Circuits Lab 2

Current Flow in Series Circuits

You have used a single wire and battery to light a bulb and found configurations for which the bulb does light and others for which the bulb does not light. You have also looked careful at the internal wiring of a light bulb. In doing these things you should have started to notice some regularity-- some patterns. Perhaps you have even started to form a metal picture of what is going on in the wires and bulb when they are connected in ways which allow the bulb to light. We call such a mental picture a **model**.

Our goal for this series of labs on circuits is to allow you to learn first -hand what a scientist means by a scientific model and how they go about developing, applying and improving models. You should learn a bit about electricity along the way, but the primary goal is to experience the development of a scientific model yourself. So, be sure to pay attention to that part too.

Flow in a Closed Circuit

Experiment 2.1

You have been given a battery holder with short piece of wire attached. (The short wire is actually a paperclip that has been unfolded.) Insert a battery into the holder. Feel the wire. Does it feel warm? If not, try touching it to a more sensitive part of your body such as your wrist or face. Or, compare the temperature of the wire attached to the battery to the loose wire on your table. Above all else, make uniform comparisons of temperature. For example, if you are checking temperature with your wrist, be sure to always check with your wrist rather than checking some places on the wire with your wrist and some with your fingers.

1. Does the wire feel at least somewhat warm all over? If not, describe what you observed. (There may be variation in the temperature you sense at various points along the wire. These have nothing to do with the flow of electricity).
2. Discuss what you did to ensure that your observations of the temperature of the wire at various points were “fair” and “equal” observations.

When a wire or light bulb is connected across a battery, we can make direct observations that something is happening in the circuit. For example, we feel that the wire gets warm and see that the light bulb glows. **In science, evidence to support models comes in the form of direct observations and measurements of the world around us.** Inferences, explanations,

calculations, interpretations and logical reasoning help us make sense of these observations and measurements. But, the foundation of science, its core, is the evidence that we gather from the world. Remember that point as you move through this lab.

In constructing a scientific model to account for what we have observed about circuits, it is helpful to think in terms of a flow around a circuit. We can envision the flow in a continuous loop from one end of the battery, through the rest of the circuit, back to the other end of the battery and finally through the battery. This is a continuous, **closed loop**. A **circuit** is a collection of electrically connected components such as wires, batteries and bulbs and we have found that a bulb will light when it is included in a **closed loop circuit**.

3. What *evidence* do you have that the flow in the circuit is "round trip" –that is around the entire circuit as discussed above rather than "one way" –just from the battery to the bulb where it stops? Consider not only what you have done in lab today but also your experience in the last lab where you worked to get a bulb to light with one wire.

Models and Assumptions

Sometimes as scientists work to develop models they must make some *assumptions.* Anything that we take to be true without proof is an **assumption**. We will make two assumptions in this lab:

Assumptions:

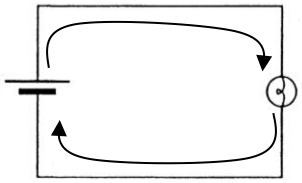
A) **There is something flowing through the entire circuit, including the bulb and battery.**
B) **The brightness of a bulb is an indication of the amount of flow through the bulb (more flow results in a brighter bulb).**

These assumptions seem reasonable to most people. We cannot claim, however, that we have direct evidence for either of these assumptions.

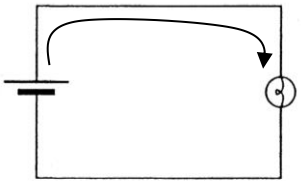
4. Based on our assumptions above, if two identical bulbs are equally bright, what does this indicate about the electric flow through them?
5. Given our assumptions, is there any way to take two identical bulbs with equal amounts of flow through them and have one bulb be brighter than the other? If so, explain.
6. Given our assumptions, if one bulb is brighter than another identical bulb what does this indicate about the flow through the brighter bulb?

Consider the following dispute between two students:

Student 1: *"When the bulb is lit, there is a flow from the battery to the bulb. There is also an equal flow from the bulb back to the battery."*



Student 2: "*The Flow is only from the battery to the bulb. We know this is so, because a battery can light a bulb, but a bulb can't do anything without a battery."*



7. Consider each sentence in the discussion between these two students. Are there sentences or phrases that you think are wrong? If so, which ones?
8. Consider each sentence in the discussion between these two students. Are there sentences or phrases that you think are not logically relevant? (These are sentences that would not add to the argument even if they are/were correct?) If so, which ones?

Because we cannot see anything flowing in an electric circuit, we cannot be sure what kind of a process accounts for our observations. Nonetheless, we will give the flow that exists in a circuit a name: electric current or just **current**.

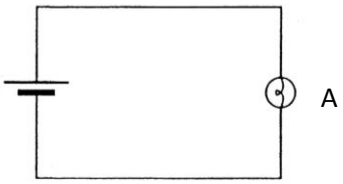
9. Re-write our two assumptions using the term current correctly.

In all of your answers that follow, try hard to use only words for which you know the precise meaning. Use the word "current" when you are talking about the flow in the circuit. Try to avoid the use of "it" in your answers. As you build your model step by step try to draw only on what we can observe in the laboratory and on what we can infer from our observations**. A good scientific model is as simple as possible and includes the fewest features necessary for making correct predictions.**

Two Bulbs

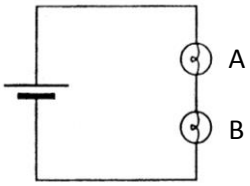
Experiment 2.1

Set up a single bulb attached to a battery so that the bulb lights as shown in the figure below. Note the brightness of the bulb.



single bulb circuit

Now add a second bulb to the circuit to form a two-bulb circuit with the bulbs connected one after the other as shown below. Two bulbs connected one after the other like this are said to be connected in **series**.



two-bulb series circuit

10. How does the brightness of Bulb A in the two-bulb series circuit compare to the brightness of Bulb A in the single bulb circuit? Are they the same brightness? If not, which is brighter?

11. Are the two bulbs (Bulb A and Bulb B) connected in series the same brightness? If not, which is brighter? Pay attention to large differences only.

12. How could you test whether a minor difference in the brightness of the bulb was due to slight differences in the bulbs themselves as opposed to their location in the circuit?

✓ *Check your progress with your instructor.*

13. In the two bulb series circuit, is the amount of current through Bulb A the same as the amount of current through Bulb B? If not, which has more? (Remember or review the assumptions that we have made in developing our model for current flow in circuits.)

14. What evidence do you have to support your answer?

15. On the basis of your observations and reasoning, what is your model for current flow? Is current "used up" in the first bulb or is the amount of current flow through both bulbs the same?

16. Does the order of the bulbs make a difference? You can check this answer by switching the bulbs and making a new observation.

17. Based solely on your observations, can you tell whether current flows from the positive end of the battery back around to the negative end of the battery or the other way around (from negative end back to positive)? If so, what is the direction of current flow?

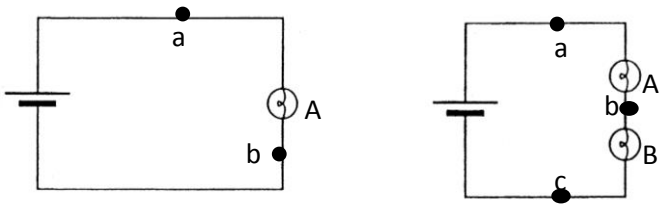
18. Refer back to question #10. How does the brightness of Bulb A in the two-bulb series circuit compare to the brightness of Bulb A in the single bulb circuit? Are they the same brightness? If not, which is brighter?

19. How does the amount of current in Bulb A in the two-bulb series circuit compare to the amount of current in Bulb A in the single bulb circuit?

20. What evidence do you have to support your answer? (Answer in 1-3 clear, concise and complete sentences. Your answer may be graded based on the quality of your writing as well as the correctness of your answer.)

✔ *Check your progress with your instructor.*

Consider the two circuits shown below in answering the following questions. The dots at a, b and c mark points in the circuit. Assume that there are 3 units of current flowing through Bulb A in Circuit 1.



Circuit 1 Circuit 2

21. How much current is there at point a in circuit 1? (Recall that there are 3 units of current flowing through Bulb A in Circuit 1.)

22. How much current is there at point b in circuit 1?

23. How much current is there through the battery in circuit 1?

24. How much current is there through Bulb A in Circuit 2? 3 units, less than 3 units, more than 3 units? Make sure that your answer is consistent with your observations of bulb brightness.

25. Let's assume that there is 1.5 units of current flowing through Bulb A in Circuit 2. How much current is there at point a in circuit 2? 1.5 units or 3 units? Think carefully here!!

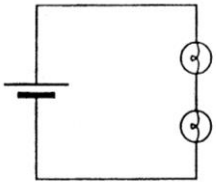
26. How much current is there at point b in Circuit 2?

27. How much current is there at point c in Circuit 2?

28. Explain your reasoning for answers 25-27 above. (Answer in 1-3 clear, concise and complete sentences. Your answer may be graded based on the quality of your writing as well as the correctness of your answer.)

29. Is the amount of current flowing through the battery in a single bulb circuit greater than, less than or equal to the amount of current flowing through the battery in a two-bulb series circuit?

Consider the following dispute between two students:



Student 1: *"In this circuit, the first bulb takes half of the current. Then the rest flows to the second bulb. This is why the bulbs are the same brightness but dimmer than a single bulb by itself."*

Student 2: *"I don't agree. We know that there must be current that flows back to the battery since we know that we need a complete circuit in order for the bulbs to light. If the first bulb takes half the current then the second bulb should take the other half of the current and there would be done left. We wouldn't need a path back to the battery.*

I think that there is the same amount of current flowing everywhere in the circuit …it is like water flowing in a pipe. But there is less flow in the two-bulb series circuit than there is in a single bulb circuit. With two bulbs there is more blockage in the circuit and so less current flows. That is why the bulbs are not as bright."

30. Do you agree Student 1, Student 2, both, neither? Explain.
31. Write down your model (your understanding or mental picture) of current flow in a series circuit.

✓ **Check your progress with your instructor.**