Digital Systems (ICT 2154) & Digital Systems and Computer Organization (ICT 2171)
4 credit

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Students need to write notes for each class

Abstract Syllabus of DSM:

- Introduction, Simplification of Boolean functions – K-map and tabulation method, NAND and NOR implementation, Combinational logic- Design of Adders/Subtractors, Binary Parallel adder[7483], Carry Look ahead Adder [74182], Multiplier using 7483, BCD adder, Magnitude Comparator [7485], Decoder [74138,7442], Combinational logic circuit design using decoders, Encoder [74148], Multiplexers [74157, 74153], Combinational logic circuit design using multiplexers, De Multiplexers, ROMS and Programmable Logic Arrays, Sequential logic –Asynchronous and Synchronous counters, Synchronous counter design, Shift registers, Shift register counters, Analysis and design of clocked sequential circuits, Memory Devices - RAM, ROM, PROM, EPROM, EEPROM, PLD.

Abstract Syllabus of DSCO:

- Introduction, Simplification of Boolean functions – K-map method, NAND and NOR implementation, Combinational logic, Design of Adders/Subtractors, code converters, Application of typical TTL integrated circuit components like Binary Parallel adder[74283], multiplier using 74283, Magnitude Comparator [7485], Decoders [74138,7442], Encoders [74148], Multiplexers [74157], combinational shifter design, De Multiplexers, Sequential logic –counters and shift registers, Computer organization- Introduction, ALU unit, Control unit, Hardwired and Micro – programming approach, Memory unit, Input and Output unit.

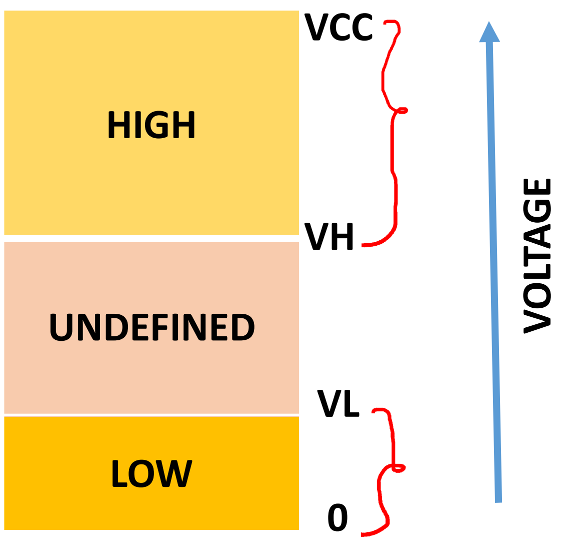
References:

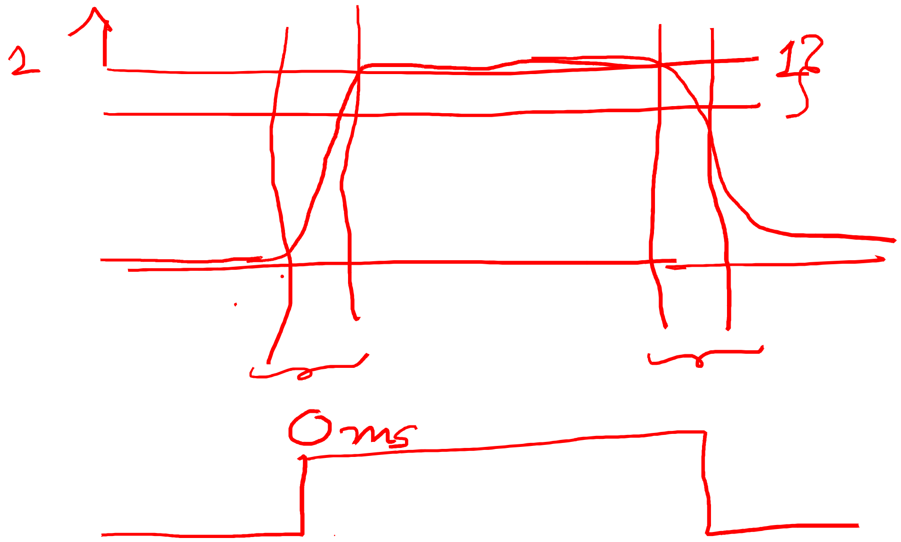
- M. Morris Mano: Digital Design, Third edition, Pearson Education, 2013
- Ronald J. Tocci and Neal S. Widmer : Digital Systems, 9th Edition, Pearson Education, 2007.
- J. F. Wakerly, Digital Design Principles and Practices, 3rd edition, Pearson Education, 2003
- Computer Organization:
  - Mohamed Rafiquzzaman and Rajan Chandra, Modern computer Architecture (3e), Galgotia publications Pvt. Ltd, 2015.
- Additional reference:
  - Digital principles and Design by Donald D. Givone

Difference between Analog and Digital

- Analog information can take any values in between the range
- Digital information takes discrete values. At the basic level, value can be ON/OFF, ONE/ZERO, TRUE/FALSE, HIGH/LOW i.e. only two values and hence the name binary.

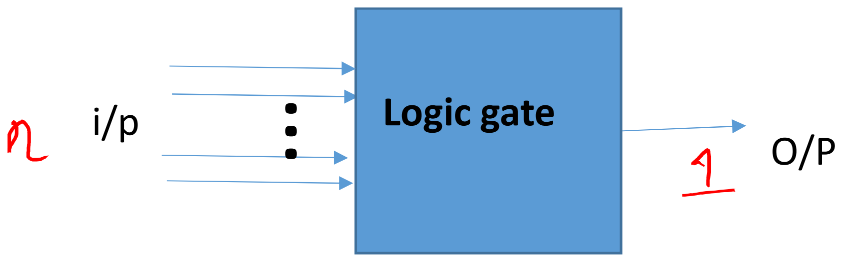
1 0 1 0





Logic gates

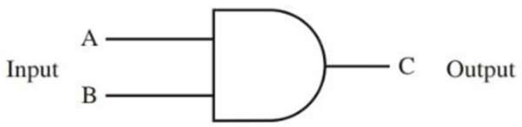
- Building blocks of digital circuit
- Electronic circuits with one or more inputs and one output.



Basic logic gates

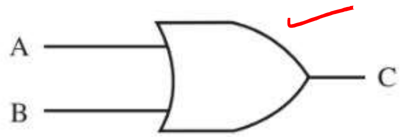
- AND , OR, NOT gates
- Graphic symbols of these 3, 2-i/p gates are shown below

AND



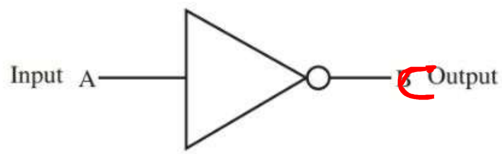
$C=A.B$ $= AB$

OR



$C=A+B$

NOT



$C=A' = \overline{A}$

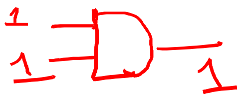
Truth Table

- Truth table of a logic gate or a logic circuit depicts the output for all possible input combinations
- AND OR NOT

AND

INPUTS		OUTPUT
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

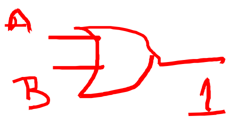
C= A.B



OR

INPUTS		OUTPUT
A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

C= A+B



$A = 1, B = 0 \quad = 1 + 0 = 1$

NOT

INPUT	OUTPUT
A	C
0	1
1	0

C=A'

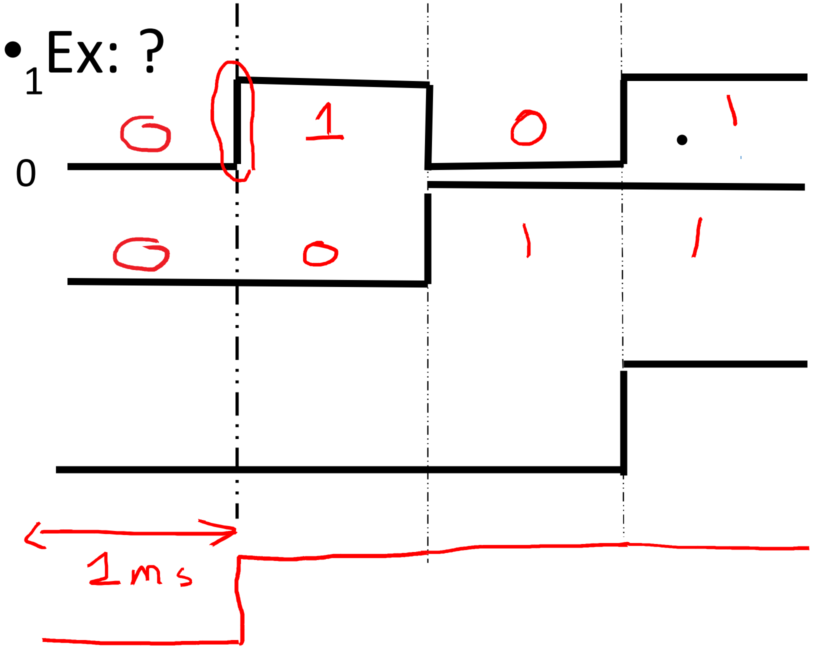
$2^1 = 2$

$2^2 = 4$ ← No. of i/p variables

↳ No. of i/p combinations

Timing diagram

- Represents the output of the gate for input signal combinations
- Ex: ?



A B

B A

C = A·B

AND

c = A + B

A	B
0	0
0	1
1	0
1	1

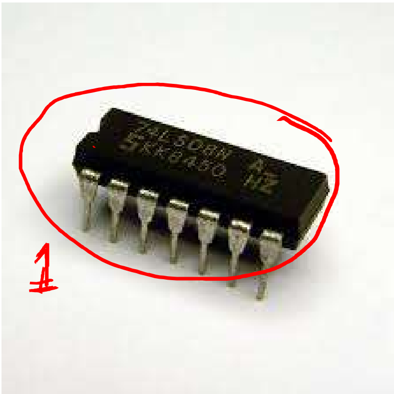
DRAW THE TIMING DIAGRAM FOR OR GATE

C = A + B

DRAW THE TIMING DIAGRAM FOR OR GATE

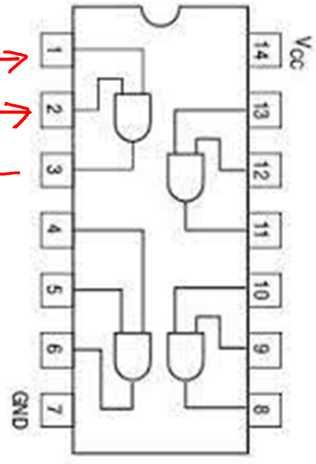
How do gates look physically

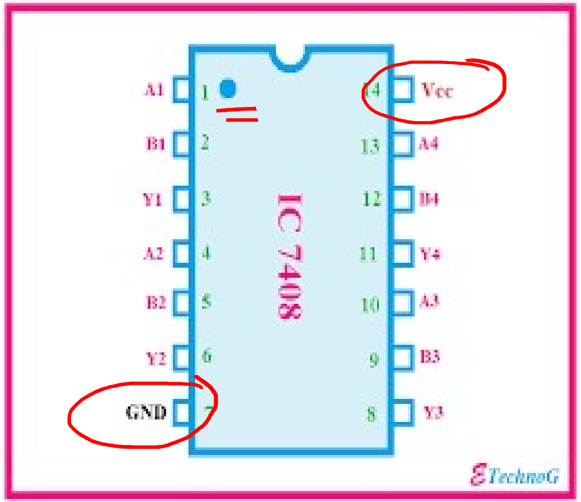
- Gates are available in the form of integrated circuits (ICs)



switches

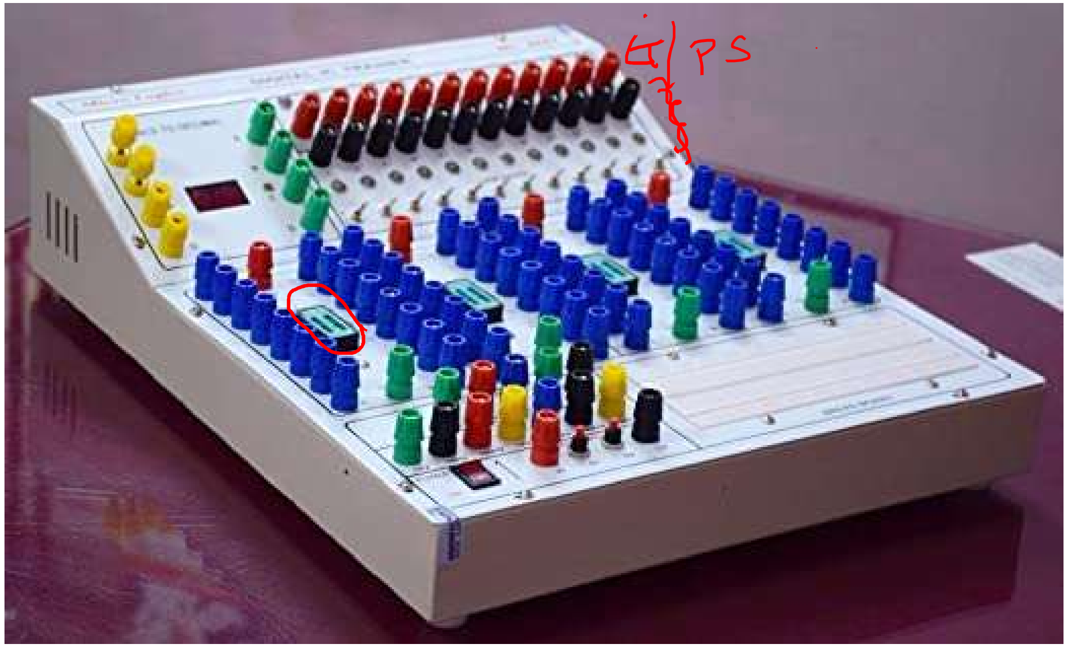
LED





- **Write the full form of SSI, MSI, LSI, VLSI, ULSI, ? And differentiate**

Digital Trainer Kit



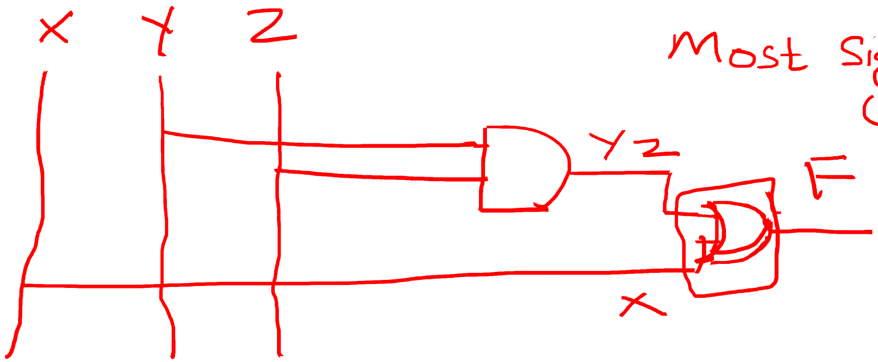
Boolean function and Logic circuit

- For the Boolean function F(x,y,z) = x + yz, draw the logic circuit, timing diagram and truth table.

$2^3 = 8$

Most Sign. Bit (MSB)

Least significant bit (LSB)



$F = x + yz$

	4	2	1	
	2^2	2^1	2^0	
	X	Y	Z	F
0	0	0	0	0
1	0	0	1	0
2	0	1	0	0
3	0	1	1	1
4	1	0	0	1
5	1	0	1	1
6	1	1	0	1
7	1	1	1	

$2^3 = 8 \Rightarrow 0$ to 7

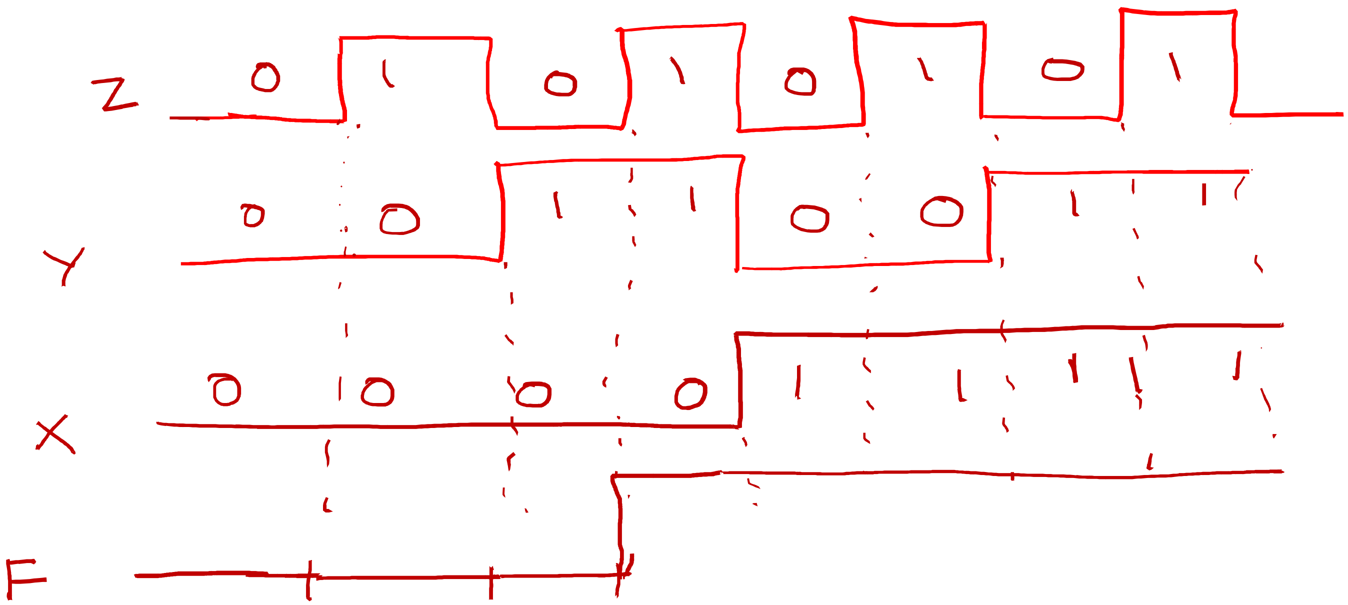
000

111

$4 + 2 + 1 = 7$

Truth Table: F(x,y,z) = x + yz

Timing Waveform: $\mathbf{F(x,y,z) = x + yz}$

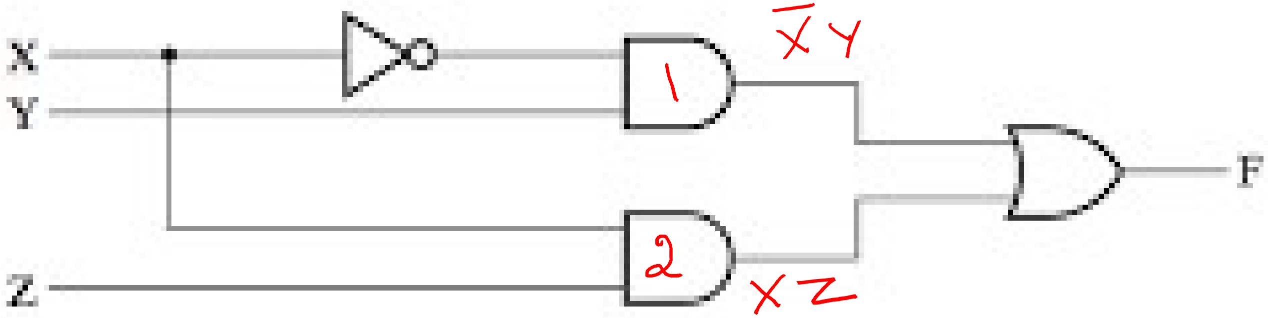


→ LSB

Interchanging x and z → MSB

4	2	1	
Z	Y	X	$F = X + YZ$
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

- Write the Boolean function and truth table for the following circuit..



$F = \bar{X}Y + XZ$

Truth Table for F=x’y+xz

x=0 y=1

x=1 z=1

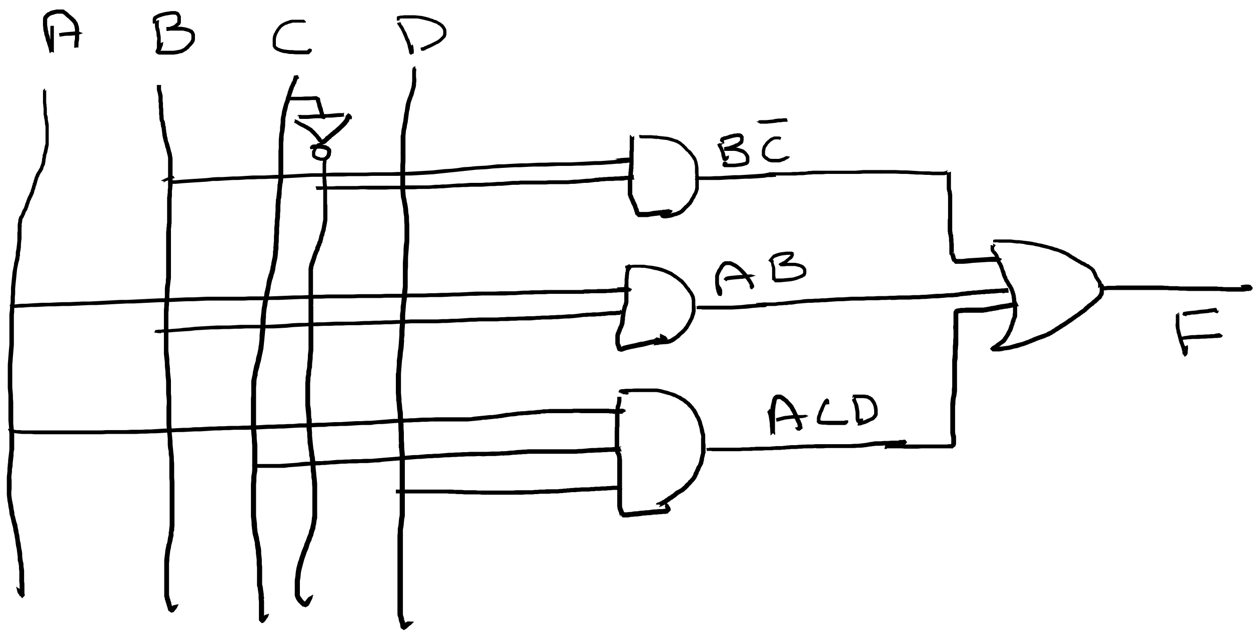
X	Y	Z	F
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Draw the logic diagram (without simplification) using basic logic gates

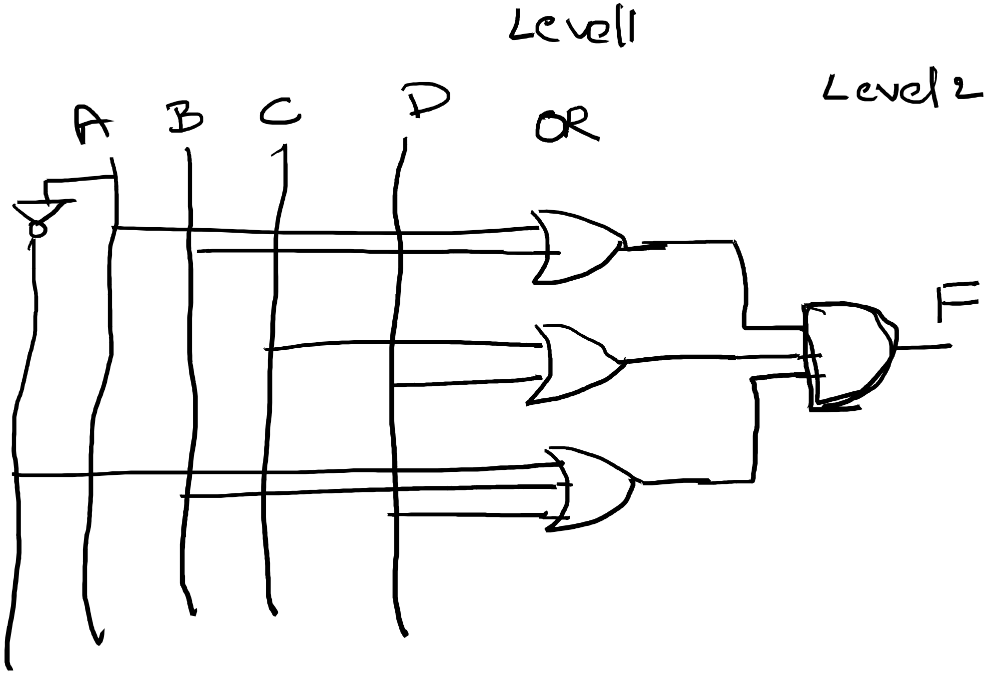
- $F = BC' + AB + ACD$

- $F = (A+B)(C+D)(A'+B+D)$

F =BC' +AB +ACD ⇒ Sum of product



F=(A+B)(C+D)(A’+B+D) → product of Sums.



Boolean Theorems

Table 2.1
Postulates and Theorems of Boolean Algebra

Postulate 2	(a)	$x + 0 = x$ $F = x$	(b)	$x \cdot 1 = x$
Postulate 5	(a)	$x + x' = 1$ 1	(b)	$x \cdot x' = 0$
Theorem 1	(a)	$x + x = x$	(b)	$x \cdot x = x$
Theorem 2	(a)	$x + 1 = 1$	(b)	$x \cdot 0 = 0$
Theorem 3, involution		$(x')' = x$		
Postulate 3, commutative	(a)	$x + y = y + x$	(b)	$xy = yx$
Theorem 4, associative	(a)	$x + (y + z) = (x + y) + z$	(b)	$x(yz) = (xy)z$
Postulate 4, distributive	(a)	$x(y + z) = xy + xz$	(b)	$x + yz = (x + y)(x + z)$
Theorem 5, DeMorgan	(a)	$(x + y)' = x'y'$	(b)	$(xy)' = x' + y'$
Theorem 6, absorption	(a)	$x + xy = x$	(b)	$x(x + y) = x$

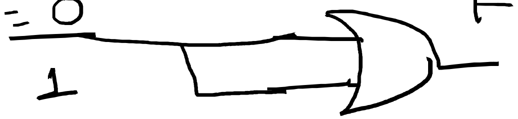
$x(1 + y) = x$
$\quad\ 1$

$x + xy = x(1 + y) = x$

- <u>Rough</u>

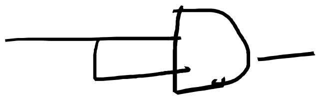
$x = 0$

1



$F = x + x = x$

x



$x \cdot x = x$

$x = 0\ 0$

$x = 1 = 1\ 1$

$x \cdot 1 = x$

$x + x + x + x + x = x$

$AB \cdot 1$

$AB + ABC + A\bar{B}C$

$A\bar{B}C$

$AB(1 + C) + AC(B + \bar{B})$

$AB + AC$

Rough

Simplify the following Boolean functions

- $X(X'+Y) =$ $\cancel{X}Y$
- $X + X'Y =$ $\underbrace{(X+X')}_{1}(X+Y) = X+Y$
- $X'+XY=?$ $X'+Y$
- $(X+Y)(X+Y') =$ X

Ex: $\underbrace{AB}_{X} + \overline{AB} \cdot C = AB + C$

$\overline{X} \cdot C = X + C$

Exe: $AB + \overline{A}\,\overline{B} \cdot C$

Simplify following Boolean expressions to one term using Boolean theorems

- A’B(D’+C’D)+B(A+A’CD)

$$= \bar{A}B\bar{D} + \underline{\bar{A}B\cancel{\bar{C}}D} + AB + \underline{\bar{A}B\cancel{C}D}$$

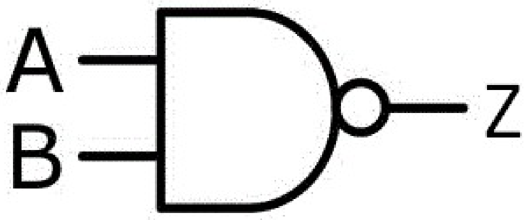
$$= \underline{\bar{A}B\cancel{\bar{D}} + \bar{A}B\cancel{D}} + AB$$

$$= \cancel{\bar{A}}B + \cancel{A}B = \underline{\underline{B}}$$

Simplify following Boolean expressions to one term using Boolean theorems :$A'B(D'+C'D)+B(A+A'CD)$

Universal gates

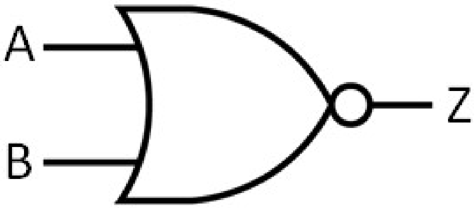
- NAND gates



$= \overline{A. B}$

A	B	Z= $\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

- NOR gates



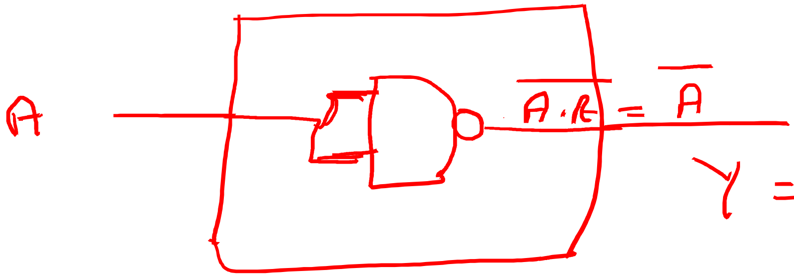
$= \overline{A+B}$

A	B	Z= $\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

Implement basic logic gates using NAND gates

- NOT using NAND gate:

$Y = \overline{A}$ $\quad\quad\quad\quad$ $Y = \overline{A \cdot B}$



$Y = \overline{A}$

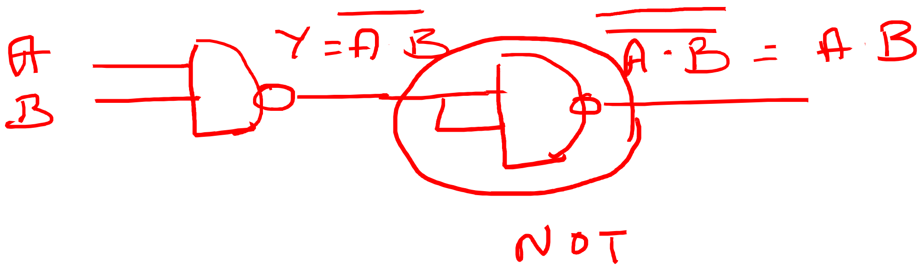
Implement basic logic gates using NAND gates

- AND using NAND gate:

AND $Y = A \cdot B$

NAND: $Y = \overline{A \cdot B}$

$\overline{\overline{x}} = x$



Implement basic logic gates using NAND gates

- OR using NAND gate:

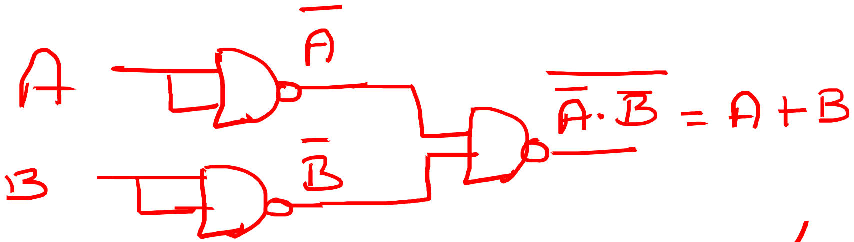
$Y = A + B$

$Y = \overline{A \cdot B} = \bar{A} + \bar{B}$

$\uparrow \quad \uparrow$

if we apply $\bar{A}$ $\bar{B}$ to NAND $= \overline{\bar{A} \cdot \bar{B}} = \bar{\bar{A}} + \bar{\bar{B}}$

$= A + B$



OR

Implement basic logic gates using NOR gates

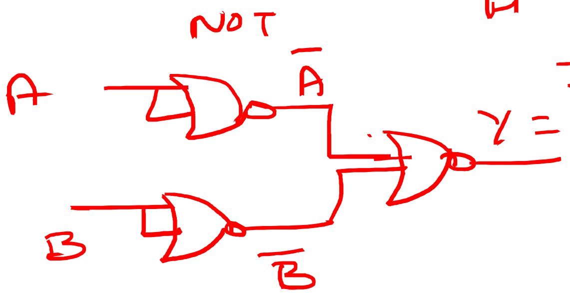
- NOT using NOR gate:

Implement basic logic gates using NOR gates

- AND using NOR gates:

$$Y = \overline{A + B} = \overline{A} \cdot \overline{B}$$

$\overline{A}$ $\quad$ B



$$Y = \overline{\overline{A} + \overline{B}} = \overline{\overline{A}} \cdot \overline{\overline{B}} = AB$$

Implement basic logic gates using NOR gates

- OR using NOR gates:

$$Y = \overline{A + B}$$

Any questions ?