6. Resistance – Computations and Measurements

MTVW 18-Feb-13

Objectives

1. To construct graphite resistors and investigate the effect of geometry on equivalent resistance.
2. To investigate the operation of variable resisters including a thermister and CdS cell.
3. To compare the analysis of series and parallel circuits with experimental measurements.

Equipment

- 12V and 5V DC power supplies (these are in the same case),
- Four digital multimeters,
- Wooden pencil with graphite lead exposed
- Two leads with attached alligator clips on one end,
- 2Ω power resistor,
- Ruler with cm scale,
- One SPST switch,
- 2B graphite drawing stick, (1 cm squared graph paper supplied by student)
- 100 ohm and 402 ohm carbon resistors,
- 1 kΩ potentiometer,
- CdS cell,
- Thermistor.

Experiment

Provide answers to questions and observations in the Worksheets section.

1. Investigating Graphite – Voltage, Current, Resistivity, etc…

1. Figure 1 shows a circuit designed to investigate the resistive properties of graphite. The circuit on the left is the one you will construct, and the one on the right is its equivalent. Note, graphite is commonly found as the "lead" in lead pencils, so we will be using lead pencils as our graphite resistors. Wire up the circuit in Figure 1. Attach the ends of the graphite lead to the circuit using the alligator clips. **With the switch closed, measure and record the current, *I*, and the voltage appearing across the graphite for incremental lengths between x=0 and x=L, where L is the total length of graphite.** Record the values in Table 1. Plot the voltage vs. *x* on Graph 1.

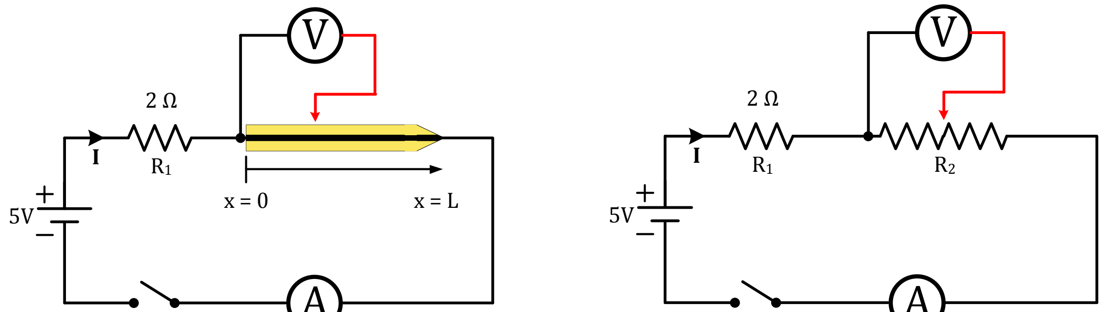

Figure 1: Series resistive circuit with a graphite lead and its equivalent circuit.

2. Determine the following quantities about the graphite and enter them into Table 1:
    1. The magnitude and direction of the electric field, E.
    2. Using Ohm's Law, $\boldsymbol{R = V/I}$, determine the resistance, R, of the entire graphite lead.
    3. Compute the conductivity, σ, of the graphite lead. The diameter of the graphite lead is 2.0 mm, and $\boldsymbol{J = \sigma E}$ where J is the current density, $I/($*cross sectional area*$)$,
    4. The resistivity of the graphite lead. Note, $\boldsymbol{R = \rho L/A}$, and $\boldsymbol{\rho = 1/\sigma}$.

2. Resistor Configurations and Equivalent Resistance.

1. Assume the resistance of the geometry in Figure 2 (i) between A-A is R. Predict how the resistance of the geometries between A-A and B-B in (ii) – (v) relates to R and enter your predictions into Table 2. Think about series and parallel combinations of resistors and how the equivalent resistance is affected. Note, the predictions should be whole number multiples or fractions of R.
2. Using the graphite sticks, carefully draw on a sheet of graph paper (with 1 cm squares) as accurately as possible each of the geometries in Figure 2 and measure the resistance between A-A and B-B using an ohmmeter. Enter the measured resistances into Table 2.

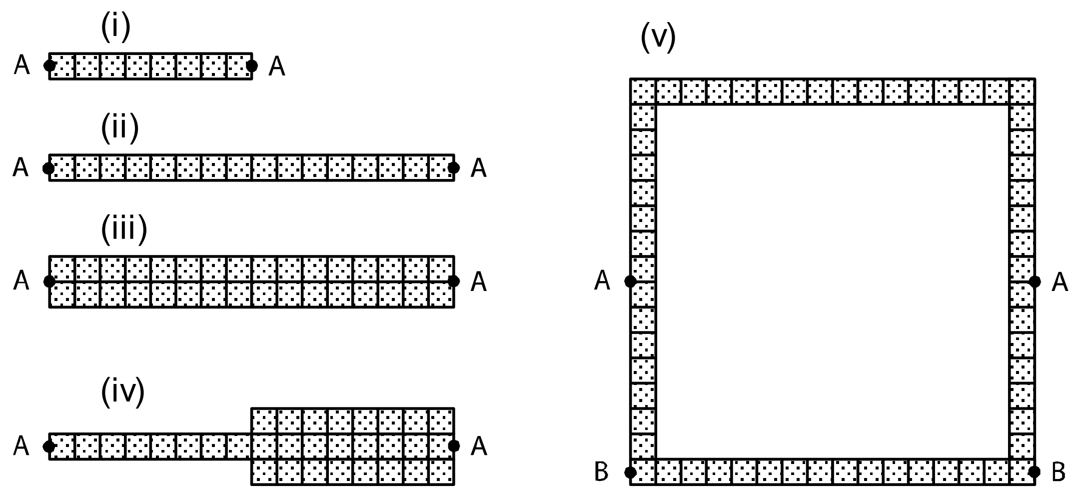

Figure 2: Geometries of graphite resistors to be constructed.

3. Variable resistances of thermistors and CdS cells.

1. Connect an ohmmeter (you may have to change the range) across the terminals of the thermistor as shown below. Record your observations on how temperature affects the resistance.

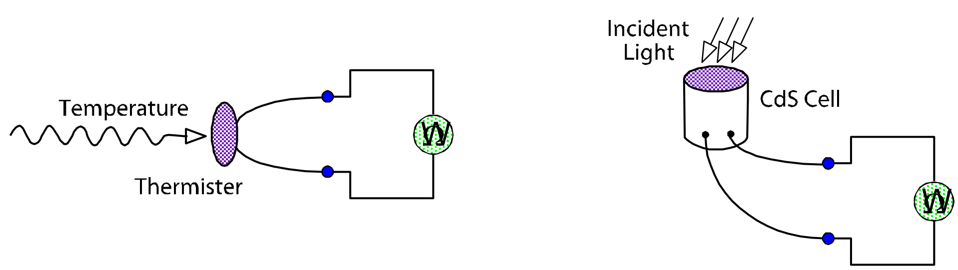

Figure 3: Examples of variable resistors

2. Connect an ohmmeter (you may have to change the range) across the terminals of the CdS cell. Record your observations on how a change in the intensity of incident light on the CdS cell affects its resistance.

4. Analysis of Resistive Circuits

1. For the series circuit shown in Figure 4 compute R, V_{100} and V_{POT} when V_S = 12 V and I = 40 mA. Enter the computed values into Table 3.
2. For the parallel circuit compute R_2, I_1 and I_2 when V_S = 12 V and I = 50 mA. Enter the computed values into Table 4.
3. Connect the *series circuit* shown in Figure 4. Adjust R until $I = 40\ mA$. Record the measured values in Table 3 for I, V_S, V_{100} and V_{POT} and compare with the computed values.
4. Connect the *parallel circuit* shown in Figure 4. Adjust R_2 until $I=50\ mA.$ Record the measured values in Table 4 for I, V_S, I_1 and I_2 and compare with the computed values.

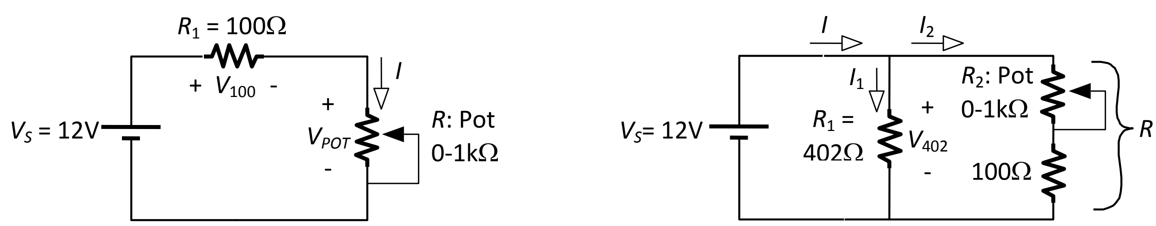

Figure 4: Series circuit and parallel circuit to be analyzed and constructed.

LAB 6 WORKSHEET – Name:______________________ Section:_________

Student ID: _______________

Table 1: Measured and Calculated Properties of Graphite

L (mm)						
Voltage, V						
Current, I						
Graphite	**R (Ω)**	**σ (Ωm)$^{-1}$**	**E (V/m)**	**ρ (Ωm)**		

Graph 1: Empty Graph for V vs Length of Graphite

Table 2: Resistance Measurements for Graphite Topologies.

Geometry	***(i)***	***(ii)***	***(iii)***	***(iv)***	***A-A (v)***	***B-B (v)***
Relationship to (i)						
Measured Ω						

2 a) How does temperature affect the resistance of the thermistor?

2 b) How does a change in the intensity of incident light on the CdS cell affect its resistance?

Table 3: Series Circuit Computations and Measurements.

Series Circuit	***I***	V_S	V_{100}	V_{POT}	$E - V_{100} - V_{POT}$
Computed					
Measured					

Compare:

Table 4: Parallel Circuit Computations and Measurements.

Parallel Circuit	I	V_S	I_1	I_2	$I - I_1 - I_2$
Computed					
Measured					

Compare: