Computer Engineering
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Number Systems

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CPE1401 – Digital System Design

https://elchm.ssru.ac.th/pongrapee_ka/

Number systems

- **Base 10** (Decimal)
  Represent any number using 10 digits [0–9]
- **Base 2** (Binary)
  Represent any number using 2 digits [0–1]
- **Base 8** (Octal)
  Represent any number using 8 digits [0–7]
- **Base 16** (Hexadecimal)
  Represent any number using 10 digits and 6 characters [0–9, A, B, C, D, E, F]

Base 10 (Decimal) [0..9]

$$3245 = (3 \times 10^3) + (2 \times 10^2) + (4 \times 10^1) + (5 \times 10^0)$$

$$= (3 \times 1000) + (2 \times 100) + (4 \times 10) + (5 \times 1)$$

$$= (3000) + (200) + (40) + (5)$$

$$= 3245$$

Remark: 3245 can be written as 3245_{10}

Attempt a quiz

Quiz **2A**, Page **1**, Question **1**

Base 2 (Binary) [0..1]

$$1010_2 = (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (0 \times 2^0)$$

$$= (1 \times 8) + (0 \times 4) + (1 \times 2) + (0 \times 1)$$

$$= (8) + (0) + (2) + (0)$$

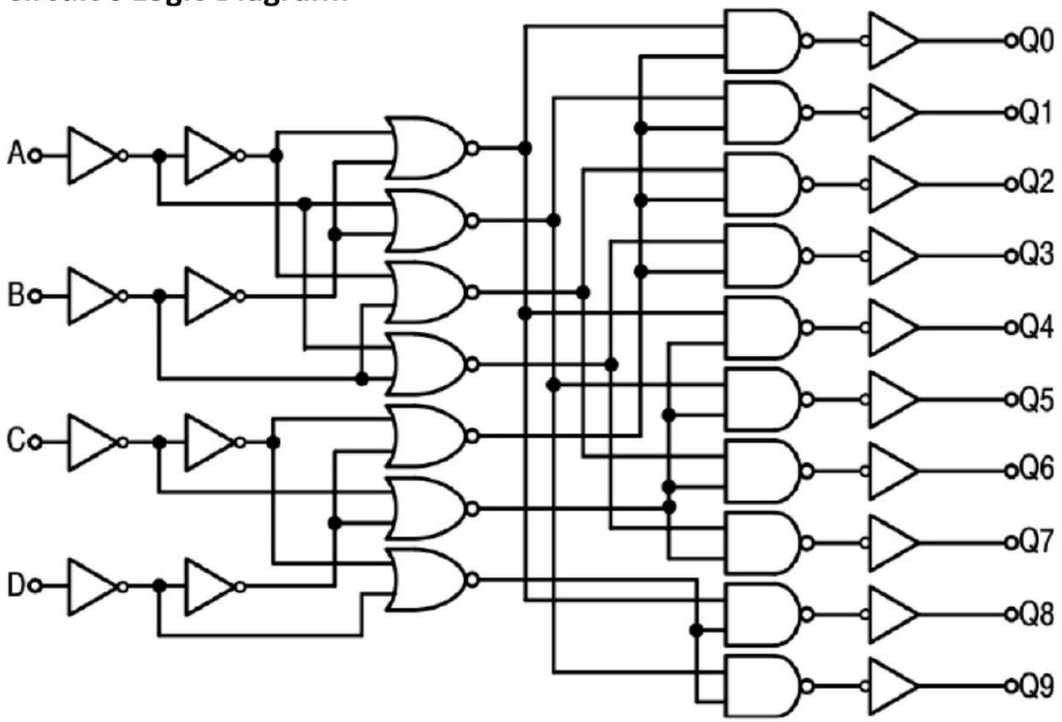
$$= 10$$

Attempt a quiz

Quiz **2A**, Page **2**, Question **2**

Binary is a base of logic and computing (machine language).

Circuit's Logic Diagram:-



Source: electronics.stackexchange.com

Truth Table:

D	C	B	A	Q_0	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8	Q_9	Decimal Value
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	1	0	0	0	0	0	0	0	2
0	0	1	1	0	0	0	1	0	0	0	0	0	0	3
0	1	0	0	0	0	0	0	1	0	0	0	0	0	4
0	1	0	1	0	0	0	0	0	1	0	0	0	0	5
0	1	1	0	0	0	0	0	0	0	1	0	0	0	6
0	1	1	1	0	0	0	0	0	0	0	1	0	0	7
1	0	0	0	0	0	0	0	0	0	0	0	1	0	8
1	0	0	1	0	0	0	0	0	0	0	0	0	1	9

Base 8 (Octal) [0..7]

$$1024_8 = (1 \times 8^3) + (0 \times 8^2) + (2 \times 8^1) + (4 \times 8^0)$$

$$= (1 \times 512) + (0 \times 64) + (2 \times 8) + (4 \times 1)$$

$$= (512) + (0) + (16) + (4)$$

$$= 532$$

Attempt a quiz

Quiz **2A**, Page **3**, Question **3**

10 11 12 13 14 15

Base 16 (Hexadecimal) [0..9, A, B, C, D, E, F]

$$2AF_{16} = (2 \times 16^2) + (10 \times 16^1) + (15 \times 16^0)$$

$$= (2 \times 256) + (10 \times 16) + (15 \times 1)$$

$$= (512) + (160) + (15)$$

$$= 678$$

Attempt a quiz

Quiz **2A**, Page **4**, Question **4**

HTML color

Specifying colors using 6-digit codes (instead of 9) can save space in the HTML document.

	R	G	B	
	255	0	0	FF0000
	255	127	0	FF7F00
	255	255	0	FFFF00
	127	255	0	7FFF00
	0	255	0	00FF00
	0	255	127	00FF7F
	0	255	255	00FFFF
	0	127	255	007FFF

	R	G	B	
	240	160	160	F0A0A0
	220	180	140	DCB48C
	200	200	120	C8C878
	180	220	140	B4DC8C
	160	240	160	A0F0A0
	140	220	180	8CDCB4
	120	200	200	78C8C8
	140	180	220	8CB4DC

	R	G	B	
	238	170	170	EEAAAA
	221	187	153	DDBB99
	204	204	136	CCCC88
	187	221	153	BBDD99
	170	238	170	AAEEAA
	153	221	187	99DDBB
	136	204	204	88CCCC
	153	187	221	99BBDD

Source: R. A. Nonenmacher from Wikimedia Commons

Conversion from base-10 to base-2

2^6	2^5	2^4	2^3	2^2	2^1	2^0
64	32	16	8	4	2	1

$$\begin{array}{r|l} 22 & \\ \hline 16 & \end{array} \qquad \begin{array}{r|l} 6 & \\ \hline 4 & \end{array} \qquad \begin{array}{r|l} 2 & \\ \hline 2 & \end{array}$$

$22 = 1^{6} \; 0 \; 1^{2} \; 1 \; 0_{2}$

Conversion from base-10 to base-2

2^6	2^5	2^4	2^3	2^2	2^1	2^0
~~64~~	~~32~~	16	8	4	~~2~~	1

$\frac{29}{16}$ $\frac{13}{8}$ $\frac{5}{4}$ $\frac{1}{1}$

29 = 1 1 1 0 1

13 → 5 → 1

$_2$

Conversion from base-10 to base-16

16^3	16^2	16^1	16^0
4096	256	16	1

	1000	232	8
	256	16	1

		232		8	
1000 =		3		~~14~~	8
		3		E	8 $_{16}$

Attempt a quiz

Quiz **2B**, Page **1**, Question **1**