
Computer Science 110
Algorithms to Machines Laboratory

Logic in the Sandbox

Today's lab will introduce logic components that are the foundations of the digital world. You will "construct" electrical circuits using a simulator called *Circuit Sandbox* and observe their behaviors. Because the circuits are simulated, they are extremely easy to build, compared to working with actual wiring, switches, bulbs, etc. Nonetheless, the concepts explored are exactly the same as if we were working with a box of parts instead of a simulator display.

In the Dock, launch *Circuit Sandbox* (the beachball icon). You may be interested to learn that *Circuit Sandbox* was created by Gordon College computer science students, Daniel Stahl and Kevin Wellwood in the spring of 2005.

Getting to know the simulator

1. Connect a V_{cc} input to an LED output. What happens?

2. Connect a grounded terminal input to an LED output. What happens?

Explain what V_{cc} and "grounded terminal" appear to mean in this simulator.

3. Connect a button input to an LED. Play with it a little bit. What happens?

4. Connect a button input to a NOT logic component and then connect the NOT to an LED. What happens?

Explain what NOT means in this simulator.

5. Connect a toggle switch input to an LED. Play with it a little bit. What happens?

6. Connect two toggle switches to the two inputs of an AND (2) logic component, then attach an LED. What happens?

7. Connect two toggle switches to the inputs of an OR (2) logic component, then attach an LED. What happens?

Explain what AND (2) and OR (2) mean in this circuit.

8. What do you *expect* AND (4) to do? When will the LED light up?

What do you *expect* OR (4) to do? When will the LED light up?

Use 4 switches and one LED to test the meaning of AND (4) and OR (4). Keep track of what happens using the table below. Before building the circuit, fill in the first 4 columns of the following table with all possible combinations of switch positions. Check this with your TA before continuing.

<i>Switch-1 position</i>	<i>Switch-2 position</i>	<i>Switch-3 position</i>	<i>Switch-4 position</i>	<i>LED with AND (4)</i>	<i>LED with OR (4)</i>
On	On	On	On		
On	On	On	Off		
On	On	Off	On		
On	On	Off	Off		

Digging deeper

9. Ask the TA to provide the files you need to continue. From the menu choose:

File | Load Custom Component | Desktop | circuitSandboxComponents | mystery0

Using as many switches and LEDs as you think are necessary, experiment on this circuit until you determine what its purpose is. In other words, under what circumstances does the bulb illuminate?

Keep track of your experiments by creating a data table such as in the previous question.

10. Next load the Custom Component called *mystery1*. Using as many switches and LEDs as you think are necessary, experiment on this circuit until you determine what its purpose is. In other words, under what circumstances does the bulb illuminate?

Keep track of your experiments by creating a data table such as in the previous question.

Unearth buried treasures

11. CHALLENGE #1 - Load the Custom Component called *challenge*. Using as many switches and LEDs as you think are necessary, experiment on this circuit until you determine what its purpose is. In other words, under what circumstances does the bulb illuminate?

Keep track of your experiments by creating a data table such as in the previous question.

12. CHALLENGE #2 – Experiment with the NAND (2) circuit. Explain what it does.

13. CHALLENGE #3 – Using nothing but NAND (2) and any needed input device, build a circuit that does the same thing as the NOT logic component. Draw a picture of your completed circuit:

14. CHALLENGE #4 – Using nothing but NAND (2) and any needed input device, build a circuit that does the same thing as the AND (2) logic component. Draw a picture of your completed circuit:

15. CHALLENGE #5 (*Difficult*) – Using nothing but NAND (2) and any needed Input device, build a circuit that does the same thing as the OR (2) logic component. Draw a picture of your completed circuit:

16. CHALLENGE #6 – Reflect on the last few challenge exercises and explain why the NAND logic component is often referred to as the universal logic component.