Indian Institute of Information Technology - Vadodara

EL - 101
Digital Logic Design

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Lecture # 2
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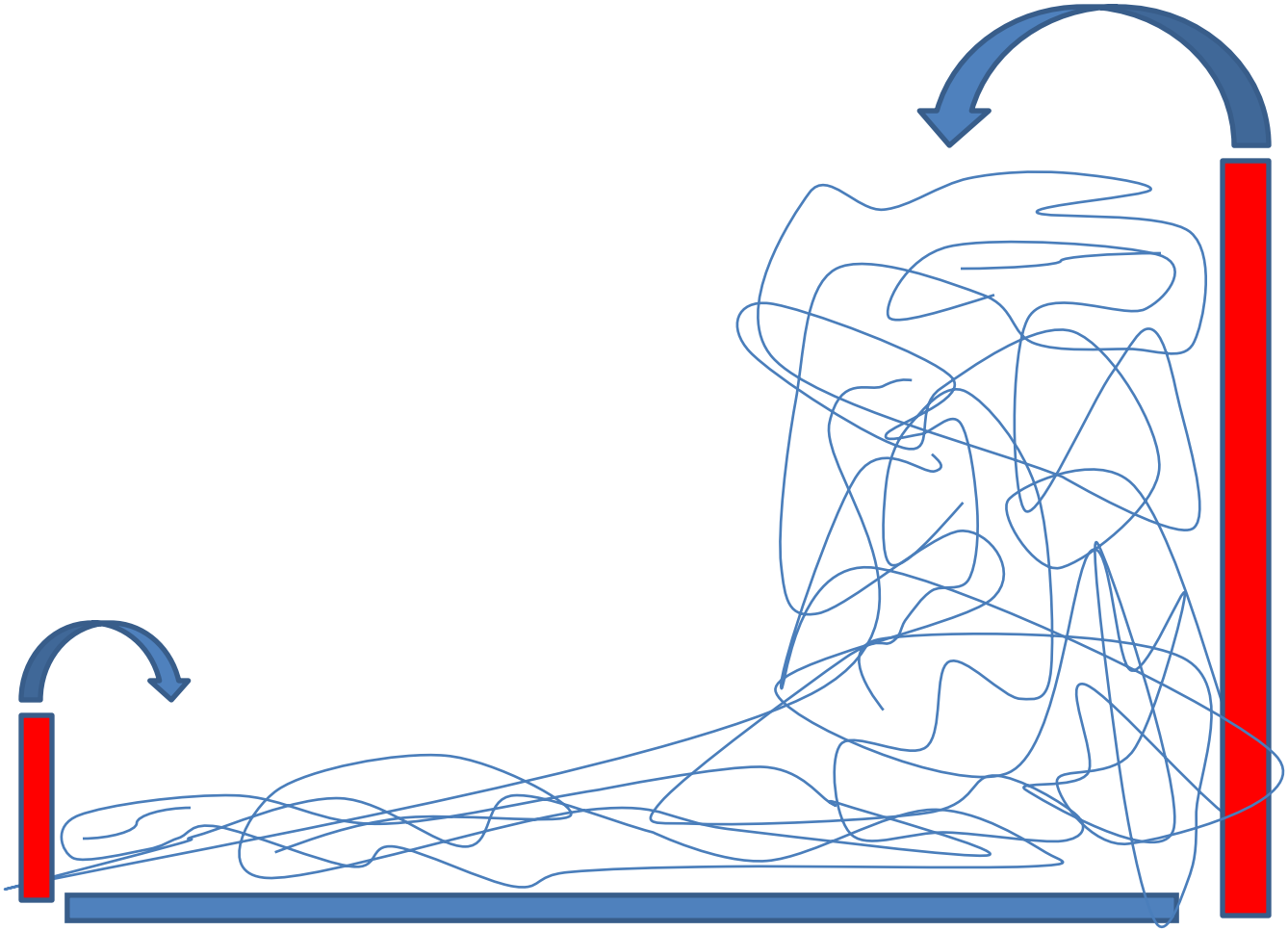
How to learn swimming ?



Number System

- Decimal Number System:
  1. Most commonly used by us.
  2. Ten-valued representation => [0, 9] => coefficients
  3. Coefficients are multiplied with powers of 10.
  4. Hence, it has “base” or “radix” 10.

Example: $7392 = 7x10^3 + 3x10^2 + 9x10^1 + 2x10^0$

Recall that we usually write the coefficients only.

Number System

- Base - *r* number system:

$a_n \cdot r^n + a_{n-1} \cdot r^{n-1} + \ldots + a_2 \cdot r^2 + a_1 \cdot r + \ldots + a_0$

$(.)\ a_{-1} \cdot r^{-1} + a_{-2} \cdot r^{-2} + \ldots + a_{-m} \cdot r^{-m}$

- Coefficients range: [0, *r*-1]

Binary System

- It is a different number system.
- Coefficients => 0 and 1 => *bits.*
- Each coefficients are multiplied by powers of 2.
- And the results are added to get the decimal equivalent number.

Why binary system ?

- The most fundamental system for representation in computers.

- Unanimously used by all the digital machines.

Binary System

- Example:

  $11011 = 1x2^4 + 1x2^3 + 0x2^2 + 1x2^1 + 1x2^0$

  $= 2^4 + 2^3 + 2^1 + 2^0$

  $= 27$

  Ans: $(11011)_2 = (27)_{10}$

- Equivalence relation between two system:

  $(\text{Number})_{\text{base-}a} = (\text{Number})_{\text{base-}b}$

Binary System

- Example:

  $(11011.11)_2 = (?)_{10}$

  Ans:

Arithmetic Operations in Binary System

- Remember:

  Answers should contain with 0s and 1s.

- Binary Addition:
  1. Similar to decimal addition.
  2. 1+0 = 0+1 = 1
  3. 1+1 = 10
  4. 1+1+1 = 11

Binary addition

- Example:

```
augend:        1 0 1 1 0 1
addend:        1 0 0 1 1 1
             + --------------------
sum:         1 0 1 0 1 0 0
```

Binary subtraction

1. similar to decimal rules.
2. except: borrows in a given significant position add “2” to a minuend digit.

Example:

```
minuend:      1 0 1 1 0 1
subtrahend:   1 0 0 1 1 1
            - _____________
difference:   0 0 0 1 1 0
```

Binary multiplication

1. Simplest and similar to decimal rules.
2. A product = either multiplicand or “0”
3. 1 x 1 = 1; 0 x 0 = 0 x 1 = 1 x 0 = 0

Example: multiplicand: 1 0 1 1
multiplier: x 1 0 1
---
1 0 1 1
0 0 0 0
1 0 1 1
---
product: 1 1 0 1 1 1

Other popular number systems in computers

- Octal system:

  - 8 coefficients.

  - coefficients range: [0, 7].

- Example:

  $(123.4)_8 = (?)_{10}$

Other popular number systems in computers

- Hexadecimal system:
  - 16 coefficients.
  - 0 to 9 are as per the decimal system.
  - A to F letters are used for 10 to 15, respectively.

  means:

  A => 10
  B => 11
  C => 12
  D => 13
  E => 14
  F => 15

- Example:

$$(B44B)_{16} = (?)_{10}$$

Usage in computer work

- 8 *bits* = 1 *byte*

  example: 1100 1010 = 1 byte of data

  application: A keyboard character is represented in one byte codeword.

- 2^{10} => K (kilo) bytes
- 2^{20} => M (mega) bytes
- 2^{30} => G (giga) bytes
- 2^{40} => T (tera) bytes

  example: computer hard disk capacity.