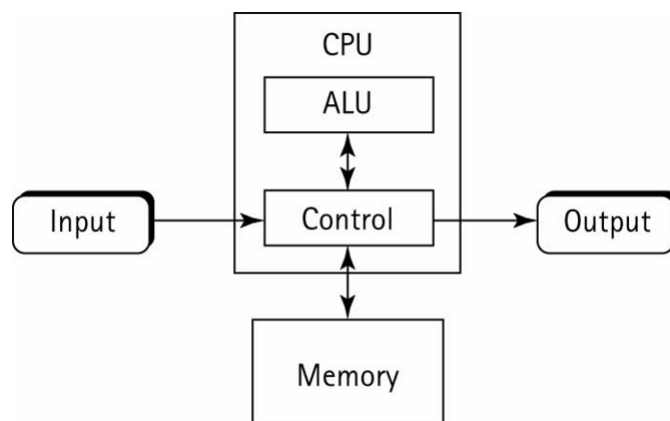


## Bits and Data Storage

## Basic Hardware Units of a Computer



## Bits and Bit Patterns

- **Bit:** Binary Digit (0 or 1)
- Bit Patterns are used to represent information.
  - Numbers
  - Text characters
  - Images
  - Sound
  - And others

## Boolean Operations

- **Boolean Operation:** An operation that manipulates one or more true/false values
- Specific operations
  - AND
  - OR
  - XOR (exclusive or)
  - NOT

## The Boolean operations AND, OR, and XOR (exclusive or)

### The AND operation

$$\begin{array}{r} 0 \\ \text{AND } 0 \\ \hline 0 \end{array} \quad \begin{array}{r} 0 \\ \text{AND } 1 \\ \hline 0 \end{array} \quad \begin{array}{r} 1 \\ \text{AND } 0 \\ \hline 0 \end{array} \quad \begin{array}{r} 1 \\ \text{AND } 1 \\ \hline 1 \end{array}$$

### The OR operation

$$\begin{array}{r} 0 \\ \text{OR } 0 \\ \hline 0 \end{array} \quad \begin{array}{r} 0 \\ \text{OR } 1 \\ \hline 1 \end{array} \quad \begin{array}{r} 1 \\ \text{OR } 0 \\ \hline 1 \end{array} \quad \begin{array}{r} 1 \\ \text{OR } 1 \\ \hline 1 \end{array}$$

### The XOR operation

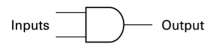
$$\begin{array}{r} 0 \\ \text{XOR } 0 \\ \hline 0 \end{array} \quad \begin{array}{r} 0 \\ \text{XOR } 1 \\ \hline 1 \end{array} \quad \begin{array}{r} 1 \\ \text{XOR } 0 \\ \hline 1 \end{array} \quad \begin{array}{r} 1 \\ \text{XOR } 1 \\ \hline 0 \end{array}$$

## Gates

- **Gate:** A device that computes a Boolean operation
  - Often implemented as (small) electronic circuits
  - Provide the building blocks from which computers are constructed
  - VLSI (Very Large Scale Integration)

A pictorial representation of AND, OR, XOR, and NOT gates as well as their input and output values

**AND**



Inputs	Output
0 0	0
0 1	0
1 0	0
1 1	1

**OR**



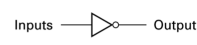
Inputs	Output
0 0	0
0 1	1
1 0	1
1 1	1

**XOR**



Inputs	Output
0 0	0
0 1	1
1 0	1
1 1	0

**NOT**

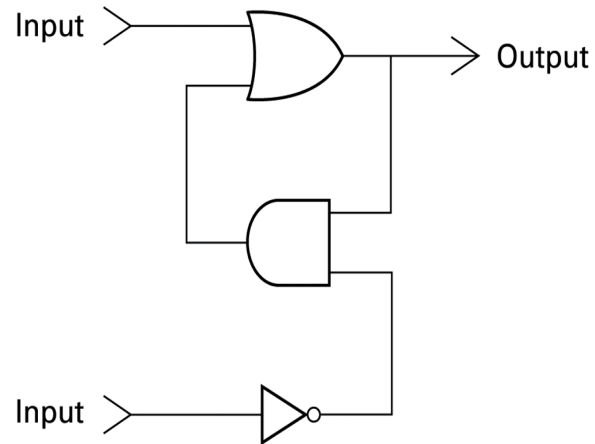


Inputs	Output
0	1
1	0

## Flip-flops

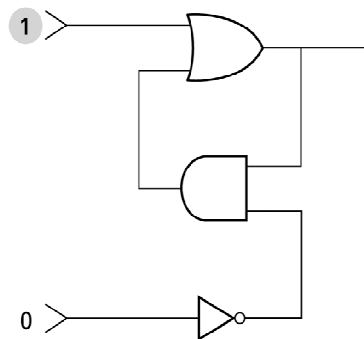
- **Flip-flop:** A circuit built from gates that can store one bit.
  - One input line is used to set its stored value to 1
  - One input line is used to set its stored value to 0
  - While both input lines are 0, the most recently stored value is preserved

### A simple flip-flop circuit



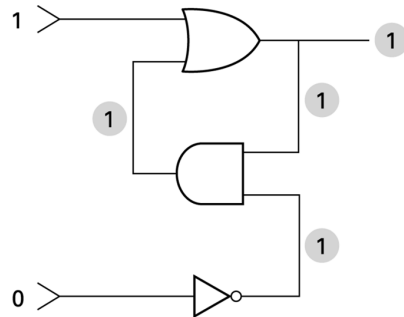
### Setting the output of a flip-flop to 1

a. 1 is placed on the upper input.



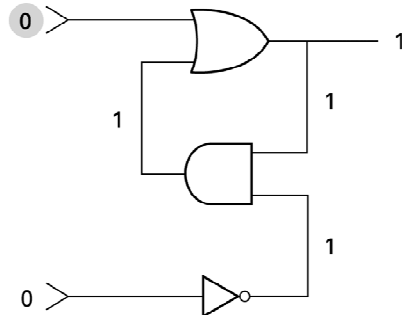
## Setting the output of a flip-flop to 1 (continued)

b. This causes the output of the OR gate to be 1 and, in turn, the output of the AND gate to be 1.

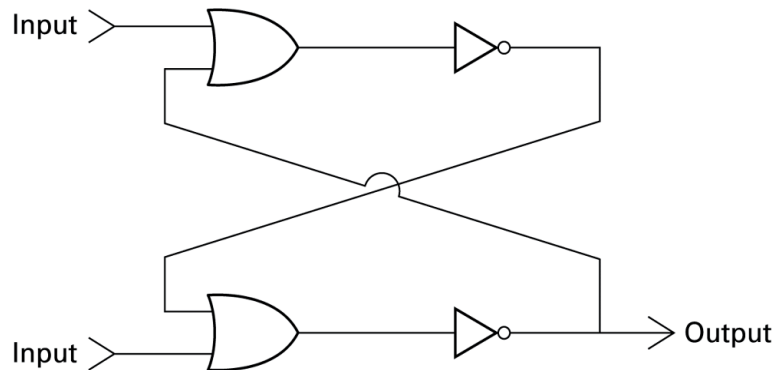


## Setting the output of a flip-flop to 1 (continued)

c. The 1 from the AND gate keeps the OR gate from changing after the upper input returns to 0.



## Another way of constructing a flip-flop



\*\* Usually abstracted out as a box that stores a bit \*\*

## Main Memory Cells

- **Cell:** A unit of main memory (typically 8 bits which is one **byte**)
  - **Most significant bit:** the bit at the left (high-order) end of the conceptual row of bits in a memory cell
  - **Least significant bit:** the bit at the right (low-order) end of the conceptual row of bits in a memory cell





## Memory Terminology

- **Random Access Memory (RAM):** Memory in which individual cells can be easily accessed in any order
- **Dynamic Memory (DRAM):** RAM composed of volatile memory (usually when referring to RAM we mean DRAM)
- **Read Only Memory (ROM) :** RAM that cannot store new values; limited to pre-stored data

## Measuring Memory Capacity

- **Kilobyte:**  $2^{10}$  bytes = 1024 bytes
  - Example: 3 KB = 3 times 1024 bytes
- **Megabyte:**  $2^{20}$  bytes = 1,048,576 bytes
  - Example: 3 MB = 3 times 1,048,576 bytes
- **Gigabyte:**  $2^{30}$  bytes = 1,073,741,824 bytes
  - Example: 3 GB = 3 times 1,073,741,824 bytes

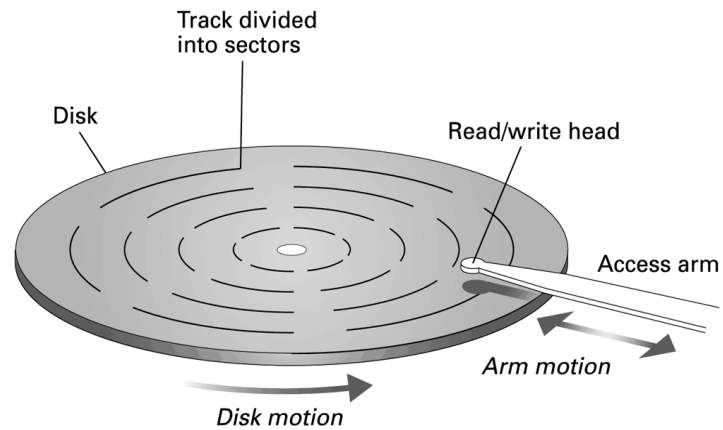
## Mass Storage

- On-line versus off-line
- Typically larger than main memory
- Typically less volatile than main memory
- Typically slower than main memory

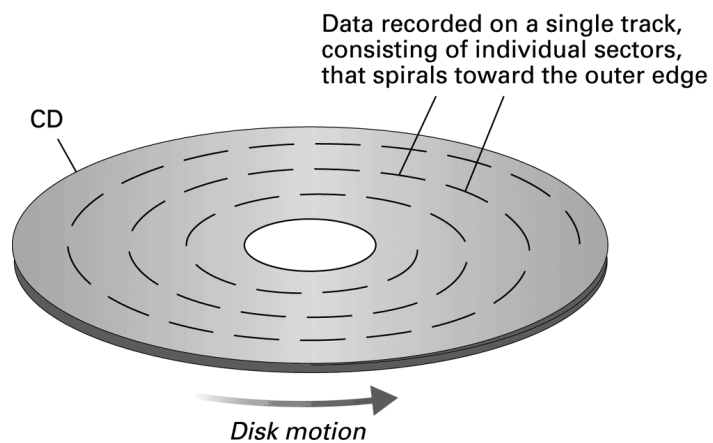
## Mass Storage Systems

- Magnetic Systems
  - Disk
  - Tape
- Optical Systems
  - CD
  - DVD
- Flash Drives

## A magnetic disk storage system



## CD storage



## Files

- **File:** A unit of data stored in mass storage system
  - **Fields** and **keyfields**
- Physical record versus Logical record
- **Buffer:** A memory area used for the temporary storage of data (usually as a step in transferring the data)