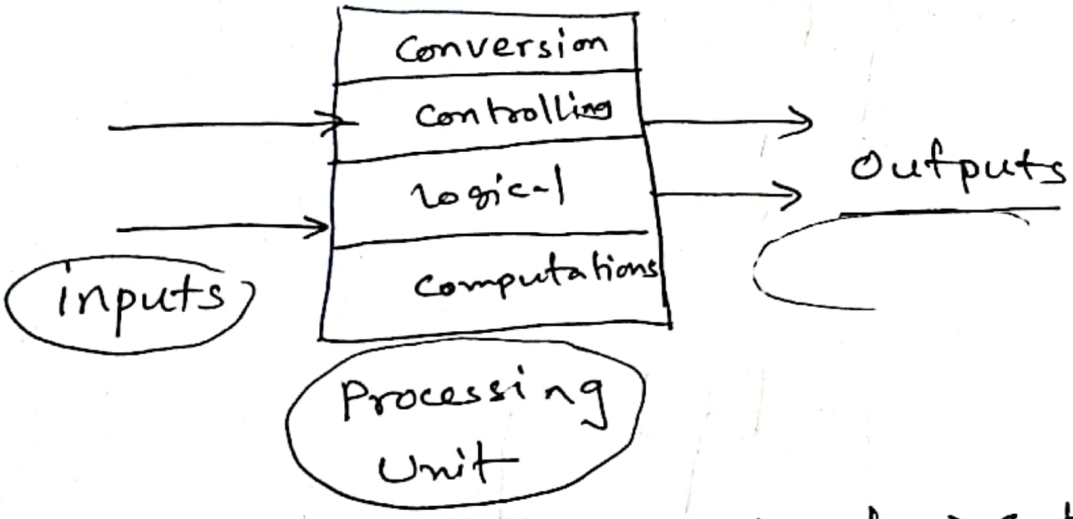
Electronic circuits

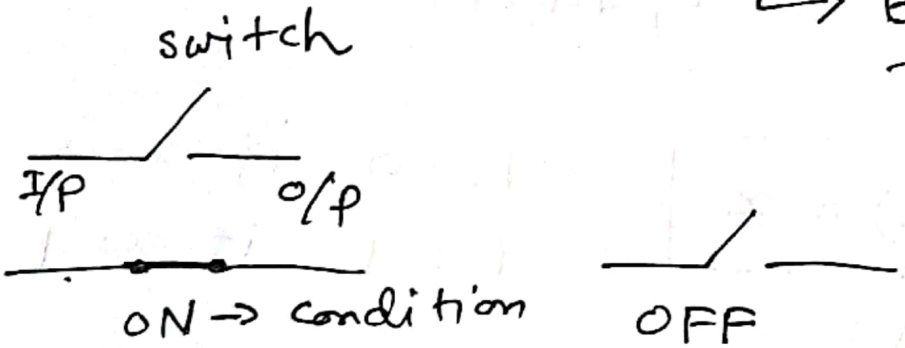


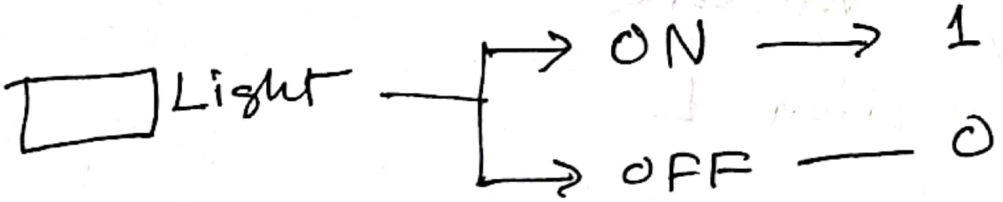
Signals → Analog signal ↔ continuous values

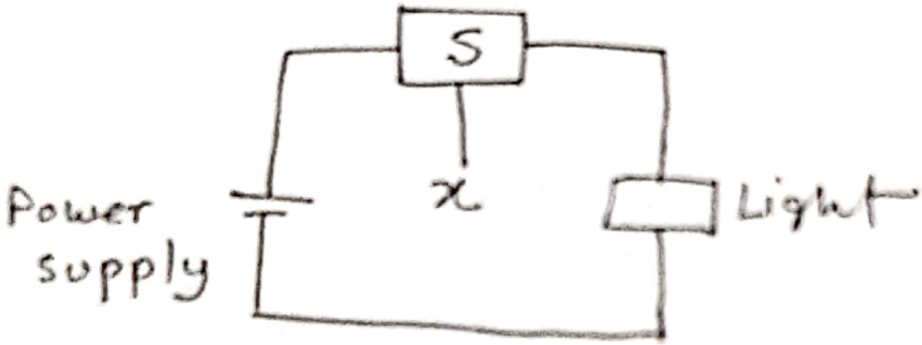
Digital signal → Discrete values

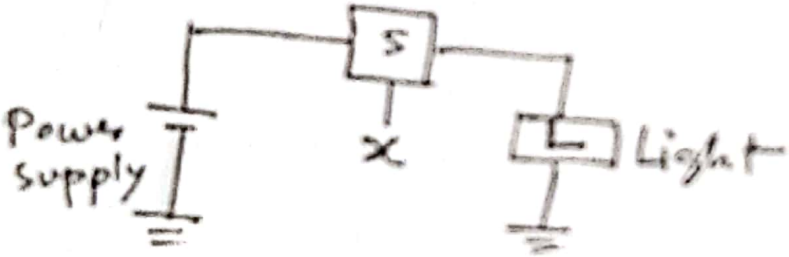
→ Decimal signal (0-9)

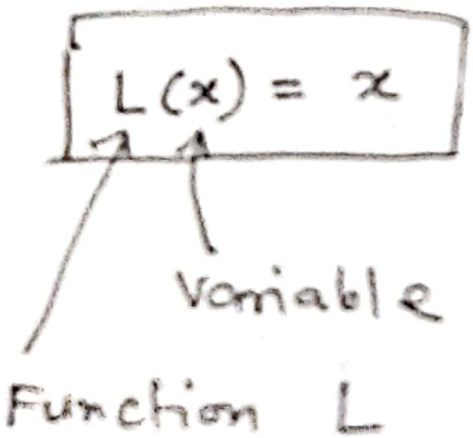
→ Binary signal (0-1)





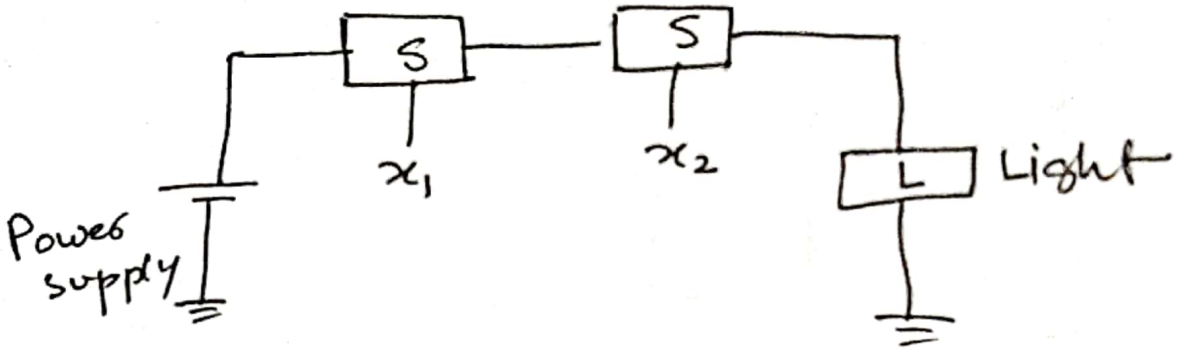


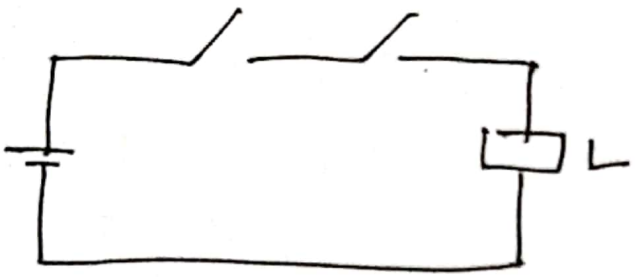




L = 0 if x = 0

L = 1 if x = 1





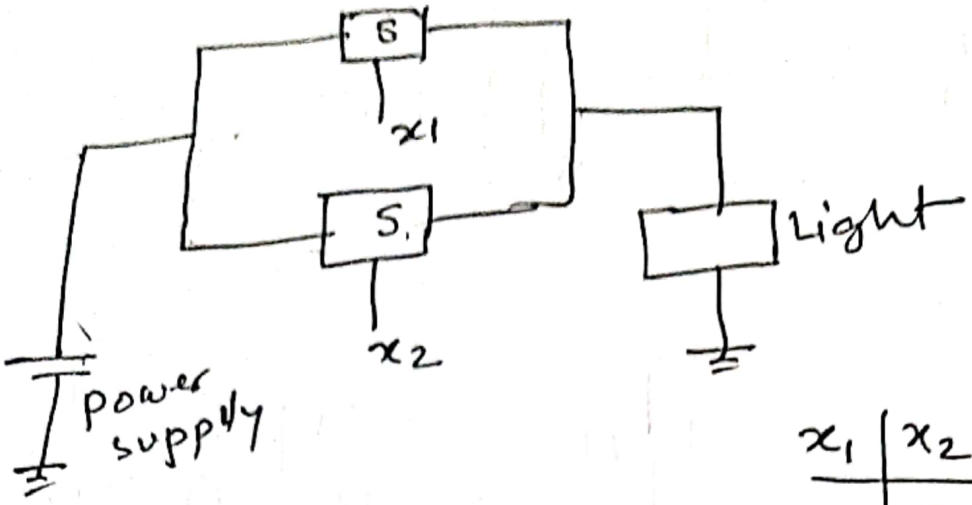
x_1	x_2	L
0	0	0
0	1	0
1	0	0
1	1	1

$L(x_1, x_2) = x_1 \cdot x_2$

'.' → Logical AND function.

$f(x_1, x_2) = x_1 \cdot x_2$

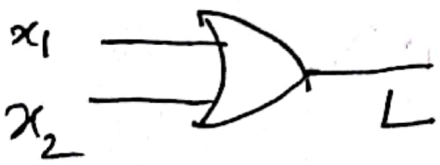
Logic gate (AND gate)



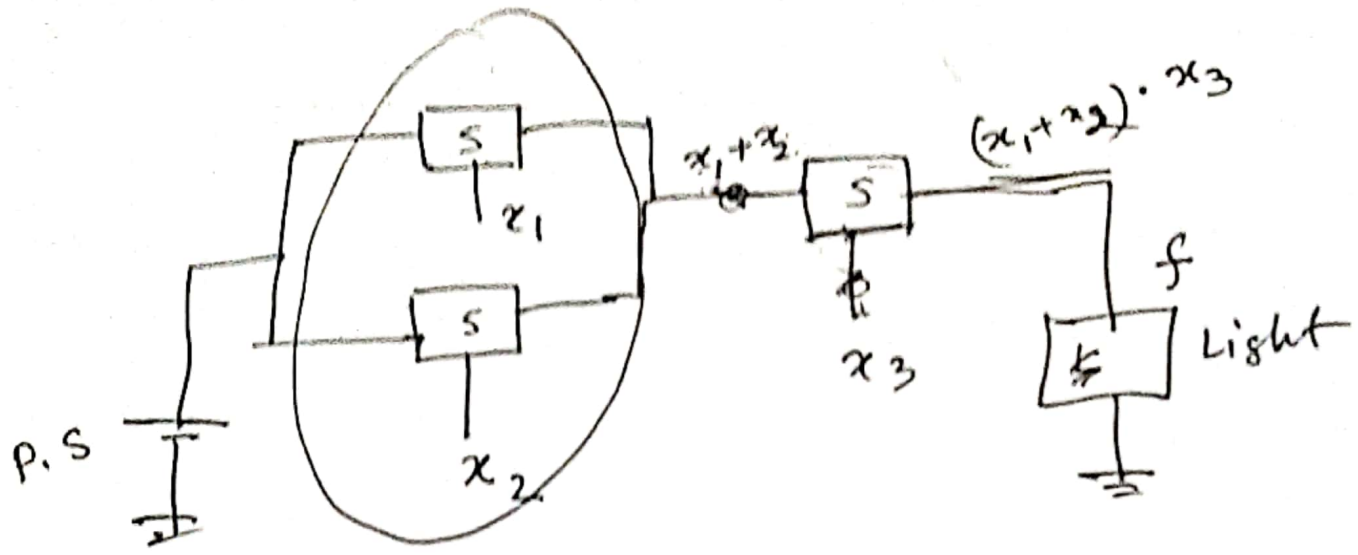
x_1	x_2	L
0	0	0
0	1	1
1	0	1
1	1	1

$L(x_1, x_2) = x_1 + x_2$

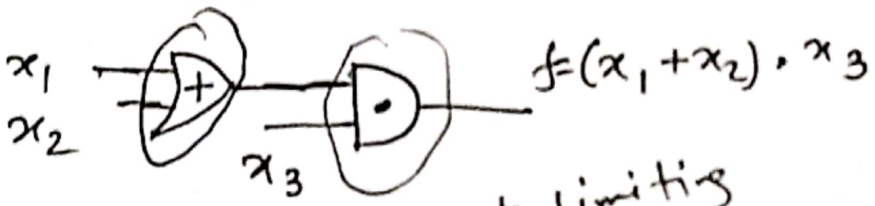
(+) → logical OR



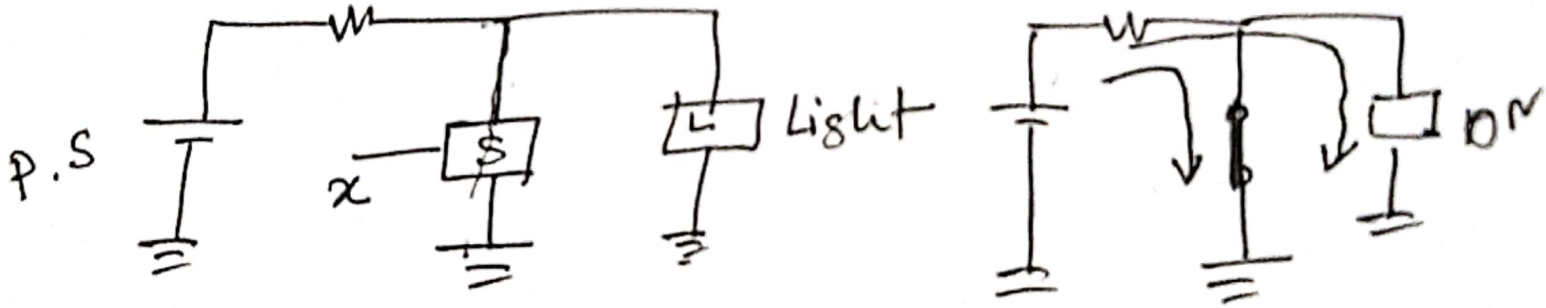
$L(x_1, x_2) = x_1 \stackrel{+}{=} x_2$



$$f(x_1, x_2, x_3) = (x_1 + x_2) \cdot x_3$$



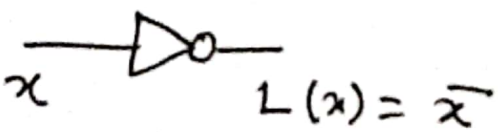
current limiting resistor.



$$L(x) = \bar{x}$$

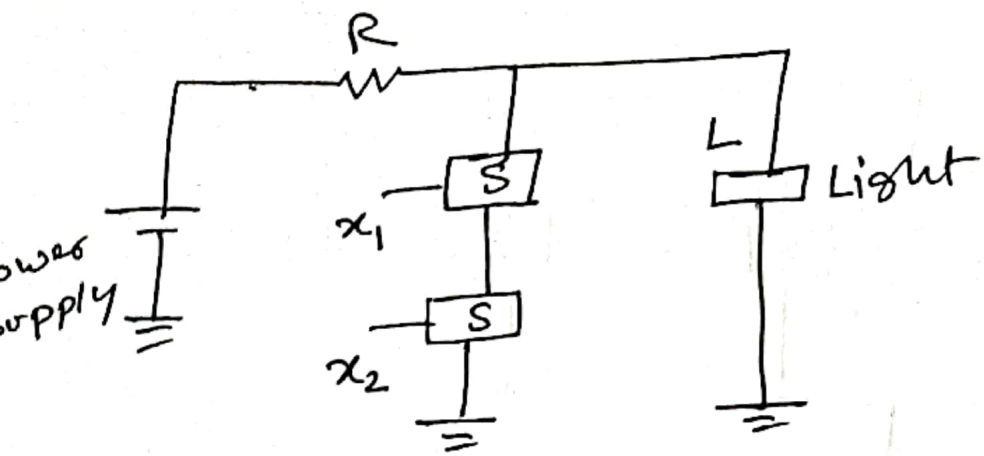
$L = 0$ if $x = 1$

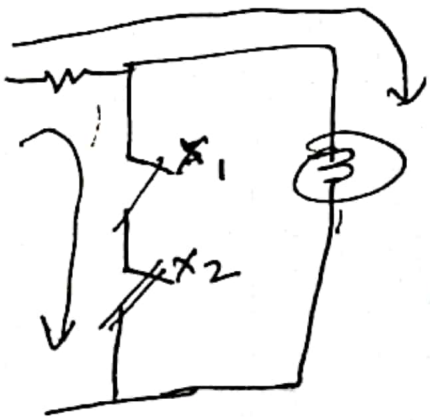
$L = 1$ if $x = 0$



NOT gate

$$x' = !x = \sim x = \text{NOT } x$$



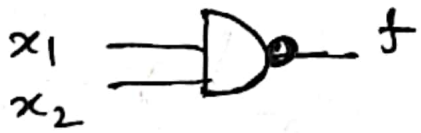


x_1	x_2	L
0	0	1
0	1	1
1	0	1
1	1	0

AND

x_1	x_2	L
0	0	0
0	1	0
1	0	0
1	1	1

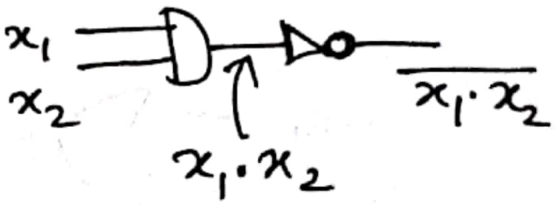
$$L(x_1, x_2) = \overline{x_1 \cdot x_2}$$



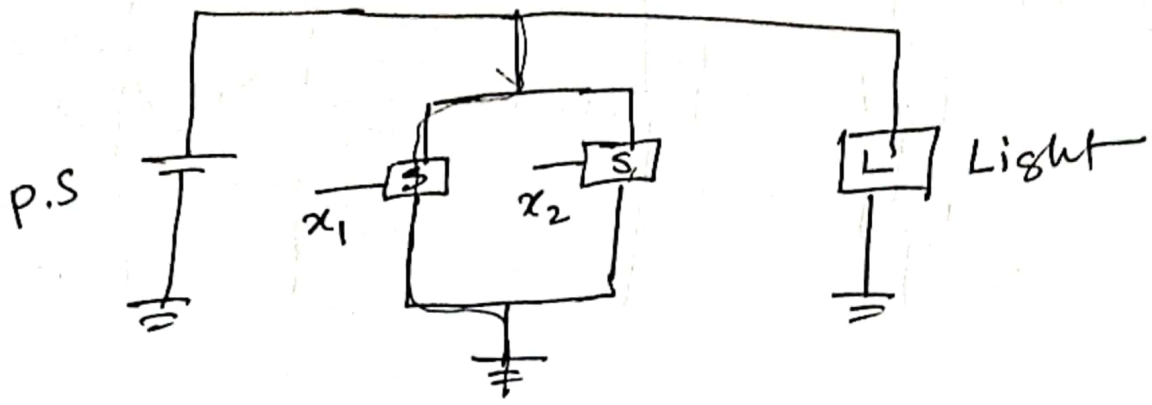
NAND gate

NAND

AND + NOT



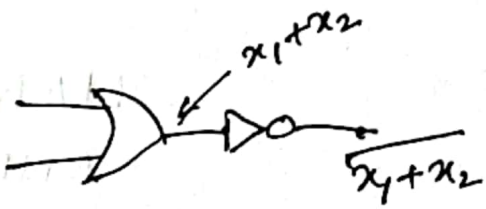
$$f(x_1, x_2) = \overline{x_1 \cdot x_2}$$

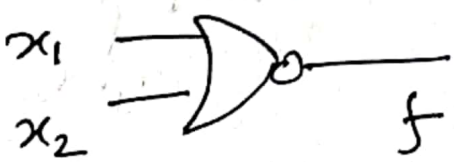


x_1	x_2	L
0	0	1
0	1	0
1	0	0
1	1	0

x_1	x_2	L	$\bar{L}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

$L(x_1, x_2) = x_1 + x_2$

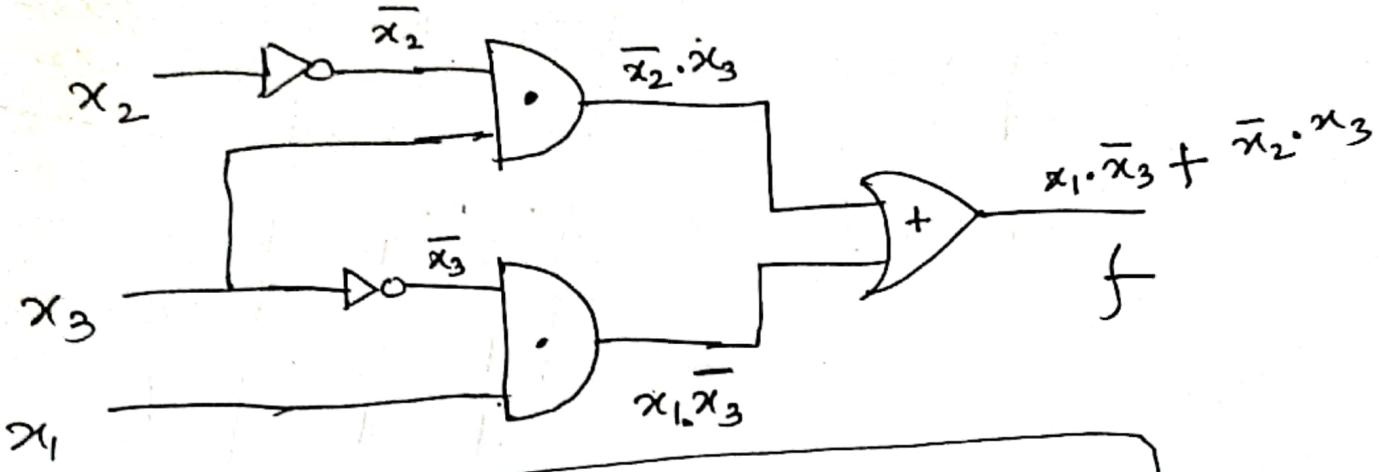




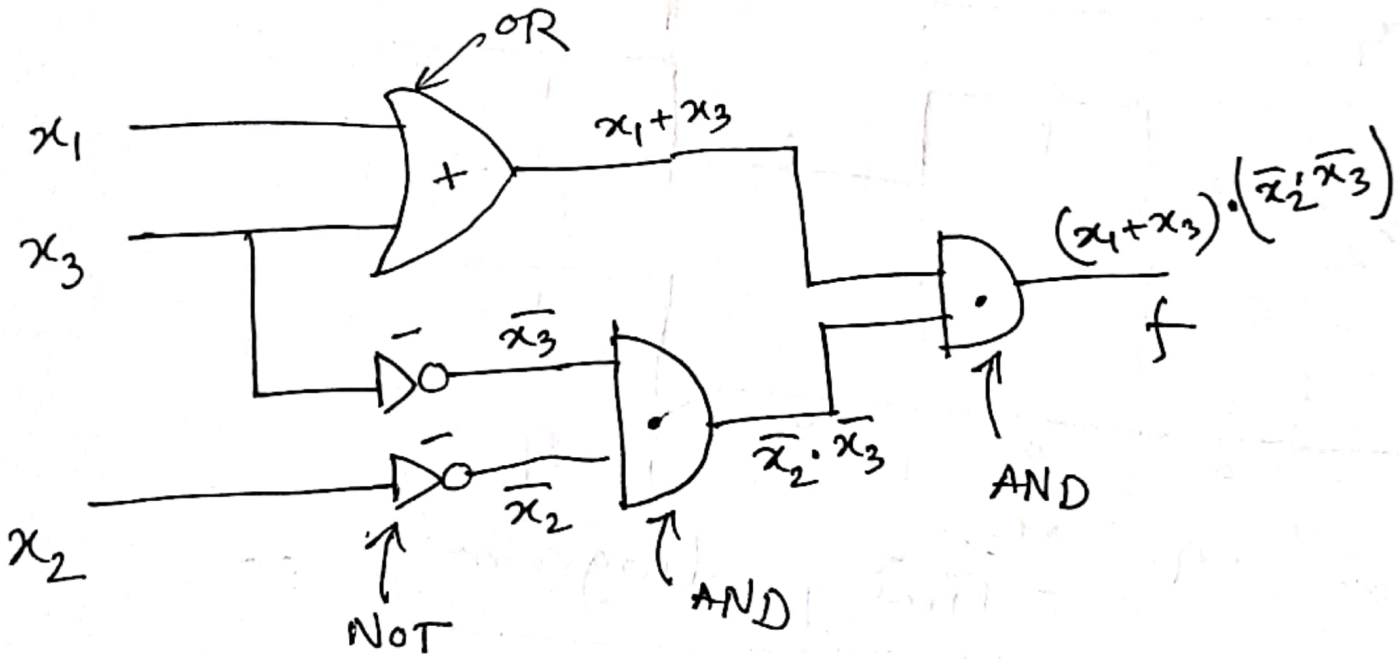
$$f(x_1, x_2) = \overline{x_1 + x_2}$$

NOR gate

OR + NOT

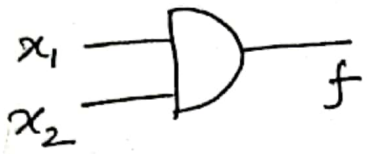


$$f(x_1, x_2, x_3) = x_1 \cdot \bar{x}_3 + \bar{x}_2 \cdot x_3$$



$$f(x_1, x_2, x_3) =$$

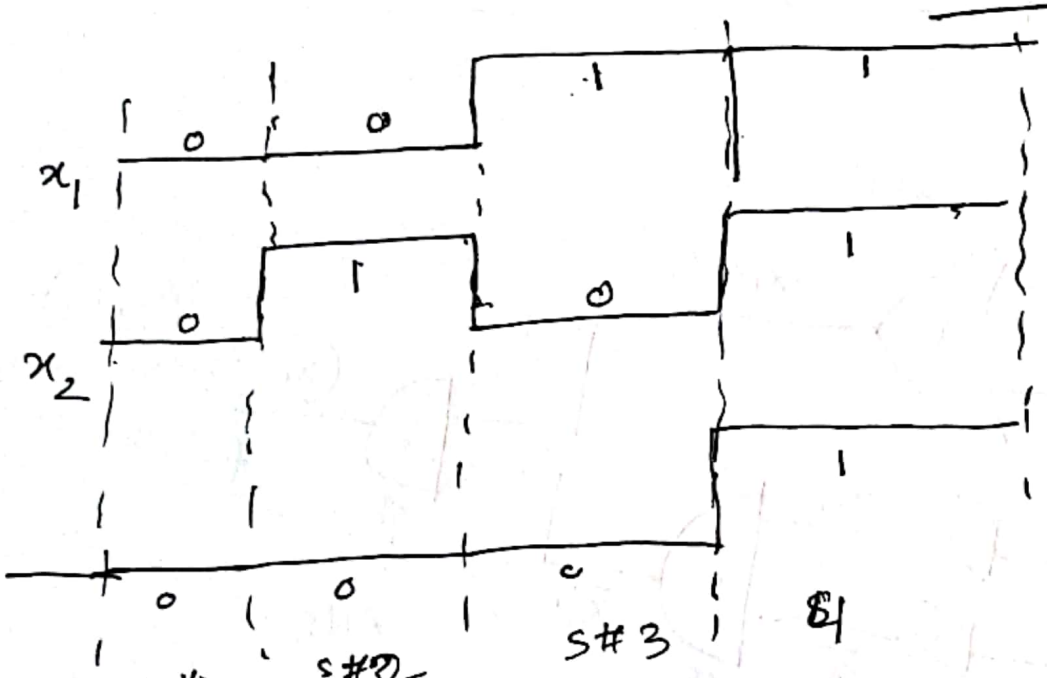
AND



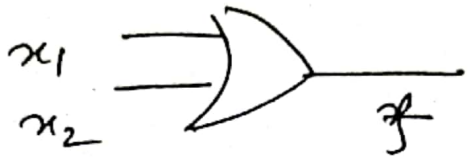
symbol

x_1	x_2	$f(x_1, x_2) = x_1 \cdot x_2$
0	0	0
0	1	0
1	0	0
1	1	1

Truth Table

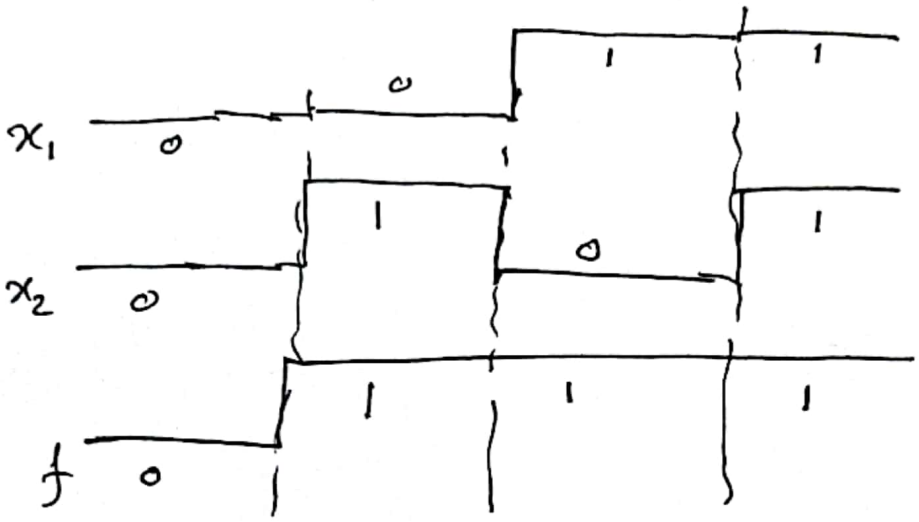


Timing diagram

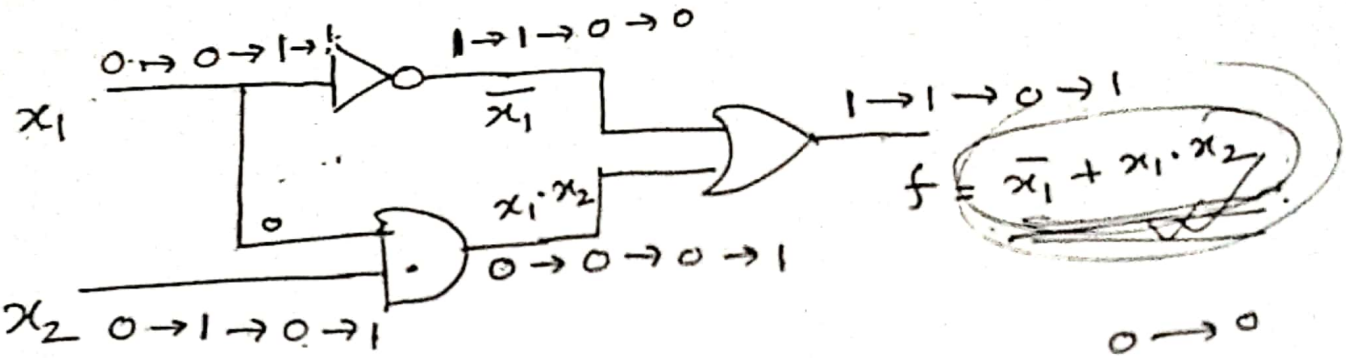


Truth Table

x_1	x_2	f
0	0	0
0	1	1
1	0	1
1	1	1



Timing diagram



Truth Table

x_1	x_2	f	
0	0	1 ✓	$\bar{x_1} \cdot \bar{x_2}$
0	1	1 ✓	$\bar{x_1} \cdot x_2$
1	0	0 ✗	
1	1	1 ✓	$x_1 \cdot x_2$

Minterm

$0 \rightarrow 0$
$1 \rightarrow 1$
$2 \rightarrow 10$
$3 \rightarrow 11$
$4 \rightarrow 100$
$5 \rightarrow 101$
$6 \rightarrow 110$
$7 \rightarrow 111$

$$f = \bar{x_1} \cdot \bar{x_2} + \bar{x_1} \cdot x_2 + x_1 \cdot x_2$$

$$= \bar{x_1} (\bar{x_2} + x_2) + x_1 \cdot x_2$$

$$= \bar{x_1} + x_1 x_2$$

1	2	f
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

$\bar{x_1} \bar{x_2} \bar{x_3}$

0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

$\bar{x_1} \bar{x_2} x_3$