# Computer
Fundamentals & Programming

Storage devices

Why Don't Computers Use Base 10?

- Base 10 Number Representation
  - That's why fingers are known as "digits"
  - Natural representation for financial transactions
    - Exactly represent $1.20
  - Even carries through in scientific notation
    - 1.5213×10^4
- Implementing Electronically
  - Hard to store
    - ENIAC (First electronic computer) used 10 vacuum tubes / digit
  - Hard to transmit
    - Need high precision to encode 10 signal levels on single wire
  - Messy to implement digital logic functions
    - Addition, multiplication, etc.

Binary Representations

- Base 2 Number Representation
  - Represent 15213_{10} as 1101101101101_2
  - Represent 1.20_{10} as $1.0011001100110011[0011]\ldots_2$
  - Represent 1.5213×10^4 as $1.1101101101101_2 \times 2^{13}$
- Electronic Implementation
  - Easy to store with bistable elements
  - Reliably transmitted on noisy and inaccurate wires
  - Straightforward implementation of arithmetic functions
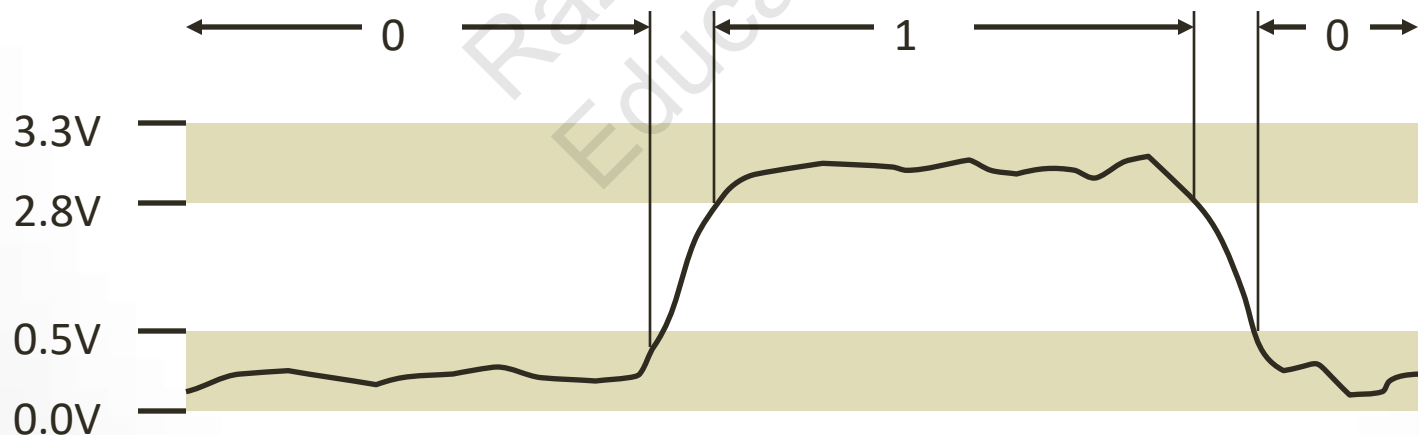
Byte-Oriented Memory Organization

- Programs Refer to Virtual Addresses
  - Conceptually very large array of bytes
  - Actually implemented with hierarchy of different memory types
    - SRAM, DRAM, disk
    - Only allocate for regions actually used by program
  - In Unix and Windows, address space private to particular "process"
    - Program being executed
    - Program can touch its own data, but not that of others
- Compiler + Run-Time System Control Allocation
  - Where different program objects should be stored
  - In any case, all allocation within single virtual address space

Encoding Byte Values

- Byte = 8 bits

  - Binary 00000000_2 to 11111111_2

  - Decimal: 0_{10} to 255_{10}

  - Hexadecimal 00_{16} to FF_{16}

    - Base 16 number representation

    - Use characters '0' to '9' and 'A' to 'F'

Hex	Decimal	Binary
0	0	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
A	10	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

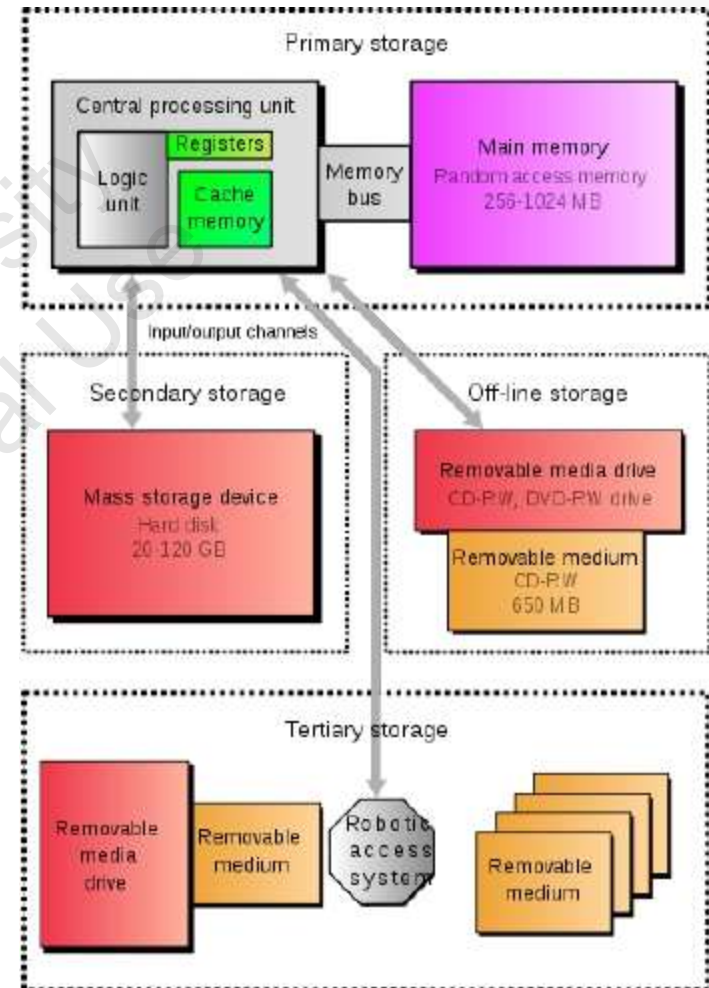# Storage Devices

Storage Devices

- A **storage device** is used in the computers to store the data.

- Provides one of the core functions of the modern computer.

Storage Devices

Types of Storage

There are four type of storage:

- Primary Storage
- Secondary Storage
- Tertiary Storage
- Off-line Storage

Storage Devices

Primary Storage

- Also known as **main memory.**

- Main memory is directly or indirectly connected to the central processing unit via a memory bus.

- The CPU continuously reads instructions stored there and executes them as required.

- Example:
  - RAM
  - ROM
  - Cache

Storage Devices

Primary Storage

RAM

- It is called Random Access Memory because any of the data in RAM can be accessed just as fast as any of the other data.
- Random access instead of sequential access

RAM is used by the central processing unit (CPU) when a computer is running to store information that needs to be used very quickly, but it does not store any information permanently.

Storage Devices

Primary Storage

ROM

- This memory is used as the computer begins to boot up.

- Small programs called firmware are often stored in ROM chips on hardware devices (like a BIOS chip), and they contain instructions the computer can use in performing some of the most basic operations required to operate hardware devices.

- ROM memory cannot be easily or quickly overwritten or modified.
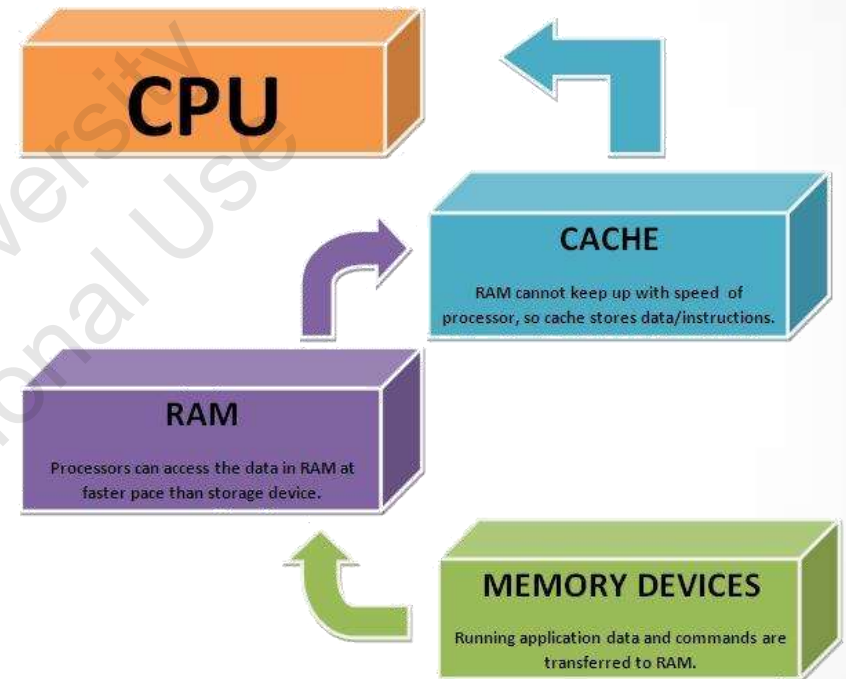
Storage Devices

Primary Storage

Cache

Cache is a high-speed access area that can be either a reserved section of main memory or a storage device.

Most computers today come with L3 cache or L2 cache, while older computers included only L1 cache.

CPU

CACHE
RAM cannot keep up with speed of processor, so cache stores data/instructions.

RAM
Processors can access the data in RAM at faster pace than storage device.

MEMORY DEVICES
Running application data and commands are transferred to RAM.

Storage Devices

Secondary Storage

- It is not directly accessible by the CPU.

- Computer usually uses its input/output channels to access secondary storage and transfers the desired data using intermediate area in primary storage.

- Example:
  - Hard disk

Storage Devices

Secondary Storage

Hard Disk

- The hard disk drive is the main, and usually largest, data storage device in a computer.
- Hard disk speed is the speed at which content can be read and written on a hard disk.
- A hard disk unit comes with a set rotation speed varying from 4500 to 7200 rpm.
- Disk access time is measured in milliseconds.

Storage Devices

Secondary Storage

Hard Disk

Internal Hard disk

External Hard disk

Storage Devices

Secondary Storage

Hard Disk

	Internal Hard disk	**External Hard disk**
Portability	No	Yes
Price	Less expensive	More expensive
Speed	Fast	Slow
Size	Big	Small

Storage Devices

Tertiary Storage

- Typically it involves a robotic mechanism which will mount (insert) and dismount removable mass storage media into a storage device.

- It is a comprehensive computer storage system that is usually very slow, so it is usually used to archive data that is not accessed frequently.

- This is primarily useful for extraordinarily large data stores, accessed without human operators.

Storage Devices

Tertiary Storage

- Examples:
  - Magnetic Tape
  - Optical Disc

Storage Devices

Tertiary Storage

Magnetic Tape

- A magnetically coated strip of plastic on which data can be encoded.

- Tapes for computers are similar to tapes used to store music.

- Tape is much less expensive than other storage mediums but commonly a much slower solution that is commonly used for backup.

Storage Devices

Tertiary Storage

Optical Disc

- **Optical disc** is any storage media that holds content in digital format and is read using a laser assembly is considered optical media.
- The most common types of optical media are
    - Blu-ray (BD)
    - Compact Disc (CD)
    - Digital Versatile Disc (DVD)

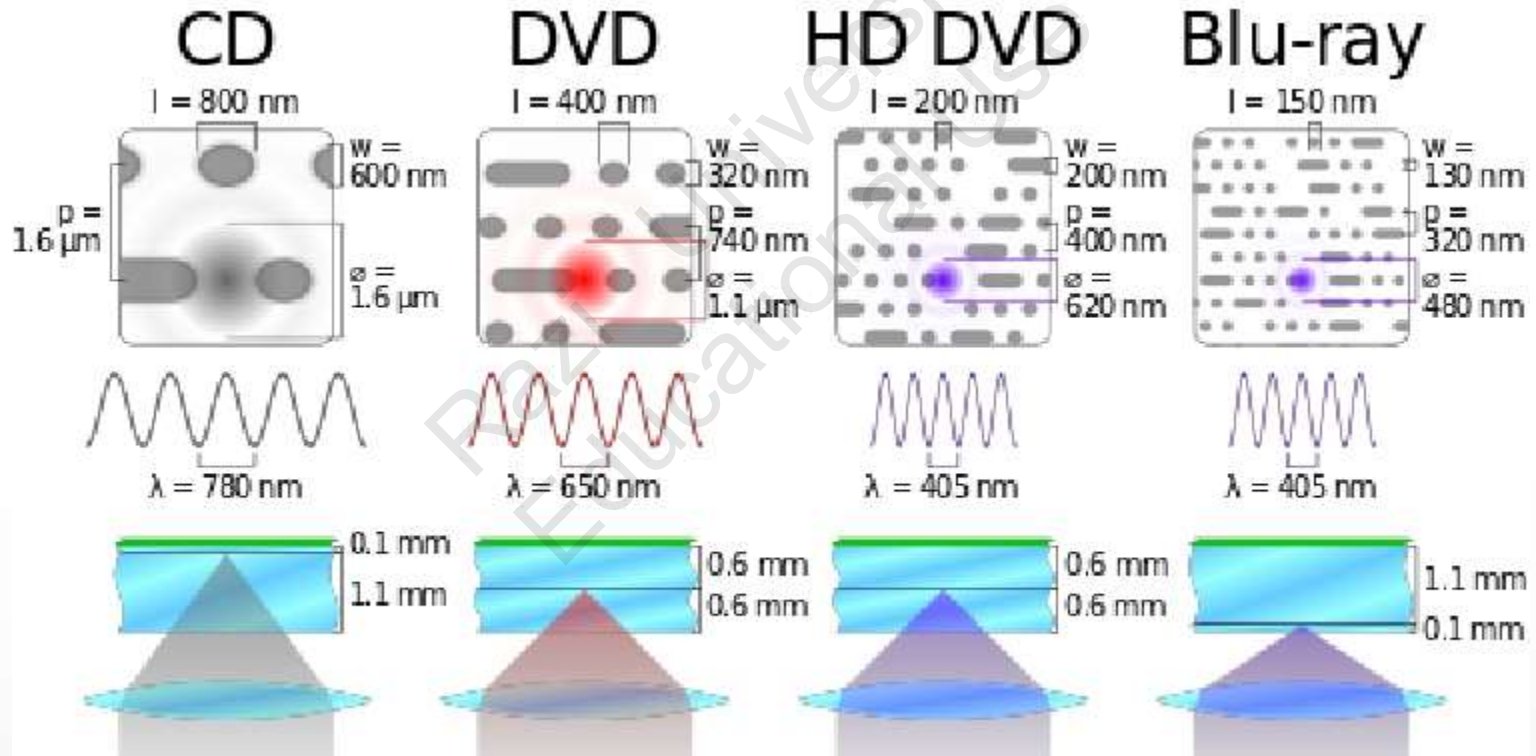# Storage Devices

Tertiary Storage

Optical Disc

	CD	DVD	BD
Capacity	700MB	4.7GB – 17GB	50GB
Wavelength	780nm	650nm	405nm
Read/Write Speed	1200KB/s	10.5MB/s	36MB/s
Example	• CD-ROM, • CD-R • CD-RW	• DVD-ROM • DVD+R/RW • DVD-R/RW • DVD-RAM	• BD-R • BD-RE

Storage Devices

Tertiary Storage

Optical Disc

Storage Devices

Off-line Storage

- Also known as **disconnected or removable storage.**

- Is a computer data storage on a medium or a device that is not under the control of a processing unit.

- It must be inserted or connected by a human operator before a computer can access it again.

Storage Devices

Off-line Storage

- Examples:
  - Floppy Disk
  - Zip diskette
  - USB Flash drive
  - Memory card

Storage Devices

Off-line Storage

Floppy Disk

- A soft magnetic disk.
- Floppy disks are portable.
- Floppy disks are slower to access than hard disks and have less storage capacity, but they are much less expensive. Now, has been retired!
- Can store data up to 1.44MB.
- Two common sizes: 5 ¼" and 3 ½".

Storage Devices

Off-line Storage

Floppy Disk

5 ¼ inch Floppy Disk   3 ½ inch Floppy Disk

Storage Devices

Off-line Storage

Zip Diskette

- Hardware data storage device developed by Iomega that functions like a Standard 1.44 floppy drive.

- Capable to hold up to 100 MB of data or 250 MB of data on new drives.

- Now it is less popular as users needed larger storage capabilities.

Storage Devices

Off-line Storage

USB Flash Drive

- A small, portable flash memory card that plugs into a computer's USB port and functions as a portable hard drive.

- Flash drives are available in sizes such as 256MB, 512MB, 1GB, 2GB, 8GB, 16GB, 32GB … and are an easy way to transfer and store information.

Storage Devices

Off-line Storage

Memory Card

- An electronic flash memory storage disk commonly used in consumer electronic devices such as digital cameras, MP3 players, mobile phones, and other small portable devices.

- Memory cards are usually read by connecting the device containing the card to your computer, or by using a USB card reader.

Storage Devices

Off-line Storage

Memory Card

Secure Digital card (SD)

MiniSD

Compact Flash

Memory Stick

MultiMedia card

XD-Picture card

Memory card reader

Storage Devices

Storage Device Features

- Volatility
- Accessibility
- Mutability
- Addressability

Storage Devices

Volatility

- Two types of volatility:
    - Volatile Memory
    - Non-Volatile Memory

Storage Devices

Volatility

Volatile Memory

- Requires constant power to maintain the stored information.

- The fastest memory technologies.

- All contents are erased when the system's power is turned off or interrupted.

- It has been more popularly known as **temporary memory**.
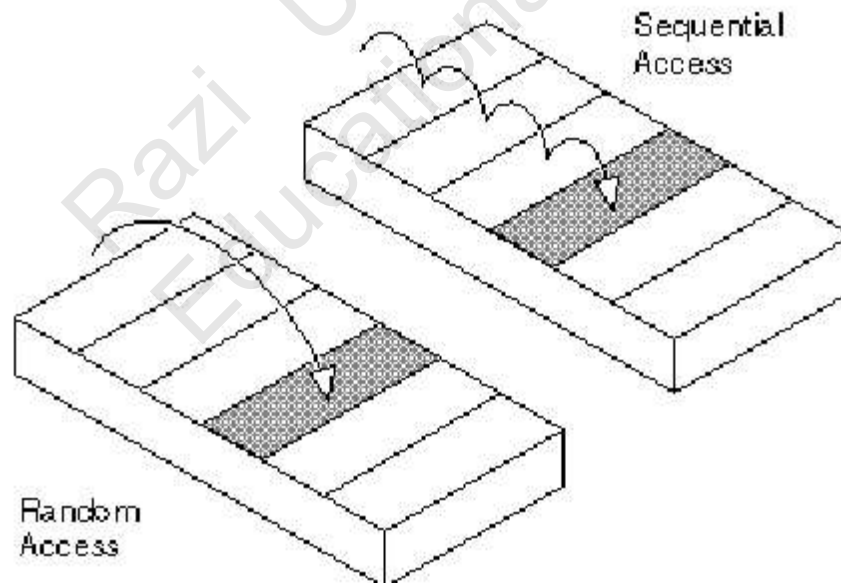
Storage Devices

Volatility

Non-Volatile Memory

- Will retain the stored information even if it is not constantly supplied with electric power.

- Non volatile memory is the device which keeps the data even when the current is off.

- It is suitable for long-term storage of information.

Storage Devices

Accessibility

- Refers to reading or writing data records
- Two types of accessibility:
  - Random access
  - Sequential access

Storage Devices

Accessibility

Random Access

- Any location in storage can be accessed at any moment in approximately the same amount of time.

- Such characteristic is well suited for primary and secondary storage.

Storage Devices

Accessibility

Sequential Access

- The accessing of pieces of information will be in a serial order, one after the other; therefore the time to access a particular piece of information depends upon which piece of information was last accessed.

- Such characteristic is typical of off-line storage.

Storage Devices

Mutability

- Allows information to be overwritten at any time.

- A computer without some amount of read/write storage for primary storage purposes would be useless for many tasks.

- Three types of mutability:
  - Read/write storage or mutable storage
  - Read only storage
  - Slow write, fast read storage

Storage Devices

Mutability

Read/Write Storage or Mutable Storage

- Allows information to be overwritten at any time.
- A computer without some amount of read/write storage for primary storage purposes would be useless for many tasks.

Storage Devices

Mutability

Read Only Storage

- Retains the information stored at the time of manufacture, and **write once storage** (WORM) allows the information to be written only once at some point after manufacture.

- These are called **immutable storage**.

Storage Devices

Mutability

Slow Write, Fast Read Storage

- Read/write storage which allows information to be overwritten multiple times, but with the write operation being much slower than the read operation.

Storage Devices

Addressability

- Three types of addressability
  - Location-addressable
  - File addressable
  - Content-addressable

Storage Devices

Addressability

Location-addressable

- Each individually accessible unit of information in storage is selected with its numerical memory address.

Storage Devices

Addressability

File addressable

- Information is divided into files of variable length, and a particular file is selected with human-readable directory and file names.

Storage Devices

Addressability

Content-addressable

- Each individually accessible unit of information is selected based on the basis of (part of) the contents stored there.

- Content-addressable storage can be implemented using software (computer program) or hardware (computer device), with hardware being faster but more expensive option.

- Hardware content addressable memory is often used in a computer's CPU cache.

Storage Devices

Other Example of Storage Devices
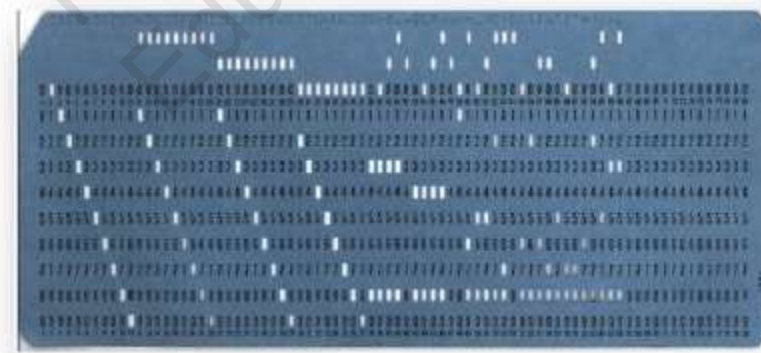
- Punch card
- Cloud storage

Storage Devices

Other Example of Storage Devices

Punched Card

- Early method of data storage used with early computers

- Punch cards also known as Hollerith cards

- Containing several punched holes that represents data

Storage Devices

Other Example of Storage Devices

Cloud Storage

- Cloud storage means "the storage of data online in the cloud," wherein a data is stored in and accessible from multiple distributed and connected resources that comprise a cloud.

- Cloud storage can provide the benefits of greater accessibility and reliability; rapid deployment; strong protection for data backup, archival and disaster recovery purposes.

Storage Devices

Other Example of Storage Devices

Cloud Storage

- Examples:
  - Google Drive
  - Flickr
  - Microsoft Sky Drive
  - Dropbox