COMPS266F
Computer Architecture

TUTORIAL 0 : FUNDAMENTAL KNOWLEDGE IN COMPUTER ARCHITECTURE

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Section 1

FUNDAMENTAL CONCEPTS OF A COMPUTER

Section 1 :
Fundamental Concepts of a Computer

- Question 1 :

  According to Von Neumann’s architecture, what are the basic components of a computer?

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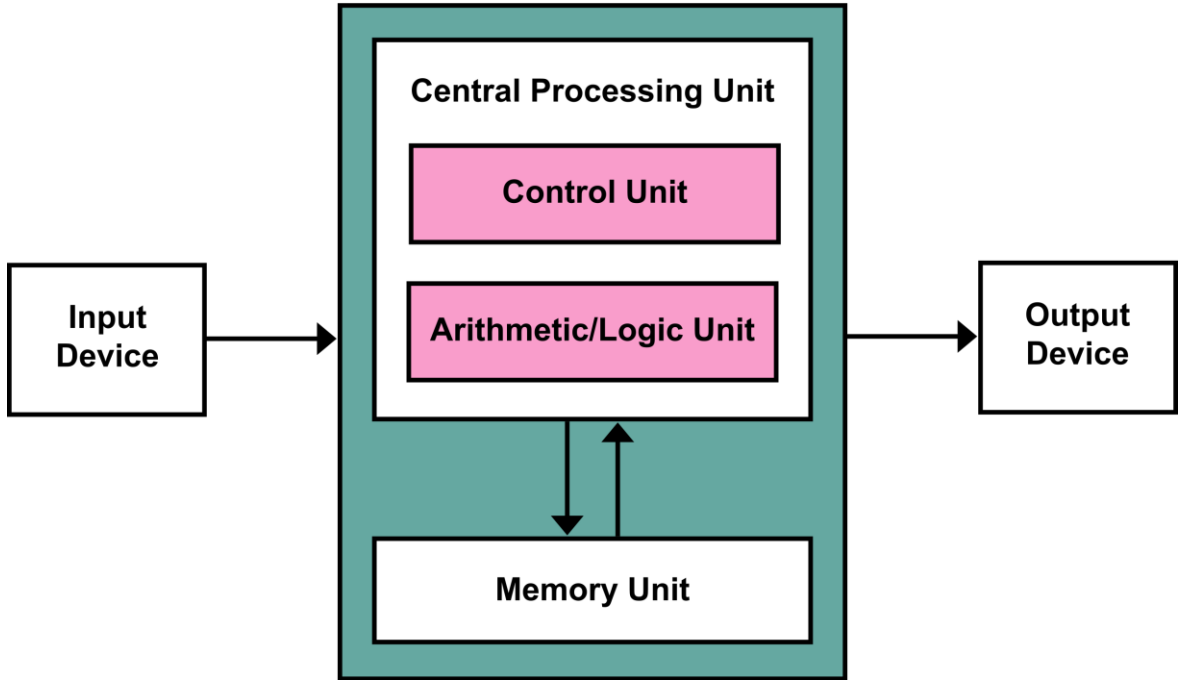
- According to Von Neumann's architecture, basic components of a computer are Central Processing Unit (CPU), memory and Input and Output (I/O).



Section 1 : Fundamental Concepts of a Computer

- Question 2 :

  Central Processing Unit (CPU) is the brain of the computer, it contains several components, what are they?

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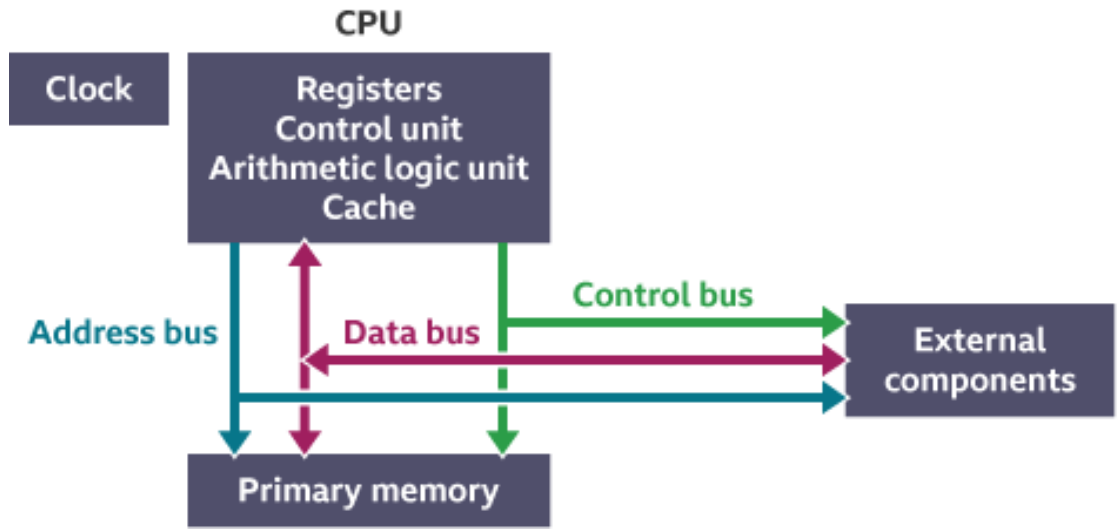
- Question 2 : Central Processing Unit (CPU) is the brain of the computer, it contains several components, what are they?

- They are arithmetic / logic unit (ALU), control unit (CU), registers, cache memory, bus and clock.



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Section 1 :
Fundamental Concepts of a Computer

- Question 3 :

  To perform data transmission, computer applies “energy pulses” to transmit a series of data. In fact, what representation is used in this behavior? How to perform a data transmission?

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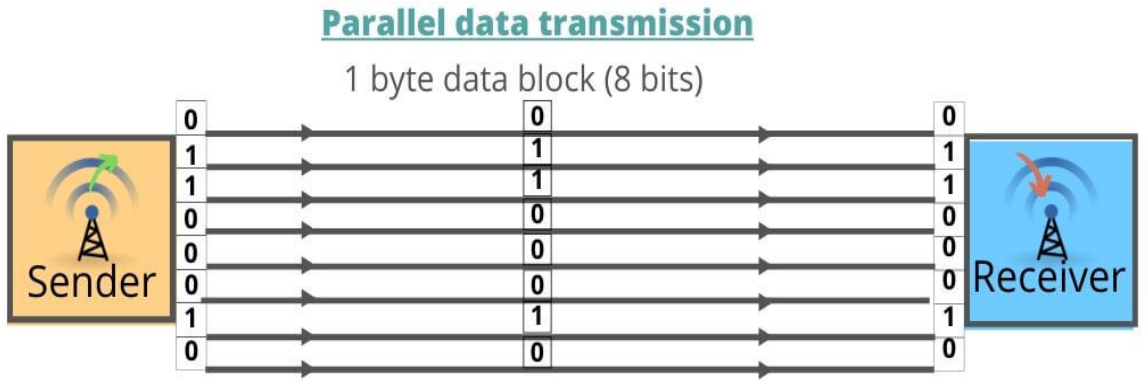
- Binary representation. It applies combinations of “1” as a pulse and “0” as no pulse in a series of cables.



Section 2

DATA REPRESENTATION

Section 2 : Data Representation

- Question 4 :

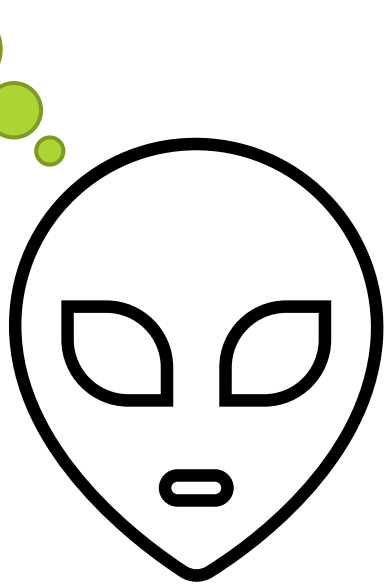
  Binary, octal, decimal and hexadecimal representations are common in computers to represent numeric data. No matter what type of the representation, what is the common factor of these representations? You may use an example to support your conclusion.

Section 2 : Data Representation

- Question 4 : Binary, octal, decimal and hexadecimal representations are common in computers to represent numeric data. No matter what type of the representation, what is the common factor of these representations? You may use an example to support your conclusion.

- The range of a digit must be 0 to the base value -1.
- Examples :
  - In binary representation, the range of each digit must be 0 or 1. (2 – 1 = 1)
  - In octal representation, the range of each digit must be in 0 to 7. (8 – 1 = 7)

9 + 1 = 10 in decimal
1 represents tens (1×10^1)
0 represents units (0×10^0)



Section 2 : Data Representation

- Steps in converting a value to other number systems
  - Remainder Theorem
  - Multiplication Theorem
  - Re-order the binary digits (for octal and hexadecimal)

Section 2 : Data Representation – An Example

Binary	Octal	Decimal	Hexadecimal
23 / 2 = 11 … 1 11 / 2 = 5 … 1 5 / 2 = 2 … 1 2 / 2 = 1 … 0 1 / 2 = 0 … 1 0.5 x 2 = 1.0 --- 1 0.0 x 2 = 0.0 --- 0 $23.5_{10} = 10111.1_2$ $27.4_8 = 010\ 111.100$ $= 1\ 0111.1_2$	23 / 8 = 2 … 7 2 / 8 = 0 … 2 0.5 x 8 = 4.0 --- 4 0.0 x 8 = 0.0 --- 0 $23.5_{10} = 27.4_8$ OR $23.5 = 10111.1_2$ $= 010\ 111.100_2$ $= 27.4_8$	Q : 23.5_{10} $2^4 + 2^2 + 2 + 1 + 2^{-1}$ $= 23.5_{10}$ $2 \times 8 + 7 + 4 \times 8^{-1}$ $=23.5_{10}$ $1 \times 16 + 7 + 8 \times 16^{-1}$ $= 23.5_{10}$	23 / 16 = 1 … 7 1 / 16 = 0 … 1 0.5 x 16 = 8.0 --- 8 0.0 x 16 = 0.0 --- 0 $23.5_{10} = 17.8_{16}$ OR $23.5 = 10111.1_2$ $= 0001\ 0111.1000_2$ $= 17.8_{16}$

Section 2 : Data Representation

- Question 5 : Convert with clear steps of the following values to corresponding numbering systems.
  a) 1101001.1001_2
  b) 275.46_8
  c) 509.125_{10}
  d) $BC.3A_{16}$

Section 2 : Data Representation

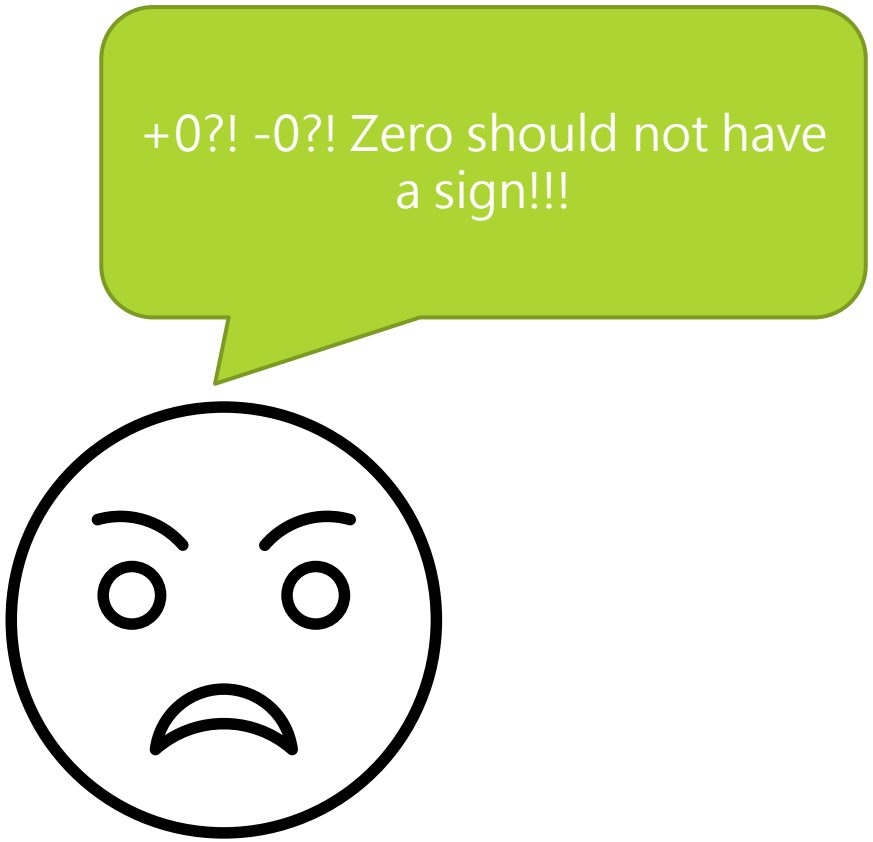
	Binary	Octal	Decimal	Hexadecimal
(a)	1101001.1001	1 101 001.100 100 = 151.44_8	$6 \times 16 + 9 + 9 \times 16^{-1}$ = 105.5625_{10}	0110 1001.1001 =69.9_{16}
(b)	010 111 101. 100 110 =1011 1101.10011_2	275.46	$2 \times 8^2 + 7 \times 8 + 5 +$ $4 \times 8^{-1} + 6 \times 8^{-2}$ =189.59375_{10}	1011 1101.1001 1000 =$BD.98_{16}$
(c)	509 / 2 = 254 … 1 254 / 2 = 127 … 0 127 / 2 = 63 … 1 63 / 2 = 31 … 1 31 / 2 = 15 … 1 15 / 2 = 7 … 1 7 / 2 = 3 … 1 3 / 2 = 1 … 1 1 / 2 = 0 … 1 0.125 x 2 = 0.25 --- 0 0.25 x 2 = 0.5 --- 0 0.5 x 2 = 1.0 --- 1 0.0 x 2 = 0.0 --- 0 509.125_{10} =111111101.001_2	111 111 101.001 =775.1_8	509.125	509 / 16 = 31 … 13 (D) 31 / 16 = 1 … 15 (F) 1 / 16 = 0 … 1 0.125 x 16 = 2.0 --- 2 0.0 x 16 = 0.0 --- 0 509.125_{10} = $1FD.2_{16}$
(d)	B = 1011 C = 1100 3 = 0011 A = 1010 BC.3A = 10111100.00111010_2	010 111 100 = 274 001 110 100 = 164 $BC.3A_{16}$ = 274.164_8	11 x 16 + 12 + 3/16 + 10/256 =188.2265625_{10}	BC.3A

Section 2 : Data Representation

- Question 6 :

  Binary number cannot represent negative value in general. Scientists applied sign magnitude, 1's and 2's complements methods to assign binary numbers to negative values. 2's complement is the most efficient way in representing negative values. What is the main issue of sign magnitude and 1's complement in terms of the value zero (0) with examples?

Section 2 : Data Representation



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- In sign magnitude and 1's complement, in representing the value zero (0), the binary representation contains "positive" and "negative" 0. For example, in 3-bits sign magnitude to represent the 0, it contains 000 (+0) and 100 (-0). Also, in 3-bits 1's complement, there are +0 (000) and -0 (111) that represent the 0 that they are unreliable and waste memory.

Section 3

LITTLE MAN COMPUTER (LMC)

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- Question 7 :

  Little Man Computer (LMC) simulate processes operated in CPU. You should able to understand the purpose of LMC programs. Study the LMC program and describe the purpose of the program. Assume only positive values can be entered by user.

Program Counter	Instruction	Program Counter	Instruction
00	IN	05	BRP 09
01	STO 90	06	LDA 90
02	IN	07	SUB 91
03	STO 91	08	OUT
04	SUB 90	09	HLT

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- Calculate the positive difference of two inputted values.

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- Question 8 :

  Write an LMC program to read in two positive numbers X and Y then calculate and return the sum of them.

Input		Output
X	Y	X + Y
0	0	0
1	7	8
8	1	9

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  Write an LMC program to read in two positive numbers X and Y then calculate and return the sum of them.

```
00 IN       - Read in the 1st value
01 STO 90   - Store in cell 90
02 IN       - Read in the 2nd value
03 ADD 90   - Add with the 1st value
04 OUT      - Print the result
05 HLT      - Quit the program

90 DAT      - Reserve for storing value
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