Continue

The central processing unit (CPU) is the computer component that's responsible for interpreting and executing most of the commands from the computer's other hardware and software. All sorts of devices use a CPU, including desktop, laptop, and tablet computers, smartphones, even your flat-screen television set. Intel and AMD are the two most popular CPU manufacturers for desktops, laptops, and servers, while Apple, NVIDIA, and Qualcomm are big smartphone and tablet CPU makers. You may see many different names used to describe the CPU, including processor, computer processor, microprocessor, central processor, and "the brains of the computer." Computer monitors or hard drives are sometimes very incorrectly referred to as the CPU, but those pieces of hardware serve entirely different purposes and are in no way the same thing as the CPU. A modern CPU is usually small and square, with many short, rounded, metallic connectors on its underside. Some older CPUs have pins instead of metallic connectors. Lifewire / Wenja Tang The CPU attaches directly to a CPU "socket" (or sometimes a "slot") on the motherboard. The CPU is inserted into the socket pin-side-down, and a small lever helps to secure the processor. After running even a short while, modern CPUs can get very hot. To help dissipate this heat, it's almost always necessary to attach a heat sink and a fan directly on top of the CPU. Typically, these come bundled with a CPU purchase. Other more advanced cooling options are also available, including water cooling kits and phase change units. Not all CPUs have pins on their bottom sides, but in the ones that do, the pins are easily bent. Take great care when handling, especially when you're installing them onto the motherboard. The clock speed of a processor is the number of instructions it can process in any given second, measured in gigahertz (GHz). For example, a CPU has a clock speed of 1 Hz if it can process one piece of instruction every second. Extrapolating this to a more real-world example: a CPU with a clock speed of 3.0 GHz can process 3 billion instructions each second. Some devices use a single-core processor while others may have a dual-core (or quad-core, etc.) processor. Running two processor units working side-by-side means that the CPU can simultaneously manage twice the instructions every second, drastically improving performance. Some CPUs can virtualize two cores for every one physical core that's available, a technique known as Hyper-Threading. Virtualizing means that a CPU with only four cores can function as if it has eight, with the additional virtual CPU cores referred to as separate threads. Physical cores, though, do perform better than virtual ones. CPU permitting, some applications can use what's called multithreading. If a thread is understood as a single piece of a computer process, then using multiple threads in a single CPU core means more instructions can be understood and processed at once. Some software can take advantage of this feature on more than one CPU core, which means that even more instructions can be processed simultaneously. For a more specific example of how some CPUs are faster than others, let's look at how Intel has developed its processors. Just as you'd probably suspect from their naming, Intel Core i7 chips perform better than i5 chips, which perform better than i3 chips. Why one performs better or worse than others is a bit more complex but still pretty easy to understand. Intel Core i3 processors are dual-core processors, while i5 and i7 chips are quad-core. Turbo Boost is a feature in i5 and i7 chips that enables the processor to increase its clock speed past its base speed, like from 3.0 GHz to 3.5 GHz, whenever it needs to. Intel Core i3 chips don't have this capability. Processor models ending in "K" can be overclocked, which means this additional clock speed can be forced and utilized all the time; learn more about why you'd overclock your computer. Hyper-Threading enables the two threads to be processed per each CPU core. This means i3 processors with Hyper-Threading support just four simultaneous threads (since they're dual-core processors). Intel Core i5 processors don't support Hyper-Threading, which means they, too, can work with four threads at the same time. i7 processors, however, do support this technology, and therefore (being quad-core) can process 8 threads at the same time. Due to the power constraints inherent in devices that don't have a continuous supply of power (battery-powered products like smartphones, tablets, etc.), their processors—regardless if they're i3, i5, or i7—differ from desktop CPUs in that they have to find a balance between performance and power consumption. Neither clock speed, nor simply the number of CPU cores, is the sole factor determining whether one CPU is "better" than another. It often depends most on the type of software that runs on the computer—in other words, the applications that will be using the CPU. One CPU may have a low clock speed but is a quad-core processor, while another has a high clock speed but is only a dual-core processor. Deciding which CPU would outperform the other, again, depends entirely on what the CPU is being used for. For example, a CPU-demanding video editing program that functions best with several CPU cores is going to work better on a multicore processor with low clock speeds than it would on a single-core CPU with high clock speeds. Not all software, games, and so on can even take advantage of more than just one or two cores, making any more available CPU cores pretty useless. Another component of a CPU is cache. CPU cache is like a temporary holding place for commonly used data. Instead of calling on random access memory for these items, the CPU determines what data you seem to keep using, assumes you'll want to keep using it, and stores it in the cache. Cache is faster than using RAM because it's a physical part of the processor; more cache means more space for holding such information. Whether your computer can run a 32-bit or 64-bit operating system depends on the size of data units that the CPU can handle. More memory can be accessed at once and in larger pieces with a 64-bit processor than a 32-bit one, which is why operating systems and applications that are 64-bit-specific cannot run on a 32-bit processor. You can see a computer's CPU details, along with other hardware information, with most free system information tools. Beyond the standard processors available in commercial computers, quantum processors are being developed for quantum computers using the science behind quantum mechanics. Each motherboard supports only a certain range of CPU types, so always check with your motherboard manufacturer before making a purchase. FAQ To test your computer's CPU temperature on a Windows PC, use a free or low-cost monitoring program like SpeedFan, Real Temp, or CPU Thermometer. Mac users should download System Monitor to monitor CPU temperature, processing load, and more. Use an isopropyl wipe to gently wipe the thermal paste off your LGA socket. Be sure to wipe in a straight line. Repeat the process as necessary, using a fresh wipe with each effort. If you're just learning about the world of computers and electronics, the terminology used to refer to different parts can be confusing. One component term you may have encountered is "CPU," which stands for "central processing unit." CPUs reside in almost all devices you own, whether it's a smartwatch, a computer, or a thermostat. They are responsible for processing and executing instructions and act as the brains of your devices. Here, we explain how CPUs interact with other parts of your devices and what makes them so integral to the computing process. What makes a CPU a CPU? Jacob Roach / Digital Trends The CPU is the core component that defines a computing device, and while it is of critical importance, the CPU can only function alongside other hardware. The silicon chip sits in a special socket located on the main circuit board (motherboard or mainboard) inside the device. It is separate from the memory, which is where information is temporarily stored. It is also separate from the graphics card or graphics chip, which renders the video and 3D graphics that are displayed on your screen. CPUs are made by arranging billions of microscopic transistors onto a single computer chip. These transistors enable the CPU to perform the computations necessary for executing programs stored in your system's memory. Functioning as tiny switches, they alternate between on and off states, conveying the binary ones and zeros that underlie all your actions on the device, whether it's watching videos or composing an email. One of the most common advancements in CPU technology is in making those transistors smaller and smaller. That has resulted in the improvement in CPU speeds over the decades, often referred to as Moore's Law. In the context of modern devices, a desktop or laptop has a dedicated CPU that performs many processing functions for the system. Mobile devices and some tablets instead utilize a system on a chip (SoC) which is a chip that packages the CPU alongside other components. Intel and AMD both offer CPUs with graphics chips and memory stored on them (you may have heard of AMD APUs), too, meaning they can do more than just standard CPU functions. What does a CPU actually do? Narumon Bowonkitwanchai/Getty Images / Getty At its core, a CPU takes instructions from a program or application and performs a calculation. This process breaks down into three key stages: fetch, decode and execute. A CPU fetches the instruction from RAM, decodes what the instruction actually is, and then executes the instruction using relevant parts of the CPU. The executed instruction, or calculation, can involve basic arithmetic, comparing numbers, performing a function, or moving numbers around in memory. Since everything in a computing device is represented by numbers, you can think of the CPU as a calculator that runs incredibly fast. The resulting workload might start up Windows, display a YouTube video, or calculate compound interest in a spreadsheet. In modern systems, the CPU acts like the ringmaster at the circus by feeding data to specialized hardware as it is required. For example, the CPU needs to tell the graphics card to show an explosion because you shot a fuel drum in a game or tell the solid-state drive to transfer an Office document to the system's RAM for quicker access. Cores, clocks, and costs Jacob Roach / Digital Trends Originally, CPUs had a single processing core. Today's modern CPU consists of multiple cores that allow it to perform multiple instructions at once, effectively cramming several CPUs on a single chip. Entry-level processors today have between two and six cores, while six to eight cores is more mainstream in gaming devices and PCs. High-end models can have anywhere up to 32 cores, and professional hardware can go beyond that. Many processors also employ a technology called simultaneous multithreading. Imagine a single physical CPU core that can perform two lines of execution (threads) at once, thereby appearing as two "logical" cores on the operating system end. These virtual cores aren't as powerful as physical cores because they share the same resources, but overall, they can help improve the CPU's multitasking performance when running compatible software. Clock speed is prominently advertised when you are looking at CPUs. This is the "gigahertz" (GHz) figure that effectively denotes how many instructions a CPU can handle per second, but that's not the whole picture regarding performance. Clock speed mostly comes into play when comparing CPUs from the same product family or generation. When all else is the same, a faster clock speed means a faster processor. However, a 3GHz processor from 2010 will deliver less work than a 2GHz processor from 2020, due to the newer model's more advanced underlying silicon. How much should you pay for a CPU? For a general outline, unless you're a hardcore gamer or someone looking to edit videos, you don't need to spend more than $200 to $300. You can help keep the cost down by avoiding the latest hardware and instead sticking to a recent generation of CPU. For Intel CPUs, that means 13th, or 14th-generation chips. You can determine their generation by the product name. For instance, the Core i7-10700K is an older 10th-generation chip, while the Core i9-14900K is a newer 14th-generation chip. AMD does something similar with its Ryzen CPUs: The Ryzen 9 3950X is a 3rd-generation chip, while the Ryzen 7 5700X is the fourth-generation CPU based on the company's Zen 3 architecture. Ryzen 4000 was released as a laptop chip line and in APU form with very limited availability on desktops through system builders. With that in mind, it's arguable which generation of AMD Ryzen CPU we're at, but the Zen 5-based Ryzen 9000 line is the latest, and most recently, AMD has unified its laptop, APU, and desktop platforms. How important is the CPU? These days, your CPU isn't as important for overall system performance as it once was, but it still plays a major role in the response and speed of your computing device, and without one, it wouldn't work at all. Gamers will generally find a benefit from higher clock speeds, while more serious work such as CAD and video editing will see an improvement from a higher CPU core count. You should bear in mind that your CPU is part of a system, so you want to be sure you have enough RAM and use an SSD over an HDD to have fast storage that can feed data to your CPU. Perhaps the largest question mark will hang over your graphics card as you generally require some balance within your PC, both in terms of performance and cost. Now that you understand the role of a CPU, you are in a better position to make an educated choice about your computing hardware. Use our CPU buying guide to learn more about the best chips currently available. Once you've done that, check the top options in our lists of the best Intel processors and the best AMD processors available right now. Jon Martindale is a freelance evergreen writer and occasional section coordinator, covering how to guides, best-of lists, and... The CPU (central processing unit) is the brain of your computer, processing instructions from programs and components. Modern CPUs use billions of microscopic transistors to interpret binary signals, enabling complex tasks at high speeds. Your CPU connects with other PC components through sockets and buses. The most important part of your computer, if you had to choose just one, would be the central processing unit (CPU). It's the primary hub (or "brain"), and it processes the instructions that come from programs, the operating system, or other components in your PC. 1's and 0's: What a CPU Does Thanks to more powerful CPUs, we've jumped from barely being able to display an image on a computer screen to Netflix, video chat, streaming, and increasingly lifelike video games. The CPU is a wonder of engineering, but, at its core, it still relies on the basic concept of interpreting binary signals (1's and 0's). The difference now is that, instead of reading punch cards or processing instructions with sets of vacuum tubes, modern CPUs use tiny transistors to create TikTok videos or fill out numbers on a spreadsheet. Justin Duino / How-To Geek CPU manufacturing is complicated. The important point is that each CPU has silicon (either one piece or several) that houses billions of microscopic transistors. As we alluded to earlier, these transistors use a series of electrical signals (current "on" and current "off") to represent machine binary code, made up of 1's and 0's. Because there are so many of these transistors, CPUs can do increasingly complex tasks at greater speeds than before. The transistor count doesn't necessarily mean a CPU will be faster. However, it's still a fundamental reason the phone you carry in your pocket has far more computing power than, perhaps, the entire planet did when we first went to the moon. Before we head further up the conceptual ladder of CPUs, let's talk about how a CPU carries out instructions based on machine code, called the "instruction set." CPUs from different companies can have different instruction sets, but not always. Most Windows PCs, for example, use the x86-64 instruction set, regardless of whether they're an Intel or AMD CPU. Macs from the year 2020 and newer, however, have ARM-based CPUs called Apple Silicon, which use a different instruction set. There is also a small but growing number of Windows PCs using ARM processors, such as the Lenovo Yoga Slim 7x. Intel Now, let's look at the silicon itself. The diagram above is from an Intel white paper published in 2014 about the company's CPU architecture for the Core i7-4770S. This is just an example of what one processor looks like—other processors have different layouts. We can see this is a four-core processor. There was a time when a CPU only had a single core. Now that we have multiple cores, they process instructions much faster. Cores can also have something called hyper-threading or simultaneous multi-threading (SMT), which makes one core seem like two to the PC. This, as you might imagine, helps speed up processing times even more. The cores in this diagram are sharing something called the L3 cache. This is a form of onboard memory inside the CPU. CPUs also have L1 and L2 caches contained in each core, as well as registers, which are a form of low-level memory. If you want to understand the differences between registers, caches, and system RAM, check out this answer on StackExchange. The CPU shown above also contains the system agent, memory controller, and other parts of the silicon that manage information coming into, and going out of, the CPU. Finally, there's the processor's onboard graphics, which generate all those wonderful visual elements you see on your screen. Not all CPUs contain their own graphics capabilities. AMD Zen desktop CPUs, for example, require a discrete graphics card to display anything on-screen. Some Intel Core desktop CPUs also don't include onboard graphics. Jason Fitzpatrick / How-To Geek Now that we've looked at what's going on underneath the hood of a CPU, let's look at how it integrates with the rest of your PC. The CPU sits in what's called a socket on your PC's motherboard. Once it's seated in the socket, other parts of the computer can connect to the CPU through something called "buses." RAM, for example, connects to the CPU through its own bus, while many PC components use a specific type of bus, called a "PCIe." Each CPU has a set of "PCIe lanes" it can use. AMD's Zen 5 CPUs, for example, have 28 lanes that connect directly to the CPU. These lanes are then divvied up by motherboard manufacturers with guidance from AMD. For example, 16 lanes are typically used for an x16 graphics card slot. Then, there are eight lanes for storage, such as a fast storage device, like an M.2 SSD. Alternatively, these eight lanes can also be split. Two lanes could be used for the M.2 SSD, and two for a slower SATA drive, like a hard drive or 2.5-inch SSD, and so on. That's 24 lanes, with the other 4 reserved for the chipset, which is the communications center and traffic controller for the motherboard. The chipset then has its own set of bus connections, enabling even more components to be added to a PC. As you might expect, the higher-performing components have a more direct connection to the CPU. As you can see, the CPU does most of the instruction processing, and sometimes, even the graphics work (if it's built for that). The CPU isn't the only way to process instructions, however. Other components, such as the graphics card, have their own onboard processing capabilities. The GPU also uses its own processing capabilities to work with the CPU and run games or carry out other graphics-intensive tasks. The big difference is component processors are built with specific tasks in mind. The CPU, however, is a general-purpose device capable of doing whatever computing task it's asked to do. That's why the CPU reigns supreme inside your PC, and the rest of the system relies on it to function. If you're building a PC, especially one for gaming, you want to make sure you choose a fast and future-proof processor. Check our guide to the best CPUs on the market to get started. Be sure to check your measurements before ordering any other parts, though. The Central Processing Unit (CPU) is like the brain of a computer. It's the part that does most of the thinking, calculating, and decision-making to make your computer work. Whether you're playing a game, typing a school assignment, or watching a video, the CPU is busy handling all the instructions to get the job done. The CPU is usually placed in a special slot called a socket on the computer's motherboard, which is like the main circuit board that connects all the parts of a computer. The CPU handles tasks like:Doing math calculations (like adding or multiplying numbers).Running apps or games.Helping the keyboard, mouse, and screen work together.Storing and retrieving information during tasks.Without a CPU, a computer wouldn't know what to do.Why CPU is Important in ComputingThe CPU is super important because it handles every task your computer does. Without it, your computer would just be a fancy box! A fast CPU means your games run smoothly, your apps open quickly, and your homework gets done faster. History of CPUThe story of the CPU started long ago and has some exciting milestones that changed how computers work. Here's a simple timeline for students:1823: A scientist named Baron Jons Jakob Berzelius discovered silicon, a material still used to make CPUs today.1947: Scientists John Bardeen, Walter Brattain, and William Shockley invented the transistor, a tiny switch that helped make modern CPUs possible.1958: Engineers Jack Kilby and Robert Noyce created the integrated circuit, which combined many transistors into a single chip.1971: Intel released the Intel 4004, the first-ever microprocessor (a CPU on a single chip), starting the era of personal computers.1979: Motorola introduced the Motorola 68000, a powerful CPU used in early computers and gaming consoles.1999: Intel launched the Celeron processors, making computers faster and more affordable.2005: AMD introduced the first dual-core processor, allowing CPUs to handle multiple tasks at once.2009: Intel released the Core i5, a four-core processor that made computers even faster.2017-2018: Intel introduced the Core i9, one of the most powerful CPUs for desktops and laptops.Each step made CPUs smaller, faster, and more powerful, helping computers do more amazing things!Components of CPUThe components of a CPU include the ALU (Arithmetic Logic Unit), CU (Control Unit), registers, cache, and clock.The red lines show how data moves between the parts, while the blue lines show how the CPU sends control signals to manage everything.Control Unit (CU): It controls the CPU's operations by reading and following instructions. It also manages the flow of data inside the CPU.ALU (Arithmetic Logic Unit): It does all the math and logic calculations, like addition, subtraction, and comparisons (such as checking if two numbers are equal).Input Unit: This part gets data from devices like a keyboard, mouse, or microphone, and sends it to the CPU to be processed.Output Unit: After the CPU processes the data, the output unit sends it to devices like a monitor, printer, or speakers so the user can see or hear the result.Internal Memory: This stores temporary data and instructions that the CPU needs while it's working, like the registers and cache memory.Main Memory: It holds the data and instructions the CPU is currently using, often in RAM (Random Access Memory).Secondary Storage: This is where data and programs are stored when they're not being used right away, like on hard drives or SSDs.Functions of the CPUThe CPU's main job is to process instructions from programs. It does this through a process called the Fetch-Decode-Execute-Store cycle:This cycle happens billions of times a second, letting the CPU handle tons of tasks super fast!Fetch: the first CPU gets the instruction. That means binary numbers that are passed from RAM to CPU.Decode: When the instruction is entered into the CPU, it needs to decode the instructions. with the help of ALU(Arithmetic Logic Unit), the process of decoding begins.Execute: After the decode step the instructions are ready to execute.Store: After the execute step the instructions are ready to store in the memory.Types of CPUsCPUs come in different types, depending on how many cores they have. A core is like a mini-CPU inside the main CPU, and more cores mean the CPU can do more tasks at once. Here are the main types:Single-Core CPU: The oldest type, used in the 1970s. It can only handle one task at a time, so it's slow for modern apps like games or web browsers.Dual-Core CPU: Has two cores, so it can handle two tasks at once. It's faster and better for multitasking, like listening to music while doing homework.Quad-Core CPU: Has four cores, making it great for heavy tasks like video editing or playing modern games. It's very fast and common in today's computers.Why is the CPU Called the Brain of the Computer?The CPU earns its nickname as the "brain" because it's responsible for thinking through and executing every task in a computer. Just like your brain processes information to make decisions, the CPU processes instructions to make your computer do what you want. Without a CPU, a computer would just be a lifeless box of parts.How Does the CPU Make Computers Faster?Modern CPUs are designed to be super efficient. Here are a few ways they speed things up:Multiple Cores: Many CPUs have multiple cores, which are like mini-CPUs that can work on different tasks at the same time. It's like having several chefs in the kitchen instead of one.Faster Clocks: The clock speed (measured in GHz, like 3.5 GHz) determines how many instructions the CPU can handle per second.Bigger Cache: More cache means the CPU can store more data close by, reducing wait times.Pipelining: This lets the CPU start working on the next instruction before finishing the current one, like a factory line.Advantages of CPUsVersatile: CPUs can handle all kinds of tasks, from simple math to running complex games.Fast: Modern CPUs process billions of instructions per second.Multi-tasking: Multi-core CPUs let you run many programs at once, like watching a video while chatting with friends.Compatible: CPUs work with tons of software, so you can use the same CPU for different apps.Disadvantages of CPUsHeat: CPUs get hot when working hard, so computers need fans or cooling systems to stay safe.Power Use: Powerful CPUs use a lot of electricity, which can raise power bills.Cost: High-performance CPUs, like Intel Core i9, can be expensive.Not Perfect for All Tasks: For tasks like graphics or video editing, specialized chips like GPUs (Graphics Processing Units) are better than CPUs.Modern ApplicationsCPUs are everywhere, not just in computers:CPU in Personal Computers: In your laptop or desktop, the CPU runs your games, apps, and homework programs, making sure everything works smoothly.Role in Mobile Devices: Your phone or tablet has a CPU too! It's smaller and uses less power but still handles calls, apps, and videos.Use in Servers and Data Centers: In big data centers, CPUs power websites like YouTube and Google, processing millions of requests every second.ConclusionThe CPU is the brain of every computer, making it possible to play, learn, and connect. From its tiny components to its super-fast cycles, the CPU is a marvel of technology. In the future, CPUs will get even faster, smaller, and more efficient, powering cool new gadgets we can't even imagine yet. So next time you use your computer or phone, give a shout-out to the amazing CPU working hard behind the scenes! Computer Fundamental Tutorial What is a Computer? Basics of Computer and its Operations Advantages and Disadvantages of Computer Classification of Computers Basic Applications of Computers History of Computers Evolution of Generation of Computers Central Processing Unit (CPU) Input Devices What are Different Output Devices? Computer Hardware What is a Computer Software? What is a Motherboard? Random Access Memory (RAM) Hard Disk Drive (HDD) Secondary Memory Introduction to Solid-State Drive (SSD) What is a Graphics Processing Unit (GPU)? What is Power Supply Unit (PSU)? What is a Computer Software? Software and its Types What is Application Software? System Software Utility Software What is a Keyboard? What is a Mouse in Computer? What is a Joystick? What is a Light Pen? What is Scanner? What is Optical Character Recognition (OCR)? What is a Barcode Reader? What is WebCam? What is a Speaker? What is a Printer? What is a Monitor? What is a Plotter? What is a Projector? What are Headphones? What is a Storage Device? Definition, Types, Examples Hard Disk Drive (HDD) Secondary Memory Introduction to Solid-State Drive (SSD) Optical Storage Systems What is Flash Drive? What is a Memory Card? Computer Memory What is Register Memory? Cache Memory Primary Memory Secondary Memory Introduction to memory and memory units