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How do laptops work?

An extensive overview by Trevor Bondy

This is a document designed for the students of Oklahoma City. We apologize if the information is oversimplified or case-specific. If you have any questions, please contact me at 405-256-2294. Thank you.

Lightweight electronics

Lightweight electronics are a kind of computer that is usually really flexible, meaning portable. Think things like laptops and smartphones. For example, you can pick up a cell phone, so it's a lightweight electronic device, but chances are, you can't pick up a NASA rocket.

A laptop is a kind of PC (personal computer) that can be easily moved. Laptops are designed to be moved, to go places that big, bulky desktop computers can't. To make it easier for consumers like yourself, hardware companies have a standard all-in-one style for laptops. Basically, that means that all of the essentials are included within the computer. Think things like the keyboard, trackpad, speakers, and a monitor. Additionally, they usually contain the other essentials, like the input for external monitors, audio sources, external mouses, external storage units, and other external devices.

A desktop computer, or stationary computer, is a computer, usually with a "tower" design. All of the input devices are external, and need to be added separately. Unlike laptops, with the all-in-one design, desktop computers need to have external mouses, keyboards, monitors, speakers, bluetooth devices, and anything else. They're also usually decently heavy, and are incapable of being regularly moved.

Parts of a laptop

The CPU

The motherboard is the computer's main part. It contains the CPU (Central Processing Unit), memory (RAM, Random Access Memory), and expansion cards for things like external video and audio, and network connections. The motherboard is essential to the use of the computer, and the computer cannot function without it. The motherboard connects to every part of the computer in some way or another.
The CPU (Central Processing Unit), also known as the computer’s processor, is one of the most essential parts of the computer. The CPU’s job is to carry out the instructions that the computer sends. For the most part, it processes inputs, stores data, and outputs results. Every action that the user does, like clicking a button or typing a sentence, the CPU is used. CPUs are usually really small, with the average size being about two inches in height and length.

The speed of a processor is measured in megahertz (MHz) and gigahertz (GHz). A faster processor can do tasks more quickly. However, the actual speed of the processor depends on many other factors, not just the processor. A CPU is an integrated circuit, also known as a chip. The integrated circuit can integrate, or mix together, millions of tiny electrical parts, arranging them into circuits and fitting them together. Computers use two different types of storage: primary and secondary. The CPU interacts mostly with the primary storage, giving it instructions for the data.

The control unit (CU) of the CPU contains the electronic signals that directs the system to carry out program instructions. However, the CPU itself does not execute program instructions. The control unit operates alongside the logic unit and memory. The control unit as well as the arithmetic logic unit are considered the heart of the CPU. The arithmetic logic unit is capable of arithmetic and logical operations, such as adding, subtracting, multiplying, and dividing. Engineers can also design the arithmetic logic unit to execute any action, not simply the basic tasks. The unit is capable of carrying out instructions on a large amount of data and has a high level of precision.
CPU clock speed is the number of "cycles" performed every second. A higher clock speed means a better-running device, and a lower clock speed means a slower device. Clock speed is measured in gigahertz (GHz), which is a step-up from normal hertz (Hz).

According to Dell technologies, "The boost clock frequency is the capability of a single CPU core to increase the processor frequency in the event of an intense workload." In other words, the boost clock frequency is how well a CPU core can react to an overload of instructions and data. The base clock speed is the default frequency of the processor. The CPU clock speed is important because it can represent the overall performance of the processor.

Every CPU has at least one core, however, a lot of professional computers typically have multiple cores. CPU cores are really complicated, but basically, they are made up of billions of tiny electric impulses within the CPU. Having more CPU cores can mean that you can multitask easier, and have the ability to execute a lot of different tasks at the same time. For basic laptops, like the Chromebooks at school, they have five cores. Nowadays, it's rather difficult to find a computer with simply one core. Dual cores are good for basic users, but could prove challenging for operating systems. Having four cores is good for most users that use the computer for relatively basic tasks. You probably couldn't run Minecraft with ray tracing technology with two or four cores. Six cores are good for video editing, animation modeling and rendering, and other forms of digital art production. Anything above eight cores are great for professional tasks, such as video editing, video streaming, engineering, or any other task like that.

The RAM

RAM, or Random Access Memory, is one of the most essential parts of a computer, and is a computer's short term memory, where the data that the CPU is using is stored. The computer has the ability to access the RAM much easier than the hard drive. RAM is a temporary storage device that can store data quickly, and temporarily. RAM is used instead of other storage devices because the CPU can access it possibly a hundred times easier, significantly speeding up the computer. This is good for processes, apps, and other things that need to execute quickly. When you turn your device off, all of the RAM data gets deleted.

When you open Google Chrome, for example, the application is loaded into the RAM. However, if you save something, like a document, the data is stored on a permanent storage device. The computers we use at school, Chromebooks, use 4 gigabytes of RAM. Basic computers have 8 gigabytes, and computers for gamers and video editing usually have 16 gigabytes. Computers for professional programming and video editing usually have 32 gigabytes of RAM. Chromebooks, for example, only need four gigabytes of RAM because of their basic abilities. The most commonly used program is Google Chrome browser, which generally doesn't need a lot of space to run. RAM is relatively expensive, which is why some schools cut corners and use four-gigabyte systems. Professional computers, ones with 16-32 gigabytes of RAM, can cost upwards of two-thousand dollars. Some laptops, like the 13-inch Macbook Pro, can cost thousands of dollars, just for 8 gigabytes of RAM.

The HDD

A HDD (Hard Disk Drive) is a type of storage commonly used as the primary storage system for both desktop and laptop computers. It works by writing bits of data and then finding it later. HDDs are non-volatile, which means that data can be stored without any power connections. HDD's are also usually capable of storing massive amounts of data at once. Besides being non-volatile, they are rather inexpensive, which is why they are used so commonly in personal computers and laptops. Inside of the hard disk, there are a series of disks called platters. There are many different sectors (partitions) of the disks, which are utilized for different things. All of these sectors have many different parts inside themselves, which can all hold a magnetic charge.

Disk fragmentation occurs when the data on an HDD loses its sequence. If you save a file on your computer, it stores the data on an empty part of the disk. Because the different parts of the file may be in different parts of the disk, it could cause problems for the CPU to find it. This could make loading files much slower and more painful. If that sector of the disk is damaged, then that means that all of the data in the section is unrecoverable. Defragmentation basically rearranges the files to be easier accessible by the different components of the computer. There are many different programs that can do this, such as Ccleaner or Avast Cleanup.

The SDD

SSDs (Solid State Drives) are another type of storage device, like the Hard Disk Drive. They are much newer and are much more optimized than their predecessors. SSDs use flash-based memory (also known as semiconductor memory), which is much faster and more compact, rather than disk-based memory. SSDs store permanent data inside an integrated circuit, typically using flash memory. The data on flash memory is, of course, non-volatile, and is written and deleted electronically. On the other hand, HDDs use physical disks inside of a container to store data, which can be unreliable and easily broken. Nowadays, most computers and laptops are using the SSDs because of their extended storage capacity and space optimization. SSDs are great for businesses, gaming, portable devices, and servers.

SSDs can have anywhere from 32 gigabytes of storage, all the way to 5 terabytes. Which if it isn't obvious, is a **lot** of data. There are many different types of SSDs. The older ones were larger, like the mSATA III, SATA III, and traditional SSDs. More modern SSDs are types like the PCIe and NVMe. The biggest difference between SSDs and HDDs is the inside of them. SSDs are electronic, which makes them a lot faster and lighter, despite being more expensive than HDDs. SSDs are usually easier to use and to install, and they have a decent durability. HDDs use physical disks, which can be damaged a lot easier. However, HDDs are usually a lot cheaper, they can last longer than SDDs, and are known as the "traditional" storage type. Solid state drives do not suffer the consequences of fragmentation nearly as badly as HDDs, making them better if you're storing massive amounts of data. SDDs are not hard drives.

Expansion cards

Most computers have expansion slots on the motherboard that you can add expansion cards (also known as peripheral component interconnect cards) on. Expansion cards allow you to add separate connections for components like video, audio, and network.

Video cards, or graphic cards, control what you see on the screen. Most computers have a graphics processing unit, which eliminates the need for video cards. However, if the performance of the GPU is lacking, an external video card may be necessary to boost the performance. The CPU, remember, the Central Processing Unit, sends information about the screen to the GPU/Video Card. The GPU organizes the data and sends the information to the monitor, where it is displayed to the user.

Laptops usually have a lot of ports, for the reasons listed above. For things like external monitors, audio sources, like headphone jacks for headphones, external mouses, like the kind you plug into a normal desktop computer, external storage units, like Universal Serial Buses (USB's), among other things. Sound cards (audio cards) are responsible for the sound that comes out of the speaker or headphones. The sound card is an integrated circuit that generates an audio signal and sends it to the connected audio source. On personal computers, like laptops, the functions of the sound card are usually directly integrated into the motherboard, like the GPU for video. Like the video card, you can add external sound cards onto the motherboard, however, a separate circuit is required.

The network card (also known as a Network Interface Card) is a type of network adapter, and allows your computer to communicate with the internet over your local area network. The network card is usually built-in to computers by default, but they can be manually added later. It can either connect via ethernet cable, which is what most professional desktop computers use, or you can additionally connect wirelessly, using Wi-Fi. Bluetooth is a kind of wireless technology that can connect the computer with other devices nearby. It's often utilized for things like keyboards, mice, and printers. Bluetooth is great for external device optimization because it doesn't require any cords or annoying setups.

Lithium-ion batteries

Laptops use a type of rechargeable battery called the lithium-ion battery. The lithium-ion battery works by using the movement of lithium ions. There are many different complex parts of lithium-ion batteries, but the most critical parts include the electrolyte, anode, cathode, and the lithium ions themselves.

While the battery is discharging, or being used, the lithium atoms are basically converted into an ion state, a state of attraction between opposite charges (positive and negative), and are separated from their electrons (an important part of the atom).

Lithium-ion batteries are used because they can charge faster, have a longer lifespan, and can possibly be cheaper. Basically, if a battery has a longer lifespan, it just means that the battery can last longer before becoming unusable, and needs to be replaced.

Lithium-ion batteries are also better for the environment. Because they're reusable, and you're not meant to throw them away, they can be recycled and turned into new batteries. The same can't be said for traditional batteries that are not rechargeable, because they work much differently. Lithium-ion batteries are still being researched and developed, and it's still a complex subject.

The screen

The screen, or monitor, is the most used output device of the computer. The monitor is the part of the computer that can display text and images while you interact with the device. Laptops usually use a type of monitor called LCD (Liquid crystal display). This is because LCD screens are generally cheaper, space-efficient, and use less power. The other type of screen is CRT (Cathode Ray Tube). This kind of screen is usually used in desktop computers, because they can potentially load data faster. This means that the screen could potentially respond faster to instructions given to it.

The refresh rate is the amount of times per second the display is able to load a new image. Your computer generates different “images” that you see. When anything happens, the entire monitor refreshes the image of the screen. The refresh rate is irrelevant to most average computer users, but businesses and gamers might consider getting monitors with a higher refresh rate, because it can load images faster. This could be useful if a lot of information is constantly being sent to the screen. The refresh rate is measured in hertz (cycles per second), the same kind of hertz that is used to measure electromagnetic waves, sound waves, the CPU clock rate, among other things. The time between refreshes is measured in milliseconds. While the content may look fine to most users, the quality of the image is constantly changing. A higher refresh rate could mean more steady and smooth video quality. The standard refresh rate for desktop monitors is 60Hz. However, technology has expanded to allow for much higher refresh rates, such as 120Hz or higher.

There are many different components that need to be working together to have a higher refresh rate. First of all, the CPU needs to be quick enough and powerful enough to render the images quick enough. Then, the GPU (Graphics processing unit) is required to execute the directions quickly and send the instructions to the screen. Finally, the monitor needs to be refreshed quickly. If the GPU was outdated, for example, it may be challenging to have a high refresh rate.

The trackpad

The trackpad is a device on laptops that can turn your movements with your hand into movements on your cursor. The trackpad performs the same action as a mouse - translating inputs from your finger onto the computer. The trackpad is basically a mouse, but converted to fit into computers. It is also possible to use a trackpad in place of a mouse, for a desktop computer, for example. Trackpads can perform all of the same functions as normal mice, as well as being able to perform special tasks. For example, a lot of Macbook and Chromebook trackpads are able to zoom in using a finger gesture of two fingers touching it, and pulling away from each other.

Environmental Impacts

If it wasn't already obvious, the production of laptops requires a large amount of metals and plastics. It also requires a lot of energy for the machinery to function properly. In fact, the production of plastic contributes to almost 4% of all global greenhouse gas emissions, which is a lot. The waste of electrical devices is expected to result in electronic production being one of the most wasteful industries. Modern laptops are only really meant to be used for a couple years, then to be disposed of. Not to mention all of the metals that are mined across the globe in order to produce the electronics.

Consider buying a desktop computer for your personal use, because even though they might be expensive, they usually last much longer and are much easier to replace. If you have a laptop computer, consider using it for as long as possible before throwing it away. If you insist on getting rid of your laptop, it should definitely be recycled, so it could possibly be used in other products.

Review

- RAM

The RAM, or Random Access Memory, is used for short-term storage, with the data being deleted afterwards. It's good for quickly loading applications without accessing the hard disk.

- Storage (HDD or SSD)

The storage is for keeping the files that are on the computer. There are two different types: Hard Disk Drives, and Solid State Drives. HDDs are usually cheaper and can store data longer, but can't store a lot of data, and are usually pretty slow.

- Video card (GPU)

The video card processes the instructions made by the CPU and sends it to the monitor, where it is displayed on the screen.

- Audio card

The audio card processes the instructions sent by the CPU and sends it to the audio input, which is by default, speakers. On desktop computers, if a speaker is not built in, an external input will be required.

- Network card

The network card allows the device to wirelessly connect to the internet. Without it, an internet connection would not be possible.

- Bluetooth card

The Bluetooth card allows the computer to connect to devices that use Bluetooth, which can save a lot of time and money for businesses that use a lot of printers, for example.

- Central processing unit
  The CPU, or Central Processing Unit, is one of the most important parts of the computer. It processes the information about the inputs on the computer and sends instructions to the other parts of the computer, which can then execute additional commands.

- The motherboard
  The motherboard holds all of the major components on a single piece of plastic. It organizes the parts and makes the computer compact.

- Monitor
  The monitor is the part of the computer that displays what you see. There are two different types of screens - LCD and CRT. LCD screens are usually the type used in most laptops. It works by refreshing what you see hundreds of times per minute.

In conclusion, lightweight electronics are still a very complex subject, and they have a lot of potential in the future. They are key to our society, and they have allowed us to work, play, and communicate much easier than before.

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