor of slimmer, lighter designs.



If your laptop doesn't have a DVD drive, you can buy an external one, shown above, that plugs into your computer. This is handy if you need to install a program from DVD, watch a movie, or back up data to disc.

The most common interface for connecting external media is USB, as mentioned in the previous section. **USB flash drives** are small data storage devices that can be used to store, transfer, and back up data. They are the most-used form of external storage today.



USB drives come in all shapes and sizes, as demonstrated in the picture above. Some USB drives are less than an inch long and extremely portable. Others are larger but store incredible amounts of data. Many can be clipped to a keychain or keyring. You can even buy encrypted USB drives if you need to store and transport very sensitive information.



**Memory cards** are another common form of external storage media. They are used primarily by digital cameras, smartphones, and tablets. The most popular memory card is the **Secure Digital (SD) card** (the three smaller cards in the photo above), though other cards exist like the CompactFlash memory card (the three larger cards in the photo above). Most laptops come with an SD card reader, and external card readers can be bought that connect to a computer via USB.

Bonus: The difference between a **disc** and a **disk** is that a disc (spelled with a c) refers to optical storage media, such as CDs or DVDs, while a disk (spelled with a k) refers to every other storage media, such as hard drives, USB flash drives, and the fossilized floppies. Many times, the two are used interchangeably, but I adhere to this distinction in this book.



A picture for posterity: the 3.5" Floppy disk. There was a time when Dad had to back up all the data on our old computer using about one-hundred of these. Today, that data would easily fit on any USB drive. In retrospect, a DVD or even a CD would have been a better backup option!

## Input Devices

If a device allows you to *put data in* to the computer, then it's an **input device**. Input devices include keyboards, touchscreens, mice or touchpads, and even webcams and microphones.

**Keyboards** are straightforward enough. They trace their legacy back to the typewriters of yesteryear and allow you to input text and numeric data with your fingers. You can buy external keyboards for any computer and type away. If your wrists hurt from typing, consider an ergonomic keyboard.

**Touchscreens** are screens you can touch to input data. If you have a smartphone or tablet, it's probably got a touchscreen. Many laptops are being built with touchscreens, too.

A **mouse** is a handheld device that detects movement in relation to the surface it rests on. When you move a mouse, the cursor on the computer screen should move along with it. When you click one of its buttons, the computer performs the appropriate command (like following a link on the Internet or opening a file). Legend has it that the mouse's size, shape, and wire "tail" led to its name. Wireless mice are commonplace, as are ergonomic mice and other variations.

A **touchpad** performs the same function as a mouse but is integrated into the chassis of a laptop. It is operated with one or multiple fingers instead of with the whole hand. One-finger interactions move the cursor on the computer screen, while two- or three-finger interactions allow for scrolling through documents, navigating back and forth in a web browser, and more.



Above is a picture of a typical laptop keyboard and touchpad. Some users don't like the smaller, compacted laptop keyboards and touchpads, so they use wireless keyboards and mice. These are cheap, easy upgrades that may make laptop use at home easier. One common form of wireless technology is **Bluetooth**, and many computers today come with Bluetooth integrated. For those that don't, a Bluetooth dongle that plugs into a computer's USB port can be purchased inexpensively.

A **webcam** (short for web camera) is a camera designed specifically for recording video to be streamed across the Internet, such as for video chats. **Microphones** are essential for having audio to accompany any recorded video.

Most laptops come with an integrated webcam and microphone, which look like little dots above the top edge of the screen. Usually a light next to the webcam will light up to notify you when the webcam is capturing video.

External webcams with integrated microphones may be purchased to upgrade the existing webcam in a computer if the video or audio quality is lacking. I've noticed that some webcams provide adequate video quality but poor audio quality. If this is the case, you can remedy this by buying a standalone microphone or a headset with a built-in microphone.



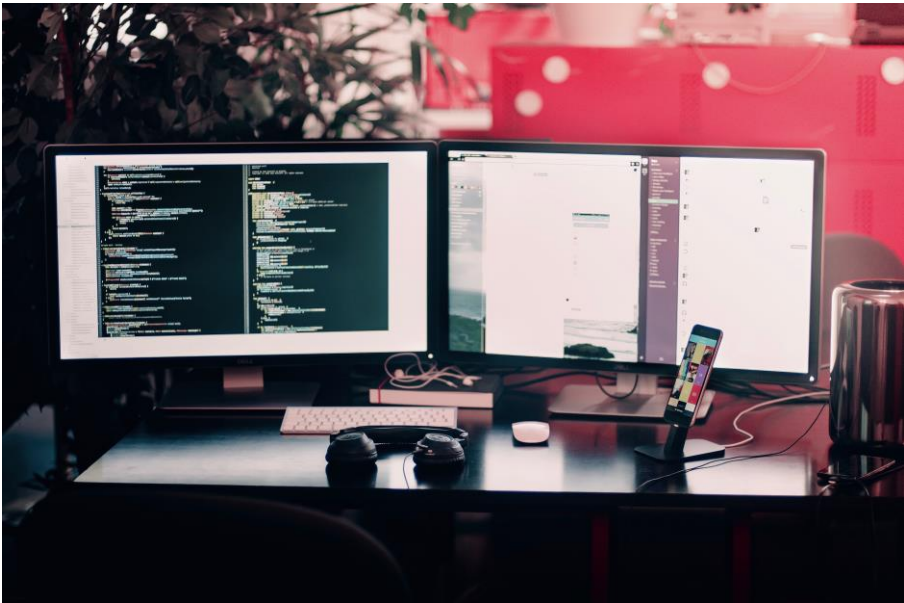
The webcam above connects to the computer via USB and mounts on top of the monitor. Webcams like this usually come with built-in microphones, though I've found that microphone quality may not be as robust as video quality on these units.

## Output Devices

If a device *puts out* some kind of information, then it's an **output device**. Output devices include computer screens and monitors, speakers, and even the vibration unit in your cellphone.

A **monitor** is the standalone unit that most people picture when they think of a desktop computer. Its job is to display an interface that you can use to interact with the computer. Unlike other components, it has its own power adapter that must be plugged in; it does not get its power from the computer. Settings such as brightness, contrast, and color warmth can be adjusted using menu buttons on the monitor. Monitors range from small to very wide. If you have a computer and a TV, and both have HDMI ports, you can plug your computer into your TV and use the TV as a monitor!

A **screen** might sound like the same thing as a monitor. For the purposes of this book, I make the following distinction: The screen is the physical part that depicts an image, while the monitor is the whole unit that includes the screen. Thus, a laptop has a screen, not a monitor, and a desktop has a monitor that by definition includes a screen.



Both desktops and laptops will allow external monitors to be connected, and often you can connect more than one, as in the picture above. If you do a lot of work with computer code, audio engineering, or graphic design, for example, two monitors can dramatically increase your productivity. Some people get spoiled to two monitors and wonder how they could ever get any work done with only one!

Bonus: A touchscreen is both an input and output device. It outputs data (a picture) that you use to input data (by touching the screen).

## Software Components

Unlike hardware, software is very upgradeable, and often easy to upgrade. In fact, due to the cost of building hardware compared to the cost of programming software, there are many times when software is written to fix hardware problems. This is one reason why it's important to keep software updated, as we'll explore soon.

From a user's perspective, software is also highly customizable. You can download and install a **program** (a series of instructions for your computer) to perform a specific function that you need. If you have the know-how, you can even write your own programs. Programs can be very simple or incredibly complex, depending on their function.

Let's take a look at the different kinds of software on your computer. We'll start with what happens when you turn the computer on and follow the sequence from there.

## Firmware

When you push the power button, what happens inside your computer? A lot, actually. First, some lightweight software known as **firmware** begins executing on the CPU. The firmware performs a health check on the computer's hardware and, once it determines the hardware is functioning correctly, it prepares the computer to run the operating system, which is the main software you interact with.

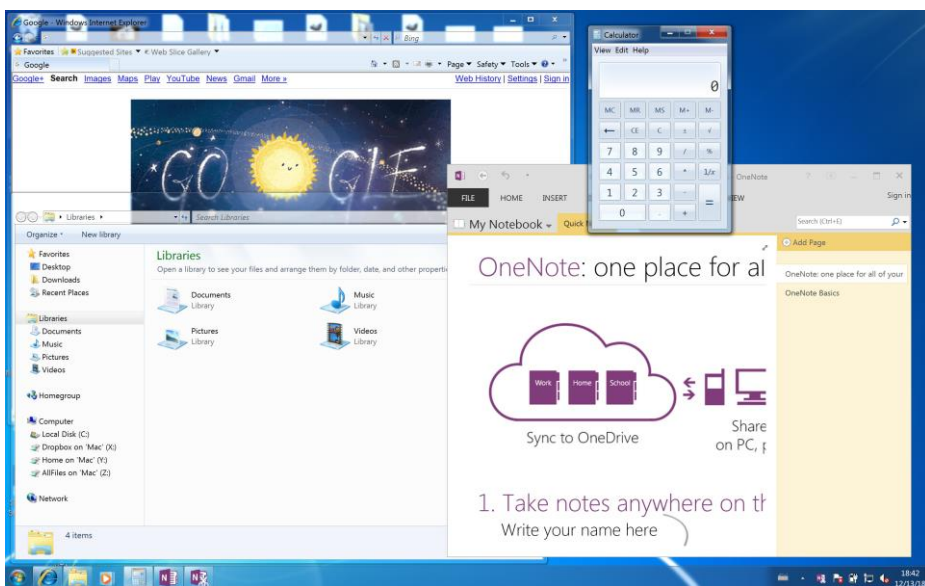
Most of the time, you will never interact with firmware. There may be the rare occasion that your operating system won't **boot** (meaning it won't start up), and the firmware will notify you of a problem and, potentially, the steps you can take to solve it. Otherwise, you'll likely just see a logo of your computer's manufacturer on the screen before the operating system assumes control.

Sometimes, manufacturers will release firmware updates. These are good to install because issues in firmware could prevent your computer from ever booting into the operating system, which is the topic of the next section.

## Operating System

Once the firmware determines that the computer is healthy and ready to run, it loads the operating system. The **operating system (OS)** is the primary software that controls the computer and is what you directly interact with. You probably know it as Windows if you own a PC or macOS (formerly OS X) if you own a Mac.

The operating system provides a **graphical user interface (GUI)** that is displayed on the screen to make input easy. This means that, instead of typing commands into the computer to make it do things (ever seen hackers in movies?), you can click or tap icons and buttons to make the computer do what you want.



The screenshot above shows the Windows 7 operating system. The GUI includes the Desktop, Start menu, and numerous windows displaying open programs.

The operating system also acts as a sort of bridge between the programs you run and the hardware they run on. When you start a program, like Microsoft Word, the operating system loads the program and allocates space in RAM for the program to run. It interprets your input from hardware (mouse or keyboard) and converts it into the appropriate output (like a button being clicked or the letters you typed appearing on the screen). The OS also interfaces with external hardware (printers, USB flash drives, and even your smartphone) and provides software and hardware diagnostics.

## Drivers

If you ever insert a new USB flash drive into your computer, you might see a message pop up saying that the operating system is installing device drivers. A **driver** is simply a piece of software that allows your operating system to communicate with a hardware device. The hardware inside your computer, as well as anything you connect externally, works because your operating system can “talk” to it via a driver.

Drivers can be updated when manufacturers release new versions, and should be updated if updates are available. One common computer problem is that a driver somehow becomes corrupted or inoperable. If the driver for your computer’s speakers becomes corrupted or stops working, you won’t be able to hear any sound, even though there’s nothing wrong with your speakers themselves. If this should happen, it’s best to check for a driver update.

Windows users can check for updated drivers by Googling (or Binging) your computer’s manufacturer and model number followed by the word “drivers.” An example would be “Dell Latitude E6410 drivers.” Make sure you only go to the manufacturer’s official website, *which may not be the first thing to appear in search results*. Scout around the site and see if there are any driver updates available; some manufacturers offer scanners that make this process easy by detecting which drivers are out-of-date. If there are no updates available, you can try uninstalling and then reinstalling the driver via Device Manager on Windows.

Mac users will likely never need to worry about searching for updated drivers because Apple manages driver updates as part of standard system updates. For external hardware, find the manufacturer’s website and search for any updated drivers there.

## Programs and Apps

When most people think of software, they think of programs and apps that accomplish various tasks on your computer. These are self-explanatory; you click on an icon to run a program and (hopefully) the program runs.

A program runs as a process processed by the processor. (Say that five times fast.) In other words, any program you launch gets a segment of the CPU's time so the CPU can do the work required for the program to run (also called *executing*). When multiple programs are running at once, they really aren't running at the same time. In reality, program gets a slice of the CPU's clock so that it can run. As a simple example, if five programs are open at once, they might each get one-fifth of the processor's time.

A program's data is stored in RAM while it runs, and when you close the program (or if it terminates on its own), then its space in RAM is freed up. Any files used by the program are copied to RAM as well. As I mentioned in the Memory and Storage section of this chapter, this is why it's important to save your data early and often. RAM does not maintain its data when it loses power, so if for some reason your computer crashes, any data stored in RAM (i.e., not saved to storage) is lost.

Also, if you have too many programs running at once, you can quickly run out of space in RAM or CPU availability for running the programs. One would think that, with faster processors and more RAM in our computers these days, this wouldn't be as much of a problem. Unfortunately, that doesn't seem to be the case, as software developers create newer versions of programs and operating systems that are increasingly resource-hungry. Also, if one program doesn't clean up after itself after it's through executing (creating what's called a memory leak), it can cramp the other programs and could eventually freeze the whole system up.

The takeaway here is that when you have an operating system and multiple programs running at once, it's easy to bog your computer down. When you can, save your files and close any programs that you're not using. This will free up your CPU and RAM so they can devote more time and space to the other programs that you *are* using.

One question I sometimes hear is, “What’s the difference between a program and an app?” Some would say that an **app** is on your smartphone while a program is on your computer, but when you get down to it, an app is a program and a program is an app. They’re just two names that refer to the same thing. In recent years, Microsoft has been referring to programs as apps on Windows 10, and Apple has its App Store available on Mac computers, so any distinction between the two is becoming more and more blurred.

## Types of Programs and Apps

There are some basic categories of programs that you probably use every day. Before we take a closer look at them, I need to explain some terms that I'll be using in this section and throughout the book in regards to programs and apps.

**Freeware** refers to software that is completely free for you, the user, to install. A sub-category of freeware is **free and open-source software (FOSS)**, which is not only free but also allows anyone to modify the source code if they wish. (Source code is the instructions to the computer that make the program run.)

There is also **freemium** software, which provides a certain level of functionality for free but an additional level of functionality at a cost. Additionally, there is what's known as **crippleware**, software that's free but disables certain critical features unless a premium (paid) version is used. For both freemium software and crippleware, the incentive to buy is to unlock full functionality via a pay-to-use version of the product. (For example, if you use a crippleware video editor to compile footage from your vacation, it may splash a watermark on top of your final video. That's not very cool, in my opinion, but then again, the developers have to make money.)

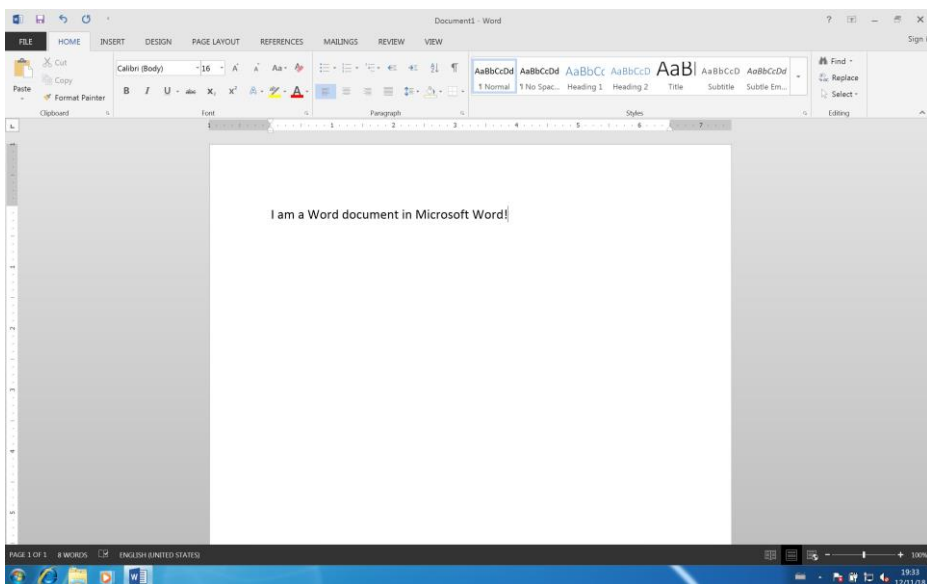
Finally, there is **commercial software**, sometimes called **payware**. This is software that you absolutely must pay for or subscribe to in order to use. The retailer may offer a free trial for a short period of time, usually a week to a month, during which you can use the software unhindered. After that time expires, you will be required to pay in order to keep using the program.

In the next section, I'll take you through some categories of software. These may overlap somewhat, so I've tried to categorize them based on primary purpose or intended use.

## Office Suites

Every computer you buy comes with some kind of **office suite** installed, even if it's a simple one. Office suites are software packages that include programs for productivity like a **word processor** for editing documents, a **spreadsheet program** for crunching numbers and data, a **presentation program** for creating slide decks, and more.

The most common office suite is Microsoft Office, which is commercial software available on both Windows and Mac operating systems. You are probably at least familiar with Microsoft Word, Excel, and PowerPoint that are included in the Office package. Macs come with an office suite preinstalled that includes Pages, Numbers, and Keynote, corresponding to Word, Excel, and PowerPoint, respectively.



Above is a screenshot of Microsoft Word, the most common word processor and a very powerful tool if you know how to use it. I'll note that I used Word to write and format this book!

A good free office suite is LibreOffice, formerly known as OpenOffice.org. LibreOffice includes the same basic programs that Microsoft Office does, but they are completely free. If you don't want to buy or subscribe to Microsoft Office, LibreOffice is a good alternative.

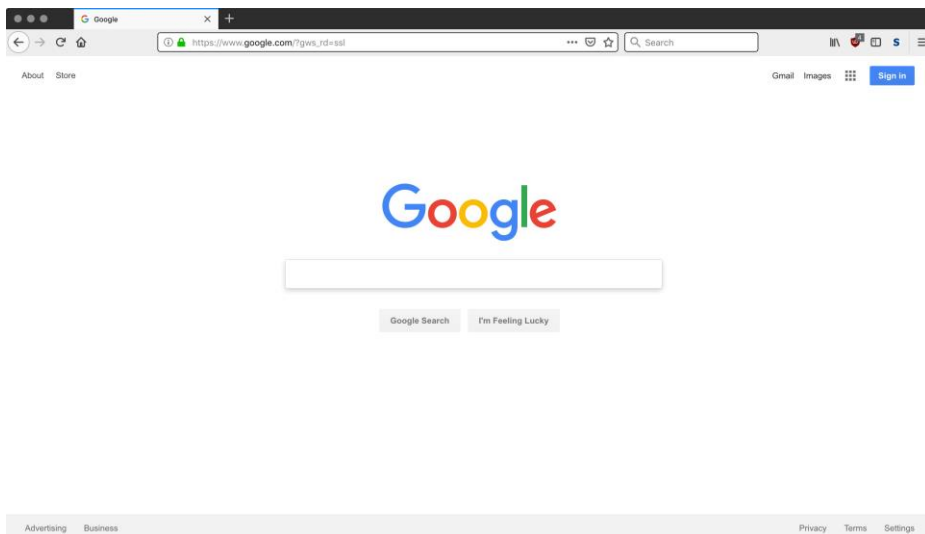
Another option is Google Drive, an office suite you access through your web browser (see the Web Browsers section, coming up next). Google Drive encompasses the subprograms Google Docs, Sheets, and Slides (equivalent to Word, Excel, and PowerPoint, respectively), and also includes Forms, which lets you create personalized surveys. Google Drive stores all your documents on a remote server and there are no programs to download. All you need to use Google Drive is a Google account. Google Drive comes with 7 GB of free online storage, and you can also buy more storage space on Google's servers if you need it.

## Web Browsers

Whether you know it or not, a **web browser** (usually just called a browser) is what you use to access webpages on any device. A browser allows you to *browse* the World Wide Web so you can read the news, check social media, and pay your bills.

All computers come with a default browser. If you own a Windows machine, you're probably familiar with Internet Explorer, replaced by Microsoft Edge on Windows 10 computers. Mac users are likely familiar with Safari.

You can install other browsers, too. Google Chrome is available for both PCs and Macs, and has the advantage of being fast, lightweight, and easy to use. Mozilla Firefox is also widely available and is known for its security features (such as preventing websites from tracking you) and the ability to install add-ons or plug-ins. Other browsers include Opera and Brave, but there are so many others out there that it's impossible to address them all here.



The picture above shows Mozilla Firefox directed to the Google home page at Google.com. Note the icons in the top-right for add-ons I have installed to eliminate annoying pop-ups and other intrusive advertisements.

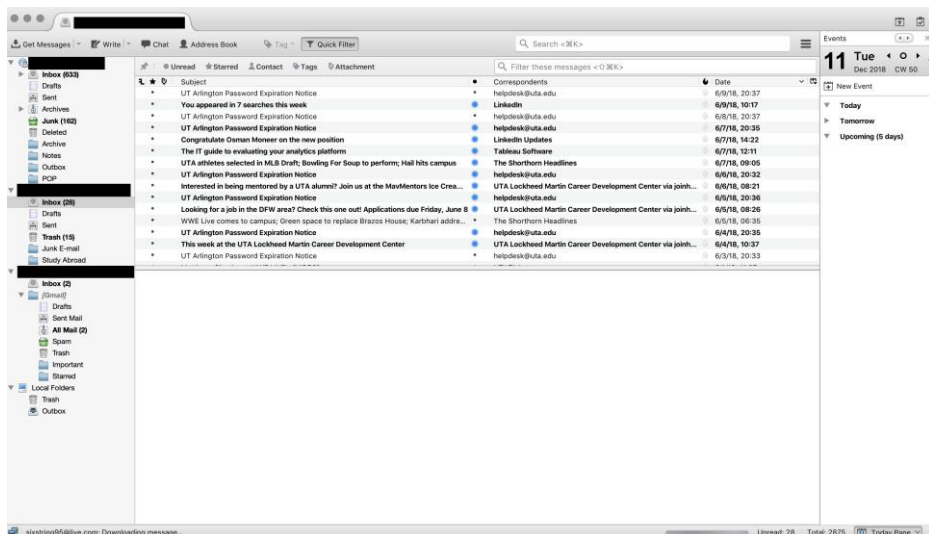
Unfortunately, there is not a single do-it-all, jack-of-all-trades web browser. Some browsers work better on certain websites than others. The best all-around browser I know of is Mozilla Firefox. In my experience, it will load ninety-nine percent of websites flawlessly; it also provides features to protect your information online. A close runner-up is Google Chrome for its simplicity and integration with other Google software such as Gmail and Google Drive.

Since all of the browsers included here are either free or already provided to you, I suggest you try some out and find out what you like the most. If you download one and don't like it, you can uninstall it. (More on uninstalling in the CCleaner section of Chapter Four.)

## Email Clients

An **email client** is a program that downloads your email so you can read it, delete it, and reply to it. This is in contrast to **webmail**, which you must access by logging in to a website through your browser. Email clients allow you to read your emails when you're offline, while you cannot access webmail unless you have an Internet connection.

In the Microsoft Office suite, Outlook is the email client. On Mac computers, the Mail app serves this purpose. There are also third-party email clients available for download.



The Mozilla Thunderbird client is pictured above. Thunderbird doesn't have the sleekest interface, but is a free option available to both Windows and Mac users. I've found it to be a good option for managing multiple email accounts—and as you can see in the screenshot, I need to delete some emails!

To set up a mail client, you must know your email address and password. Most mail clients make this a breeze: Input your email address and password, and the client takes care of the rest. Sometimes, however, it can take a little tweaking depending on how the **email server** (the remote computer your email client will be contacting) is set up.

Once your email address is set up in the client, the client will synchronize with the email server and new messages will appear as a list. You can then do things like delete emails, sort emails into folders, and create rules for emails to be automatically sorted into folders or spam instead of your inbox. In all of these cases, the client will update the server.

There are two main methods of an email client interacting with an email server: POP and IMAP. POP stands for Post Office Protocol, and works similar to how the post office delivers your mail: When your email client contacts the email server to check for new emails, the emails are downloaded to the client and then immediately deleted from the server, just like how the post office no longer has a copy of a letter mailed to you once they deliver it to your mailbox. IMAP stands for Internet Message Access Protocol, and keeps messages on the server even after downloading them to the client. When an email is deleted on the client side, it will then be deleted on the server side as well.

It's important to understand this distinction between POP and IMAP if you need to configure your email settings. Some email providers allow for POP or IMAP. I recommend using IMAP because your email messages will remain on the server unless you explicitly delete them. IMAP is likely the default method your email client and email provider use, anyway.

If your email client stops working, or you're away from your computer, in most cases you can access your email through a web browser; this is called webmail. You need to know the website of your email provider (such as Outlook.com or Yahoo.com), your email address, and your password. As mentioned at the start of this section, you can only access webmail if your computer is connected to the Internet.

## Games

Ah, games. Whether you play Candy Crush or solitaire, the idea is the same. Any game app uses your computer's CPU to generate graphics on your screen. Higher-end video games require computers with fast processors, graphics cards, lots of RAM, and lots of storage in order to be playable—and many hard-core PC gamers build their own PCs from individual parts so they can play these games at the highest quality. Regardless, games can be very resource-intensive, so it's a good idea to close any other apps in order to optimize performance. Also, it's important to monitor your computer's temperature. If fans are running for long periods of time or you notice the chassis or computer case heating up, it might be a good idea to take a break and let the computer cool down.



How about a nice game of chess? Most computers come with at least some games preloaded. I have fond memories of playing solitaire on our old computer with Grandma.

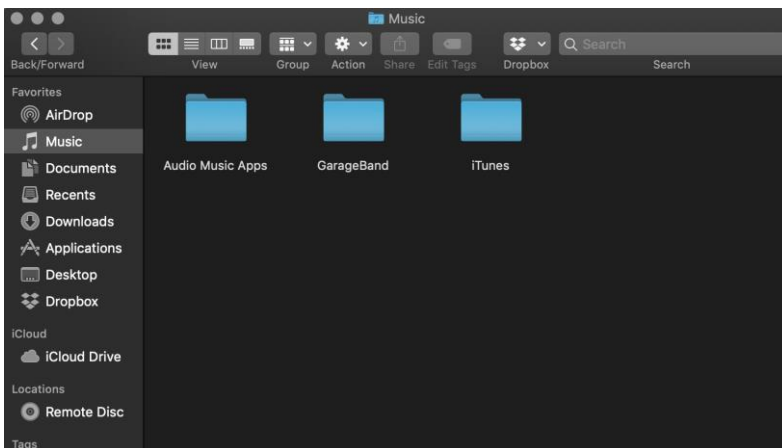
The app stores on both Windows and Mac offer many other games for download, some free and some paid. Be aware that some free games will come with advertisements, and I advise against clicking on any of those. You should also know that the more games you have installed, the higher the likelihood that your computer's overall performance will suffer. That's not *always* the case, but it can be, especially on computers with lower-performance hardware.

## Utilities and Background Tasks

**Utilities** include programs like calculators and dictionaries that provide a simple service as well as programs that help keep your computer running optimally. Many of these run in the background without your knowledge.

One of the main utilities you should be familiar with is **antivirus** software. An antivirus keeps your computer free from malicious software (called **malware**) that would otherwise do all kinds of unpleasant things like deleting your data or making your computer unusable. Many computers come with built-in antivirus protection, and it's usually a good idea to install additional antivirus software for more protection. I'll cover antivirus software and malware in greater detail in the Preventing Malware section of Chapter Three.

**File managers** are programs included in the operating system that allow you to navigate your computer's storage like a filing cabinet and manipulate data in the form of files and folders. On Windows, the file manager is called File Explorer; on Mac, the file manager is called Finder. Both display a graphical view of files and folders so it's easy to navigate from one place to the next.



Pictured above is Finder on a Mac. By double-clicking on one of the folders pictured, the window will update to show me the contents of the folder. In the left pane are quick links to other locations on my filesystem, such as Documents and Downloads. Along the top are various options to change how files are displayed and group items by name and date, for example.

There is plenty of other software I didn't cover here, and to do so would not only bore you but also be irrelevant a year from now because software is always changing. There are plenty of other programs that run behind the scenes that you'll never interact with, so I'm not concerned about addressing them in this book. If you're interested, you can check out the [Wikipedia article on utility software](#) for a good primer, and go down the rabbit hole from there.



# Thanks for Reading This Sample

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## About The Author



Matthew R. Baker is an avid reader, ardent writer, armchair philosopher, part-time traveler, lifelong musician, greenhorn genealogist, linguist at leisure, first-born son, older brother, good friend, and computer guy... in no particular order. He worked as Client Support Guru in one chapter of his life, and some people still call him Guru. He holds a Bachelor of Science in Information Systems and a Certificate of Localization and Translation in German from the University of Texas at Arlington. *How Computers Work and What to Do When They Don't* is his first book.

Visit Matthew's website at [MatthewRBaker.com](http://MatthewRBaker.com) and follow him on Facebook at [fb.me/BakerMatthewR](https://fb.me/BakerMatthewR) and on Twitter [@BakerMatthewR](https://twitter.com/BakerMatthewR).