

## Pre-Lab 3

Carefully read the entirety of Lab 3, then answer the following questions. Attach a separate sheet of paper, if necessary, to show all work and calculations.

1. Derive a truth table for Circuit 1.

<b>A</b>	<b>B</b>	<b>C</b>	<b>F</b>
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

2. Derive a truth table for Circuit 2.

<b>A</b>	<b>B</b>	<b>F</b>
0	0	
0	1	
1	0	
1	1	

3. Derive a truth table for Circuit 3.

<b>A</b>	<b>B</b>	<b>C</b>	<b>F</b>
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

4. Derive a truth table for Circuit 4.

<b>A</b>	<b>B</b>	<b>C</b>	<b>F</b>
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

5. Derive a truth table for Circuit 5.

<b>A</b>	<b>B</b>	<b>F</b>
0	0	
0	1	
1	0	
1	1	

6. Derive a truth table for Circuit 6.

<b>A</b>	<b>B</b>	<b>F</b>
0	0	
0	1	
1	0	
1	1	

7. Write up a rough draft of your process flow for debugging a circuit. Include at least four steps, and place them in the order you will use them.



## Lab 3: Troubleshooting

Troubleshooting is an important part of building digital circuits. Frequently, one or more errors in a design will lead to incorrect output values, or undesired effects such as short circuits. This lab will present you with multiple circuits that don't work. Your job will be to diagnose the problem(s) that exist in the circuit.

For lab resources and information, go to the following URL or scan the QR code. [doctor-pasquale.com/digital-systems-lab-3](https://doctor-pasquale.com/digital-systems-lab-3)



### 3.1 Circuit Debugging

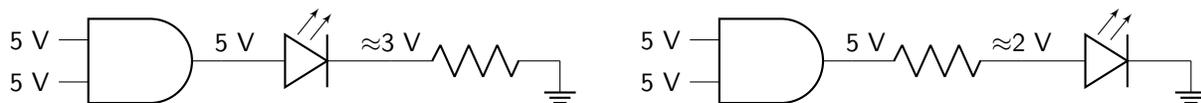
In order to debug a circuit, it is important to first understand exactly what the circuit is **supposed** to do. With combinational circuits, a truth table can be used to determine what the circuit output(s) should be for each combination of input variables. Next, it is important to understand what the circuit **does** do.

After comparing the ideal circuit output with the real circuit output, then it's time to start going through your list of troubleshooting steps and finding the problem(s) and correcting them.

### 3.2 Logic Probe

A logic probe can be used to quickly determine the logic level (HIGH or LOW) of any connection in a digital circuit. A thin metal probe can be inserted into a breadboard hole, on top of a logic chip pin, or on the ends of an LED or resistor. The internal circuitry of the logic probe causes a sound to be emitted, and an LED to light up, based on the value of the signal at that location.

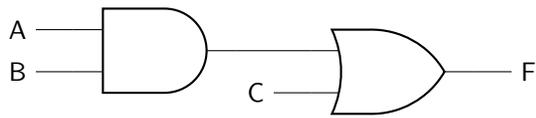
Logic probes are superior to using a single LED to debug a circuit because it is able to distinguish between a LOW and a float, which a single LED is unable to do. Some care must be taken on where a logic probe can be placed, however. Only digital logic signals of HIGH and LOW will be valid. Anything that is in between those two voltage ranges does not correspond to a digital logic level and therefore may not read correctly on the logic probe. This will predominantly occur in the case of a current-limiting resistor and LED combination.



**Figure 3.1:** Circuit diagrams showing the voltage values present at various connections around a current-limiting resistor and an LED. Whether the resistor is placed at the cathode of the LED (left) or anode of the LED (right), the voltage level in between the two circuit elements will be indeterminate.

Figure 3.1 shows voltage values in an example circuit where the output of a logic gate is HIGH. The connection made directly after the output of the logic gate will be 5 V, a well-established logic signal value. However, whether the current-limiting resistor is placed at the cathode of the LED (figure 3.1 left) or anode of the LED (figure 3.1 right), the voltage level in between the resistor and LED will not correspond to any logic level. The readout of a logic probe used at the intersection of an LED and a resistor is therefore indeterminate and should not be probed to determine the output of a logic gate.

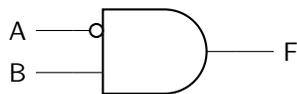
**Circuit 1:** Circuit 1 is defined by the circuit diagram below. Make as many observations about the circuit as you need to determine what is wrong with the circuit. When you have come to a conclusion, discuss it with your instructor to receive a stamp.



Instructor Stamp: \_\_\_\_\_

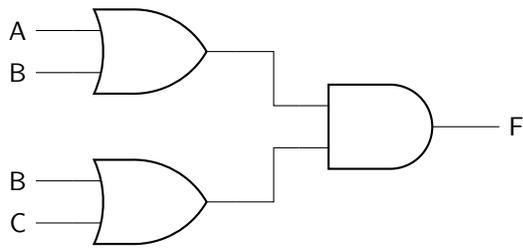
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**Circuit 2:** Circuit 2 is defined by the circuit diagram below. Make as many observations about the circuit as you need to determine what is wrong with the circuit. When you have come to a conclusion, discuss it with your instructor to receive a stamp.



Instructor Stamp: \_\_\_\_\_

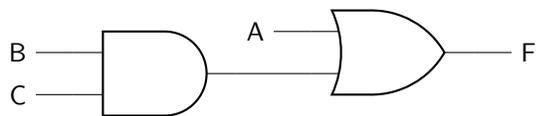
**Circuit 3:** Circuit 3 is defined by the circuit diagram below. Make as many observations about the circuit as you need to determine what is wrong with the circuit. When you have come to a conclusion, discuss it with your instructor to receive a stamp.



Instructor Stamp: \_\_\_\_\_

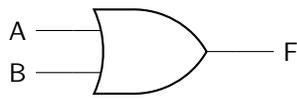
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**Circuit 4:** Circuit 4 is defined by the circuit diagram below. Make as many observations about the circuit as you need to determine what is wrong with the circuit. When you have come to a conclusion, discuss it with your instructor to receive a stamp.



Instructor Stamp: \_\_\_\_\_

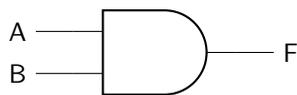
**Circuit 5:** Circuit 5 is defined by the circuit diagram below. Make as many observations about the circuit as you need to determine what is wrong with the circuit. When you have come to a conclusion, discuss it with your instructor to receive a stamp.



**Instructor Stamp:** \_\_\_\_\_

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**Circuit 6:** Circuit 6 is defined by the circuit diagram below. Make as many observations about the circuit as you need to determine what is wrong with the circuit. When you have come to a conclusion, discuss it with your instructor to receive a stamp.



**Instructor Stamp:** \_\_\_\_\_

## Lab 3 Homework

Carefully read each question before answering. Show all work or justify your answers to receive credit. Attach a separate sheet of paper, if necessary, to show all work and calculations.

1. What are 5 possible causes of: the output of your circuit is (or appears to be) always LOW.

2. What are 5 possible causes of: some outputs of your circuit are correct, while others are not.

3. What are 3 possible causes of: the “current limited” LED on the power supply lights up.

4. Now that you have debugged several circuits, revise your process flow from the pre-lab. Include at least six steps, and place them in the order you will use them. You will use this process flow to help debug future circuits. Continue adding to it as you come up with new things to check.