Data Manipulation 1

Sabah Sayed

Topics

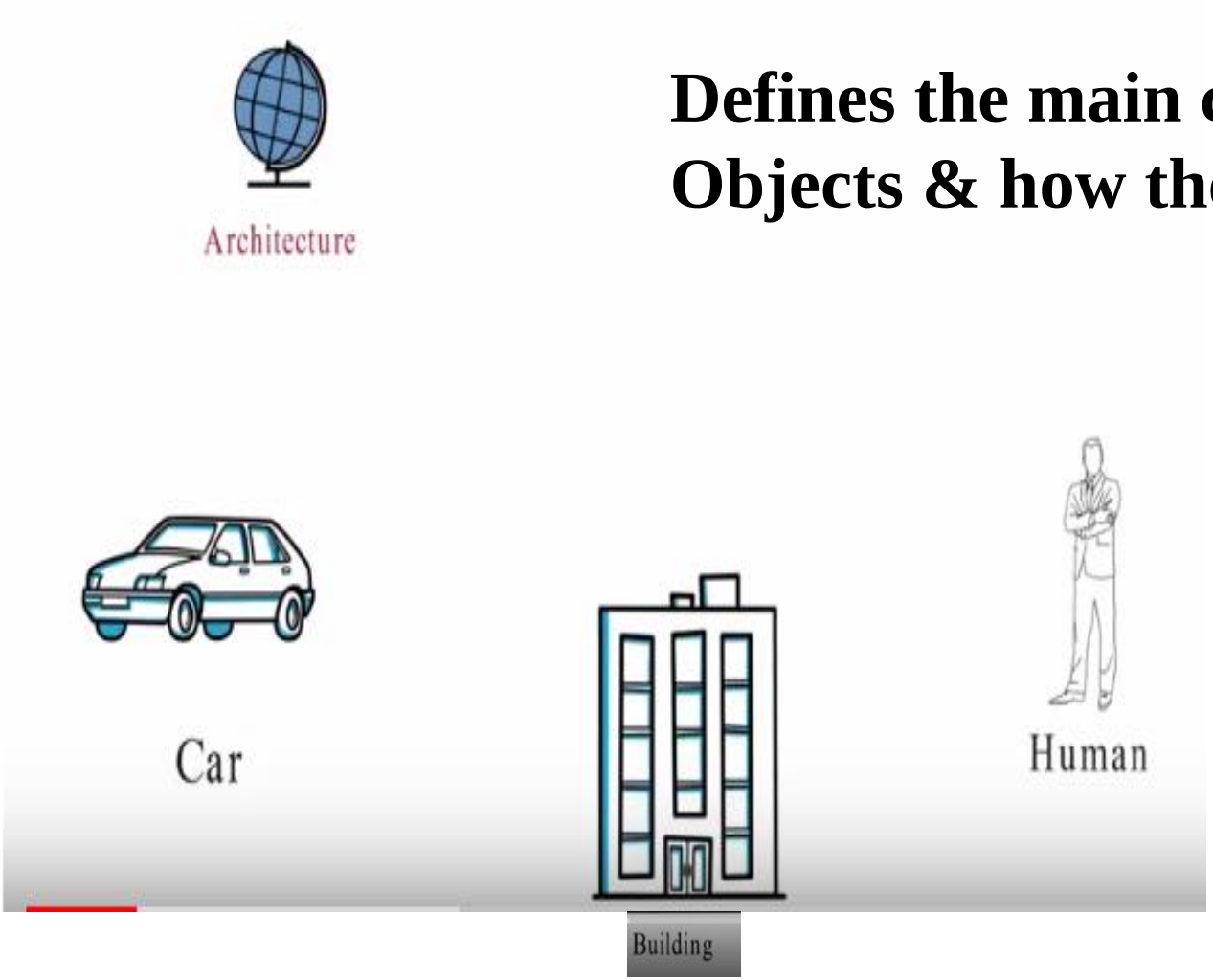
1. Computer Architecture.
2. Central Processing Unit (CPU).
3. Main Memory.
4. Storage Devices.
5. I/O devices.
6. Busses.
7. Von Neumann Computer Architecture.

Chapter 2: Data Manipulation

- 2.1 Computer Architecture
- 2.2 Machine Language

- How computer manipulates data
- What is the basic architecture of computer
- How computer is programmed by means of encoded instructions, i.e. machine language

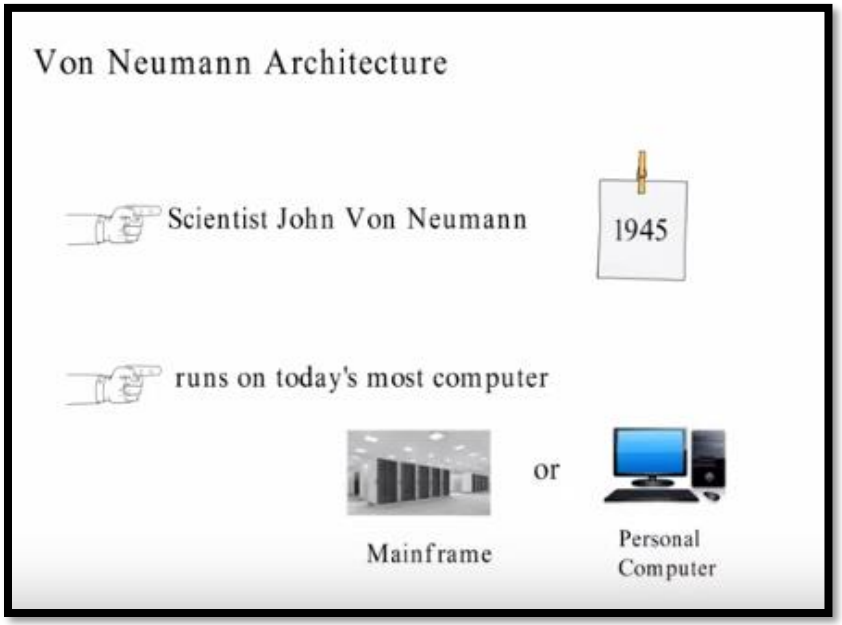
What is an Architecture?

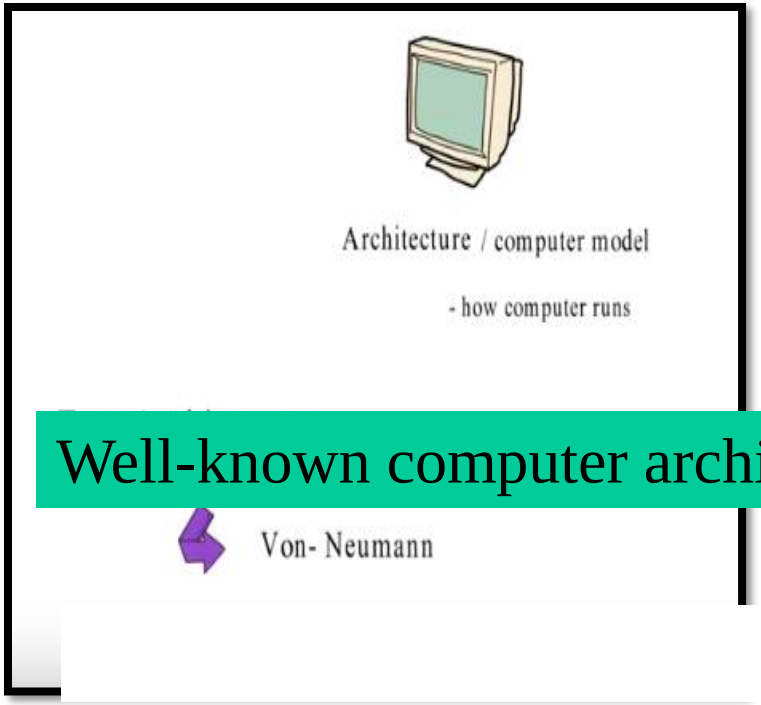


Defines the main components of Objects & how they can work

Computer Architecture

- Studies the **basic parts of a computer** and how they **work together**

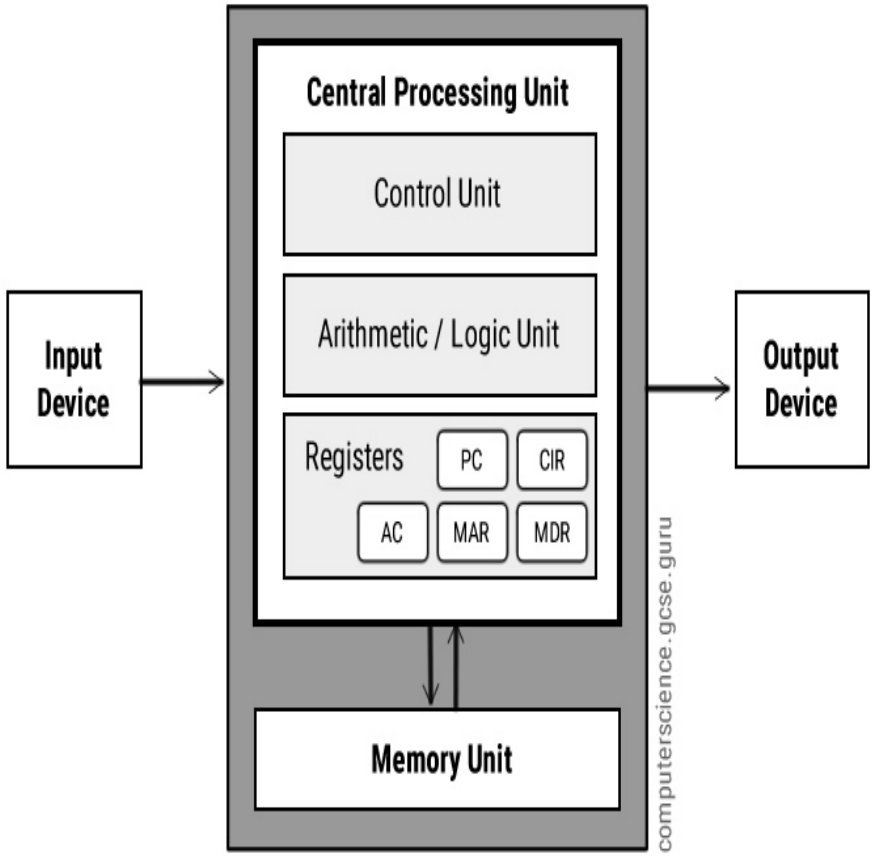




Computer Architecture composed of 5 main Components

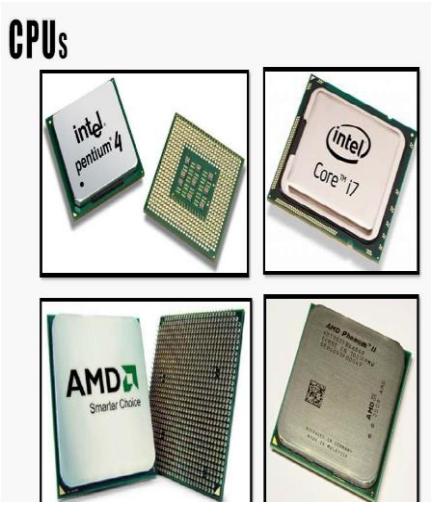
1) **Central Processing Unit (CPU) or processor:**
2) **Main Memory**
3) **Storage Devices**
4) **I/O Devices**
5) **Bus**

CPU and RAM are plugged Inside the Motherboard



Central Processing Unit (CPU)

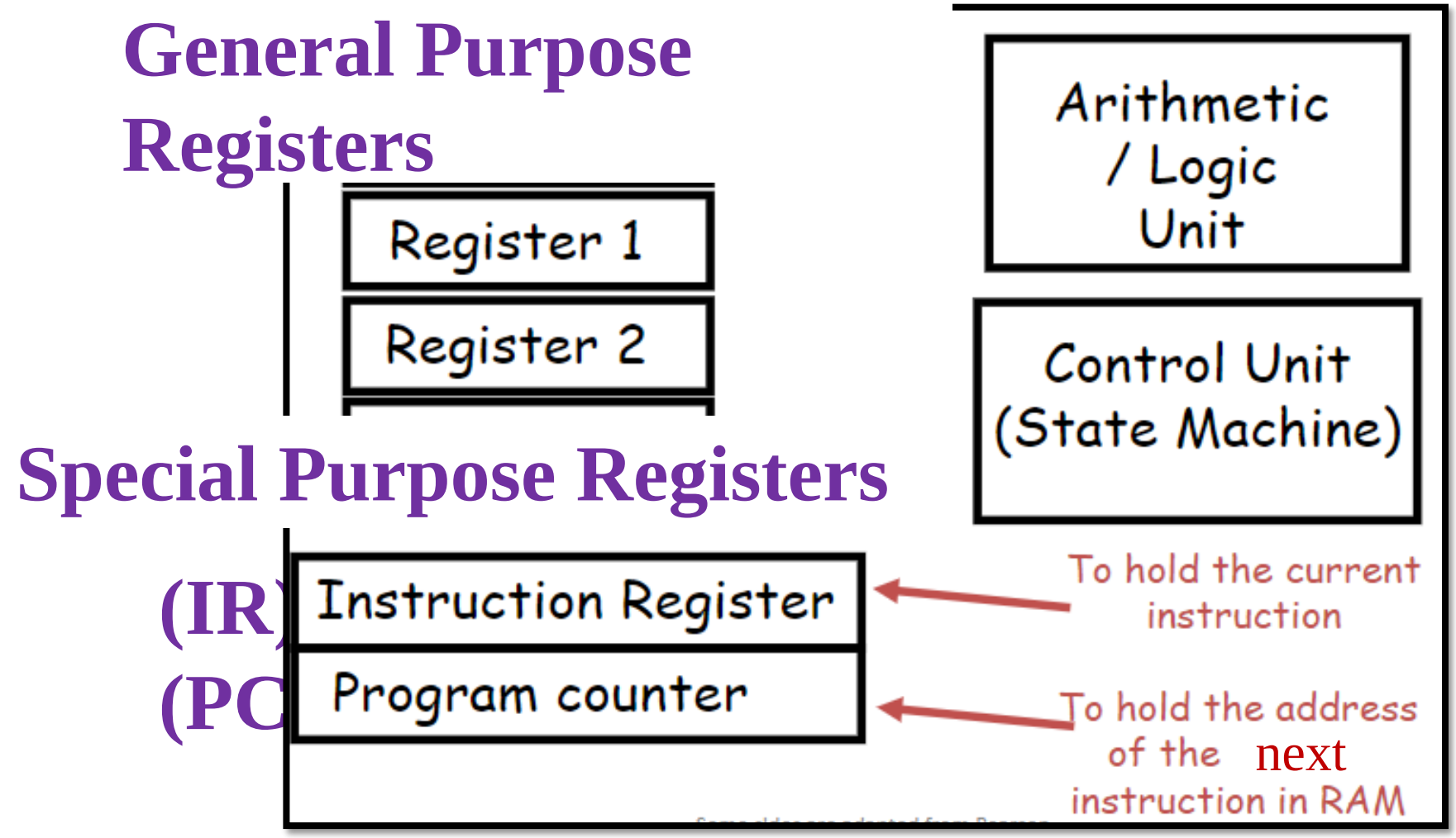
- **Called Processor**
  - **In Mobile Internet Devices (MID), called Microprocessor**
- **The Brain of the computer**
  - **Controls & coordinates all functions of a computer**
  - **Manipulates data**
  - Perform **arithmetic calculation** such as addition, subtraction, multiplication, etc.
  - **Read/write** instruction & data **from/to** memory
  - **Execute** the instructions



CPU Components

1. **Arithmetic/Logic unit (ALU)**
   - **Executes/Performs all arithmetic and logical operations on data being processed**
     - **e.g., +, -,*, /, >, <, etc.**
2. **Control unit (CU)**
   - **Fetches & decodes (i.e., reads and interprets) instructions from memory**
3. **Registers**
   - **High-speed memory inside CPU to temporarily hold data and instructions for processing**
   - **Two types of registers:**
     - General purpose : can be used for any task. hold the inputs/results to/from the arithmetic/logic Unit.
       - **e.g., Accumulator (AC), R0, R1,…**
     - Special purpose: used for special task
       - **e.g., Program Counter (PC) & Instruction Register (IR)**

Inside the CPU



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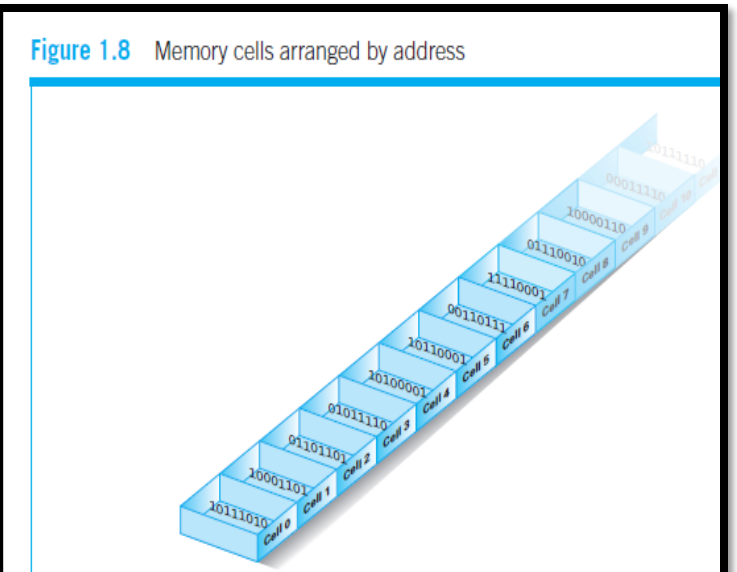
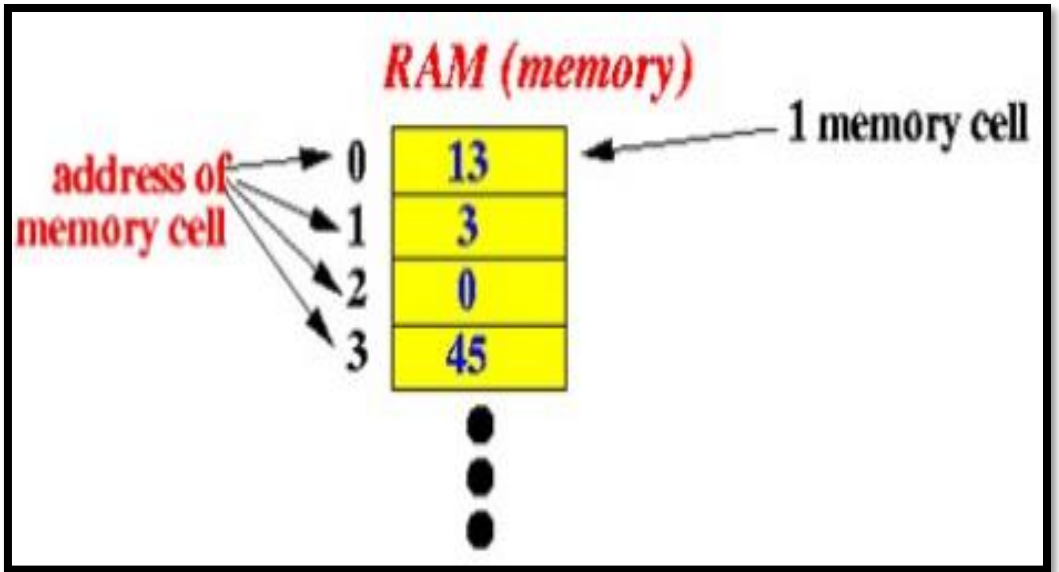
Main Memory (RAM) Structure

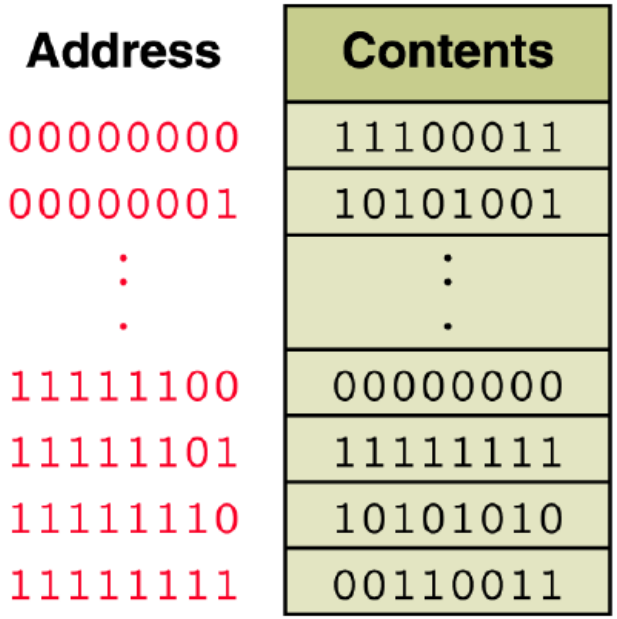
- Consists of many memory **cells** (storage units) of a fixed size.
- Each cell has an **address** associated with it: 0, 1, …
- A cell is the minimum unit of access (fetch/store a complete cell).
- The time that CPU takes to fetch/store a cell is the same for all cells.
- Stores data and running programs





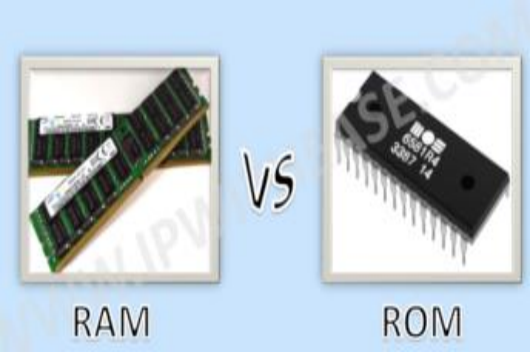
Main Memory

- The size of Memory (i.e., # of cells) is a power of 2
- Memory is accessed in words: 4 bytes (32-bits) or 8 bytes (64-bits)
- Called **RAM**: **R**andom **A**ccess **M**emory
  - Why it is called Random?
    - As the CPU can access the memory cells **in any order**



Address	Contents
00000000	11100011
00000001	10101001
⋮	⋮
11111100	00000000
11111101	11111111
11111110	10101010
11111111	00110011

Types of Memory
RAM vs ROM



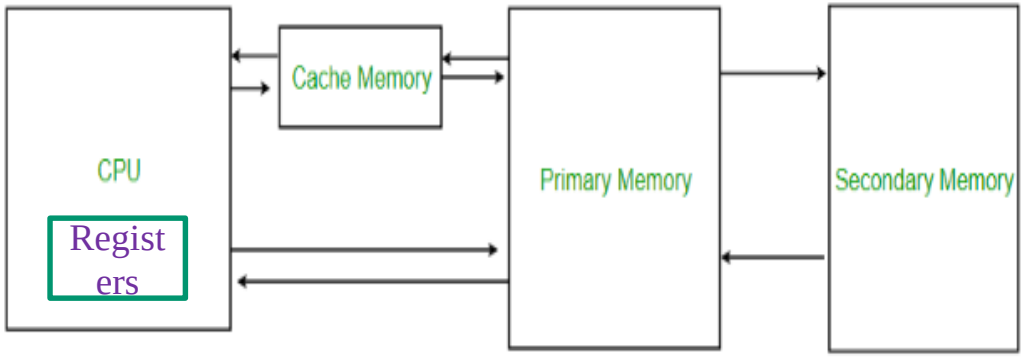
RAM	ROM
Random Access Memory	Read Only Memory
Volatile	Non-volatile
Store data and programs that need to be executed	Store info. to boot the computer (BIOS)
Its content can be changed	Its content can’t be changed
Large size (GB)	Small size (MB)

Cache Memory

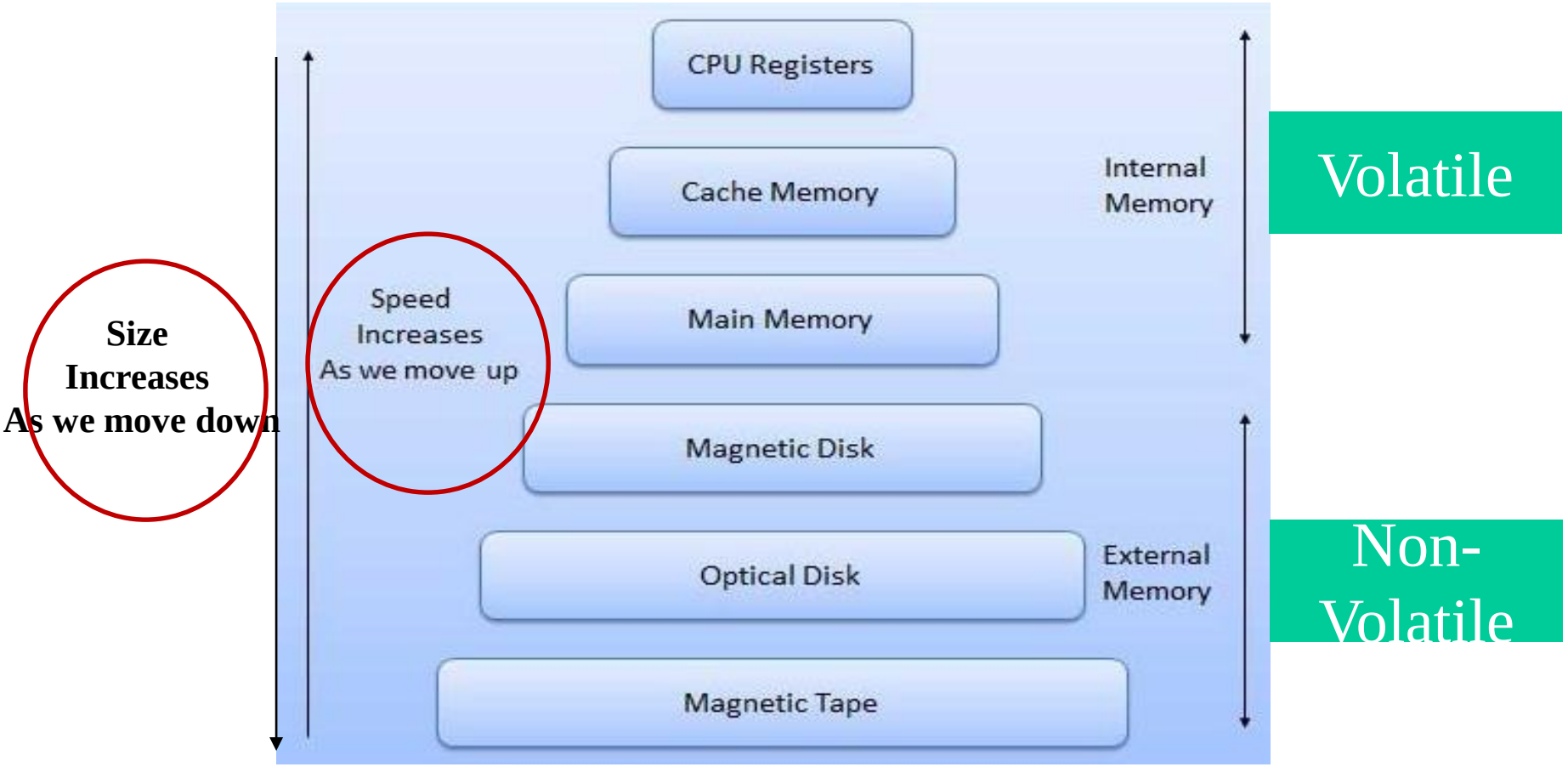
- A portion (several hundred KB) of high-speed memory Located within the CPU itself.
- Keep a copy of a portion of main memory that is needed in the near future.
- Data transfers from registers to Cache memory and from Cache memory to main memory.
- Any changes made to cache memory are then transferred collectively to main memory.
- Rapid the CPU because it is not delayed by main memory communication.

Memory Hierarchy

- The **memory is characterized** based on two main factors:
  - **Capacity (i.e., Size)**: amount of data that can be stored in a memory
  - **Access time (i.e., Speed)**: the time to read/write data from/to a memory
- **Different types of memory**:
  - **Registers** (**available inside CPU & very small size (e.g., word)**)
  - **Cache** (**high-speed** memory, **available inside CPU & has larger size than registers & used to speed the access to main memory**)
  - **Primary memory** (Main memory)
  - **Secondary memory** (e.g., hard disk, CD)



Memory Hierarchy



Computer Architecture composed of 5 main Components

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Mass Storage/ Storage Devices

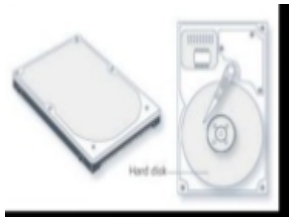
- Called, **Secondary Storage**
- **e.g., hard disk, flash memory, CDs, DVDs**
- **Advantages over Main memory**
  - **Store** data and programs **permanently**
  - **Non-Volatile** (i.e., the data are **not erased** if the computer turned off)
  - **Larger size**
  - **Lower cost**
  - **Can be removed**
- **Disadvantages over Main memory**
  - **Consume more time to access**
    - So, it is **slower**

Main Memory(RAM)

- Called, **RAM**: **R**andom **A**ccess **M**emory
- **Stores** data and programs (i.e., instructions) **only** during **processing**
- **Volatile** (i.e., the data are **erased** if the computer turned off)

Storage Devices

- **e.g., hard disk, flash memory, CDs**
- **Store** data and programs **permanently**
- **Non-Volatile** (i.e., the data are **not erased** if the computer turned off)

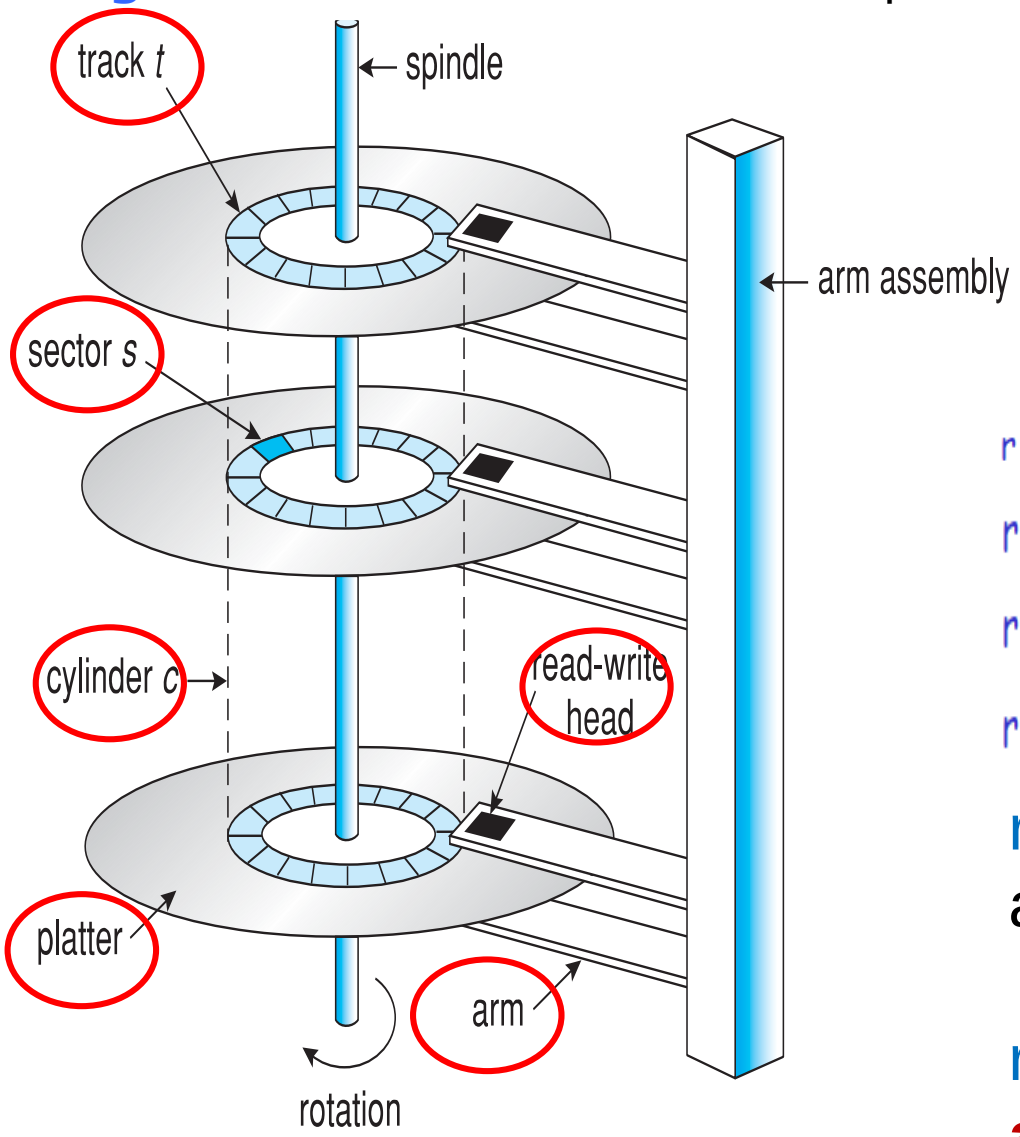


Mass Storage Categories

- Magnetic Devices
  - Magnetic disks
  - Magnetic tape (high data capacity)
- Optical Devices
  - CDs (MBs)
  - DVDs (GBs)
  - Blu Ray (5 times the capacity of DVDs)
- Solid State Devices: very useful to provide portable data storage. However, they are not reliable
  - Flash drives (i.e., Flash memory devices)
  - Solid-state disks (SDD) (used **to replace** magnetic disks)

Magnetic Disk

Magnetic disks consist of several platters



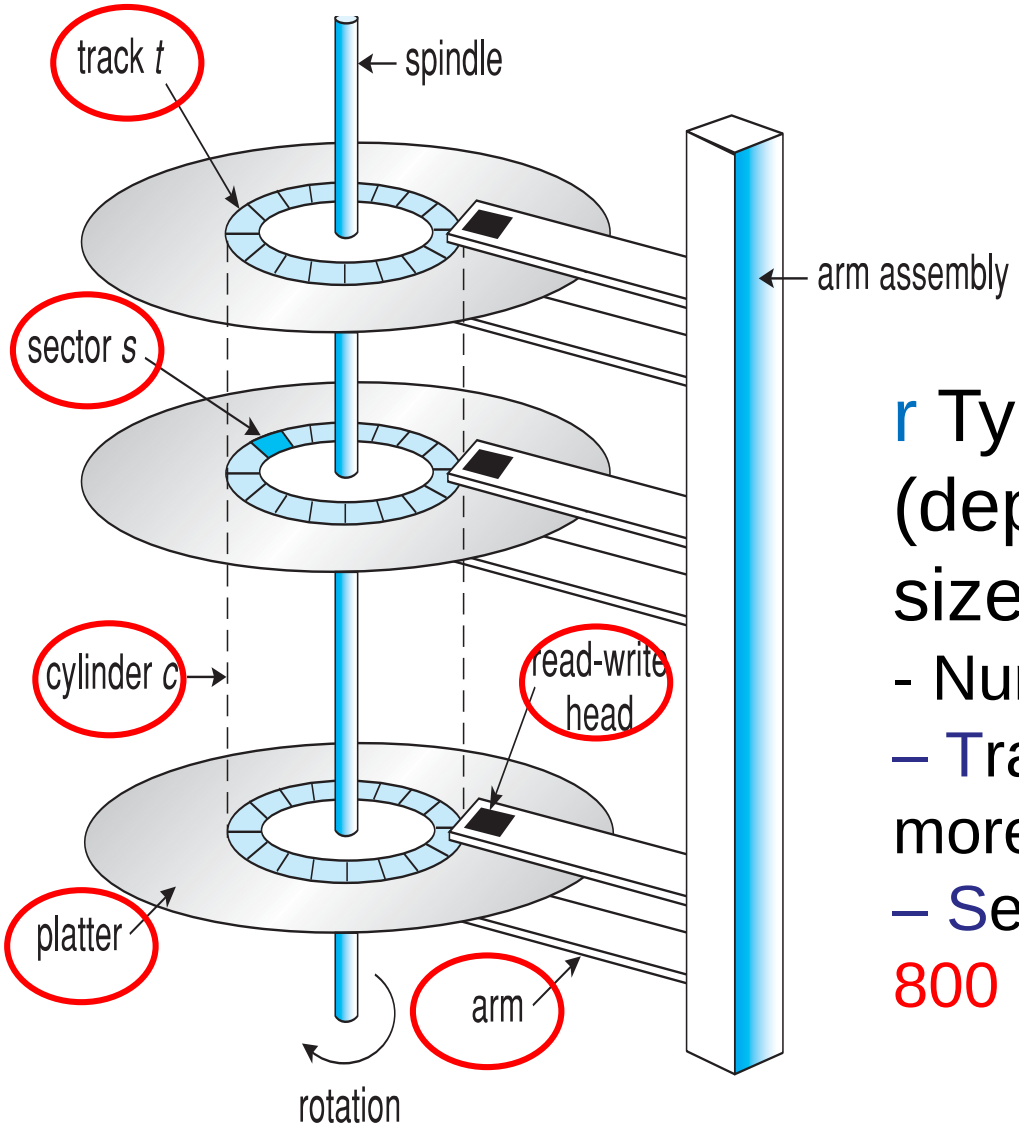
- Think of disks as a stack of platters
- Use both sides of platters
- Two read-write heads at end of each arm

- Tracks: concentric rings on platter
- Tracks split into sectors
- Sectors may be grouped into blocks
- Addressable unit is typically a block

- **sector** is the smallest addressable unit
- The set of tracks that are **at one**

Magnetic Disk

Magnetic disks consists of several platters



r Typical numbers (depends on the disk size):

- Number of platters: 1-6

– Tracks per platter: 500 to more than 20,000

– Sectors per track: 32 to 800

Disk Capacity

- Disk capacity depends on number of platters used and the density in which the tracks and sectors are placed.
- **Lower-capacity disk** may consist of a single platter.
- **High-capacity disk** capable of holding terabytes, consist of 3 - 6 platters.
- Data may be stored on both **the upper and lower** surfaces of each platter.

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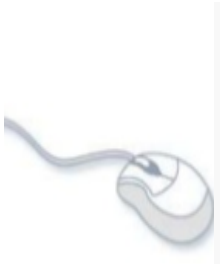
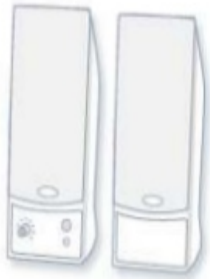
I/O Devices



- **Input Devices**
  - Mouse, Keyboard, Scanner, Microphone

- **Output Devices**
  - Monitor, Speaker, Printer



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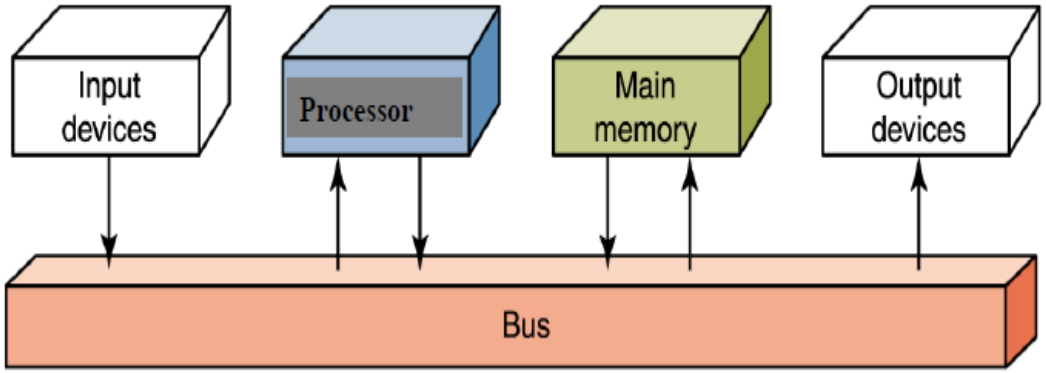
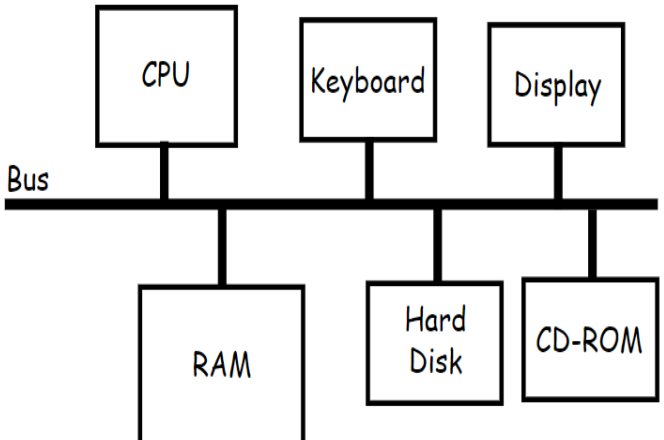
Buses

- A bus connects parts of the CPU to one another. It also links the CPU to the various components of the system board.

- Is **channel** (i.e., **collection of wires**) used **to transfer bits** among all computers components
- **Bus Width**: the amount of data (in bits) CPU can transmit at any time (multiple of 2)
  - e.g., the bus width can be 8, 16, 32, 64, or 128 bits



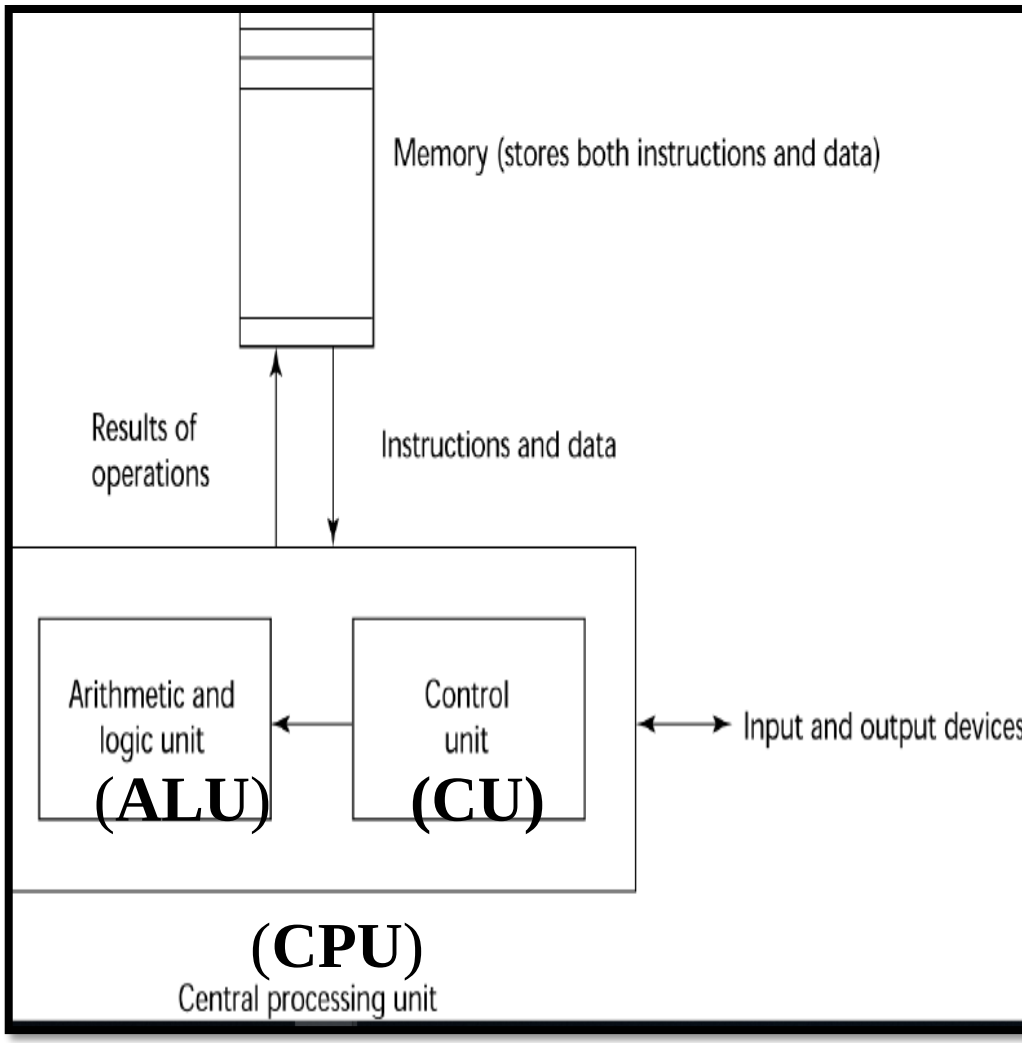


Von Neumann Computer Architecture

- Has proposed the idea of **Stored Program Concept**
  - A program can be encoded as bit patterns (i.e., 0's and 1's) and stored in main memory.
  - Then, the CPU can fetch the instructions and execute them.
  - In turn, the program to be executed can be altered easily.

Von Neumann Computer Architecture

- The **1st CPU** was invented by Von Neumann
  - Data and programs (i.e., instructions) stored in memory as 0's & 1's
  - Memory is separate from CPU
  - Instructions and data are fetched from memory to CPU

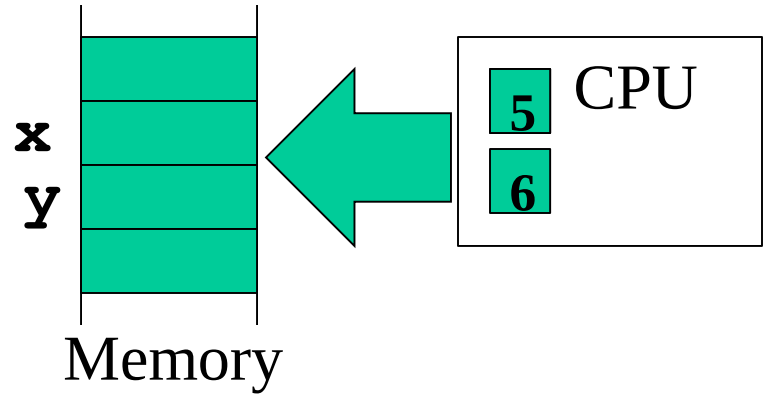


Pseudo Code for Von Neumann Architecture

```
initialize the program counter
repeat forever
  fetch the instruction pointed by
  the counter
    increment the counter
    decode the instruction
    execute the instruction
      store result
end repeat
```

Computer Architecture Influence

- Imperative languages like Java, C, C++, C#, Python, etc. are most dominant, because of von Neumann computers
- Basis for imperative languages
  - Variables model memory cells
  - Assignment statements model piping
  - Iteration is efficient



Example for Von-Neumann Architecture