



**Zagazig University
Faculty of Science
Physics Department**



Practical Physics

**For
First Year Students**

التجارب العملية – الفصل الدراسي الثاني

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Experiment (1)

Surface Tension

Aim of the experiment:

To determine the coefficient of surface tension of water

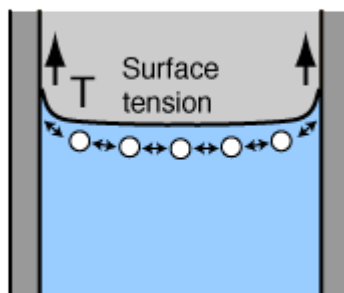
Theory

The force F which a liquid surface exerts on anybody with which it is in intimate contact is directly proportional to the length of the line of L

$$F=TL$$

And the units of surface tension is dyne/cm or Newton/m and its dimensions MT^{-2}

The constant of proportionality, T is called the coefficient of surface tension of the liquid. Here are the values of surface tension of some common liquids.



To understand why the phenomenon of surface tension arises, we must think of intermolecular attraction.

Molecules of any substance want to pack together so that their average separation is low. In solids, this separation is fixed, whereas in gases, the random motion due to heat predominates. In liquids, there is some random motion but, on the average, the molecular separation is low.

Capillary Action



Capillary action occurs when the adhesion to the walls is stronger than the cohesive forces between the liquid molecules. The height to which capillary action will take water in a uniform circular tube is limited by surface tension.

Acting around the circumference, the surface tension force directed upward is= $2\pi rT\cos\theta$

Balances the weight of water inside the capillary tube above the surface of water, this weight is given by:

$$\pi r^2 h \rho g$$

Therefore

$$\pi r^2 h \rho g = 2\pi r T \cos\theta$$

$$T = r h \rho g / 2 \cos\theta$$

In case of water $\rho=1$ and $\cos \theta=1$

$$T = r h g / 2 \quad (1)$$

Apparatus

- Capillary tube
- Two beakers, one contain water and the other is empty
- Mercury
- Sensitive balance
- Ruler

Procedure

1. Fit the capillary tube vertically inside the beaker which is containing the water.
2. Fix the capillary tube in this position and measure the high of water inside it is $= h = \dots\dots\dots\text{cm}$
3. Clean the capillary tube, and then full it by a certain length of mercury say l cm.
4. Find the mass of empty beaker $m_1 = \dots\dots\dots\text{gm}$
5. Put this amount of mercury in the empty beaker and then find the mass of beaker and mercury together $m_2 = \dots\dots\dots\text{gm}$
6. Find the mass of mercury $M = m_2 - m_1 = \dots\dots\dots\text{gm}$
7. We can the radius of the capillary tube by:

$$M = \pi r^2 h \rho g$$

$$r = (M / \pi h \rho g)^{1/2}$$

7. Substitute by the vales r , $\rho=1$ and $\theta = 0$ in equation (1) we determine the value of the coefficient of surface tension T
8. $T = \dots\dots\dots\text{dyne /cm}$

Experiment (2)

SIMPLE PENDULUM

Hypothesis:

The longer the length of a simple pendulum, the longer the period of oscillation

Aim of the experiment:

To investigate how the period of a simple pendulum varies with its length.

Variables

Manipulated: The length of the pendulum, l

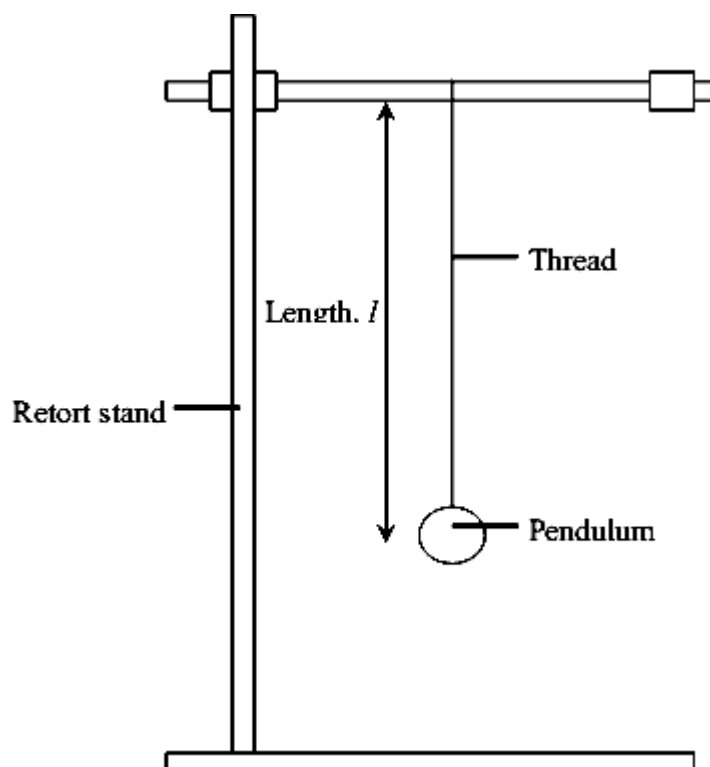
Responding: The period of the pendulum, T

Constant: The mass of the pendulum bob, gravitational acceleration

Apparatus and Materials

- Pendulum bob
- Length of thread about 100 cm long
- Retort stand,
- Stopwatch

Setup



Procedure

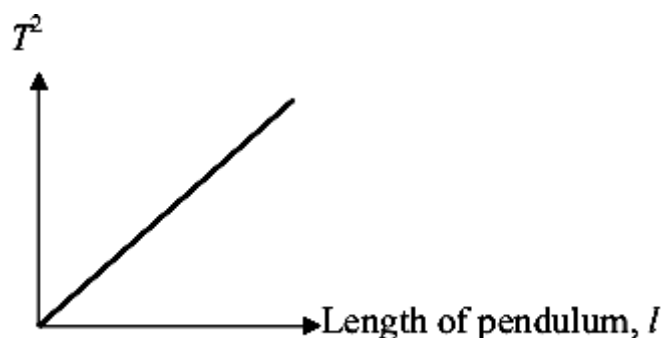
1. The thread is tied to the pendulum bob. The other end of the thread is tied around the arm of the retort stand so that it can swing freely. The length of the pendulum, l is measured to 80 cm as per the diagram.
2. With the thread taut and the bob at rest, the bob is lifted at small amplitude (of not more than 10°). Ensure that the pendulum swings in a single plane.
3. The time for ten complete oscillations of the pendulum is measured using the stopwatch.

4. Step 3 is repeated, and the averages of both readings are calculated.
5. The period of oscillation, T is calculated using the average reading divided by the number of oscillations, i.e. 10.
6. T^2 is calculated by squaring the value of T .
7. Steps 1 to 6 are repeated using $l = 70$ cm, 60 cm, 50 cm, and 40 cm.
8. A graph T^2 versus l is plotted.

Recording of data:

Length of pendulum, l (cm)	Time of oscillations, t (s)			Period of oscillation, T	
	t_1	t_2	Average	$T = t/10$ (s)	T^2 (s ²)
80					
70					
60					
50					
40					

Graph of T^2 vs l



Discussion

The graph of T^2 versus l shows a straight line passing through the origin. This means that the period of oscillation increases with the length of the pendulum, with T^2 directly proportional to l .

Conclusion

The longer the length of the pendulum, the longer the period of oscillation. The hypothesis is proven valid.

Experiment (3)

HOOKE'S LAW AND A SIMPLE SPRING

Aim

To measure the spring constant of a spring using two different methods

Theory

If a weight, $W = mg$, is hung from one end of an ordinary spring, causing it to stretch a distance x , then an equal and opposite force, F , is created in the spring which opposes the pull of the weight. If W is not so large as to permanently distort the spring, then this force, F , will restore the spring to its original length after the load is removed. The magnitude of this restoring force is directly proportional to the stretch,

$$F = -kx$$

The constant k is called the spring constant. To emphasize that x refers to the change in length of the spring we write

$$F = mg = -k \Delta \ell \quad (1)$$

In this form it is apparent that if a plot of F as a function of Δl has a linear portion, this provides confirmation that the spring follows Hooke's Law and enables us to find k .

An additional approach is possible. One definition of simple harmonic motion is that it is motion under a linear, “Hooke's Law” restoring force. Note that for simple harmonic motion, the period does not depend upon the amplitude of the oscillation.

For such a motion, we have

$$T^2 = 4\pi^2 \frac{m}{k} \quad (2)$$

Where k again is the spring constant, T is the period of the pendulum and m is the mass that is oscillating. Thus, the mass includes the mass of the spring itself. However, the entire spring does not vibrate with the same amplitude as the load (the attached mass) and therefore it is reasonable to assume that the effective load (m) is the mass hung from the end of the spring plus some fraction of the mass of the spring. Based on similar experiments, one third of the mass of the spring is a good estimation of the effective load due to the spring, thus

$$m = m_{\text{load}} + m_{\text{es}} = m_{\text{load}} + \frac{1}{3} m_{\text{spring}}$$

Where: m_{es} is the effective load of the spring. Using this in Eq. (2), we find

$$k = \frac{4\pi^2 \left\{ m_{\text{load}} + \frac{1}{3} m_{\text{spring}} \right\}}{T^2} \quad (3)$$

The effective load of the spring can be determined for a particular spring using the following process. The equation for T^2 can be written in terms of m_{load} and m_{es} ; m_{es} can then be determined from a graph of T^2 versus m_{load} . Note that this assumes that m_{es} is constant.

Eq. (3) uses an approximation for the contribution of the mass of the spring to the oscillation. If we rewrite Eq. (2) as the effective mass of the spring and hanging mass (load), then

$$T^2 = \frac{4\pi^2\{m_{\text{load}} + m_{\text{es}}\}}{k} \\ = \frac{4\pi^2}{k} m_{\text{load}} + \frac{4\pi^2}{k} m_{\text{es}} \quad (4)$$

Where: m_{load} is the hanging mass and m_{es} is the effective mass of the spring. If we assume that the effective spring mass is the same for all loads, then a graph of period squared T^2 vs. hanging mass (m_{load}) is a straight line, where $\frac{4\pi^2}{k}$ is the slope and $\frac{4\pi^2}{k} m_{\text{es}}$ is the intercept.

Procedure

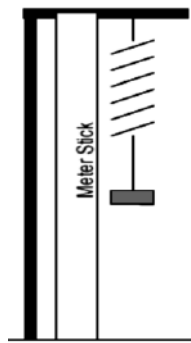
Part 1

1. Hang a spring from a horizontal metal rod.

2. Attach a mass hanger directly to the bottom of the hanging spring and record the position of the bottom of the mass hanger relative to a meter stick.
3. Add masses to the spring and record the position of the bottom of the mass hanger.

Part 2

1. **Hang a mass from the spring and use a stopwatch to time 15 oscillations of the mass and spring.**
2. Repeat for other masses.



The purpose of this experiment was to determine the spring constant k of a steel spring using two different methods. First we investigated the relationship between the force applied to a spring and the displacement of the spring from its rest length in order to verify Hooke's law.

We hung masses of 0.01 kg, 0.20 kg, 0.30 kg, 0.04 kg, 0.05 kg, 0.06 kg, 0.70 kg, and 0.80 kg from the springs, and recorded the vertical displacements. We made four

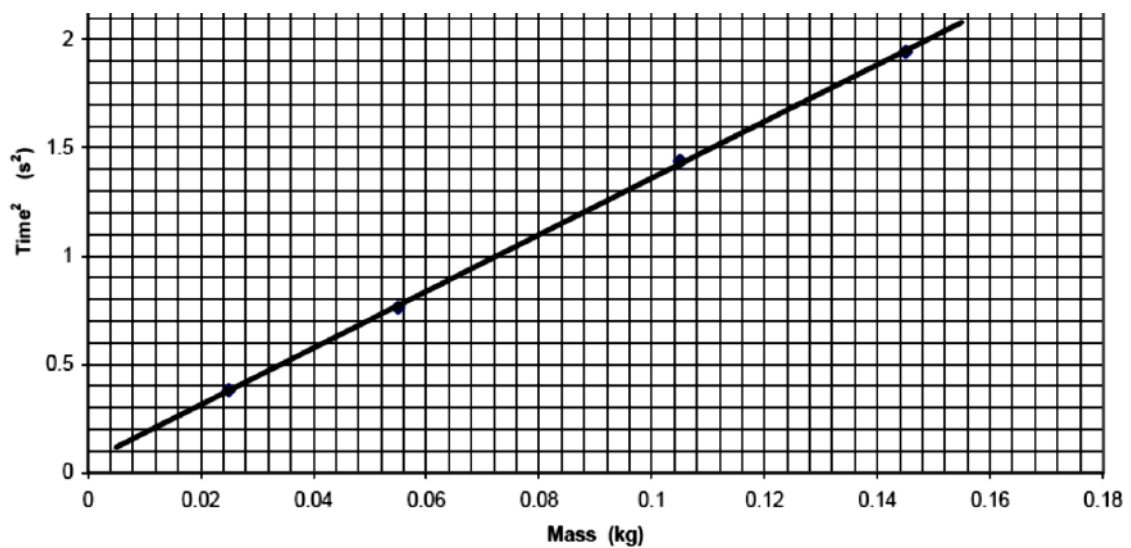
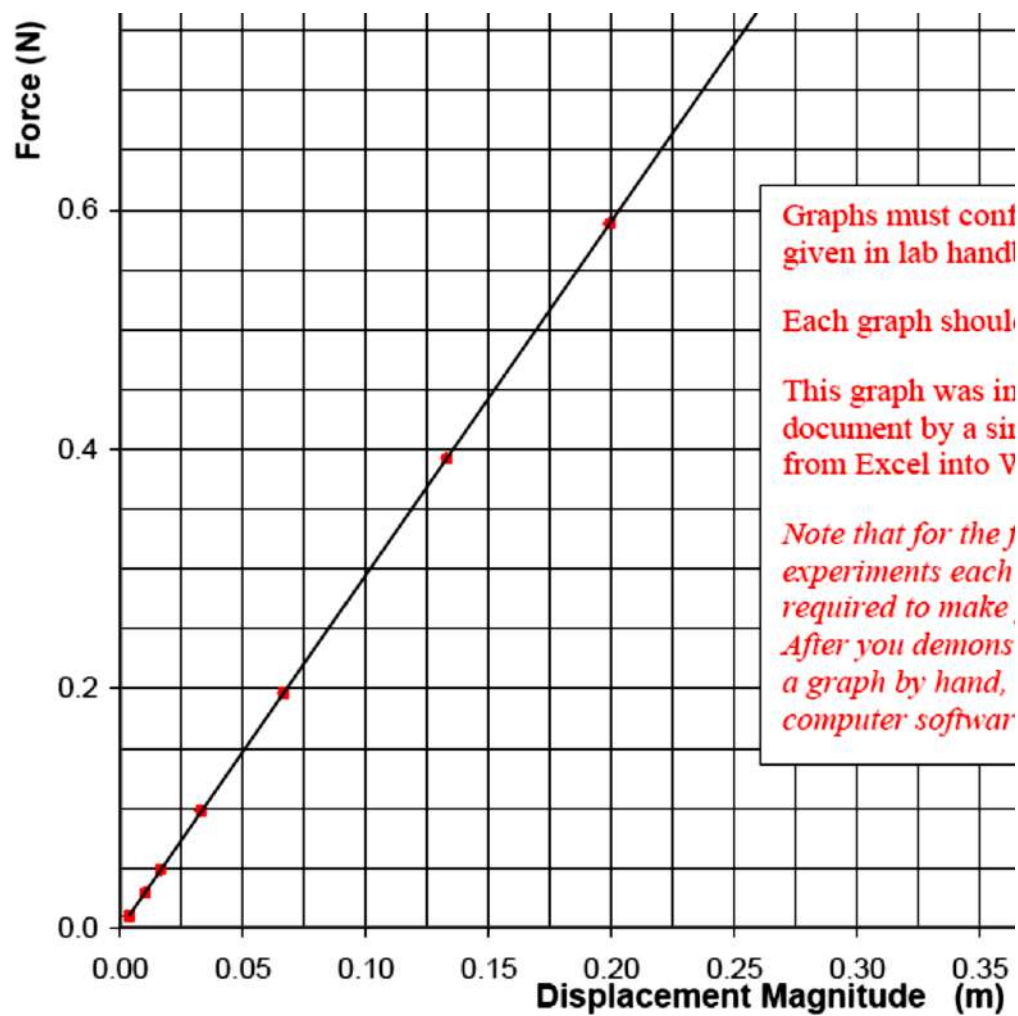
measurements for each mass hung from the spring and used the average of the four values in order to reduce random error. In this method, the main cause of error was measurement. We found a spring constant of $k = 2.94 \pm 0.01 \text{ N/m}$. Our results confirmed Hooke's Law, the well known relationship that the magnitude of an elastic restoring force on a spring is directly proportional to the displacement of the spring. This relationship is named after the 17th century scientist Hooke who studied it.

Next we measured the period of a mass hung from one end of a spring and set into vertical oscillation. We performed this process using the four different masses 0.145 kg, 0.105 kg, 0.055 kg, and 0.025kg. The period of each mass was measured three times using three different amplitudes of oscillation.

We found that the spring constant depended on the effective mass of the spring and the period of oscillation.

The period of the motion was the same whether the amplitude of the oscillation is large or small. In this method, the main cause of error was reaction time.

Using this method we found a spring constant of $2.98 \pm 0.02 \text{ N/m}$.

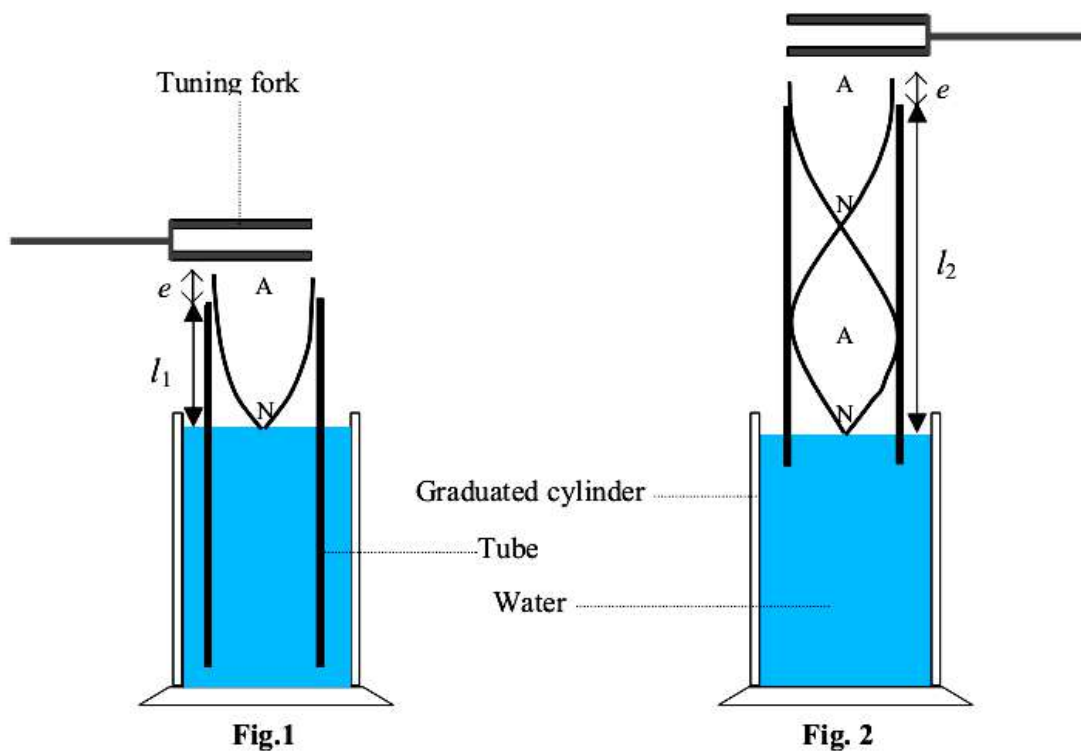


Experiment (4)

Speed of Sound Wave

Apparatus

- 1000 ml graduated cylinder,
- Resonance tube,
- Set of tuning forks range 256 Hz to 512 Hz,
- Vernier calipers
- Meter stick
- Stand (longest upright type)
- Clamp and wooden block



Procedure

1. Clamp the tube so that the water in the graduated cylinder closes its lower end. The tube should be free to slide vertically through the clamp jaws. Take an approximate value of 300 m s^{-1} for the speed of sound to obtain a rough estimate of the quarter wavelength resonance position.
2. Strike the highest frequency (512 Hz) tuning fork on the wooden block, and hold it in a horizontal position just above the mouth of the tube (Fig. 1).
3. Slide the tube slowly up/down until the note heard from the tube is at its loudest; resonance is now occurring.
4. Tighten the clamp in this position and measure the length of the air column (from the water level to the top of the tube) l with a metre stick.
5. Clamp the tube (or its extension) so that the air column is 2 or 3 cm less than $3l_1$ (Fig. 2).
6. Obtain a second weaker resonance with the same tuning fork by again sliding the tube until the note heard is at its loudest, at the three-quarters wavelength resonance position.

7. Clamp the tube in this position and measure with a metre stick, the air column length l_2 at this resonance.
8. Repeat this procedure to obtain the corresponding values of l_1 and l_2 for all the tuning forks in order of decreasing frequency.
9. Record the measurements in a table.
10. Calculate the wavelength using) $2(l_2 - l_1) = \lambda$ in each case.
11. Calculate the speed of sound from $C = \lambda f$, for each of the tuning forks.
12. Find the average value for the speed of sound.

Results

f/Hz	l_1/m	l_2/m	λ/m	$c/\text{m s}^{-1}$

The average value of the speed of sound in air =
m/sec.

Notes

The experiment can be done using just one tube.

Proceed to obtain resonance as before. Measure the length l_1 . The antinode forms above the top of the tube and so an end correction factor has to be added to the length. From theory, it is found that the correction factor $e = 0.3d$, where d is the average internal diameter of the tube (measured using a vernier calipers).

Hence

$$\lambda = 4(l_1 + 0.3d)$$

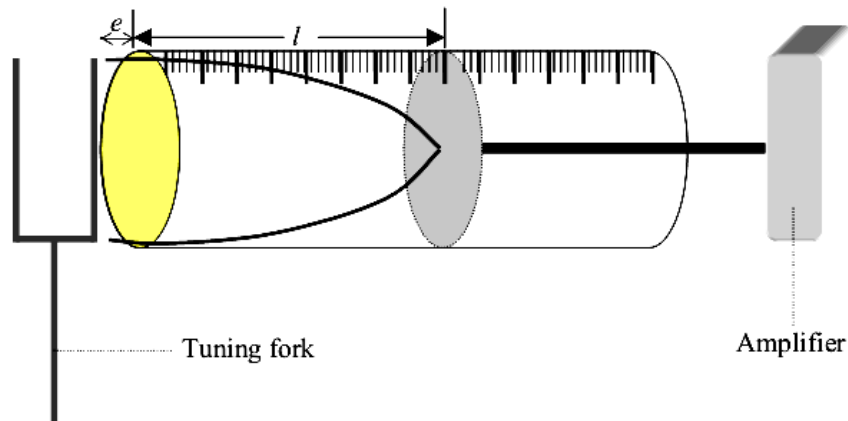
$$c = f\lambda$$

$$c = 4f(l_1 + 0.3d).$$

Calculate a value of c for each tuning fork and find an average value for the speed of sound.

If a resonance tube is not available, use 50 cm lengths of 40 mm and 30 mm plastic pipes.

A specially designed apparatus called a resonometer can also be used to obtain the data.



Beginning with the highest frequency tuning fork and a very short column of air, adjust the piston until the sound from the vibrating air column is loudest; this is the first resonance point. Measure the length l of the air column at resonance. Proceed to use the set of tuning forks to complete the data table as in the previous method (it is difficult to distinguish resonance for frequencies below 340 Hz).

$$\lambda = 4(l + e) \quad \text{where } e \text{ is the end correction factor}$$

$$\lambda = 4(l + 0.3d) \quad \text{where } d \text{ is the internal diameter of the tube}$$

$$c = f\lambda$$

$$c = 4f(l + 0.3d).$$

It is also possible to cause resonance in the air column using a signal generator and a loudspeaker; the 8 Ω , 5 cm diameter model of loudspeaker is ideal. Clamp the loudspeaker in a horizontal position just above the mouth of the tube. Connect the loudspeaker to the low impedance output of the signal generator. Gradually increase the signal generator frequency from zero until the air column resonates. Calculate the speed of sound using the same procedures as before. Repeat the experiment for different lengths of the air column.

Experiment (5)

Specific Latent Heat

Heating of Wax or Naphthalene

Hypothesis:

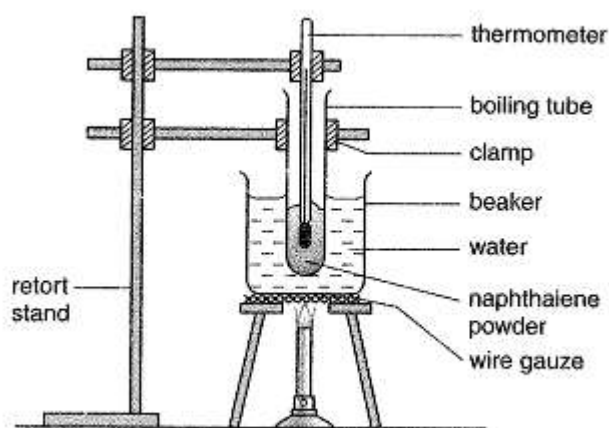
During the change of state of naphthalene from solid to liquid, there is no change in temperature when heat is continuously supplied

Aim of the experiment:

To observe the change in phase with temperature when wax or naphthalene is melting

Apparatus and Materials:

- Boiling tube
- Wax powder or naphthalene
- Beaker
- Thermometer
- Bunsen burner
- Stopwatch, retort stand, tripod stand, wire gauze



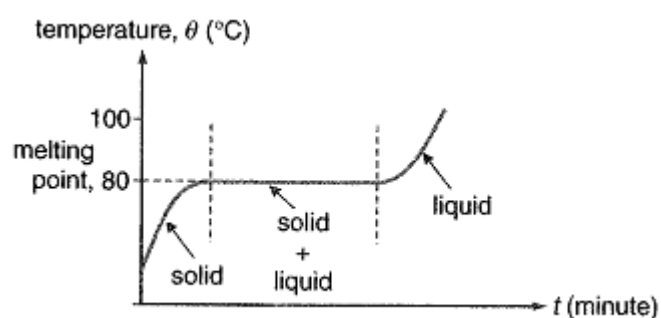
Procedure:

1. The apparatus is set up as shown in the diagram.
2. The initial temperature of the naphthalene is recorded.
3. The Bunsen burner is lighted and the stopwatch started.
4. The temperature of the wax or naphthalene is recorded at 1 minute intervals until the temperature reaches 90°C .
5. The state of the naphthalene is observed and tabulated throughout the heating process.
6. A graph of temperature against time is drawn.

Results:

Time, t (minute)	Temperature of naphthalene, θ ($^{\circ}\text{C}$)
0	
1	
2	
3	
...	

Graph of temperature against time:



Discussion:

- The temperature-time graph shows that the temperature of wax or naphthalene rises until the wax or naphthalene starts to melt.
- The wax starts to melt at 80°C. The temperature remains constant at this value for several minutes while the wax continues to melt with the heat.

- After the wax or naphthalene has completely melted, the temperature begins to rise with continued heating.

Conclusion:

The temperature of the wax or naphthalene remains constant during a change of state from solid to liquid.

Part II

Cooling of wax (or naphthalene

Hypothesis:

During the change of state of naphthalene from liquid to solid, there is no change in temperature

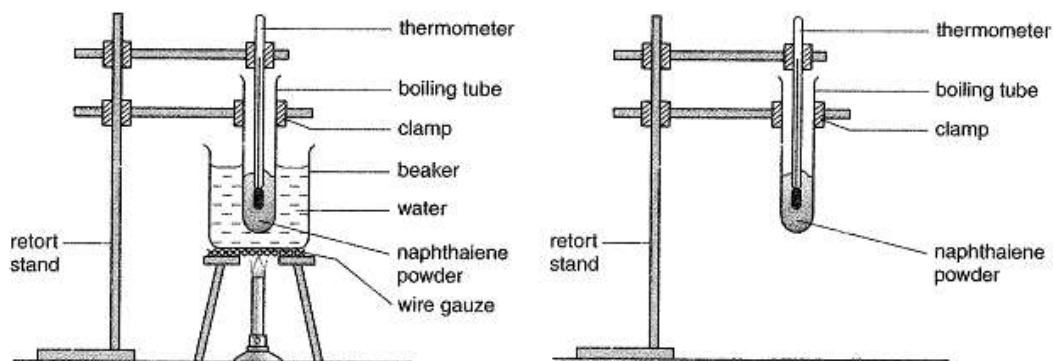
Aim of the experiment:

To observe the change in temperature when naphthalene is freezing

Apparatus and Materials:

- Boiling tube
- Naphthalene powder
- Beaker
- Thermometer
- Bunsen burner, stopwatch, retort stand, tripod stand, wire gauze

Set up:



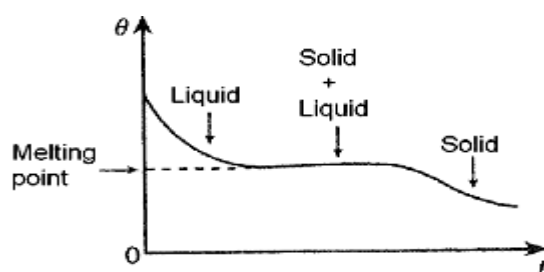
Procedure:

1. The apparatus is set up as shown in the diagram.
2. The naphthalene (or wax) is heated until the temperature reaches 95°C .
3. The boiling tube is then removed from the water bath and the outer part of the tube is dried.
4. The temperature of the naphthalene is recorded every half minute until the temperature drops to about 60°C and 35°C in case of wax.
5. A graph of temperature against time is drawn.

Results:

Time, t (minute)	Temperature of naphthalene, θ ($^{\circ}\text{C}$)
0	
1	
2	
3	
...	

Graph of temperature against time:



Discussion:

- The temperature-time graph shows that the temperature of naphthalene drops until 80°C where it stays constant for several minutes as it freezes.
- After the naphthalene has completely frozen, the temperature continues to drop.

Conclusion:

- The temperature (or wax) of the naphthalene remains constant during a change of state from liquid to solid

5 Determination the Power of Convex Lens

1.1 Apparatus

- 1. Optical bench with stages
- 1. Positive lens
- 1. Lens holder
- 1. Image screen with holder
- 1. Plane mirror with holder
- 1. Illuminated object (could use a desk lamp and a pin or aperture)

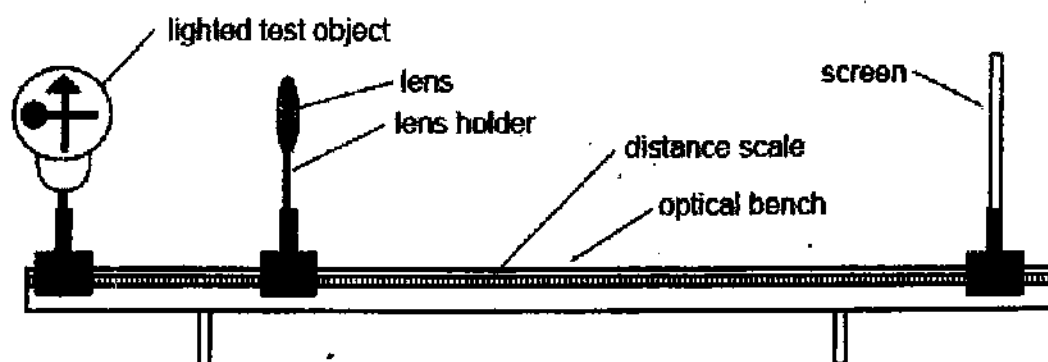
1.2 Theory

The object and image distances, S_o and S_i , both measured from the center of a thin lens, are related by the lens formula

$$\frac{1}{f} = \frac{1}{S_o} + \frac{1}{S_i} \quad (1)$$

Where: f is the focal length of the lens. The image distance S_i is positive for a real image and negative for a virtual image.

Similarly, the object distance S_0 is positive for a real object and negative for a virtual object. A real image is formed by light rays that converge after passing through the lens. A real image can be projected onto a screen. A virtual image is formed by light rays that diverge after passing through the lens. To the eye viewing these refracted rays, they appear to come from an image located on the other side of the lens. A virtual image cannot be projected onto a screen.



Every lens has a focal length f , the same distance from the center plane of the lens on each side even if the radii are different. As it does in mirrors, the focal length of a lens depends on the values of the radius. But unlike mirrors, it also depends on the index of refraction of the lens material n (since rays pass through the lens material). The relationship is

$$\frac{1}{f}(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

A converging lens has a positive focal length, $f > 0$, and is therefore also called a positive lens. A diverging lens has a negative focal length, $f < 0$. For this reason a diverging lens is also called a negative lens. Algebraic signs should be observed carefully in Eq. (1.1).

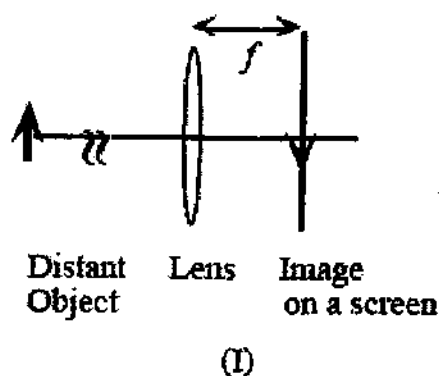
1.3 Experimental Procedure

In this portion of the experiment, you will determine the focal length of a positive lens. For every procedure described below, make at least three determinations of the focal length. Sample tables for recording your measurements have been provided at the end of this experiment. Be sure to record the correct number of significant figures, for example, $50.0\text{cm} \pm 0.1\text{cm}$. Report your results along with uncertainties.

1.3.1 Focal length by parallel rays

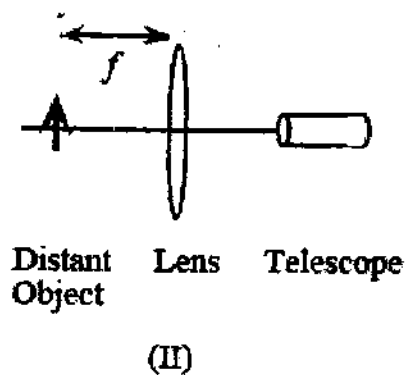
Method I

Form a sharp image of a distant object (10 m or farther) upon a screen and measure the distance from the center of the lens to the screen [Fig 1.1(I)]. This distance is equal to the focal length (f) of the lens. Draw a ray diagram for this method. Make several independent measurements. Record you measurements in a



Method II

Focus a telescope on a distant object and without changing the adjustment of the telescope; place it on an optical bench. Aim it toward the converging lens. Place an illuminated object on the other side of the lens [Fig 1.1 (II)].

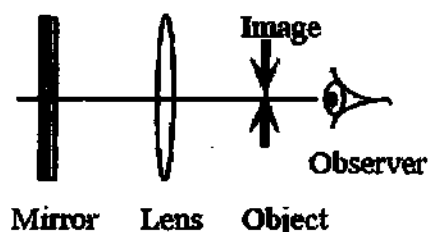


Keep the telescope, the lens, and the object at the same height above the bench. Look through the telescope and move the lens either toward or away from the object until you get a sharp image of the object in the telescope.

Measure the distance from the center of the lens to the object. This distance is equal to the focal length of the lens. Make three or more independent measurements for the lens provided and take the average of your results.

1.3.3. Focal length by parallax

Place a vertical plane mirror just behind the lens [Fig 1.1 (III)]. Set an illuminated object (a pin or short vertical wire) in front of the lens. Look past the illuminated object toward the lens. You should see an inverted of the object.



(III)

Move the object toward or away from the lens until its image appears to “float” directly above the object. When this happens, its image appears to “float” directly above the object.

When this happens, diagram and explain how this method works. Take several measurements, calculate the average of your measurements and assign errors.

General Method

1. Using the optical bench place the object at distance S_o more than its focal length of the lens. Then measure the corresponding value of the image distance S_i as shown in figure 1
2. Repeat the step 1 for different object distances and measure the different image distances.
3. Record your results in the following table.
4. Draw a graph between $\frac{1}{S_o}$ on vertical axes and $\frac{1}{S_i}$ on horizontal axes. We obtain a straight line intersecting the two axes at two intersecting points

5. Find the two intersection points on the two axes represents F_1 and F_2 and the power of convex lens is given from:

$$F = \frac{F_1 + F_2}{2} \text{ diopeter}$$

6 Determination the Power of the Diverging Lens

1.1 Apparatus

- 1. Optical bench with stages
- 1. Positive lens (convex lens)
- 1. Negative lens (concave lens)
- 1. Lens holder
- 1. Image screen with holder
- 1. Plane mirror with holder
- 1. Illuminated object (could use a desk lamp and a pin or aperture)

Theory

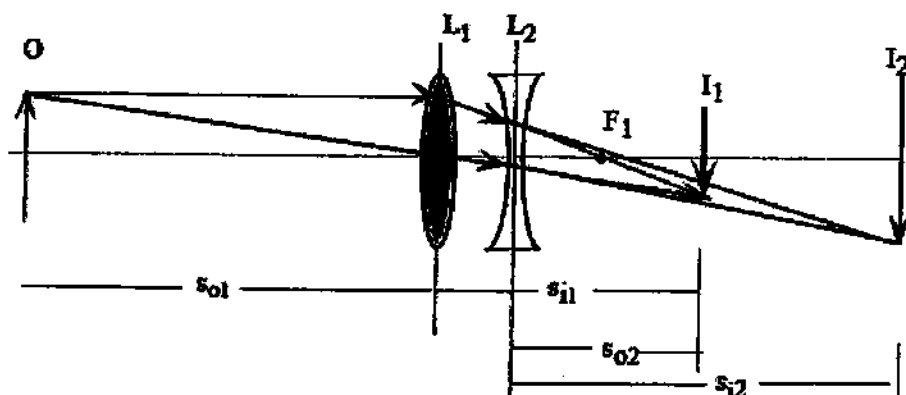
A diverging lens by itself does not form a real image. Therefore the methods described for positive lenses cannot be used to determine the focal length of a diverging lens. In this part of the experiment, we will learn two methods for determining the focal length of a negative lens.

We know that the focal length of a group contains two lenses one of it is convex and the other is concave is given by:

$$\frac{1}{f_{group}} = \frac{1}{f_{convex}} + \frac{1}{f_{concave}} \quad (1)$$

Focal length by virtual object

Set up an illuminated object, positive lens, and screen as in the Focal length by conjugate foci subsection of Sec. 1.2.1 and obtain a sharp image I_1 on the screen. Record the image distance from the positive lens as S_{i1} . Now place the diverging lens between the converging lens and the screen. The original image I_1 serves as a virtual object (negative object distance) for the diverging lens. Without moving the screen record the distance S_{o2} with due care for the algebraic signs. The diverging lens will cause the image to lie farther from the positive lens (see Figure 1). Now move the screen until the new image I_2 is in focus. Record the distance of the screen from the negative lens as S_{i2} .



This arrangement results in a real image if the converging lens focal length is shorter than the magnitude of the focal length of the diverging lens. The two positions of the screen recorded above are a pair of conjugate points of the diverging lens. Compute the focal length of the lens using Eq. (1.1). Make at least three measurements.

s_{i2} : Is represents the focal length of diverging lens

$f_{concave}$

The power of the concave lens is

$$P = \frac{1}{f_{concave}} = \dots \text{Diopeter}$$

2. Combination with a convex lens

1. Put the convex lens on the carriage in front of the light source.

2. Put the plane mirror behind the convex lens either on the same carriage or on separate one.
3. Move the lens and the mirror together near and far from the source until an inverted image smaller than the object is formed for the source coinciding with it.
4. Measure the distance from the lens to the source. This is the focal length of the convex lens.
5. Place the two lenses on one carriage (the convex and the concave lenses) in front the light source
6. Place the plane mirror behind the concave lens and move the combination near and far the optical source until the image of the source coinciding on it.
7. Measure the distance from the optical source to the mid point between the convex lens and concave lens. This distance represents the focal length of combination, f_{group} .
8. Substitute by the values of f_{group} and f_{convex} in equation (1) to get the value of $f_{concave} = \dots m$

Calculate the power of the concave lens from:

$$P_{concave} = \frac{1}{f_{concave}} = \dots \text{diopeter}$$

7 Meter Bridge

Introduction to Meter Bridge

The working of a Meter Bridge is based on the principle of Wheat stone bridge. It is a simpler form of Wheat stone bridge and is more accurate because, the resistances R and S can be changed in a continuous fashion. It is called a meter bridge it consists of a wire AB of one meter length.

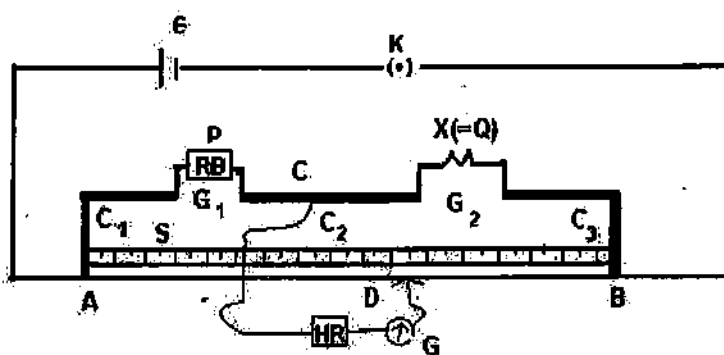


Fig : Meter Bridge

The meter bridge as shown in figure consists of three thick strips C_1 , C_2 and C_3 made of copper or brass. The resistances of these strips are almost zero. The shapes and positions of the strips fixed on a wooden board are as shown in figure. A manganin wire of uniform cross section and 1 m length is stretched tight between the two terminals A and B . A jockey J slides over the wire.

A graduated meter scale S is fixed by the side of the wire for taking the lengths of the wire. The lengths are to be measured from the end where +ve terminal of battery is connected i.e. end A in the figure. A battery of emf ' ε ', a plug key ' K ' are connected between the two terminals A and B . A resistance box ' RB ' is connected in the gap ' G_1 '. The unknown resistance ' X ' is connected in gap ' G_2 '. In between the centre C of strip C_2 and the jockey ' J ', a galvanometer G and a high resistance ' $H.R$ ' are connected in series. When the jockey is at a point ' D ' on the wire, it divides the wire into two parts AD and DB of lengths l_1 and l_2 .

As the wire is of uniform cross section, we can have resistance of AD length of wire $= R = l_1 \sigma$ and resistance of DB length of wire $= S = l_2 \sigma$ where σ is the resistance per unit length of the wire. Now, the circuit is exactly similar to a Wheatstone bridge with resistance in $RB = P$.

Unknown resistance $X = Q$ and $R = l_1 \sigma$ and $S = l_2 \sigma$.
When the bridge is balanced, we have

$$\frac{P}{X} = \frac{R}{S} = \frac{l_1}{l_2}$$

But in a meter bridge $l_2 = (100 - l_1)$. So the balanced condition of a meter bridge is

$$\frac{P}{X} = \frac{l_1}{100 - l_1}$$

Experimental Procedure for Meter Bridge

A suitable value of resistance P is kept in the resistance box. In the beginning, the high resistance H.R is included in series with the galvanometer in the circuit. The connections are checked for deflections in galvanometer by pressing the jockey first near A and then at B. If these deflections are in opposite directions, the connections are proper. Otherwise, the connections are to be checked. The jockey is now pressed at various points on the wire from 'A' to towards 'B', until we get near null deflection in the galvanometer. At this stage, the high resistance is shunted and the exact balance point giving null deflection at D is obtained.

The length l_1 from A to D is noted. The unknown resistance X can be calculated from equation (1).

Specific resistance of the material of a given wire can also be determined using meter bridge. We keep the given wire in gap G_2 and determine its resistance (R) as described above. The specific resistance of the material of the wire (ρ) is calculated from

$$\rho = \frac{\pi r^2 R}{L}$$

Precautions

The following precautions are to be observed with a meter bridge experiment.

- The current must be kept at low value. Otherwise, resistance of wire changes on getting heated and affects the values.
- The current should not be passed continuously for a very long time. The wire gets heated and values will be altered.
- The jockey should not be dragged along the wire. Otherwise, the wire gets deformed and its resistance gets altered.

Importance of High Resistance (hr) in Meter Bridge

The galvanometer is a very sensitive current meter . It should be protected from high currents flowing through it. For this reason, a high resistance is included in series with the galvanometer. When the balancing point is not obtained, because of H.R in series, the current through galvanometer will be small. But, when the near balance is obtained, the H.R is to be shunted for getting an accurate value for balancing length. Now, there will be no damage to galvanometer, because already near balance is achieved and current through galvanometer will be very small.

Uses

The meter bridge can be conveniently used to

- Determine an unknown resistance
- Compare two resistance
- Determine the specific resistance of the material of a wire.

8 Ohm's Law

Purpose

In this experiment, you will use Ohm's law to determine the resistance of several resistors. You will also investigate ohmic and non-ohmic resistances.

Equipment

- Voltmeter,
- Ammeter (0-500 mA),
- Resistor (100 W), and
- Variable DC power supply (0-10V),

Theory:

According to Ohm's law, the voltage across a resistor is proportional to the current passing through it:

$$V = IR \quad (1)$$

Where the ratio of the voltage (V) over the current (I) is called the resistance (R). The unit of resistance is ohm, which is equal to one volt per ampere. For common conductors such as metals, the resistance is a constant if the temperature does not change significantly.

At certain temperature, resistance is ohm, which is equal to one volt per ampere. For common conductors such as metals, the resistance is a constant if the temperature does not change significantly. At certain the resistance of a resistor depends on its geometric parameters (the length and the cross sectional area), its physical property (resistivity): the resistance of a resistor depends on its geometric parameters (the length and the cross sectional

$$R = \frac{\rho L}{A} \quad (2)$$

Where: ρ , L and A are, respectively, the resistivity, the length and the cross sectional area of the resistor. A resistor is called a "linear device", as opposed to a "non linear device" such as a diode that does not obey the linear Ohm's law even without significant change in temperature. In this experiment we will study a regular resistor with constant resistance only.

Procedure:

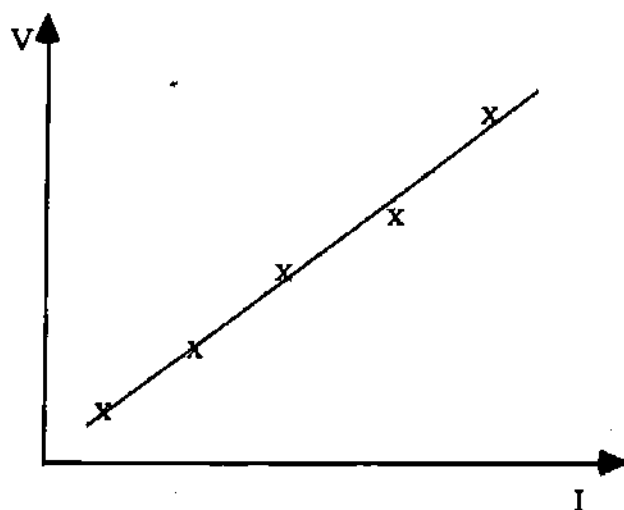
1. Construct a circuit as shown in Fig. 1:

Note: The voltmeter does not have to be connected to the circuit.

You can measure the voltage across any two points by touching the points with the two leads of the voltmeter.

2. Measure the current for ten different voltages, with an increment of one volt. Record the current and the voltage in your data table. Calculate the resistance R at each different voltage, using Ohm's Law. You need to keep at least two significant digits for both the measured data and the calculated resistance. Use a data table as suggested in Table [1]

3. Plot a graph between the voltage on the vertical axes and the current on the horizontal axes we obtain a straight line whose slope is the electric resistance



1				
2				
3				
4				
5				
6				

2. Resistors in Series and in Parallel

Objective:

1. To study the equivalent resistances of two fundamental connections of resistors - resistors in series and in parallel.

2. To practice more complicated construction of circuits.

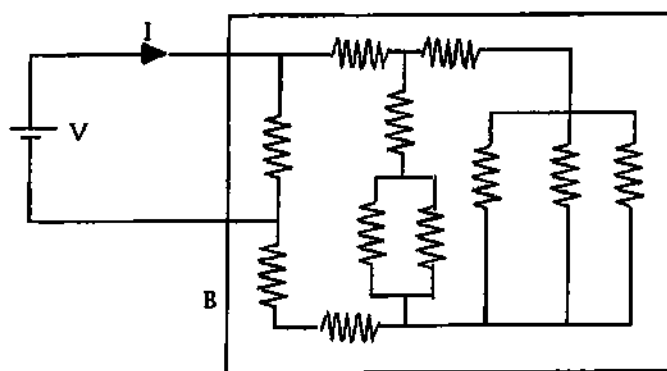
Equipment

- Three resistors with different resistances ranging from 50 to 200 ohms,
- Voltmeter (or voltage sensor),
- Ammeter (or current sensor),
- DC power supply,

Theory:

In the last experiment we studied Ohm's law for a single resistor. As a matter of fact, Ohm's law applies not only to a single resistor, but also to a part or the whole circuit network, as long as it is non active (no power supplies in that part of the circuit) and linear (no non-linear device in the circuit). For the example shown in Fig.(1), The battery is supplying a device contained in a box B. The device is a complex network of many resistors. To the power supply (say, the Electric Power Board), the whole device can be considered as a single resistor, the equivalent resistance of which is also called the "input resistance" (a special case of the more general "input impedance") of the device.

The equivalent resistance depends of the construction of the device, and can be calculated from the individual resistances if the construction is known. In this experiment, we will study the two simplest combinations: resistors in series and in parallel.



If two resistors R_1 and R_2 are connected in series, the current passing through the two resistors are equal, and the total voltage is equal to the sum of the individual voltages across the two resistors (Fig. 2).

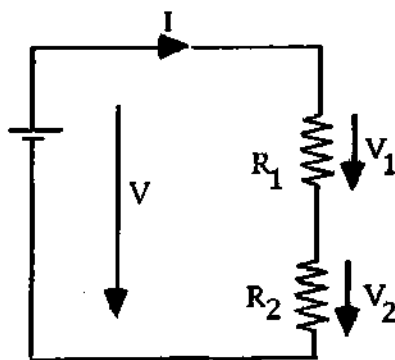


Figure (2)

$$V = V_1 + V_2$$

Applying Ohm's law for all terms in the above equation, we have

$$R = I_1 R_1 + I_1 R_2$$

Since $I = I_1 = I_2$, we obtain

$$R = R_1 + R_2 \quad (1)$$

Equation (1) says that the equivalent resistance of the resistors connected in series is equal to the sum of the individual resistances. It is not hard to see that this rule applies to any number of resistors connected in series.

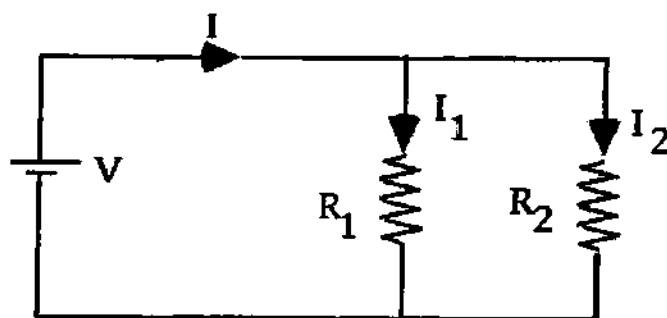


Figure (3)

On the other hand, if two resistors R_1 and R_2 are connected in parallel, the voltages across the two resistors are equal, and the total current is equal to the

sum of the individual currents passing through the two resistors (Fig. 3).

$$I = I_1 + I_2$$

Again applying Ohm's law to the terms in the above equation, we have

$$\frac{V}{R} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$$

Since $V = V_1 = V_2$, we obtain the relationship between the equivalent total resistance R and the individual resistances R_1 and R_2 :

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \quad (2)$$

Likewise, the above relationship applies to any number of resistors connected in parallel.

Equations (1) and (2) can be used to find the equivalent resistance of more complex networks such as the ones shown in figures (4) and (5). It is left to the students to figure out the ways to do it in the following procedure.

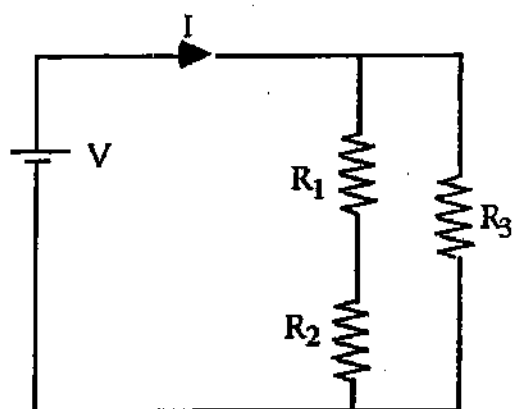


Figure 4

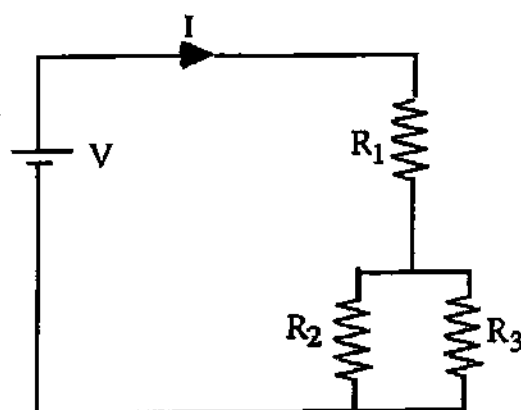


Figure 5

Procedure

1. Turn on the computer and interface. Use the voltage sensor and the current sensor to measure the voltages and currents. Get to the appropriate program to run this experiment with the help of your instructor. Use the method learned from the previous experiment to measure the resistances of the three resistors R_1 , R_2 and R_3 . Record these values in your data table. You do not have to make a hard copy of the plot, but do use the linear fitting program to obtain the resistances.

2. Construct a circuit in series like Figure 2, but with three resistors in series instead of two. Run the program again to obtain the total resistance of the three resistors in series.

Record the value in your data table.

3. Meantime, calculate the theoretical total resistance by making use of Eq. (1) and the individual resistances obtained in step 1. Calculate the difference between the theoretical and the experimental values. Find the percentage error.

4. Construct a circuit in parallel like Figure 3 with three resistors. Repeat the procedure stated in step 2 to find both the experimental and theoretical equivalent resistances and the percentage error.

5. Construct a mixed circuit of Figure 4. Repeat the measurement and calculation described above.

5. Construct a mixed circuit of Figure 5 and repeat the measurement and calculation.