

Intro to Computer Architecture

CISC 3310 — CUNY Brooklyn College

Lecture Notes



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Intro to Computer Architecture: Motivation

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When shopping for a device  , how do you decide which one to buy?

- Physical appearance
- Type (desktop, laptop, smartphone, etc.)
- Technical aspects and features
- Recommendations from Family/Friends
- Ads you've seen
- Discount price

To which of these points should you pay most of your attention while making such a decision?

That is, knowing more on which of these points will benefit you the most in the long run?



Analogy: Buying a Car 🚗

Imagine you decided to buy a car: you plan to use this car on a daily basis to commute to your job (on weekdays) and drive to national parks (on weekends).

You are visiting a car showroom right now. An agent you met points to a 2012-made sedan (4-door mid-size) car and says: "This car was made just for you! It has great room inside, a beautiful polished silver color, and impressive high-quality leather seats!"

- Have the agent's words convinced you to take this car?
- What other information would you like to learn about this car before making your decision?



Intro to Computer Architecture: Motivation

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The previous example emphasizes that the functionalities of a car matter the most: they can tell how useful this car will be to you and, most likely, how many years it will serve you. The same idea applies to *any* electronic device or product, including computers and smart devices.

In this course, we will learn *how* computers are built and *how* they work.

In other words, this course will focus on the **hardware** aspects of a computer and the way in which all hardware components interact with each other to create this nowadays-essential but, nevertheless, marvelous device. This knowledge will not only make you a better programmer but a mindful computer user and buyer.



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Intro to Computer Architecture: Motivation

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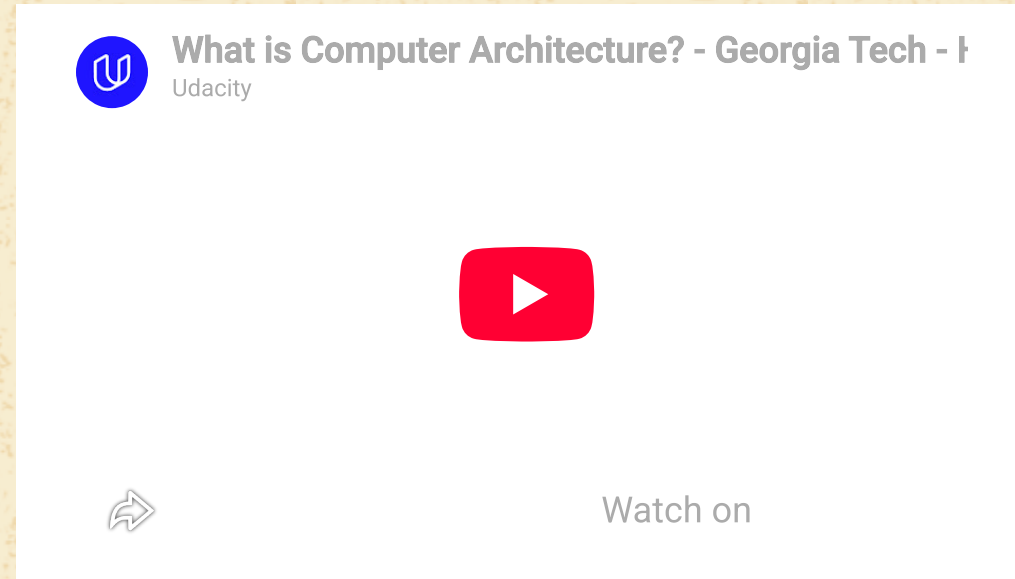
Any questions so far?



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Intro to Computer Architecture

This video explains what the term **Computer Architecture** is about:



<https://www.youtube.com/watch?v=MAYDdVZawls>

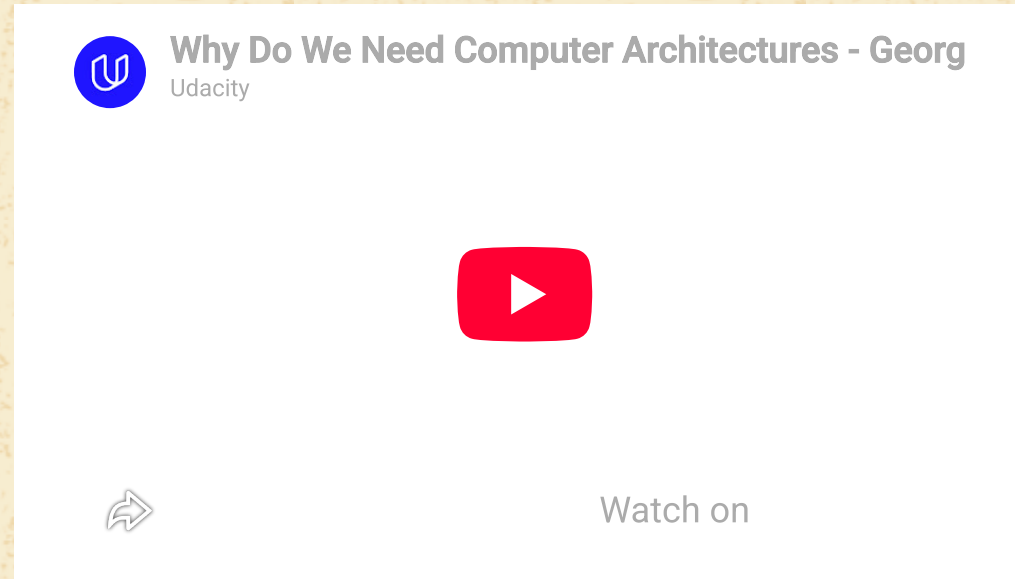


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Intro to Computer Architecture

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Another video explaining why we need to consider architecture when designing a device:



<https://www.youtube.com/watch?v=2gNkitc3CgQ>



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Intro to Computer Architecture: Definitions

Our course's name is **Principles of Computer Architecture**, but we often hear the terms "Architecture" and "Organization" in the same context. What exactly does each of these mean?

Computer Architecture is the way a computer is constructed/designed, and, as a consequence, the way that it behaves. It includes aspects like the instructions that the computer can understand, the data types it works with, the structure of the processor (will define and discuss the word 'processor' later), the way memory is accessed, and the way input & output devices are connected to the computer.

Computer Organization is about how the computer uses all the given hardware devices to accomplish the goals of the computer's creator/programmer. In short, it is about the way that the computer is controlled (that is, how it works.)

Another angle: Computer Architecture consists of both (1) Computer Organization and (2) the set of all the basic instructions that the computer understands, called **Instruction Set Architecture (ISA)**.



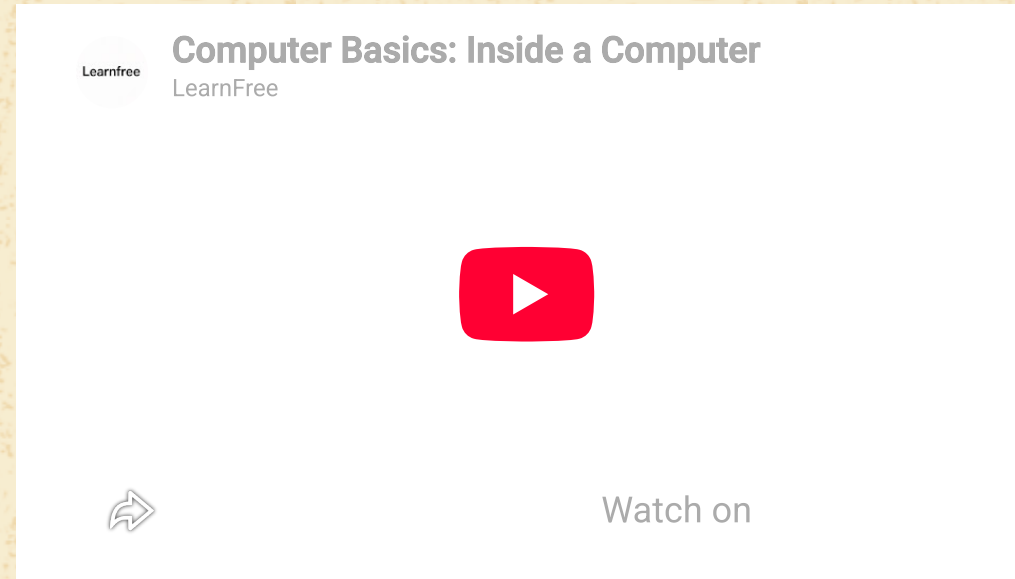
Why Studying Computer Architecture?

- Understanding how a computer processes and executes instructions can help you optimize code or data for better performance.
- Knowing how to explore your device's features enables you to fully utilize your computer's capabilities.
- Familiarity with hardware components and terminology empowers you to make informed purchasing decisions that align with your needs.
- While this course won't make you a certified technician, it provides a strong foundation for future hardware-related training if you ever need it as part of your job.



Hardware Components of a Computer

Let's watch a video introducing us to hardware components of a computer:



<https://www.youtube.com/watch?v=HB4I2CgkcCo>

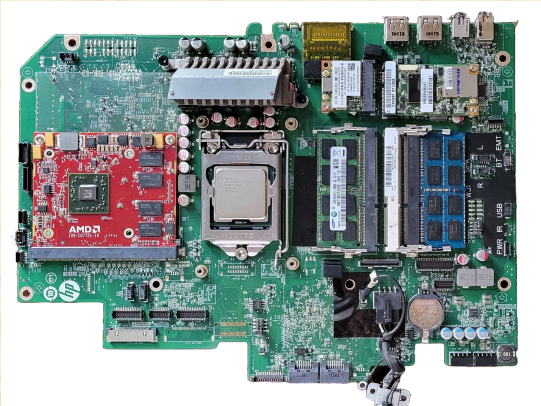


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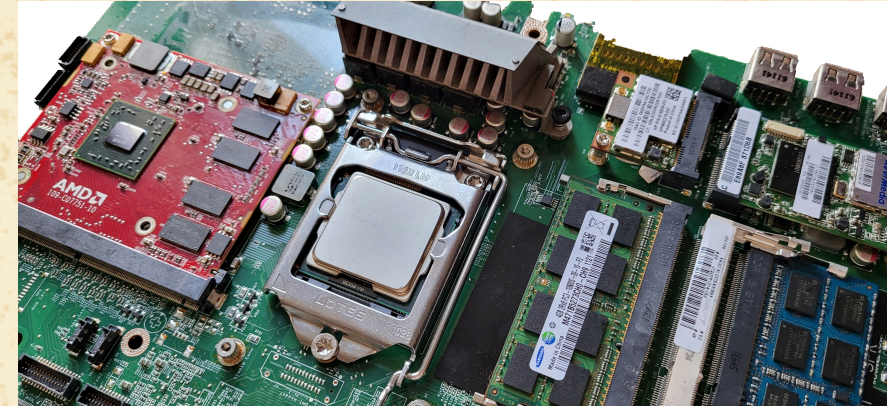
Hardware Components of a Computer

Hardware components that every computer has are:

1. The **motherboard** is a large board-like chip hosting multiple devices and chips that are essential for the computer's operation, such as the CPU, RAM (memory), cache, graphics cards (GPU), buses and wires connection all these devices, and many more. Every modern desktop and laptop computer, every cell phone device, and many other devices have a motherboard.



Motherboard, Top View. [Miriam Briskman](#), [CC BY-NC 4.0](#).



Motherboard, Oblique-Angle View. [Miriam Briskman](#), [CC BY-NC 4.0](#).



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Hardware Components of a Computer

2. The **CPU** (= Central Processing Unit), also referred to sometimes as the **processor** or **microprocessor**, is the brain of the computer that calculates things (e.g., adding numbers,) makes decisions (e.g., executes if-else statements,) and, in general, runs a program's instructions.

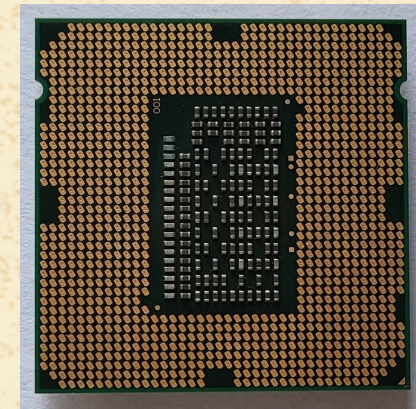
A CPU might contain multiple **cores**, each of which, like an independent brain, can perform computations and execute instructions independently and in parallel to the other cores. A quad-core CPU, for example, contains 4 cores.



Closeup of the CPU on the Motherboard. [Miriam Briskman](#), [CC BY-NC 4.0](#).



The CPU chip, Top (Outer) View. [Miriam Briskman](#), [CC BY-NC 4.0](#).

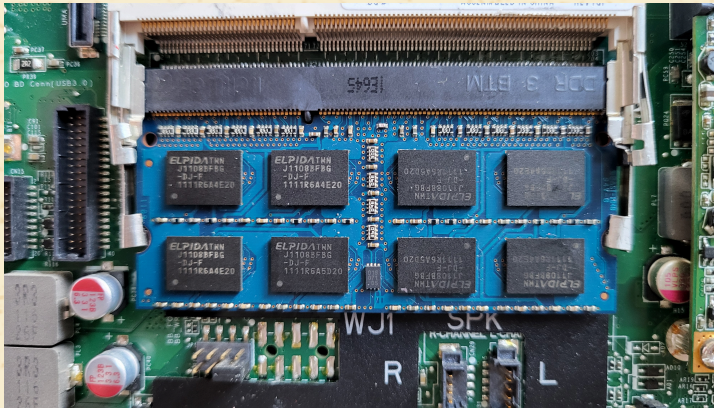


The CPU chip, Bottom (Inner) View. [Miriam Briskman](#), [CC BY-NC 4.0](#).



Hardware Components of a Computer

2. **Main Memory**, also known as **RAM** (= Random Access Memory), or simply "**memory**", is a chip that stores the values of variables, arrays, and objects, as well as all the currently running programs' instructions. Every program is built up of instructions, and every program uses variables (such as the arguments and return value from the `main()` function), which means every program resorts to storing data in memory during its execution. Memory is a volatile device: once the computer is turned off, the data in it is deleted.



Closeup of a 2GB Memory Stick.
[Miriam Briskman](#), [CC BY-NC 4.0](#).



The Blue 2GB Memory Chip, Front.
[Miriam Briskman](#), [CC BY-NC 4.0](#).



Hardware Components of a Computer

3. **ROM** (Read-Only Memory) is a small chip that stores a short program called **BIOS** that runs when the computer “boots” (turns on or restarts): it preps the computer hardware and operating system for the computer to flawlessly launch and work. ROM is non-volatile, and cannot be deleted since it is "read-only" (deleting the contents of the ROM will result in the computer not being able to launch properly.)

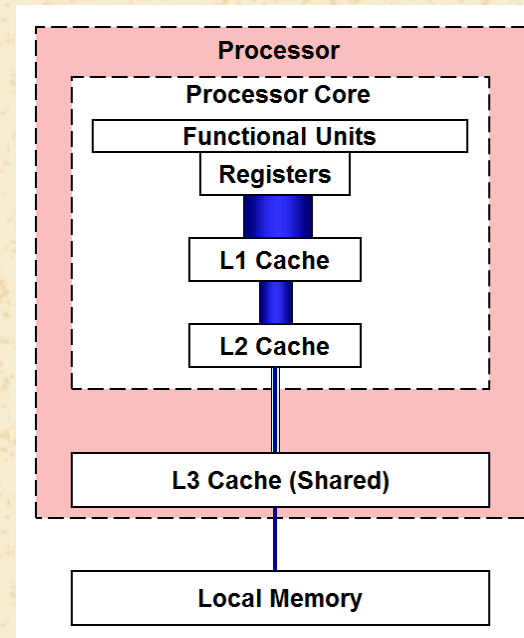


The ROM chip (encircled in red.) [Miriam Briskman](#), [CC BY-NC 4.0](#).



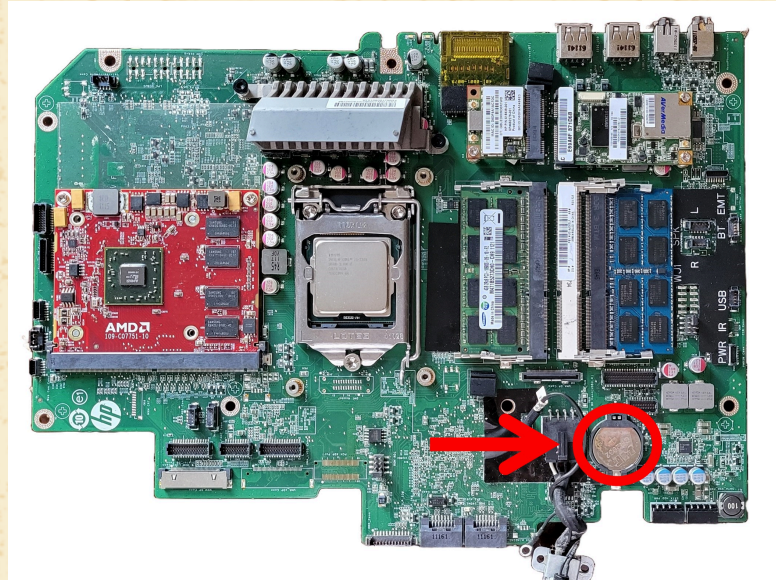
Hardware Components of a Computer

4. The **cache** is a temporary storage of data located between the CPU and RAM. Accessing cache is faster than accessing RAM in most cases. A computer might have a few cache levels, from smallest to largest: Level 1 (smallest), Level 2, and Level 3. In newer devices, cache is located inside the CPU chipset since the closer cache is to the CPU, the faster it works.



Hardware Components of a Computer

5. **Buses** allow different components, such as the CPU, cache, and memory, along with various input and output devices, to communicate with each other. Buses include wires, optical fibers, and any software that makes them operate. Buses are integrated deeply into the motherboard.
6. Every computer also has a **power unit** or **battery** that feeds electricity to the computer's clock.



The motherboard's battery. [Miriam Briskman](#), CC BY-NC 4.0.



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Hardware Components of a Computer

7. The **Storage** (also **Secondary Storage**) component of the computer permanently stores data (until you decide to delete it.)

- i. **Hard disk drives** have higher storage capacity, are cheap, but are slower.
- ii. **Solid-state drives** are faster and use less power but are more expensive.



A hard disk drive. [Miriam Briskman](#), [CC BY-NC 4.0](#).



A solid-state drive. By [David290](#), [CC BY-SA 4.0](#), via Wikimedia Commons.



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Hardware Components of a Computer

8. Given that both hard disk drives and solid-state drives are situated inside the computer, computers might also have **external storage** devices, such as portable hard disk or solid-state drives, or such transportable plug-and-play devices as a **USB flash drive** and an **optical disc** (CD, DVD, Blu-ray, etc.)



External Hard Drive. [Harke](#), [CC BY-SA 3.0](#), via Wikimedia Commons.



USB Flash Drive. [Evan-Amos](#), Public domain, via Wikimedia Commons.



Optical Compact Disk (CD). [Original uploader: Sakurambo](#), [CC BY-SA 2.5](#), via Wikimedia Commons.



Hardware Components of a Computer

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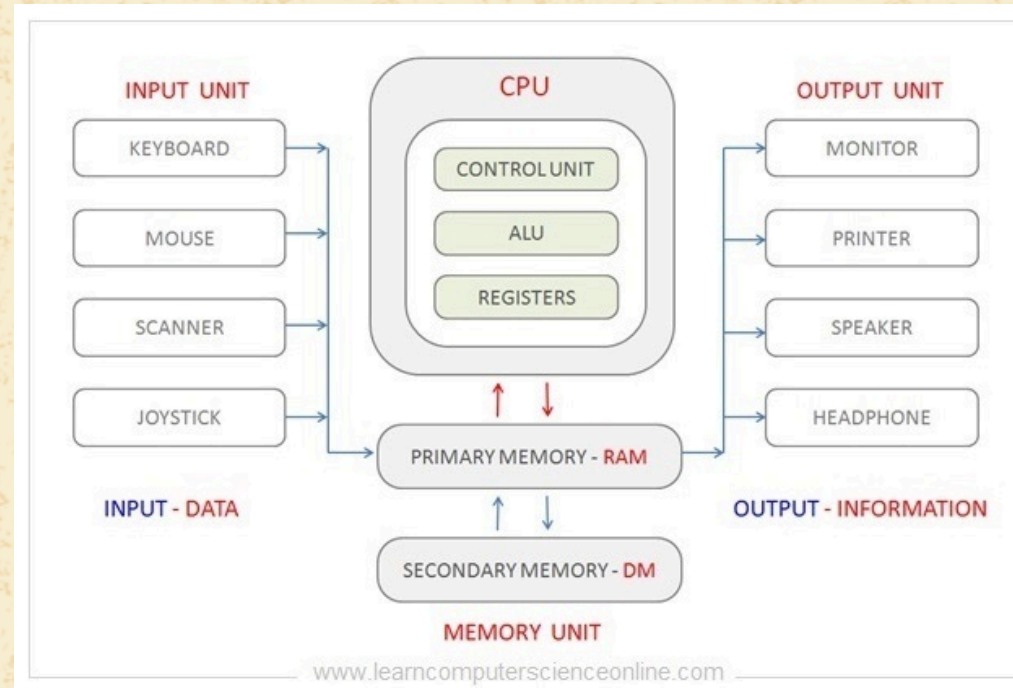
9. Since computations are mostly useless if they are not communicated to the outside world, a computer uses **input & and output devices**:

- i. **Input device** examples: the keyboard, mouse (or touchpad), joystick, camera, and microphone.
 - Include devices that transmit user's data into the computer.
- ii. **Output device** examples: the monitor, speakers, printer, and Braille embosser.
 - Consist of devices that let the computer deliver data to the user.



Hardware Components of a Computer

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Taken from <https://www.learncomputerscienceonline.com/introduction-to-computer-system/>.



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Hardware Components of a Computer

Optional hardware components that a computer might have include:

- Ports: USB, HDMI, Ethernet, Audio (headphones), etc. Here are [images of various computer ports](#).
- SD or microSD card slots
- CD-ROM read/write drives
- Graphics cards (also called video cards or GPUs.)
- Sound cards
- Wi-Fi or other network cards
- Additional memory slots
- Touch screen/display

We will learn more about the basic and optional hardware devices listed above and on the previous slides as we proceed with our course's topics.



Hardware Components of a Computer

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Any questions so far?



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Practical Example: Which Desktop to Buy?

Scenario: Johnny, a heavy computer gamer, wants to purchase a desktop that will run high-quality video games smoothly, without games freezing or suddenly crashing. Which of these 3 desktops should Johnny consider buying, and why?

	Desktop №1	Desktop №2	Desktop №3
Display	23", LCD, 16:10, 3840 x 2160	20.5", LED, 16:9, 2560 x 1440	27", Curved, 21:9, 1920 x 1200
CPU	Intel i7, 4.3 GHz, 20 cores, 28 threads	AMD Ryzen 9, 4.9 GHz, 16 cores, 32 threads	Intel i9, 3.2 GHz, 24 cores, 32 threads
Cache	64KB L1, 28MB L2, 33MB L3	256KB L1, 4MB L2, 68MB L3	128KB L1, 20MB L2, 24MB L3
RAM	3200 MHz, 16GB, DDR4, 2Rx8	1700 MHz, 8GB, DDR3, 1Rx16	5600 MHz, 64GB, DDR5, 1Rx8
Storage	7000 RPM SATA 2TB HDD	SAS 850GB SSD	6500 RPM SCSI 1TB HDD

The above table contains so many details! We first need to explain what they mean before advising anything to Johnny.



Practical Example: Which Desktop to Buy?

We will first explain what the terms and abbreviations in the **red boxes** mean, and then proceed to deciding which device is best for Johnny's lifestyle.

	Desktop №1	Desktop №2	Desktop №3
Display	23", LCD, 16:10, 3840 x 2160	20.5", LED, 16:9, 2560 x 1440	27", Curved, 21:9, 1920 x 1200
CPU	Intel i7, 4.3 GHz, 20 cores, 28 threads	AMD Ryzen 9, 4.9 GHz, 16 cores, 32 threads	Intel i9, 3.2 GHz, 24 cores, 32 threads
Cache	64 KB L1, 28 MB L2, 33 MB L3	256 KB L1, 4 MB L2, 68 MB L3	128 KB L1, 20 MB L2, 24 MB L3
RAM	3200 MHz, 16 GB, DDR4, 2Rx8	1700 MHz, 8 GB, DDR3, 1Rx16	5600 MHz, 64 GB, DDR5, 1Rx8
Storage	7000 RPM, SATA 2 TB, HDD	SAS 850 GB, SSD	6500 RPM, SCSI 1 TB HDD

First thing first: let's begin with the display.



Computer Display

- **23"**, or 23 inches, is the **diagonal size of the display in inches**. It indicates how large the computer screen is.
- **16:10** is the ratio of the screen's width to the screen's height, called the **aspect ratio**. It tells how large the width is with respect to the height. [**Challenge question**: If you know both the diagonal size and the aspect ratio, what famous math theorem will you use to find the sizes of the width and height in inches? **Hint**: there are 90 degrees between two adjacent edges of the screen.]
- **3840 x 2160** is the **pixel resolution**. Bigger numbers mean more pixels built into the display, a higher resolution, and, therefore, much sharper quality of the displayed images.
- **LCD**, **LED**, and **Curved** are 3 monitor types, representing the technologies used to build the display. LCD ("liquid crystal display") uses a liquid crystal solution between two layers of polarizing material. When an electric current is passed through the liquid, it either blocks or allows light to pass through, which forms images. LED ("light emitting diode") is an LCD using LED backlights instead of fluorescent lights. A curved display uses LCD or LED but has an inward-curved screen. LCDs are more affordable, and LEDs are thinner, brighter, and more energy-efficient than traditional LCDs, with better contrast ratios and more vivid colors.

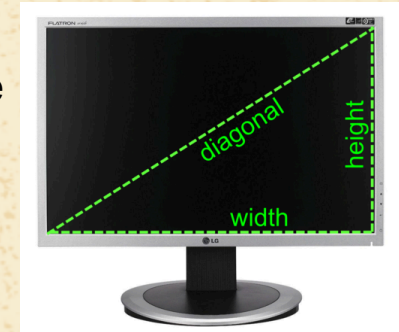


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Units of Measure

Before we continue explaining the rest of the terms, we need to see some common units of measure:

Name	Symbol	Power of 10	Power of 2	Name	Symbol	Power of 10	Power of 2
Kilo	K	1 thousand = 10^3	$2^{10} = 1024$	Milli	m	1 thousandth = $10^{-3} = \frac{1}{10^3}$	$2^{-10} = \frac{1}{2^{10}}$
Mega	M	1 million = 10^6	2^{20}	Micro	μ	1 millionth = 10^{-6}	2^{-20}
Giga	G	1 billion = 10^9	2^{30}	Nano	n	1 billionth = 10^{-9}	2^{-30}
Tera	T	1 trillion = 10^{12}	2^{40}	Pico	p	1 trillionth = 10^{-12}	2^{-40}
Peta	P	1 quadrillion = 10^{15}	2^{50}	Femto	f	1 quadrillionth = 10^{-15}	2^{-50}
Exa	E	1 quintillion = 10^{18}	2^{60}	Atto	a	1 quintillionth = 10^{-18}	2^{-60}
Zetta	Z	1 sextillion = 10^{21}	2^{70}	Zepto	z	1 sextillionth = 10^{-21}	2^{-70}
Yotta	Y	1 septillion = 10^{24}	2^{80}	Yocto	y	1 septillionth = 10^{-24}	2^{-80}



CPU Features

- **Intel** and **AMD** are CPU chipset manufacturers/brands, producing most of the CPUs available in the market. Both companies produce high-quality CPUs; however, the differences between them are that Intel CPUs have greater performance per core, are more power efficient, and have high clock tick speeds, while AMD CPUs are less expensive, stay cooler than Intel CPUs, come with larger cache, and have better onboard graphics chips.
- **i7** and **i9** are **brand modifiers**: the greater the number, the more powerful the tasks that this CPU can perform are. Similarly, **Ryzen 9** is a **brand and level** number of the AMD CPUs.
- **4.3 GHz** is the **CPU's speed**. "GHz" is read as "Giga Hertz", where hertz is a unit of frequency measuring the number of clock cycles per second. During 1 clock cycle, the CPU can run up to several computer instructions, so the more cycles there are, the more instructions it can run. 4.3 Giga Hertz means that the CPU can run at least 4.3 billion of instructions per second!
- Each CPU **core** can run instructions in parallel and independently of other cores. Some cores can run 2 sequences of instructions (= **threads**) at the same time, called **dual-threaded** or **hyper-threaded** cores, while those that can run only 1 sequence at a time are **singly-threaded**. A CPU with 20 cores and 28 threads means $28 - 20 = 8$ cores are hyper-threaded, and $20 - 8 = 12$ are singly-threaded. Such a device can run at least 20 programs simultaneously!



Cache Features

We learned that **cache** is a small storage container (chip) that the CPU uses to store some frequently used variables and data. The CPU accesses data in cache much faster than accessing data in main memory because cache is located closer to the CPU than memory is and, the closer the storage container is to the CPU, the faster the CPU will access it. Nowadays, cache is built inside the CPU chipset box for best performance.

- After performing some testing on CPUs, manufacturers found out that the CPU will benefit from having several levels of cache: **Level 1**, or **L1** for short, is the fastest and closest cache to the CPU. Each core has its own Level 1 cache storage; **Level 2 (L2)** cache is slightly larger, slower, and further away from the CPU, and, again, every core has its own L2 storage; **Level 3 (L3)** cache is the largest, slowest, and furthest. Unlike L1 and L2, all the cores share the same one L3 cache storage.
- Each cache storage has its own size. For example, **64KB L1** means that each core has a level 1 cache of the size of 64 kilobytes. **33MB L3** means that there is one, large level 3 cache memory of 33 megabytes shared by all the cores. The listed L2 cache size sometimes stands for the total of L2 sizes for all the cores, but at other times, it indicates the cache size per core. Since **28MB L2** is closer in size to the L3 cache size, this is the total L2 cache size across all cores.



Memory Features

- **3200 MHz** is the **speed of the bus** that carries data from the CPU to memory and vice versa. 3200 MHz is equal to 3200 megabytes transferred per second, but this rate might be even larger, as we explain further below.
- **16GB** is the size of the RAM installed on the computer: 16 gigabytes. The greater the RAM size is, the more responsive the programs running on the computer will be. That is, a large app won't be lagging and won't crash the larger main memory is.
- **SDRAM**, standing for "synchronous dynamic RAM", was invented in 1988 and worked faster than conventional RAM by automatically synchronizing with the CPU clock, thus preventing the CPU from needlessly waiting between memory accesses. However, this tech, by itself, allows only 1 transfer per cycle. **DDR**, or "Double Data Rate", is a technique from 2000 that lets RAM transfer data **twice** per clock cycle (= 2 bits instead of 1.) **DDR2** (from 2003) is 2 times faster (4 bits) than DDR because of an enhanced input/output bus signal and uses less power. **DDR3** (from 2007) is 2 times faster (8 bit transfers) than DDR2 and features a 40% power use reduction. **DDR4** uses bank groups of memory, each of which can transfer 8-bits independently. E.g., 8 groups means transfers of $8 \times 8 = 64$ bits = 8 bytes at a time. Finally, **DDR5** is 2 times faster (16 bits per bank) than DDR4 and features channel efficiency, improved power management, and optimized performance. If our DDR4 RAM has 8 groups, it means that our transfer speed is $3200 \times 8 \text{ bytes} = 51.2$ gigabytes transferred per second!



Memory Features

- **2Rx8**, generally written as "MRxN", where M and N are powers of 2, is the rank and width of RAM and represents the number of memory **chips** and their arrangement on the RAM stick. Each chip is a container of data. DDR2, DDR3, and DDR4 RAMs require that each rank has a 64-bit-wide data bus. The rank doesn't affect the speed of RAM, but has a few other effects on the behavior of the memory stick, including (1) Price, since memory sticks with certain rank arrangements are more expensive to produce, and (2) Performance: some ranks cause an increase in latency, negatively affecting RAM performance.
 - **1Rx16**: the memory stick has 4 chips on it ($64\text{-bit-wide bus}/16 = 4$), and all these 4 chips are located on 1 side of the stick. This configuration is known for higher latency, so avoiding using such a stick is advised.
 - **2Rx16**: 4 chips on both sides (8 chips in total), so this stick has a greater memory capacity (latency is still high.)
 - **1Rx8**: 8 chips ($64/8 = 8$) on one side. Better performance than 1Rx16 and is also cost-effective. 2nd-to-best choice.
 - **2Rx8**: 8 chips ($64/8 = 8$) on both sides of the stick. It can fit more data than 1Rx8. Best choice.
 - **1Rx4**: 16 chips ($64/4 = 16$) on one side. It is more expensive, but has a slightly better performance.
 - **2Rx4**: 16 chips ($64/4 = 16$) on both sides. Can contain as twice much data as 1Rx4, but is expensive.
 - **4Rx4**: 16 chips ($64/4 = 16$) on 2 rows on each side. Can contain as twice much data as 2Rx4, but is expensive.



Storage Features

- **SSD** is the abbreviation of a Solid-State Drive, and **HDD** is the abbreviation of a Hard Disk Drive. See a smaller comparison between the two on [slide 17](#). An HDD, since it is a disk, works by rotation for information to be retrieved from one of the disk's **sectors** (= areas.) An SSD, on the other hand, looks more like a memory stick and doesn't rotate or move to operate (which is why it is in 'solid state'.)
- **7000 RPM** is the number of rotations per minute of a disk and tells the **speed of the disk**. This only applies to disks, like Hard Disk Drives and Magnetic Tapes, which work by rotation. The higher this number is, the greater the disk's speed is.
- **2TB** (2 terabytes = 2 trillions of bytes) is the size of that secondary storage device. The greater the storage's size is, the more files, images, videos, etc., you can store on it.
- **SATA**, **SAS**, and **SCSI** are 3 common connectivity technologies of secondary storage devices. A certain computer might support only 1 of them, so you need to know which technology is supported by your computer before replacing secondary storage. [This article](#) and [this article](#) compare the advantages and disadvantages of these technologies.



Practical Example: Which Desktop to Buy?

Now that we understood what these terms mean, we can go back to answer our question.

Since the most critical hardware component for games to run without lagging or crashing is a high RAM size, Johnny should get a device with greater RAM size (nowadays, at least 8 GB.) Also, having more computer cores/threads will improve the responsiveness of the game, so Johnny should strive towards more cores/threads, if available. Since Desktop №3 has the greatest RAM size, and since the number of cores is also large, Johnny should choose **Desktop №3** out of the given 3 desktops.

	Desktop №1	Desktop №2	Desktop №3
Display	23", LCD, 16:10, 3840 x 2160	20.5", LED, 16:9, 2560 x 1440	27", Curved, 21:9, 1920 x 1200
CPU	Intel i7, 4.3 GHz, 20 cores, 28 threads	AMD Ryzen 9, 4.9 GHz, 16 cores, 32 threads	Intel i9, 3.2 GHz, <u>24 cores, 32 threads</u>
Cache	64KB L1, 28MB L2, 33MB L3	256KB L1, 4MB L2, 68MB L3	128KB L1, 20MB L2, 24MB L3
RAM	3200 MHz, 16GB, DDR4, 2Rx8	1700 MHz, 8GB, DDR3, 1Rx16	5600 MHz, <u>64GB</u> , DDR5, 1Rx8
Storage	7000 RPM SATA 2TB HDD	SAS 850GB SSD	6500 RPM SCSI 1TB HDD



Practical Example: Which Desktop to Buy?

Another scenario: Lorry is a YouTube content creator and frequently deals with large MP4 (video) files. She is looking for a computer where she can save the various MP4 files she is working on, without resorting to saving them on a cloud elsewhere outside the computer. Which of the following desktop computers meets her need?

	Desktop №1	Desktop №2	Desktop №3
Display	23", LCD, 16:10, 3840 x 2160	20.5", LED, 16:9, 2560 x 1440	27", Curved, 21:9, 1920 x 1200
CPU	Intel i7, 4.3 GHz, 20 cores, 28 threads	AMD Ryzen 9, 4.9 GHz, 16 cores, 32 threads	Intel i9, 3.2 GHz, 24 cores, 32 threads
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RAM	3200 MHz, 16GB, DDR4, 2Rx8	1700 MHz, 8GB, DDR3, 1Rx16	5600 MHz, 64GB, DDR5, 1Rx8
Storage	7000 RPM SATA 2TB HDD	SAS 850GB SSD	6500 RPM SCSI 1TB HDD

Which hardware component will you pay attention to in this scenario? **Hint:** the focus is on storing large files.



Practical Example: Which Desktop to Buy?

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Any questions so far?



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Looking Up Info Online about a Computer

Fun class activity: [This page](#) lists the details of an HP computer model. Where on this page can you find:

1. The number of CPU cores in this model's CPU?
2. The size in Megabytes or Gigabytes of main memory?
3. The size in Gigabytes or Terabytes of secondary storage
4. The type of the secondary storage devices installed on this computer?

Now, let's repeat the same activity for [this Dell laptop computer](#).



Looking Up Info Online about a Computer

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Any questions so far?



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The Buildup of a Computer

The construction of a computer consists of several layers of building blocks:

Atoms → Molecules → Transistors → Logic Gates → Circuits → Chips → Systems → Computer

On top of hardware lies the software, starting from the operating system, up to various computer utilities, up to user applications.

Note how closely these layers resemble the biological layers of a human:

Atoms → Molecules → Organelles → Cells → Tissues → Organs → Organ Systems → Human

On top of the body lay the personality, thoughts, emotions, and other qualities that make us who we are.



Topics in this Course

We will learn about most of the mentioned computer layers as we advance throughout the course:

- **Transistors**, which are simple electric switches, and **Logic Gates**, which are small structures made of transistors and wires and used for redirecting electric currents, are covered in Topic 3: Boolean Algebra & Logic Gates.
- **Circuits**, which are meaningful, more complex structures made of logic gates, are studied in Topic 4: Circuits.
- **Chips**, which are complex structures made of circuits, as well as **Systems**, such as the memory and I/O systems, are studied across Topic 5: Computer Instructions, Topic 6: MARIE: Architecture Example, Topic 7: Memory, and Topic 8: I/O.
- In Topic 9: Intro to Assembly Language, we will code in a popular **assembly language** called NASM ("Netwide Assembler"), a low-level language sitting above machine language, which controls computer hardware directly.
- In Topic 10: Performance & Architecture Types, we will see ways to improve a computer's performance by making changes to its hardware and learn about popular architecture types in the market.
- In Topic 11: Intro to Operating Systems we will leave the hardware world and find out about the software that sits on top of the hardware: a computer's operating system.



Moore's Law

Gordon Moore, the founder of Intel, said in 1965 that:

"The density of transistors in an integrated circuit will double every year."

and then updated his statement after 10 years, saying that:

"The density of silicon chips doubles every 18 months."

This statement is known as **Moore's Law** and emphasizes the amazing advancement in computer technology: every several months, computer engineers come up with an invention that makes building blocks smaller, which means many of them get to fit into a computer's body, thus making the computer more powerful (and light!)



Moore's Law

This 'law' isn't a physics law and, highly likely, won't remain true forever. In fact, the production of silicon chips got slower in recent decades, which violated the law.

Creating a chip smaller than an atom is currently unfeasible, which poses a physical limitation on that law. In addition, chip and other component production costs might be an obstacle. Costs increase every year, slowing down the chip production.

Facing these limitations could actually result in scientists considering looking into new technologies that are not affected by these obstacles and that will make computers in the future even smaller, faster, and better.



Moore's Law

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Any questions?



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Intro to Computer Architecture: Sources

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