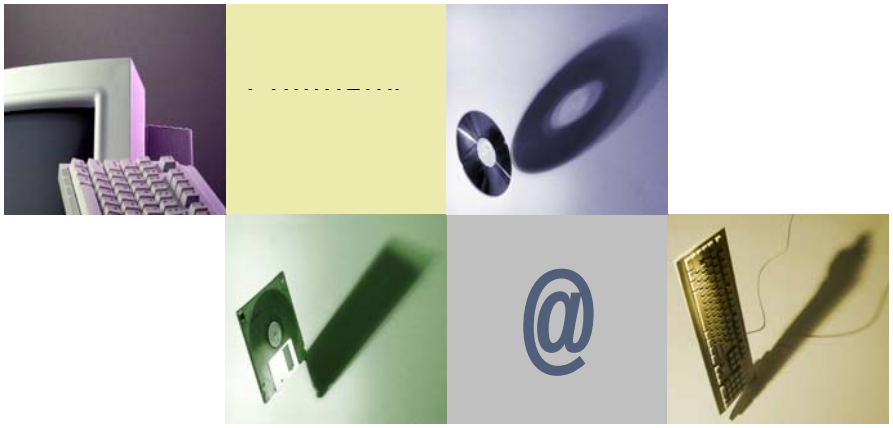
Computer Hardware



Digital Computer Concept and Practice

Computer (revisited)

- Computer = Hardware + Software
  - Hardware
    - Electronic circuit and mechanism
    - I/O unit, central processing unit, storage unit
    - Bus: channel that allows devices inside computer to communicate with each component
  - Software
    - Programs that control the operation of the computer system.
    - Coded by using high-level programming languages, such as C, JAVA etc. (easier and more efficient for humans)

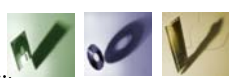
Basic Components (revisited)

- Input unit
- Central Processing Unit (CPU)
- Output unit
- Storage unit (secondary storage)
- I/O unit, secondary storage, multimedia devices, …

  ➔ Peripheral equipment

Basic Components

- **Input Unit**
- **Central Processing Unit (CPU)**
- **Memory (Primary Storage)**
- **Output Unit**
- **Secondary Storage**



Input Unit

- Input unit is any hardware components that allow users to enter data and instructions.

Input Unit

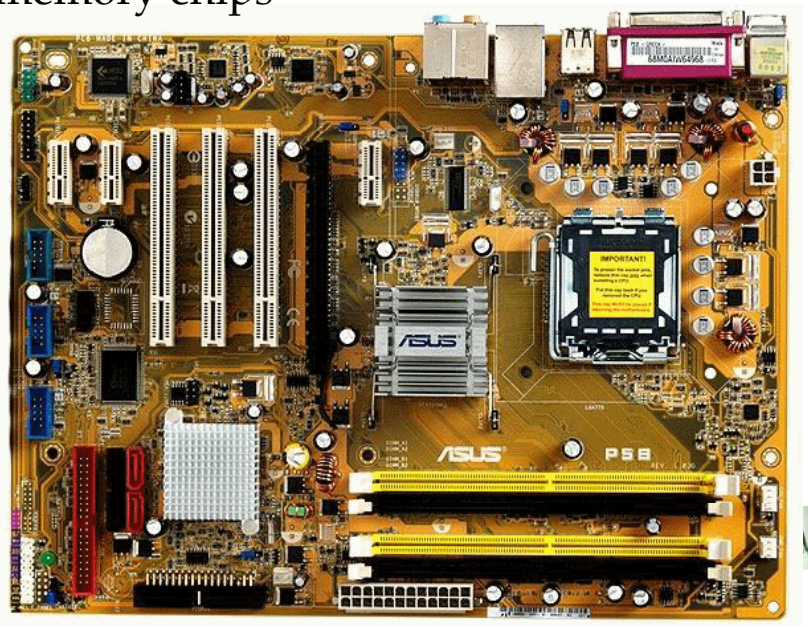
- Input device types
  - Typing: keyboard
  - Pointing: mouse, trackball
  - Scanning
    - Barcode reader, handheld/flatbed scanner

- Terminal (now, it is a concept, not a physical device)
  - Input device + Display + Server Connector

Server
- a computer that provides services to other computers (clients), or
- the software that runs on it
  e.g. the internet sites like Google and Yahoo

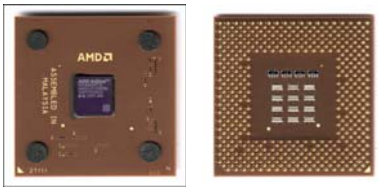
Where is a CPU Located?

- Motherboard (Mainboard)
  - Main circuit board in a system unit
  - Contains adapter cards, processor chips and memory chips



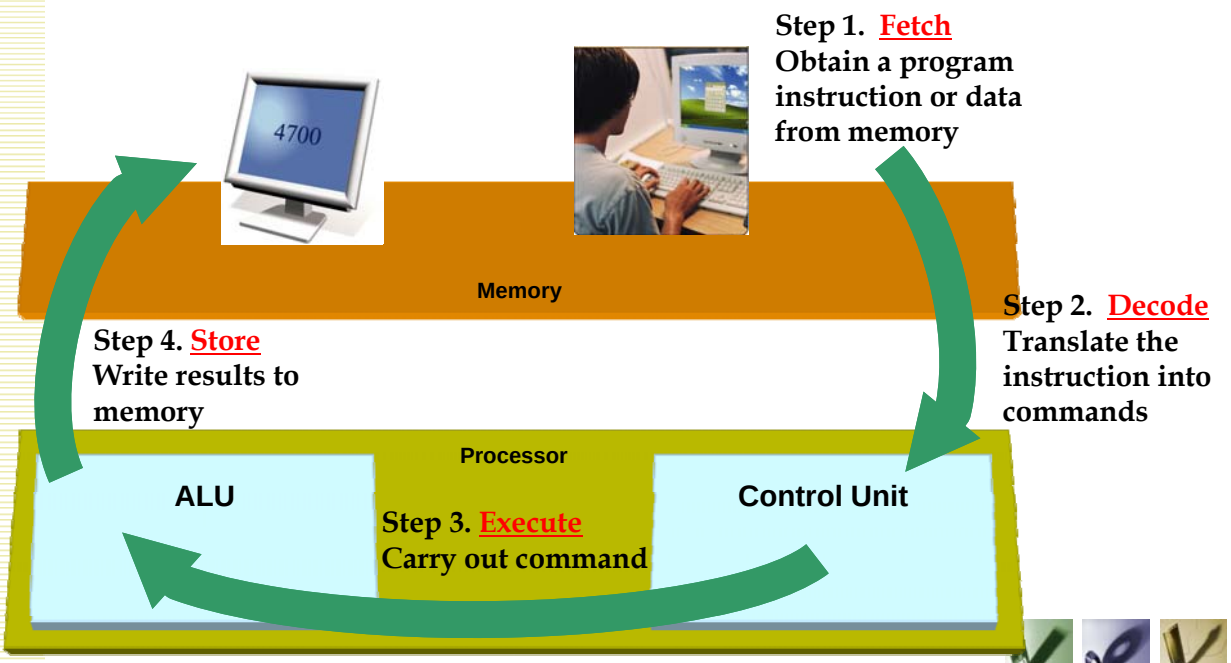
Central Processing Unit (CPU)

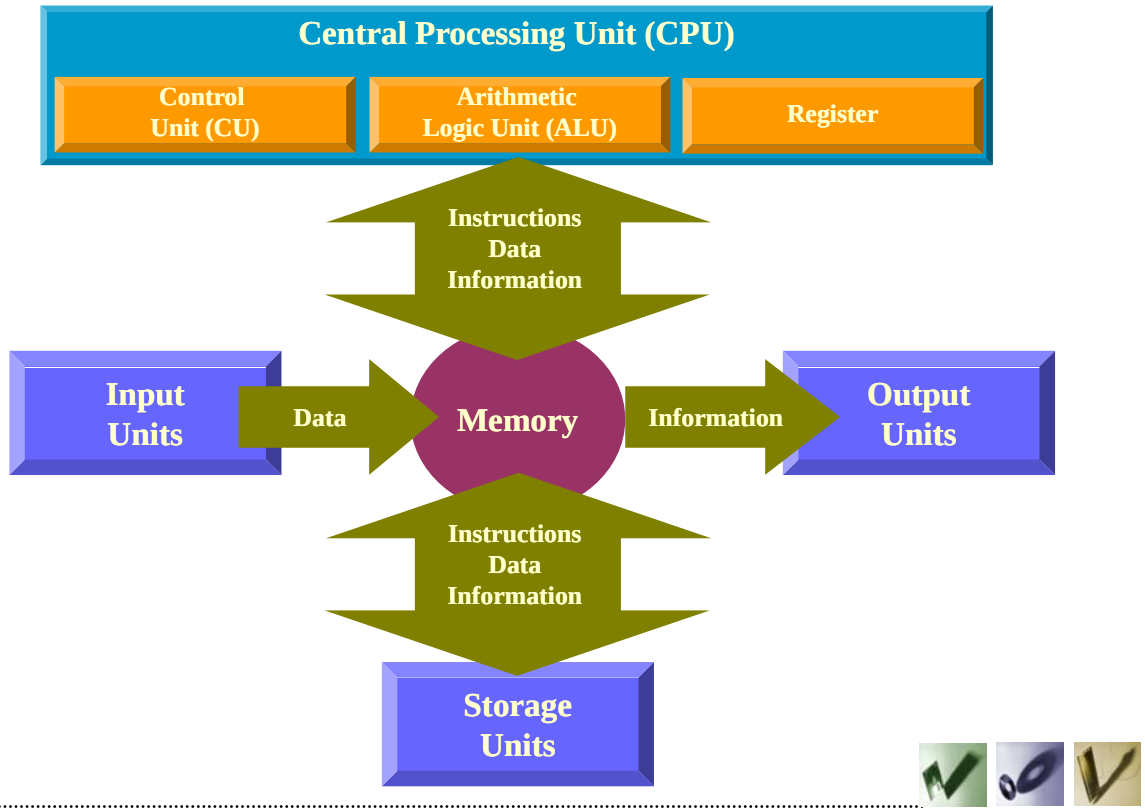
- Interprets and carries out basic instructions that operate a computer
- Control input, output and storage units (roughly true)



CPU Process Cycle

Execute programs: A CPU reads stored instructions in order from storage units, and it decodes and executes the actions that they indicate.

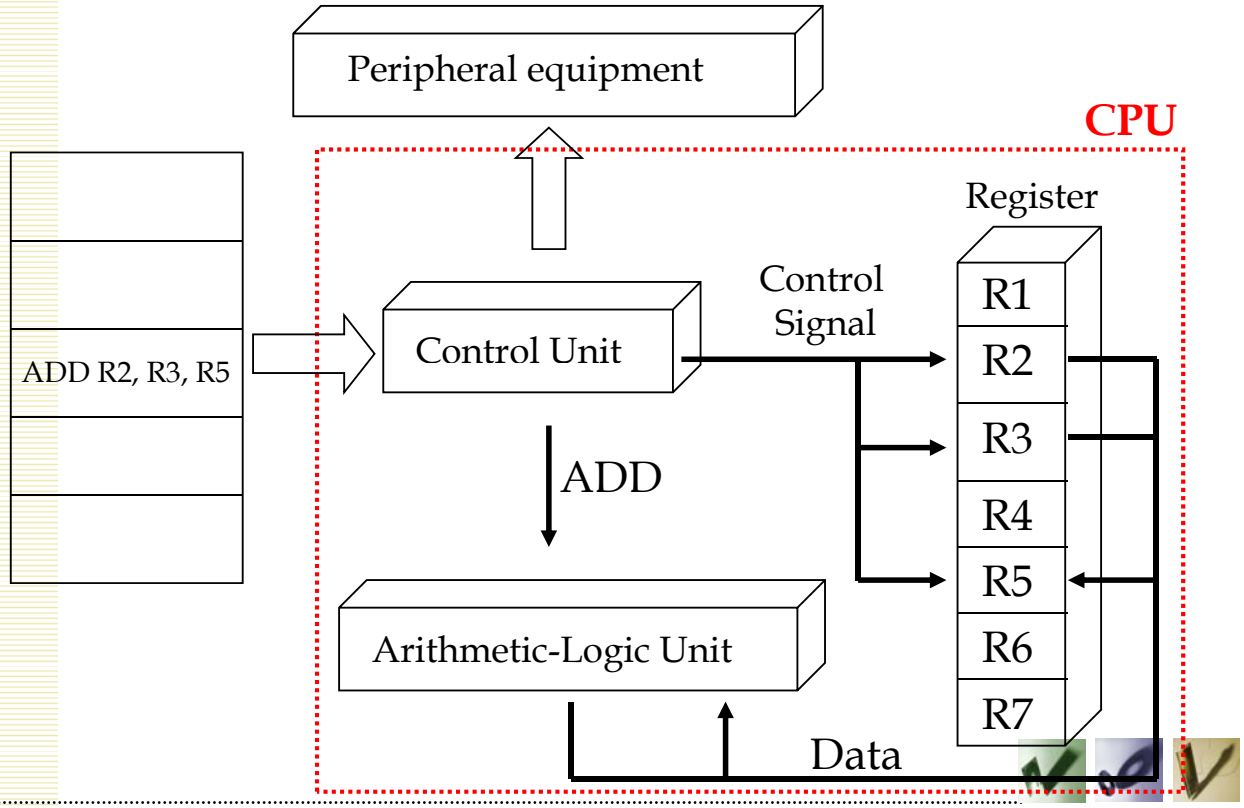




CPU Components

- CPU: ALU + CU + Register
  - Arithmetic-Logic Unit (ALU)
    - It performs arithmetic, comparison and logical operations.
  - Control Unit (CU)
    - It directs and coordinates operations in a computer.
  - Register
    - Temporary high-speed storage area that holds data and instructions.

Example

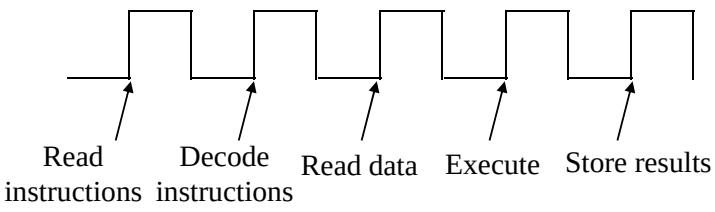


Capacity and Performance of a PC (1)

- Information processing performance
  - 8-bit Machine: 8 bits (1 byte) processing at a time
  - 64-bit Machine: 64 bits (8 bytes) processing at a time
- Computer processing speed
  - MHz/GHz: the number of machine cycles per second (1 GHz = one billion ticks of system clock per second)
  - MIPS (Million Instruction Per Second)
  - MFLOPS (Million Floating-point Operation Per Second)
  - GFLOPS, TFLOPS
    - Intel Pentium: 10 GFLOPS
    - IBM Cell (PS3): ~200 GFLOPS

What is the System Clock?

- Controls timing of all computer operations
- The speed which a processor executes instructions
- The faster the clock, the more instructions the CPU can execute per second.



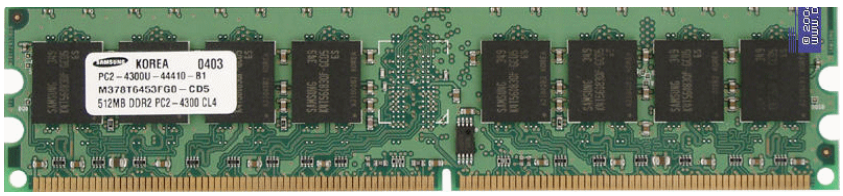
Capacity and Performance of a PC (2)

- Memory capacity
  - Number of bytes a storage medium can hold
    - KB: 1 kilobytes = 2^{10} bytes = 1024 bytes
    - MB: 1 megabytes = 1024 x 1024 bytes
    - GB: 1 gigabytes = 1024 MB

Kilobyte (KB)	1 thousand
Megabyte (MB)	1 million
Gigabyte (GB)	1 billion
Terabyte (TB)	1 trillion
Petabyte (PB)	1 quadrillion
Exabyte (EB)	1 quintillion
Zettabyte (ZB)	1 sextillion
Yottabyte (YB)	1 septillion

Memory

- Primary storage (main memory unit)
- Consists of one or more chips on motherboard or other circuit board
- Memory capacity
  - Usually, 512MB or 1GB~ (MS Vista: 2GB~)

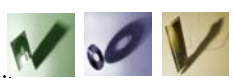


Memory

- Electronic components that store instructions, data, and information
- Stores the bits and bytes (instructions and data)
- Directly accessible by the CPU
- Memory types: RAM + ROM

Memory Types: RAM

- Random Access Memory (RAM)
  - Temporary memory
  - Can read/write data
  - Any information stored in RAM is lost when the computer is turned off. ➔ volatile
    - Hence, need a secondary memory device

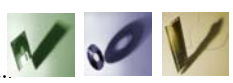


Memory Types: RAM

- Types
  - SRAM (Static RAM)
    - It does not need to be periodically refreshed.
    - It retains data bits in its memory as long as power is being supplied.
    - Expensive
  - DRAM (Dynamic RAM)
    - It needs to be periodically refreshed.
    - Structural simplicity
    - Cheaper than SRAM
    - SDRAM (Synchronous DRAM), DDR (Double Data Rate) SDRAM, RDRAM (Rambus DRAM)

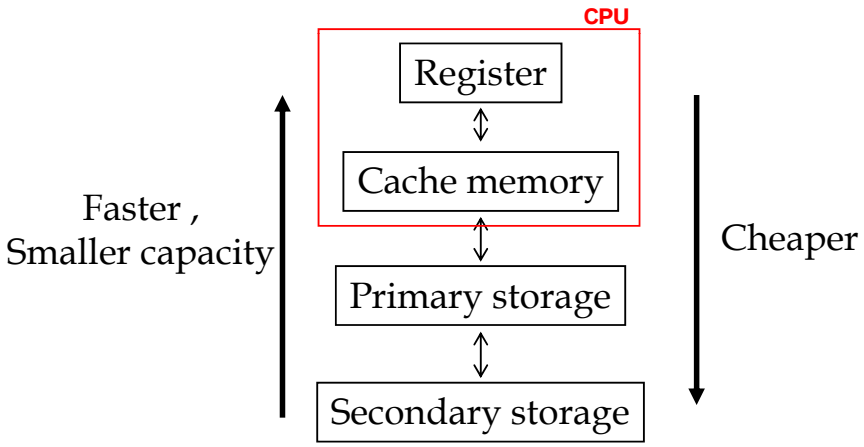
Memory Types: ROM

- ROM (Read Only Memory)
  - Permanent memory
  - Any information stored is retained when the computer is turned off → non-volatile
- Types of ROM
  - PROM (Programmable ROM)
  - EEPROM (Electrically Erasable PROM): rewritable
- cf.) BIOS (or CMOS) setup
  - Before: CMOS (Complementary Metal-Oxide-Semiconductor)
  - Now: EEPROM or flash ROM

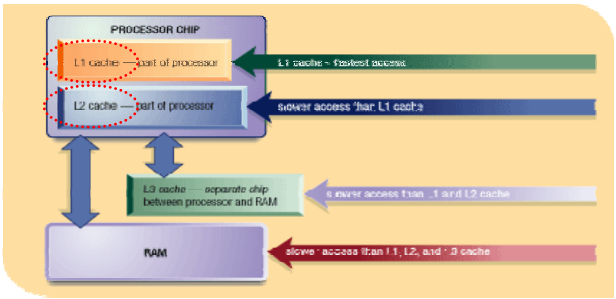


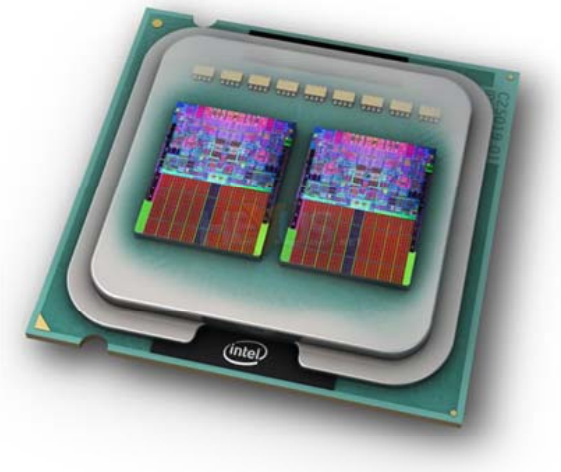
Cache Memory

- Helps speed up computer processes by storing frequently used instructions and data.



Cache Memory





- L1 cache built into processor
- L2 cache slower but has larger capacity

Output Unit

- Output: data that has been processed into a useful form (information)
- Output device: any hardware components that can convey information to user.

Output Unit: Monitor

- Monitor (or display)
  - Output device that visually conveys information
  - Information on display device: soft copy
  - Monitor types
    - CRT (Cathode-Ray Tube) or LCD (Liquid Crystal Display)
  - Resolution: number of horizontal and vertical pixels in a display device

More details → Ch 4. Multimedia

Output Unit: Printer

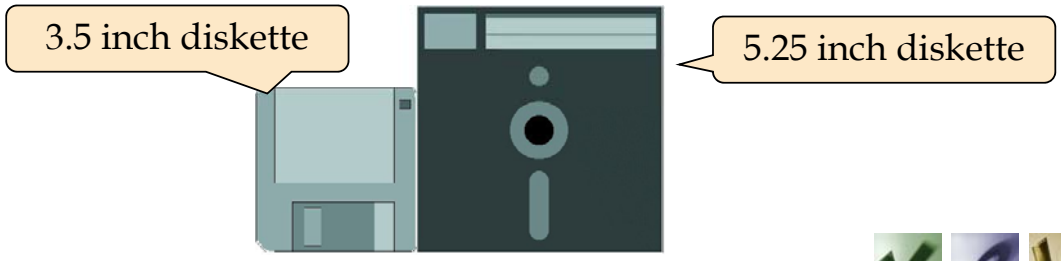
- Printer
  - Output device that produces text and graphics on a physical medium (hard copy)
- Types
  - Resolution: 1200 DPI, 600 DPI
  - Color of contents: B/W, color
  - Printing ways: laser, ink-jet, dot matrix

Secondary Storage

- Used to store data and programs
- Mass storage available and more permanent
- Required for two reasons:
  - The working memory of the CPU is limited in size and cannot always hold the amount of data required.
  - Data and programs in secondary storages do not disappear when the power is turned off.
- Secondary storage types
  - Magnetic disks (FDD, HDD)
  - Optical discs (CD, DVD)

FDD

- Floppy Disk Drive (Diskette)
  - Two types
    - 3.5 inch: 1.44MB
    - 5.25 inch: 1.2MB
  - Strength: cheap and portable
  - Weakness: reading and writing speed is slow



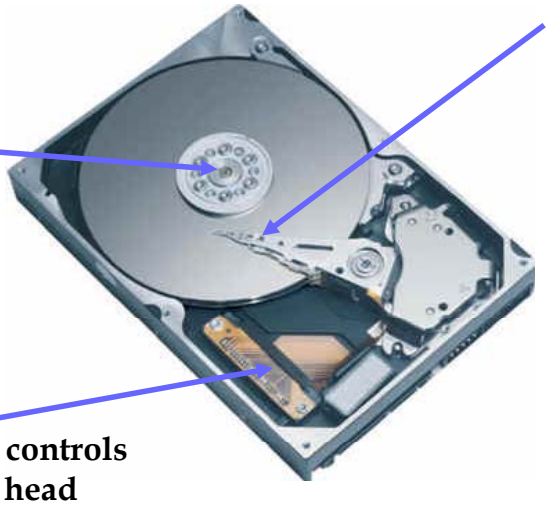
HDD

- Hard Disk Drive
  - Consists of several inflexible, circular platters that store items electronically
  - High-capacity storage
  - Hard disks are permanently mounted inside the computer (cf. external HDD)

HDD

- How does a hard disk work?

Small motor spins platters while computer is running.

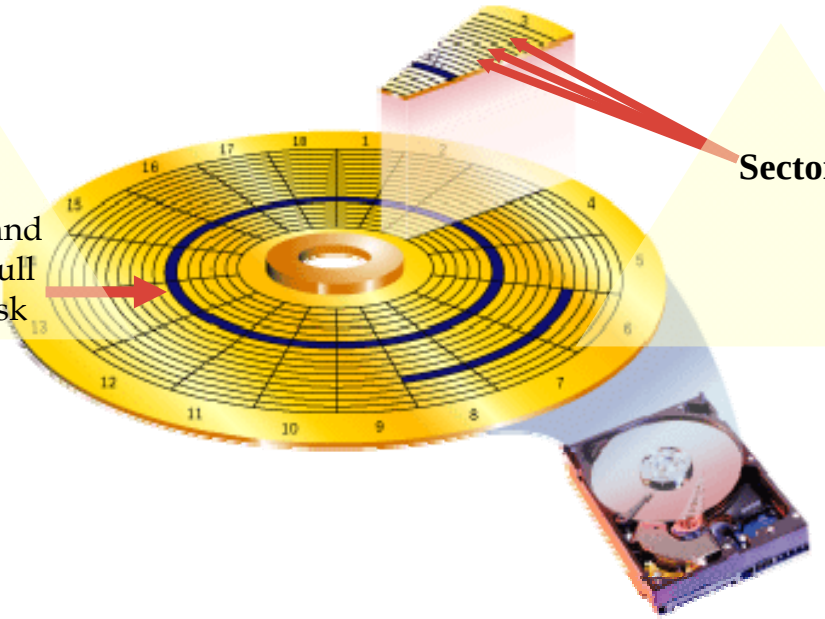


When software requests a disk access, read/write heads determine current or new location of data.

Circuit board controls movement of head actuator and a small motor.

HDD

Track
is narrow recording band that forms full circle on disk



Sector

- Formatting prepares disk for use and marks bad sectors as unusable

Optical Discs

- Flat, round, portable metal discs made of metal, plastic, and lacquer
- Types
  - CD-ROM: 700MB
  - DVD-ROM: 4.7~8.5GB
  - Blu-ray Disc (BD): 25~50GB