Resistance, Ohm's Law and Kirchoff's Laws

Universiti Teknologi MARA
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PHY631: A Physical Science Activity

Name:______________________________ HP: ______________ Lab#: Intro

Objectives

The goal of today's activity is to physically investigate the behaviour of resistors when joined together in series and in parallel, the current that will flow through it and the potential drop across it and its relationship as found by Ohm and Kirchoff.

At the end of this activity, students will be able to:

1. Measure resistance of resistors using an ohmmeter.
2. Read the colour coding on carbon resistors and determine its resistance.
3. Measure, using an ohmmeter, effective resistances for resistors connected in series or in parallel or its combination.
4. Obtain a simple relationship to determine effective resistance in a series or parallel circuit.
5. Explore, explain and describe the current-voltage characteristics for ohmic devices.
6. Measure current and potential differences for devices connected in a single loop and two loops circuit respectively.
7. Obtain Ohm's Law and also Kirchoff's Laws of current and voltage.

Background Information

Background:

Current in a circuit obeys the natural law and flows from a high potential point to a low potential point (electrons move in the opposite direction). It changes with changes in the magnitude of the electromotive force of a source (unlimited source of electrons) and the changes in obstacles (resistance). While resistive devices such as a bulb may have a linear relationship between the current through that device and the potential difference across it, other devices such as a diode or semiconductor may have a nonlinear relationship. In fact, for some conductors, the linearity relationship is temperature dependent. Device that obeyed the linear relationship was first found by Ohm and Ohm's Law is now used when describing the characteristic of current-voltage relationship for good conductors. Hence, when many conductors or resistors are connected together in a circuit, it is convenient to use Ohm's Law to determine the current flow in a circuit.

Resistance of a resistor is a measure of how difficult for current to flow through a circuit element and Ohm's Law provides us with a way of determining the resistance in a circuit or the amount of current flowing in a circuit if the resistance is known. In addition, when devices are connected in more than a single loop, the current at a node or junction and the sum of the potential drops or potential rise in the loop have been found to obey Kirchoff's Laws. Your investigation today will involve obtaining both Ohm's Law and Kirchoff's Laws by using a combination of laboratory measurements.

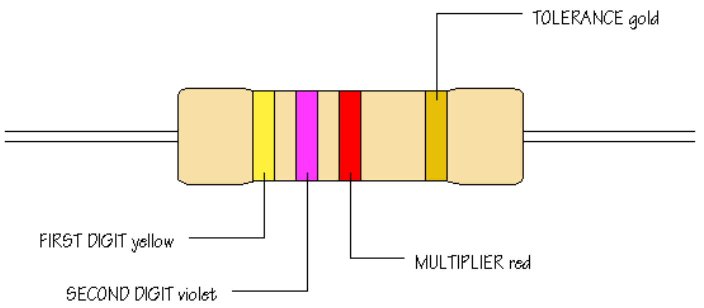
Student Activity

Investigation 1-Resistors & Resistances

Prediction 1: (Make your intelligent guess)
Given a carbon resistor:

i) Will an ohm-meter read the resistance differently if the probe of the meter is reversed?
ii) Will the ohm-meter give the same reading as those obtained by reading the color code?

Example: (shown in figure)
First digit is 4 (color is yellow)
Second digit is 7 (color is violet
Third digit is multiplier, power or 2, 10^2 or 100. So the resistor is 4700 ohms.
The last band is the tolerance. Since its gold the resistance is within +/- 5%. So the value of R can be as high as 4935 ohms and as low as 4465 ohms.



Activity 1:

Read the color coding of a few of the resistors provided and find the resistors 100 Ω, 1 kΩ, 10 kΩ and 470 kΩ. For each of the resistors, use a multimeter in the ohm-meter mode to measure the resistances by placing the probes of the meter across the resistors. Then change the polarity of the probe and observe the reading again. Record the reading and compare with the reading from the color coding. Tabulate the data in Table 1.

Table 1

Color on resistors Bands 1-3: Black=0, brown=1, red=2, orange=3, yellow=4, green=5, blue=6, violet=7, gray=8, white=9 Band 4: none=±20%, silver=±10%, gold=±5%	Resistance read from coding, Ω	Resistance from ohm-meter, Ω	Resistance from ohm-meter, (reversed polarity) Ω

Questions

1. Does changing polarity of the meter probes affect the meter reading? Why or why not?
2. Which reading, the color coding or the ohm-meter is more reliable? Explain.

Investigation 2-Resistors & Resistances

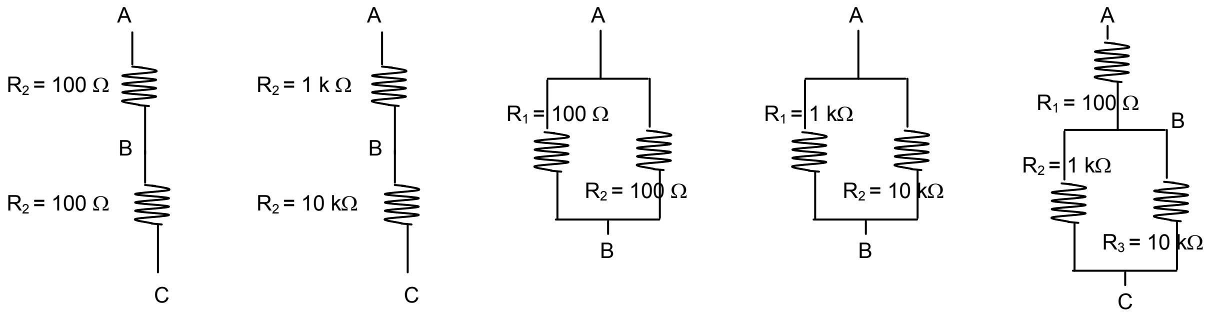
Prediction 2: (Series & Parallel Circuit-Make your intelligent guess)

Using the brightness of the bulbs (the total power) in the previous investigation as a guide, what happens to the effective or total resistance when bulbs are added in series and in parallel respectively?

Activity 2:

i) Connect the resistors in activity 1.1 as shown in the configuration below and use the ohmmeter to measure the effective resistances. Record your reading in Table 3.

Table 3



R_{AB}= ______ Ω R_{AB}= ______ Ω R_{AB}= ______ Ω R_{AB}= ______ Ω R_{AB}= ______ Ω

R_{BC}= ______ Ω R_{BC}= ______ Ω R_{BC}= ______ Ω

R_{AC}= ______ Ω R_{AC}= ______ Ω R_{AC}= ______ Ω

Questions

1. What happens to the total resistance when resistances are connected in series? Does it increase or decrease? Can you write down a possible mathematical relation to determine the effective resistance?
2. What happens to the total resistance when resistances are connected in parallel? Does it increase or decrease? Can you write down a possible mathematical relation to determine the effective resistance?

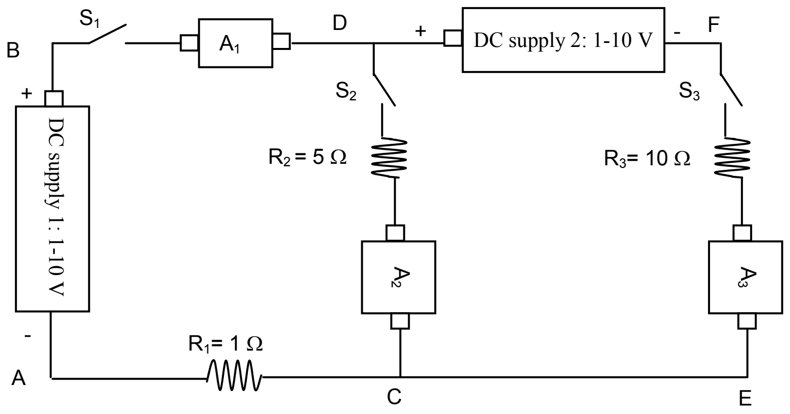
Investigation 3 – Ohm's Law and Kirchoff's Laws

Prediction 3 (Make your intelligent guess)

i) What happens to the current read by ammeters A_1, A_2 and A_3 and the voltage across the resistors R_1 and R_2, in the circuit shown below, when only switches S_1 and S_2 is thrown down? Will all ammeters read the same values or different values? Will the current flow from point A to B to C to D and back to A or will it go in the opposite direction? Will the sum of the potential drops (V=IR) across resistors be equal to the emf of the power supply?

ii) What happens to the current read by ammeters A_1, A_2 and A_3 and the voltage across the resistors R_1 and R_2, in the circuit shown below, when only switches S_1 and S_2 is thrown down and the emf from the DC power supply 1 is increased or decreased? Will all ammeters read the same values or different values? Will the sum of the potential drops (V=IR) across resistors be the same as the emf of power supply 1 every time a new emf is chosen?

iii) What happens to the current read by ammeters A_1, A_2 and A_3 and the voltage across the resistors R_1 and R_2 and R_3, in the circuit shown below, when only switches S_2 and S_3 is thrown down?



iv) What happens to the current read by ammeters A_1, A_2 and A_3 and the voltage across the resistors R_1, R_2 and R_3, in the circuit shown below, when only switches S_1, S_2 and S_3 is thrown down Will all ammeters read the same values or different values? Will the sum of the potential drops (V=IR) across resistors in loop BACDB be the same as the emf of power supply 1? Will the sum of the potential drops (V=IR) across resistors in loop DFECD be the same as the emf of power supply 2? Will all the current flow into or out of junction C?

Activity 3:

(Set the initial voltages and the resistances as shown in the figure and record your readings in Table 4 and Table 5.)

i) Connect the circuit as shown in the figure above. Throw down switches S_1 and S_2 and record the current on ammeters A_1, A_2 and A_3. Using the voltmeter (multimeter), measure the emf (note the polarity of the probes, a positive value indicate your probes are connected with the red probe on the high potential end and the black probe on the low potential end) of power supply 1 (V_{DA} or V_{BA}). Then measure the potential across resistors R_1 (V_{AC}), R_2 (V_{CD}) and resistors R_{12} (V_{AD}). [Based on the current flow or the polarity of the potential difference, label the high (+) and low potential (-) points in the circuit or across each resistors.] Then increase the emf on the dc power supply from 1 V to 10 V in increments of 1 V. Observe and record your readings in Table 5. Record also the directions of current flow at junctions C and D respectively.

ii) Set the voltage of power supply 1 to 5 V and power supply 2 to 5 V and throw down all switches S_1, S_2 and S_3. Record the current on ammeters A_1, A_2 and A_3. Then measure the potential across resistors R_1 (V_{AC}), R_2 (V_{CD}) R_3 (V_{FE} or V_{FC}), R_{12} (V_{AD}) and resistors R_{32} (V_{FD}) Record your readings in Table 6. Record also the directions of current flow at junctions C and D respectively. Repeat the above when the emf on power supply 2 is changed to 10 V.

Table 4

Laboratory: S_1 & S_2 down						
V_{DA} V	I_1 A	I_2 A	I_3 A	V_{AC} V	V_{CD} V	V_{AD} V
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
$V_{AC}+ V_{CD}+ V_{DA}$ = ____ V						
Current directions at C: I_1 ___, I_2 ___ Current directions at D: I_1 ___, I_2 ___						

Table 5

Laboratory: All switches down										
V_{DA} V	I_1 A	I_2 A	I_3 A	V_{AC} V	V_{CD} V	V_{AD} V	V_{DF} V	V_{FE} V	V_{ED} V	V_{FD} V
5							5			
5							10			
$V_{AC}+ V_{CD}+ V_{DA}$ = ____ V							$V_{FE}+ V_{ED}+ V_{DF}$ = ____ V			
Current directions at C: C: I_1 ___, I_2 ___, I_3 ___ Current directions at D: D: I_1 ___, I_2 ___, I_3 ___										

Questions

1. What happens to the current in the circuit as the emf is increased? [Draw a current-voltage graph and determine the relationship between current in a wire and the potential drop across it.].
2. What can you conclude about the current-voltage relationship from the graph that you plotted?
3. How is the slope of the line useful to you?
4. Is the slope or its inverse comparable to the resistance in the circuit? Explain.
5. What is the sum of the current at junction C or D when all the switches are down?
6. If you were to take the loop BACDB, can you identify and label which device suffers a potential drop or potential rise? What is the sum of the potential drop and the potential rise in the loop BACDB and the loop DFECD respectively?
7. How would you determine the currents I_1, I_2 and I_3, if all the ammeters in the configuration were removed? State Kirchoff's current and voltage law.