

Recitation 9/25

Welcome back! :)

**Vote Ash, Ahmed, and Garrett
for best recitation TAs**

Schedule for Today

- Connecting circuits and boolean algebra
- Logic Gates
- CMOS
- User input demo in C (echo.c)

Boolean Algebra

Boolean rules

❖ Identity

- $A \& 1 = A$
- $A \& 0 = 0$
- $A | 1 = 1$
- $A | 0 = A$
- $\sim\sim A = \text{NOT NOT } A = A$

❖ Associative

- $A \& (B \& C) = (A \& B) \& C$
- $A | (B | C) = (A | B) | C$

❖ Distributive

- $A \& (B | C) = (A \& B) | (A \& C)$
- $A | (B \& C) = (A | B) \& (A | C)$

❖ More Identity

- $A \& A = A$
- $A | A = A$
- $A \& \sim A = 0$
- $A | \sim A = 1$

❖ De Morgan's Law

- $\sim(A \& B) = \sim A | \sim B$
- $\sim(A | B) = \sim A \& \sim B$

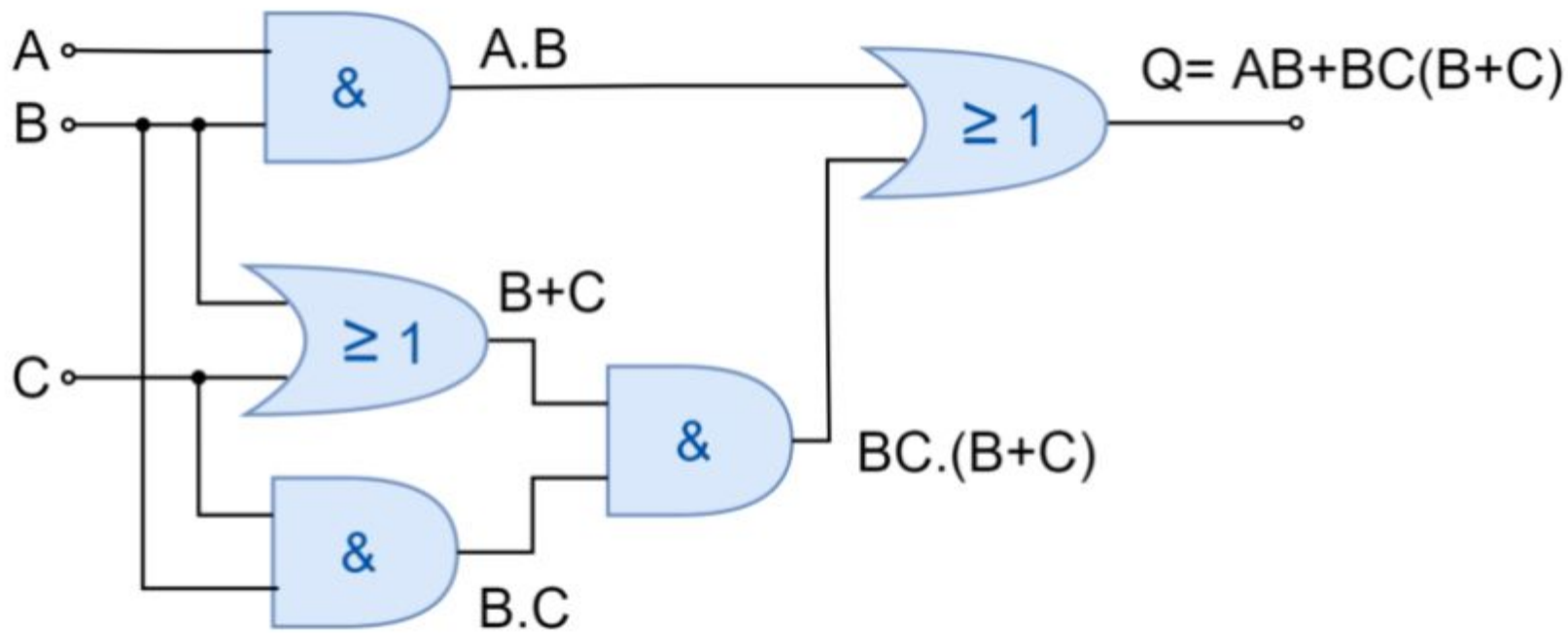
Other formats you might see:

$A \& B \rightarrow A * B$ or $A \wedge B$

$A | B \rightarrow A + B$ or $A \vee B$

$\sim A \rightarrow !A$ or A' or $\neg A$

Intuitively, you can think of $A * B$ as saying “both A **and** B have to be 1 for this not to be 0” and $A + B$ as saying “only one of these have to be 1 for this to be greater than 0”.



Simplify: $Z = A \& ((A \mid \sim A) \mid \sim B)$

$$Z = A \ \& \ ((A \mid \sim A) \mid \sim B)$$

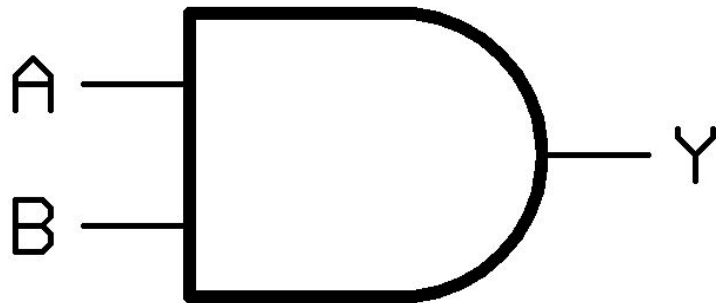
$$Z = A \ \& \ (\text{True} \mid \sim B)$$

$$Z = A \ \& \ \text{True} = A$$

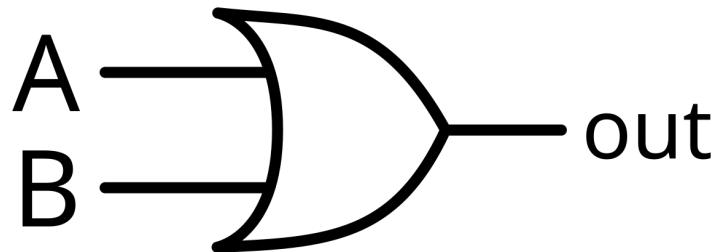
Logic Gates

Symbols

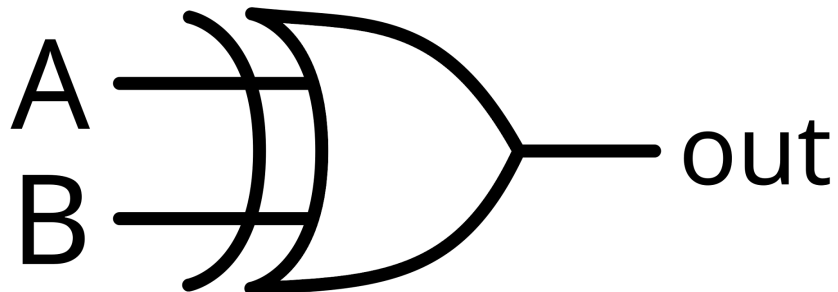
AND Gate



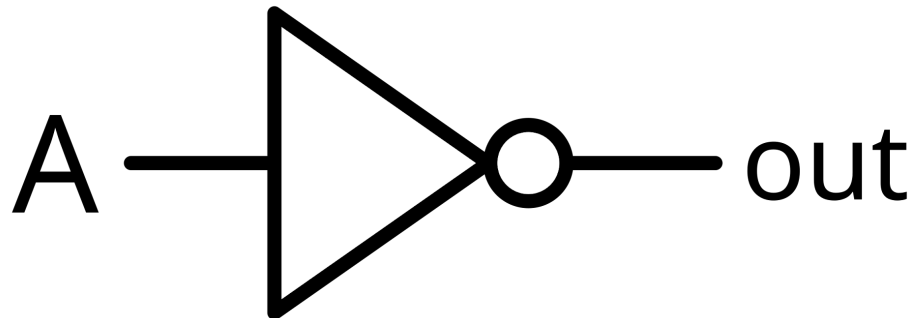
OR Gate



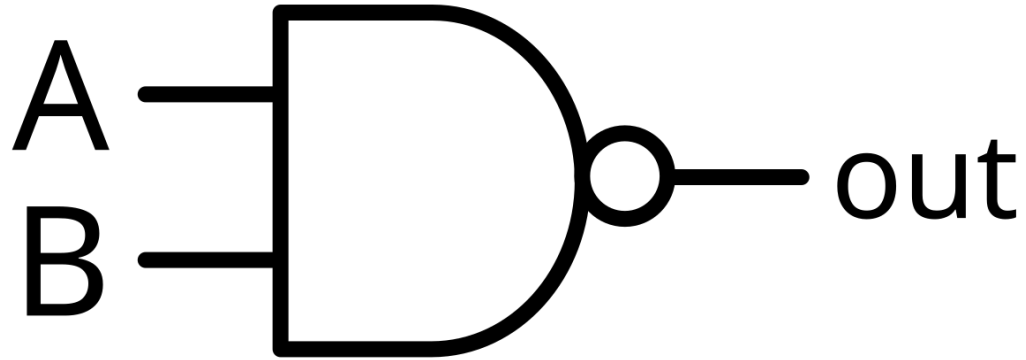
XOR Gate



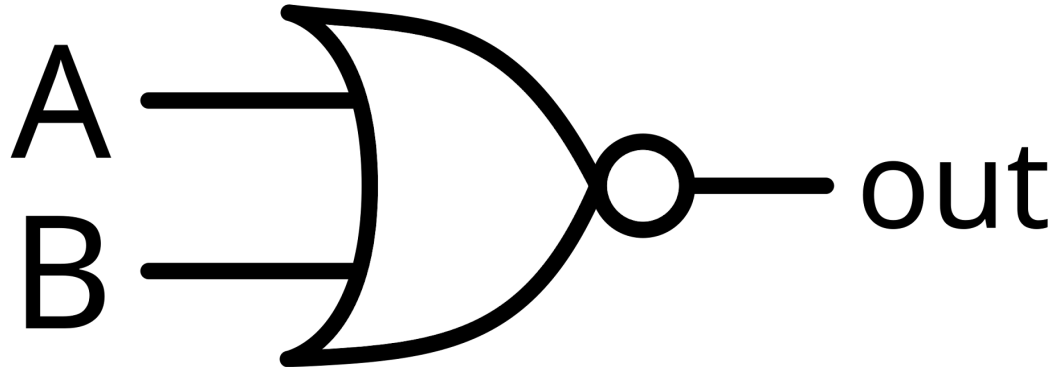
NOT Gate



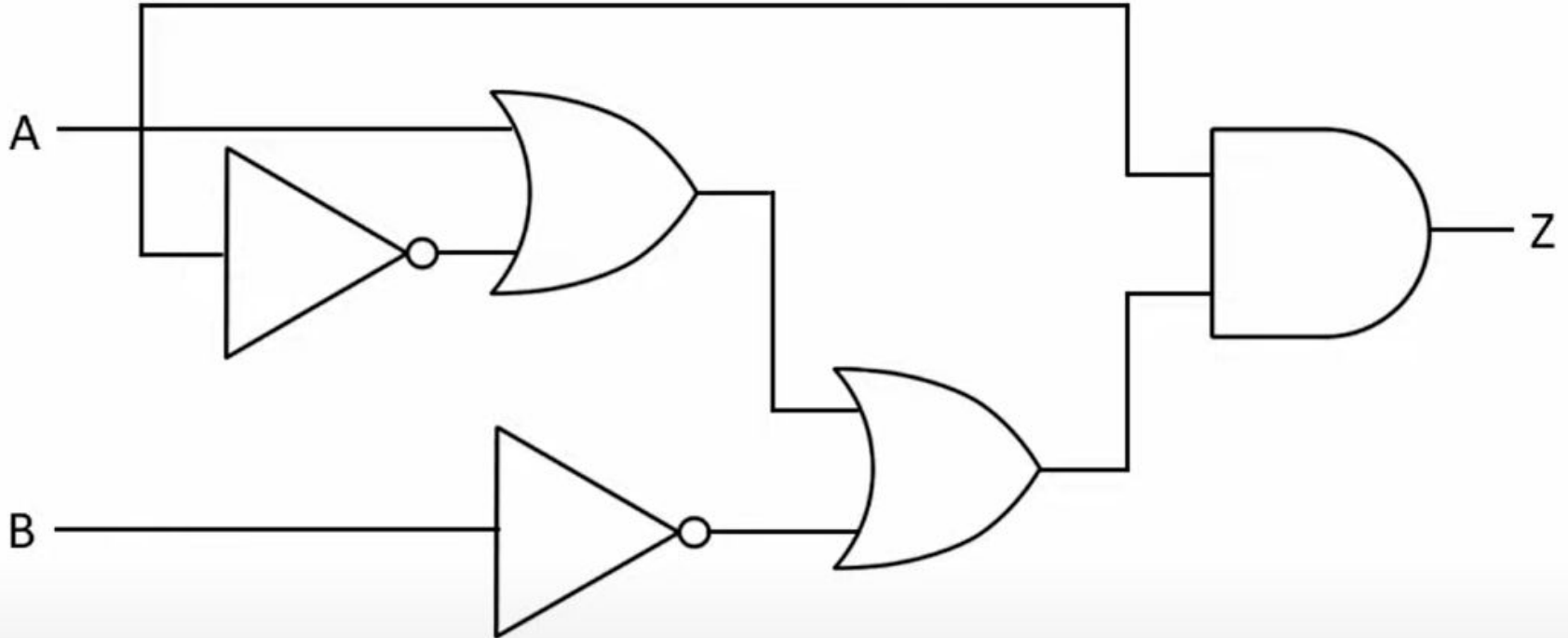
NAND Gate



NOR Gate



Write a truth table for Z:

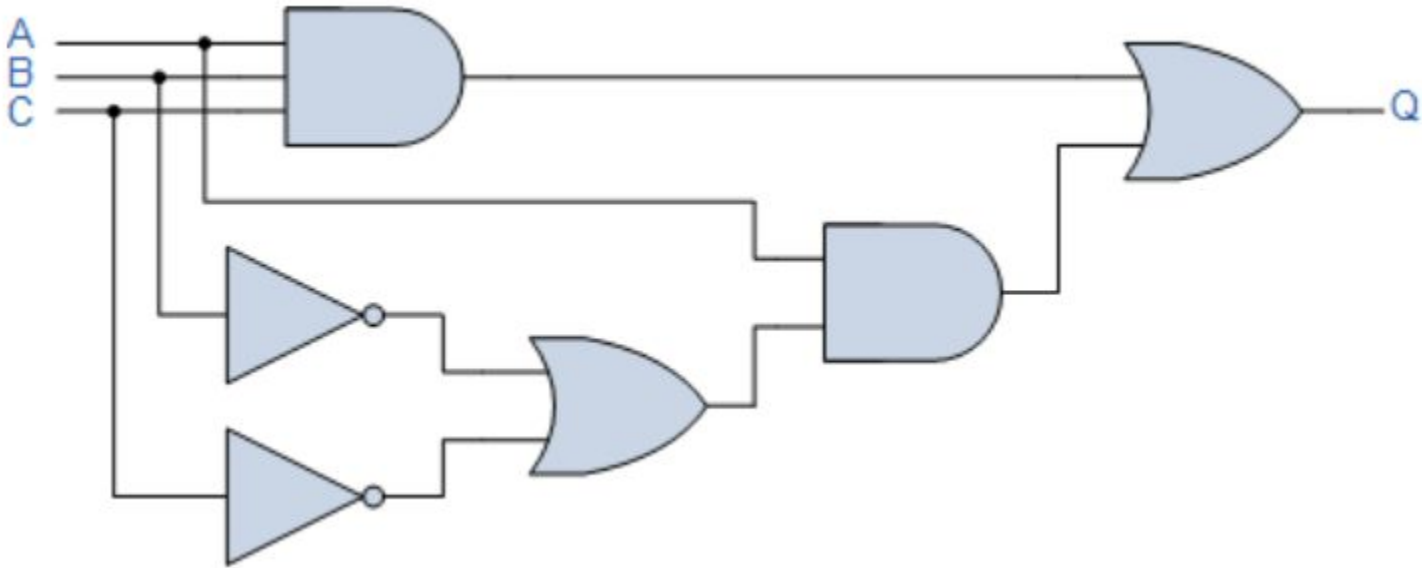


A	B	Z
0	0	0
0	1	0
1	0	1
1	1	1

So $Z = A???????$

...yes

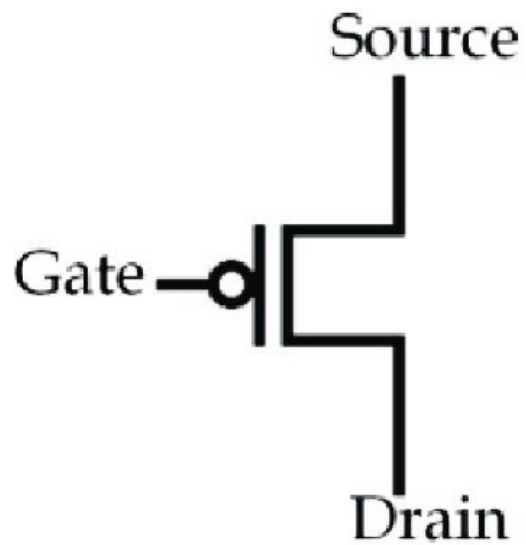
Write a truth table for:



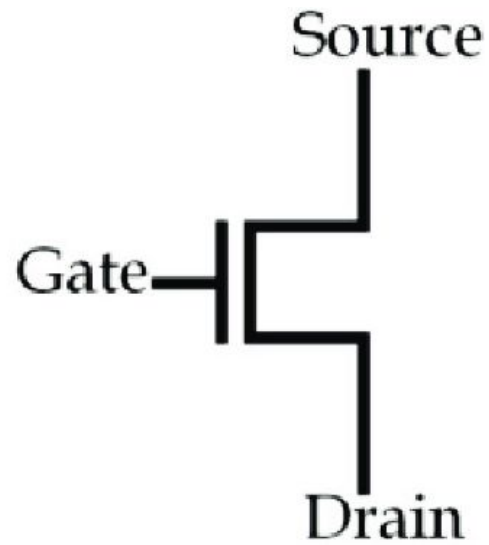
Answer: only for people who go to recitation

Transistor Review

Label & Conditions?



(a)



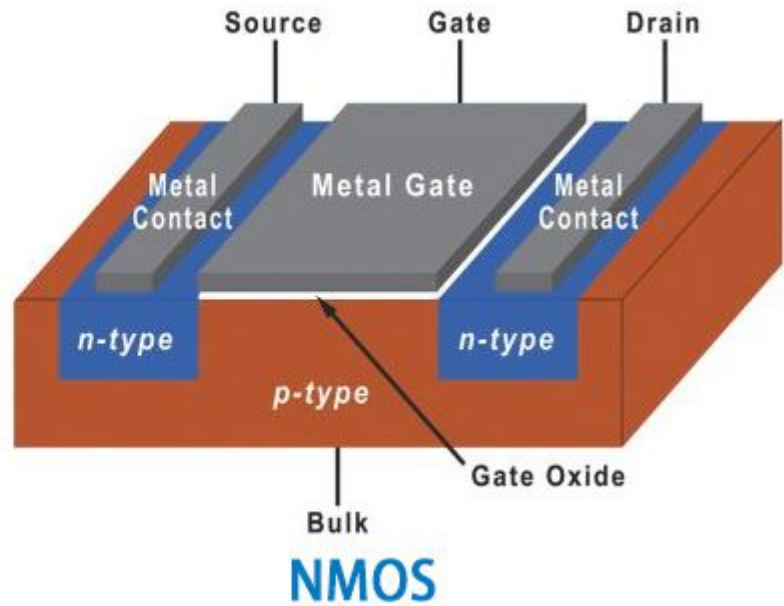
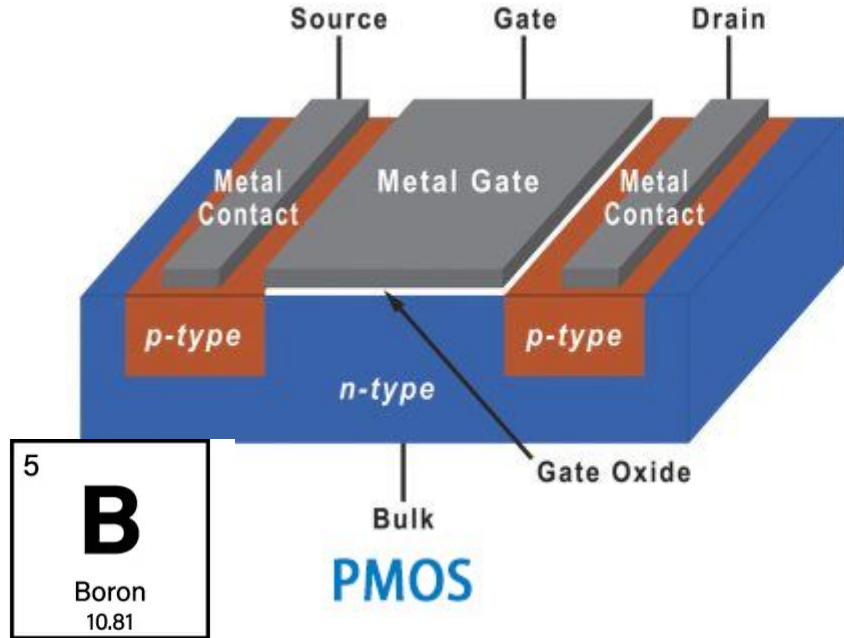
(b)

A little Chemistry

																		15 P Phosphorus [Ne] 3s ² 3p ³ Nonmetal																		
																		Atomic number																		
																		Symbol																		
																		Name																		
																		Electron configuration																		

																		13	14	15	16	17	18																																															
																		5	6	7	8	9	10																																															
																		B	C	N	O	F	Ne																																															
																		Boron	Carbon	Nitrogen	Oxygen	Fluorine	Neon																																															
																		13	14	15	16	17	18																																															
																		Al	Si	P	S	Cl	Ar																																															
																		Aluminium	Silicon	Phosphorus	Sulfur	Chlorine	Argon																																															
																		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36																																			
																		K	Ca	Sc	Ti	Va	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr																																			
																		Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium	Arsenic	Selenium	Bromine	Krypton																																			
																		37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54																																			
																		Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																																			
																		Rubidium	Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Technetium	Ruthenium	Rhodium	Palladium	Silver	Cadmium	Indium	Tin	Antimony	Tellurium	Iodine	Xenon																																			
																		55	56	57 - 71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86																																			
																		Cs	Ba	lanthanides	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																																			
																		Cesium	Barium																			Hafnium	Tantalum	Tungsten	Rhenium	Osmium	Iridium	Platinum	Gold	Mercury	Thallium	Lead	Bismuth	Polonium	Astatine	Radon																		
																		87	88	89 - 103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118																																			
																		Fr	Ra	Actinides	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og																																			
																		Francium	Radium																			Rutherfordium	Dubnium	Seaborgium	Bohrium	Hassium	Meitnerium	Darmstadtium	Roentgenium	Copernicium	Nihonium	Flerovium	Moscovium	Livermorium	Tennessine	Oganesson																		
																		57	58	59	60	61	62	63	64	65	66	67	68	69	70	71																																						
																		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu																																						
																		Lanthanum	Cerium	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium	Thulium	Ytterbium	Lutetium																																						
																		89	90	91	92	93	94	95	96	97	98	99	100	101	102	103																																						
																		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr																																						
																		Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium																																						

A little Chemistry

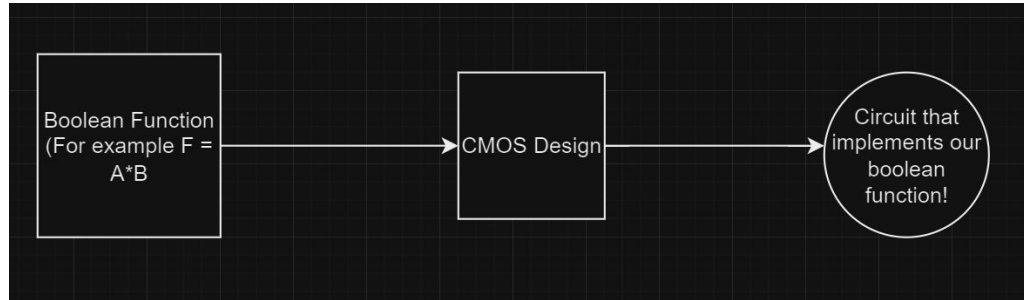
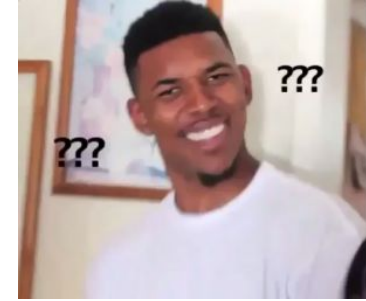


5
B
Boron
10.81

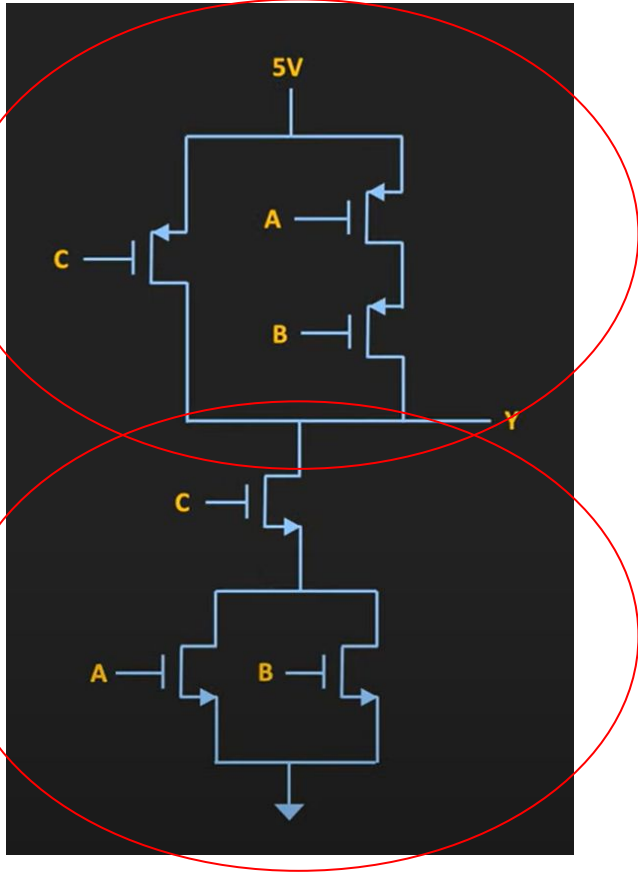
CMOS

So what is CMOS and what's its purpose?

- CMOS: Complementary Metal Oxide Semiconductor



Parts of a CMOS network!



Pull Up Network



Pull Down Network

A Simple Example: AND2

1) **Boolean function: $Y = (A*B)$**

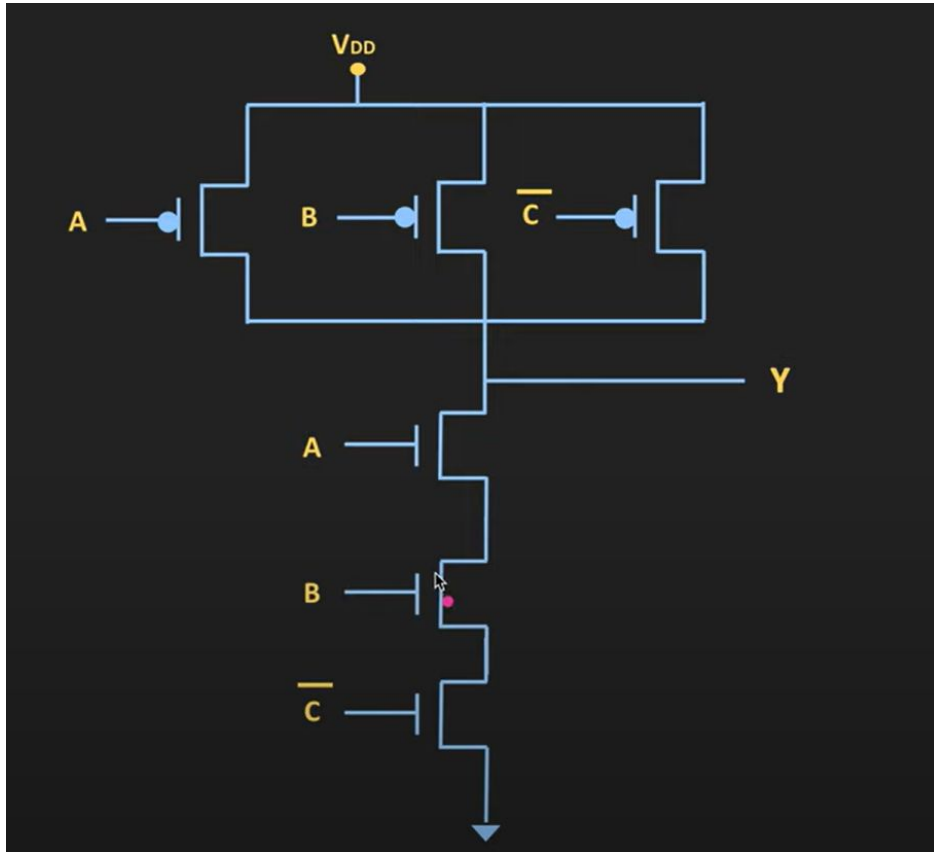
2) **Truth Table:**

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

3) **PUN**

4) **PDN**

Going from CMOS -> Function



To connect Ground to Y:

$$A = B = \sim C = 1$$

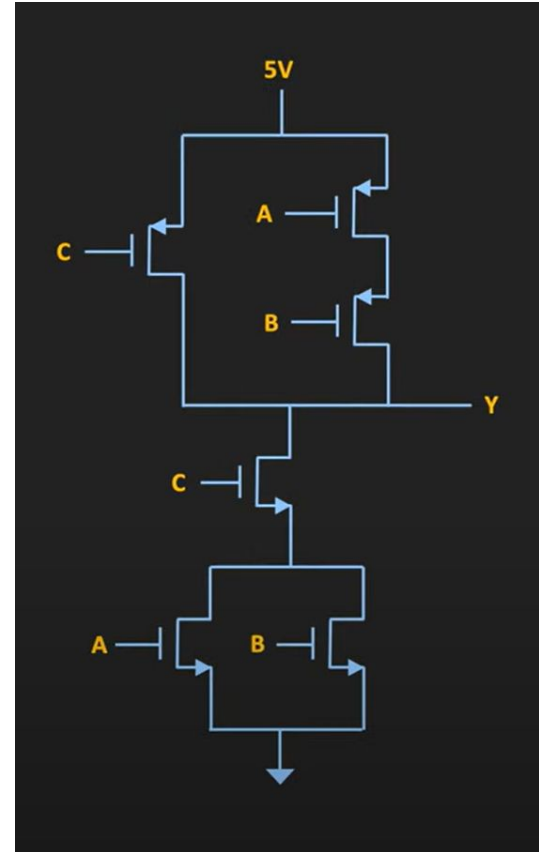
Therefore: GND -> $Y = A \& B \& \sim C$

Invert this expression: $\sim(A \& B \& \sim C)$

Optional Simplify: $\sim A \mid \sim B \mid C$

Going from Function -> CMOS

- $Y = C' + (A'B')$



If you're looking for this code, it's in edpost #589 titled "Recitation today!"

Demo: echo.c

This is helpful for HW03