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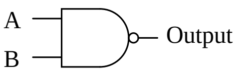
Logic Gates and Boolean Algebra

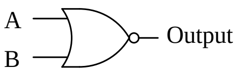
Questions

Question 1

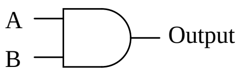
Identify each of these logic gates by name, and complete their respective truth tables:



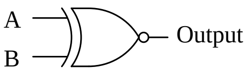
A	B	Output
0	0	
0	1	
1	0	
1	1	



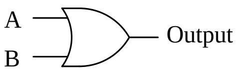
A	B	Output
0	0	
0	1	
1	0	
1	1	



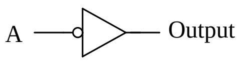
A	B	Output
0	0	
0	1	
1	0	
1	1	



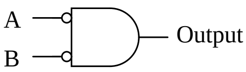
A	B	Output
0	0	
0	1	
1	0	
1	1	



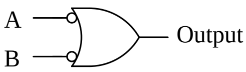
A	B	Output
0	0	
0	1	
1	0	
1	1	



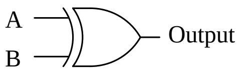
A	Output
0	
1	



A	B	Output
0	0	
0	1	
1	0	
1	1	



A	B	Output
0	0	
0	1	
1	0	
1	1	

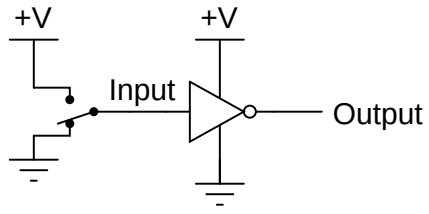


A	B	Output
0	0	
0	1	
1	0	
1	1	

file 02776

Question 2

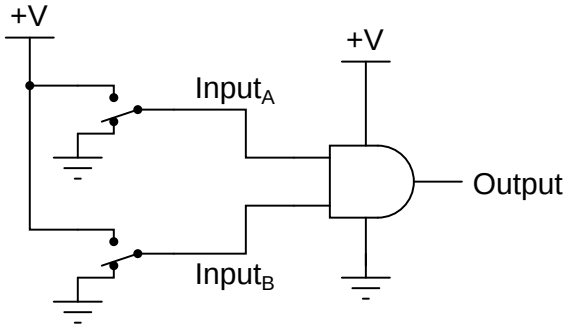
Identify the type of logic gate shown in this schematic diagram, and explain why it has the name it does:



file 02761

Question 3

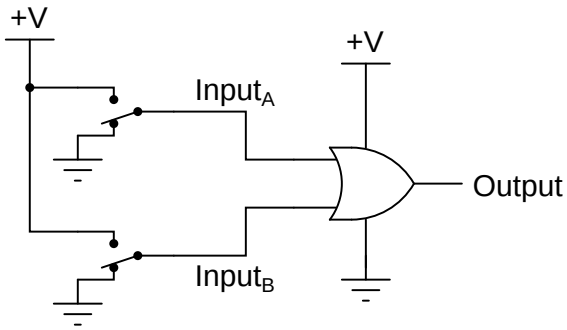
Identify the type of logic gate shown in this schematic diagram, and explain why it has the name it does:



file 02760

Question 4

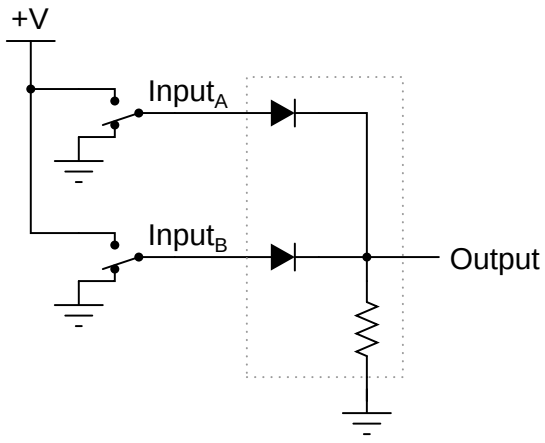
Identify the type of logic gate shown in this schematic diagram, and explain why it has the name it does:



file 02759

Question 5

Crude logic gates circuits may be constructed out of nothing but diodes and resistors. Take for example this logic gate circuit:

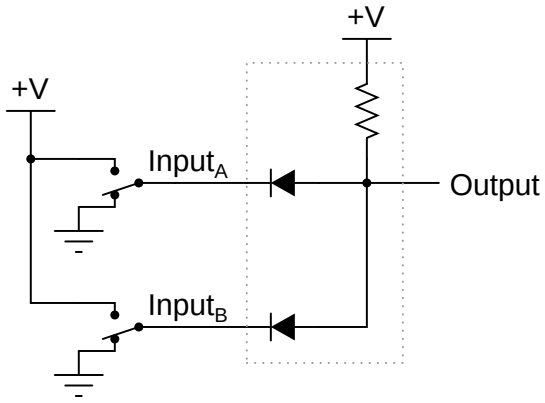


Identify what type of logic function is represented by this gate circuit (AND, OR, inverter, etc.).

file 02763

Question 6

Crude logic gates circuits may be constructed out of nothing but diodes and resistors. Take for example this logic gate circuit:

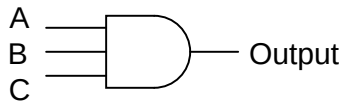


Identify what type of logic function is represented by this gate circuit (AND, OR, inverter, etc.). Also, trace the directions of all currents in this circuit.

file 02762

Question 7

Complete the truth table for a three-input AND gate:



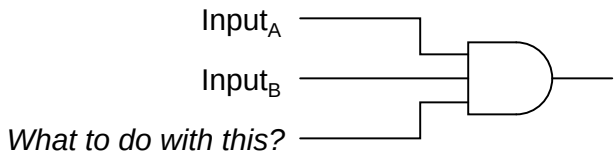
A	B	C	Output
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

file 02915

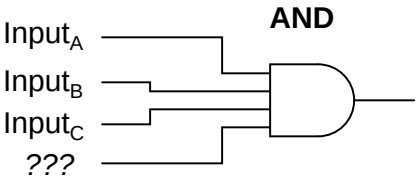
Question 8

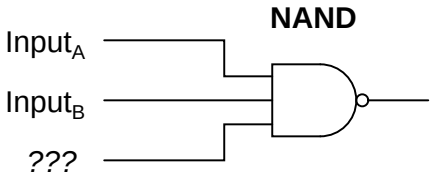
Suppose you needed a two-input AND gate, but happened to have an unused 3-input AND gate in one of the integrated circuits ("chips") already in the system you were building. Of course, you could just add another IC containing 2-input AND gates, but it seems a shame to waste the 3-input gate already there.

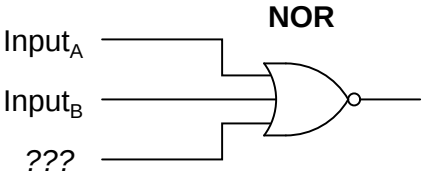
Explain what you would need to do with the third input terminal on this gate in order to use it as a 2-input AND gate:

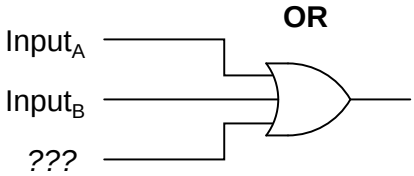


Now, explain what to do with each of the following gates' extra inputs, in order to use each of them to implement the intended function only on the remaining inputs:







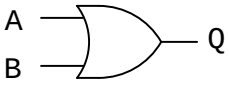


In each case, describe why your solution works.

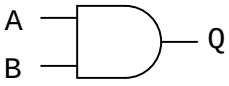
file 02948

Question 9

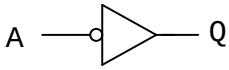
Write the Boolean expression for each of these logic gates, showing how the output (Q) algebraically relates to the inputs (A and B):



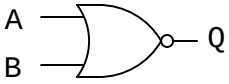
Q =



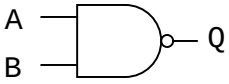
Q =



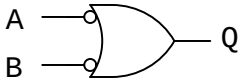
Q =



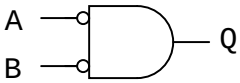
Q =



Q =



Q =

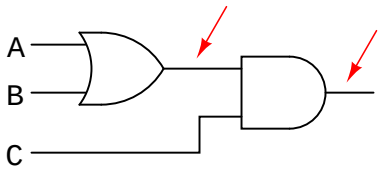


Q =

file 02778

Question 10

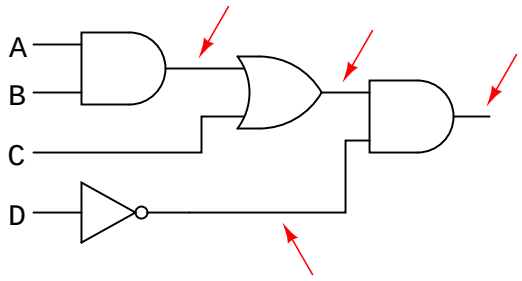
Convert the following logic gate circuit into a Boolean expression, writing Boolean sub-expressions next to each gate output in the diagram:



file 02782

Question 11

Convert the following logic gate circuit into a Boolean expression, writing Boolean sub-expressions next to each gate output in the diagram:



file 01301

Question 12

Complete the truth tables for these two Boolean expressions:

$$\text{Output } = \overline{A} + \overline{B} + C$$

A	B	C	Output
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

$$\text{Output } = A(B + AC + \overline{A})$$

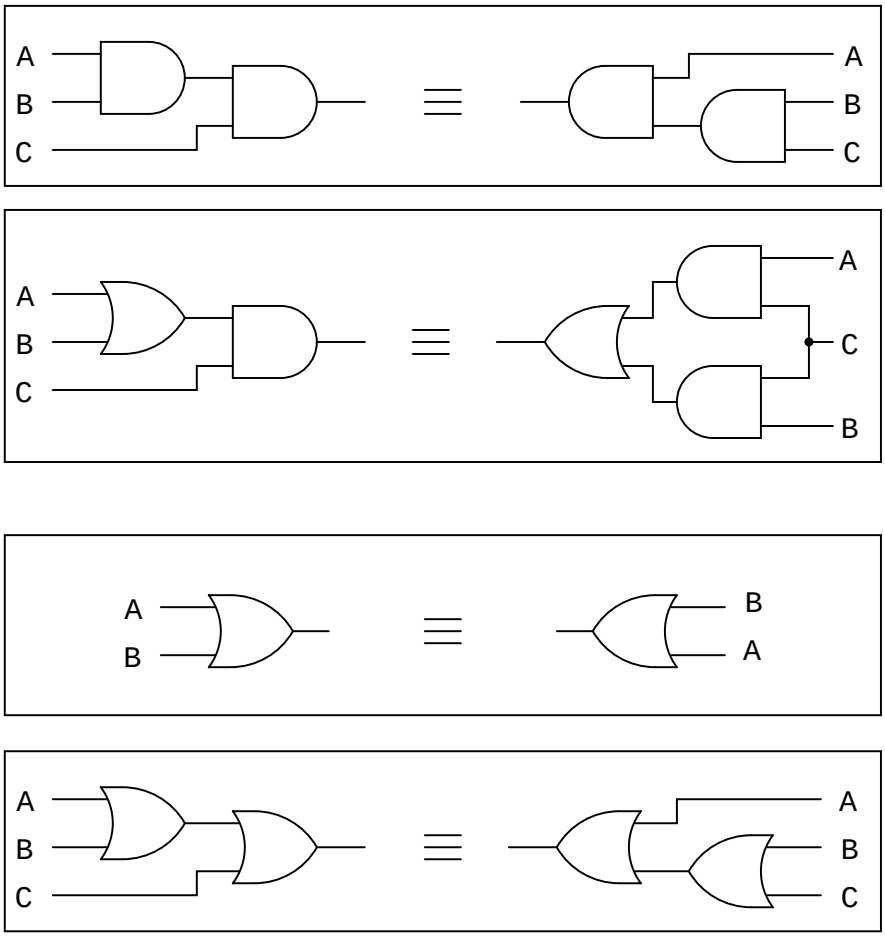
A	B	C	Output
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

file 02821

Question 13

Like numeric algebra, Boolean algebra is subject to the laws of *commutation*, *association*, and *distribution*. These laws allow us to build different logic circuits that perform the same logic function.

For each of the equivalent circuit pairs shown, write the corresponding Boolean law next to it:



Note: the three short, parallel lines represent "equivalent to" in mathematics.

file 01303

Question 14

An automotive engineer wants to design a logic circuit that prohibits the engine in a car from being started unless the driver is pressing the clutch pedal while turning the ignition switch to the "start" position. The purpose of this feature will be to prevent the car from moving forward while being started if ever the transmission is accidently left in gear.

Suppose we designate the status of the ignition switch "start" position with the Boolean variable S (1 = start; 0 = run or off), and the clutch pedal position with the Boolean variable C (1 = clutch pedal depressed; 0 = clutch pedal in normal, unpressed position). Write a Boolean expression for the starter solenoid status, given the start switch (S) and clutch (C) statuses. Then, draw a logic gate circuit to implement this Boolean function.

file 02796

Question 15

A student makes a mistake somewhere in the process of simplifying the Boolean expression $\overline{\overline{X}Y + Z}$. Determine what the mistake is:

$$\overline{\overline{X}Y + Z}$$

$$\overline{\overline{X}Y}\,\overline{Z}$$

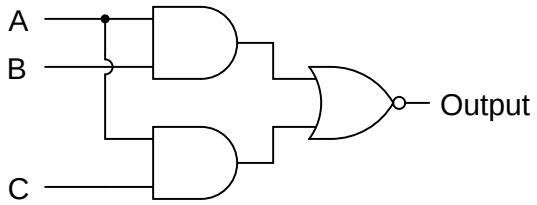
$$\overline{\overline{X}} + \overline{Y}\,\overline{Z}$$

$$X + \overline{Y}\,\overline{Z}$$

file 01319

Question 16

Write the Boolean expression for this TTL logic gate circuit, then reduce that expression to its simplest form using any applicable Boolean laws and theorems. Finally, draw a new gate circuit diagram based on the simplified Boolean expression that performs the exact same logic function.



file 01318