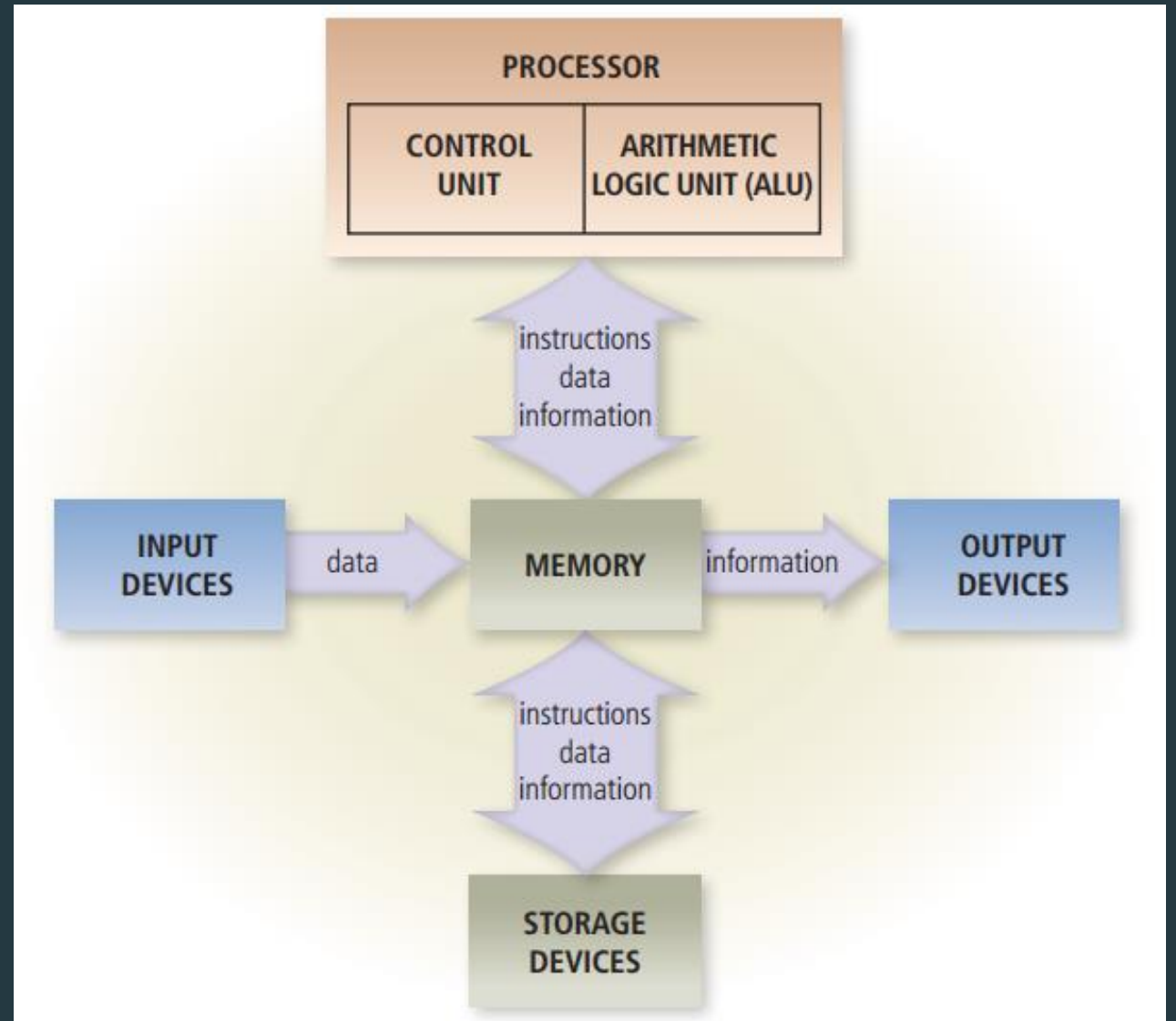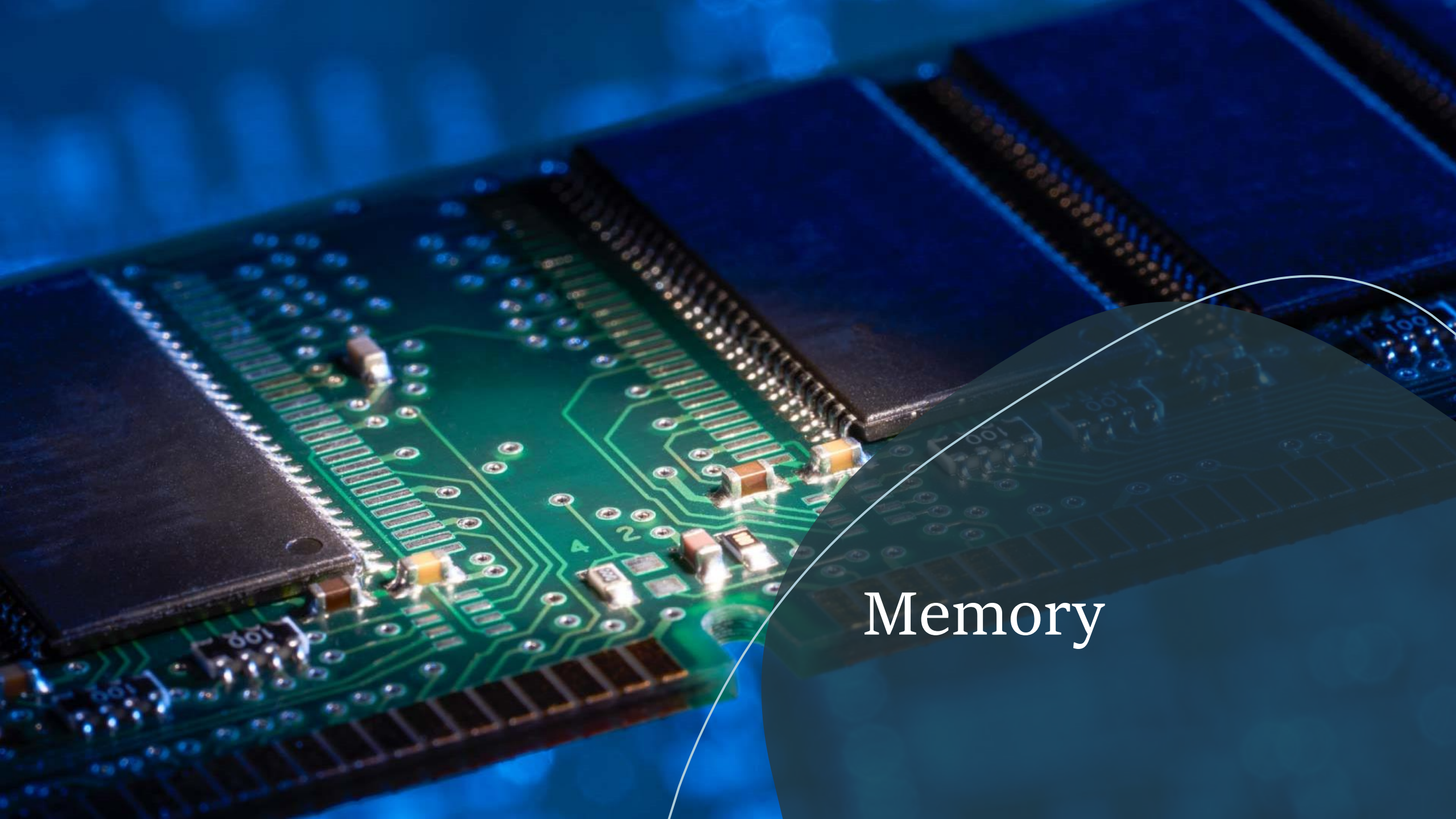# Computer Hardware Components

Recall

- The processor has two components:
    - Control Unit
    - Arithmetic Logic Unit

- Every instruction goes through the machine cycle: *fetch*, *decode*, *execute*, and *store*.

- Instructions to be executed are stored in the *memory*.

- The *system clock* synchronizes all operations in the processor.

Memory

Memory

- Memory consists of electronic components that store instructions waiting to be executed by the processor, data needed by those instructions, and the results of processing the data.

- There are three basic categories of items stored in the memory. These are:
    - Operating System
    - Applications
    - Data being processed and the resulting information

Memory Address

- Each byte of data stored in memory is identified by a memory address.

- Memory size is commonly measured in *gigabytes* (GB).

Types of Memory

Memory

- Internal (Primary Memory)
  - RAM
    - Static RAM
      - Registers
      - Cache
    - Dynamic RAM
      - SDRAM
      - DDR SDRAM
      - DDR2
      - DDR3
      - DDR4
      - RDRAM
  - ROM
    - PROM
    - EPROM
    - EEPROM
- External (Secondary Storage)
  - Magnetic Storage
    - Magnetic Tape
    - Magnetic Disk
      - HDD
      - FDD
  - Optical Storage
    - CD
    - DVD
    - BRD
    - HVD
  - Flash Storage
    - Memory card
    - Flash drive
    - SSD

Internal Memory

Internal Memory (Primary Memory)

1. Random Access Memory (RAM)

   - Also called *main memory*, consists of memory chips that can read from and written to by the processor

   - Is volatile, meaning it loses its contents when power is removed

2. Read Only Memory (ROM)

   - Is nonvolatile, meaning its contents are not lost when power is removed

   - ROM chips, called *firmware*, contain permanently written data or instructions, e.g., a computer or a mobile device's start-instructions

RAM

Parameter	SRAM	DRAM
Full form	Static Random Access Memory	Dynamic Random Access Memory
Read/Write speed	Faster	Slower
Storage component	Uses transistor to store single bit of data	Uses separate capacitor to store each bit of data
Price	Expensive	Economical
Power consumption	More	Less
Refresh	No need to refresh to maintain data	Needs periodically to maintain data, i.e., thousands of time per second
Used in	Registers and cache	Main memory

Video: SRAM vs DRAM

Types of RAM

(1) Static RAM (SRAM)

- Registers – small, high-speed storage locations that temporarily hold data and instructions inside the processor

- Cache – high-speed storage that stores frequently used instructions and data; has larger capacity than registers

  - *L1 cache* is built directly on the processor chip, has a very small capacity

  - *L2 cache* is slightly slower than L1 cache but has a larger capacity; *advanced transfer cache* (ATC) is a type of L2 cache built directly on the processor chip making it perform faster

  - *L3 cache* is a cache on the motherboard that is separate from the L2 cache; exists only on computers that uses ATC L2 cache
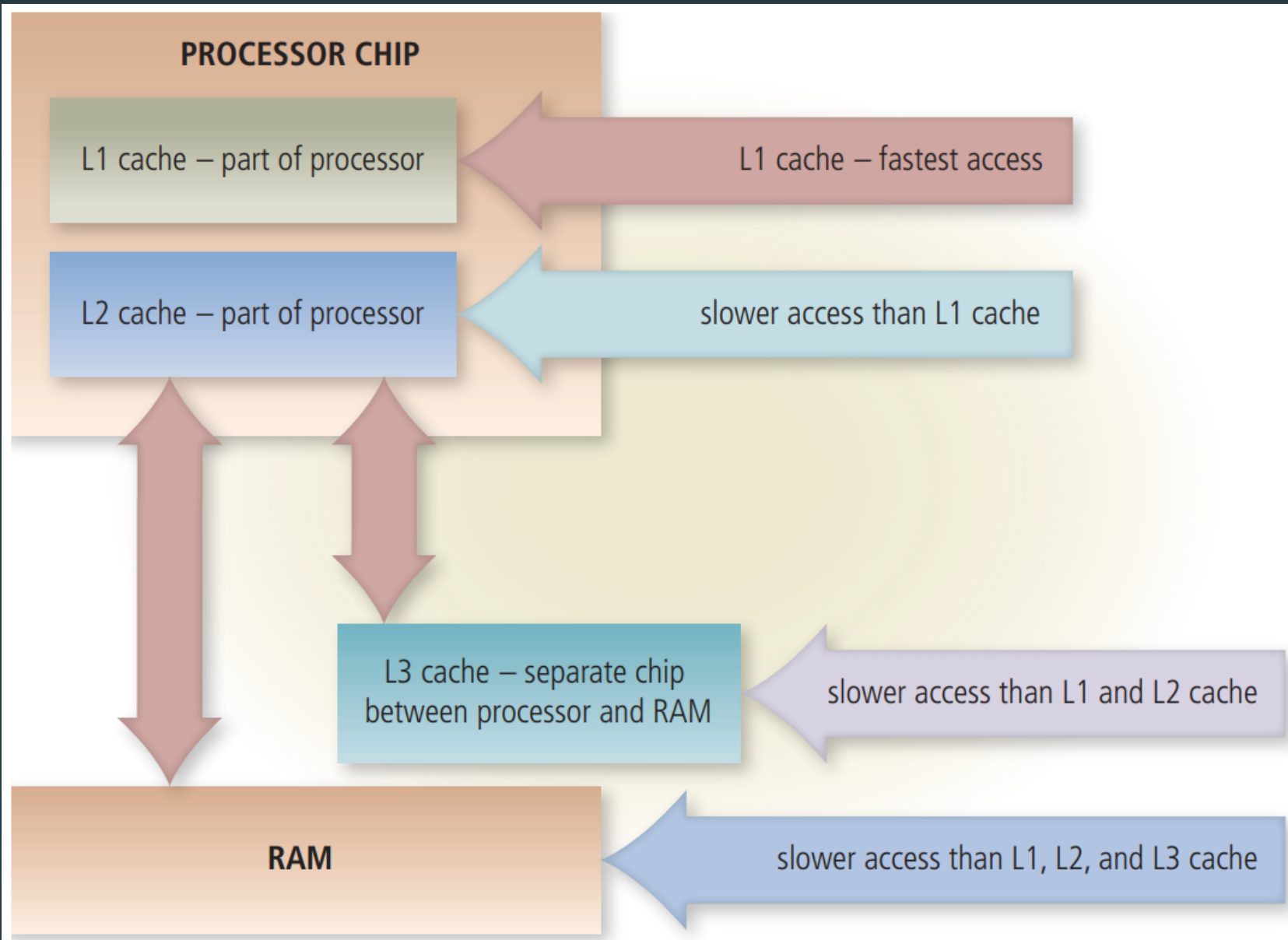
When the processor needs an instruction or data, it searches memory in this order:

1) L1 cache
2) L2 cache
3) L3 cache (if it exists)
4) RAM

Delay is greater with each level of memory it must search.

If the instruction or data is not found in primary memory, then it must search in secondary storage (e.g. hard disk or optical disc), which has a much slower speed.

Memory Access Time

Memory Access time is the amount of time it takes the processor to read data or instructions from memory.

Term	Abbreviation	Speed
Millisecond	ms	One-thousandth of a second
Microsecond	µs	One-millionth of a second
Nanosecond	ns	One-billionth of a second
Picosecond	ps	One-trillionth of a second

Types of RAM

(2) Dynamic RAM (DRAM)

Name	Comments
SDRAM (Synchronous DRAM)	• Synchronized to the system clock • Much faster than DRAM
DDR SDRAM (Double Data Rate SDRAM)	• Transfers data twice, instead of once, for each clock cycle • Faster than SDRAM
DDR2	• Second generation of DDR • Faster than DDR
DDR3	• Third generation of DDR • Designed for computers with multi-core processors • Faster than DDR2
DDR4	• Fourth generation of DDR • Faster than DDR3
RDRAM (Rambus DRAM)	• Much faster than SDRAM

Memory Modules

- RAM chips usually reside on a memory module, which is a small circuit board. Memory slots on the motherboard hold memory modules.
  - Single Inline Memory Module (SIMM) has pins on opposite sides of the circuit board that _connect_ together to form a single set of contacts
  - Dual Inline Memory Module (DIMM) has pins on opposite sides of the circuit board that _do not connect_ and thus form two sets of contacts

Figure 6-13 Memory modules contain memory chips.
© mvcola / Shutterstock.com; © TerryM / Shutterstock.com
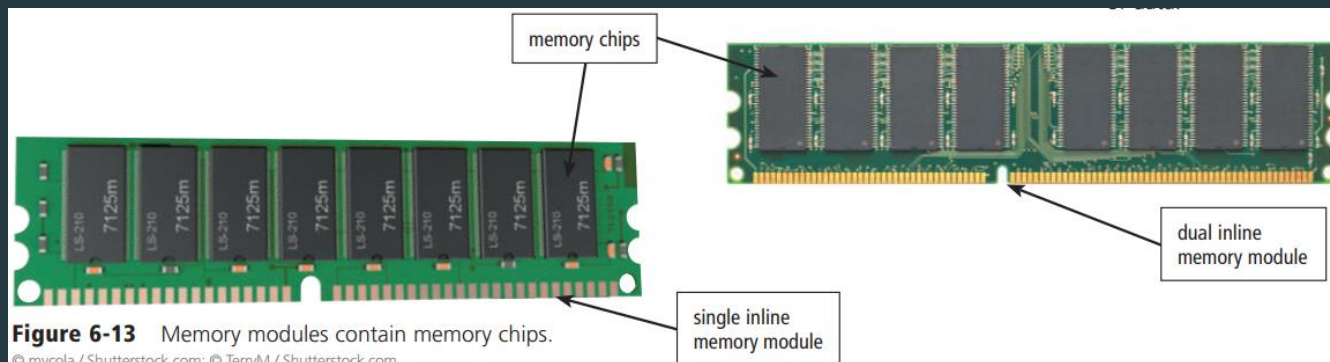
ROM

- Programmable ROM (PROM)
  - One Time Programmable (OTP)
  - Programmable by user using an external programming device
- Erasable PROM (EPROM)
  - Reusable
  - Content can be erased using UV light
  - Programmable by user using an external programming device
- Electrically Erasable PROM (EEPROM)
  - Clears entire blocks with single operation
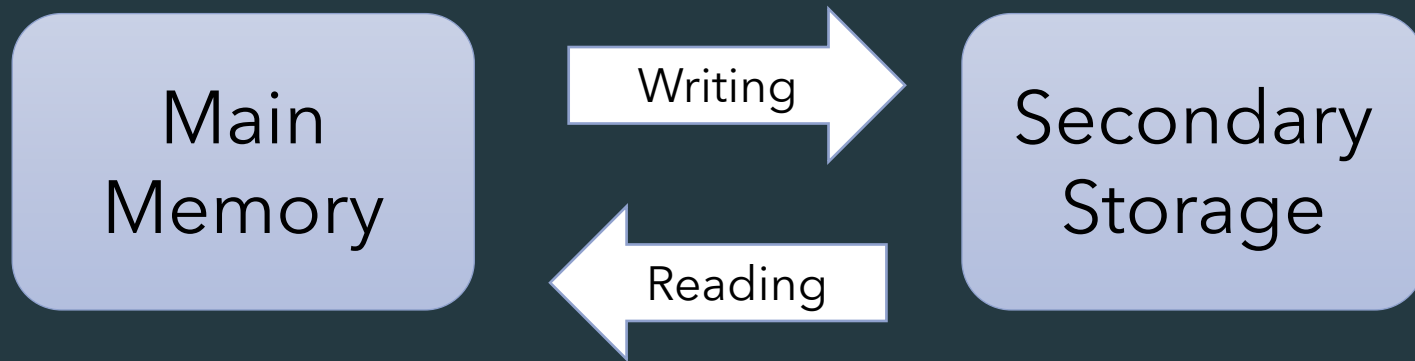 - Programmable in-place (no need to remove from circuit board)
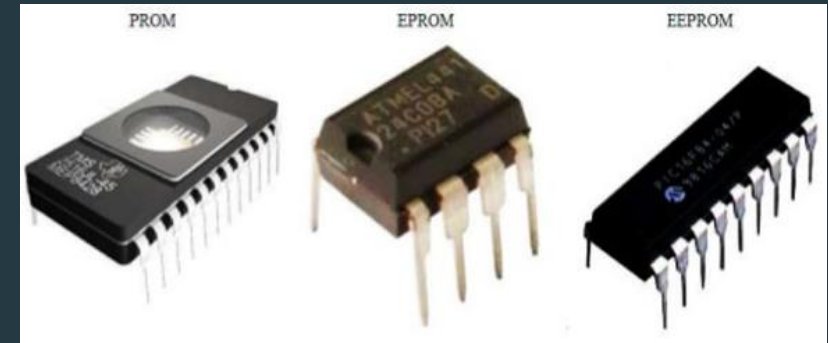
Video: Erasing data from EPROM

External Memory

External Memory (Secondary Storage)

A storage device is the hardware that records or retrieves items to/from storage media.

Main Memory	→ Writing →	Secondary Storage
	← Reading ←	

Storage Capacity

Capacity is the number of bytes that a storage medium can hold.

| Storage Term	Approximate Number of Bytes	Exact Number of Bytes
Kilobyte (KB)	1 thousand	2^{10} or 1,024
Megabyte (MB)	1 million	2^{20} or 1,048,576
Gigabyte (GB)	1 billion	2^{30} or 1,073,741,824
Terabyte (TB)	1 trillion	2^{40} or 1,099,511,627,776
Petabyte (PB)	1 quadrillion	2^{50} or 1,125,899,906,842,624
Exabyte (EB)	1 quintillion	2^{60} or 1,152,921,504,606,846,976
Zettabyte (ZB)	1 sextillion	2^{70} or 1,180,591,620,717,411,303,424
Yottabyte (YB)	1 septillion	2^{80} or 1,208,925,819,614,629,174,706,176

Storage Access Time

- Storage Access Time measure the amount of time it takes a storage device to locate an item on a storage medium.

- The transfer rate is the speed with which the data and instructions are transferred to/from a storage device.

- Transfer rates for storage are stated in *KBps* (kilobytes per second), *MBps* (megabytes per second), or *GBps* (gigabytes per second).
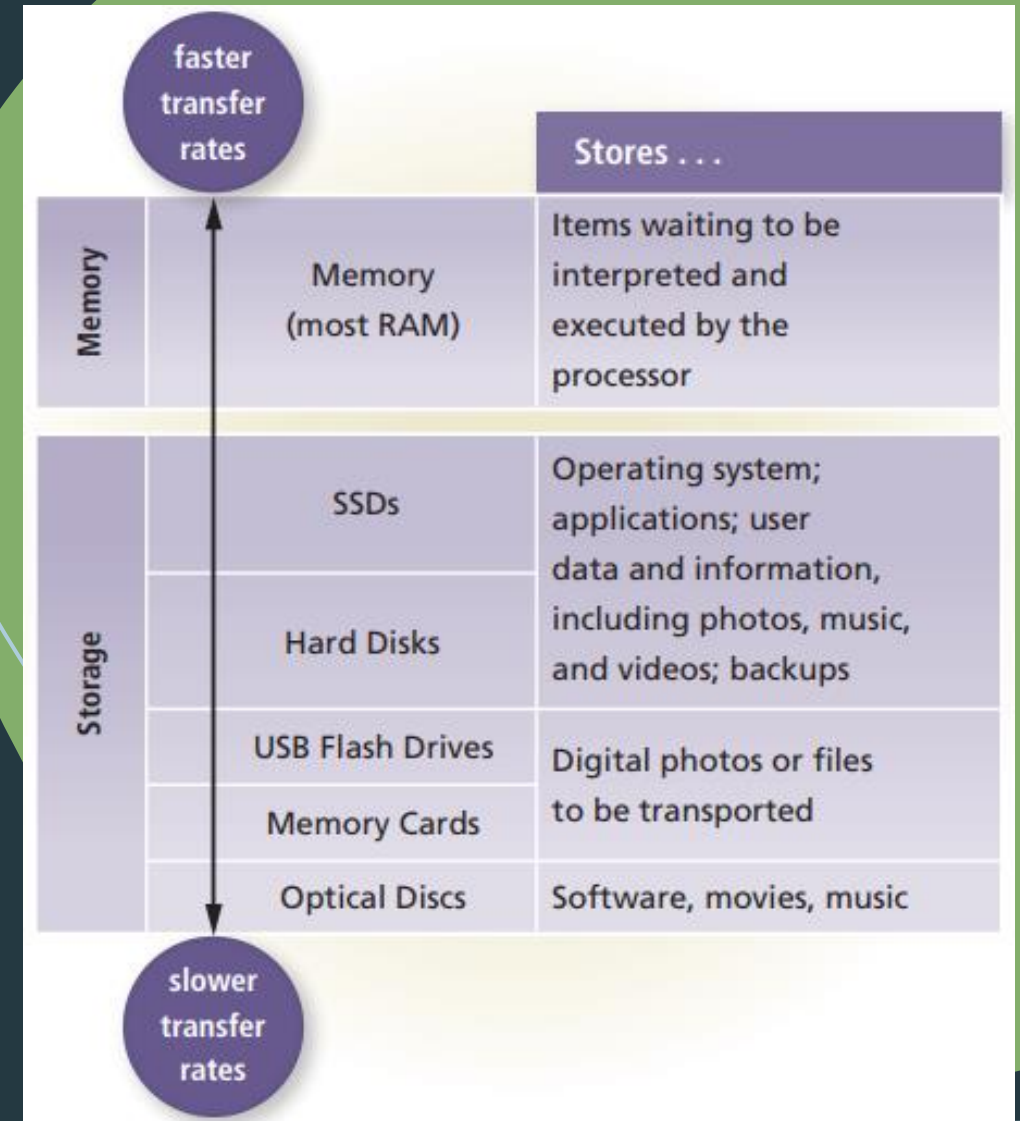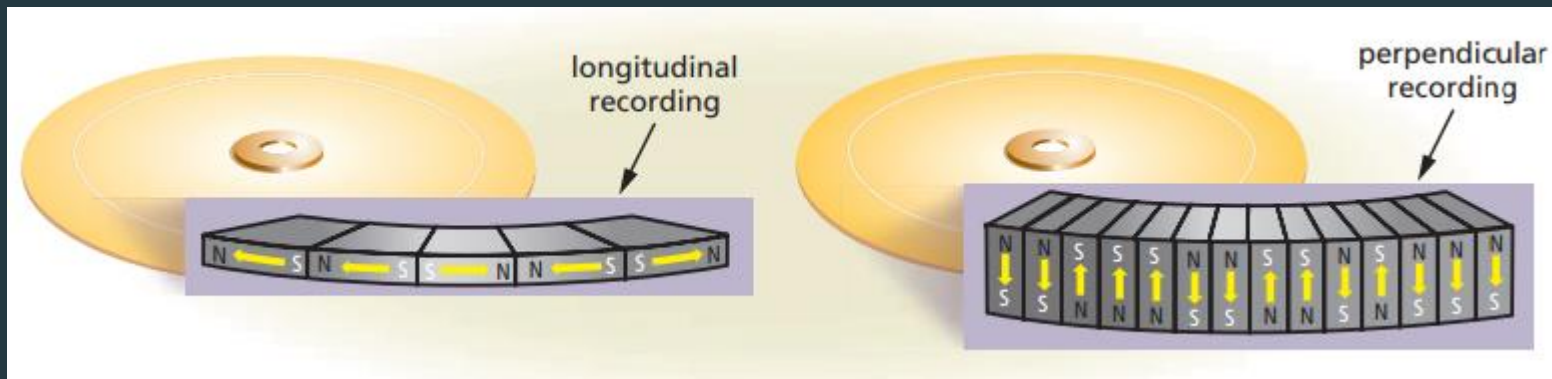
Hard Disk

A hard disk, also called a hard disk drive (HDD), is a storage device that contains one or more flexible, circular platters that use magnetic particles to store data and instructions.
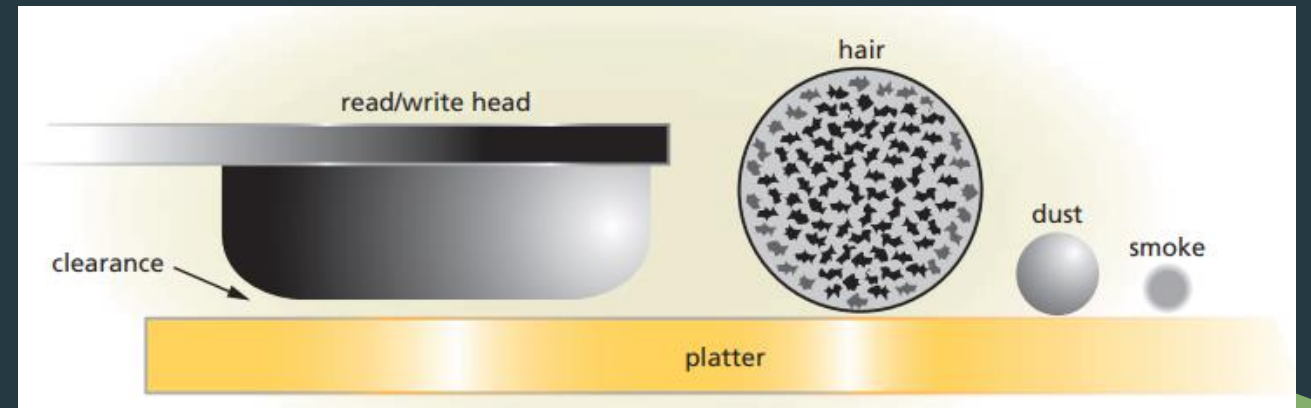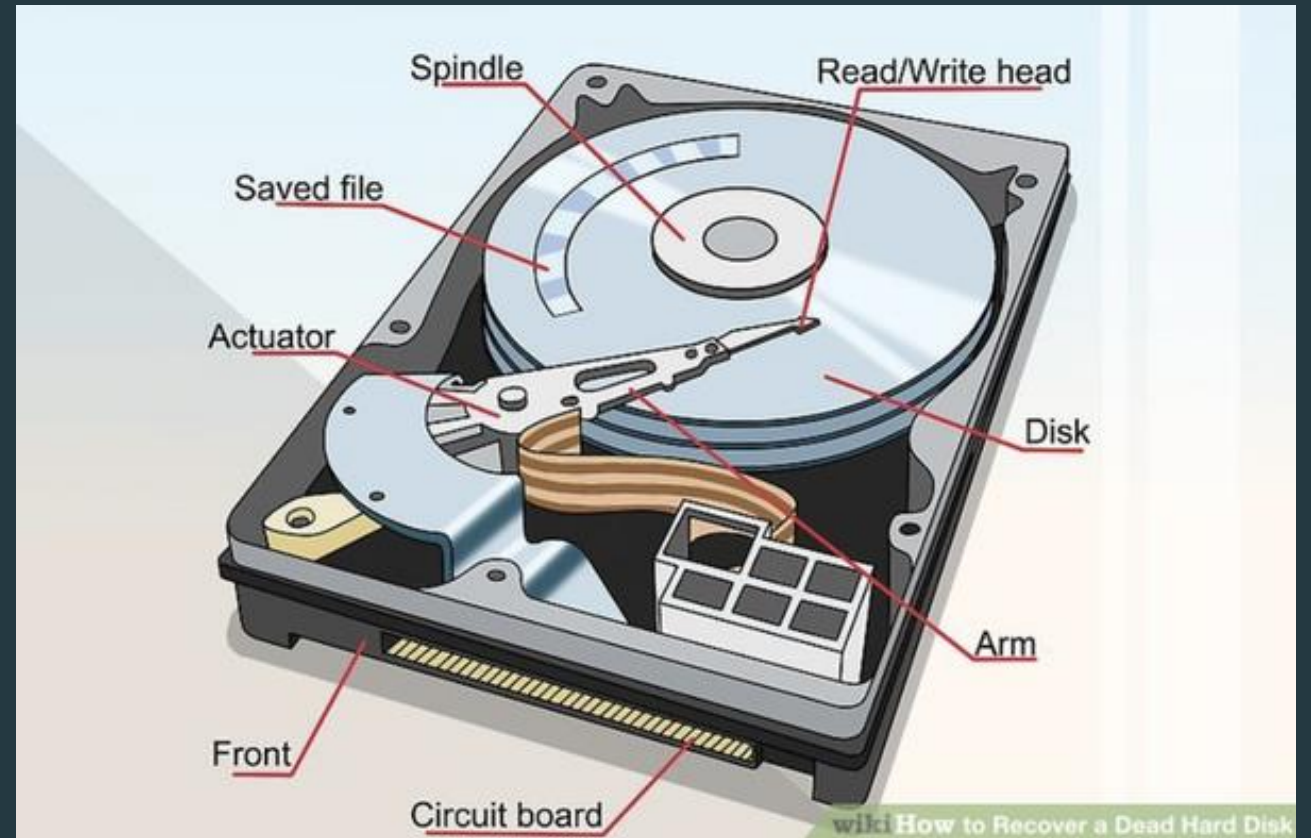
Hard Disk

- The storage capacity of hard disks varies and is determined by
  - Platter – made of aluminum, glass, or ceramic and has a thin coating of alloy material that allows data and instructions to be recorded magnetically on its surface
  - Composition of magnetic coating on the platter
    - Longitudinal recording aligns the magnetic particles horizontally around the surface of the disk
    - Perpendicular recording aligns the magnetic particles vertically, making much greater storage capacity possible
  - Density – the number of bits in an area on a storage medium

Hard Disk
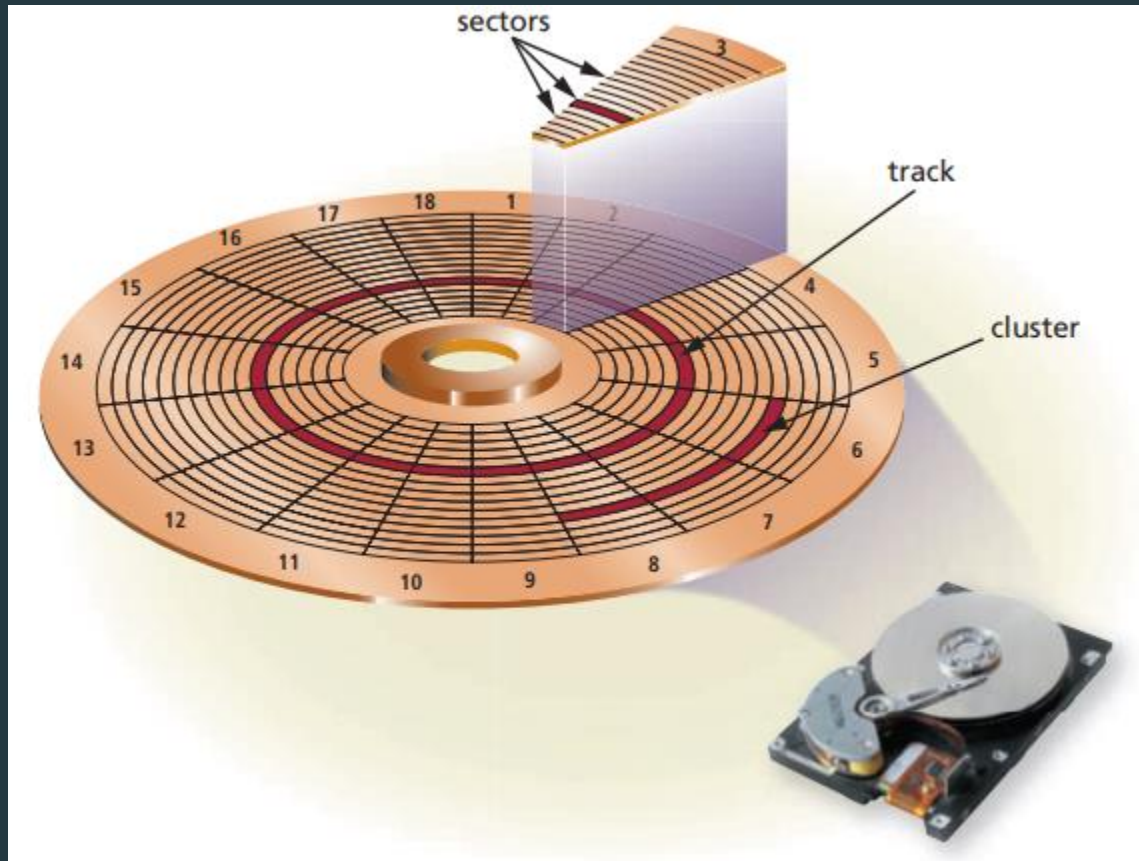
Formatting is the process of dividing the disk into tracks and sectors so that the OS can locate data on the disk easily.

A track is a narrow recording band that forms a full circle on the surface of the disk, The disk's storage locations consists of wedge-shaped sections, which break the tracks into smaller arcs called sectors. A sector can typically store 512 bytes of data.

How a Hard Disk Works

Step 1
The circuit board controls the movement of the head actuator and a small motor.

Step 2
A small motor spins the platters while the computer is running.

Step 3
When software requests disk access, the read/write heads determine the current or new location of the data.

Step 4
The head actuator positions the read/write head arms over the correct location on the platters to read or write data.

While the computer is running, the platters in the hard disk rotate at a high rate of speed. This spinning, which usually is 5,400 to 15,000 *revolutions per minute* (rpm), allows nearly instant access to all tracks and sectors on the platters.

The platters continue to spin until power is removed, or slow down after a period of time to save power.

Video: How HDD works

Optical Discs

- An optical disc is a type of storage medium that consist of a flat, round, portable disc made of metal, plastic, and lacquer that is written and read by a laser.
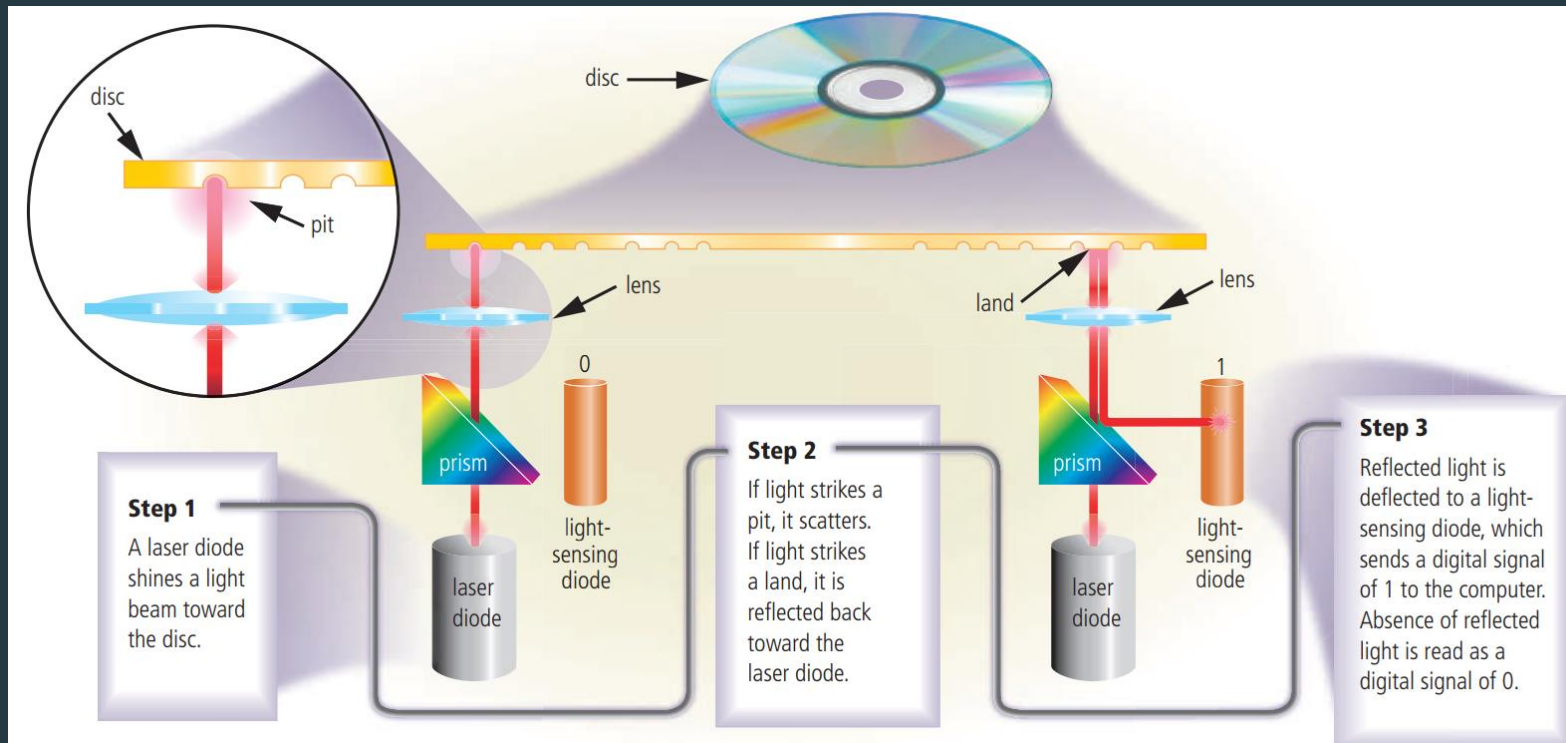
Video: How optical discs work

Flash Memory Storage

- Flash memory is a type of nonvolatile memory that can be erased electronically and rewritten.

- Flash memory chips are a type of *solid-state media*, which means that they consist entirely of electronic components such as integrated circuits and contain no moving parts.

- The lack of moving parts makes flash memory *more durable and shock-resistant* than other types of media, such as magnetic disks or optical discs.

Video: How SSD work

Solid-State Drive

- A solid-state drive (SSD) is a flash memory storage device that has its own processor to manage its storage.

- SSDs have several advantages over traditional (magnetic) hard disks: higher storage capacities, faster access time (up to 80 times faster), faster transfer rates, quieter operation, more durable, lighter weight, less power consumption (leads to longer battery life), less heat generation, and longer life.

- The disadvantages of SSDs are that data recovery in the event of failure can be more difficult and cost is higher per gigabyte.

Memory Cards

Memory card is a removable flash memory storage device that is inserted into a slot in a computer, mobile device, or card reader/writer.

USB Flash Drives

- USB flash drives, sometimes called a *thumb drive* or *pen drive,* is a flash memory storage device that plugs in a USB port on a computer or mobile device.

Cloud Storage

- **Cloud storage** is an Internet services that provides storage to computers and mobile device users.

- Cloud storage is available for home and business users, with various degrees of storage services available. Cloud storage fee arrangements vary, depending on the user's storage requirements.

Video: Cloud storage