# Chapter 2
# COMPUTER MEMORY

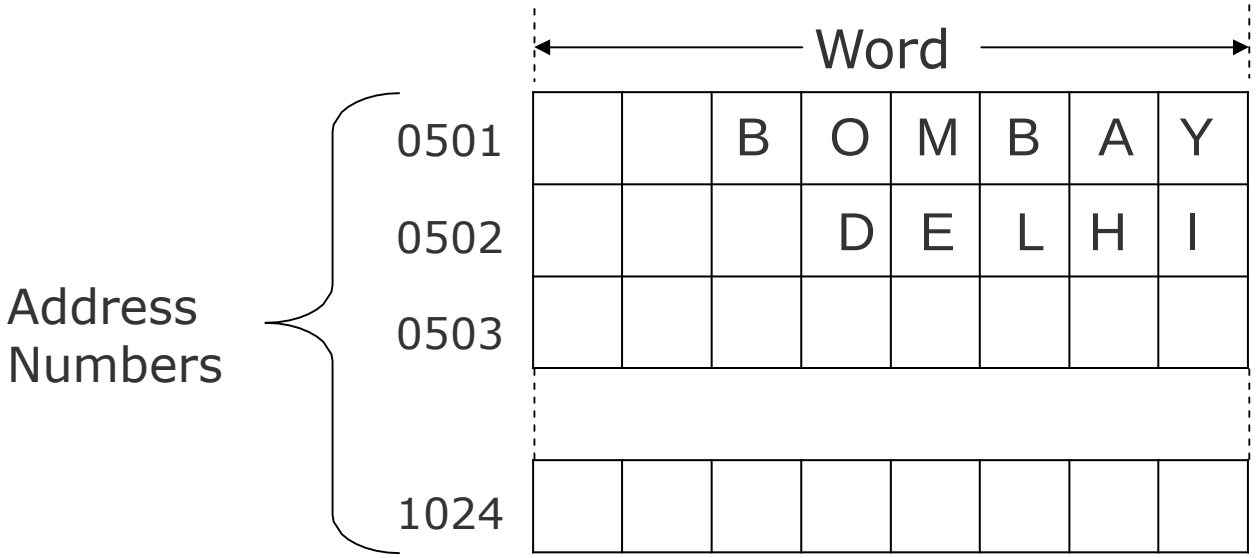
# MAIN MEMORY

- Every computer has a temporary storage built into the computer hardware
- It stores instructions and data of a program mainly when the program is being executed by the CPU.
- This temporary storage is known as main memory, primary storage, or simply *memory*.
- Physically, it consists of some chips either on the motherboard or on a small circuit board attached to the motherboard of a computer
- It has random access property.
- It is volatile.

# STORAGE EVALUATION CRITERIA

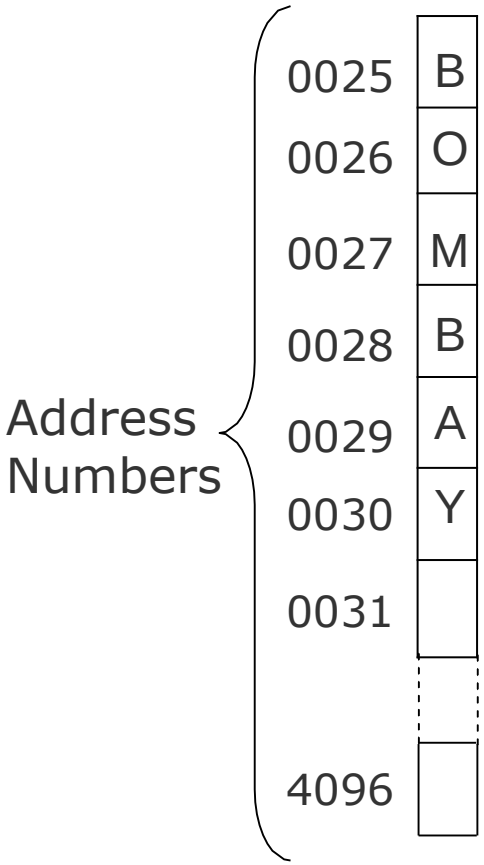
| Property | Desirable | Primary storage | Secondary storage |
|---|---|---|---|
| Storage capacity | Large storage capacity | Small | Large |
| Access Time | Fast access time | Fast | Slow |
| Cost per bit of storage | Lower cost per bit | High | Low |
| Volatility | Non-volatile | Volatile | Non-volatile |
| Access | Random access | Random access | Pseudo-random access or sequential access |

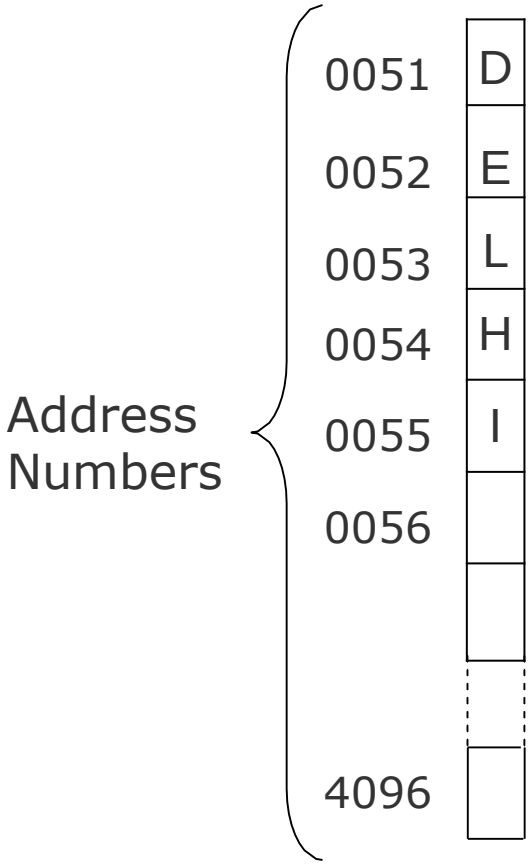
# FIXED WORD LENGTH MEMORY




- Storage space is always allocated in multiples of word-length
- Faster in speed of calculation than variable word-length memory
- Normally used in large scientific computers for gaining speed of calculation

# VERIABLE WORD-LENGTH MEMORY




- Each memory location can store only a single character
- Slower in speed of calculation than fixed world-length memory
- Used in small business computers for optimizing the use of storage space

**Note:** With memory becoming cheaper and larger day-by-day, most modern computers employ fixed-word-length memory organization

# MEMORY CAPACITY

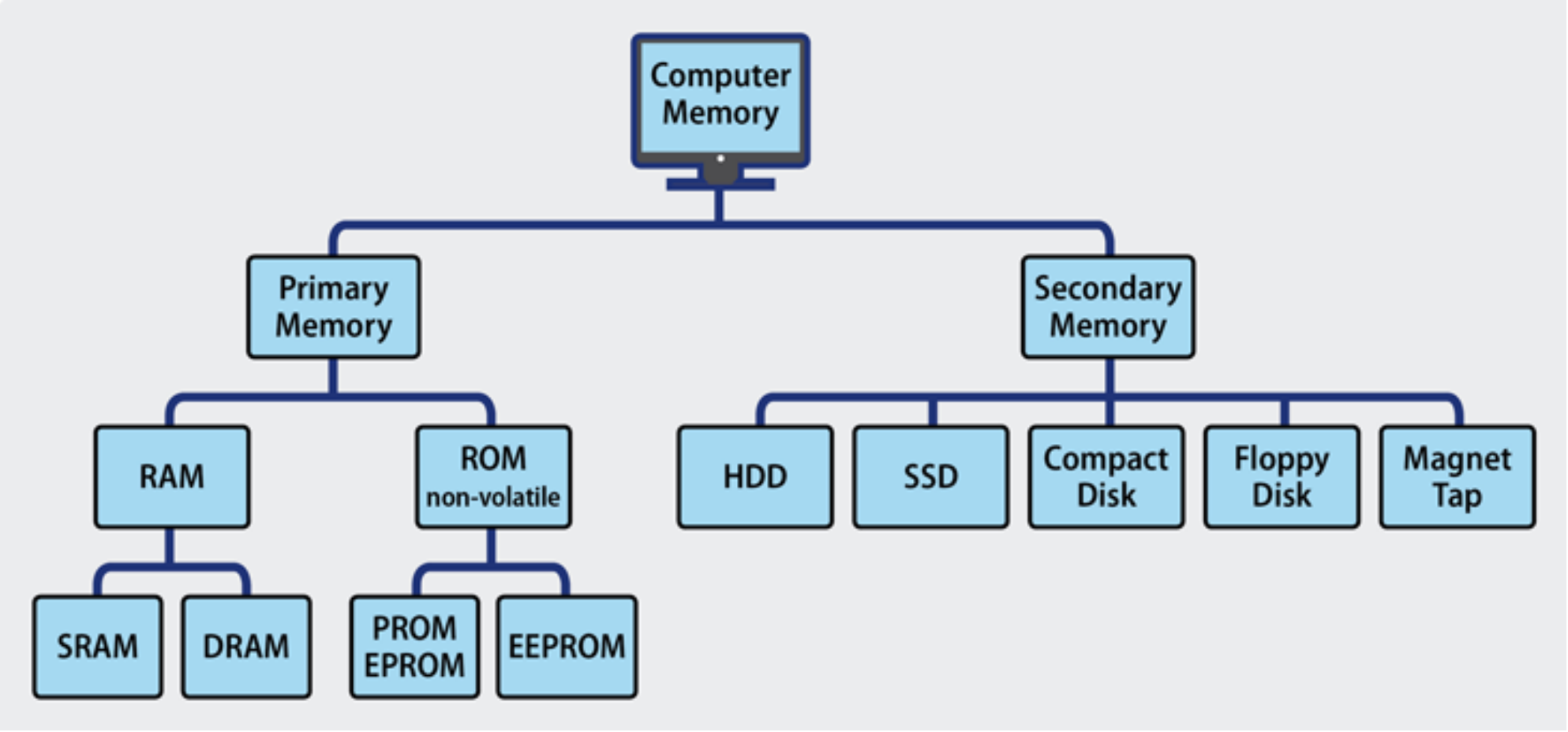
- Memory capacity of a computer is equal to the number of bytes that can be stored in its primary storage
- Its units are:

Kilobytes (KB) : 1024 ($2^{10}$) bytes

Megabytes (MB) : 1,048,576 ($2^{20}$) bytes

Gigabytes (GB) : 1,073,741824 ($2^{30}$) bytes

# TYPES OF COMPUTER MEMORY



# PRIMARY MEMORY

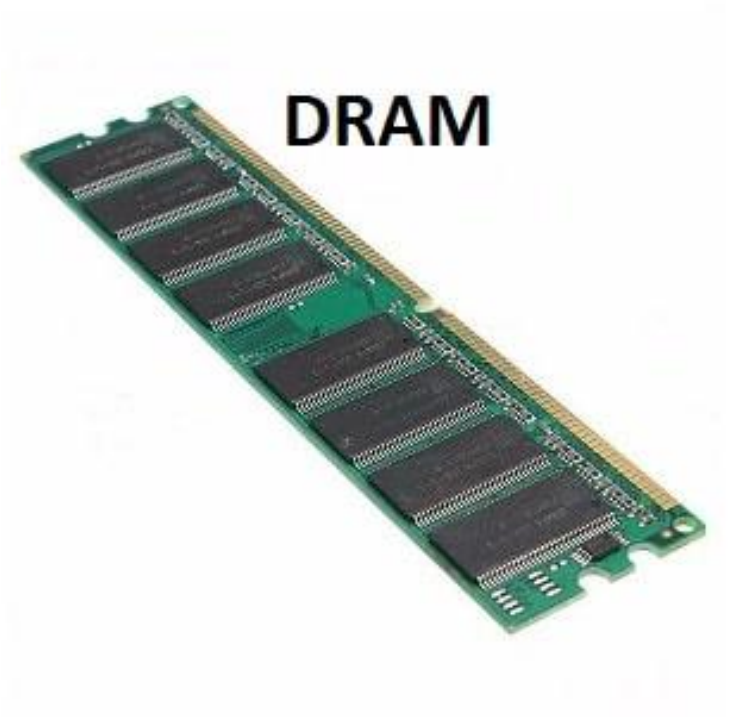
# RANDOM ACCESS M EMORY (RAM)

- Also called ‘main memory’
- Implemented as ‘solid state’ (electronic) random access memory (RAM)
- RAM is fast, small with low power consumption, but relatively expensive (cost per bit) and volatile (data is lost when switched off)
- Like a CPU, it is build as an IC (integrated circuit)
- How does RAM work?
  - https://www.youtube.com/watch?v=2CJcotBkf6w

# RANDOM ACCESS M EMORY (RAM)

- Two basic RAM technologies:
- Static RAM (**SRAM**) – uses a flip-flop circuit and remembers as long as it has power but costs more
- Dynamic RAM (**DRAM**) – uses a capacitor to hold charge, which leaks out so needs refreshing but costs less
- Most PC systems (and games consoles etc) use dynamic RAM because of cost.

# RANDOM ACCESS M EMORY (RAM)




# RANDOM ACCESS M EMORY (RAM)

- Modern computers have multiple Gigabytes (GB) of RAM in a small number of chips mounted on a circuit board package called a ‘dual in-line memory module’ (DIMM) which mount in slots on the motherboard.
- There is also ‘single in-line memory module’ (SIMM)

# READ ONLY MEMORY (ROM)

- ROM: Read Only Memory
- Also known as ‘firmware’
- A variation on the previous main memory
- The data or program instructions are built into the chips when they are made and cannot be changed
- Non-volatile – will retain data when power removed
- Used for code that does not change, such as PC BIOS

http://computer.howstuffworks.com/rom.htm

# TYPES OF ROM

| Type | Usage |
|---|---|
| Manufacturer-programmed ROM | Data is burnt by the manufacturer of the electronic equipment in which it is used. |
| User-programmed ROM<br>or<br>Programmable ROM (PROM) | The user can load and store "read-only" programs and data in it |
| Erasable PROM (EPROM) | The user can erase information stored in it and the chip can be reprogrammed to store new information |

# TYPES OF ROM

| Type | Usage |
| --- | --- |
| Ultra Violet EPROM (UVEPROM) | A type of EPROM chip in which the stored information is erased by exposing the chip for some time to ultra-violet light |
| Electrically EPROM (EEPROM) or Flash memory | A type of EPROM chip in which the stored information is erased by using high voltage electric pulses |

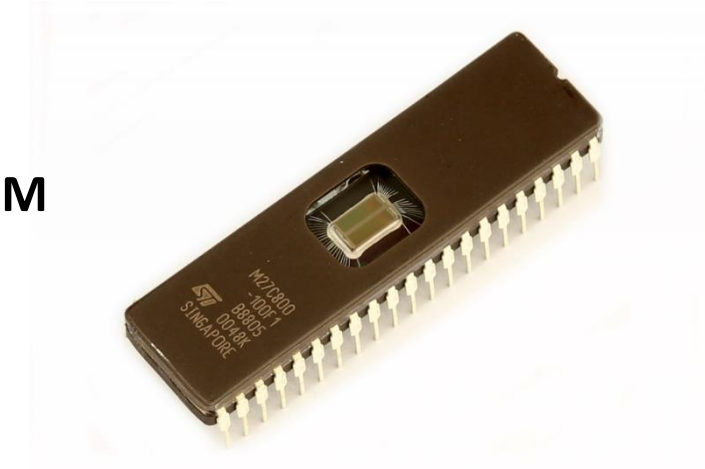
# TYPES OF ROM

PROM


EPROM


EEPROM


UVEPROM



# QUICK BRAIN – Sample Question 1

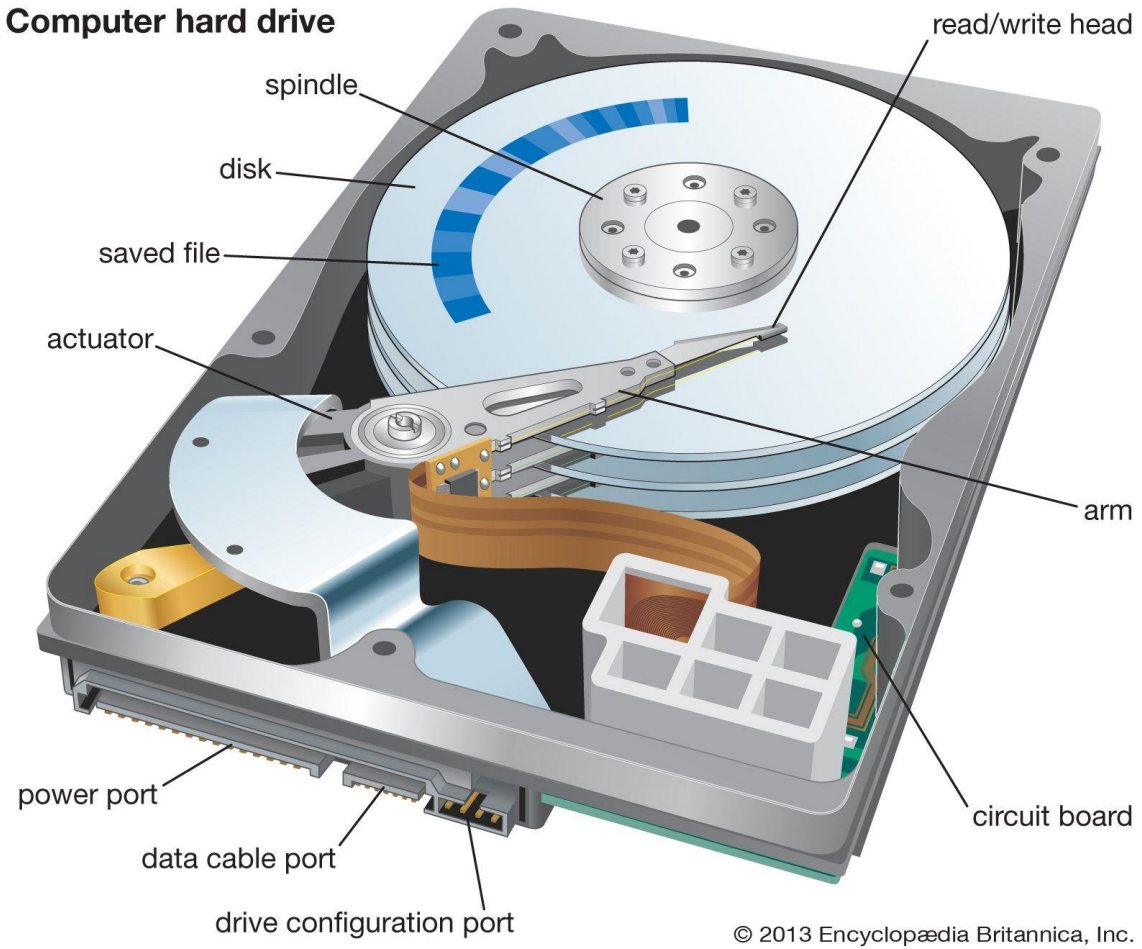
1. How does RAM work?
2. State the differences between SRAM & DRAM

# SECONDARY MEMORY

# HARD DISK

- Also called ***backing store*** - *n*ormally implemented as a hard-disk drive (HDD)
- Non-volatile, low cost per bit, high power consumption, many times slower than RAM
- Originally developed by IBM for mainframes - been massive advances in data storage density and overall capacity – even in laptops and desktops

# HARD DISK


Computer hard drive
read/write head
spindle
disk
saved file
actuator
arm
circuit board
power port
data cable port
drive configuration port
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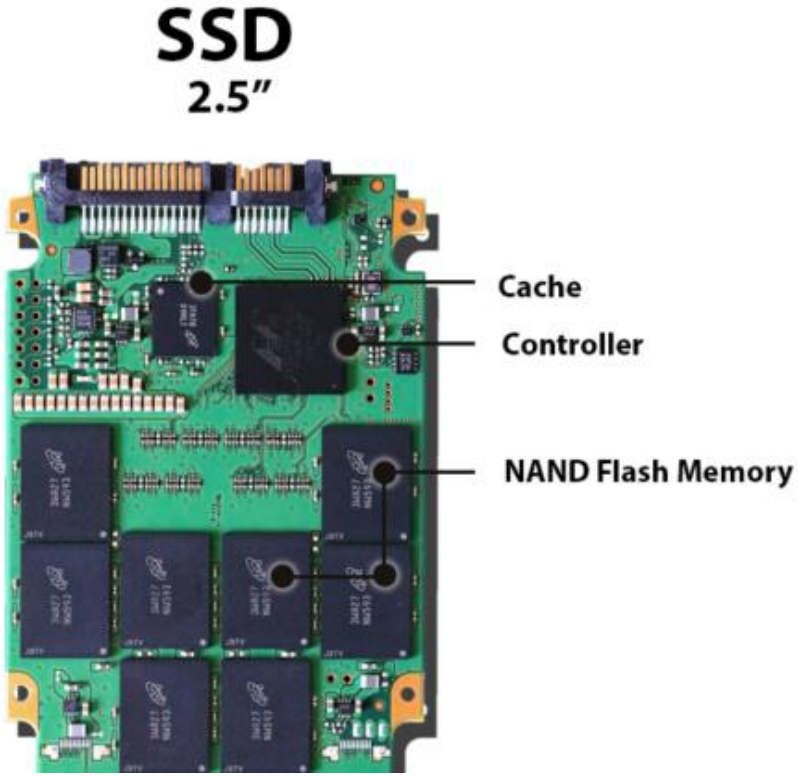
# HARD DISK

- HDD capacity now multi-terabytes (TB)
- Multiple 'platters' are held in a stack, coated with a magnetic material, and divided into sectors, tracks and clusters
- These partitioned platter surfaces can be magnetised in two ways – giving binary storage
- A read/write head hovers over the spinning disk surfaces and through electro-magnetism can detect (read) the values or record (write)new data

http://www.ntfs.com/hard-disk-basics.htm

# SOLID STATE DISK

- SSD capacity multi-terabytes (TB)
- Uses interconnected flash-memory chips, not magnetic media, to store data.
- No moving parts, SSDs can deliver improved reliability.
- Significant increase in the performance of a computer equipped with an SSD.
- SSDs consume far less power than traditional hard drives.



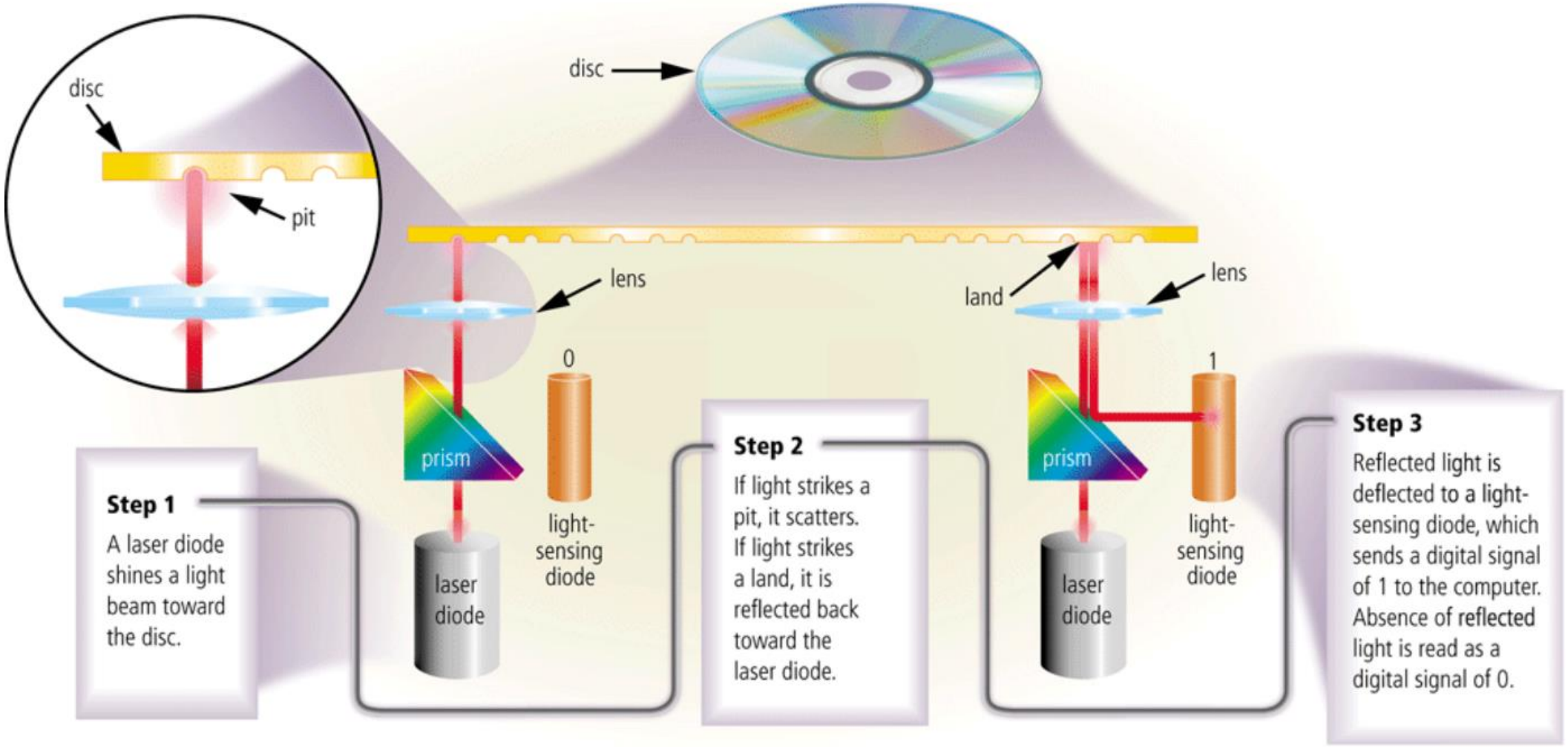

https://computer.howstuffworks.com/solid-state-drive.htm

# OPTICAL DISK

- Originally based on **Compact Disk** (CD) technology from the music industry – have variations like CD-R
- Then came **Digital Versatile Disk** (DVD) from the movie industry - due to higher data compression and thus storage capacity
- Now we have **Blu-ray** disks
- Hard disks (HDD) use spots of *magnetism* to store data
- Optical disks use spots of *light* – as reflective disk surface stamped with **"*pits*"** and **"*lands*"-** giving a binary storage system - read by bouncing a laser off the surface and detecting changes in reflection from pits and lands

http://electronics.howstuffworks.com/cd.htm
http://electronics.howstuffworks.com/dvd.htm
http://electronics.howstuffworks.com/blu-ray.htm

# OPTICAL DISK



# FLASH MEMORY

- Use flash **RAM technology** as secondary storage
- Common examples include **USB memory stick** and **camera data cards**
- Should be regarded as temporary storage as they are less reliable long term than hard disk or optical storage
- Subject to physical damage

# PRIMARY VS SECONDARY MEMORY

| Parameter | Primary memory | Secondary memory |
|---|---|---|
| Nature | The primary memory is categorized as volatile & nonvolatile memories. | The secondary memory is always a non-volatile memory. |
| Alias | These memories are also called internal memory. | Secondary memory is known as a Backup memory or Additional memory or Auxiliary memory. |
| Access | Data is directly accessed by the processing unit. | Data cannot be accessed directly by the processor. It is first copied from secondary memory to primary memory. Only then CPU can access it. |
| Formation | It's a volatile memory meaning data cannot be retained in case of power failure. | It's a non-volatile memory so that that data can be retained even after power failure. |

# CACHE MEMORY

- It is commonly used for minimizing the memory- processor speed mismatch.
- It is an extremely fast, small memory between CPU and main memory whose access time is closer to the processing speed of the CPU.
- It is used to temporarily store very active data and instructions during processing.

*Cache is pronounced as "cash"*

# QUICK BRAIN – Sample Question 2

1. What is secondary storage? What are the two types of secondary storage? Briefly explain
2. Why secondary storage is essential?