Digital Logic Circuit Design

Hajar Falahati

Department of Computer Engineering
IRAN University of Science and Technology

hfalahati@iust.ac.ir

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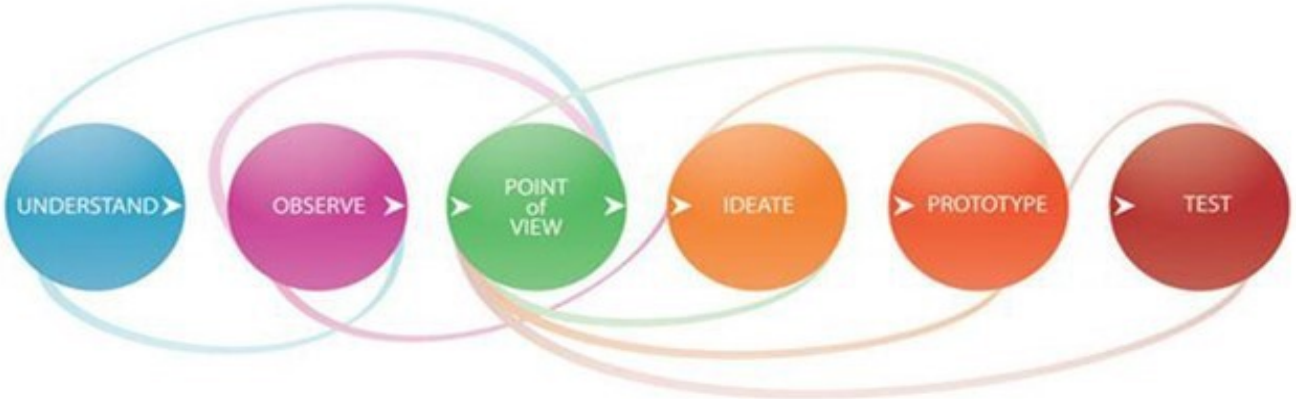
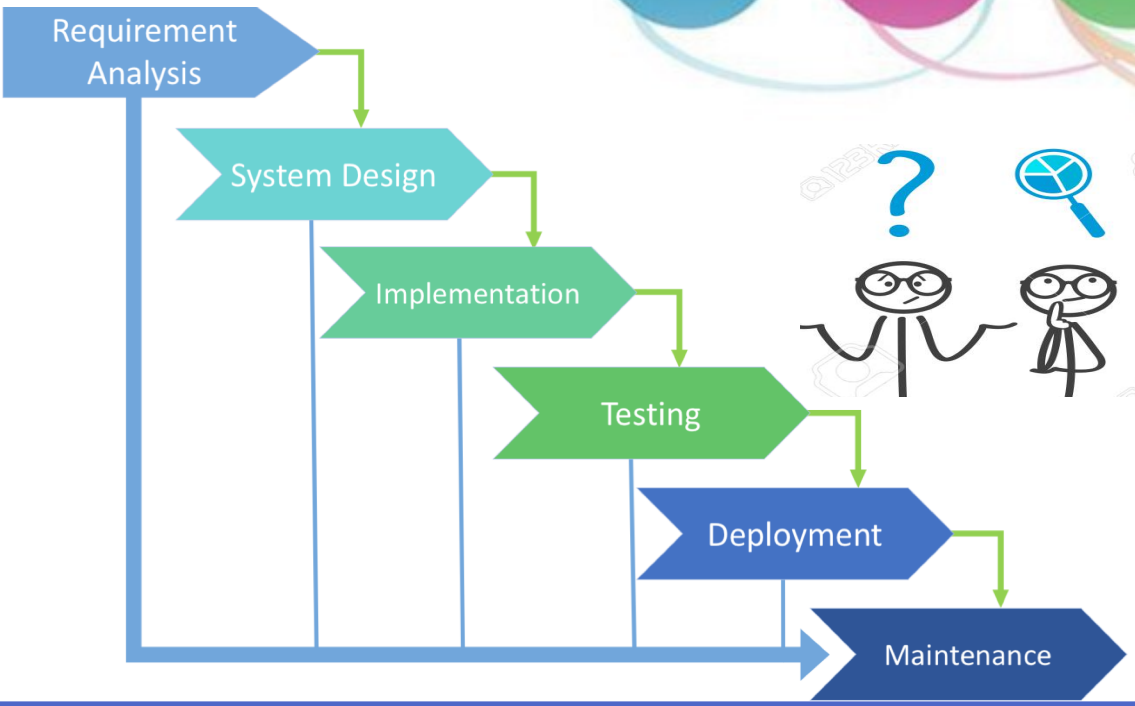
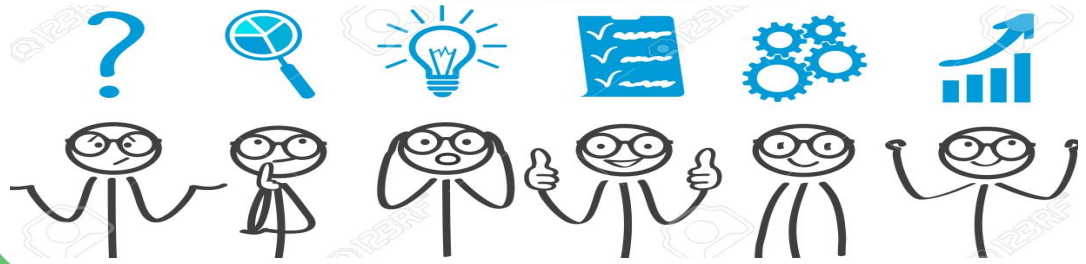






Outline

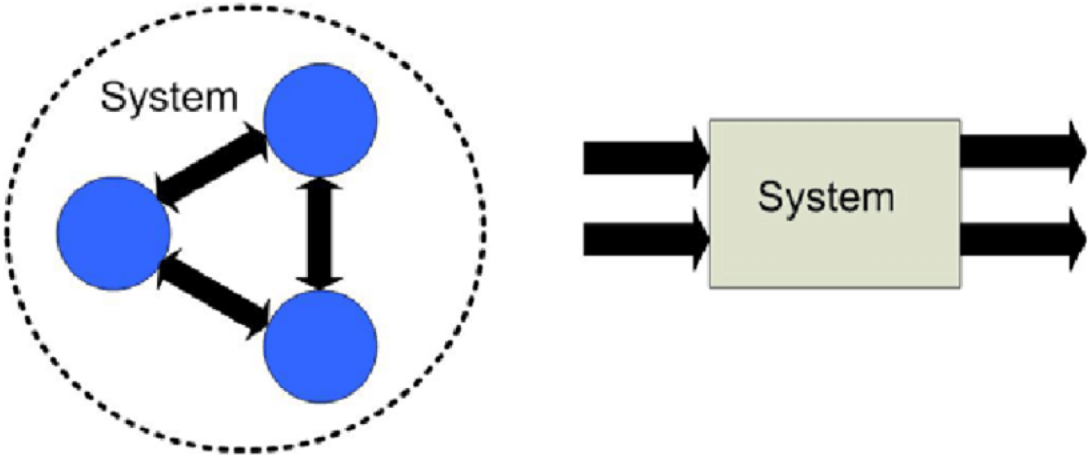
- Digital Systems
- Computer Organization
- Number Systems

Basic Concepts

System

- A **set** of **interacting components** that **acts as a whole**

- Performs the desired functions
  - Behavior

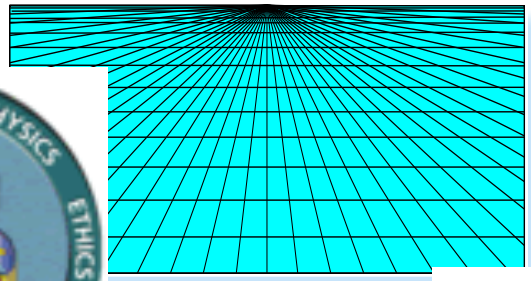


Computer System

- A computer combined with peripheral equipment and software
- Combination of hardware, software, user and data
  - **Performs desired functions**

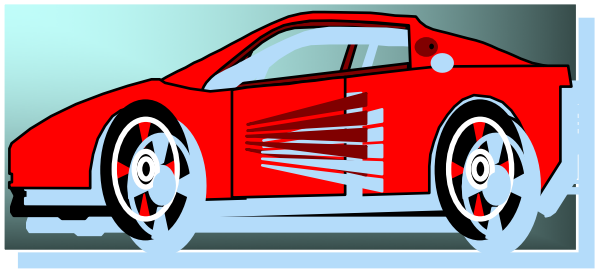
Computer Systems Are Every Where!

Life Sciences



Aerospace

Internet & Ecommerce



CAD/CAM

Digital Biology

Military Applications

Computer

- **Brukes Goldsten, Von Neuman**
  - Preliminary discussion of the **logical design** of an **electronic computing instrument**
  - 1946

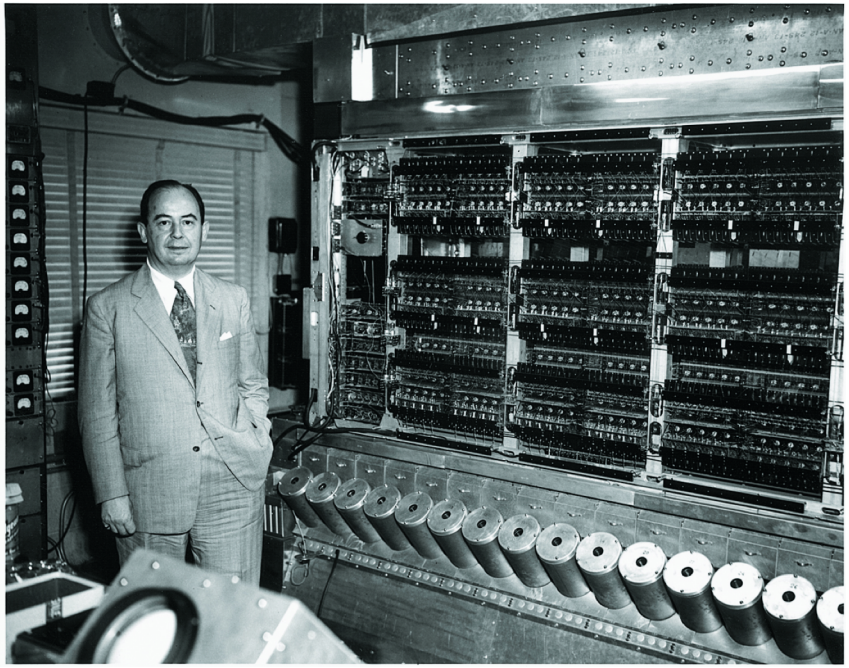
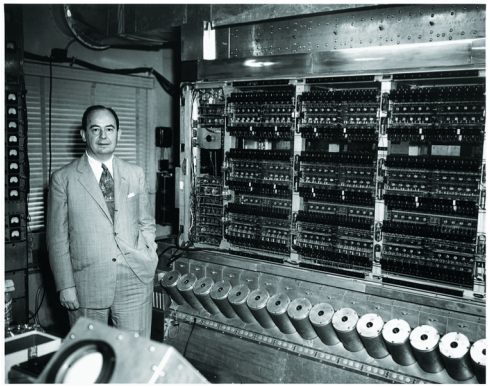
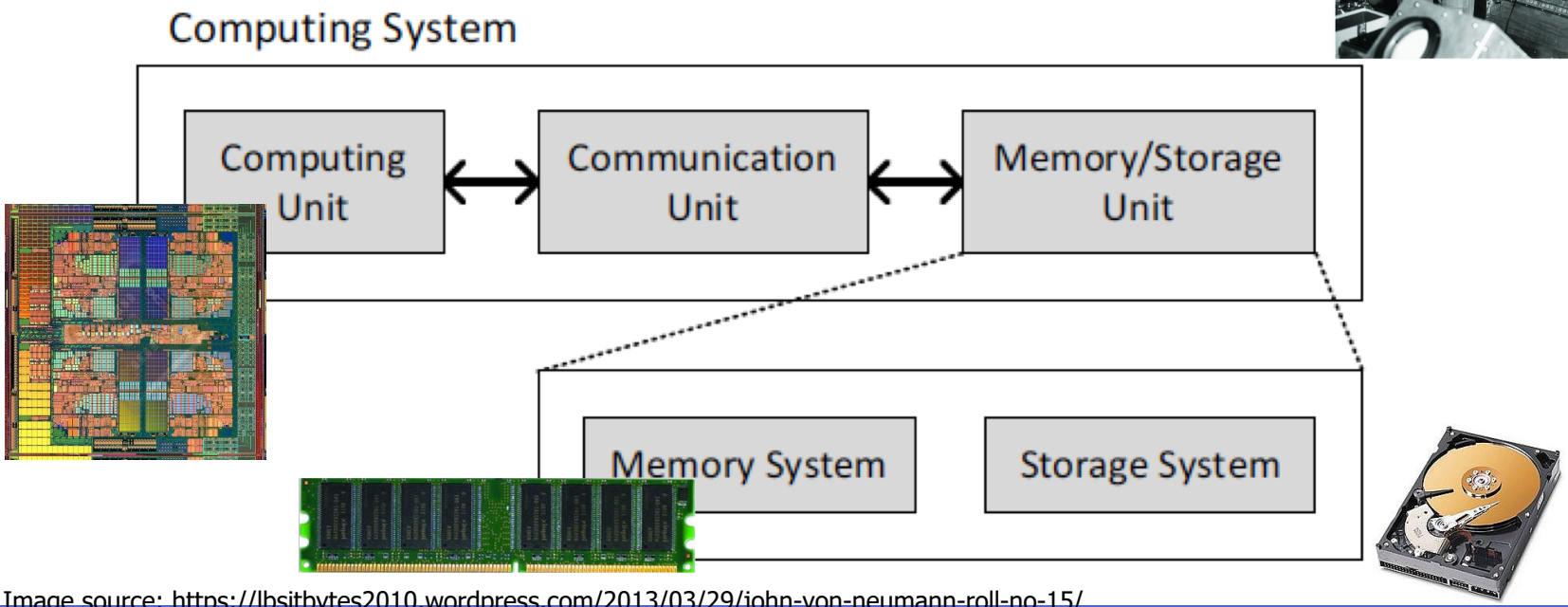


Image source: https://lbsitbytes2010.wordpress.com/2013/03/29/john-von-neumann-roll-no-15/

Components

- **Three key components**
  - Computation
  - Communication
  - Storage / Memory





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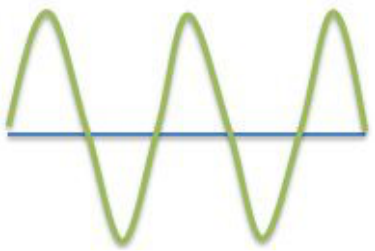
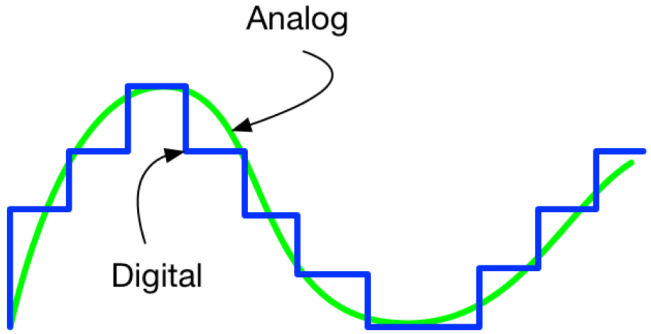
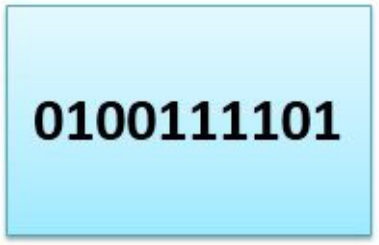
Digital Vs. Analog

- Analog
  - Time-varying signals
  - Take **any** value across a **continuous time** domains
  - Sensing and actuating environmental values



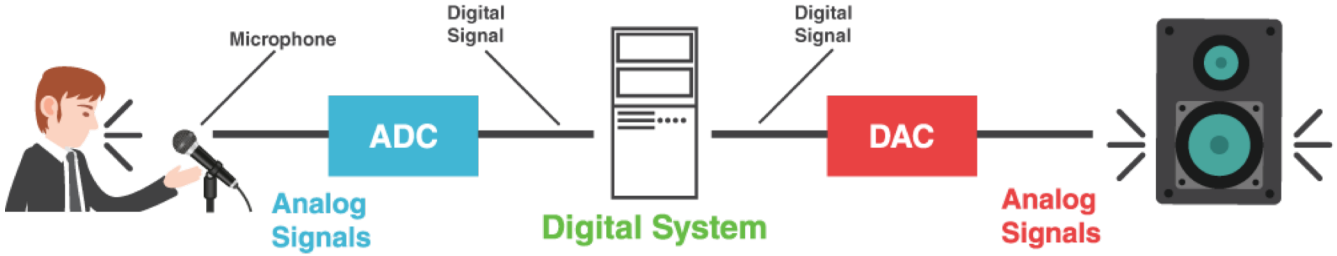
- Digital
  - **Finite** values in **discrete time** domains
  - Algorithmic control
  - Data processing





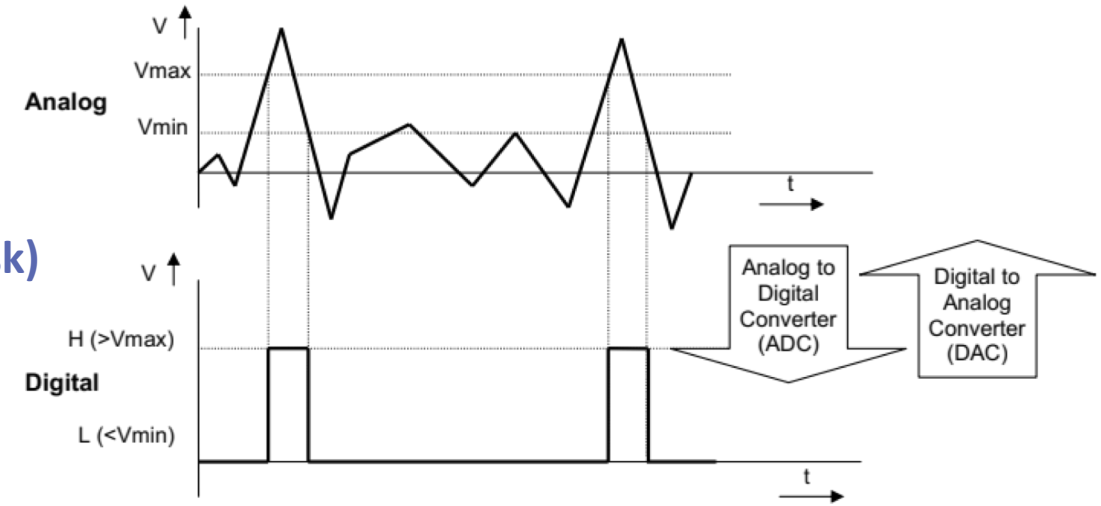
Digital System

- Takes a set of discrete information as inputs
- Takes discrete internal information as system state
- Generates a set of discrete information as outputs



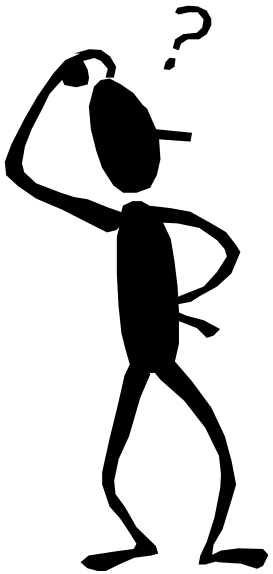
Digital Computer Systems

- Binary values
  - **Digits:** 0,1
  - **Words (symbol):** False (F), True (T)
  - **Words:** Low (L), High (H)
  - **Words:** On, Off
  - **Voltage (CPU)**
  - **Electrical charge (DRAM)**
  - **Magnetic Field Direction (Disk)**
  - **Surface Pits/Lights (CD)**



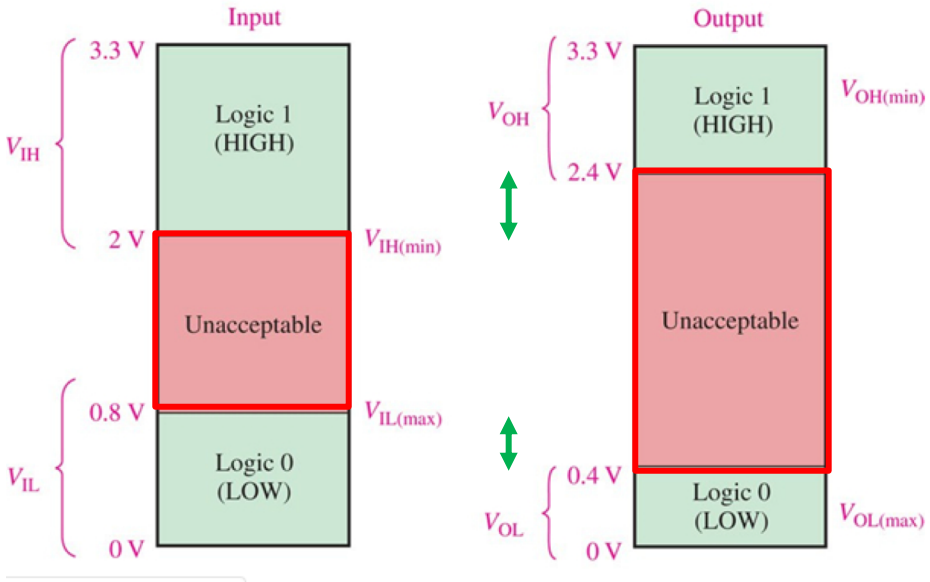
Example of analog and digital representations of human Heart Beat:

Why Digital?



Why Digital?

- High noise immunity
- Better reliability

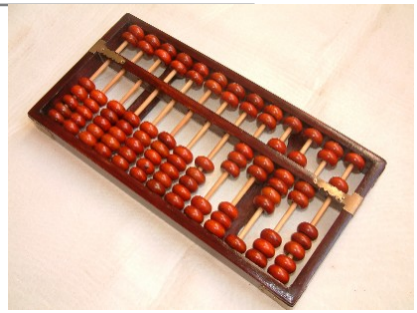


Why Digital?

- Design simplicity
  - No complex mathematics formula and details of physical processes
  - Modular design
- Higher implementation ability
  - Easier implementation, e.g., storage devices
- Programmability
  - Easy to program
- More flexibility
  - Easy to program and modify

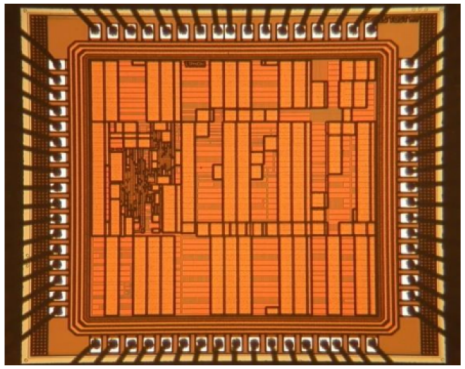
Digital Computer System: Trend

- Non-Electronic Computing Machines



- Electro-Mechanical Computers

- Electronic Computers

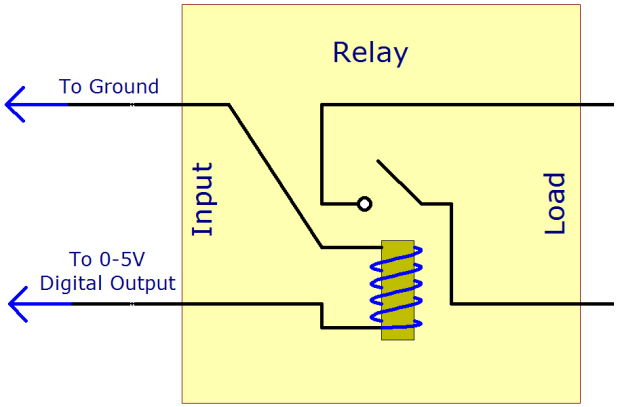


Non-Electronic Computing Machines

- Punch machine
  - Punch cards
  - Presenting digital information by the presence or absence of holes.

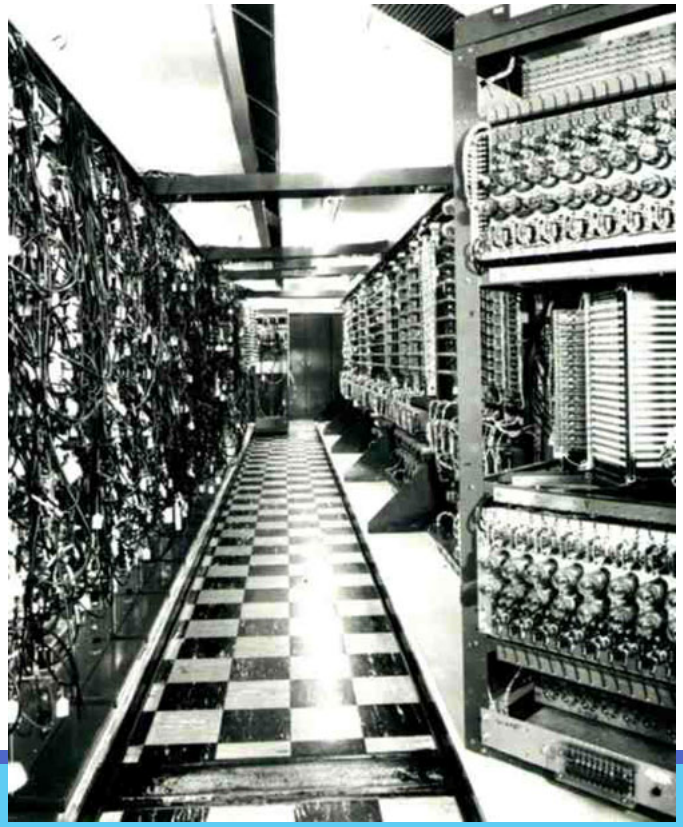
Electro-Mechanical Computers

- Electric switches drove mechanical relays to perform the calculation
- Low operating speed



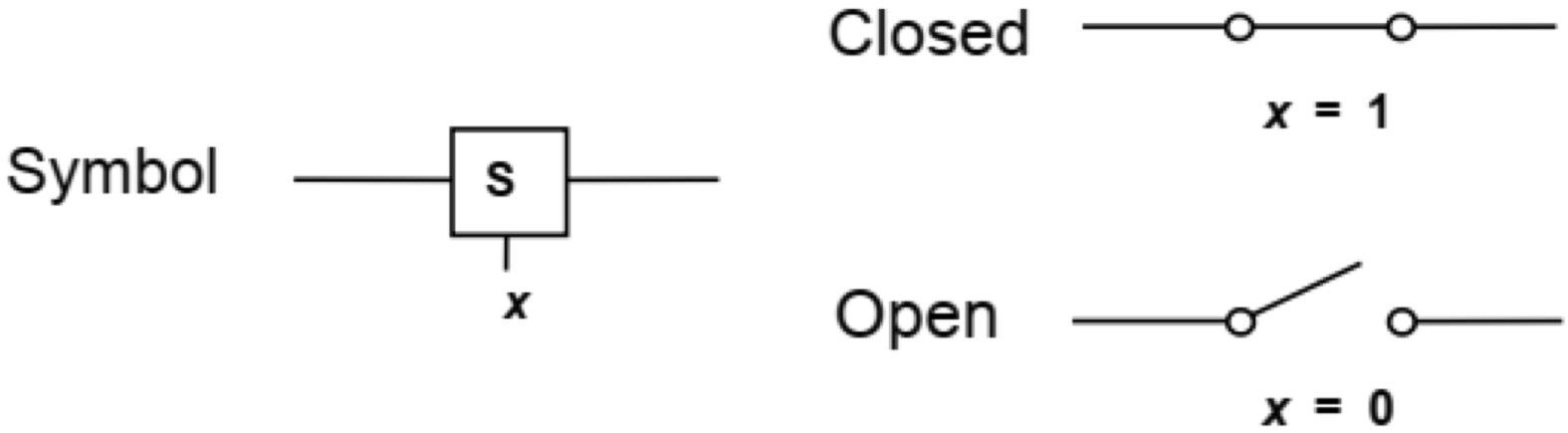
Electronic Computers: 1st Generation

Generation	year	Technology
1st generation	1945-1955	Vacuum tubes



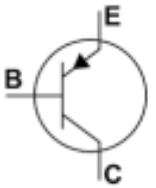
Electronic Computers: 2nd Generation

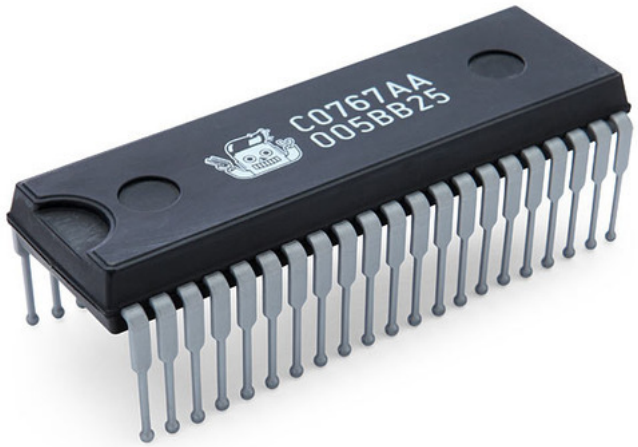
Generation	year	Technology
1st generation	1945-1955	Vacuum tubes
2nd generation	1955-1965	BJT transistors



Electronic Computers: 3rd Generation

Generation	year	Technology
1st generation	1945-1955	Vacuum tubes
2nd generation	1955-1965	BJT transistors
3rd generation	1965-1974	Integrated Circuits

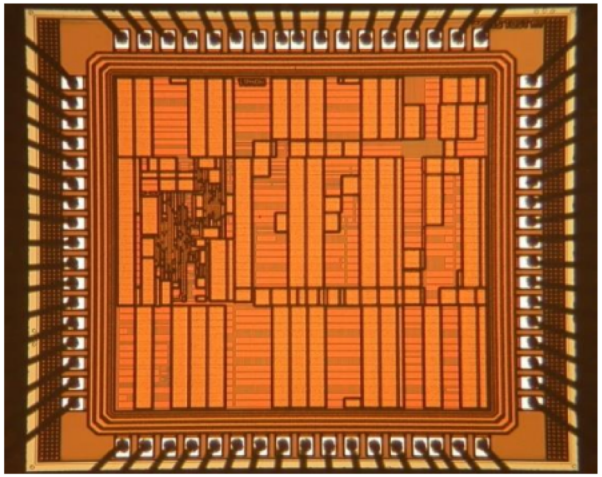




Integrated Circuits (ICs)

- A collection of gates fabricated on a single silicon chip
  - Many Applications
  - Low power
  - Small area
  - High speed

Discrete Circuits

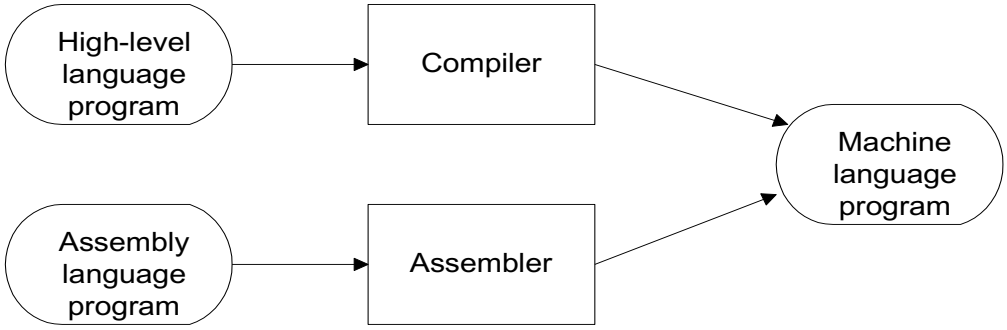


Integrated Circuits

Computer Organization

Software

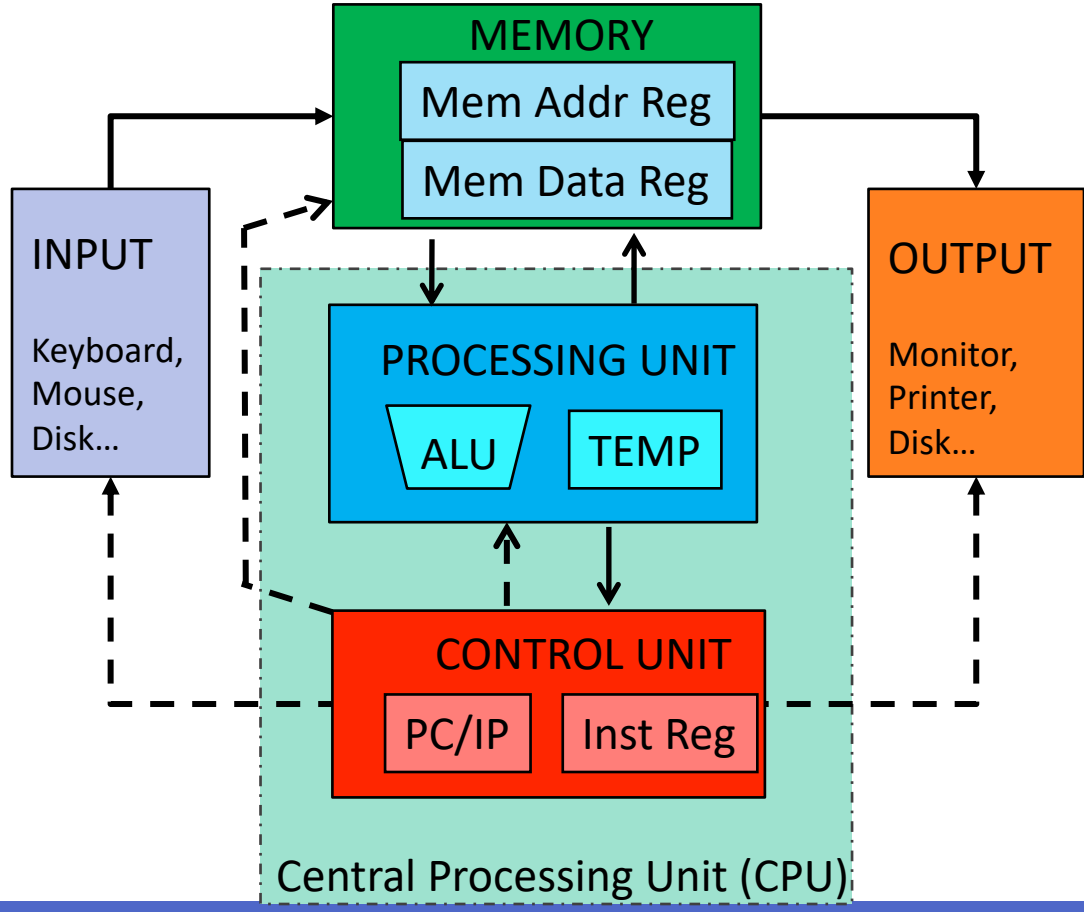
- Programming
  - Process of designing a list of instructions
- Application programs
  - Word processor, drawing programs, inventory management programs,…
- System programs
  - Operating systems, language translation programs, utility programs, performance monitoring programs, ….



Translation of computer programs into machine language

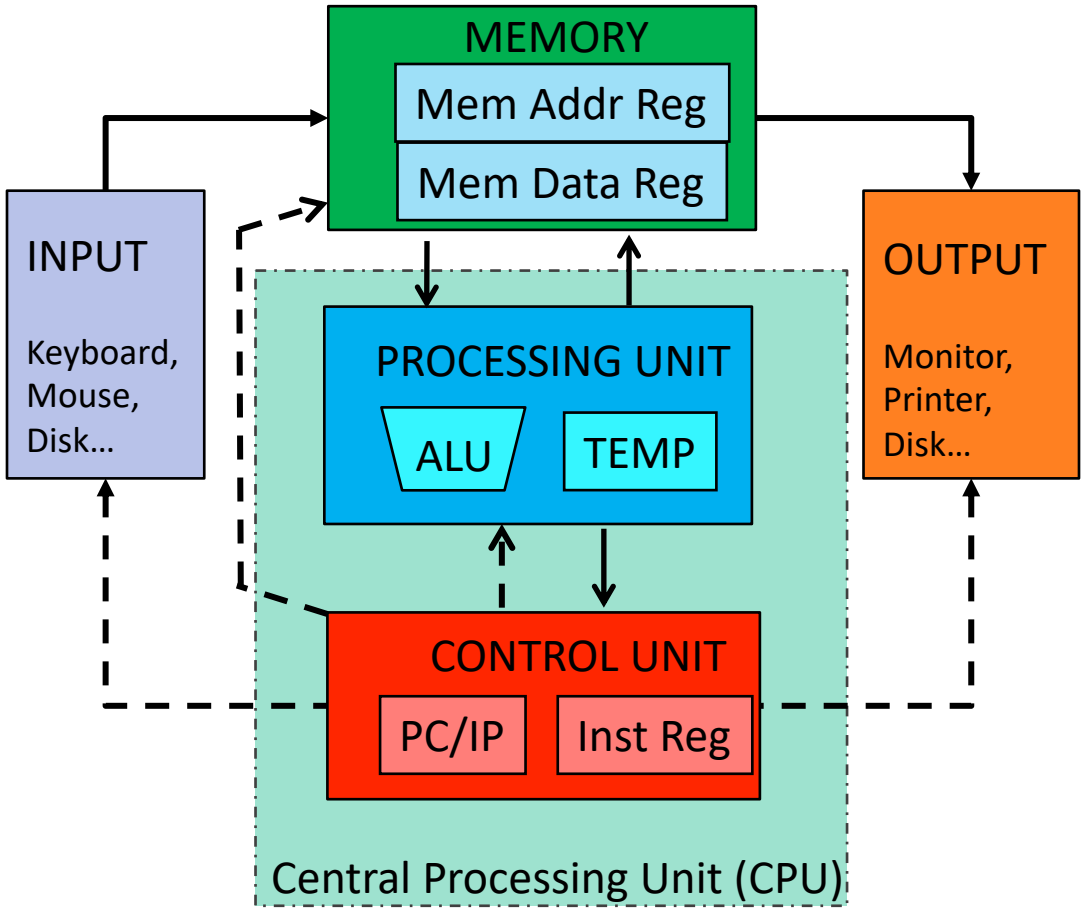
Hardware

- Computer organization
- Microarchitecture
  - Datapath connections
  - Placement of functional units
  - Pipeline configuration
  - Cache configuration



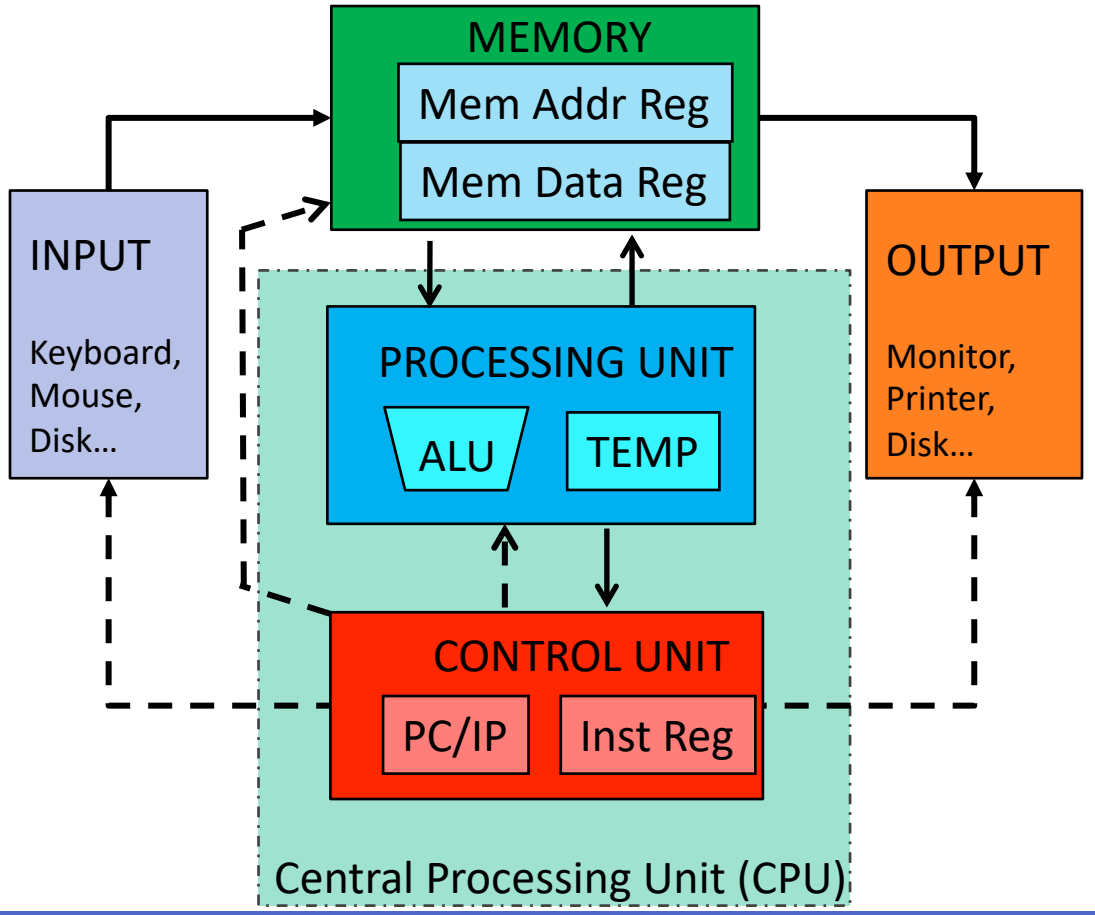
Processing Unit

- Arithmetic/logic unit (ALU)
  - Performs various operations



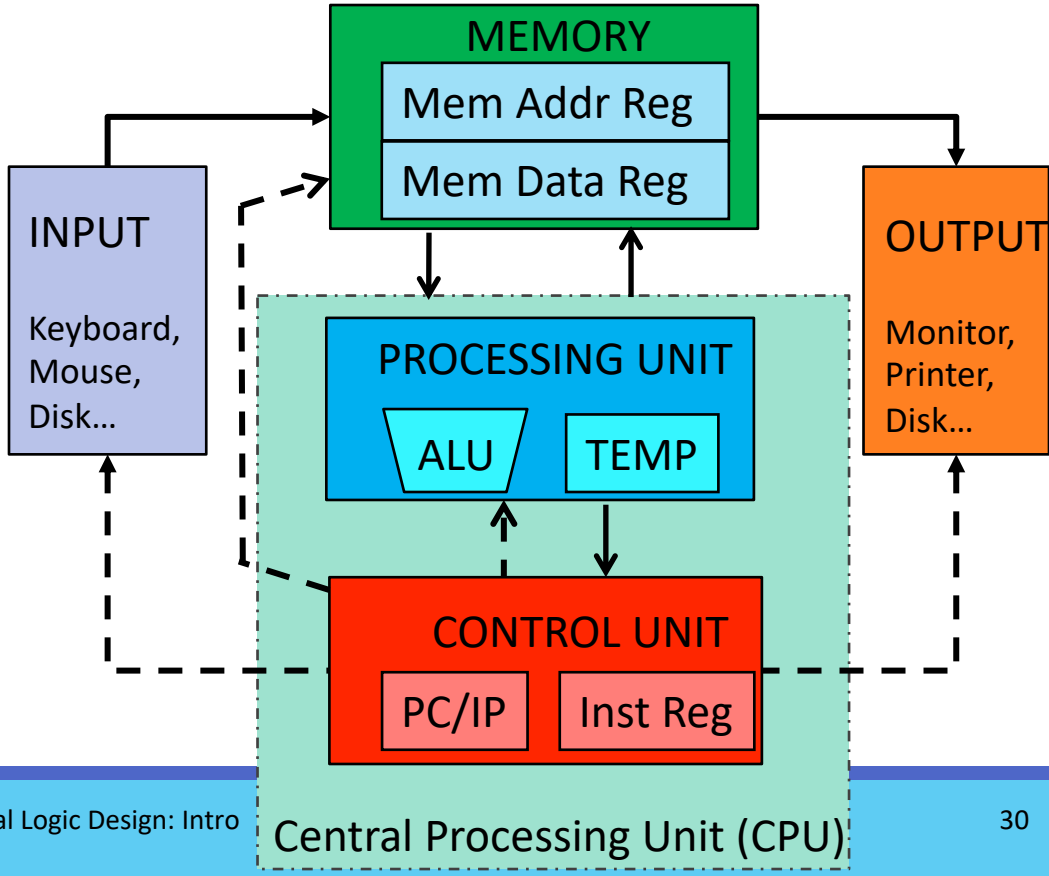
Memory

- Stores programs
- Store input data
- Store output data
- Store intermediate data



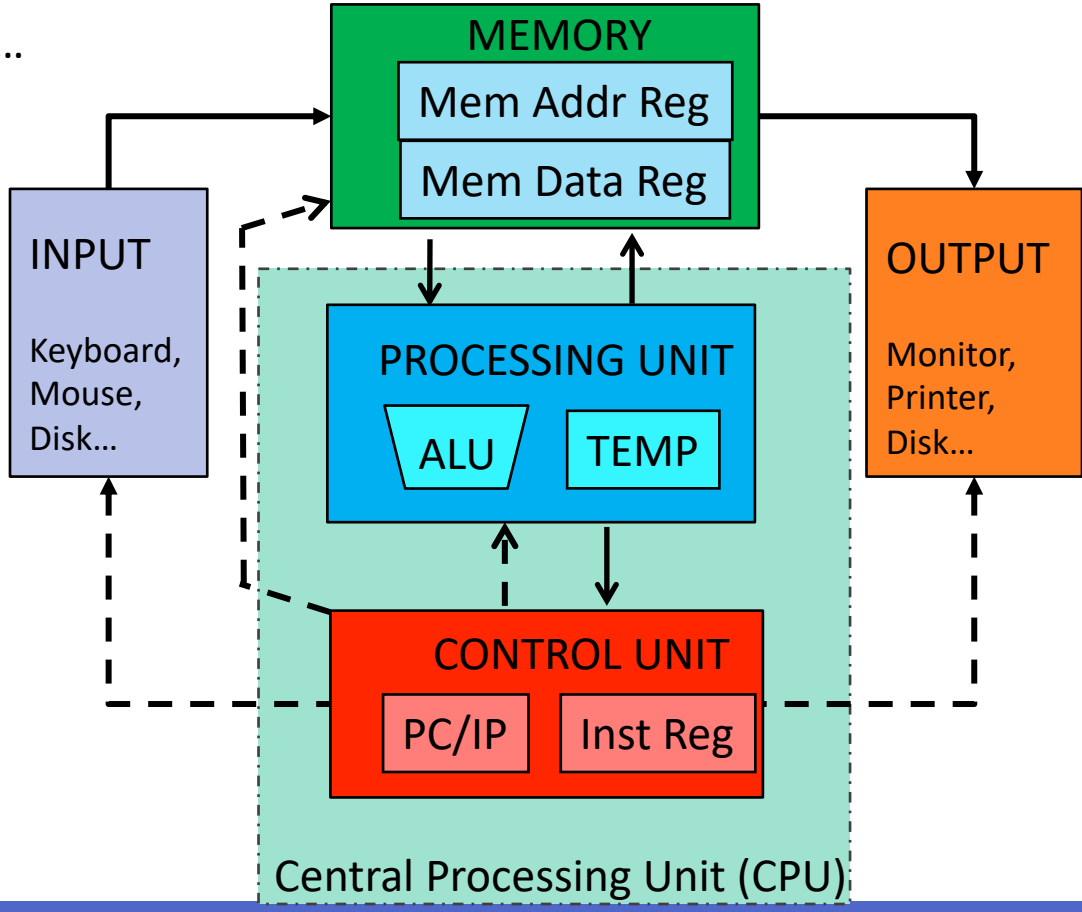
Control Unit

- Control unit (CU)
  - Follows the stored list of instructions
  - Supervises the flow of information among other components



Input / Output

- I/O devices
  - Printers, monitors, keyboard, …

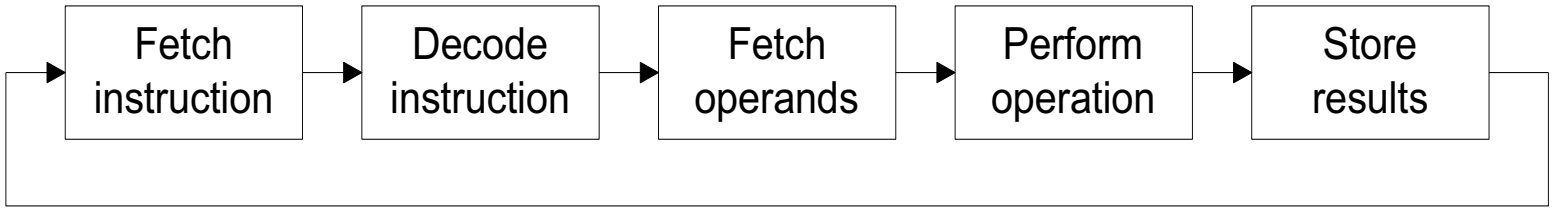


Information Representation

- Numeric data
  - Binary number system
- Numeric input/output codes
  - ASCII
- Instruction codes
  - Operation code and memory addresses of operands and result

Instruction Cycle

- Fetch the next instruction into the control unit
- Decode the instruction
- Fetch the operands from memory or input devices
- Perform the operation
- Store the results in the memory/ send the results to an output device



Instruction cycle of a stored program computer.

Thank You