

Laboratory: Ohm's Law

(Science Workshop 750 using Built-in Power Output)

Concept	<i>DataStudio</i>	<i>ScienceWorkshop</i> (Mac)	<i>ScienceWorkshop</i> (Win)
Electricity	P48 Ohm's Law.DS	(See end of activity)	(See end of activity)

Equipment Needed	Qty	Equipment Needed	Qty
Light bulb, 3 volt (from EM-8656)	1	Resistor, 10 ohm (from EM-8656)	1
Patch Cords (SE-9750)	2	Wire leads, 10 inch (from EM-8656)	2

What Do You Think?

What is the relationship between current and voltage in a simple resistor? What is the relationship between current and voltage in the filament of an incandescent light bulb?



Take time to answer the 'What Do You Think?' question(s) in the Lab Report section.

Background

Georg Simon Ohm discovered that when the voltage (potential difference) across a resistor changes, the current through the resistor changes. He expressed this as

$$I = \frac{V}{R}$$

where I is current, V is voltage (potential difference), and R is resistance. Current is directly proportional to voltage and inversely proportional to resistance. In other words, as the voltage increases, so does the current. The proportionality constant is the value of the resistance. Since the current is inversely proportional to the resistance, as the resistance increases, the current decreases.

A resistor is 'Ohmic' if as voltage across the resistor is increased, a graph of voltage versus current shows a straight line (indicating a constant resistance). The slope of the line is the value of the resistance. A resistor is 'non-Ohmic' if the graph of voltage versus current is not a straight line. For example, if resistance changes as voltage changes, the graph of voltage versus current might show a curve with a changing slope.



For certain resistor, the value of its resistance does not change appreciably. However, for a light bulb, the resistance of the filament will change as it heats up and cools down. At high AC frequencies, the filament doesn't have time to cool down, so it remains at a nearly constant temperature and the resistance stays relatively constant. At low AC frequencies (e.g., less than one Hertz), the filament has time to change temperature. As a consequence, the resistance of the filament changes dramatically and the resulting change in current through the filament is interesting to watch.

In the first part of this activity, investigate the relationship between current and voltage in a simple ten-ohm (Ω) resistor. In the second part, investigate the relationship between current and voltage in the filament of a small light bulb.

<p>SAFETY REMINDER</p> <ul style="list-style-type: none"> Follow all safety instructions. 	<p>THINK SAFETY ACT SAFELY BE SAFE!</p>
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For You To Do

Part A – Resistor

Use the ‘Output’ feature of the interface to supply voltage to a ten-ohm resistor. Use *DataStudio* or *ScienceWorkshop* to measure the output voltage across the resistor and the current through the resistor (the current drawn from the interface).

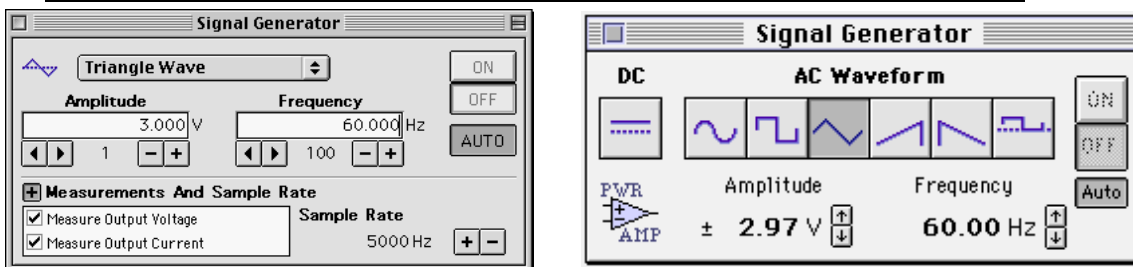


Use the program to display the voltage and current. Use a plot of voltage versus current to confirm the resistance value of the resistor.

PART IA: Computer Setup for Resistor

1. Connect the *ScienceWorkshop* interface to the computer, turn on the interface, and turn on the computer.
2. Connect banana plug patch cords into the ‘OUTPUT’ ports on the interface.
3. Open the document titled as shown:

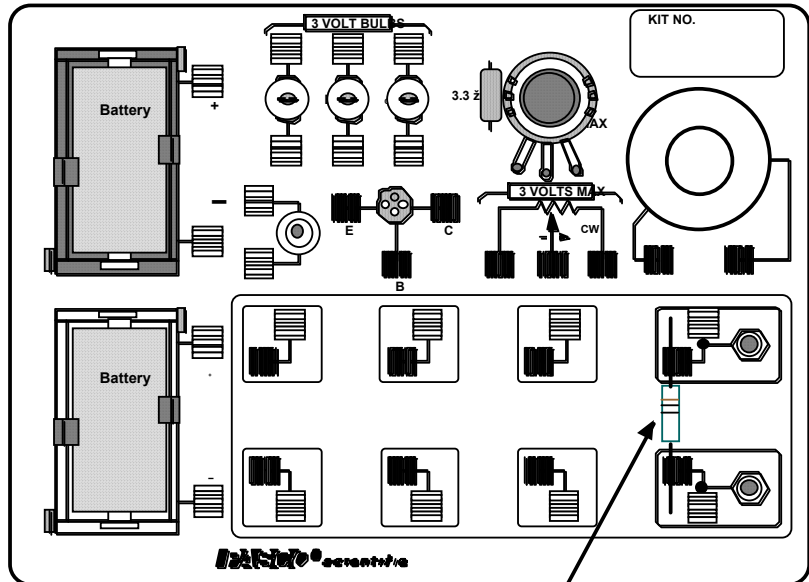
<i>DataStudio</i>	<i>ScienceWorkshop</i> (Mac)	<i>ScienceWorkshop</i> (Win)
P48 Ohm's Law.DS	(See end of activity)	(See end of activity)



- The *DataStudio* document opens with a Signal Generator window and a Scope display. The document also has a Workbook display. Read the instructions in the Workbook.
- The Scope display will show the voltage from the ‘Output’ of the interface to the ten-ohm resistor and the output current from the interface through the resistor.
- The Signal Generator is set to produce a triangle wave at 60 Hz. It is set to ‘Auto’ so it will automatically start or stop the signal when you start or stop measuring data.
- In *DataStudio*, make sure that ‘Measure Output Voltage’ and ‘Measure Output Current’ are checked in the Signal Generator window.
- Arrange the Scope display and the Signal Generator window so you can see both of them.

PART IIA: Equipment Setup - Resistor

- You do not need to calibrate a sensor because, in this activity, the interface is the sensor.
1. Place a ten-ohm (Ω) resistor in the pair of component springs nearest to the banana jacks at the lower right corner of the AC/DC Electronics Lab Board.
 2. Connect banana plug patch cords from the 'OUTPUT' ports of the interface to the banana jacks on the AC/DC Electronics Lab circuit board.

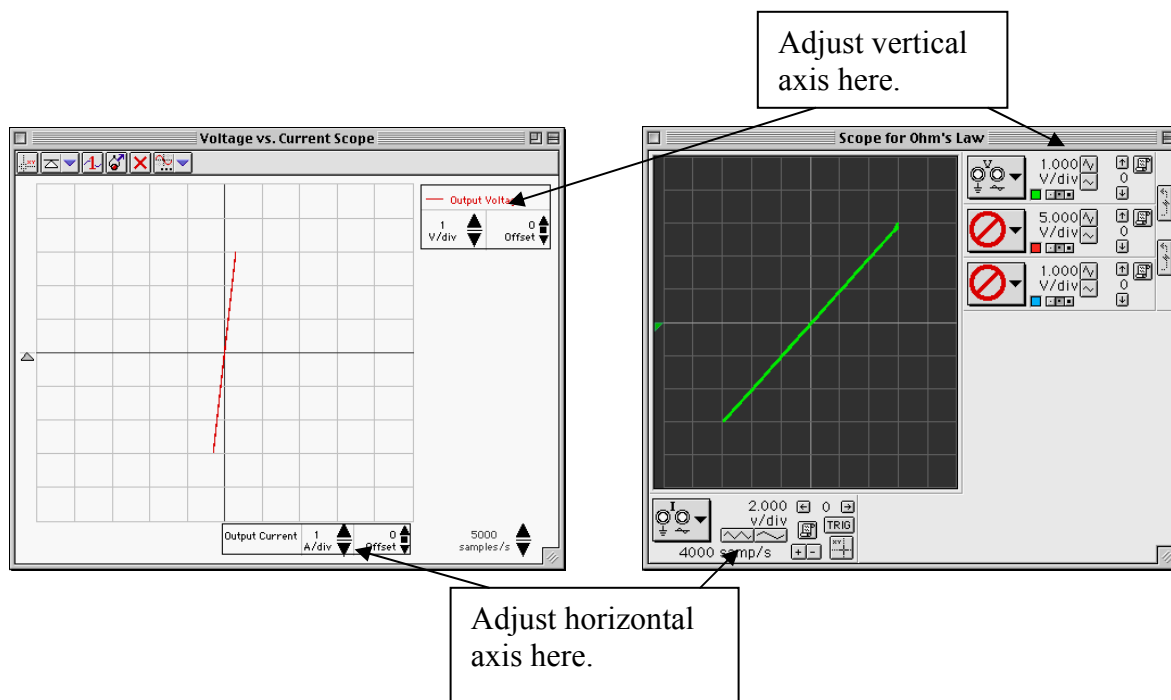


10 1/2 RESISTOR (BROWN, BLACK, BLACK)

Part IIIA: Data Recording – Resistor

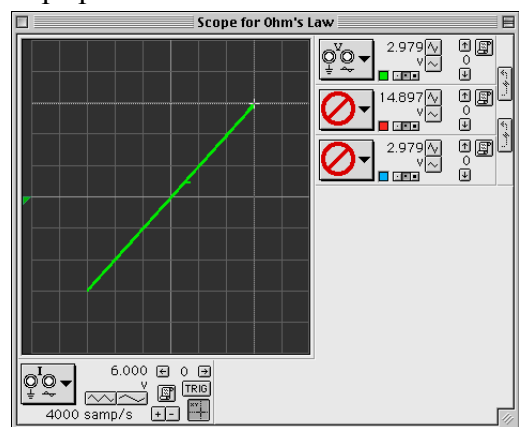
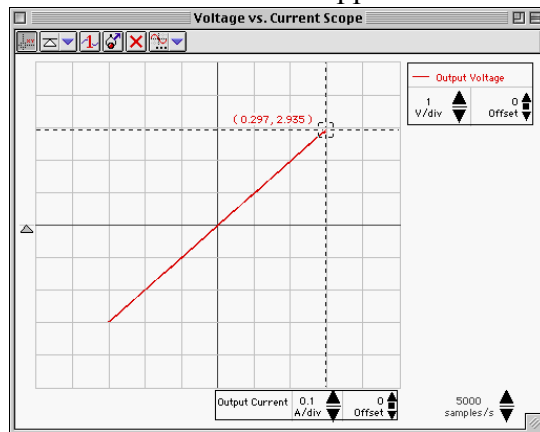
1. Begin measuring data. (Click 'Start' in *DataStudio* or 'MON' in *ScienceWorkshop*.)

- Observe the Scope display of Voltage and Current. Adjust the vertical axis or the horizontal axis if necessary.
2. Observe the trace of voltage vs. current for a few seconds and then stop measuring data.



Analyzing the Data – Resistor

- Use the ‘Scope’s built-in analysis tools to determine the voltage and current for the ten-ohm resistor.
 - In *DataStudio*, click the ‘Smart Tool’. Move the ‘Smart Tool’ so it shows the coordinates of a point on the trace of voltage versus current. **Result:** The ‘X-Y’ coordinates are voltage and current.
 - In *ScienceWorkshop*, click the ‘Smart Cursor’. Move the cursor into the display area of the Scope. **Result:** The value for voltage appears below the ‘V/div’ control for the vertical axis and the value for current appears above the ‘sweep speed’ control for the horizontal axis.



- Use the coordinates of the point on the trace to determine the ratio of voltage versus current. Record the ratio as the resistance of the resistor.
 - In *DataStudio*, the ‘X’ coordinate is the current and the ‘Y’ coordinate is the voltage. Divide one by the other to calculate the resistance.
 - In *ScienceWorkshop*, the output current displayed in the Scope must be converted. Multiply the ‘X’ coordinate by 0.05 to determine the actual current. The ‘Y’ coordinate is the actual voltage. Divide the voltage by the current.

$$\text{resistance (ten-ohm resistor)} = \underline{\hspace{2cm}} \text{ volt/amp}$$

Optional

- Replace the ten-ohm resistor with a 100-ohm resistor.
- Adjust the horizontal scaling (x-axis) in the Scope display as needed.
- Repeat the experiment. Record the new ratio as the resistance of the resistor.

$$\text{resistance (100 } \Omega) = \underline{\hspace{2cm}} \text{ volt/amp}$$

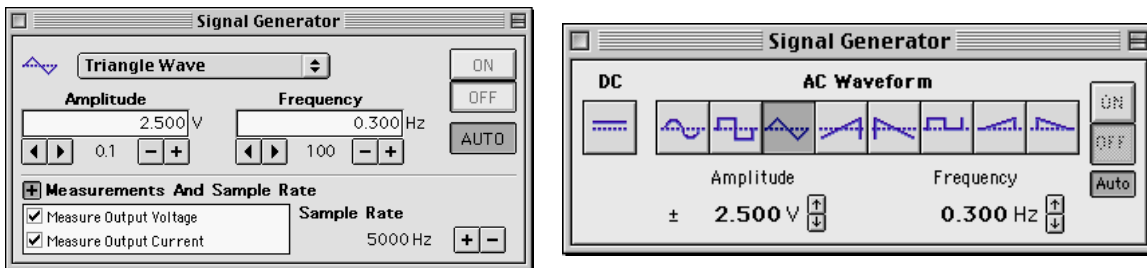
Part B – Light Bulb

Use the 'Output' feature of the interface to supply voltage to small light bulb. Use *DataStudio* or *ScienceWorkshop* to measure the output voltage across the light bulb filament and the current through the filament (the current drawn from the interface).


Use the program to display the voltage and current. Use a plot of voltage versus current to confirm the resistance value of the resistor.

PART IB: Computer Setup for Light Bulb Filament

1. Change the Amplitude and Frequency of the output AC waveform. Click the Signal Generator window to make it active.
2. Click the Amplitude value to highlight it. Type in '2.5' as the new value. Press <enter> or <return> on the keyboard to record your change.

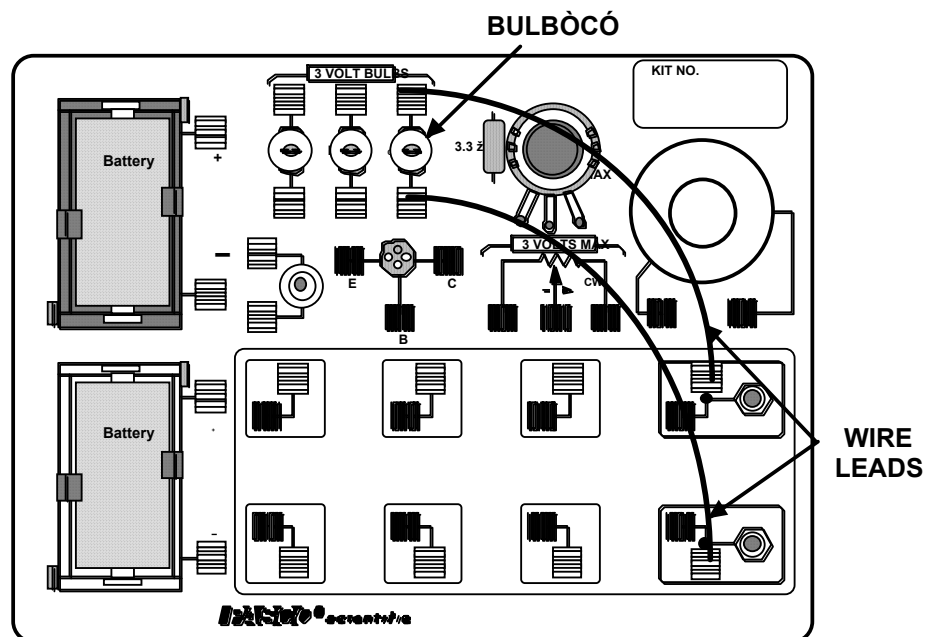


3. Click the Frequency value to highlight it. Type in '0.30' as the new value. Press <enter> or <return> on the keyboard to record your change.
 4. Adjust the sweep speed in the Scope display to 50 samples/second.
- In *DataStudio*, click the 'down' arrow next to 'samples/s'.

- In *ScienceWorkshop*, click the '+' button () next to 'samp/s'.

PART II: Equipment Setup for Light Bulb Filament

1. Remove the resistor from the component springs on the AC/DC Electronics Lab circuit board.
2. Use two of the 10" wire leads



to connect between the component springs near the banana jacks and the component springs above and below **3 VOLT BULB “C”**.

PART III: Data Recording – Light Bulb Filament

1. Start measuring data. Observe the Scope display of voltage versus current for the light bulb filament. Adjust the vertical and horizontal scales if necessary.
2. Wait a few seconds and then stop measuring data.

Analyzing the Data – Light Bulb Filament

Use the built-in analysis tools in the Scope display to find the coordinates at several points on the trace of voltage versus current. Calculate the ratio of voltage to current at each point.

Answer the questions in the Lab Report section.

Lab Report - Activity P40: Ohm's Law

What Do You Think?

What is the relationship between current and voltage in a simple resistor? What is the relationship between current and voltage in the filament of an incandescent light bulb?

Data

resistance (ten-ohm resistor) = _____ volt/amp

resistance (100 Ω) = _____ volt/amp

Questions

1. Compare the ratio of voltage and current from the Scope display to the resistance of the resistor(s) used.
2. Does each resistor you used have a constant resistance?
3. Does the light bulb filament have a constant resistance (constant ratio of voltage to current)? Why or why not?
4. The slope of the graph for the light bulb is not symmetric. Why is the trace on the Scope different when the filament is heating up compared to the trace when the filament is cooling down?

Name _____

Class _____

Date _____

Appendix: Modify a ScienceWorkshop File

Modify an existing *ScienceWorkshop* file.

Open the ScienceWorkshop File

Open the file titled as shown:

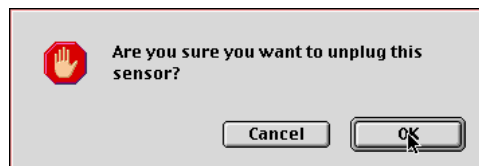
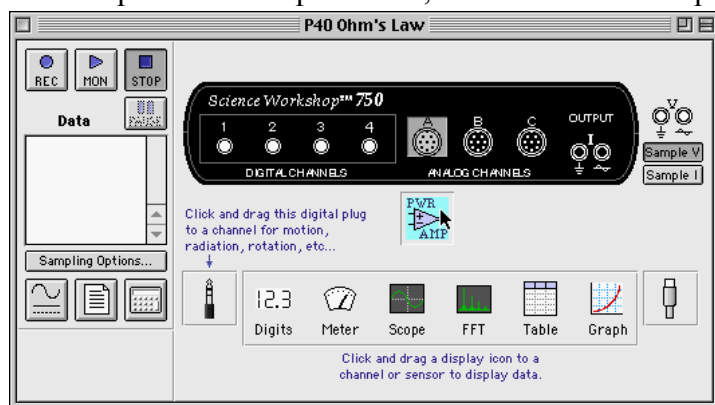
<i>ScienceWorkshop</i> (Mac)	<i>ScienceWorkshop</i> (Win)
P40 Ohm's Law	P40_OHM.SWS

This activity uses the 'Output' feature of the *ScienceWorkshop* 750 interface to provide both output voltage and output current.

- Remove the Power Amplifier in the Experiment Setup window.
- Select 'Sample I' (sample the output current).
- Change the 'Scope' display to show output voltage versus output current.

Remove the Power Amplifier Icon

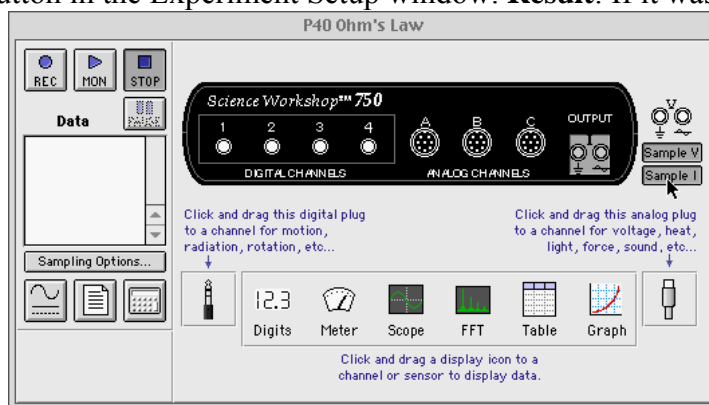
In the Experiment Setup window, click the Power Amplifier icon and press <delete> on the



keyboard. **Result:** A 'warning' window opens. Click 'OK' to return to the setup window.

Select 'Sample I'

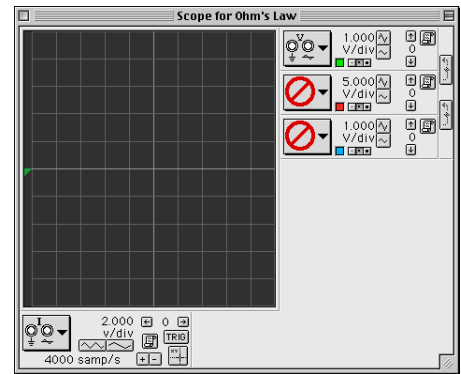
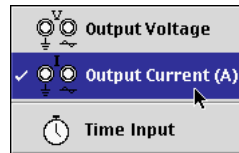
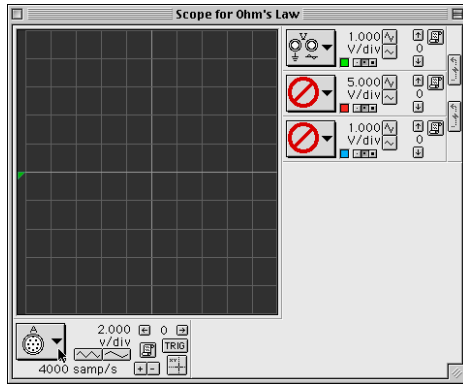
Click the 'Sample I' button in the Experiment Setup window. **Result:** If it was not already open,





the 'Signal Generator' window opens.

Change the Scope Display

The 'Scope' shows the 'Channel A' icon on its X-axis. Click the 'X-Axis Input' menu and select 'Output Current (A)'.



Set the 'sweep speed' to 2.000 v/div. Hint: Click the 'Decrease/Increase Sweep Speed' buttons ( ).

Results

The *ScienceWorkshop* document has a 'Scope' (oscilloscope) display of Output Voltage (V) versus Output Current (I) and the Signal Generator window which controls the output.