# LAB 7 BULBS AND BATTERIES
## (SERIES AND PARALLEL CIRCUITS)

**Objectives:**

- To learn to design and wire simple circuits using batteries, wires, and switches.
- To learn to use symbols to draw circuit diagrams.

## Part 1 - Introduction to Electrical Symbols

The key to solving electric circuit problems is understanding the symbols of the devices used, and the functions of the devices. Recognizing resistors, batteries, bulbs, switches, etc. make the calculations (or the conceptual ideas) much easier. The following symbols will be used in this and the next lab experiment:

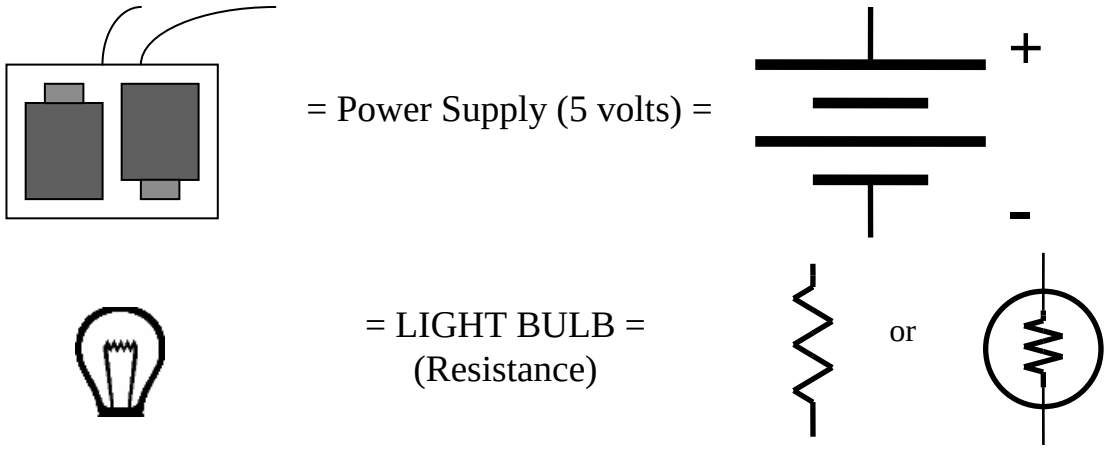



***Figure 1 - Electrical symbols and elements***

It would also be very helpful to look at the online help page for this lab.

## Part 2 - Developing a Model for Current Flow

The electrical charge that flows in a circuit is known as the current, with units of Amps = coulombs/second. When we hook a power supply (a "battery") with some wires and some light bulbs, we can form a circuit. Under the right conditions, we will get a current to flow and the bulbs will light up. Depending on how the bulbs are arranged in the circuit, they may be different levels of brightness (assuming all bulbs start out with identical characteristics).

1. Different models. Below are displays with 4 different models for how current could flow in a circuit. Which diagram best describes your view of how current flows in the circuit? Why? Talk it over with your partners. After you have discussed the various ideas with your instructor and the rest of the class, you will be asked to test your model with some bulbs and a power supply.

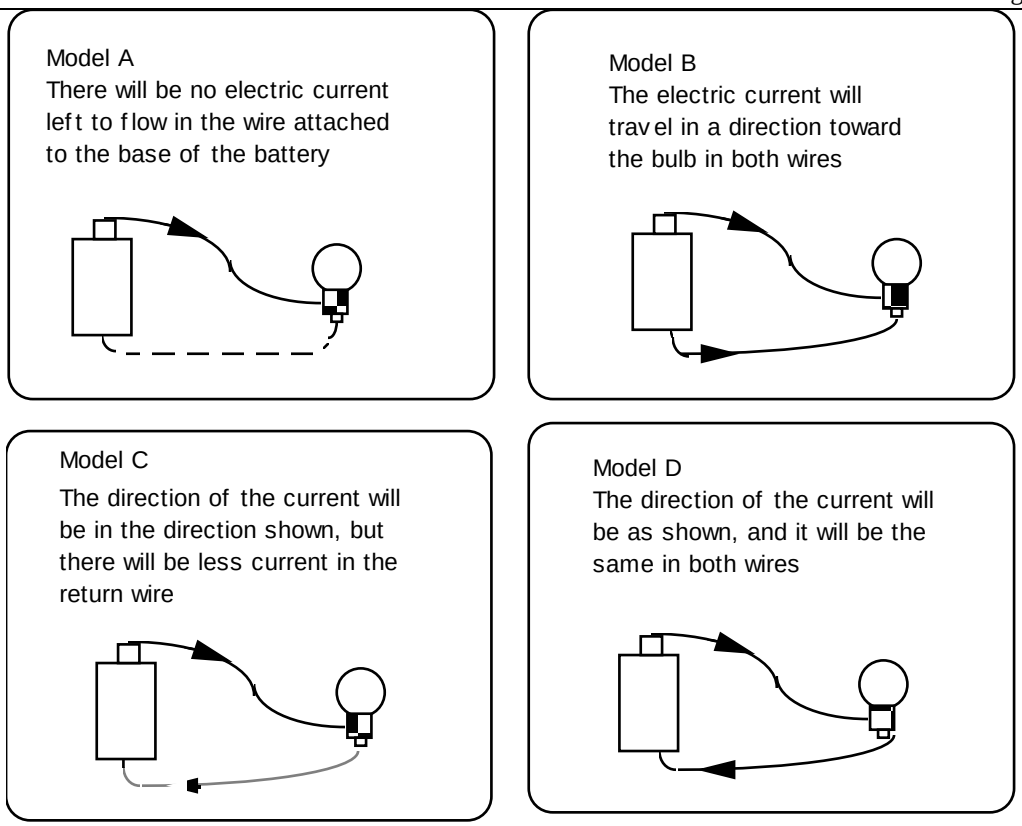



*Figure 2 - **Four alternative models for current flow***

*Question* *Answer on the Data/Question sheet:*
*a) Which model did your group pick? What were some of the reasons why you picked that one?*
*b) What were some of the reasons why you did not choose the other three models?*

## Part 3 - Circuit Connections and Electrical Diagrams

We will be connecting the power supply (the "battery") to the light bulbs in various combinations. The light box has "sockets" for the banana plug wires. In an actual electrical circuit, these wires would be soldered onto circuit boards to make the connections. We want temporary connections, but something easy to connect and disconnect. The RED wire from GREEN port (+5) on the power supply (like the "+" side of the battery) and the BLACK wire goes to the BLACK (ground) port on the power supply (the "-" side of the battery).

1. Connecting one bulb to power supply. Take one of the bulbs and connect one of its wires to the plus side (red wire) using one of the alligator clips. Connect the other wire from the bulb to the other lead from the battery (the black wire - minus side of battery). An example is shown on the next page:

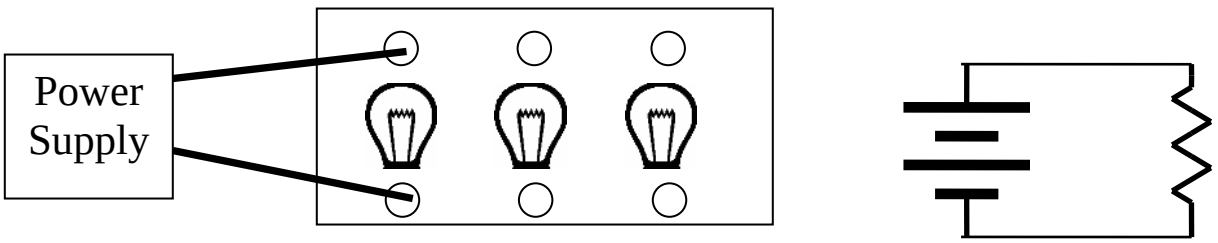



***Figure 3 - Battery/bulb connections and electrical circuit diagram***

Notice the picture of the setup on the left, and the electrical diagram on the right. The picture is easy to follow when we start doing the wiring, but the electrical circuit on the right is a much more compact way to write the same information. As we get accustomed to the electrical diagrams, they will replace the "pictures".

2. Disconnect the bulb. Open one of the alligator clips to release the two wires.

*Questions* *Answer on the Data/Question sheet.*
*a) What happened to the light bulb when you disconnected one of the alligator clips? Is this what you expected? Does this strengthen your idea of the current model, or does it cause a problem with your model? - Explain.*

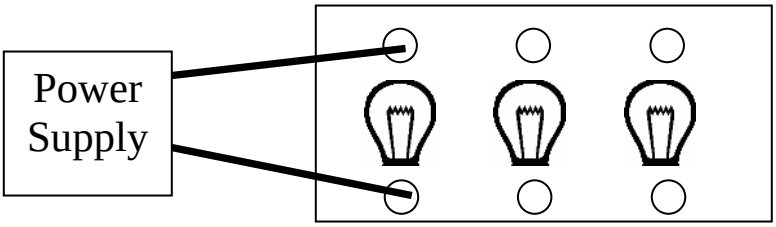
We will be connecting the battery to combinations of these bulbs, to see how the circuit configuration affects the brightness of the bulbs. This will help us identify the current model.

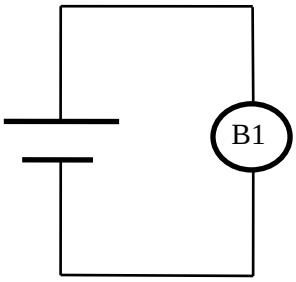
## Series Circuits

*Prediction* *Answer this on the Data/Question sheet:*
*Look at the diagrams on the next page ... Suppose you connected the battery to one, two, or three bulbs in a series configuration: predict the relative brightness of each of the bulbs in each of the configurations. In which circuit will the bulbs be the brightest, and which the weakest? Will the bulbs be of different brightness within a particular circuit?*

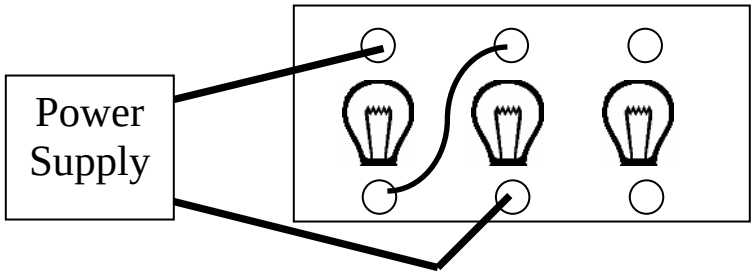
3. Circuit connections. Connect the battery to one of the bulbs. Keep in mind how bright that one bulb appears to be? Now connect it to two bulbs in series, and then three in series (look at the circuit diagrams below).

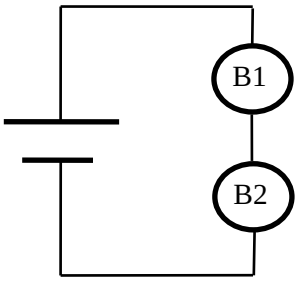
**One Bulb in Series**




**Two Bulbs in Series**

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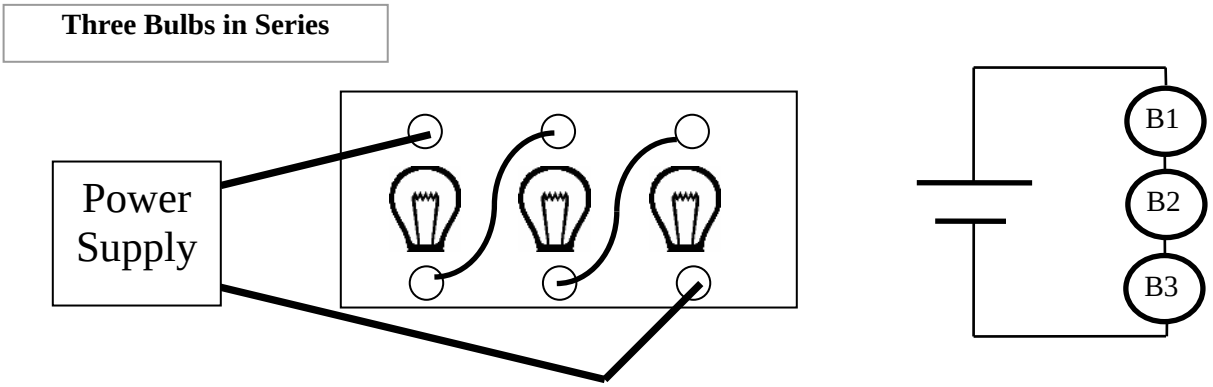



***Figure 4 - Bulb configurations and Circuit diagrams for Series circuits***

*Questions* *Answer these on the Data/Question sheet:*
*a) When you added a second bulb, or a third bulb, what happened to the brightness of the bulbs? Is this what you expected? What possible explanation do you have for this?*

*b) Did your observations match your predictions? If not, why not? What does this information do to the model that you proposed (support it or refute it?)*

*c) With two or three bulbs in the circuit, were the bulbs of relatively equal brightness, or did the brightness drop off in one direction or the other? What does this information do to the model that you proposed (support it or refute it?)*

4. Model refinement. Using the information you gathered above, look back to the page with the four models and decide (as a group) which model you want to propose for the current flow in a circuit.

***CLASS DISCUSSION**: When all the groups have gotten to this point, the instructor will lead a class discussion about the ideas from the previous section. If there are still groups not yet done, you could start to read the next section to be ready.*

*There is room on the Data/Question sheet for notes during the discussion.*

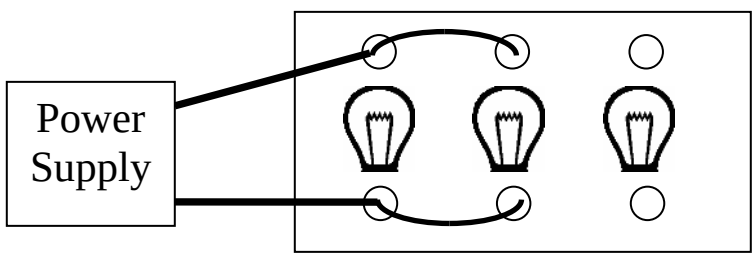
## Parallel Circuits

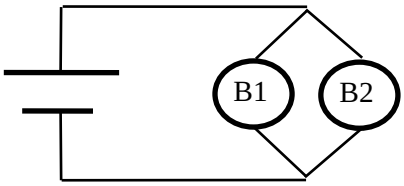
Suppose you connected the bulbs in a parallel configuration instead of series. Parallel circuits have multiple paths for the current to flow.

*Prediction* *Answer this on the Data/Question sheet:*
*Look at the diagram below ... Suppose you connected the battery to two or three bulbs in a parallel configuration: predict the relative brightness of each of the bulbs in each of the configurations. In which circuit will the bulbs be the brightest, and which the weakest?*

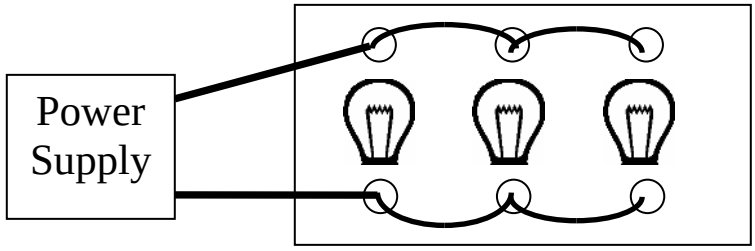
5. Circuit connections. Now connect the bulbs as shown in the circuit diagrams below:

**Two Bulbs in Parallel**




**Three Bulbs in Parallel**



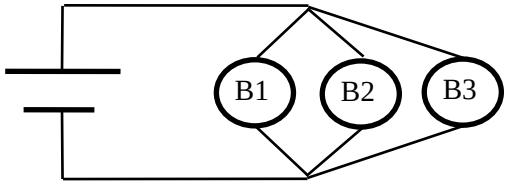




***Figure 5 - Bulb connections and Circuit diagrams for Parallel circuits***

6. Connecting bulbs. Put the wires from the bulbs together with one of the wires from the battery and clamp them all with the alligator clips. You could then just unclamp, add a bulb, and clamp again to get three bulbs together.

*Question* *Answer this on the Data/Question sheet:*
*a) Comparing the circuit when you had two bulbs to three bulbs, what effect did adding the third bulb have on the brightness of the other two? Did you expect this? What explanation could account for this?*

*b) Did your observations match your predictions? If not, why?*

*c) In each of the circuits, were all the bulbs of equal brightness, or was there a trend within that circuit?*

*d) How did the brightness of the three bulbs in parallel compare to the brightness of the three bulbs in series?*

*e) What sort of current flow model could you come up with for the parallel circuits - based on your observations of the series circuits and the parallel circuits? Since there are different paths, address the issue of potentially different currents in each path. How does that compare to the series with only one path?*

*f) In comparing the two types of circuits, series and parallel, in which circuit would the battery last longer?*

*Prediction* *Answer on the Data/Question sheet.*
*Which circuit could withstand the "loss" of a bulb (burned out) and still continue lighting?*

7. Comparing loss of a bulb in series and parallel. Connect two bulbs in series. Gently pull one bulb out of it's socket (to simulate a bulb burning out). Note what happens to the circuit. Now wire them in parallel, and gently pull out one of the bulbs from the socket. Note what happens to the circuit.

*Question* *Answer on the Data/Question sheet.*
*a) What happened to the series circuit when you pulled out the bulb? What happened to the parallel circuit? Can you give an explanation for these effects?*

***CLASS DISCUSSION**: When all the groups have gotten to this point, the instructor will lead a class discussion about the ideas from the previous section. If there are still groups not yet done, you could start to read the next section to be ready.*

*There is room on the Data/Question sheet for notes during the discussion.*

## Part 4 - More Complex Series and Parallel Circuits

*Prediction* *Answer on the Data/Question sheet.*
*Consider the circuit, shown in (a) below, consisting of a battery and two bulbs, B and C, in series. What will happen if you add a third bulb, D, in parallel with bulb C (as shown in (b))? You should be able to answer this question about the relative brightness of B, C, and D based on previous observations. The tough question is: how does the brightness of B change?*

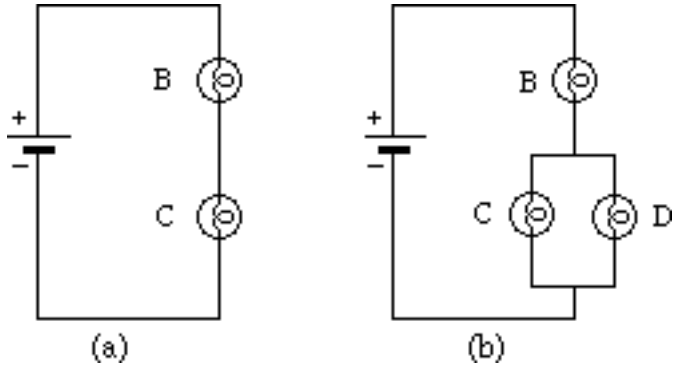



***Figure 6 - Two different circuits with identical bulbs***

1. Wiring the circuits. Wire up the circuit shown in (a) above. Note the brightness of the bulbs. Then add another bulb in series with bulb C as shown in (b) above. Note the new brightness of all the bulbs.

*Question* *Answer on the Data/Question page.*
*a) How does the brightness of C and D compare to each other in circuit (b)?*

*b) How did the brightness of B change when bulb D was added?*

*c) From your answer in b) ... what do you think the total resistance of the C and D combination is compared to just C?*

***CLASS DISCUSSION**: When all the groups have gotten to this point, the instructor will lead a class discussion about the ideas from the previous section.*

*There is room on the Data/Question sheet for notes during the discussion.*

# DATA/QUESTION SHEET - LAB 7 BULBS AND BATTERIES
## (SERIES AND PARALLEL CIRCUITS)

## Part 2 - Developing a Model for Current Flow

*Question* *a) Which model did your group pick? What were some of the reasons why you picked that one?*

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*b) What were some of the reasons why you did not choose the other three models?*

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## Part 3 - Circuit Connections and Electrical Diagrams

*Questions* *a) What happened to the light bulb when you disconnected one of the alligator clips? Is this what you expected? Does this strengthen your idea of the current model, or does it cause a problem with your model? - Explain.*

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### Series Circuits

*Prediction* *Look at the diagrams on Page 3 and 4 (Figure 4). Suppose you connected the battery to one, two, or three bulbs in a series configuration: predict the relative brightness of each of the bulbs in each of the configurations. In which circuit will the bulbs be the brightest, and which the weakest? Will the bulbs be of different brightness within a particular circuit?*

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*Questions* *a) When you added a second bulb, or a third bulb, what happened to the brightness of the bulbs? Is this what you expected? What possible explanation do you have for this?*

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*b) Did your observations match your predictions? If not, why? What does this information do to the model that you proposed (support it or refute it?)*

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*c) With two or three bulbs in the circuit, were the bulbs of relatively equal brightness, or did the brightness drop off in one direction or the other? What does this information do to the model that you proposed (support it or refute it?)*

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***CLASS DISCUSSION**: When all the groups have gotten to this point, the instructor will lead a class discussion about the ideas from the previous section. If there are still groups not yet done, you could start to read the next section to be ready.*

Notes:

## Parallel Circuits

*Prediction* *Look at the diagrams on Page 5 (Figure 5) ... Suppose you connected the battery to two or three bulbs in a parallel configuration: predict the relative brightness of each of the bulbs in each of the configurations. In which circuit will the bulbs be the brightest, and which the weakest?*

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6. Connecting bulbs.

*Question* *a) Comparing the circuit when you had two bulbs to three bulbs, what effect did adding the third bulb have on the brightness of the other two? Did you expect this? What explanation could account for this?*

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*b) Did your observations match your predictions? If not, why?*

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*c) In each of the circuits, were all the bulbs of equal brightness, or was there a trend within that circuit?*

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*d) How did the brightness of the three bulbs in parallel compare to the brightness of the three bulbs in series?*

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*e) What sort of current flow model could you come up with for the parallel circuits - based on your observations of the series circuits and the parallel circuits? Since there are different paths, address the issue of potentially different currents in each path. How does that compare to the series with only one path?*

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*f) In comparing the two types of circuits, series and parallel, in which circuit would the battery last longer?*

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*Prediction* *Which circuit could withstand the "loss" of a bulb (burned out) and still continue lighting?*

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7. Comparing loss of a bulb in series and parallel.

*Question* *a) What happened to the series circuit when you pulled out the bulb? What happened to the parallel circuit? Can you give an explanation for these effects?*

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***CLASS DISCUSSION**: When all the groups have gotten to this point, the instructor will lead a class discussion about the ideas from the previous section. If there are still groups not yet done, you could start to read the next section to be ready.*

Notes:

## Part 4 - More Complex Series and Parallel Circuits

*Prediction* *Consider the circuit, shown in (a) on page 7 (Figure 6). What will happen if you add a third bulb, D, in parallel with bulb C (as shown in (b))? You should be able to answer this question about the relative brightness of B, C, and D based on previous observations. The tough question is: how does the brightness of B change?*

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1. Wiring the circuits.

*Question* *a) How does the brightness of C and D compare to each other in circuit (b)?*

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*b) How did the brightness of B change when bulb D was added?*

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*c) From your answer in b) ... what do you think the total resistance of the C and D combination is compared to just C?*

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***CLASS DISCUSSION**: When all the groups have gotten to this point, the instructor will lead a class discussion about the ideas from the previous section.*

Notes:

## How do I write up this lab? … What is required for this lab report?

Consult the Rubric for this experiment and the "Lab Report Instructions" document (both found on the Lab Schedule page).

Questions/Suggestions -> Dr. Scott Schneider - S_SCHNEIDER@LTU.EDU

*Portions of this laboratory manual have been adapted from materials originally developed by Priscilla Laws, David Sokoloff and Ronald Thornton for the Tools for Scientific Thinking, RealTime Physics and Workshop Physics curricula. You are free to use (and modify) this laboratory manual only for non-commercial educational uses.*