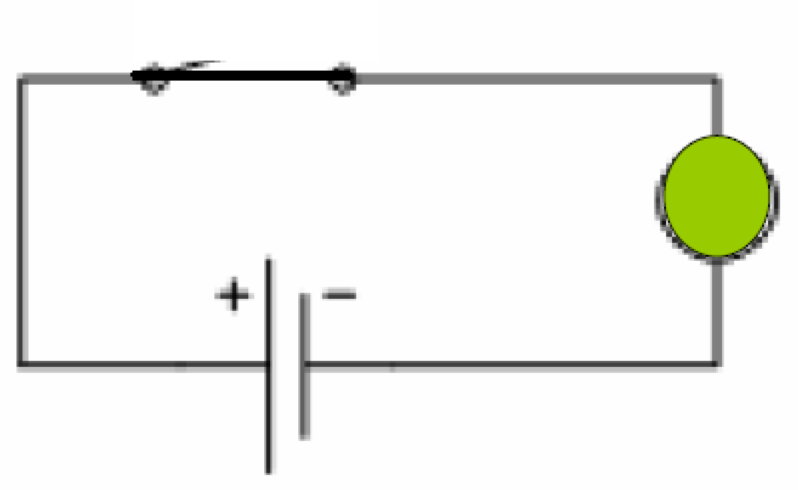
Logic Gates

- They can be in only 2 states either ON or OFF.
- A simple switch is an example for such a device witch can either be ON or OFF.

Logic Gates cont…

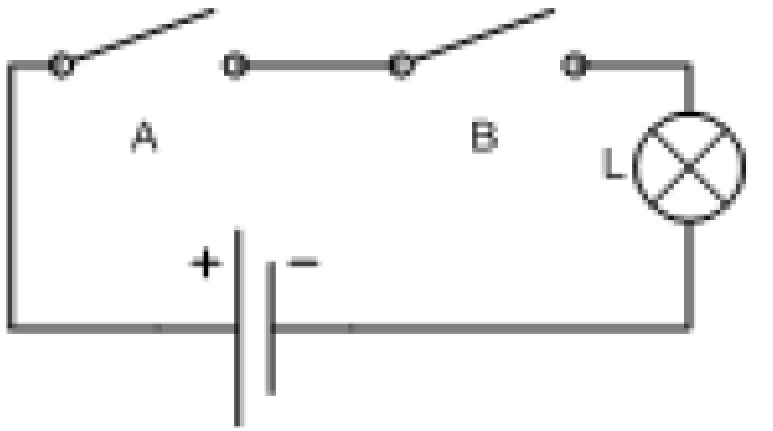


Switch	Bulb
0	0
1	1

Fundamental logic gates

1. AND — are all inputs are true?
2. OR — is at least one input is true?
3. NOT — flip the truth value

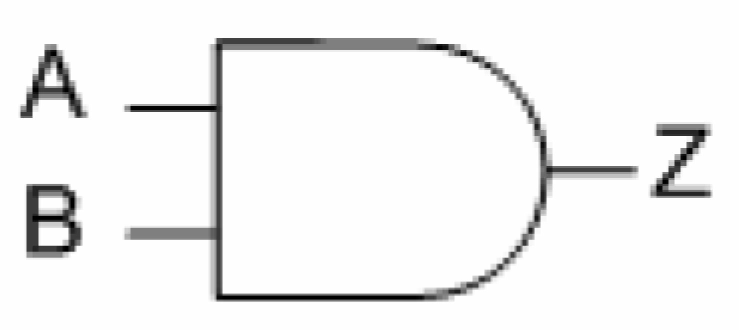
AND gate



A	B	L
0	0	0
0	1	0
1	0	0
1	1	1

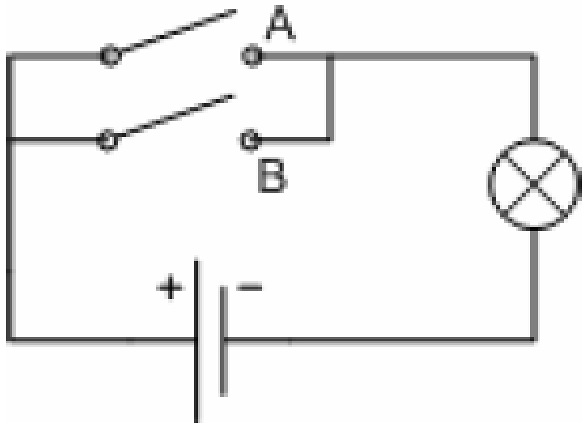
$$L = A.B$$

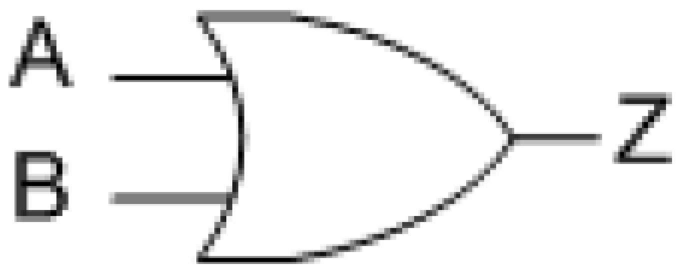
Symbol



A	B	Z
0	0	0
0	1	0
1	0	0
1	1	1

OR Gate

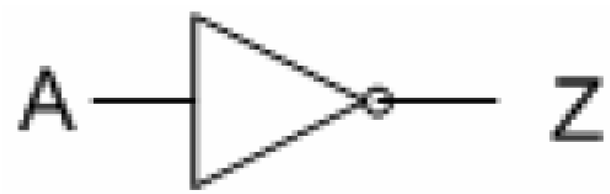




$$Z = A + B$$

A	B	Z
0	0	0
0	1	1
1	0	1
1	1	1

NOT gate



$$Z = \overline{A}$$

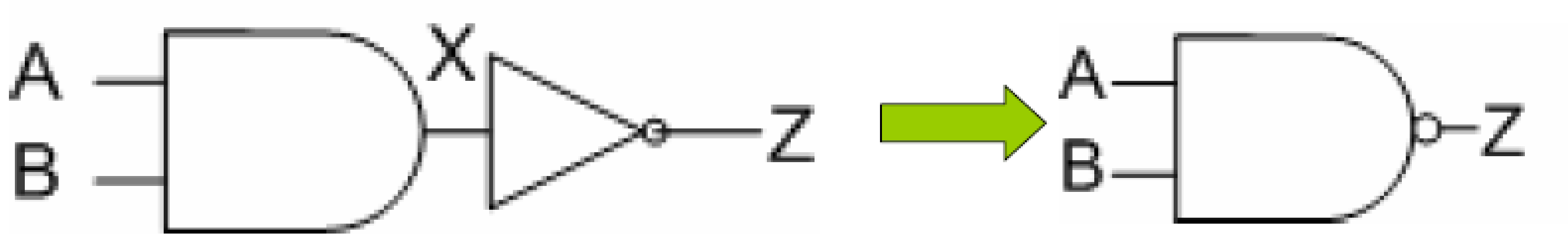
A	Z
0	1
1	0

Also called the Inverter

Gate Networks

- The AND, OR and NOT gates can be interconnected together to form other gates & logic networks.
- These are also called *combinational networks*.
- Based on these fundamental gates NAND, NOR, XOR and XNOR gates are formed.

NAND gate



A	B	X (A.B)	(Z)
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

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

NOR Gate

A	B	Z
0	0	1
0	1	0
1	0	0
1	1	0

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

XOR Gate

- Exclusive OR gate

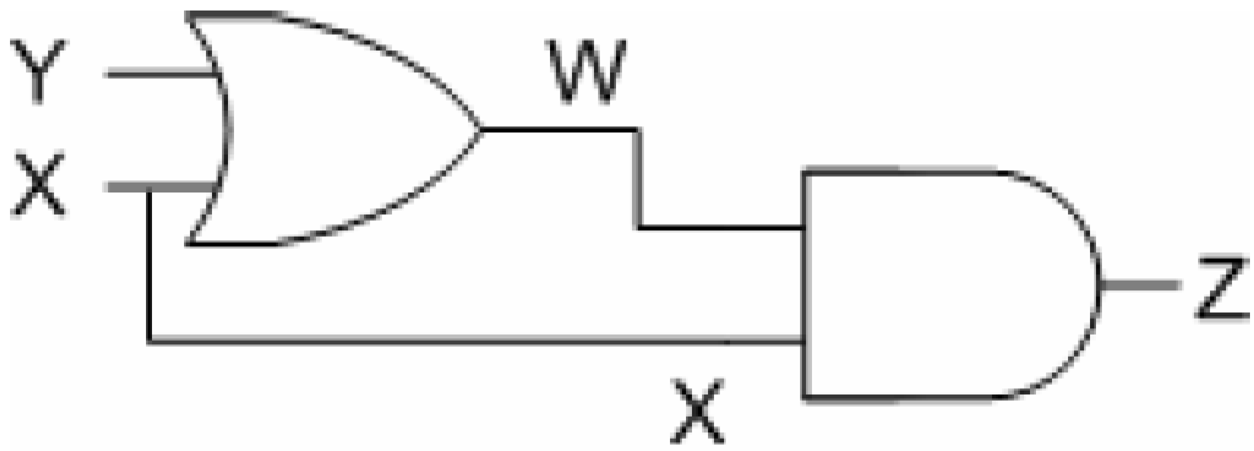
A	B	Z
0	0	0
0	1	1
1	0	1
1	1	0

$$Z = \overline{A}.B + A.\overline{B}$$

Logic Network Example

Build the Gate Network

Z=x(X + Y)


Y
X
W
X
Z

Boolean Algebra

Boolean Algebra is an algebra that deals with binary variables and logic operations. These variables are designated by letters such as A,B,x and y. the three basic logic operations are AND, OR, AND NOT.

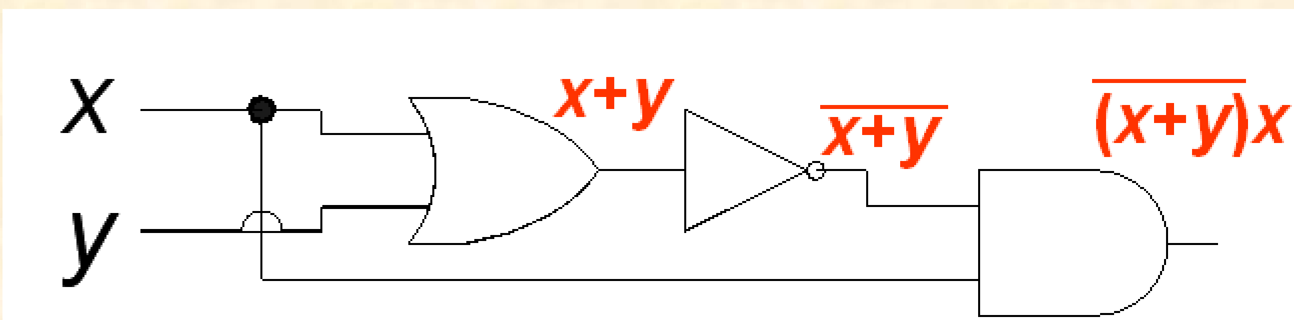
<u>BOOLEAN FUNCTION:</u>

$$F=x + y'z$$

Q. Construct the truth table and Logic diagram of this Boolean Function.

- Write the circuits for the following Boolean algebraic expressions

b) $\overline{(x+y)}x$

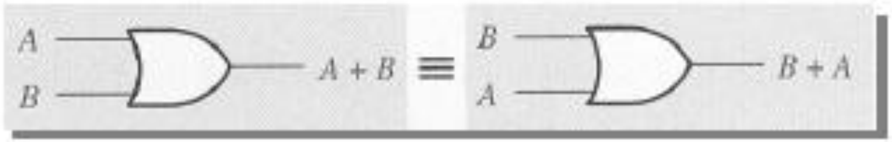


Laws of Boolean Algebra

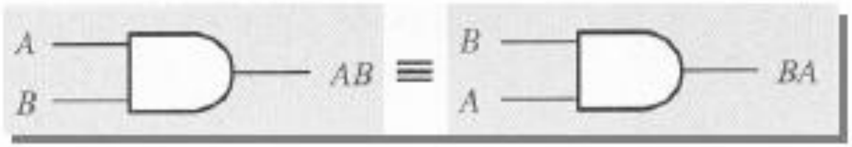
- Commutative Laws
- Associative Laws
- Distributive Law

Commutative Laws of Boolean Algebra

$$A + B = B + A$$

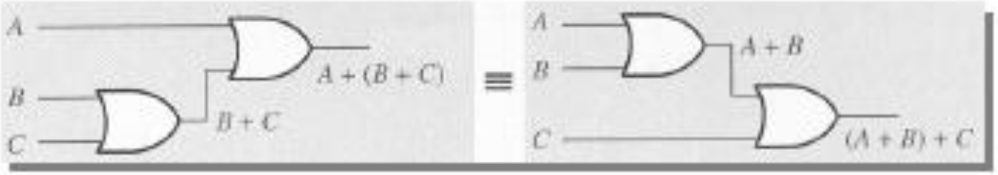


$$A \bullet B = B \bullet A$$

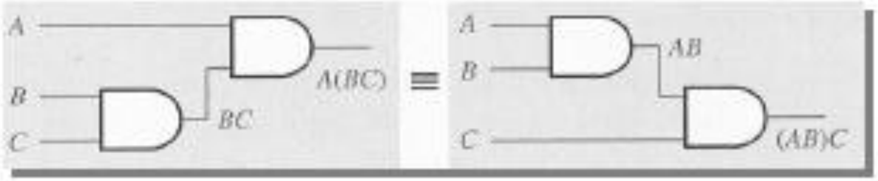


Associative Laws of Boolean Algebra

$$A + (B + C) = (A + B) + C$$



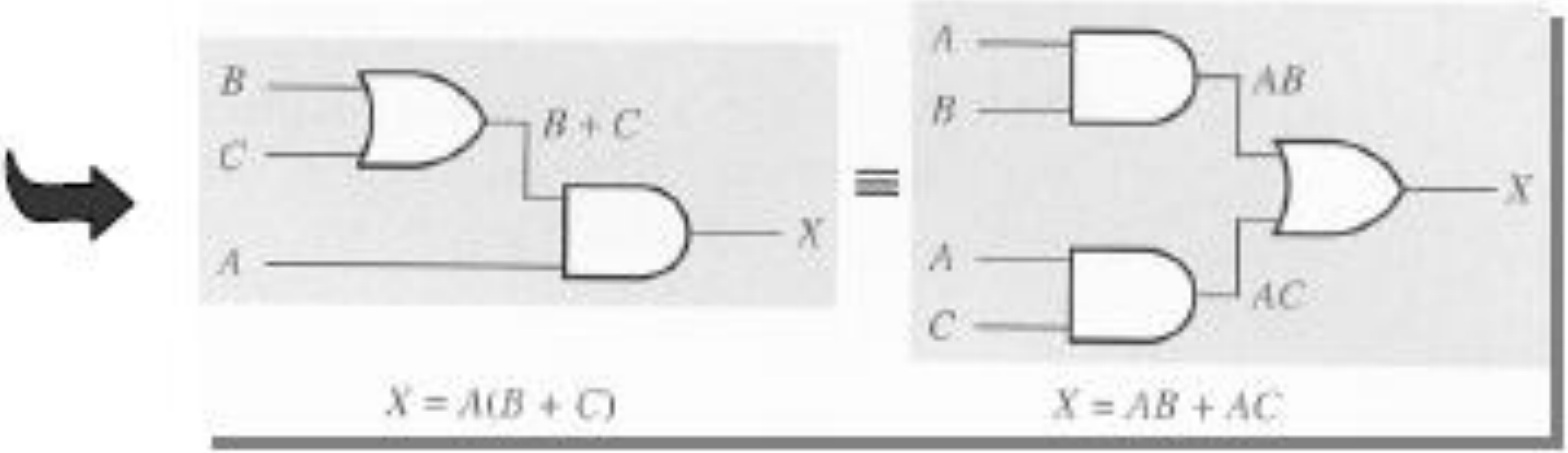
$$A \bullet (B \bullet C) = (A \bullet B) \bullet C$$



Distributive Laws of Boolean Algebra

$$A \bullet (B + C) = A \bullet B + A \bullet C$$

$$A\,(B + C) = A\,B + A\,C$$



Rules of Boolean Algebra

1. $A + 0 = A$
2. $A + 1 = 1$
3. $A \cdot 0 = 0$
4. $A \cdot 1 = A$
5. $A + A = A$
6. $A + \overline{A} = 1$
7. $A \cdot A = A$
8. $A \cdot \overline{A} = 0$
9. $\overline{\overline{A}} = A$
10. $A + AB = A$
11. $A + \overline{A}B = A + B$
12. $(A + B)(A + C) = A + BC$

Rules of Boolean Algebra

- Rule 1 $X = A + 0 = A$

- Rule 2 $X = A + 1 = 1$

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

OR Truth Table

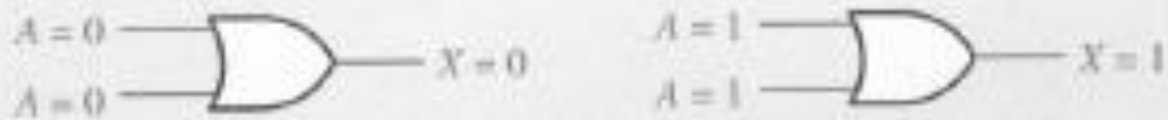
- Rule 3 $X = A \cdot 0 = 0$

- Rule 4 $X = A \cdot 1 = A$

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

AND Truth Table

Rules of Boolean Algebra



- Rule 5 $X = A + A = A$

- Rule 6 $X = A + \bar{A} = 1$

- Rule 7 $X = A \cdot A = A$

- Rule 8 $X = A \cdot \bar{A} = 0$

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

OR Truth Table

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

AND Truth Table

Rules of Boolean Algebra

- Rule 9 $\overline{\overline{A}} = A$

- Rule 10: A + AB = A

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

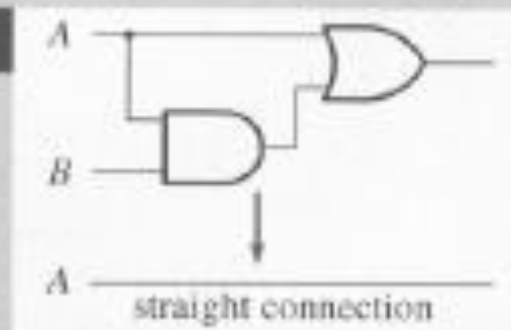
AND Truth Table

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

OR Truth Table

A	B	AB	A + AB
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	1

equal

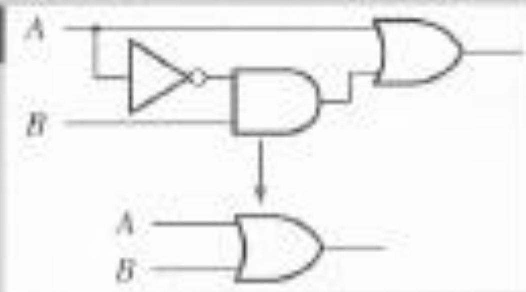


Rules of Boolean Algebra

- Rule 11: $A + \overline{A}B = A + B$

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

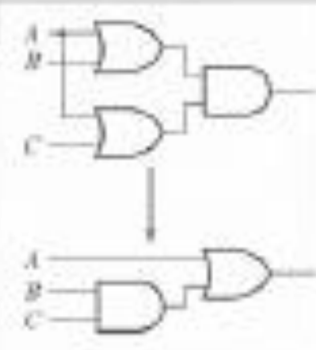
$A + \overline{A}B$ and $A + B$: equal



- Rule 12: $(A + B)(A + C) = A + BC$

A	B	C	$A + B$	$A + C$	$(A + B)(A + C)$	BC	$A + BC$
0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0
0	1	0	1	0	0	0	0
0	1	1	1	1	1	1	1
1	0	0	1	1	1	0	1
1	0	1	1	1	1	0	1
1	1	0	1	1	1	0	1
1	1	1	1	1	1	1	1

$(A + B)(A + C)$ and $A + BC$: equal



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DeMorgan's Theorems

- Theorem 1

$$\overline{(x+y)} = \overline{x} \cdot \overline{y}$$

- Theorem 2

$$\overline{(x \cdot y)} = \overline{x} + \overline{y}$$

Remember:

"Break the bar, change the operator"

- DeMorgan's theorem is very useful in digital circuit design
- It allows **ANDs to be exchanged with ORs by using invertors**
- DeMorgan's Theorem can be extended to any number of variables.

Example of DeMorgan's Theorem

$$F = \overline{X.Y} + \overline{P.Q} \quad \longleftarrow \quad \text{2 NAND plus 1 OR}$$

$$= \overline{X} + \overline{Y} + \overline{P} + \overline{Q} \quad \longleftarrow \quad \text{1 OR with some input invertors}$$

Complement of Functions

$$F=AB+C'D'+BD$$

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

Assignment

1. What do you understand by Gates. Explain different types of gates.
2. Design And gate Using NANAD gate.
3. Design OR gate using NOR gate.
4. What are the universal gate. Explain with the help of Gate.