PHYS 231 Oct. 29, 2025

Today: Digital Electronics & Logic Gates

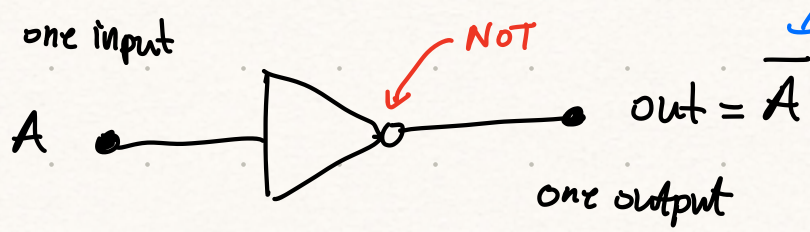
In digital electronics, we work w/ voltages that are in only one of two possible states

LO → 0 → 0 V
HI → 1 → 5 V

Digital signals are processed using logic gates.

Types of logic gates:

1. NOT (inverter)



line is read as "NOT A"

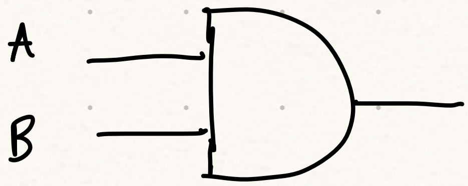
Inverter truth table

A	out = $\overline{A}$
0	1
1	0

In a truth table, list all possible inputs on left & corresponding outputs on right.

All other logic gates have two (or more) inputs.

2. AND



$out = A \cdot B$

logic operation "AND", not multiplication.

read as "A and B"

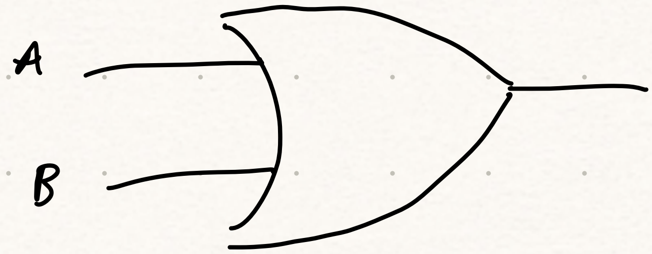
Truth table

A	B	$out = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1

outputs are like the product of the input states.

3. OR gate

read as "A OR B"



out $= A + B$

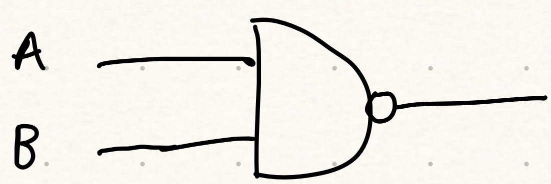
logic operation "OR", not addition.

Truth table

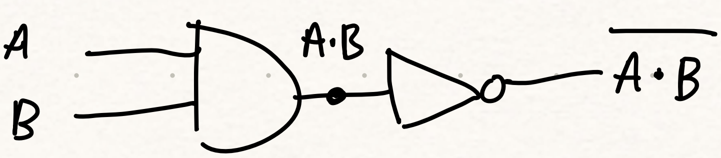
A	B	out $= A+B$
0	0	0
0	1	1
1	0	1
1	1	1

4. NAND (NOT AND)

read as "A NAND B" or "NOT A AND B".



out $= \overline{A \cdot B}$

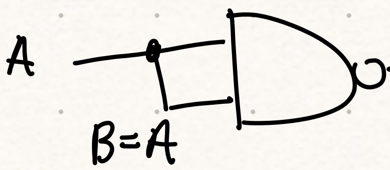


Truth Table

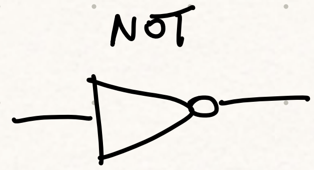
A	B	$A \cdot B$	out $= \overline{A \cdot B}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

Note: All of the other logic gates can be constructed using only NAND gates. $\rightarrow$ NAND is industry standard.

Eg. Try connecting the inputs A and B of an NAND gate together.



out = $\overline{A \cdot A}$ $\Rightarrow$



A	B	out = $\overline{A \cdot B}$
0	0	1
~~0~~	~~1~~	~~1~~
~~1~~	~~0~~	~~1~~
1	1	0

$A \neq B$

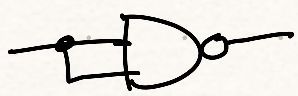
$\Rightarrow$

A	out = $\overline{A}$
0	1
1	0

Exercise for the student: Design an OR gate using only NANDs

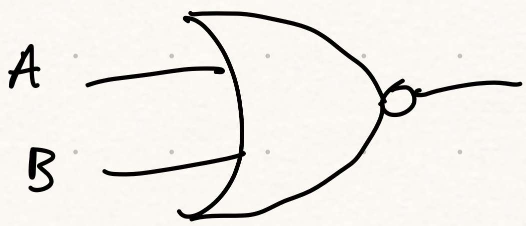
$\rightarrow$ need 3 NANDs to make an OR

$\rightarrow$ make use of NOT gate above



Need for Lab #7 next week.

5. NOR (NOT OR)

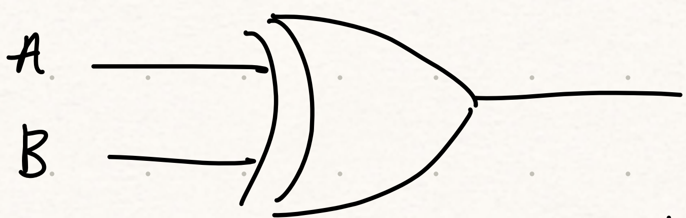


$out = \overline{A+B}$

Truth table

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

6. XOR (Exclusive OR)



$out = A \oplus B$

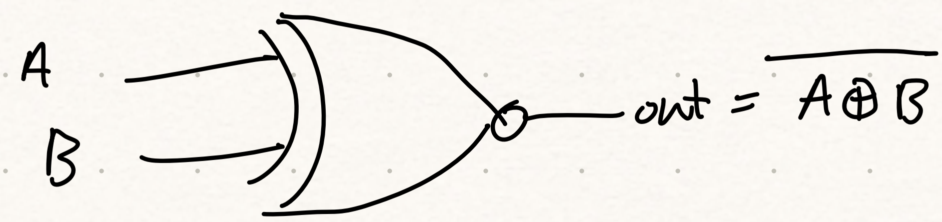
"exclusive OR" operation.

like the OR gate truth table expect input $(A,B)=(1,1)$ is excluded from producing $out = 1$.

Truth Table

A	B	$out = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

7. XNOR (NOT exclusive OR)



Truth Table

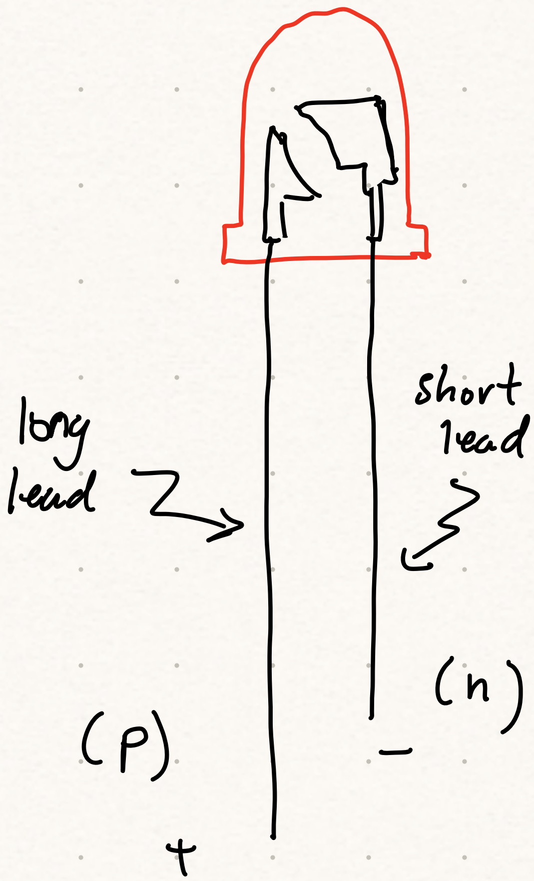
A	B	$A \oplus B$	out = $\overline{A \oplus B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	0	1

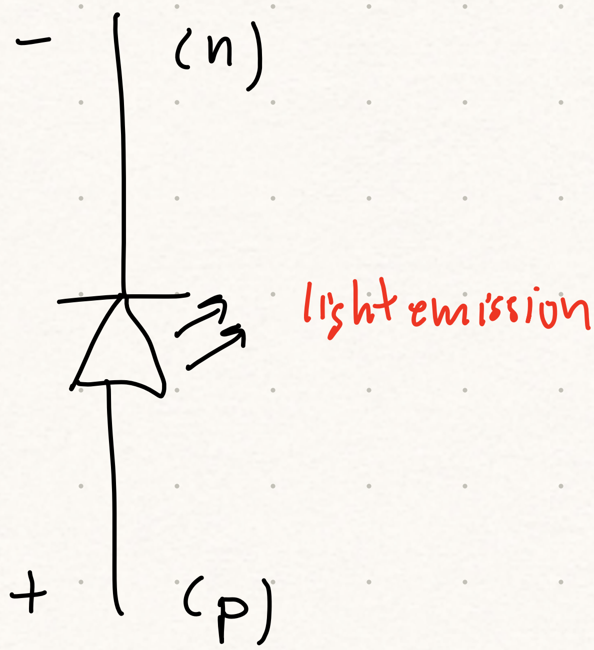
Experiment #7 (Next week) Digital Basics

Part: Test one of the available logic gates.
(NOT, NAND)

Logic gates require +5V & gnd to operate.
Check data sheets to identify where +5V & gnd go.

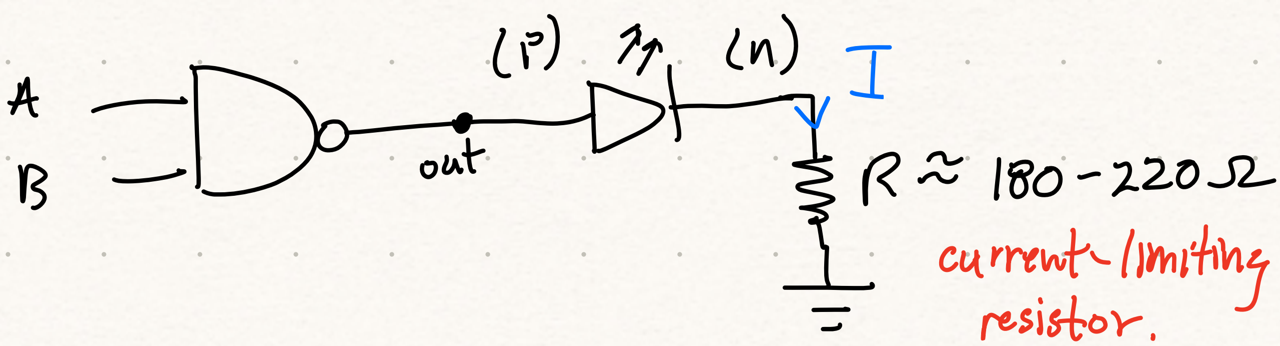
Use light-emitting diodes (LEDs) to monitor the output of a logic gate.





When pos. terminal of an LED is higher in volt. than the neg. terminal by an amount V_{thresh}, LED lights up ($V_{thresh} \sim 2V$)

To test a logic gate (NAND)



If out = 5V (HI), then LED is conducting.

$$5V - V_{thresh} - IR = 0 \Rightarrow I = \frac{5V - V_{thresh}}{R}$$

potential barrier that
we need to overcome to
make the diode conduct current.