



**Faculty Of Computers and Information  
Mansoura University**



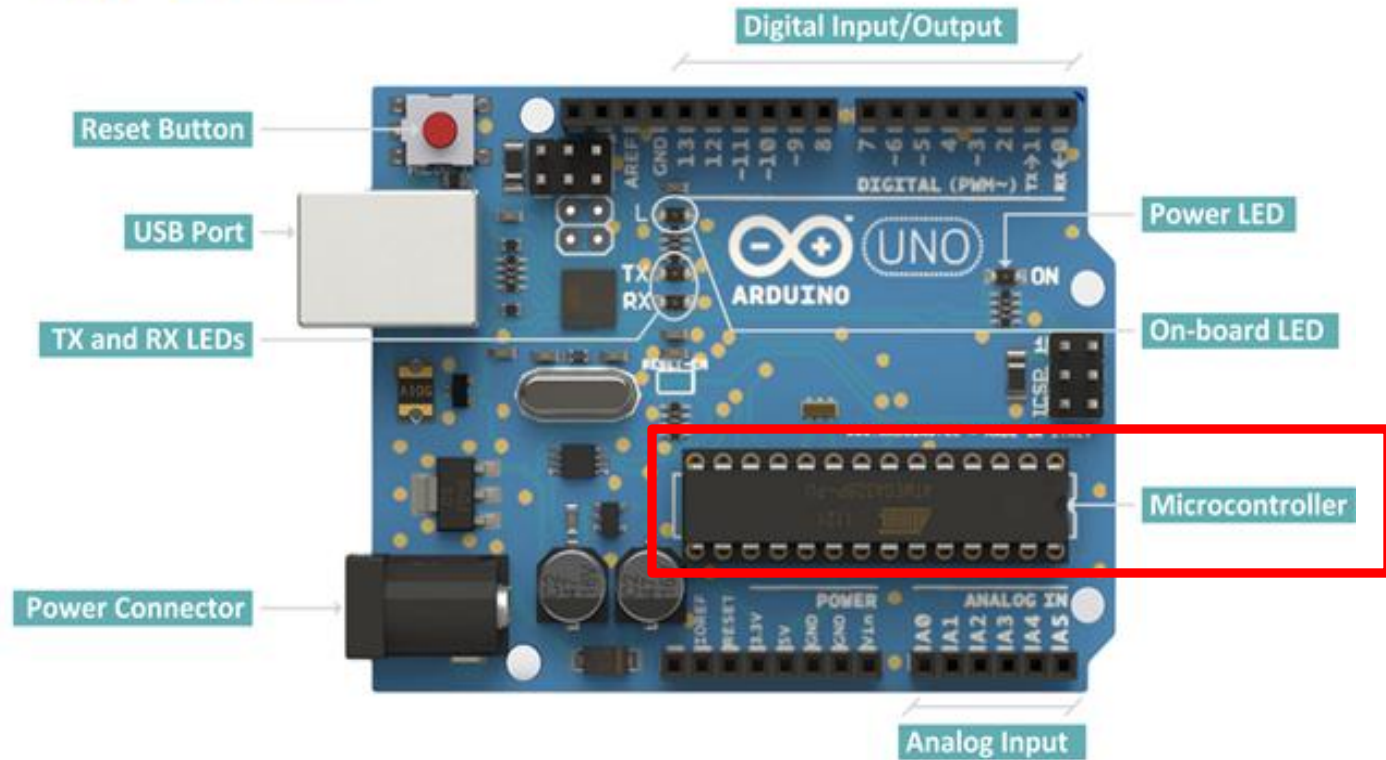
# **Hardware of Real-time Systems**

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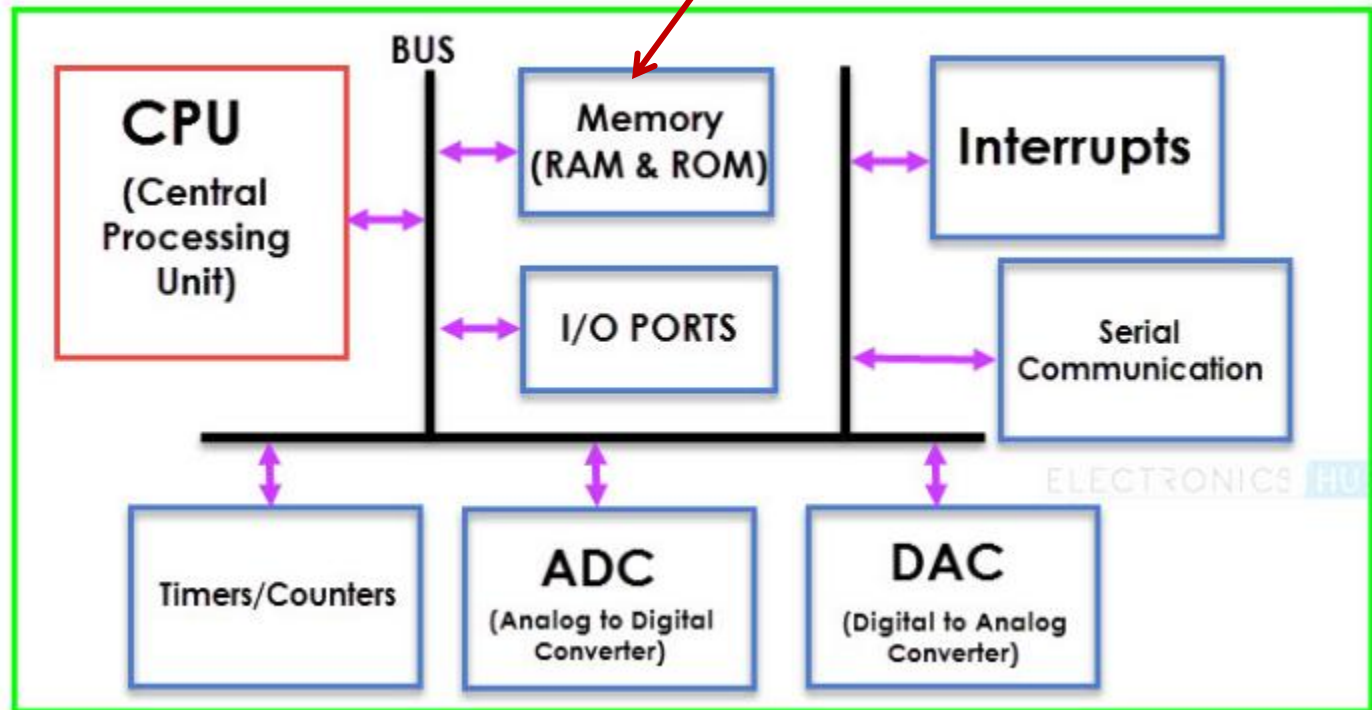
# “ ARDUINO UNO “



# Microcontroller

A Microcontroller is a **VLSI** Integrated Circuit (IC) that contains electronic computing unit and logic unit (**CPU**), **Memory** (Program Memory and Data Memory), **I/O Ports** (Input / Output Ports) and few other components integrated on a single chip.

Program = Set of Instructions



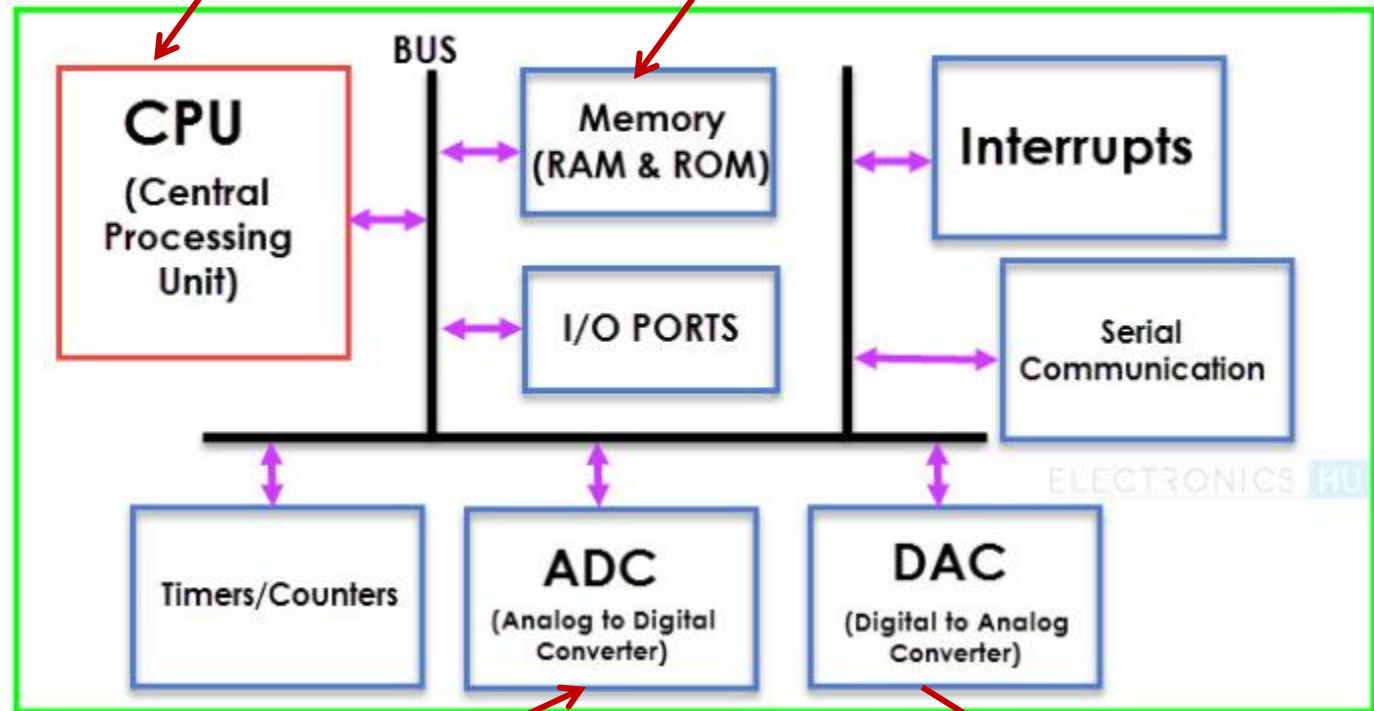
Instructions need some data



# Microcontroller

Instructions Execution Unit

Program = Set of Instructions



Sensors

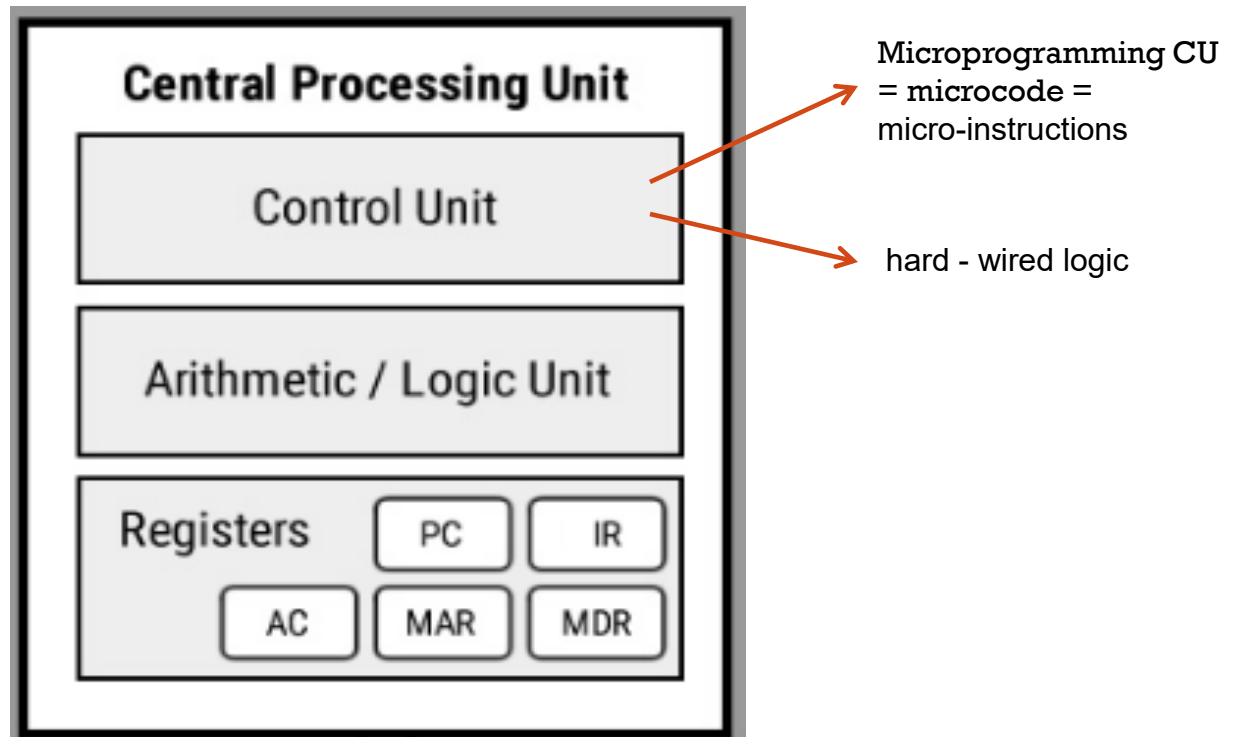
Actuators

Input data

Output data



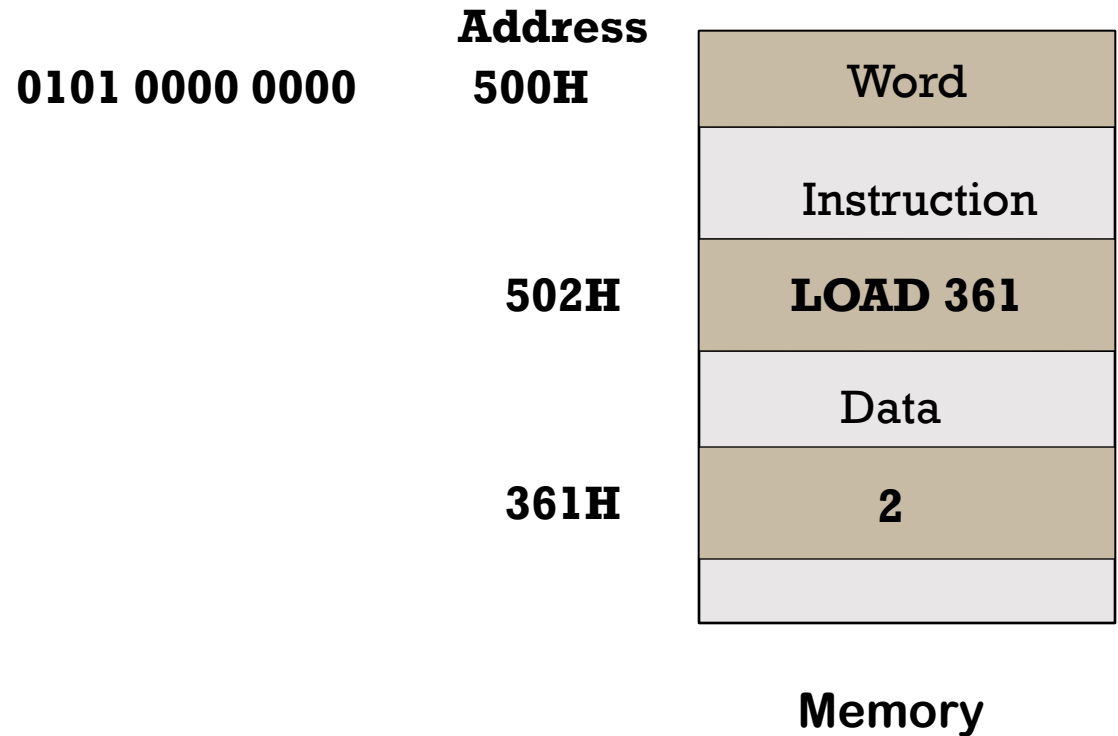
## You need to know some basic concepts !



**Note:** each register has a size in bits, and the number and size of registers are varying among different processors architectures.



# YOU NEED TO KNOW SOME BASIC CONCEPTS!



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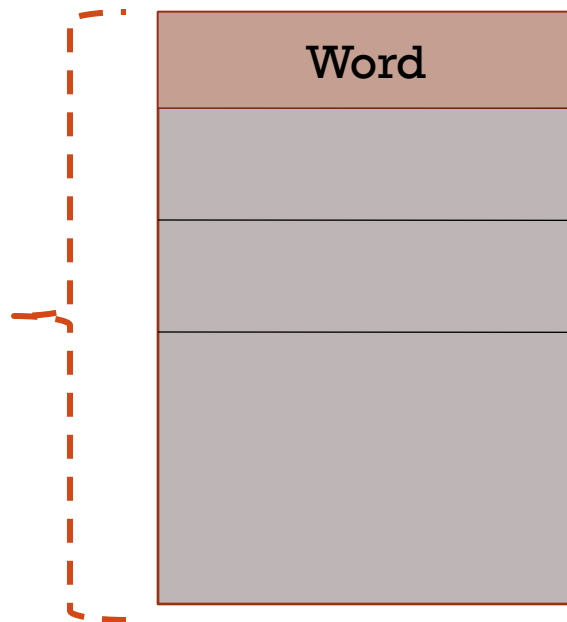
0000 0000 0000 0000	0000	
0000 0000 0000 0001	0001	
0000 0000 0000 0010	0002	
0000 0000 0000 0011	0003	
0000 0000 0000 0100	0004	
0000 0000 0000 0101	0005	
...		
0000 0000 0100 1001	0049	
0000 0000 0100 1010	004A	
0000 0000 0100 1011	004B	
...		
1111 1111 1111 1111	FFFF	
<b>Binary</b>	<b>Hex</b>	<b>Memory</b>
<b>Address</b>		<b>Bytes</b>

Figure 1.2: Memory and Addresses

0xFFFFFFFF	1000 0000
	.....
	.....
0x00000008	0100 1001
0x00000007	1100 1100
0x00000006	0110 1110
0x00000005	0110 1110
0x00000004	0000 0000
0x00000003	0110 1011
0x00000002	0101 0001
0x00000001	1100 1001
0x00000000	0100 1111
<b>Main Memory</b>	



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**Memory  
( 1MB)**

## **Size in bits**

$$\text{memory size in words} = \frac{\text{memory size in bits}}{\text{word size}}$$

$$\text{memory size in words} = \frac{2^{10} \times 2^{10} \times 2^3}{2^3} = 2^{20} \text{ words}$$

$$\# \text{ bits for address} = 2^{\text{20}} \text{ words} = 20 \text{ bits}$$

**Memory size in words**





# YOU NEED TO KNOW SOME BASIC CONCEPTS!



**Memory  
( 1MB)**

0001 0001 0010 0010 1111

0x1122F

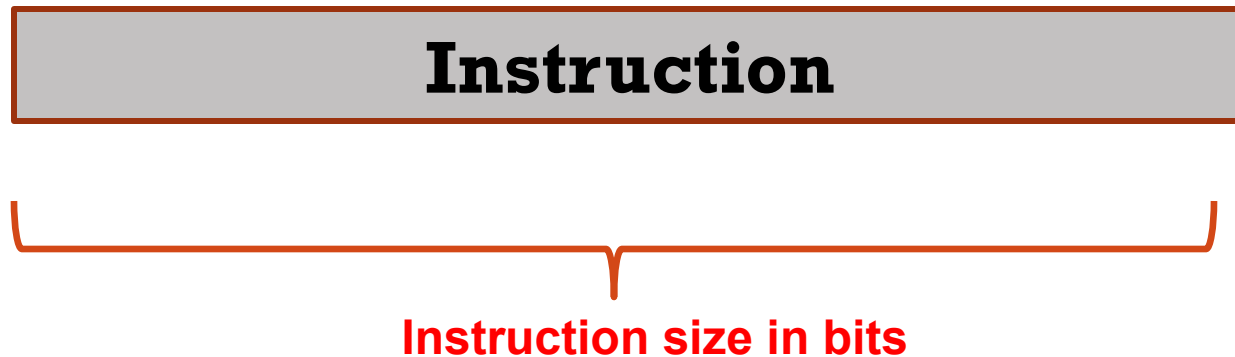
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$$\# \text{ bits for address} = 2^{20} \text{ words} = 20 \text{ bits}$$



**You need to know some basic concepts !**



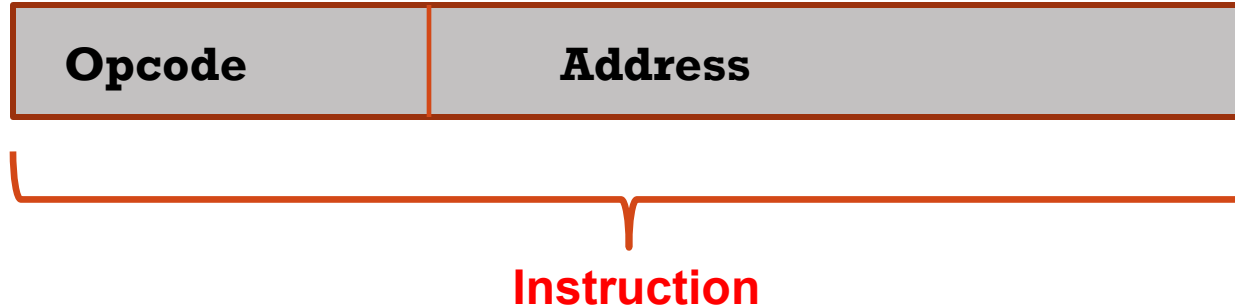
**Example:**

**LOAD 361H = 1010 0011 0110 0001**

**Note:** each family of processors has its own set of instructions for handling various operations.



**You need to know some basic concepts!**



**Example:**

LOAD 361H = 1010 0011 0110 0001

How many operations supported by this microprocessor?

What is the maximum memory size can be addressed by this microprocessor?



## Q

- A. Consider a hypothetical 8-bit microprocessor (word size = 8bits) having 16-bit instructions composed of two fields: the first byte contains the operation code and the remainder is the operand address. [4 Marks]
1. What is the instruction size in bits?
  2. What is the operand address size in bits?
  3. What is the maximum directly addressable memory capacity (in words)?
  4. How many numbers of instructions that word contains?

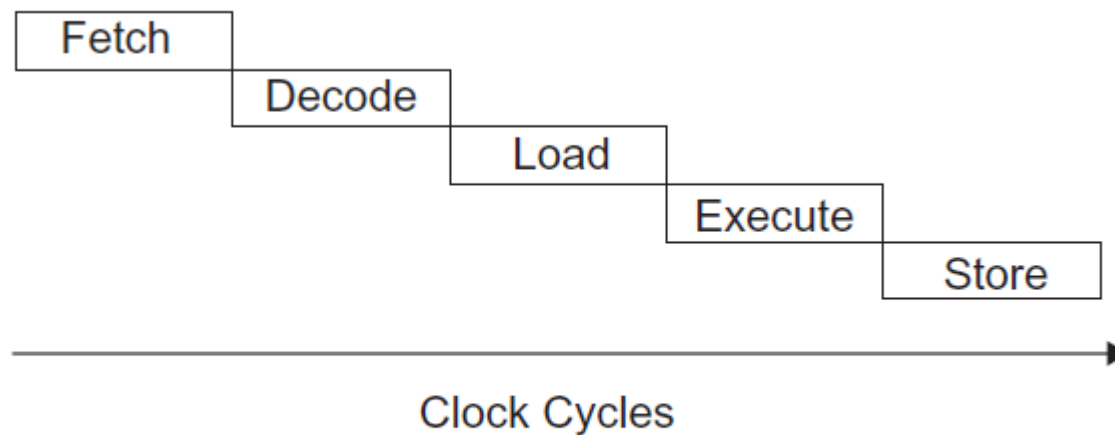


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			register-direct mode
Instruction with one address operand	→ 1	INC R1	}
Instruction with two addresses	→ 2	ADD R1, R2	
Instruction with three addresses	→ 3	SUB R1, R2, R3	
Instruction with zero address	→ 4	PUSH	
Instruction with register-indirect addressing mode	→ 5	ADD R1, [R2]	
Instruction with direct addressing mode	→ 6	INC [1234H]	
Instruction with immediate addressing mode	→ 7	ADD R1, 5	



**You need to know some basic concepts!**

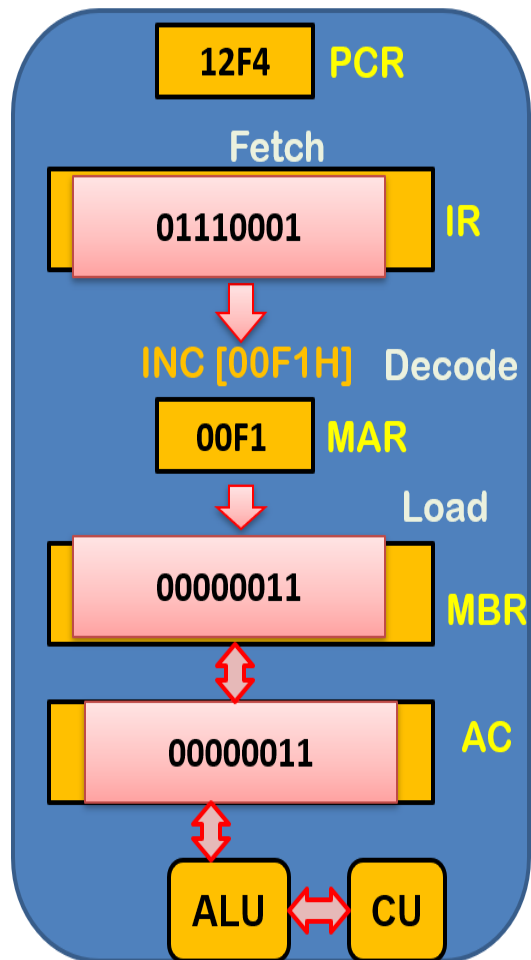


**Figure 2.3.** Sequential instruction cycle with five phases.

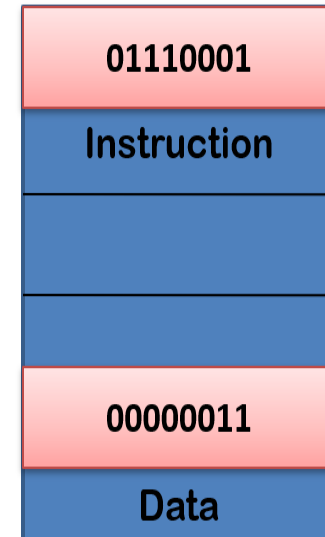


## You need to know some basic concepts!

CPU



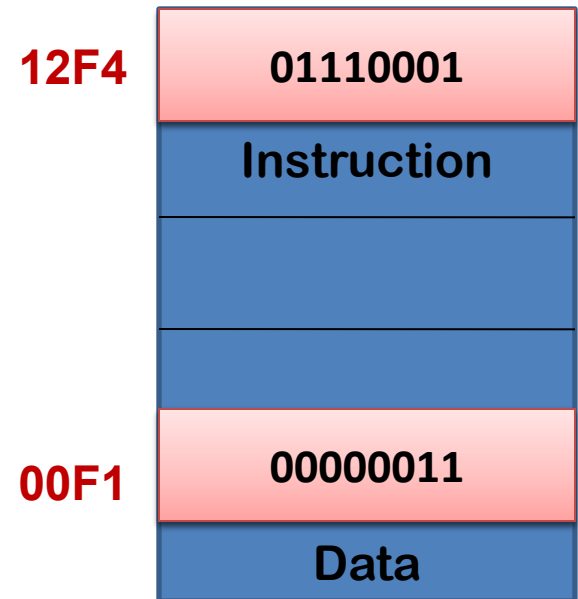
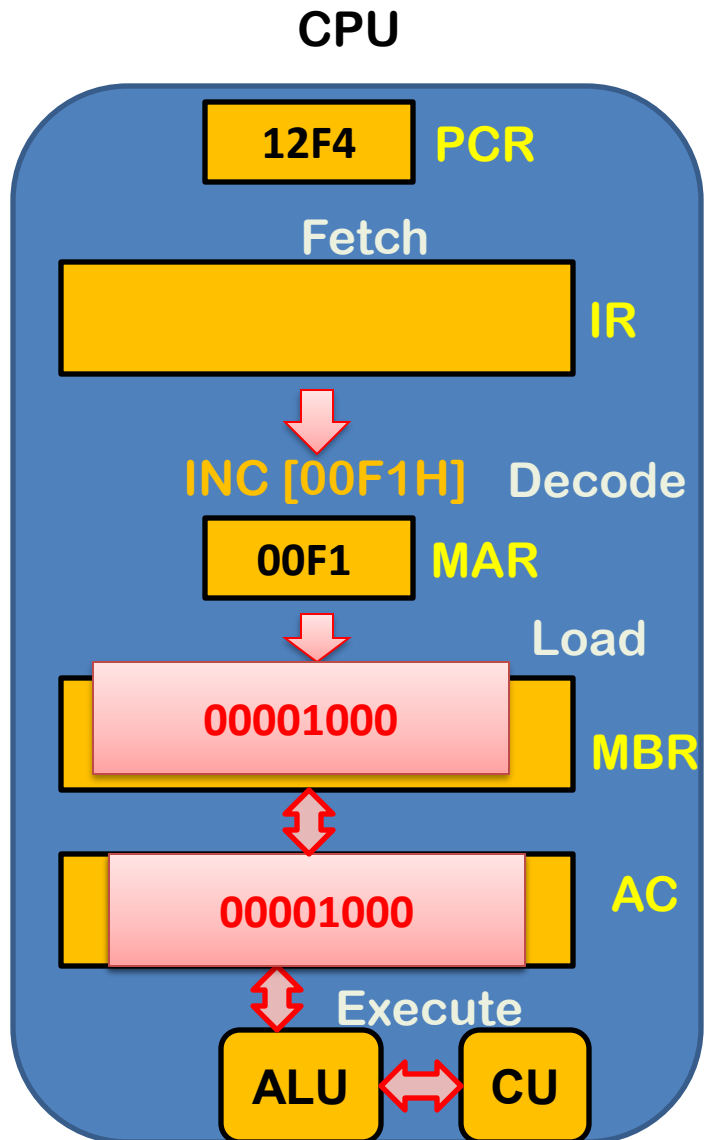
12F4



00F1

Memory

# You need to know some basic concepts!



**Memory**



# You need to know some basic concepts!

