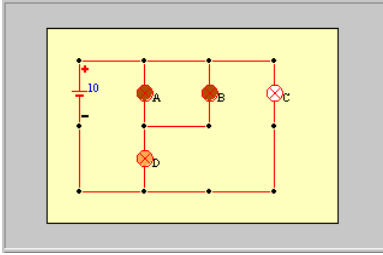


## Worksheet for Exploration 30.1: Circuit Analysis



This Exploration begins with four identical light bulbs connected to a battery (**voltage is given in volts and current is given in amperes**). Often, you will be asked to find the current through, the voltage across, the resistance, and/or the power consumed by a given bulb (or group of bulbs). To solve these types of problems you will use Ohm's law,  $V = IR$ , and an equation for power,  $P = VI = I^2R = V^2/R$ , where  $V$  is the voltage,  $I$  is the current,  $R$  is the resistance, and  $P$  is the power. You will also need to use two rules that are based on conservation laws:

1. **current in = current out.** Since charge is not created or destroyed (conservation of charge), charge flowing into some point must flow back out unless there is a circuit element that can store charge (a capacitor).
2.  **$\Delta V$  through a complete loop = 0.** The electric force is a conservative force (which is why we can define an electrostatic potential:  $V$ ). This means that if you start at one point in a circuit and add up all the potential increases and subtract all the decreases in potential as you trace out a loop, then when you get back to the place you started, the potential must be the same.

Let's use these rules for the initial circuit. The brightness of the bulbs is an indication of the current through the bulbs (brightness actually goes as  $I^2$ ). [Restart](#).

- a. Rank the bulbs in order of brightness (and therefore in order of current through them), from highest to lowest.
- b. [Show the currents](#) (in the data table) through the bulbs to check your answer. The arrows indicate the direction of the current through the circuit.

$$I_A = \underline{\hspace{2cm}}$$

$$I_B = \underline{\hspace{2cm}}$$

$$I_C = \underline{\hspace{2cm}}$$

$$I_{\text{Battery}} = \underline{\hspace{2cm}}$$

- c. Find the current through bulb D by determining how much current must be coming into the node (the dot where the wires come together) above bulb D. The current is coming from bulbs A and B.

$$I_D = \underline{\hspace{2cm}}$$

- d. Check your answer by verifying that the current coming into the node below bulb D (from bulb C and bulb D) is equal to the current going out of the node and into the battery.

$$I_C + I_D = \underline{\hspace{2cm}}$$

- i. This should equal  $I_{\text{Battery}}$ . Why?

Now consider the voltage across various elements. [Show the voltages](#) (in the data table) across the bulbs.

- e. Why is the voltage across bulb C the same as the voltage across the battery (think about tracing a path around the outside "loop" of the circuit)?

- f. Why is the voltage across bulb A equal to the voltage across bulb B?

- g. Find the voltage across D by picking a complete loop to trace around (battery  $\rightarrow$  bulb A  $\rightarrow$  bulb D  $\rightarrow$  battery) OR (battery  $\rightarrow$  bulb B  $\rightarrow$  bulb D  $\rightarrow$  battery) OR (bulb C  $\rightarrow$  bulb D  $\rightarrow$  bulb A) OR (bulb C  $\rightarrow$  bulb D  $\rightarrow$  bulb B) and finding the value of the voltage for bulb D that makes the change in potential equal to zero.

- i. Diagram of loop you chose (with currents labeled):

- ii. For the loop, using  $\Delta V = 0$ , write your equation of the voltage drops and increases:

- h. Using  $V = IR$ , what is the resistance of bulb D? (Check that it is the same as bulbs A, B, and C).

$$R_D = \underline{\hspace{2cm}}$$

$$R_A = \underline{\hspace{2cm}}$$

- i. What is the power dissipated by bulb D?

$$P = \underline{\hspace{2cm}}$$