

LAB 7

Circuits

Read Hewitt Chapter 23

What to learn and explore

Every electrical circuit must have at least one source (which supplies electrical energy to the circuit) and at least one load (which removes electrical energy from the circuit). When two or more loads are connected to a single source, they may be connected in series (end-to-end), in parallel (side-by-side), or some combination of these.

In this lab we will study series, parallel and combination circuits to learn more about how electrical current flows in these circuits. As you explore these circuits, try to identify the current paths: some circuits have a single path, while others have more than one. In a given path, the amount of current is determined by the resistance of the path: the greater the resistance, the lower the current. In lamp circuits, the lamps are what resist the current--so when there are multiple lamps in series along a path, the resistance is greater.

Please note: the circuits we are experimenting with in this lab are safe because they use low voltage, short-circuit-protected power supplies. *Do not attempt to do similar experiments with 120 Volt household power or with 12V automotive-type batteries!*

What to use

Adjustable power supplies, lamp sockets, lamps, wires, voltmeters.

What to do

Perform the following experiments to help answer the questions I have posed and other questions of your own. Try to develop mental images of charges flowing around through the wires, carrying energy they received from the power supply and depositing the energy in the light bulbs.

Always draw your circuits clearly before you build them, and try to lay out the wires so the actual circuit looks just like the drawing. This will help you more than you know!

As usual, whenever possible, (a) make predictions in writing before making observations and (b) discuss your predictions and observations with your lab partners. Sometimes your predictions will be wrong--especially in this experiment, and there's nothing wrong with that. Keep on thinking about the charges, flowing around the circuit and "spending" their energy in the lamps...this is subtle and challenging but it is a triumph when you "get it."

Comments: *When you finish the lab*, please write any thoughts and comments you have on today's experiment here. Thank you.

1) Lighting a Lamp

Study the lamp bulb and socket. How must you connect the leads from the power supply in order that current will flow through the filament?

a) Sketch your lamp and connections here: Then look at the whiteboard to see how we represent the circuit using standard symbols. Re-draw your circuit.

b) Build your circuit, using a lamp and an adjustable-voltage power supply with the voltage turned all the way down. Be sure the circuit looks exactly like what you drew. Then turn up the voltage slowly up to about 2 volts. Does it matter which end of the filament is at a higher voltage? Swap the leads on your lamp to find out.

c) Now, double the voltage across the lamp to 4 volts. With more voltage, you will also get more current. The brightness depends on both the voltage across the lamp and the current through it.) Do you expect the lamp to shine twice as brightly? Predict, then test.

d) Adjust the power supply voltage to **4.0V** and **leave it at this setting for most of the rest of the lab.** Note and remember the brightness of the single bulb with 4V across it—this will be your “standard” of comparison in the following experiments. As you observe lamps in other circuits, keep in mind that (when comparing identical lamps) the brighter a lamp, the bigger the voltage difference across it and the greater the current flowing through it. *If the same voltage difference is applied across two identical lamps, they will be equally bright. If the same current flows through two identical lamps, they will be equally bright.*

2) Series Circuit

Note and remember the brightness of the single bulb with 4V across it. Then consider a circuit with three lamps connected in series (end-to-end).

a) Start by **drawing** the circuit in the space below. (**Do not build the circuit until step e.**) Then, on your drawing, follow the current path from the + (red) terminal through the lamps and back to the negative (black). If you've drawn the circuit correctly, there should be only one path. This path has **three** lamps instead of one for the power supply to push current through.

b) Do you expect more, less or the same current to flow in this circuit than in the single-lamp circuit?

c) Do you think the lamps in the series circuit will be brighter, about the same, or dimmer than the single lamp? Why?

d) Do you think the series lamp nearest the + terminal will be brighter, dimmer or about the same brightness as that near the ground terminal? Why?

e) Build the series circuit to test your predictions. Report your results below.

f) Based on your observations, is current “used up” in the first lamp, or is the current the same in all three?

g) Based on your observations and study of the circuit, predict the voltage across each of the lamps. Touch the probes of a voltmeter (multimeter set to measure voltage) across each lamp to measure the voltage and compare with your prediction.

h) Do the voltages along the series path add up to about 4 volts?

i) Predict first, then test the following: What will happen to the brightness of the remaining two lamps if one lamp is removed from its socket?

j) Predict first, then test the following: What will happen to the brightness of the remaining two lamps if one lamp is “shorted out” (i.e., a wire is connected across the lamp terminals)? What will happen to the brightness of the shorted lamp?

3) Parallel Circuit

a) Draw a circuit in the space below with three lamps connected in parallel (side-by-side) across the terminals of the 4-volt power supply. (**Do not build the circuit until step d.**) On your drawing, trace the current paths from the + terminal through the lamps and back to the ground terminal. Is there more than one path? How many lamps are there along each path?

b) Do you expect more, less or the same current to flow through each lamp in this circuit than in the single-lamp circuit? Why?

c) Do you think the lamps in the parallel circuit will be brighter, about the same, or dimmer than the single lamp? Why?

d) Build the parallel circuit to test your predictions. Use your diagram and lay it out so it is easy to follow. Report your results below.

e) Based on your observations and study of the parallel circuit, predict the voltage across each of the lamps. Touch the probes of a voltmeter (multimeter set to measure voltage) across each lamp to measure the voltage and compare with your prediction.

f) Predict first, then test the following: What will happen to the brightness of the remaining two lamps if one lamp is removed from its socket?

g) Predict first, then test the following: What will happen to the brightness of the remaining two lamps if one lamp is “shorted out”? What will happen to the brightness of the shorted lamp? **(Don’t try this at home! If you’re not sure why, discuss it with your lab partners or your instructor.)**

h) This parallel circuit arrangement is the way electrical outlets are wired in a house. Use the small hand generator to light up the bulbs in parallel, simulating a PG&E power plant. Observe how easy it is to turn the crank as you unscrew 1, then 2, and then 3 bulbs. Remember the bike generator in the Energy lab—you have seen this before.

A power plant will burn more fuel (oil, gas, coal, etc.) as more lamps are turned on. What kind of energy are you using more of as the crank gets harder to turn?

4) Combination Circuit 1.

Many circuits do not consist of devices connected entirely in series or entirely in parallel. Often, devices in a circuit are connected in a combination of both series and parallel. We will look at two examples of combination circuits involving three lamps:

- a) Draw **circuit 1**: two lamps in series, A and B, in parallel with a third lamp, C. (**Do not build the circuit until step b**) Identify all the paths the current can take. For each path, how many lamps?

b) Predict the brightness of lamps A and B relative to the single lamp (from part 1). What about for lamps C? Build the circuit to test your predictions.

c) Predict the voltages across the different lamps. Then measure them and compare with your predictions.

d) Do the voltages along any path from positive to negative always add up to about 4 volts?

e) Predict how the brightness of lamps B and C will change if lamp A is **removed from its socket**. Then test your predictions.

f) Predict how the brightness of lamps B and C will change if lamp A is **shorted out**. Then test your predictions.

g) Predict how the brightness of lamps A and B will change if lamp C is **removed from its socket**. Test your predictions.

h) Predict how the brightness of lamps A and B will change if lamp C is **shorted out**. Test your predictions.

5) Combination Circuit 2.

a) Draw **circuit 2**: two lamps in parallel, A and B, in series with a third lamp C. **(Do not build the circuit until part b).** Identify the path(s) the current can take from positive to negative and, for each path, count the lamps.

b) Predict the brightness of lamp A relative to the single lamp (from part 1). What about for lamps B and C? Build the circuit to test your predictions.

c) Predict the voltages across the different lamps. Then measure them and compare with your predictions

d) Do the voltages along any path always add up to 4 volts?

e) Predict how the brightness of lamps B and C will change if lamp A is removed from its socket. Then test your predictions.

f) Predict how the brightness of lamps B and C will change if lamp A is shorted out. Then test your predictions.

g) Predict how the brightness of lamps A and B will change if lamp C is removed from its socket. Test your predictions.

h) Predict how the brightness of lamps A and B will change if lamp C is shorted out. Test your predictions.

6) Mystery Circuits

There are three mystery circuits that consist of an unknown combination of series and parallel connections. For each circuit, you will use the results of the previous parts of this lab to figure out how the different lamps are connected. Try the following experiments to aid in your investigation:

- Remove one lamp from its socket and see how it affects the brightness of the remaining lamps
- Short one lamp and see how it affects the brightness of the remaining lamps
- Use the voltmeter to measure the voltages across each lamp or across combinations of lamps

For each mystery circuit, discuss the results of the above experiments with your group members and then draw your best guess for how the lamps are connected. After you have drawn your circuit, check your results with the instructor.

Mystery Circuit 1: (set power supply to 12 V)

Mystery Circuit 2: (set power supply to 6 V)

Mystery Circuit 3: (set power supply to 8 V)