University of Duhok
College of Science
Department of Physics
1st Year Students
Electricity and Magnetism Lab.
Second semester

Name:
Group:
Exp. No.: 6, 7
Exp. Date:
Mark:

Series and Parallel Resistors

Objective:

Equipment:

Resistors (R_1, R_2), multimeter, and DC power supply.

Theory:

Part 1

Resistors in series: two or more resistors are connected in row, as shown in Figure 1a. The total magnitude of resistors together is equivalent to the sum of all resistors connected in series as shown in Figure 1b.

The equivalent resistance for resistors in series is can be calculated through this equation:

$$R_{equ} = R_1+R_2+R_3+\cdots$$

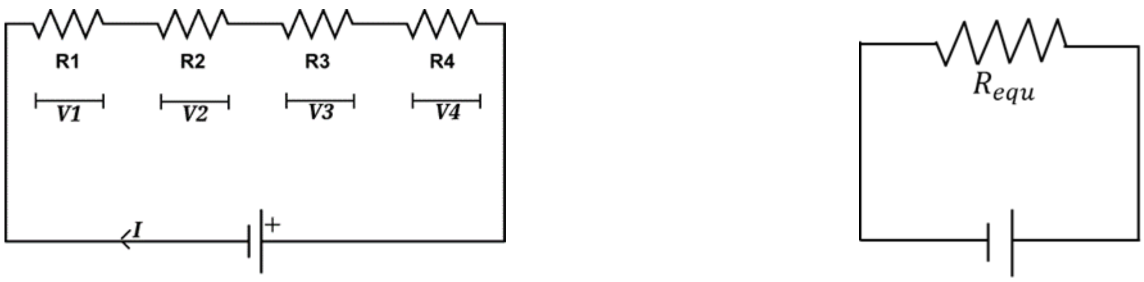


Figure (1) a- Circuit for resistors in series. b- The equivalent circuit.

A series circuit has just one current path, it follows that all the components in a series circuit carry the same current I.

$$I_{eq}=I_1=I_2=I_3=\dots\dots\dots=I_n.$$

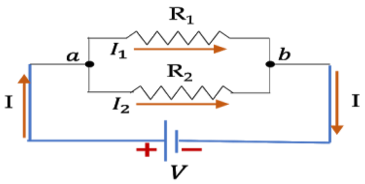
In a series circuit, the applied voltage is equal to the sum of the voltage drops.

$$V_{eq}=V_1+V_2+V_3+\dots\dots\dots+V_n.$$

Part 2

When two or more resistors are connected between the same two nodes, they are in parallel as shown in the figure (2a). The equivalent resistance of Parallel connected resistors as shown if figure (1b) can be calculated using below formula:

$$\frac{1}{R_{equ}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots.. $$



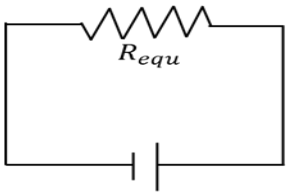


Figure (2) a- Circuit for resistors in parallel b- The equivalent circuit.

The currents in the individual resistances are called the ‘‘branch currents,’’ and the battery current I is often called the ‘‘line current. In a parallel circuit, the battery current I is equal to the sum of the branch currents.

$$I_{eq}=I_1+I_2+I_3+\ldots\ldots+I_n.$$

the battery voltage V is applied equally to all n resistances; that is, the same voltage V is applied to all the parallel branches.

$$V_{eq}=V_1=V_2=V_3=\ldots.=V_n$$

Procedure:

Part 1

1. Take two resistors. Measure the resistance of each resistor individually and equivalent resistance (R_{eq}) using the ohmmeter Record the values in Data Table 1.
2. Now, connect the resistors in series, as shown in Figure 1a, and set the power supply at 3 V.
3. Record the voltage and current across each resistor, and put them in the Data Table 1.
4. Calculate the equivalent resistance (Req) of the circuit, based on your measured values of R1 and R2. Enter the value into Data Table 1.

Data Table 1:

R_1 (theo) =
R_2 (theo) =
R_{eq} (theo) =

R_1 (measured)		V_1(measured)		I_1(measured)		R_1 (Calculated)	
R_2 (measured)		V_2(measured)		I_2(measured)		R_2 (Calculated)	
R_{eq}(measured)		V_{eq}(measured)		I_{eq} (measured)		R_{eq}(calculated)	

Part 2

1. Take two resistors. Measure the resistance of each resistor individually and equivalent resistance (R_{eq}) using the ohmmeter Record the values in Data Table 2.
2. Now, connect the resistors in series, as shown in Figure 2a, and set the power supply at 3 V.
3. Record the voltage and current across each resistor, and put them in the Data Table 2.
4. Calculate the equivalent resistance (Req) of the circuit, based on your measured values of R1 and R2. Enter the value into Data Table 2.

Data Table 2:

R_1 (theo) =
R_2 (theo) =
R_{eq} (theo) =

R_1 (measured)		V_1(measured)		I_1(measured)		R_1 (Calculated)	
R_2 (measured)		V_2(measured)		I_2(measured)		R_2 (Calculated)	
R_{eq}(measured)		V_{eq}(measured)		I_{eq} (measured)		R_{eq}(calculated)	

Questions:

1. In which connection the $V_T=V_1=V_2=\cdots$? And why?
2. In which connection the current will be same in all resistors?
3. Which kind of connections will have higher equivalent resistance (R_{eq})?
4. Which kind of connections we are using in our homes and why?
5. Give an example for series connection application?

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Magnetic Force

Purpose:

CAUTION:

1. Always reduce the current through the electromagnet to zero before opening the circuit of the magnet coils.
2. Remove wrist watches before placing hands near the magnet gaps.

Physical Principles: MAGNETIC FORCE ON A CURRENT-CARRYING WIRE In a uniform magnetic field B, the force on a straight wire perpendicular to the field and carrying i amperes of current in a particular direction is

$$F = il \, x \, B\text{-}, \quad F = il \, x \, B^{\perp} \quad \dots\dots\dots 1$$

L is the segment of the length of the wire within the field and perpendicular to the field ($B^{\perp}$). In this experiment an electro-magnet will be used, oriented so that the uniform magnetic field in the air gap between the pole faces is horizontal. If a current is passed through a straight conductor which is suspended in the gap perpendicular to the field direction, the resultant force will be vertical and if the magnitude of the current, the magnetic field B and the length l are known, F can be calculated by Eq (1) and could be measured practically by means of a dynameters. (Its direction can be found by right hand rules).

Equipment:

The experimental set-up is shown in Figure 1. The current I in the magnet coil is supplied by an adjustable power supply. The strength of B is determined by I. Note that the current i through the horizontal conductor is supplied by a separate power supply.

Procedure:

1. When no current in both, the electromagnet and the wire, bring that segment of the moving wire to still position and record the deflection of the laser on the ruler. This is d0 and is the zero point.
2. Switch on both power supplies. The voltage for the electromagnet is set at 3 A, do not change it.
3. Start from minimum current I through the wire.
4. Read the deflection on the ruler (d1 –d2), find the average and deduct it from the zero-point d_0.

5. Repeat steps 3 and 4 for several reading and put them in the table below.
6. Then determine the torsion F needed to bring the wire to equilibrium for each value. 5cm deflection is equivalent to 10 mN force
7. Present the measurements of force versus balance current graphically,
8. From the graph find a value for B as indicated below.
9. You can also directly calculate B for each (F, i) pair. From these individual measurements you can directly estimate the statistical errors on your overall measurement of B. You can also calculate the average B and compare with that you obtained from the graph.

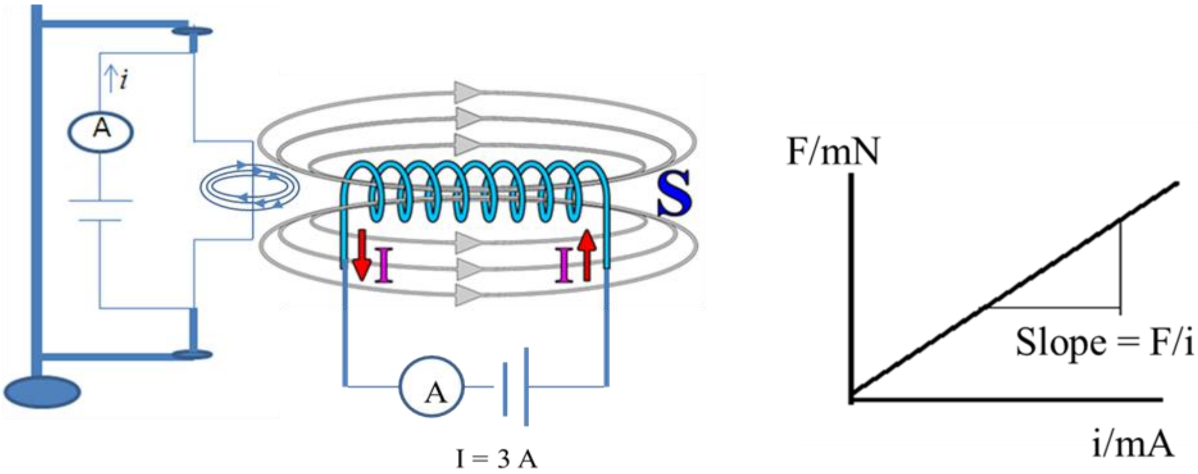

Figure 1

Data table:

d_0 =

i/A	Deflection (d_1-d_2)	Average/cm	d /cm = average –d_0	F/ mN

Form equation **(1)** $\boldsymbol{B = F/il}$ $\quad , so\ \boldsymbol{B = slope/l}$

$\boldsymbol{Slope}\ =$ $\qquad\qquad\qquad \boldsymbol{B} =$

Questions:

1- Why is it not a good idea to call magnetic-field lines “magnetic lines of force?
2- If the magnetic force does no work on a charged particle, how can it have any effect on the particle’s motion as you have seen by the deflection of the wire?

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Liquid Conductivity

Objective:

Description

The electrical conductivities of solutions of strong electrolytes, weak electrolytes,

Background

In order for an electric current to be conducted, some charged, mobile carriers such as free electrons or free ions must be present. Metals have mobile electrons to carry current. A solution which contains ions can conduct electricity.

A strong electrolyte contains a relatively large number of ions and is a good conductor; a weak electrolyte produces fewer ions and is a poor conductor. A non-electrolyte has very few ions; it is more of an insulator than a conductor.

In terms of test devices that make use of lamps or flashing diodes, solutions of strong electrolytes cause the devices to flash brightly and often, those of weak electrolytes flash dimly and infrequently, and those of nonelectrolytes do not flash.

Strong electrolytes are thought to dissociate completely into ions. Most salts, such as NaCl, and some acids, such as HCl and $HNO3$, are examples of strong electrolytes. A few salts (e.g., $CdI2$) and a few acids and bases (e.g., acetic acid, ammonia) are weak electrolytes. These substances are only partially dissociated into ions when dissolved in water. Non-electrolytes do not dissociate at all. Ethanol is a non-electrolyte, for example.

To sustain a direct current, some process of oxidation or reduction must occur. The several volts battery makes use of a direct current and, although safe and inexpensive, is limited for this reason.

Procedure

1. Plug the conductivity apparatus into an electrical power supply outlet (figure 1).
2. First put about 25 ml of tap water into the container and then put the tips of the metal sticks in the water about an inch apart. Make sure the two sticks don't touch each other and make sure the distance between the electrodes is not changing while you make measurements. The water will act like a wire connecting the metal sticks and completing the circuit which will make the current flow.
3. Measure the current by an ammeter for different voltage supply.
4. Change the water to distilled water and repeat the step above.
5. Add salt (1 tea spoon) to the water and record the current.
6. Do the same for sugar
7. Record the results in the table 1.
8. Plot diagram for results (figure 2).

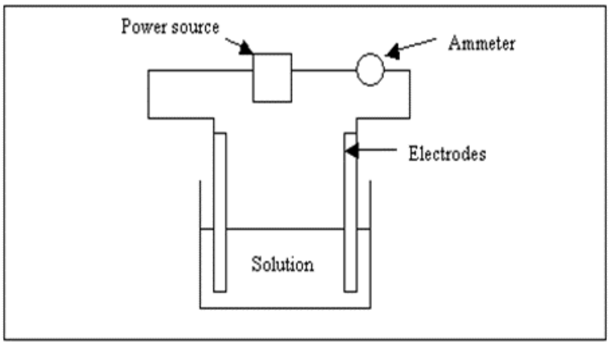

Figure 1: circuit diagram

Figure 2

Data Table:

Voltage/v	Ammeter reading			
	Tap water	Distil water	Salt solution	Sugar solution

Questions & Discussion

1. Why does the tap water conduct electricity more than the distilled water?
2. Why does the solution of salt conduct electricity much more than the sugar solution?
3. How would you expect the electrical conductivity be for the following solutions: milk, lemon juice, sport drinks, vinegar, and soft drink? Put them in the order from high to low conductivity.

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Capacitors in Series and parallel

Objective:

Equipment

DC Power supply, Multimeter, 3 capacitors of different values, Wires.

Theory:

A capacitor consists of two conducting objects (plates) separated by a nonconducting medium (dielectric). Figure (1) shows a capacitor connected to a battery. Capacitance is the ability of an capacitor to store electric charge. The capacitance of an ideal capacitor is defined as the ratio of the charge on the conducting plates to the potential difference across them (C = Q / V) where Q is the magnitude of the net charge on each surface, and V is the potential difference between the two conducting surfaces. The SI unit of capacitance is the farad (F). the capacitors can be connected in series and parallel.

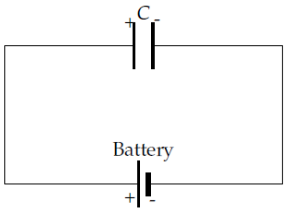

Figure 1.

Capacitors in Series

Theoretically the equivalent capacitance for the series connection is given by

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

Capacitors in Series all have the same current flowing through them. Therefore, each capacitor will store the same amount of electrical charge, Q on its plates regardless of its capacitance.

$$Q_{equ.} = Q_1 = Q_2 = Q_3$$

the equivalent voltage for the series connected capacitors is the sum of the voltage across each capacitor.

$$V_{equ.} = V_1 + V_2 + V_3$$

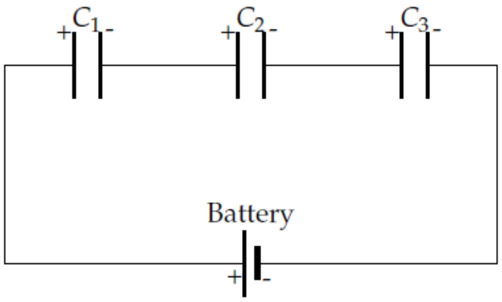

Figure 2. Capacitors connected in series

Capacitors in parallel

The equivalent capacitance for parallel connection is given by

$$C = C_1 + C_2 + C_3$$

The total charge *Q* is the sum of the individual charges:

$$Q_{equ.} = Q_1 + Q_2 + Q_3$$

The voltage (V) connected across all the capacitors that are connected in parallel is the same. Then, Capacitors in Parallel have a “common voltage” supply across them giving:

$$V_{eq} = V_1 = V_2 = V_3$$

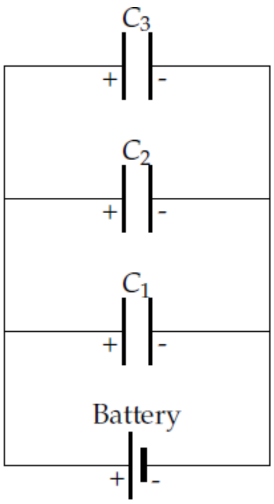

Figure 3. Capacitors connected in parallel

Procedure:

1. Make sure each capacitor is discharged (V=0) by touching ends of the lead wire to the terminals of the capacitor.
2. Use the capacitance meter to measure the capacitance of each capacitor and record in data table.
3. Connect the capacitors in series (for series part) and in parallel (for parallel part) (**but don't connect the to the power supply**) and pay **attention to the polarity of the capacitors** and measure the equivalent capacitance of the (series or parallel) connected capacitors.
4. Connect the connected capacitance in (series or parallel) to the power supply, and set the power supply at 3 V.
5. Measure the total voltage and individual voltage across each capacitor and record in the table.
6. Calculate total of the charges and amount of the charges of each capacitor.

Data Table of series part

C_1 (theo) =
C_2 (theo) =
C_3 (theo) =
C_{eq} (theo) =

C_1 (measured)		V_1(measured)		Q_1(Calculated)	
C_2 (measured)		V_2(measured)		Q_2(Calculated)	
C_1 (measured)		V_1(measured)		Q_1(Calculated)	
C_{eq}(measured)		V_{eq}(measured)		Q_{eq} (Calculated)	

Data Table of parallel part

C_1 (theo) =
C_2 (theo) =
C_3 (theo) =
C_{eq} (theo) =

C_1 (measured)		V_1(measured)		Q_1(Calculated)	
C_2 (measured)		V_2(measured)		Q_2(Calculated)	
C_1 (measured)		V_1(measured)		Q_1(Calculated)	
C_{eq}(measured)		V_{eq}(measured)		Q_{eq} Calculated)	

Questions:

1. Which way should capacitors be connected to give you the larger capacitance value of the capacitors? And why?

You have three identical capacitors. You connect two of them in parallel and to a 12V power supply. If you add the third capacitor in parallel with the other two.

2. How does the voltage across the first two capacitors changes?
3. How does the charge on the first two capacitors change?
4. Theoretically, calculate total charges for bott (Series and Parallel) connected capacitors and compare with the experimental value.