Online Lab: Resistivity

Name: Date:

Instructor: Section:

Objective:

The resistivity of different metals is determined by finding the resistance of wires of a known diameter as a function of their length. It is also shown that the resistance of a wire of fixed length is inversely proportional to its cross-sectional area.

Theory:

Resistivity (ρ) is a fundamental material property, while the resistance (R) of an electrical conducting wire depends on several factors, such as: type of conductor material, length of the conductor, cross-sectional area, and the temperature of the wire. At a constant temperature, the resistance (R) of a given conductor is directly proportional to its length (L) and inversely proportional to its cross-sectional area (A).

This resistance is given by the following formula:

$$R = \rho L / A \tag{1}$$

A plot of R vs. L will result in a straight line that has a slope equal to ρ/A. Thus the resistivity is given by

$$\rho \ = \ (slope) \ A \ = \ (slope) \ \pi \ r^2 \ = \ (slope) \ \pi \ (d/2)^2 \tag{2}$$
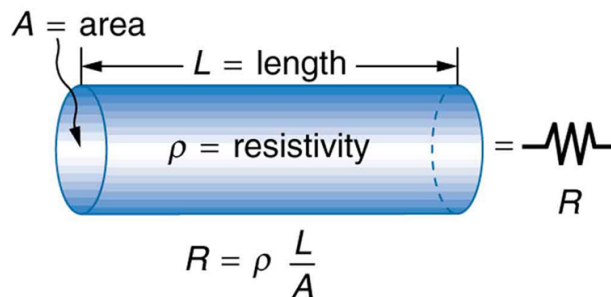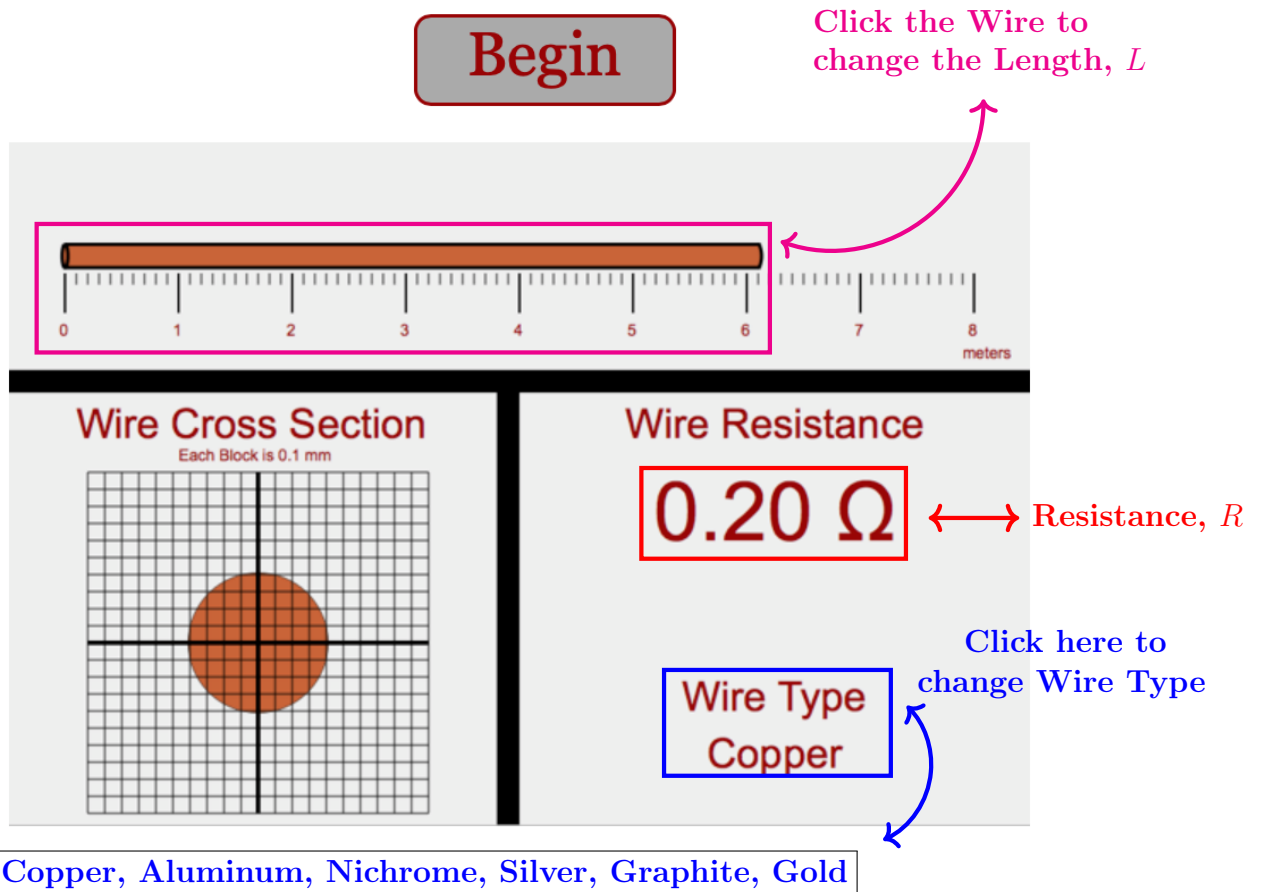
Online Experiment Setup Instructions

1. Today's Online Lab we are going to use one of the physicsaviary.com simulations.
   Go to the following website:
   http://www.thephysicsaviary.com/Physics/Programs/Labs/ResistanceOfWireLab/

2. The figure below shows what you should see on your screen.
   Click **Begin** to start the simulation.

,

Begin

Click the Wire to change the Length, L

Wire Cross Section
Each Block is 0.1 mm

Wire Resistance

0.20 Ω ⟷ **Resistance, R**

Wire Type
Copper

Click here to change Wire Type

Copper, Aluminum, Nichrome, Silver, Graphite, Gold

How to Measure the Wire Cross-Section

Wire Cross Section
Each Block is 0.1 mm

Measure the radius of the wire by counting the number of blocks in the grid. For example, in the Wire Cross Section on the right, the cross section is about 6.0 blocks from the center of the wire to the edge for a wire radius:
$r = 0.1$ mm $\times 6.0 = 0.6$ mm $= 0.0006$ m.

The **Cross-Sectional Area**, A of a wire can be found by: $A = \pi r^2$. In the example to the right,

$A = \pi r^2 = \pi \times (0.0006 \text{ m})^2$
$A = 1.13 \times 10^{-6} \ m^2$ or 1.13 E -6 m^2

r
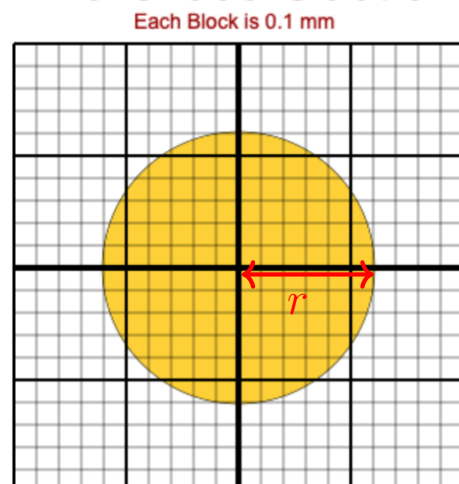
Part A: Resistance versus Length

For this part you will be simulating the resistance, R of a wire as a function of varying length, L and fixed cross section area, A to determine the resistivity, ρ.

1. Click on the Wire until the length, L reads **between 7 and 8 meters**.

2. Measure the radius, r of the wire using the method described on page 2.
   Record the radius in milimeters (mm) and meters (m) in Table 1 below.

3. Calculate the cross sectional area, A using the method described on Page 2.
   Record this value in Table 1 below.

Table 1: Radius and Cross Sectional Area Data

Wire Radius (mm)	Wire Radius (m)	Cross Sectional Area, πr^2 (m^2)

4. Using the ruler at the top of the simulator, Measure the length of the wire.
   Record this value <u>Wire Length</u> column in Table 2, row 1.

5. Select a **Wire Type** of <u>Copper</u>.
   Record the Wire Resistance in the Copper Resistance Column of Table 2.

6. Select a **Wire Type** of <u>Aluminum</u>.
   Record the Wire Resistance in the Aluminum Resistance Column of Table 2

7. Select a **Wire Type** of <u>Nichrome</u>.
   Record the Wire Resistance in the Nichrome Resistance Column of Table 2.

8. Select a **Wire Type** of <u>Silver</u>.
   Record the Wire Resistance in the Silver Resistance Column of Table 2.

9. Click on the Wire until the length, L reads **between 5 and 7 meters**.
   Measure and Record the Wire Length in Row 2, Table 2.

10. Repeat Steps 5 - 8 for this length.

11. Click on the Wire until the length, L reads **between 3 and 5 meters**.
    Measure and Record the Wire Length in Row 3, Table 2.

12. Repeat Steps 5 - 8 for this length.

13. Click on the Wire until the length, L reads **between 1 and 3 meters**.
    Measure and Record the Wire Length in Row 4, Table 2.

14. Repeat Steps 5 - 8 for this length.

Data Section: Resistance vs Length

Table 2: Resistance versus Length

Wire Length (m)	Copper Resistance (Ω)	Aluminum Resistance (Ω)	Nichrome Resistance (Ω)	Silver Resistance (Ω)

Table 3: Resistivity of Different Metals for Wire Length between 7 and 8 meters

Metal	Slope (Ω/m)	$\rho_{experimental}$ (Ω m)	$\rho_{accepted}$ (Ω m)	$\%_{error}$
Copper			1.68×10^{-8}	
Aluminum			2.65×10^{-8}	
Nichrome			100×10^{-8}	
Silver			1.59×10^{-8}	

Data Analysis: Resistance versus Length

1. Using your data in Table 2, create a scatter graph of Resistance, R on the Y-axis versus Length L on the X-axis for each of the 4 types of wires. Label the x-y axes including units and Title your graph with Metal Resistance vs Length. See Figure 1 for an example graph. For example, "Copper Resistance vs Length". Comment on your graphs below.
   Upload your graphs with this Lab Report in D2L.

2. Measure the slope of the line for each of the 4 graphs using any method you are comfortable with. Record the slope values in Column 3 of Table 3.

3. Use Equation 3 to calculate the measured resistivity, $\rho_{experimental}$ using your slope values and the measured Cross sectional Area in Table 1 for each of the metals in Table 3. Record these values in Column 4 of Table 3.

4. Compare your measured resistivity values $\rho_{experimental}$ to the accepted resistivity values $\rho_{accepted}$ using the equation below. Record these values in Column 6 of Table 3. Do they agree? Explain any differences.

$$\%_{Error} \;=\; \left(\frac{\rho_{experimental} - \rho_{accepted}}{\rho_{accepted}} \right) \;\times\; 100 \tag{3}$$

5. <u>**Take a photo or scan a copy showing ALL of your calculations and upload it with this Lab Report in D2L.**</u>

Part B: Resistance versus Cross-sectional Area

For this part you will be simulating the resistance of a wire with varying cross sectional area and fixed length in order to determine its resistivity.

1. Select a **Wire Type** of <u>Gold</u>.

2. Click on the Wire to select a new length, L.
   Read and Record the Wire Length here. L =

3. Measure the radius, r of the wire using the method described on page 2.
   Record the Wire Radius in milimeters (mm) and meters (m) in Table 4, Columns 1 and 2.

4. Record the Wire Resistance Row 1, Column 5 of Table 4.

5. Click on the Cross Sectional Area of the simulation to change the wire diameter to another random value.

6. Repeat Steps 3 - 5 until you have 4 different sets of measurements.

7. Calculate the Cross Sectional Area, A for each Wire Radius in Column 2 of Table 4.
   Record these values in Column 3 of Table 4.

8. Calculate $1/A$ for each Cross Sectional Area in Column 3 of Table 4.
   Record these values in Column 4 of Table 4.

Data Section: Resistance versus Cross-Sectional Area

Table 4: Resistance versus Cross-sectional Area

Wire Radius (mm)	Wire Radius (m)	Cross Sectional Area, $A = \pi r^2$ (m^2)	$1/A$ (m^{-2})	Wire Resistance (Ω)

Data Analysis: Resistance versus Cross-Sectional Area

1. Using your results from Table 4, create a scatter graph of Resistance (Ω) on the Y-axis versus $1/A$ ($\times~10^6~m^{-2}$) on the X-axis. Label the x-y axes including units and Title your graph: Resistance vs Cross Sectional Area. See Figure 2 for an example graph. Calculate the slope of the line. What is the physical meaning of the slope?
Upload your graph with this Lab Report in D2L.

2. From the slope of the line, find the resistivity of gold:

   Resistivity of gold, $\rho_{experimental} = \frac{SLOPE~\times~10^{-6}}{L} =$

3. Compare your measured resistivity value for gold $\rho_{experimental}$ to the accepted value of $\rho_{accepted} = 2.44 \times 10^{-8}$ (Ω m). Do they agree? Explain any differences.

$$\%_{Error} = \left(\frac{\rho_{experimental} - \rho_{accepted}}{\rho_{accepted}} \right) \times 100 \qquad (4)$$

4. **Take a photo or scan a copy showing ALL of your calculations and upload it with this Lab Report in D2L.**
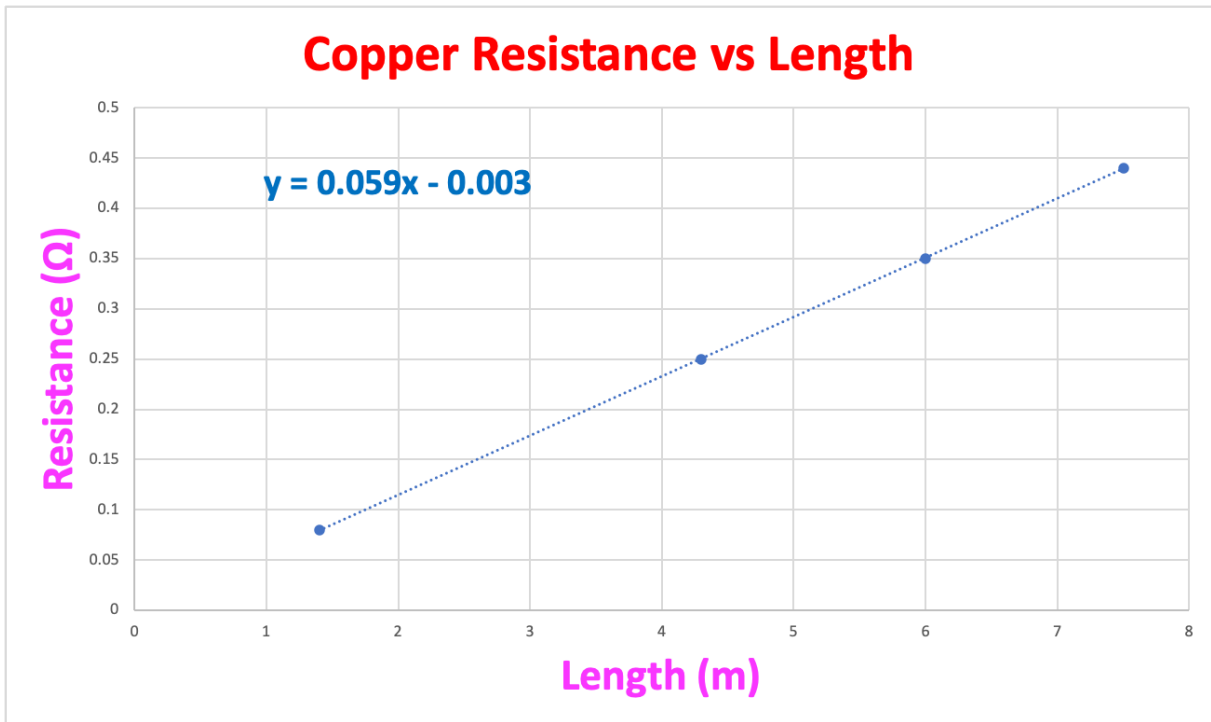
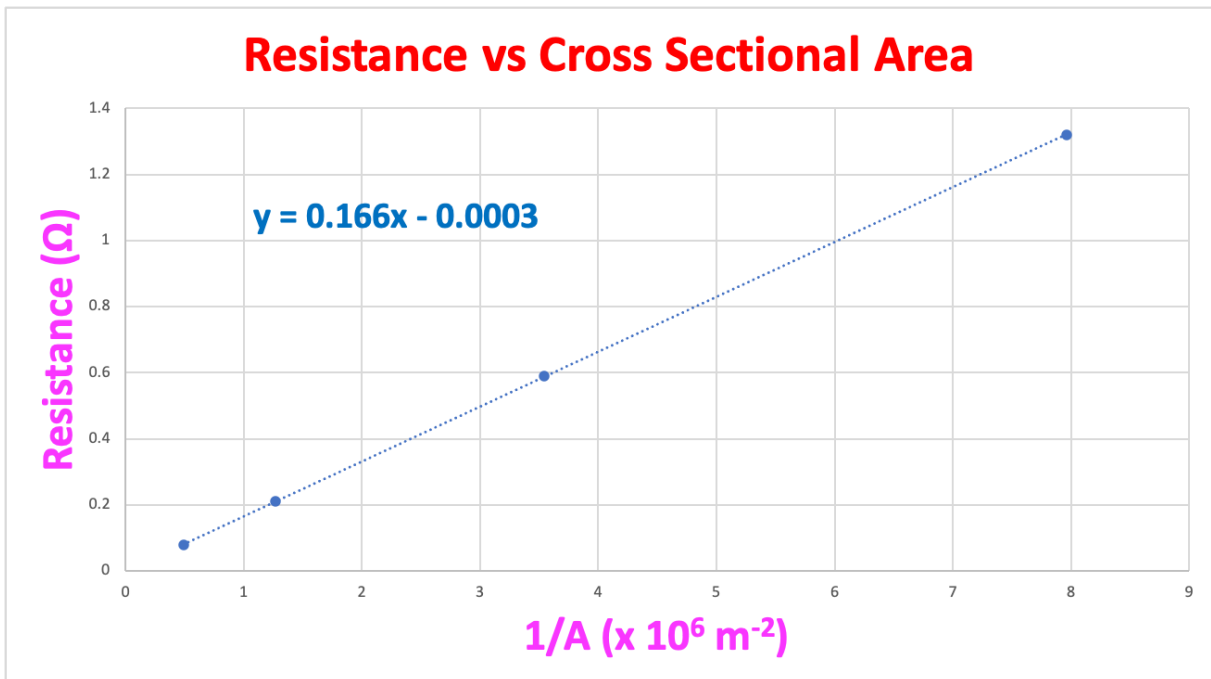Figure 1: Example graph of Resistance versus Length.

Figure 2: Example graph of Resistance versus Cross Sectional Area.