PHYS 231 Nov. 4, 2024

Digital Electronics

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

LO → 0
HI → 1

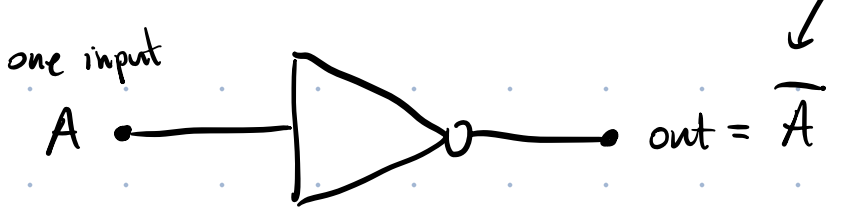
Typically 0V will correspond to (LO, 0)
5V " " " (HI, 1)

Digital signals are processed using logic gates.

Types of logic gates:

1. NOT (inverter)

denotes "NOT A".



(A logic gate, not an op amp).

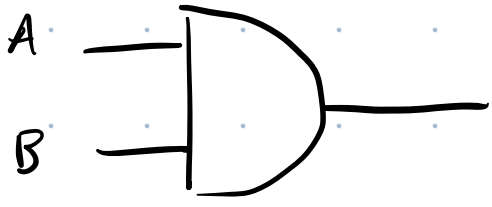
Inverter Truth Table

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

possible inputs

All possible inputs are listed on left, & corresponding outputs are listed on right.

2. AND



out = A • B

logic operation "AND", not multiplication

read as "A AND B"

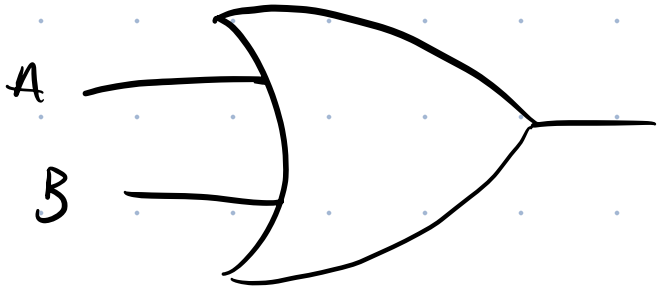
truth table

A	B	out = A·B
0	0	0
0	1	0
1	0	0
1	1	1

output is LO unless both A AND B are HI.

3. OR gate

read as "A OR B"



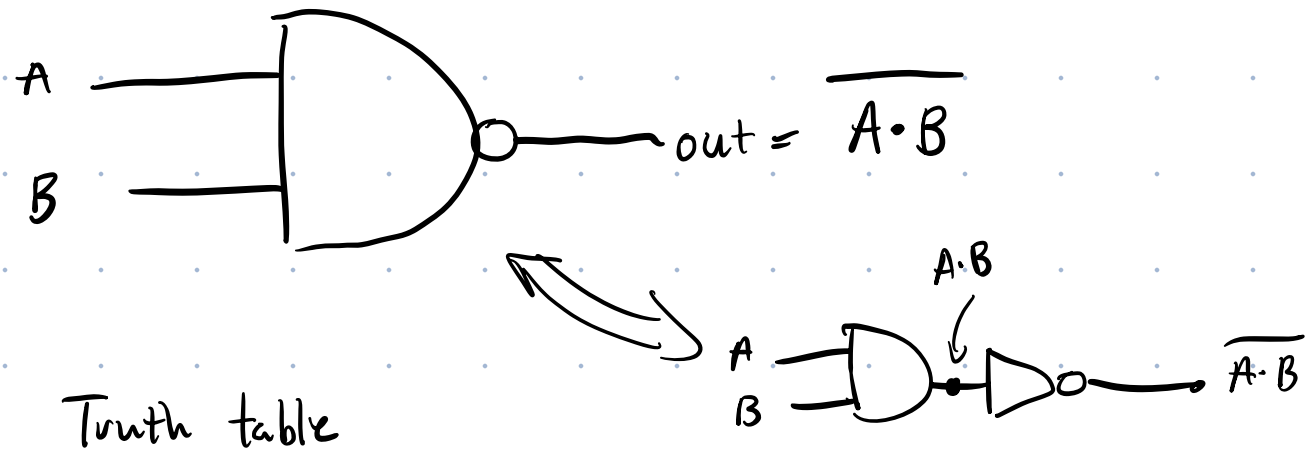
out = A + B

logical OR operation, 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)

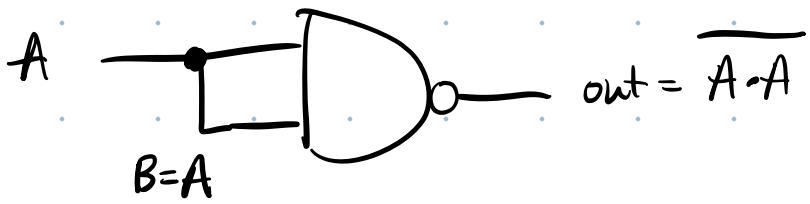


Truth table

A	B	A · 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. ∴ NAND has become the industry standard.

Eg. Try connecting A & B inputs of a NAND together.



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

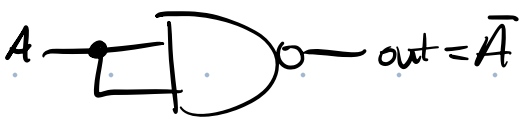
$A \neq B$

$\Rightarrow$

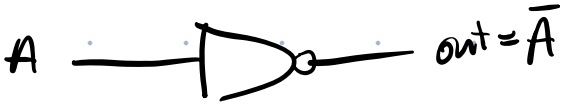
A	out = $\overline{A \cdot A}$
0	1
1	0

truth table of a NOT gate

∴



$\Updownarrow$



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

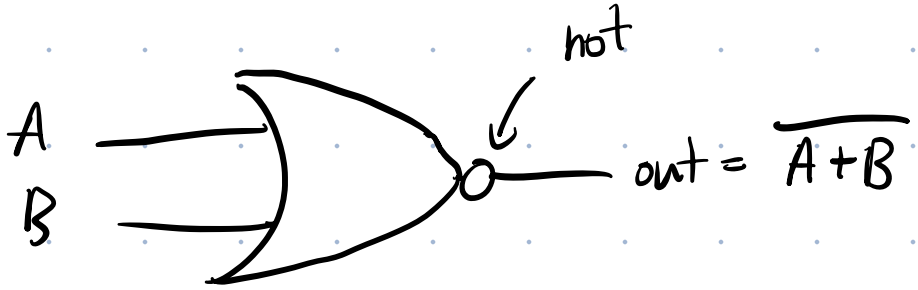
→ need 3 NANDs to make an OR

→ make use of NOT gate (above)

Exp. #7 on Thursday

Other Logic gates

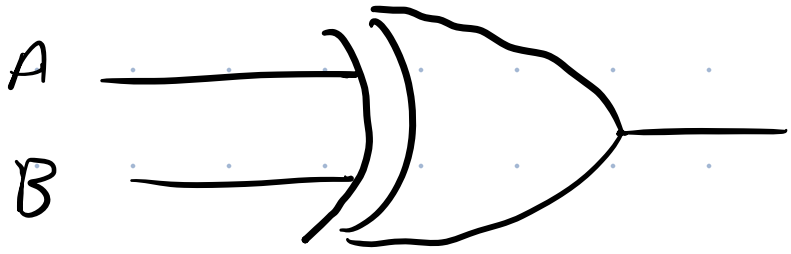
NOR (NOT OR)



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

XOR (Exclusive OR)

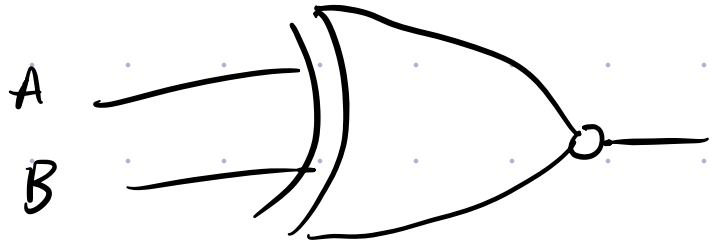
"exclusive OR operation."



A	B	out = A⊕B
0	0	0
0	1	1
1	0	1
1	1	0

like the OR gate output except the last line is "excluded" from being #1.

XNOR (NOT Exclusive OR)



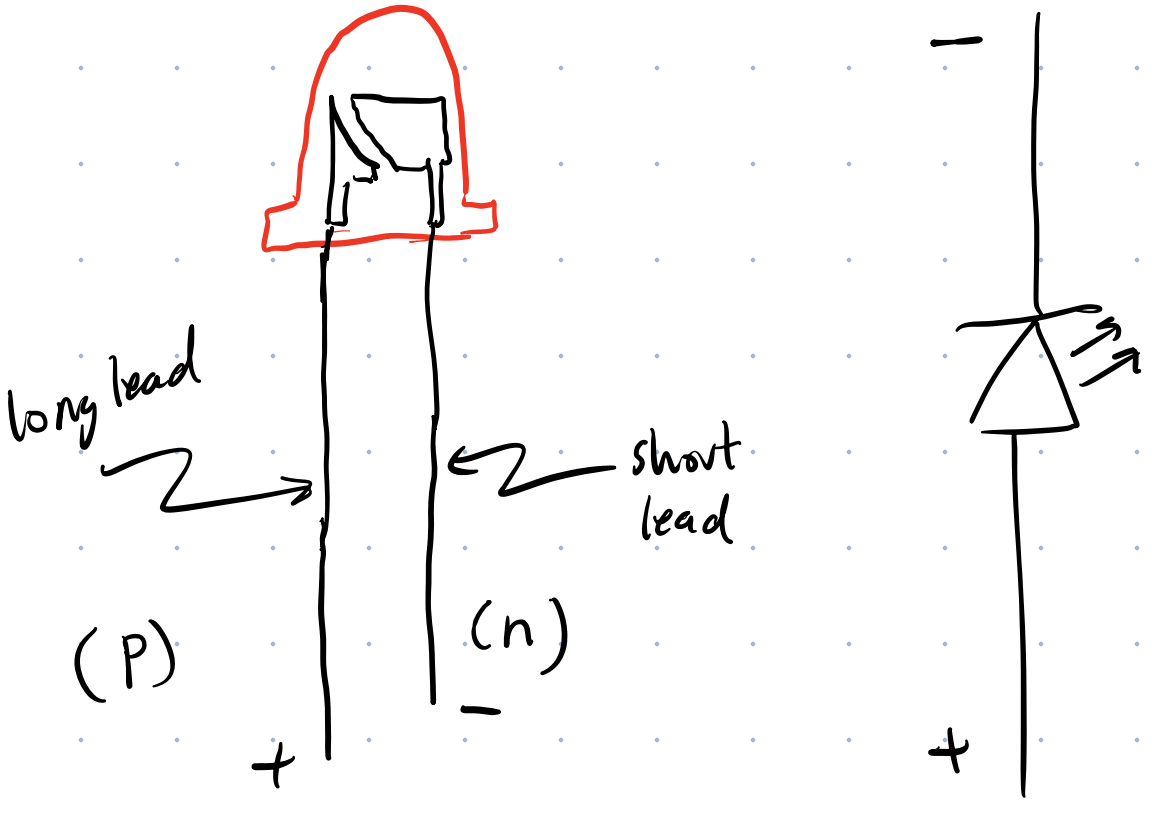
A	B	A⊕B	out = $\overline{A \oplus B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	0	1

Experiment #7 Thursday (Digital Basics).

Part 1: Test one of the available logic gates. (NOT, NAND).

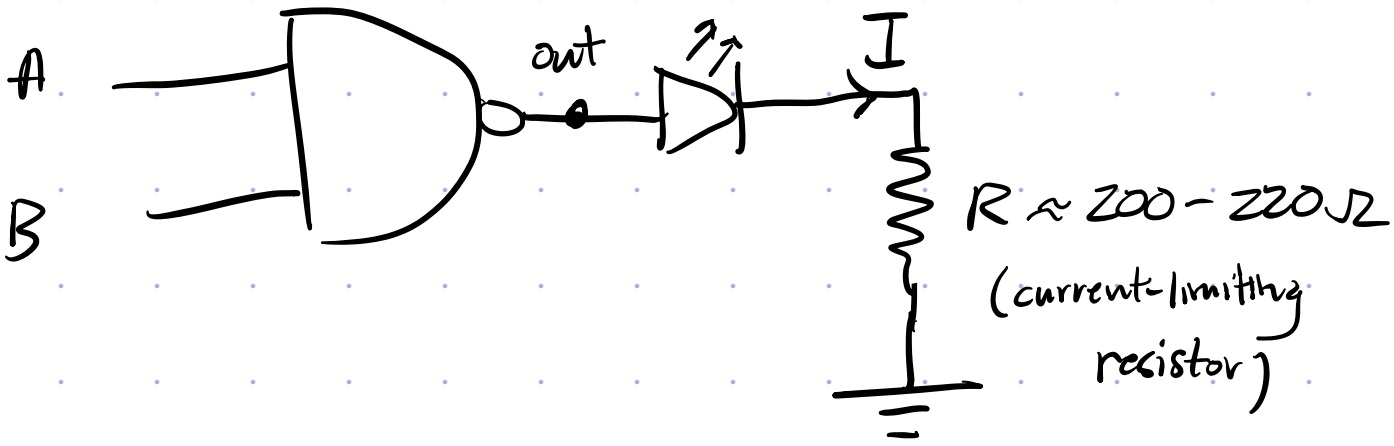
Logic gates require +5V & gnd to operate. Check data sheets to identify where +5 & gnd go.

Use light-emitting diode (LED) 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. ($\Delta V \sim 2V$)

To test a logic gate: (NAND, for example)



If out = 5V,

then $\therefore \quad 5V - V_{thresh} - IR = 0$

$$\therefore \quad I = \frac{5V - V_{thresh}}{R}$$