PhyzLab: , on the Range

an investigation of voltage, resistance, and current

PERIOD	1.		
	2.		
GROUP	3.		
	4.		

• Focus Question •

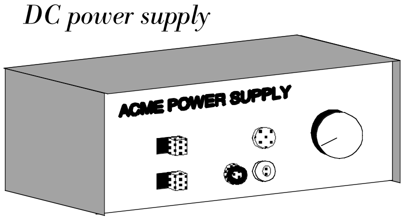
What is the relationship between voltage, resistance and current in an electric circuit?

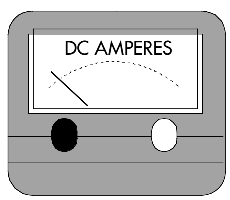
• Apparatus •

___ variable DC power supply
___ voltmeter: preferred range: ________ (ask your instructor)

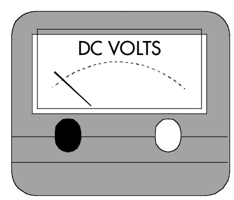
___ ammeter: preferred range: ________ (ask your instructor)
___ 8 connecting wires
___ 3 resistors with known resistance
>>> RECORD THE RESISTANCE VALUES: _________ , _________ , __________
___ resistor with unknown resistance
>>> RECORD THE UNKNOWN RESISTOR ID/NAME:___________________________
___ minibulb (#1487 14.4 V) in blue socket

DC power supply

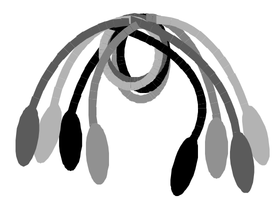




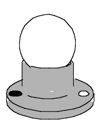
ammeter



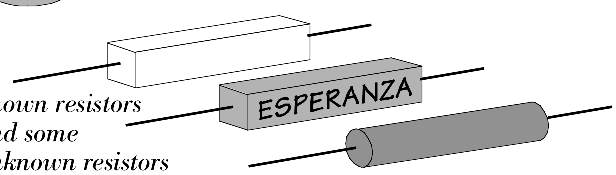
voltmeter



connecting wires



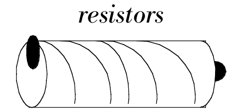
mini bulb in blue socket



known resistors and some unknown resistors

NOTE: The small cylindrical and rectangular resistors are made of ceramic (like fine china). If you drop them, they will most likely break. If you bend the wire leads, they will fatigue and break, so please do not bend the wire leads. Handle them with care.

some unknown resistors



wire-wound wood resistor

• Discussion •

To determine the relationship between voltage, resistance and current in an electric circuit, you need to construct an electric circuit.

Current will flow through the circuit only if there is a potential (voltage) difference across the circuit. The potential difference is provided by the **power supply**. The potential will be regulated by the **power supply** and will be measured with a **voltmeter**.

If the positive and negative terminals of the power supply or battery are connected directly, a so-called short circuit will exist and the power supply will be damaged or destroyed. Therefore, a **resistor** is connected between the terminals.

The current flowing through the circuit will be measured with an **ammeter**.

The strategy will be to collect several corresponding current and voltage readings for circuits with known resistance and determine a pattern linking voltage, resistance, and current.

• Procedure •

1. MEET YOUR METER

Before answering the following questions, make sure each meter is correctly zeroed. When the meter is not connected to a circuit, the needle should point to the zero mark on the meter. Not to the left or right of zero, but zero exactly. If your needle needs to be zeroed, ask your instructor for assistance.

a. What is the range of the voltmeter? From __________V (lowest reading) to __________V (highest reading).

b. What is the size of the divisions on the voltmeter? In other words, what is the smallest increment on the

voltmeter (if the needle went to the **first** mark past the zero point)? ____________________ V

c. Suppose your voltmeter were connected to a voltage whose true value was 0.275481 V. What value would your meter show? (Your meter is not capable of the level of precision shown in the true value.)

V = ______________________________

d. What is the range of the ammeter? From __________A (lowest reading) to __________A (highest reading).

e. What is the smallest increment on the ammeter? In other words, what is the smallest increment on the

ammeter (if the needle went to the **first** mark past the zero point)? ____________________ V

f. Suppose your ammeter were connected to a current whose true value was 0.275481 A. What value would your meter show? (Your meter is not capable of the level of precision shown in the true value.)

I = ______________________________

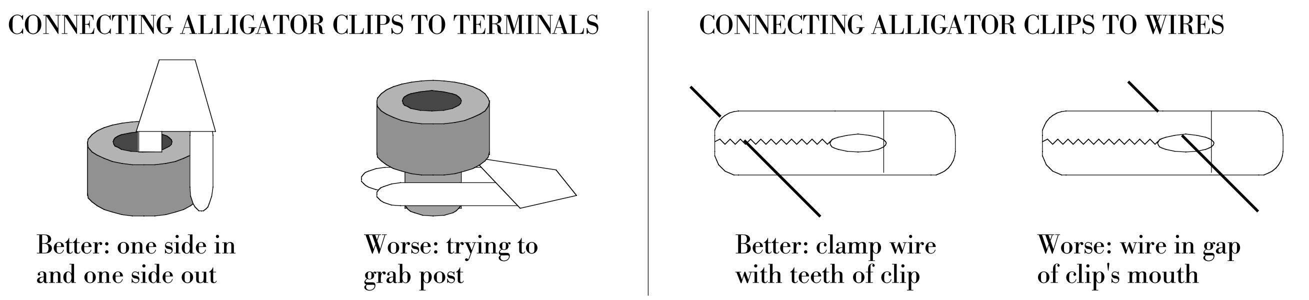
g. The device that measures the rate at which charge passes through the circuit is the

______________________________; the device that measures the amount of energy each unit of charge has is

the ____________________________.

2. MAKING CONNECTIONS

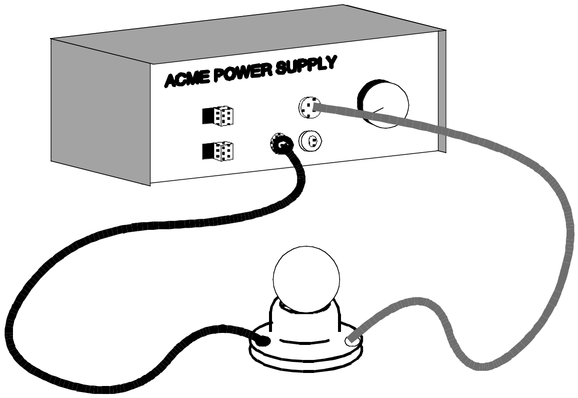
a. Note the wiring tips shown below.



b. **MAKE SURE THE POWER SUPPLY IS SWITCHED OFF AND THE KNOB IS TURNED ALL THE WAY DOWN. IF APPLICABLE, MAKE SURE IT IS SWITCHED TO DC INSTEAD OF AC.**

c. Wire the circuit as shown in the following diagram. Use the power supply, two connecting wires, and a minibulb in its socket. **Use the blue-socket bulb (#1487).**

d. Turn the power supply on and **slowly** turn the knob higher and higher until you see the bulb glow. DO NOT MAKE THE BULB BRIGHT; DOING SO BURNS IT OUT!

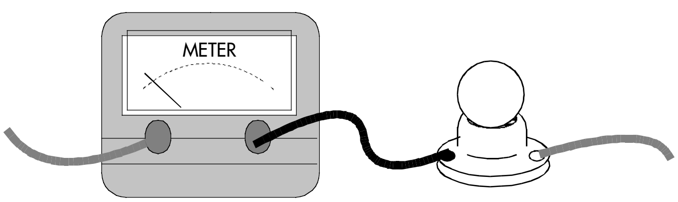


Connect alligator clips to bulb socket terminals by having the clip grab the mini-screw or metal tab beneath the screw on the terminal.

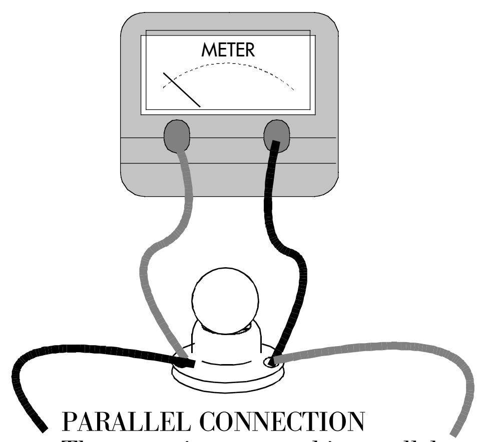
If need be, an alligator clip can grab another alligator clip (for multiple connections to a single bulb terminal, for example). As long as there is a metal-to-metal connection, a conducting path exists.

e. Using additional wires and the ammeter, connect the ammeter to the circuit somehow so that it correctly measures the current passing through the bulb. At least one wire should connect the ammeter to the bulb socket. If the needle appears to move the wrong way when the circuit is working correctly, reverse the connections to the meter. The meter is connected correctly when the bulb brightness and the meter reading vary in accordance with the power supply knob. That is, as the power is turned up, the ammeter reading should increase, and the brightness of the bulb should increase. THE BULB SHOULD BE QUITE BRIGHT WITHOUT THE CURRENT EXCEEDING 0.2 A. If it is not, try a different wiring configuration. See the diagrams below for ideas. Obtain a PhyzBlessing when you have it working correctly.

f. Remove the ammeter and return the circuit to its original state (shown on the previous page). Using additional wires and the voltmeter, connect the voltmeter to the circuit so that it correctly measures the voltage across the bulb. At least one wire should connect the voltmeter to the bulb socket. If the needle appears to move the wrong way when the circuit is working correctly, reverse the connections to the meter. The meter is connected correctly when the bulb brightness and the meter reading vary in accordance with the power supply knob. That is, as the power is turned up, the voltmeter reading should increase, and the brightness of the bulb should increase. The bulb should be bright with less than the maximum voltage. If it is not, try a different wiring configuration. Obtain a PhyzBlessing when you have it working correctly.



SERIES CONNECTION
The meter is connected in series with the bulb. Connections to the power supply are not shown.



PARALLEL CONNECTION
The meter is connected in parallel with the bulb. Connections to the power supply are not shown.

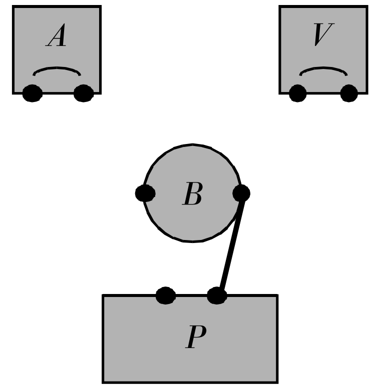
g. Now wire the circuit with both meters in place. Both meters are connected correctly when the bulb brightness and both meter readings vary in accordance with the power supply knob. There should be only one wire connected to each terminal of the power supply and one wire connected to each active terminal of each meter. The current is much less than 1 A.

Examine the diagram above. It shows one meter connected in series with the bulb and one meter connected in parallel with the bulb.

h. Which of the meters—if either—is/are connected in **series** with the bulb?

i. Which of the meters—if either—is/are connected in **parallel** with the bulb?

j. In the diagram to the right, the power supply is labeled P, the bulb is labeled B, the ammeter is labeled A and the voltmeter is labeled V. Use lines to show the wire connections in a correctly wired circuit. Connect your wires at the circular terminals shown on each device. Your wires must go **around** the devices, not **through** them. Draw them accordingly, and don't draw wires crossing each other.



k. Obtain a PhyzBlessing for the diagram before moving on.

3. THE LOW-VALUE RESISTOR

a. High Tech Option. (For Low Tech, skip these italicized instructions.)
i. Obtain a computer. Turn it on and let it complete its start-up cycle.
ii. Open the spreadsheet template "1.xx Ohm on the Range." (Apple Menu → Excel PhyzSheets → Ohm on the Range XL, where 1.xx is the unit number.)
iii. Save the spreadsheet to the appropriate place in the Student Work folder. . Delete "XL" or "XL1" from the title and replace it with PG, where P is your period and G is your group (e.g., 4th period group C would have a PG code of "4C").
iv. Enter your group's PG code in the data table of your spreadsheet.
v. When the instructions below call for recording data, do so in the spreadsheet.

Turn the power supply knob down and switch it off. Replace the bulb in the circuit with the lowest -rating known resistor. Make sure the resistor in your completed circuit has the lowest -rating.

ONE PERSON IN THE GROUP MUST HOLD THE RESISTOR. NEVER ALLOW CURRENT TO PASS THROUGH THE CIRCUIT LONG ENOUGH TO ALLOW THE RESISTOR TO GET UNCOMFORTABLY HOT. IF THE RESISTOR GETS TOO HOT TO HANDLE, TURN OFF THE POWER SUPPLY AND MOVE ON TO THE NEXT RESISTOR.

b. Turn the **knob** on the **power supply** down to zero.

c. If your power supply has an ON/OFF switch, turn the **power supply** ON.

d. Adjust the **power supply knob** until the ammeter shows a current of **0.10 A** flowing through the circuit. QUICKLY read the voltmeter—as precisely as possible—and record the potential drop (voltage) across the resistor in the VL column (VL represents voltage of the low-resistance resistor).

e. Record the voltage on the data table, proceed by adjusting the knob to attain the subsequent values of current shown on the data table.

NOTE: You may not be able to fill all the places in the data table. For example, you may not be able to get a current of 0.8 A to flow through a given resistor. Fill in only the slots you can within the limitations of the equipment. It is acceptable to leave some slots blank! ABSOLUTELY DO NOT *INVENT* DATA to fill in the tables (the pattern you find at first may not continue through *all* data points)!

4. THE MEDIUM-VALUE RESISTOR
Make sure the resistor in your completed circuit has neither the lowest nor the highest -rating. Follow the procedures b-e in part 3. Use the column headed VM.

5. THE HIGH-VALUE RESISTOR
Make sure the resistor in your completed circuit has the highest -rating. Follow the procedures b-e in part 3. Use the column headed VH.

6. THE UNKNOWN RESISTOR
Make sure the resistor in your completed circuit is the "named" unknown. Follow the procedures b-e in part 3. Use the column headed VU.

• Low-Tech Analysis • (Skip this section if you are doing the high-tech analysis)

1. Plot the data you collected on the blank graph provided. Label each set of points. Do not connect the points.

2. For each data set, draw the single best line you can make that passes near or through all the data points. DO NOT "CONNECT THE DOTS." Draw a single line that shows a general trend in the data. This should be a straight line with a constant slope.

3. Measure the slope of each straight line you drew on your graph (from #2 above). Calculate the slope using current and voltage values that lie directly on the line; do **not** use any observed data values. Show values used and calculations used to determine each slope value. (Should the slope values include units?)

____ :

____ :

____ :

Unknown :

4. Determine the average quotient of the voltage divided by the current. Calculate and record the quotient for each data point. (There is space for this on the data page.) Then calculate and record the average of those quotients. Compare these averages to the slopes of the corresponding data sets.

5. Which analysis gives more accurate results:
___determination of slope or
___calculation of the V/I average?

• High-Tech Analysis • (Skip this section if you are doing the low-tech analysis)

1. What is the slope of each line, as indicated by the best fit line (note that the best fit line equation is displayed in the form **y = mx + b** where the value **m** is the slope). Record your answers using the correct number of significant figures and attach the correct units of measure. (Excel cannot do either of these tasks.)

_____ · best fit slope =

_____ · best fit slope =

_____ · best fit slope =

Unknown · best fit slope =

2. At the bottom of each column of V/I ratios, notice the average V/I value in that column. Make sure that none of the cells in the column has a value of 0 or text of any kind. Blank cells are OK (they are ignored in the calculation).

_____ · VL/I average =

_____ · VM/I average =

_____ · VH/I average =

Unknown · VU/I average =

7. Prepare the spreadsheet for printing. Select File: Page Setup..., the select “Landscape” orientation and select “Fit to 1 page.” OK the settings and then do a “Print Preview” to see that all the data fits on one page. If it does, print one copy for each member of the lab group.

8. Print one copy of the graph for each member of the group.

• Answer • (Everyone does the following sections)

Based on your findings, what is the relationship between voltage, resistance, and current? Write your answer in the form of an equation if possible. (Remember that equations are written using symbols for quantities, not symbols for units.)

• Mystery Sister / Mr. Resistor •

a. What is the name of your unknown resistor?

b. What is the resistance of your unknown resistor?

c. How did you determine the value of the unknown resistance?

d. Get an exact value from the instructor and calculate the percent **error** (not difference) in your value of resistance. Show the calculation (even if the percent error is zero).

ACCEPTED RESISTANCE = ________________________

Percent **Error** Calculation:

PERCENT **ERROR** = ________________________