Experimental Physics

1st level Laboratory

(First Term)

Students of Third Year (Science)

Faculty of Basic Education

Prepared By

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PREFACE

Physics is the study of matter and energy and the interaction between them. It reveals the magic behind the wonderful existence of natural phenomenon. Hi-tech gadgets, modern machinery, gigantic skyscrapers, speedy trains, superior infrastructure are some of the marvels of physics.

Practical physics has laid the groundwork in the fields of engineering, technology and medical diagnostics. In practical physics the student obtain laboratory skills, design experiments and apply instrumentation such as electronic circuits to observe and measure natural phenomena. To master the science of physics practical one needs to have a complete and thorough knowledge of all the experiments. Hence we bring to you **“Std. XII Sci. : PHYSICS PRACTICAL HANDBOOK”** a handbook which covers all the experiments of Std. XII. This handbook written according to the needs and requirement of the board exam helps the student to score high. It includes different sets of experiments with proper steps and neat and labeled diagrams. These experiments help the student to understand the practical applications of many principles and laws involved in Std. XII. The handbook also includes all the useful tables given at the end. And lastly, we would like to thank all those who have helped us in preparing this book. There is always room for improvement and hence we welcome all suggestions and regret any errors that may have occurred in the making of this book. *A book affects eternity; one can never tell where its influence stops.*

Equation of a Straight Line

The equation of a straight line is usually written this way:

$y = mx + b$

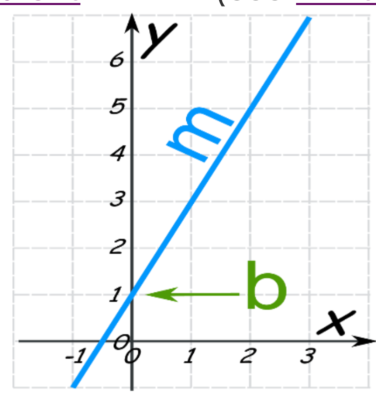
(or "$y = mx + c$" in the UK)

What does it stand for?

$$y \;=\; m\,x + b$$

Slope or Gradient

y when x=0 *(see Y Intercept)*



y = how far up

x = how far along

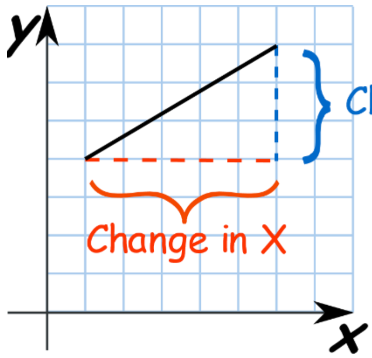
m = Slope or Gradient (how steep the line is)

b = value of **y** when **x=0**

How do you find "m" and "b"?

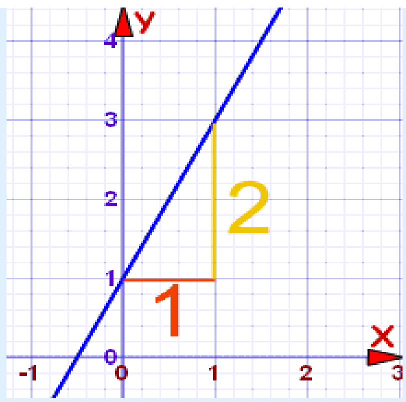
- b is easy: just see where the line crosses the Y axis.
- m (the Slope) needs some calculation:

m = *Change in Y*/ **Change in X**



Knowing this we can work out the equation of a straight line:

Example 1



m = 2**1** = 2

b = 1 *(value of **y** when x=0)*

So: y = 2x + 1

With that equation you can now ...

... choose any value for x and find the matching value for y

For example, when x is 1:

y = 2×**1** + 1 = 3

Check for yourself that x=1 and y=3 is actually on the line.

Or we could choose another value for x, such as 7:

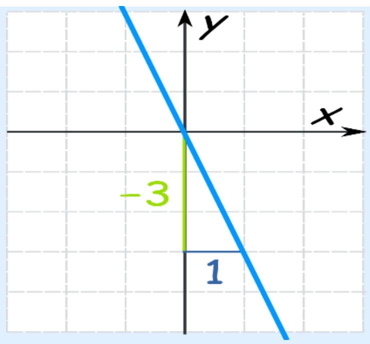
y = 2×**7** + 1 = 15

And so when x=7 you will have y=15

Positive or Negative Slope?

Going from left-to-right, the cyclist has to **P**ush on a **P**ositive Slope:

Example 2



m = −*3*/**1** = −3

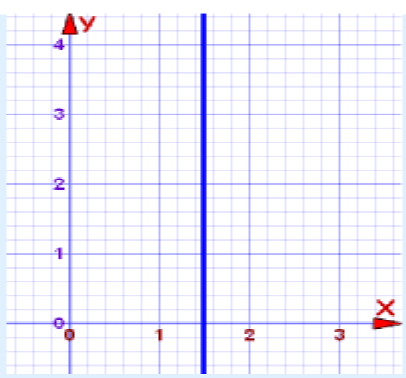
b = 0

This gives us **y = −3x + 0**

We do not need the zero!

So: y = −3x

Example 3: Vertical Line



What is the equation for a vertical line?
The slope is **undefined** ... and where does it cross the Y-Axis?

In fact, this is a **special case**, and you use a different equation, not "**y**=...", but instead you use "**x**=...".

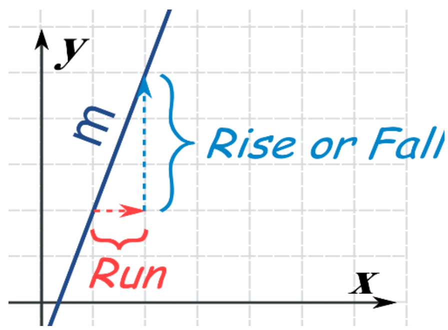
Like this:

x = 1.5

Every point on the line has **x** coordinate **1.5**,
that is why its equation is **x = 1.5**

Rise and Run

Sometimes the words "rise" and "run" are used.



- Rise is how far up
- Run is how far along

And so the slope "m" is:

m = *rise*/**run**

You might find that easier to remember.

EXERCISES 2

1. (a) On a single graph plot the following curves:

$$y = 1.5x + 3$$

$$y = x^2$$

$$y = \frac{1}{3}x^3$$

for values of x between - 3 and + 3.

(b) By observing the points of intersection of the curves in (a) find the roots of each of the equations:

$$x^2 - 1.5x - 3 = 0$$

$$\frac{1}{3}x^3 - 1.5x - 3 = 0$$

(Note that in order to obtain reasonably accurate values for the roots, the grid Δx should <u>not</u> exceed 0.1 in the regions near the solutions).

2. The relation between the time of swing or period, T, of a pendulum and its length L is given by

$$T = 2\pi\sqrt{L/g}$$

where g is a constant.

The value of L and T obtained from an experiment are:

L(cm)	:	24	49	74	105	150
T(sec)	:	1.02	1.45	1.80	2.07	2.48

(a) Determine g by the following way. Substitute each pair of the values for L and T into the above formula to obtain a value for g, then find the mean $\bar{g}$.

(b) Determine g from the graph of T^2 vs L.

(c) State which method you would consider to give the more accurate value of g, and why.

3. To obtain the coefficient of friction between two wooden surfaces the following formula was used:

$$coefficient\ of\ friction = \frac{mass\ of\ pan + mass\ in\ pan}{mass\ of\ tray + mass\ in\ tray}$$

Or $$\mu = \frac{p + w}{T + W}$$

where

p = mass of pan, w = mass in pan

T = mass of tray, W = mass in tray

The values of w and W obtained by experiment were as follows:

W(gm) :	0	200	400	600
w(gm) :	21	86	143	208

What is the value of the coefficient of friction, μ?

4. The relation between the current i sent through a galvanometer of resistance G by a cell of constant e.m.f. E, when the external resistance is R, is given by

$$i = \frac{E}{R + G}$$

The relation between the current i and the deflection θ it produces in a tangent galvanometer is given by $i = k \tan \theta$

where k is a constant.

Determine graphically the resistance G of the galvanometer from the experimental results:

R (ohm) :	1	5	14	26	38	61

θ (degree) :	71	63	51	40	32	23

5. A ball rolls down a slope. The distances s covered at different times t are given below.

t (sec) :	0	1	2	3	4	5	6
s (m) :	0	2	8	18	32	50	72

Plot the graph of s against t.

(a) The velocity, v, of the ball is the instantaneous rate at which distance is covered, (i.e. the velocity is the rate of increase of s with respect to t). What is the velocity after 1 sec., 2 secs., 3 secs., 4 secs., and 5 secs.?

(b) The acceleration, a, of the ball is the instantaneous rate at which the velocity increases, (i.e. the acceleration is the rate of increase of v with respect to t). Draw the velocity - time graph and from it find the acceleration after 1 sec., 3 secs., and 5 secs. Is the acceleration constant? What is the relation between v and t?

(c) Find the area (in velocity - time units) under the (v, t) curve between the third and the fourth seconds. Compare your answer with the distance covered during the fourth second as read off from the (s, t) graph. What conclusion can you draw from your observations?

6. Using the values of s and t of Problem 5, plot log s against log t. Hence determine the relationship between s and t.

7. The data below refer to the amplitudes of successive swings of the pendulum vibrating in a viscous medium.

Number of swings (x) :	1	2	3	4	5	6	7	8	9	10
Amplitude of swings (θ):	7.6	6.3	5.2	4.3	3.6	2.9	2.5	2.0	1.7	1.4

The relation between θ and x is of the form $\theta = ae^{bx}$

where θ is in radians.

(a) Show that the above relation can be converted to

$$\log \theta = \log a + 0.4343\, bx$$

(b) Plot log θ vs x and determine the constants a and b from the graph.

8. (a) Using the method of "Points in Pairs", find the slope and its error for the best line that passes through the experimental points:

x :	0	1	2	3	4	5	6	7	8	9
y :	0.2	1.0	1.9	2.9	4.2	4.8	6.2	7.1	8.0	8. 8

(b) Plot the experimental points and the best line determined in (a) on the same sheet.

Experiment [1]

Length Measurement

Vernier Caliper, Micrometer Screw, and Spherometer

Purpose of the Experiment

The purpose of this experiment is for students to understand the operating principles and usages of various length measurement instruments and to learn to address errors in the measurement. In general, the most frequently used length measurement instrument is the meter scale or rule. However, meter scales possess the following innate disadvantages:

1. Poor accuracy (the smallest scale marking or division is 1/10 cm, and any length below this scale can only be estimated).
2. Inability to measure the radius of curvature for spherical surfaces.

To overcome these drawbacks, we typically use more precise measurement instruments:

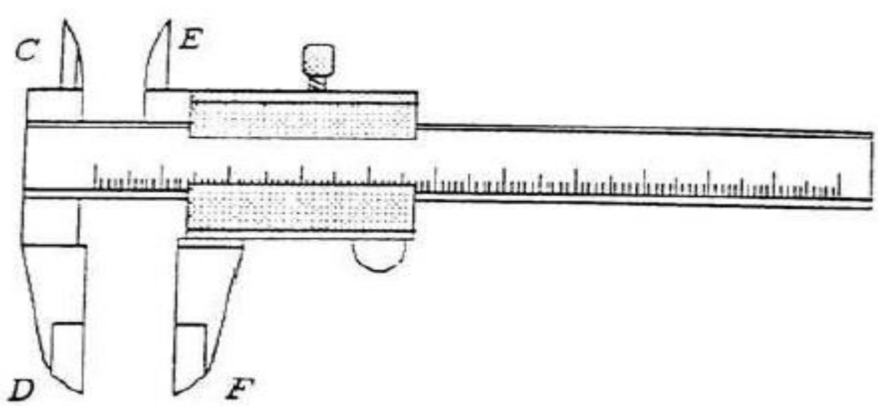
1. Vernier caliper **2. Micrometer screw** **3. Spherometer**

These instruments are used for various purposes and will be used frequently in other experiments. Although the Vernier caliper and the micrometer screw have already been introduced briefly in high school curricula, we hope that students can use this experiment as an opportunity to develop a comprehensive understanding of length measurement.

Experimental Principle

A. Vernier caliper

Figure 1



The Vernier caliper consists of a main scale and a vernier scale, and enables readings with a precision of 1/200 cm. Figure 1 shows that the main scale is fitted with Jaws C and D on either side, with the straight edges connecting C and D vertically to the main scale forming a right angle. Simultaneously, Jaws E and F are fitted on the Vernier scale, which moves over the main scale. When the jaws of the main and the Vernier scales contact each other, the zeros of both scales should coincide. If the zeros do not coincide, a zero point calibration must be performed instantly. The distance between C and E or between D and F is the length of the object that is being measured.

We first use an example to demonstrate how to read the Vernier caliper, followed by simple equation readings.

Figure 2

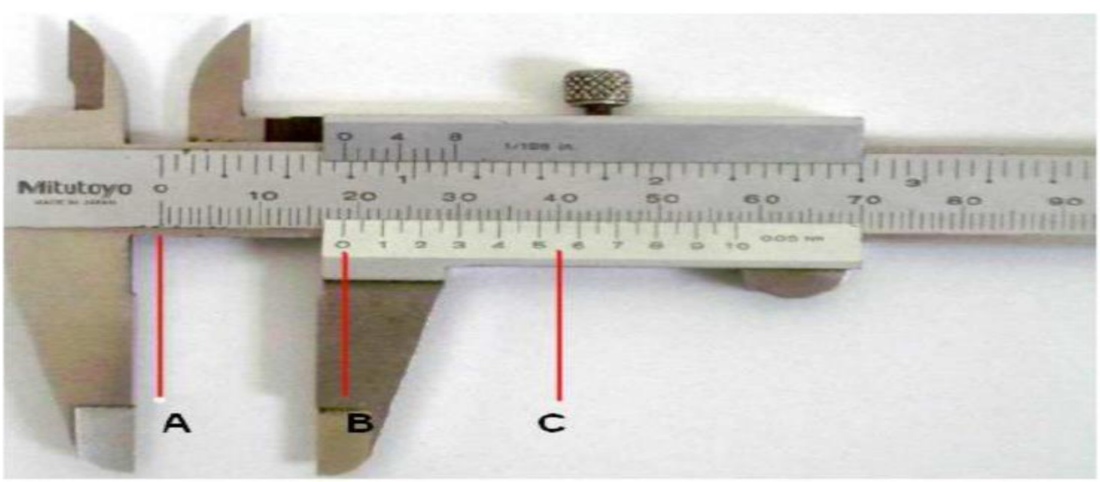


Figure 3

The Vernier scale in Figure 2 is graduated into 20 divisions or scale markings, which coincide with the 39 smallest divisions on the main scale (i.e., 39 mm). Assuming the length of one division on the Vernier scale is S, then S can be obtained as follows

S = 1.95 mm. (1)

In Figure 3, the zero on the Vernier scale is located between 18 and 19 mm on the main scale, whereas the 11th division on the Vernier coincides with the 40 mm on the main scale. Thus, AB is the length of the object, and

AB = AC − BC (2)

where the length of *AC* is 40 mm and *BC* is the length of the 11 divisions on the Vernier scale. Therefore,

AB = 40 − 11 × S = 40 − 11 × 1.95 = 18.55. (3)

However, although these calculations are easy, repeating them in each reading is time consuming. In fact, some contemplation enables Vernier caliper reading to be as direct and rapid as straight ruler reading. We hereby convert (3) into (4).

AB = 18 + 11 × _2 − 1.95_ = 18 + 11 × 0.05 (4)

Where 18 represents the division (i.e., 18 mm) on the main scale that precede the location where the zero on the Vernier scale points in Figure 3. Furthermore, 11 represents the division on the Vernier scale that coincides with a division on the main scale. A closer look indicates that 0.05 is marked on the Vernier caliper.

<u>Thus, a reading of the Vernier caliper can be obtained rapidly following these steps</u>:

1. Determine that the zero on the Vernier scale is located between divisions *n* and *n+1* on the main scale;

2. Identify division *m* on the Vernier scale as coinciding to a certain division on the main scale;

3. Determine how many units *M* one division on the Vernier scale is equivalent to. This unit is typically displayed on the Vernier scale. For example, Figure 3 shows that one division on the Vernier scale is equal to 0.05 mm. (Note: when we say that one division on the Vernier scale is equal to 0.05 mm, this does not mean that one division on the Vernier actually measures 0.05 mm. The actual length of one division on the Vernier scale shown in Figure 3 is in (1)). If the Vernier caliper does not show how many divisions a scale marking or divisions on the Vernier scale is equivalent to, we can obtain this information through calculations. The method is specified in a subsequent passage.

4. The reading should be n + m × M (A closer inspection shows that the value of m × M is displayed on the Vernier caliper. Therefore, a Vernier caliper reading is as simple as a straight ruler reading, and we can obtain the measurements instantly).

In labs, Vernier calipers possess various specifications. For example, the one shown in Figure 3 contains a Vernier scale, whose 20 divisions coincide with the 39 smallest divisions on the main scale.

We provide the following examples to demonstrate how to calculate how many divisions one marking on the Vernier scale equals.

Example 1: The 20 divisions on the Vernier scale coincide with the 39 smallest markings on the main scale (mm). Thus, the length of one division on the Vernier scale is

$$S = \frac{39}{20} = 1.95.$$

Therefore, one division on the Vernier scale is equal to 2 - 1.95 = 0.05 mm.

Example 2: Ten divisions on the Vernier scale coincide with 9 smallest divisions on the main scale (mm). Thus, the length of one division on the Vernier scale is

$$S = \frac{9}{10} = 0.9.$$

Therefore, one division on the Vernier scale is equal to 1 - 0.9 = 0.1 mm.

Regarding the Vernier calipers in this lab, we have summarized the following rules by which we can obtain what one division of the Vernier scale equals.

1. When the smallest division on the main scale is *M* and *n* divisions on the vernier scale are equal to *m* divisions on the main scale, the actual length of the smallest division on the Vernier scale is S = M{m/n}
2. $\frac{m}{n}$ is not an integer, and the value of $\frac{m}{n}$ is between integers *R*-1 and *R*, that is, $R - 1 < \frac{m}{n} < R$.
3. One division on the vernier scale is equal to $D = \left(R - \frac{m}{n}\right) \times M$.

B. Micrometer screw

Figure 4 shows a micrometer screw, where A is an anvil fixed to the frame (F), and the spindle (B) channels through F and the sleeve (S) to connect to a revolution thimble (T) and a ratchet (H). S is marked with precise divisions, and the periphery of T is graduated into 50 equal parts. For one revolution of T, it moves forward or backward half a division on the sleeve, that is, 0.05 cm (metric micrometer

screw). Therefore, one division on the periphery of T equals 0.05/50 = 0.001 cm

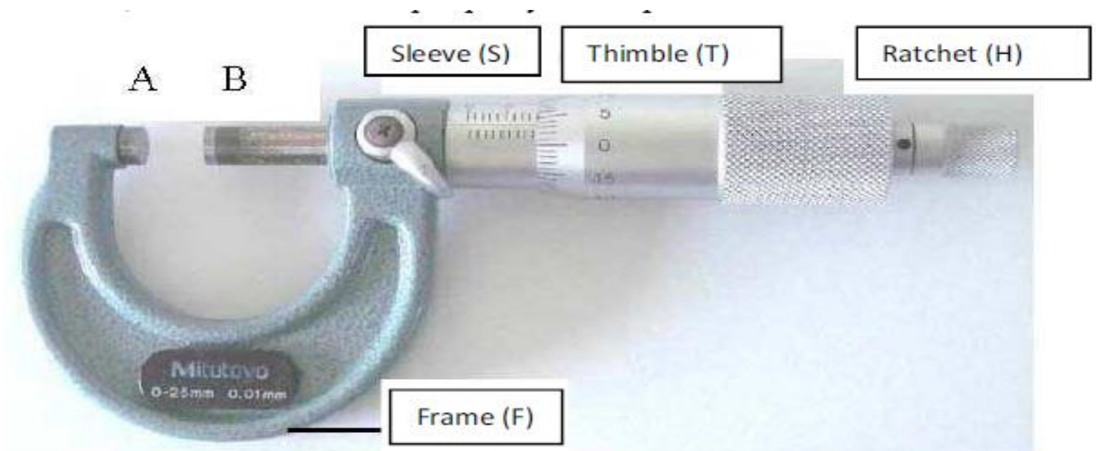


Figure 4

The ratchet is designed to ensure that the object that is placed between the anvil and the spindle undergoes a certain amount of pressure, but that the pressure does not cause significant object deformation, which would affect the precision of the measurement. Therefore, rather than directly turning the thimble to compress the object during measurement, we should turn ratchet (H) for adjustments. We will use an example to demonstrate the usage of micrometer screws.

Figure 5 shows the positions of S and T when the length of an object is *Y.* The edge of T is located between 9.5 and 10.0 mm on S, and the reading on T is 33.5. Therefore, the distance between the edge of T and the 9.5 mm on S is.

$$33.5 \times \frac{1}{100}\,\mathrm{mm} = 0.335\,\mathrm{mm}.$$

Thus, the length of the object is

$$\mathrm{Y} = 9.5 + 33.5 \times \frac{1}{100} = 9.835\,\mathrm{mm}.$$

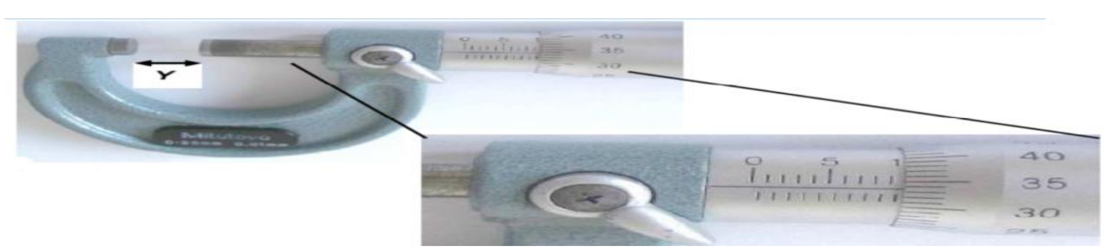


Figure S

C. Spherometer

Spherometers are used to measure the thickness of thin objects or the radius of curvature of objects. Its structure and operating principles are similar to those of a micrometer screw. Figure 6 shows that a straight ruler (S) is placed on a tripod (T) and a circular disc is located on top of the screw (I). The circular scale (G) is graduated into 100 equal parts or divisions. For one rotation of the circular scale, it
advances or recedes by 0.1 cm on S. Therefore, each division of G is equal to P{1/100}x 0.1 equals 0.001 cm.

To measure a spherical surface, first place the three legs (ABC) of the spherometer on the surface, and adjust the screw so that F is in contact with and fixes the surface. If the spherical glass being measured is positioned as shown in Figure 7, assuming its radius of curvature is *R*, the spherometer is located at points A, B, C, and D, and the tip of the central angle is at D. We assume that *h* is the distance between D and D', which is the center of the equilateral triangle formed by A, B, and C, the sides of Triangle ABC are *s*, and the distances between D' and A, B, and C are all *r.*

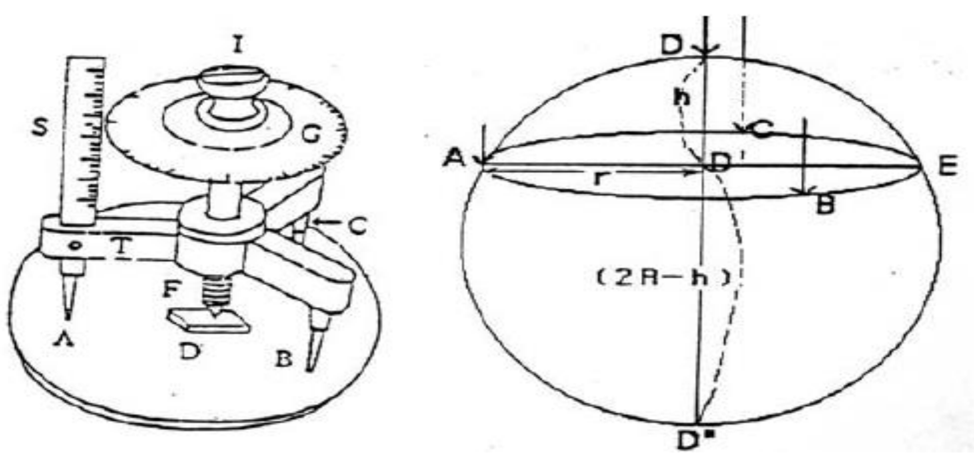


Figure 6

Based on the relationship of similar triangles, we obtain

$$\Delta ADD' \sim \Delta D''AD'$$
$$AD' : DD' = D''D' : AD' \rightarrow r : h = (2R - h) : r$$

$$\therefore R = \frac{h}{2} + \frac{r^2}{2h}.$$

Furthermore, ΔABC is an equilateral triangle, the side length of which is s; therefore

$$\frac{s}{2} = r \sin 60^o = \frac{\sqrt{3}}{2} r \rightarrow r^2 = \frac{s^2}{3}$$

$$\therefore R = \frac{h}{2} + \frac{s^2}{6h}.$$

6h**Laboratory Instruments**

1. Vernier caliper 2. Micrometer screw 3. Spherometer 4. Hollow cylinders (several)

5. Watch glass (several) 6. Plate glass 7. Coins (self-prepared)

Experimental Procedure

A. Vernier Caliper

1. Zeroing

a. Close the jaws of the vernier caliper and read the zeros;

b. Repeat the action five times and calculate the means of the errors and the standard deviations.

2. Measure the thicknesses and diameters of the coins five times, respectively, and calculate the means of the measurements and the mean standard deviations.

3. Use the results from Steps 1 and 2 to calculate the volume of the coins (including the means and mean standard deviations).

4. Select a random hollow cylinder and measure its outer and inner diameters and depths five times, respectively, and calculate the means and mean standard deviations.

5. Use the results from Steps 1 and 4 to calculate the volume of the hollow cylinder (including the means and mean standard deviations).

B. Micrometer Screw

1. Perform zeroing, same as Step A.-1, and identify the means of the errors and standard deviations.

2. Same as Step A.-2. (Measure the same coin as the one used in Step A)

3. Same as Step A.-3.

C. Spherometer

1. Zeroing: Place the spherometer on plate glass and ensure that A, B, C, and F are all contacting the glass. Read the zeros. Repeat the measurement five times and calculate the means of the errors and standard deviations.

2. Select a random watch glass, place the spherometer on the spherical surface of the glass, and ensure that the tips of the four legs are in contact with the surface. Read the scale measurement. The difference between zero and this value is *h.* Repeat this action five times and calculate the means of *h* and mean standard deviations.

3. Place the four legs of the spherometer on flat paper simultaneous. Apply a little pressure to press the tips to leave marks on the paper. Use these marks to obtain the side length *s* of Equilateral Triangle ABC. Repeat the measurement five times and calculate the means of *s* and standard deviations.

4. Based on these results, calculate the radius of curvature of the watch glass (means and mean standard deviations).

Experiment [2]

Joule's Equivalent

Aim:

Determination Of The Thermal Mechanical Equivalent using Joule Method, Joule's Equivalent (J).

Discussion:

Electric Resistance is known to result from electrons in conduction ions. This means that the free electrons lose their kinetic energy when collided with the ions. The result in the amplitude of the ions around the stability of ions. That is the electric energy turns into thermal energy.

Tools

1- Caliber filled with enough water to immerse a heating wire made of tungsten, and thermally insulated by placing it in an external caliber and between them (Fibers) to reduce the loss of heat in pregnancy and radiation.

2- Thermometer for measured the temperature.

3- Continuous voltage source or battery.

4- Ammeter.

5- Voltmeter.

6- Resistant.

Mathematical Relationship

Procedure:

1. Weigh the caliber and it is mass is M_1, and take a quantity of water and determine it is mass M_2.
2. Determine water temperature and the initial caliber using the thermometer.
3. Using A caliper, set the value of each r_1, r_2 then set a fixed distance on the rubber tube at the two point (b,c) so that (bc=1cm) remain attached to the surface of water .
4. Inundate the tube in the caliber so that two labels (b, c) remain attached to the surface of water.
5. When the water vapor comes out of it is rubber tube start recording the time and wait for a sufficient period to rise the temperature of water and the caliber from T_1 to T_2.
6. In the equation we find a coefficient of heat conductivity K for rubber.

Result:

$M_1=$ .... gm

$M_2=$ .... gm

$T_1=$ .... °C

$T_2=$ .... °C

$r_1=$ .... cm

$r_2=$ .... cm

$d= r_2-r_1=$ .... cm

$t=$ .... sec

$L=$ .... cm

Experiment [3]

Jenter method

Aim:

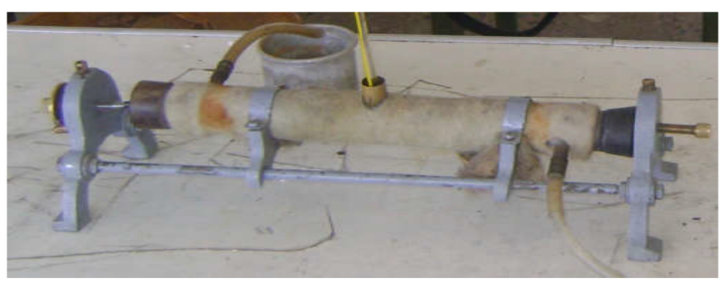
Determination of the linear (longitudinal) expansion coefficient of a rod of copper using Jenter device

Discussion:

As a result of heating a metal rod, the interfaces are increasing between their atoms, it expands. Thus, the length of the rod is greater than the linear length by a certain amount called the longitudinal expansion coefficient. Each metal has its own longitudinal expansion coefficient. Physically known, the material is expanded by heat and shrinks in cold. The phenomenon of thermal expansion of metals in telephone wires can be observed in the summer and shrinking in the winter. It is useful to know the coefficient of longitudinal expansion in the knowledge of the distance to be left between the railway poles.

Tools

Jenter device:
Shown as follows and consists of :
1-Copper Rod .
2-Mercury thermometer
3-Spheromter



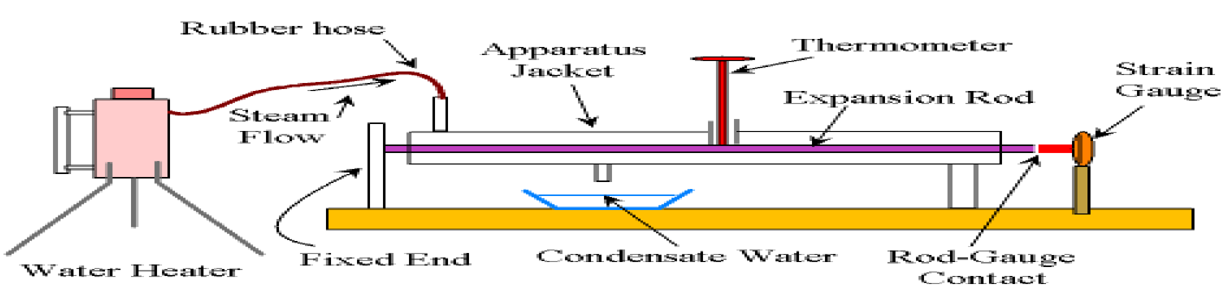


Fig. 1 : Linear Expansion Apparatus

Prove the Mathematical Relationship

If we have a metal rod ,it's length (L_0) at zero temperature and it's length (L_t) at temperature (T) , the increase in length (ΔL)due to temperature rise from (0 °C) to (T °C) is

$$\Delta L = L_T - L_o \qquad ...(1)$$

Thus , the increase unit lengths of the rod per cent °C represents the coefficient of longitudinal expansion (Y) where

$$Y = \frac{(L_T - L_o)}{L_o \ T} \qquad ... (2)$$

$$Y L_o \ T = (L_T - L_o)$$

$$L_T = Y L_o \ T + L_o$$

$$L_T = L_o \, (Y \, T + 1) \qquad ... (3)$$

If we assume that the temperature increase from (0°C) to (T_1°C), the length of the rod (L_1) is applied to equation (3) given by the relationship

$$L_1 = L_o \, (Y \, T_1 + 1) \qquad ... (4)$$

The length (L_2) when (T_2°C) is

$$L_2 = L_o \, (Y \, T_2 + 1) \qquad ... (5)$$

By dividing the equation (5) on equation (4)

$$\frac{L_1}{L_2} = \frac{L_o \, (Y \, T_1 + 1)}{L_o \, (Y \, T_2 + 1)}$$

using the binomial theorem , neglecting the limits greater than (1) by putting ($Y^2 = 0$)

$$Y = \frac{(L_2 - L_1)}{L_1 (T_2 - T_1)} \qquad ... (6)$$

These can be used to find the longitudinal expansion coefficient of the rod .

Procedure:

1. Adjust the tip of the Spherometer on the free rod tip and read it , as well as measure the initial temperature T .
2. Move the tip of the free rod tip until it allows it to stretch.
3. Ignite the flame of benzene until a stream of water vapor passes and wait until the temperature of the rod increase (T_2) greater than 95 °C .
4. Adjust the Spherometer's head , very carefully, again so touch the tip of the free rod and take it again(L_2)
5. The difference between the two Spherometers at T_1, T_2 is the increase in the length of the metal length of the rod (L_2-L_1).
6. By knowing the original length of the rod (L), you can obtain the coefficient of the longitudinal extension of a rod of copper .

Results:

L = ... cm

$\Delta L = \frac{L_2 - L_1}{10}$ = ... cm

L_1 = ... mm

T_1= .... °C

L_2 = ... mm

T_2 = ... °C

$$Y = \frac{\Delta L}{L(T_2 - T_1)} =$$

$$Y = \frac{\dots\dots..}{\dots..(\dots.. \;-\; \dots\dots)} = \quad \dots\dots\dots \; deg^{-1}$$

Experiment No. (4)

The specific heat capacity of a solid body

Aim:

Determine the specific heat capacity of a solid body by the method of mixtures.

Discussion:

If we add one body to anther and have two different temperatures , loses a quality of heat and the other body acquires it to the same temperature . the amount of heat that the first body has lost is the amount of heat the other body has acquired this method is to raise the temperature of a solid body to a high temperature and then add it directly to the fluid and set the final temperature of the mixture and fix the way to set the quality heat for any of the body s solid or liquid by the quality of the other's heat, bearing in mind that the body is not capable of being solid soluble in liquid or chemically interacting with it

Tools

1- caliber filled with enough water to immerse a heating wire made of tungsten , and thermally insulated by placing it in an external caliber and between them (libad) to reduce the loss of heat in pregnancy and radiation .

2-thermometer for measured the temperature .

3- continuous voltage source or battery .

4- ammeter.

5- voltmeter.

6- reustat .

Mathematical Relationship

we take a solid object mass (m) of material heat quality (s) and heat it in the device shown in the form that the temperature reaches the appropriate value (T) and the temperature of water vapor and take the amount of liquid mass (m) and heat quality (s) in the price (a) of its mass (m) and heat quality (s) and temperature together (T) and when the stability of the temperature of the body steel at the degree (T) we throw it into the liquid quickly and trun the mixture well and set the final temperature (T) and then if we neglect the amount of heat last un the calf and pregnancy so the amount of heat obtained by the colorie and heat equal to the amount of heat last the solid body if the liquid used is water s=1cal/gm/deg and the price is made of copper

$$S = \frac{(m_1 s_1 + m_2 s_2)(T_2 - T_1)}{m\ (T - T_2)}$$

Where

m_1 is the calorimeter mass

m_2 is the water mass

s_1 is the calorimeter specific heat = 0.2 Cal/gm/deg

s_2 is the water specific heat = 1 Cal/gm/deg

T_1 the temperature of water and calorimeter before mixture

T the temperature of the solid before mixture

T_2 the temperature of the group after mixture

m is the solid mass

Procedure:

1. Weight an empty calorimeter with the balance. Ensure that calorimeter is clean and dry. Note the mass m1 of the calorimeter

2. Pour the given water in the calorimeter. Make sure that the quantity of water taken would be sufficient to completely submerge the given solid in it. Weight the calorimeter with water and hence note the mass of the given water quantity m2
3. Place the calorimeter in its insulating cover. Measure the temperature of the water taken in the calorimeter. Record the temperature T1 of the water and the calorimeter.
4. Place a suitable amount of the solid of a specific heat s in the tube C and turn in until it closed and then put a thermometer inside the tube C to measure the temperature of the solid.
5. Start the heating and wait for about 30 min and then record the temperature of the solid T.
6. Let the solid falls in the insulating calorimeter by turning the tube C . and the record the final temperature of the mixture T2
7. Finally, weight the group(calorimeter ,water and the solid) the determine the mass of the solid m.
8. Using the Eq(1), calculate the specific heat capacity S of the solid

Result:

s_1 the calorimeter specific heat = 0.2 Cal/gm. °C

s_2 the water specific heat = 1 Cal/gm. °C

m_1 the calorimeter mass = ... gm

m_2 the water mass = ... gm

m is the solid mass = ... gm

T_1 the temperature of water and calorimeter before mixture = ... °C

T_2 the temperature of the group after mixture = ... °C

T the temperature of the solid before mixture = ... °C

Experiment [5]

Newton's Law Of Cooling

Aim:

To verification Newton's cooling act for liquid (water).

Discussion:

When an object is at a different temperature than its surroundings, it will gradually cool down or heat up until the temperatures are equal. Everyone has experienced this. You boil water to make tea and then wait several minutes until it is at a temperature at which you can drink it. You place a cold turkey in the hot oven for Thanksgiving dinner and after several hours it has reached the desired temperature. Newton's Law of Cooling relates the rate of change in the temperature to the difference in temperature between an object and its surroundings.

Tools

Thermometer
Stopwatch
Heater
Water bath
Criterion

Prove the Newton low

We choose three points on the curve (a*b*c) and draw tangential for three points and draw a line that parallel the horizontal axis and set the values of (A*B*C) and know (aA)and(bB)and(cC) and set the value of (1/aA)(1/bB)(1/cC)we find that

(1/aA)=(1/bB)=(1/cc) so that the value of (aA)(bB)(cC)

Mathematical Relationship

$$\frac{\Delta T}{\Delta t} = c(T_2 - T_1)$$

Where

$\frac{\Delta T}{\Delta t}$ is the cooling rate

C is Newton's constant

Procedure:

1. Fill a small calorimeter with water and insert a thermometer inside the calorimeter.
2. Put the calorimeter in wooden base on a heating water bath.
3. Start heating and wait until the water temperature reach to 95 °C.
4. Put the calorimeter in wooden base on a cooling water bath and let the liquid (water) in the calorimeter to cool
5. Record the temperature for every 30 second until the temperature reach to 35 °C
6. Plot the cooling curve.

Cooling Curve

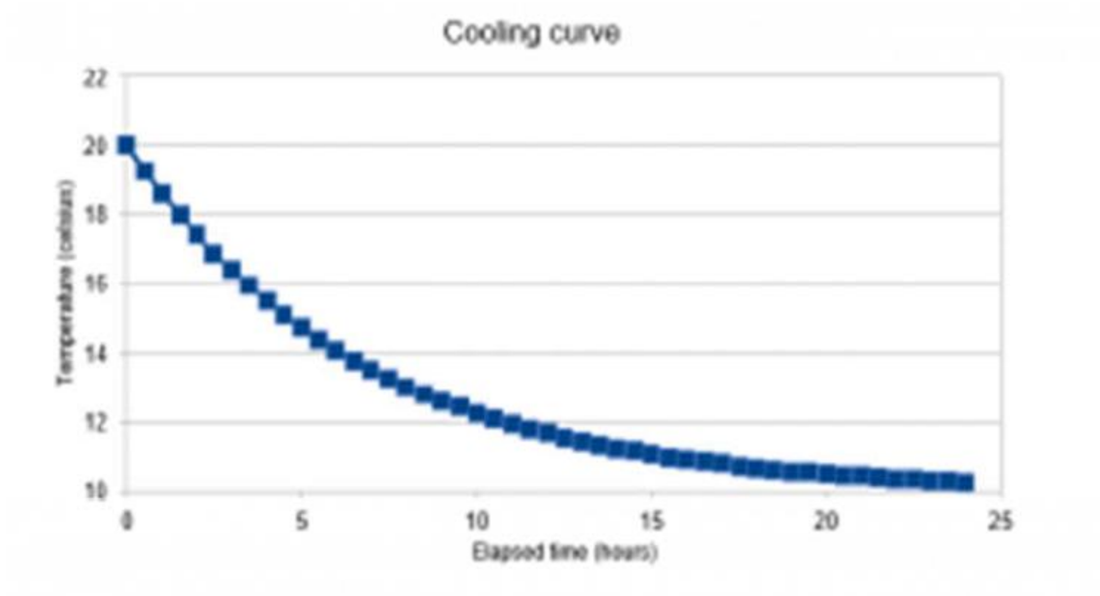


Table:

Time (t)	Temperature (T)	Time (t)	Temperature (T)	Time (t)	Temperature (T)

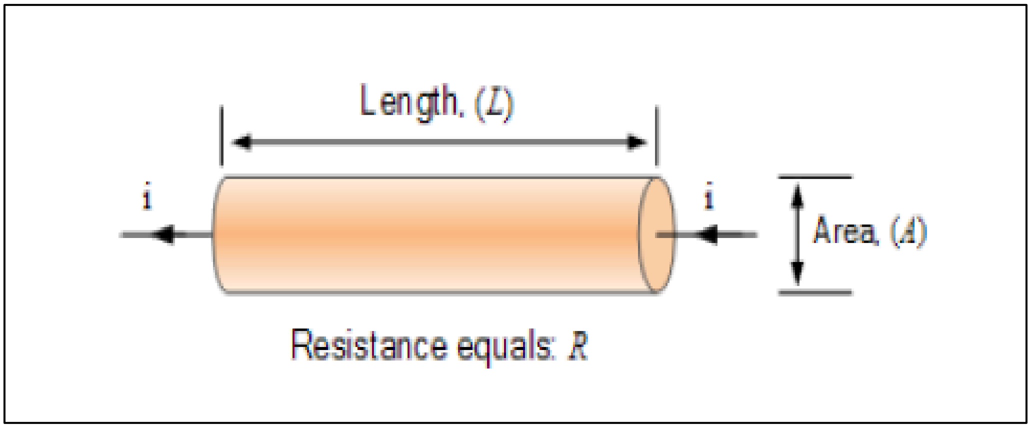
Experiment [6]

VERIFYCATION OF OHM'S LAW

Ohm's Law

According to Ohm's Law, the current flowing in a conductor is directly proportional to the potential difference across its ends provided the physical conditions and temperature of conductor remains constant.

$$\boldsymbol{I \propto V \quad \Longrightarrow \quad V = IR}$$



Resistivity (ρ)

Resistivity of materials is the resistance to the flow of an electric current, some materials resisting the current flow more than others.

Ohms Law states that when a voltage (V) source is applied between two points in a circuit, an electrical current (I) will flow between them encouraged by the presence of the potential difference between these two points. The amount of electrical current which flow is restricted by the amount of resistance (R) present. In other words, the voltage encourages the current to flow (the movement of charge), but it is resistance that discourages it.

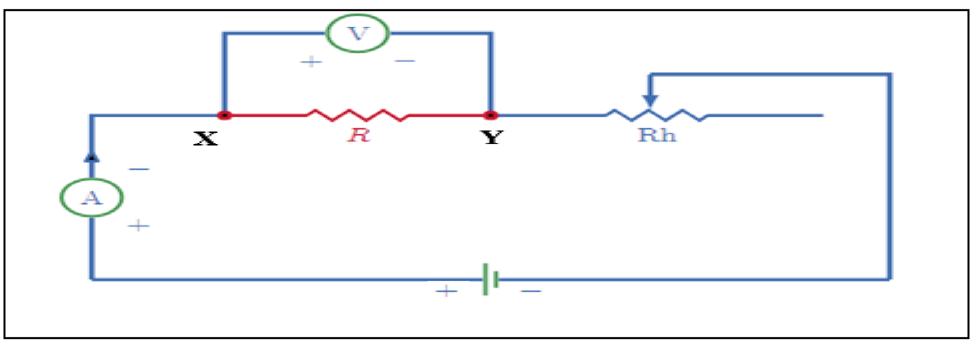
the electrical resistance of conductor can depend on many factors such as the conductor’s length, its cross-sectional area, the temperature, as well as the actual material from which it is made.

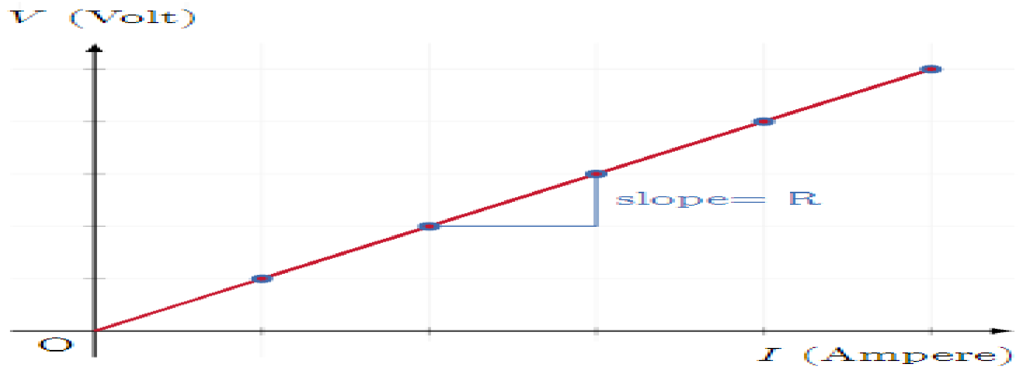
Thus, the resistance of the conductor depends on the material type (ρ) and is directly proportional to its length (L) and inversely proportional to its area (A).

$$R = \rho \frac{L}{A}$$

Experimental Method

Set up a circuit as shown in figure shown, consisting of resistance (R) made of nichrome wire **XY** of length, 0.3m and radius 0.035m, an ammeter, a voltmeter rheostat (variable resistor), a power supply (DC battery with 6volts) and connecting wires. First connect the components properly and adjust the reading of potential difference across the nichrome wire in the voltmeter (V) by changing the Rheostat value and note the corresponding current reading in the ammeter (I). Tabulate them in a table. Repeat the above step many times for different values of potential difference and note the respective readings of current each time. Plot V and I on a graph paper. We obtain a straight line passes through the origin of the graph, as shown in the figure. This shows that the current is proportional to the potential difference which verifies Ohm's law. We can get on the wire resistance by calculating the line slope





Ohm's Law: The current I is proportional to the voltage V

Procedure

1. Connect the components as it shown in the figure.
2. Adjust the rheostat to a small value for the potential difference (V) and current (I).
3. Repeat the above step many times for different values of potential difference and note the respective readings of current each time
4. Recording the data in a table.
5. Plot the data of V and I on a graph paper where (V) represented on the vertical axis and (I) on the horizontal axis.
6. Calculate the slope of strain line and find the resistance (R) for the wire.

$$Slope = R$$

7. Use the values of wire length and radius to find the specific resistance (ρ).

$$\rho = \frac{RA}{L}$$

$$L = 30cm, \qquad r = 0.04, \qquad A = \pi r^2 =$$

V	0.5	1	1.5	2	2.5	3	3.5
I							

Problems on Verification of Ohm's Law

Question 1: In an experiment to verify Ohm's law, the potential drop across the resistor with length 25cm and area of 0.5cm^2 was 4.5 V and the current through the resistor was 1.5 A. The resistivity is

A. 3.0 Ω.

B. 0.06 Ω.cm

C. 150 Ω.cm^{-1}

Question 2: The internal resistance of the voltmeter is very high (ideal voltmeter has infinite resistance), whereas that of an ammeter is very low (ideal ammeter has zero resistance). The primary reason for this is

A. The voltmeter is connected in series and ammeter is connected in parallel.

B. The voltmeter is connected in parallel and ammeter is connected in series.

Question 3: In an experiment to verify Ohm's law, a student used a bulb as a resistor. When he plotted the voltage versus the current graph, he obtained a slightly curved line instead of the expected straight line. This may be due to

A. variation in battery emf.

B. temperature dependence of the bulb resistance

C. zero error in voltmeter or ammeter

D. non-ohmic nature of bulb material

Experiment [7]
Measurement of the electrochemical equivalent of copper

Introduction

Solutions of acids, bases and salts in water can conduct electric current and they are called electrolytes. The chemical changes which occur when an electric current pass through an electrolyte are called electrolysis. The molecules of the above substances and often also their solid crystalline structures are formed due to a strong electrostatic attraction between the positive and negative ions of the atoms which form the compounds. These electrostatic forces strongly reduce in water solutions because of very high dielectric constant (e = 81) of water leading to the decay of the compounds into ions which is called ionic dissociation. For example, copper sulphate molecules dissociate into two doubly charged ions

$$\boldsymbol{CuSo_4 \longrightarrow Cu + So_4}$$

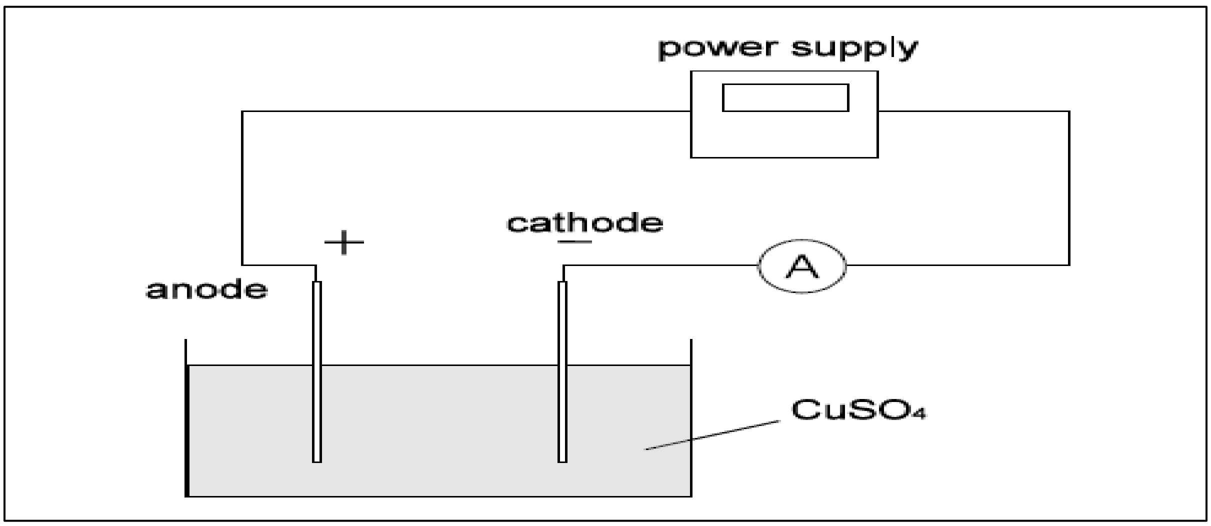
Water solutions of acids, bases and salts contain positive and negative ions which are the carriers of electric current. Other solvents which have a high dielectric constant such as methyl and ethyl alcohols also produce ionic dissociation of the chemical compounds. When a current pass through an electrolyte it can produce deposition of chemical substances on the electrodes. Faraday's first law of electrolysis states that the mass m of any substance deposited on an electrode (anode or cathode) is proportional to the electric charge q that flowed through the electrolyte

$$\boldsymbol{m = KQ = K\,I\,t}$$

where (I) is the current in a time (t), k is the electrochemical equivalent of the substance.

Apparatus and Method.

The electrochemical equivalent of copper is determined using an experimental setup, called a voltammeter shown schematically in figure. The copper sulphate CuSO4 solution is electrolyzed using two copper electrodes. During electrolysis copper is deposited on the cathode and the anode is dissolved with its mass decrease being equal to the mass increase of the cathode. The change of the mass of the electrodes is found by weighing them before and after the electrolysis. Current in the circuit is read out by an ammeter A and is adjusted by the regulated power supply. The electrochemical equivalent is calculated from the previous equation for the measurements taken for a given time t.



Measurements

Find the electrochemical equivalent of copper from the measurements made

for I = 1A, t = 30min, considering the change of masses of the anode and cathode

Procedure

1. firstly, determine the cathode mass (m_1) before connecting it in the circuit
2. Connect the circuit as it shown in the figure. Note that the cathode is connecting with the negative electrode of battery.
3. Adjust the current value on the ammeter at I = 1A.
4. Switch on a timer and wait for a period of t = 30 min.
5. After 30 min, Switch of the battery, dry the cathode and determine the cathode mass (m_2)
6. Calculate the copper mass (m) which deposited on the cathode.

$$\boldsymbol{m = m_2 - m_1}$$

7. Calculate the electrochemical equivalent of copper from the equation

$$\boldsymbol{K = \frac{m}{It} = \ ....}$$

Experiment [8]
Deflection Magnetometer

The deflection magnetometer consists of a large compass box with a small magnetic needle pivoted at the center of a circular scale so that the needle is free to rotate in a horizontal plane. A large aluminum pointer is rigidly fixed perpendicular to the magnetic needle. The circular scale is graduated in degrees. (0-0) and (90-90) readings are marked at the ends of two perpendicular diameters. The compass box is placed at the center of a wooden board one meter long. The wooden board has a millimeter scale along its axis. The zero of this scale is at the center of the compass box.

Aim

To determine the magnetic dipole moment (m) of a bar magnet and horizontal intensity (B_H) of earth's magnetic field using a deflection magnetometer.

Theory

The horizontal component of earth's magnetic field, B_H, is the component of the magnetic field of the earth along a horizontal plane whose normal vector passes through the center of the earth. B_H is measured in Tesla, T.

The magnetic dipole moment m of a magnetic dipole is the property of the dipole which tends to align the dipole parallel to an external magnetic field. m is measured in Ampere-square meters (A m^2) or, equivalently, in Joules per Tesla (J/T).

Tangent law

Consider a bar magnet with magnetic moment m, suspended horizontally in a region where there are two perpendicular horizontal magnetic fields, and external field B and the horizontal component of the earth's field B_H. If no external magnetic field B is present, the bar magnet will align with B_H. Due to the field B, the magnet experiences a torque $\boldsymbol{T_D}$, called the deflecting torque, which tends to deflect it from its original orientation parallel to B_H. If θ is the angle between the bar magnet and B_H, the magnitude of the deflecting torque will be,

$$T_D = mB \cos \theta \qquad (1)$$

The bar magnet experiences a torque T_R due to the field B_H which tends to restore it to its original orientation parallel to B_H. This torque is known as the restoring torque, and it has magnitude.

$$T_R = mB_H \sin \theta \qquad (2)$$

The suspended magnet is in equilibrium when,

$$T_D = T_R$$

$$mB \cos \theta = mB_H \sin \theta$$

$$B = B_H \tan \theta \qquad (3)$$

The above relation, called the tangent law, gives the equilibrium orientation of a magnet suspended in a region with two mutually perpendicular fields.

Working principle

In **Tan A position** (Fig. 1), prior to placement of the magnet, the compass box is rotated so that the (0-0) line is parallel to the arm of the magnetometer. Then the magnetometer as a whole is rotated till pointer reads (0-0). Finally, the bar magnet (the same one that was previously suspended in the Vibration Magnetometer) is placed horizontally, parallel to the arm of the deflection magnetometer, at a distance d chosen so that the deflection of the aluminum pointer is between 30° and 60°.

The magnet is a dipole. Suppose that, analogous to an electric dipole, there are two magnetic poles P (though in reality no single magnetic pole can exist), one positive and one negative, separated by a distance $L = 2l$, with the positive pole labeled N and the negative pole labeled S. By analogy with Coulomb's law, for each pole we would have a field.

$$B = \frac{\mu_0}{4\pi}\frac{P}{r^2} \qquad (4)$$

and a magnetic dipole moment.

$$m = PL = 2Pl$$

$$B = \frac{\mu_0 P}{4\pi}\left[\frac{1}{(d-l)^2} - \frac{1}{(d+l)^2}\right] = \frac{\mu_0}{4\pi}\frac{2md}{(d^2-l^2)^2} \qquad (5)$$

where $l = L/2$ is the half-length of the magnet

m = magnetic moment of the magnet

the magnetic permeability of free space $\mu_0 = 4\pi \times 10^{-7}\ TmA^{-1}$

and θ = deflection of aluminum pointer.

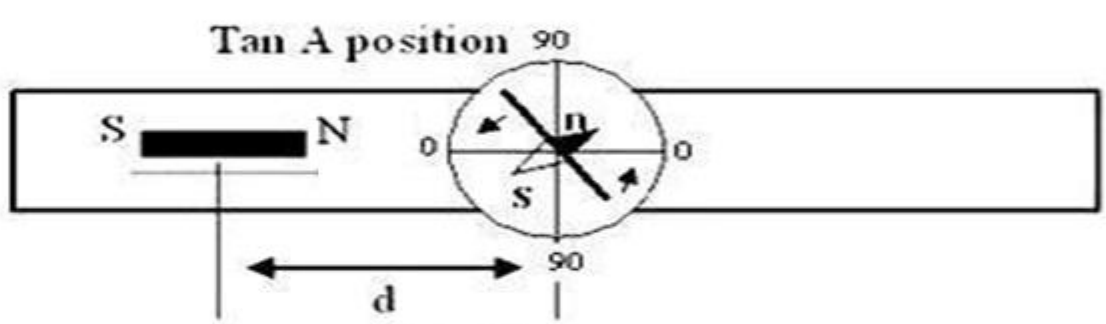


Figure 1

If $\boldsymbol{l}$ is very small respecting to the distance d, so this equation can be written as

$$B = \frac{\mu_0}{4\pi}\frac{2m}{d^3} \qquad (6)$$

Therefore, by the tangent law, at equilibrium

$$B_H \tan\theta = \frac{\mu_0}{4\pi}\ \frac{2m}{d^3} \qquad (7)$$

$$\tan(\theta) = \frac{2\mu_0 m}{4\pi B_H}\frac{1}{d^3}$$

This equation represents a straight-line equation between ($\boldsymbol{\tan\theta}$) and ($\boldsymbol{\frac{1}{d^3}}$).

Procedure

1. The compass box alone is rotated so that the (0-0) line is parallel to the arm of the magnetometer. Then the apparatus is rotated till the aluminum pointer reads (0-0).
2. The bar magnet is placed horizontally, parallel to the arm of the deflection magnetometer, at a distance d from the center of the compass needle, chosen so that the deflection lies between 30° and 60°. The reading of the ends of the pointer are noted.
3. The magnet is then reversed at the same position and the readings of the pointer are again noted.
4. The magnet is then transferred to the other arm of the magnetometer, keeping it at the same distance d, so four more deflections angles are noted as before.
5. The experiment is repeated for different values of d and an average value for θ is calculated.

6. Plot the data of tan θ and $(\frac{1}{d^3})$ on a graph paper where $(\tan\,\theta)$ is represented on the vertical axis and $(\frac{1}{d^3})$ on the horizontal axis.
7. We can get on a straight line, by Calculating the slope of it we can find the moment of the bar magnet from the next equation

$$\text{Slope} = \frac{2\mu_0 m}{4\pi B_H}$$

Results

d (cm)	Rotation angle				Average (θ)	tan θ	$\frac{1}{d^3}$
	θ_1	θ_2	θ_3	θ_4			

The horizontal intensity of earth's magnetic field at a place, $\boldsymbol{B_H}$ =................. Wbm^{-2} The moment of the bar magnet, $\boldsymbol{m}$ = ... Am^{-2}