

DC Circuits

As you work through the steps in the lab procedure, record your experimental values and the results on this worksheet. Use the exact values you record for your data to make later calculations.

DC Circuits Lab – Simulation

Open the DC Circuits simulation to do this lab.

Explore the Apparatus

2. Notice that you have your choice of dragging, stretching/shortening, or rotating each type of element. How do you drag, stretch/shorten, or rotate an element? I'll give you the first one to get you started.

(a) You drag an element by *clicking on the body of the element and dragging it*.

(b) You stretch or shorten wires, batteries, and resistors by doing what?

(c) You rotate wires, batteries, and resistors by doing what?

4. How do you open and close the circuit using the switch?

5. What happens if you hold down the Shift key while clicking and dragging the meter?

6. The (conventional) current is indicated by the little moving dots. According to our definition of current, which end of the battery is the positive end?

7. Without pressing the Shift key, pull the ammeter away from the circuit to disconnect it. Now reconnect it but swap the connections to the circuit. What happens and how do you interpret the meaning of the change? (Just do your best.)

Our digital meters are not damaged by this backwards connection but analog meters (with rotating needles) can be. So as a general practice, care should be taken when attaching meters.

8. Finish this general rule below about how meters are connected.

The circuit should be wired so that the current enters the _____ terminal of any meter it encounters.

9. If you remove the ammeter from the circuit, you find that the current _____ . Thus, we know that a current must flow *through* an ammeter. To insert an ammeter into a circuit, the circuit must be opened. The ammeter then fills in the gap created. *An ammeter measures the current flowing through itself.*

10. *A voltmeter is connected across a circuit element.* That is, it's attached to each end of the circuit element. Most of the current flows through the _____ circuit element with a negligible amount going through the _____ voltmeter. The smaller the proportion of the current that flows through it, the better the voltmeter.

11. Record the initial current and the voltage drop.

12. Now let's replace the resistor with an upside down bulb. Record your new meter readings with the bulb.

13. Record your new meter readings with the 60-V battery.

IA. Initial Observations

1. In each circuit in Figure 4 there are either two or three bulbs that are in electrically equivalent situations in that circuit. That is, with a battery (not yet present) in the circuit, they could swap positions with one another with no resulting change in their behavior.

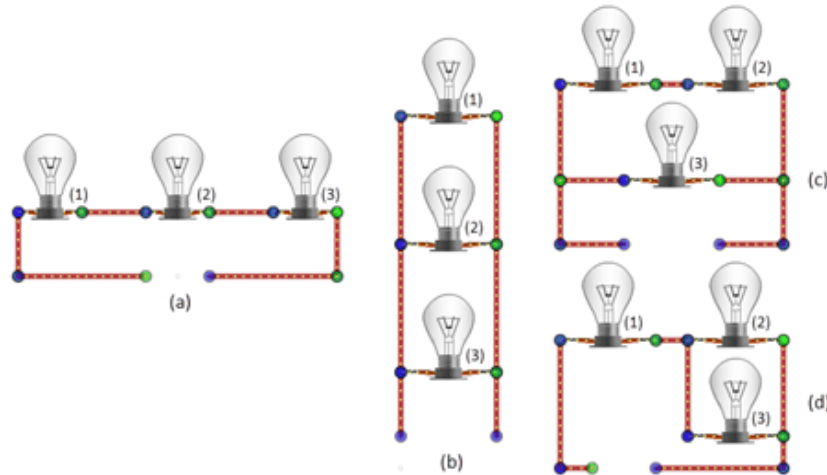


Figure 4

Record your predictions for each circuit.

(a) In circuit (a), the bulbs that are in electrically equivalent situations are which of the following? (Select all that apply. *Note: the order of these options may be different in the WebAssign question.*)

- 1
- 2
- 3

(b) In circuit (b), the bulbs that are in electrically equivalent situations are which of the following? (Select all that apply. *Note: the order of these options may be different in the WebAssign question.*)

- 1
- 2
- 3

(c) In circuit (c), the bulbs that are in electrically equivalent situations are which of the following? (Select all that apply. *Note: the order of these options may be different in the WebAssign question.*)

- 1
- 2
- 3

(d) In circuit (d), the bulbs that are in electrically equivalent situations are which of the following? (Select all that apply. *Note: the order of these options may be different in the WebAssign question.*)

- 1
- 2
- 3

3. For the ranking questions that follow, answer by using one of the symbols $<$, $>$, or $=$ in each space.

(a) How does the power dissipated (indicated by the brightness) of each bulb in circuit (a) compare?

$$P_{a1} \text{ ______ } P_{a2} \text{ ______ } P_{a3}$$

(b) How does the power dissipated (indicated by the brightness) of each bulb in circuit (b) compare?

$$P_{b1} \text{ ______ } P_{b2} \text{ ______ } P_{b3}$$

(c) How does the power dissipated (indicated by the brightness) of each bulb in circuit (c) compare?

$$P_{c1} \text{ ______ } P_{c2} \text{ ______ } P_{c3}$$

(d) How does the power dissipated (indicated by the brightness) of each bulb in circuit (d) compare?

$$P_{d1} \text{ ______ } P_{d2} \text{ ______ } P_{d3}$$

IB. Current

1. How does the current **through** each resistor in circuit (a) compare? (Use the current dots as a guide.)

$$I_{a1} \text{ ______ } I_{a2} \text{ ______ } I_{a3}$$

2. How does the current **through** each resistor in circuit (b) compare? (Use the current dots as a guide.)

$$I_{b1} \text{ ______ } I_{b2} \text{ ______ } I_{b3}$$

3. How does the current **through** a resistor in circuit (a) compare to one in circuit (b)? (Use the current dots as a guide.)

$$I_{a1,2,3} \text{ ————— } I_{b1,2,3}$$

5. How does the current flowing **through the battery** in circuit (a) compare to the current **through the battery** in circuit (b)? $I_{\text{battery a}}$

$$I_{\text{battery a}} \text{ ————— } I_{\text{battery b}}$$

6. How does the current **through the battery** in circuit (a) compare to the current **through a resistor** in (a)? $I_{\text{battery a}}$

$$I_{\text{battery a}} \text{ ————— } I_{\text{resistor a}}$$

7. How does the current **through the battery** in circuit (b) compare to the current **through a resistor** in (b)? $I_{\text{battery b}}$

$$I_{\text{battery b}} \text{ ————— } I_{\text{resistor b}}$$

8. Something entirely different is happening in circuit (b). Notice the current flowing up the left side of the circuit. Using our ranking system, we might say the following.

$$I_{\text{battery}} \text{ ————— } I_{\text{bottom left wire}} \text{ ————— } I_{\text{middle left wire}} \text{ ————— } I_{\text{top left wire}}$$

10. Close the switch and record the currents.

12. Close the switch and record the currents.

13. Based on these readings, what appears to be the relationship between the battery current and the currents in the resistors?

15. Formulate a statement about the currents flowing into and out of a junction point (blue or green dot) such as the one to the left of Resistor 3. Use words like “total,” “into,” “out of,” and “sum of.”

16. Use your statement to calculate I_{mid} and I_{top} . Use I_{1-4} from step 12 for the bulb currents.

Show your calculations for I_{mid} below.

Show your calculations for I_{top} below.

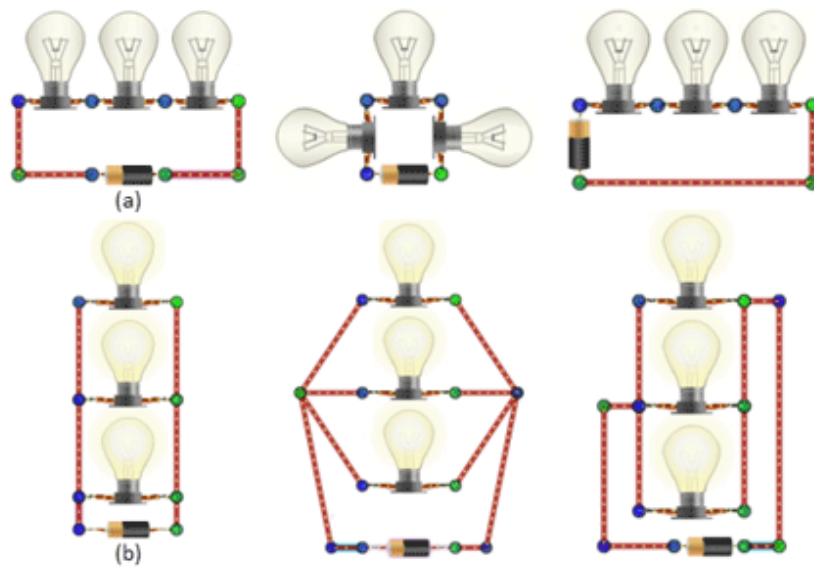


Figure 8

18. The resistors in circuit (a) are connected in *series*. The resistors in circuit (b) are connected in *parallel*. Make a general statement about the effect of removing a bulb from each type of circuit. Specifically, what happens to the current through the remaining bulbs?

IC. Voltage

3. In your investigation of current, you found the current to be the same everywhere in the series circuit. For the parallel circuit, the battery current equaled the sum of the currents in the three branches. What similar statement do you think will apply with voltages? How do you think the battery voltage will be related to the resistor voltage drops in each type of circuit? Make a statement about each type of circuit below. Use words like “total,” “across,” and “sum of.”

6. In circuit (c), bulbs _____ and _____ are connected in _____, and this pair is connected in _____ with bulb _____ .

7. In circuit (d), bulbs _____ and _____ are connected in _____, and this pair is connected in _____ with bulb _____ .

ID. Resistance

5. You should be able to use the resistance adjustment tool below the circuit board to adjust each resistor in Figure 12 until you return to the current flowing in the matching circuit in Figure 11. Record their values below.

IIA. Internal Resistance, Terminal Voltage, and “Dead Batteries”

3. In Table 1, record the circuit current, I , the bulb voltage, V_{bulb} , and the battery emf, \mathcal{E} .

5. Record your new readings in the “Later” row of Table 1.

Table 1: Ideal Flashlight

	I (A)	V_{bulb} (V)	\mathcal{E} (V)
Initial			
Later			

8 & 12. Complete Table 2.

Table 2: Realistic Flashlight – Data

R_{ir} (Ω)	I (A)	emf (V)	V_t (V)	V_{bulb} (V)
1.00				
50.00				

9, 12 & 14. Complete Table 3.

Table 3: Realistic Flashlight – Power and Efficiency Calculations

R_{ir} (Ω)	P_{emf} (W)	P_{ir} (W)	P_{bulb} (W)	R_{bulb} (Ω)	Eff. (%)
1.00					
50.00					

10. Show your three power calculations and the efficiency calculation in the space below.

13. Show your three power calculations and the efficiency calculation in the space below.

15. Show your bulb resistance calculations in the space below.

16. Why did the bulb resistance decrease? Do a little research and see what you can come up with. The bulbs in this virtual apparatus are designed to behave like real bulbs. So just what is it that's affecting the bulb resistance?

IIB. Simplifying Circuits, Power Dissipation, Power Supplied by a Battery – Circuit 1

3. Record the current I_1 .

Task 2: Determine the power dissipated by the 1.0-Ohm resistor.

4. Record your readings for the current through and the voltage across the 1.0- Ω resistor.


5. Record the power dissipated by the 1.0- Ω resistor.

6. There are three ways to calculate $P_{1.0 \Omega}$. Show all three calculations below.

7. Attach the negative lead of a voltmeter to point (d). Then attach the positive end to point (b) and record the voltage reading, V_{bd} . Then move the positive lead to point (c) and record the voltage reading, V_{cd} .

IIB. Simplifying Circuits, Power Dissipation, Power Supplied by a Battery – Circuit 2

4- Ω in Left-Hand Circuit

4. Take a **Screenshot**  of the full circuit board showing all four circuits and save it as “DC_Circuit.2.png” and upload it. Print it out and submit it with your lab report. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

5. Calculate the power, $P_{4\ \Omega\ \text{left}}$.

6. Show your calculations.

4- Ω in Right-Hand Circuit

7. Determine the battery current, I .

8. Determine the voltage drop, V_{ce} .

9. What is the voltage drop across the 4- Ω resistor in the right-hand circuit, $V_{4\ \Omega\ \text{right}}$?

10. Calculate the power dissipated by the $4\text{-}\Omega$ resistor in the right-hand circuit, $P_{4\ \Omega\ \text{right}}$.

11. Show your calculations for 7-10.