Lecture - 16

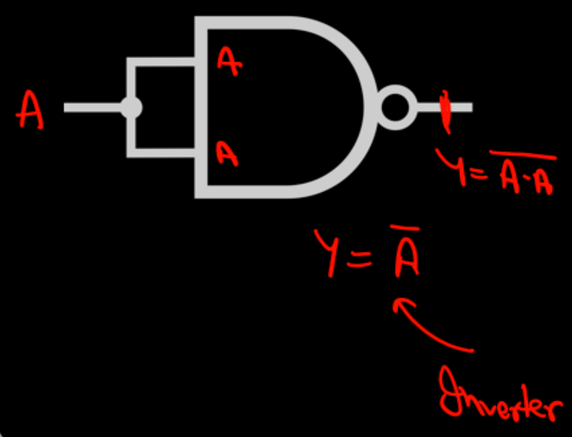
Universal Gate &

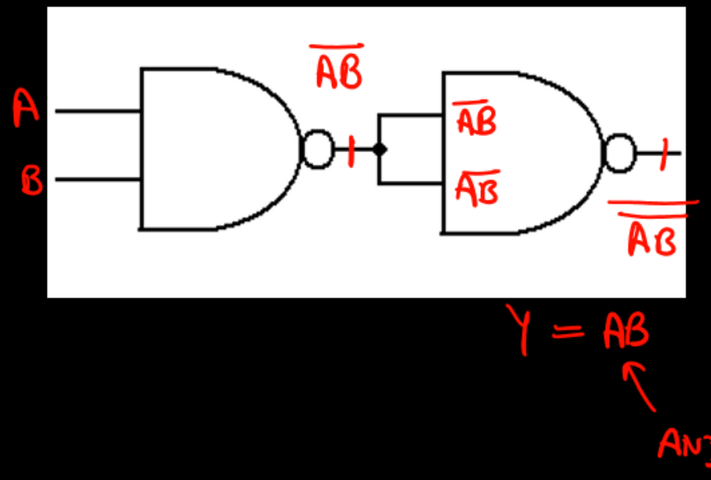
Switch Representation of Logical functions

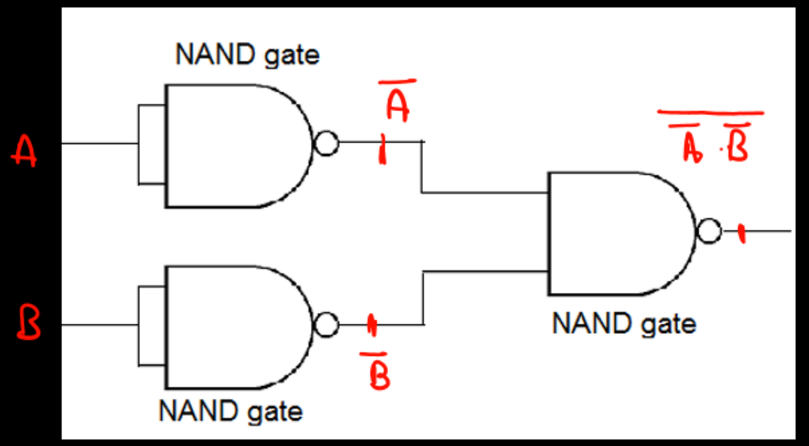
UNIVERSAL GATES

- A universal gate is a gate, which can implement any Boolean function without need to use any other gate.
- The NAND and NOR are universal gates.
- These gates are economical and easier to fabricate, and are the basic gates used in all Integrated Circuit (IC).
- In fact, an AND gate is typically implemented as a NAND gate + inverter.
- Likewise, an OR gate is typically implemented as NOR gate + inverter.
- The circuit which is designed by universal gates, are also called as Universal logic circuit.

NAND is a Universal Gate

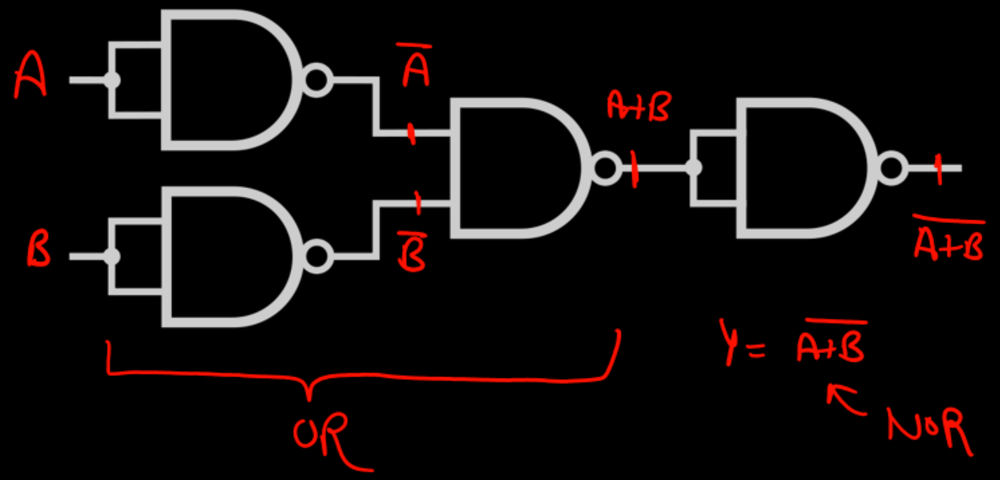


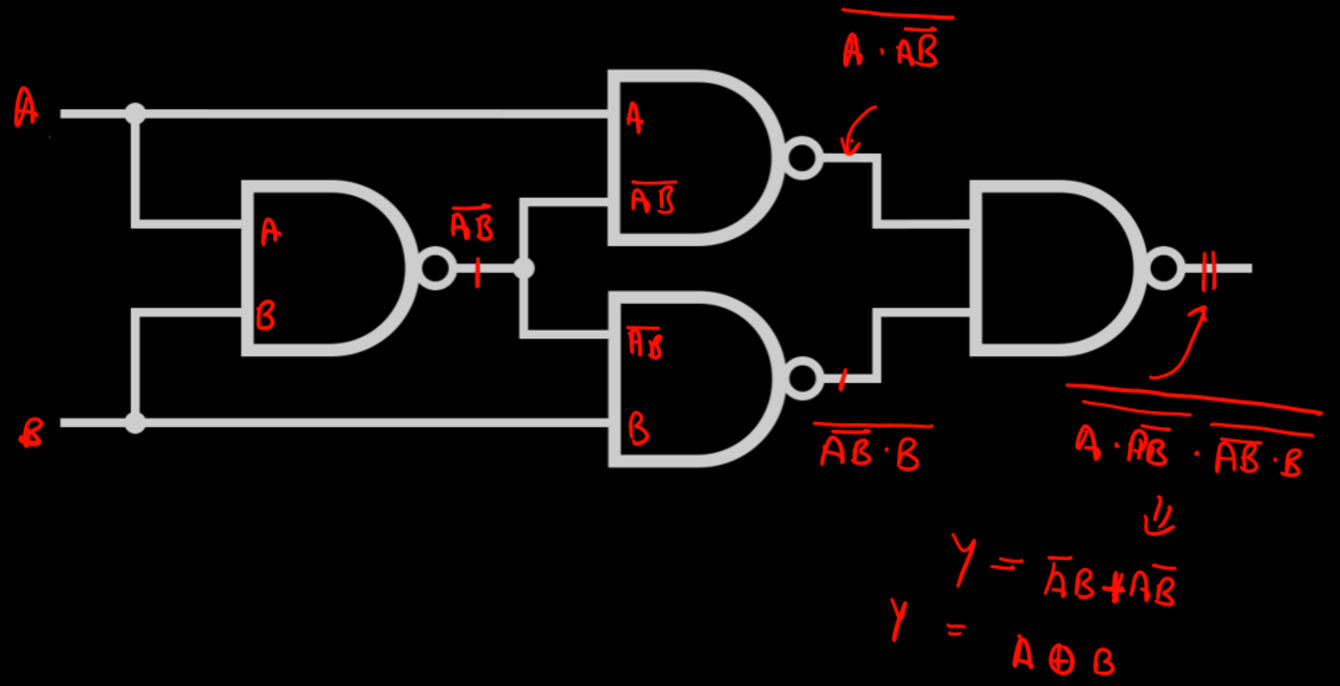


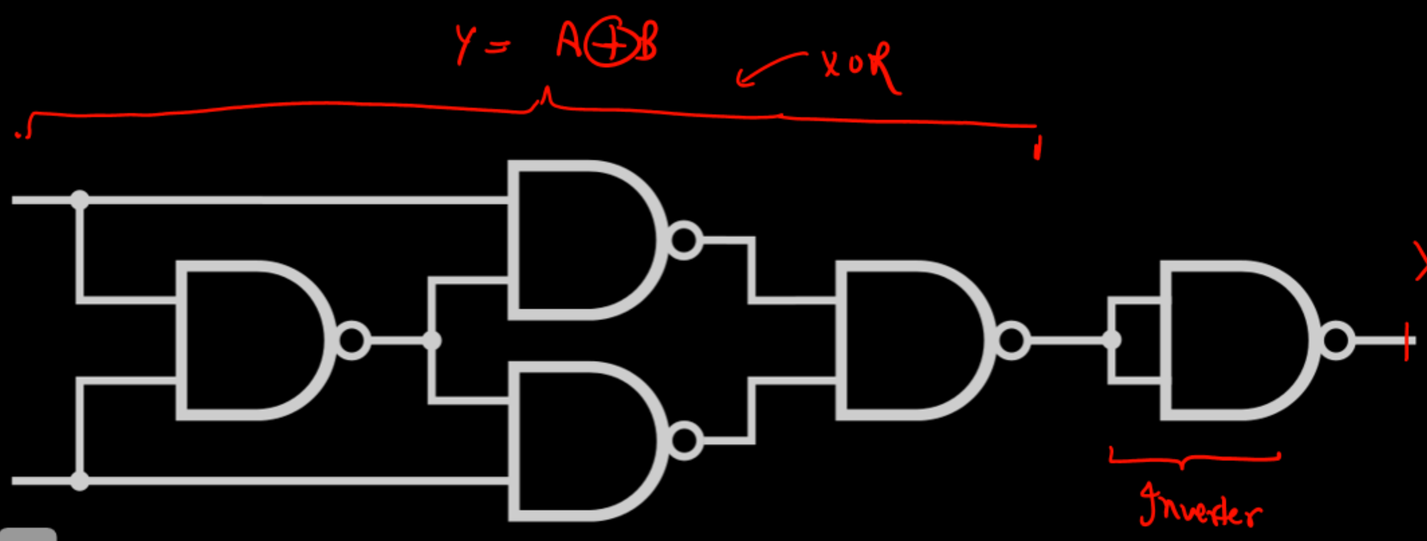


UNIVERSAL GATES

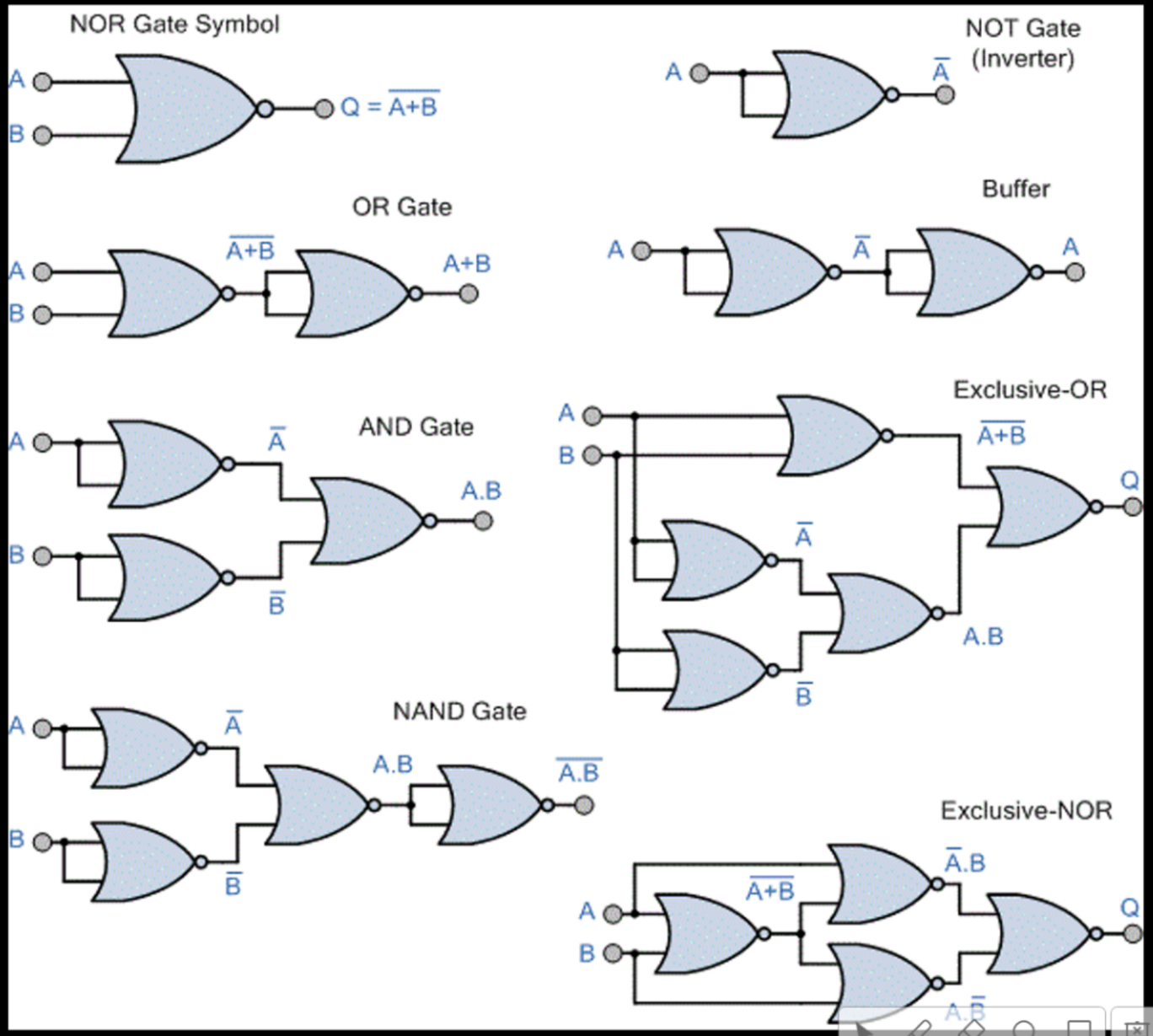
NAND is a Universal Gate







NOR is a Universal Gate



Number of Universal gates required

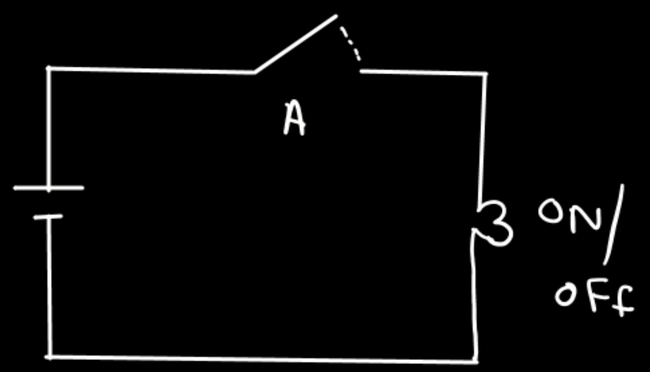
Gate	NAND	NOR
NOT	1	1
AND	2	3
OR	3	2
NAND	1	4
NOR	4	1
XOR	4	5
XNOR	5	4

Switch representation of logical function

↳ Circuit + switches

a) Buffer

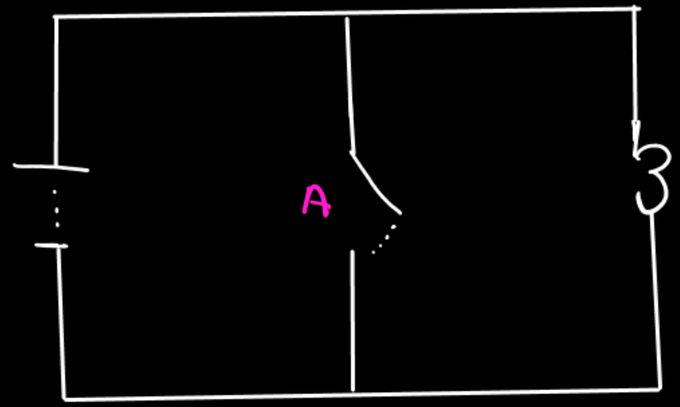
$Y = A$



A = OFF Bulb = OFF

A = ON Bulb = ON

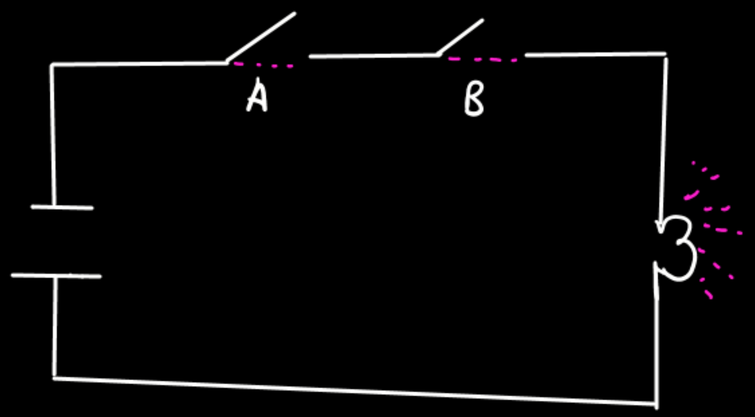
b) Inverter $Y = \overline{A}$



A = ON Bulb = OFF

A = OFF bulb = ON

c) AND

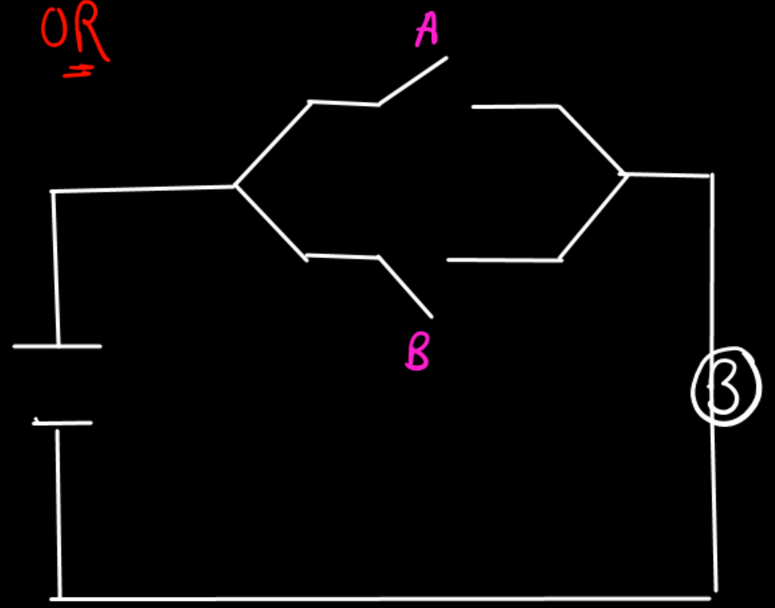


A = ON Bulb = OFF

B = ON & A = OFF ⇒ Bulb = OFF

A & B = ON ⇒ Bulb = ON

d) OR



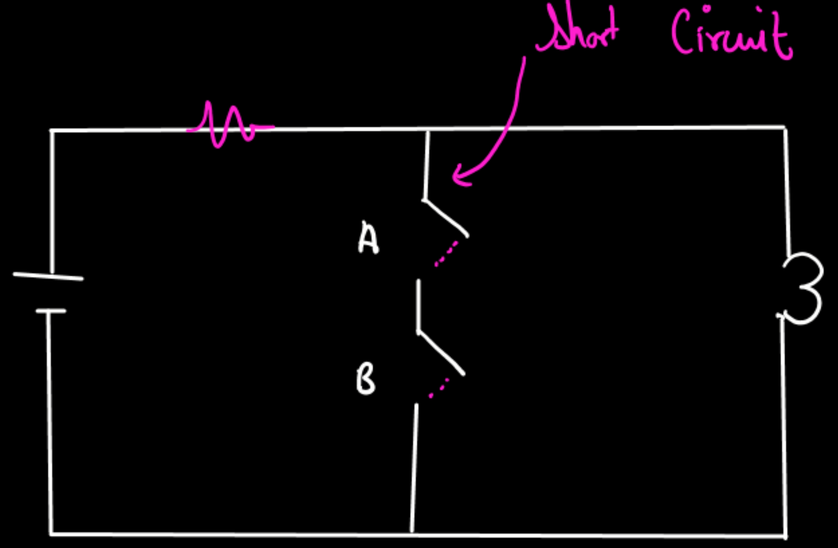
A = ON Bulb = ON

B = ON Bulb = ON

A, B = ON Bulb = ON

A, B = OFF Bulb = OFF

e) NAND Gate :



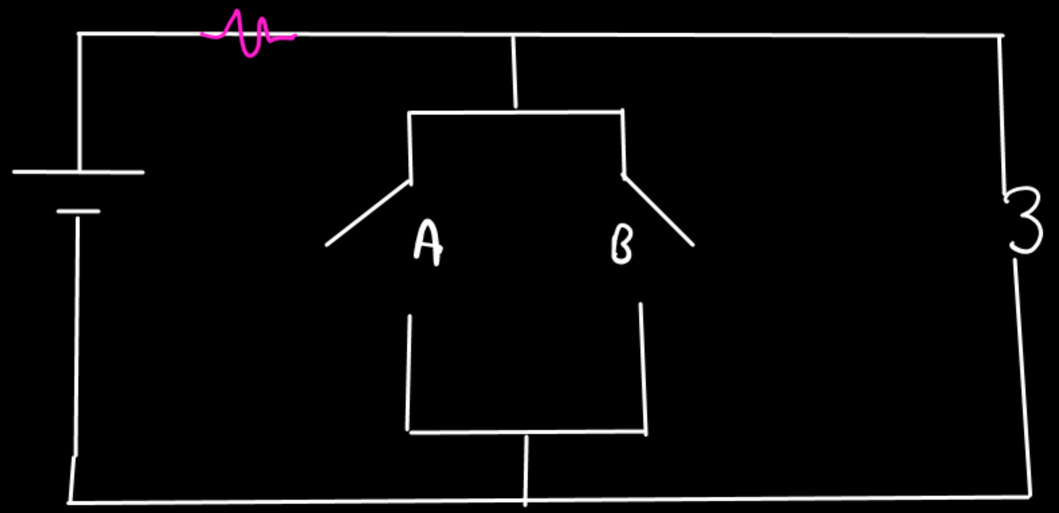
A = ON
B = ON
} Bulb = off

ON = 1
OFF = 0

$Y = \overline{AB}$

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

f) NOR Gate



A = ON , Bulb = OFF
B = ON , Bulb = OFF
A, B = OFF = Bulb = ON

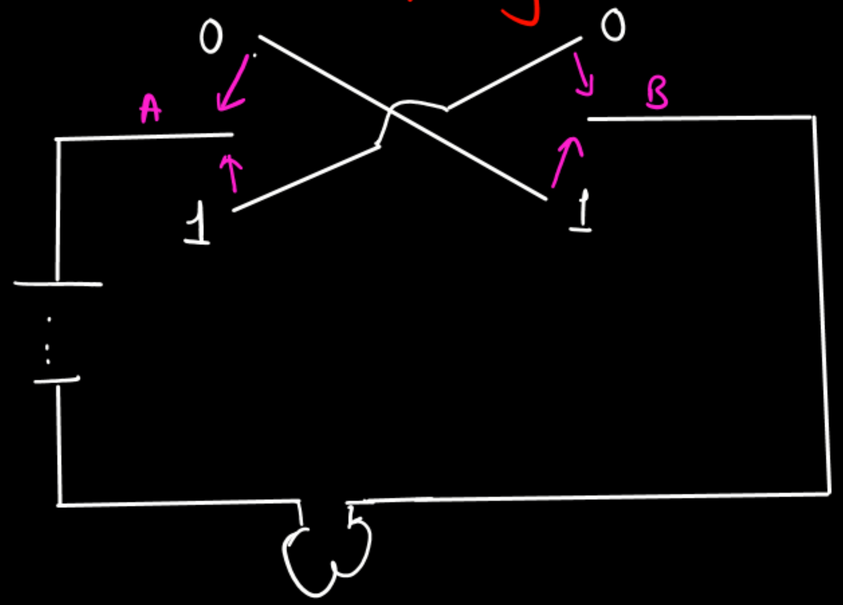
$Y = \overline{A+B}$

ON = 1
OFF = 0

A	B	A+B	$\overline{A+B}$
0	0	0	1 — high
0	1	1	0
1	0	1	0 — low
1	1	1	0

low ←

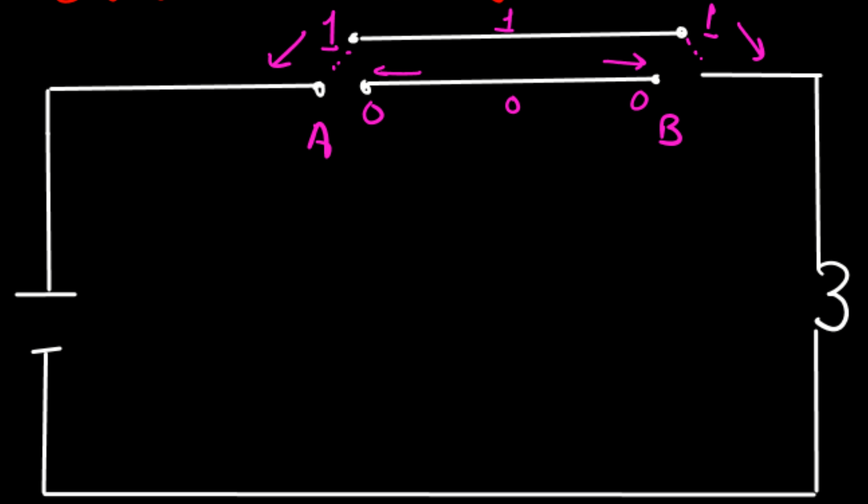
(g) XOR ⇒ Inequality detector



A = 0, B = 1 ⇒ Bulb = ON

A = 1, B = 0 ⇒ Bulb = ON

(h) XNOR → Equility Detector



A = 1, B = 1, Bulb = glow (ON)

A = 0, B = 0, Bulb = ON

⇒ Boolean Algebra