Chapter 1

GENERAL INTRODUCTION & USEFUL HINTS TO STUDENTS

1.0 Introduction

Let us embark upon an exciting journey through the wonderful world of Physics. The fundamental laws of Physics (**F** = ma, for example) are deceptively simple just by looking at them. How then has it taken so many centuries to discover them? How do we know that these laws are really true? What kind of skills do we require to test these laws of physics? At the end of this laboratory course, you should be able to answer these questions especially as it concerns the basic physics laws which are involved in this first year of your scientific career. In addition to the specific goals of the individual experiments you will perform during this course; there are two general goals for this course. First, you will have a first-hand experience with the basic concepts of physics. The second goal is to teach you how to make and interpret measurement of physical phenomenon.

In addition, you will learn how to recognize and deal with the sources of errors which are inherent part of all experiments. The apparatus normally used in the laboratories is necessarily imperfect. These imperfections cause various spurious effects which we have to learn to cope with.

1.1 Helpful Hints

a. During the laboratory session, you will be expected to think critically and try to understand what you want to do before doing it.

b. You must be consistent with the units of measurement when you perform the experiments and carry out the calculations. For example, if you are using kilograms (kg) for mass, then you must use meters (m) and Newtons (N) as your units of length and force, respectively. If you are using gram (gm) as your unit of mass, then use centimeter (cm) and dynes as your units of length and force, respectively. Mixing units is the most common type of calculation error in the laboratories.

c. Compare your results with those that are theoretically expected. If there are any major discrepancies, check to make sure you did your calculations and/or experiment correctly. Your answer must be physically reasonable. Do not merely put down your result. You must try to explain your result physically.

d. *If you have problems during the Laboratory session, ask the instructors to assist you.*

1.2 Laboratory Notebook

A well-kept laboratory notebook is one of the most important tools in any research. Write down your observations, your description of the experiment and the apparatus, ideas that come to you as you work, conclusions you arrive at and criticisms of your methods and ideas. The recordings must be done in pencil. When you are satisfied that you are correct, then and only then can you record in pen. At this point you have to make the necessary corrections when you are reporting the final results. Remember, your notebook should show that you understand what you have done in the laboratory. Thus, good discussion of the experiment, observations you have made, error analysis and the like are essential to getting a good grade out of this course.

A few general guidelines for keeping your laboratory notebook are the following:

(a) Write the date at the top right corner of the notebook.

(b) Enter all data into the notebook directly. Do not write on a piece of scrap paper.

(c) Record the readings/measurements to the appropriate number of decimal places.

(d) Indicate the appropriate units in all your results.

(e) Before you do a calculation, indicate the equation you are using and write down all the steps of your calculations in your notebook. This will assist your lecturer in grading.

(f) Write the error involved consistent with the accuracy of the instrument.

(g) Always state the precautions you took while performing the experiment.

(h) Repeat your readings as a precautionary measure.

(i) To plot points on your graph, choose appropriate scale. Scales such as 1 cm to represent 1, 2, 5 units or multiples of powers of tens i.e. 0.1, 0.2, 0.5 or 10, 20, 50, etc should be used.

(j) Start your graph from the origin (0.0), if intercept is required, otherwise start from any convenient point.

(k) Draw the best line through your points according to your judgment. Also, the best curve must be smooth and may not pass through all the data points.

(l). Ensure that the triangle used for calculating the slope of your graph is at least one-third of your whole graph in size.

(m) Label all your work to indicate what topic the experiment is connected with.

(n). Number your pages and leave a few pages at the beginning for table of values.
(o) When throwing out data points, note what you have done!

1.3 Data Presentation

Data will usually be presented in tabular or graphical forms. If you are doing an experiment in which you take one measurement a number of times to improve your accuracy, record this in neat tabular form, clearly labeling what you are doing. If you are making measurements which are to be used in making a graph, record in tabular form as x *vs* y, and always put the units in the heading. If you draw a graph, clearly mark both axes with parameters being presented, with units and scale factor; and label the graph such that a person could look at that one graph and know exactly what you had done. If you have any questions about your data presentation, please do not hesitate to ask your instructor.

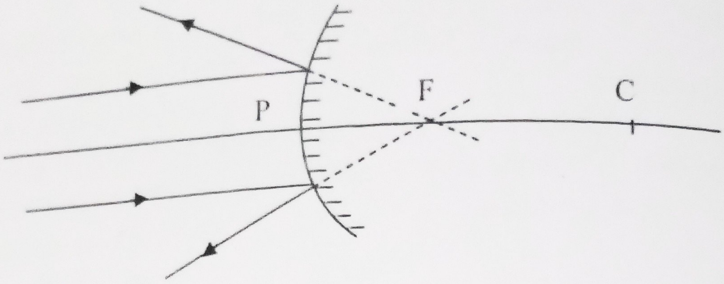


Fig 2.3: diverging or convex mirror

The geometric centre of the mirror is called the pole (P) of the mirror. The centre of the sphere of which the mirror is a part is called the centre of curvature (C) of the mirror. CP is the radius of curvature, r of the mirror while the line CP produced is the principal axis. F is the principal focus while its distance from the center of the mirror is called the focal length f. The focal length of a spherical mirror is related to the radius of curvature by

$$f = \frac{r}{2} \qquad 2.1$$

When an object is placed at a distance u from a mirror of focal length f and the image is formed at distance v from the mirror, then

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \qquad 2.2$$

The linear magnification (m) produced by a mirror is given by the relation

$$m = \frac{\text{Height of image}}{\text{Height of object}} \qquad 2.3$$

In terms of the object and image distances, we have that

$$m = \frac{v}{u} \qquad 2.4$$

Refraction

When light passes from one medium to another the angle of incidence i in the first medium is related to the angle of refraction r in the second medium by Snell's law:

$$\frac{\sin i}{\sin r} = n \qquad 2.5$$

which is a constant with n as the refractive index of the second medium with respect to the first.

This is illustrated in Fig. 2.4a using a rectangular glass block

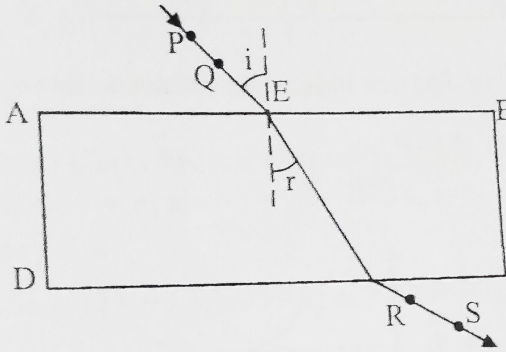


Fig. 2.4a Illustration of refraction

The incident ray PQ is laterally displaced and emerges as RS such that the angle of incidence i is equal to the angle of emergence, e. The implication is that the incident ray emerges without deviation but it is displaced.

2.3 Prisms

A ray of light is passing through a triangular glass prism as shown in Fig 2.5 EFGH is a ray passing through a prism of refracting angle A and passing from air, through the prism and back to air again.

The angle of deviation d is given by

$$d = (i - r_1) + (e - r_2) \qquad 2.6$$

Also $A = r_1 + r_2$ and d varies with the angle of incidence i.

The deviation will have a minimum value D for one angle of incidence. At this value the ray passes symmetrically through the prism.

This implies that the angle of incidence = the angle of emergence I = e

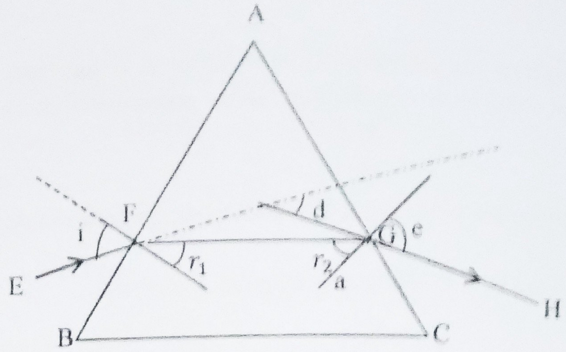
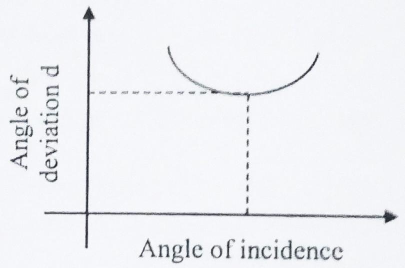


Fig. 2.5: Ray diagram illustrating refraction through a prism

And also $r_1 = r_2$. Thus $A = 2r$

And
$$i = \frac{A+D}{2} \qquad 2.7$$



Since n is the refractive index of the material of the prism, then $\frac{\sin i}{\sin r} = n$

And,

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\frac{A}{2}} \qquad 2.8$$

In conclusion at minimum deviation equation 5.8 gives us the value of n

2.4 Total Internal Reflection

The angle of incidence for which light coming from a denser medium towards a less dense medium and at which grazing incidence occurs (angle of refraction, r =

90°) is called the critical angle c. Light incident at a greater than angle c suffers total internal reflection as illustrated in figure 2.7.

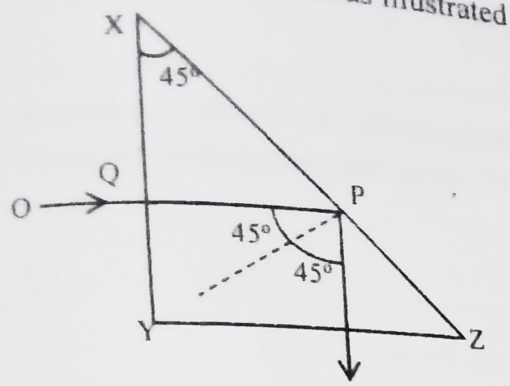


Fig 2.7: Illustration of total internal reflection

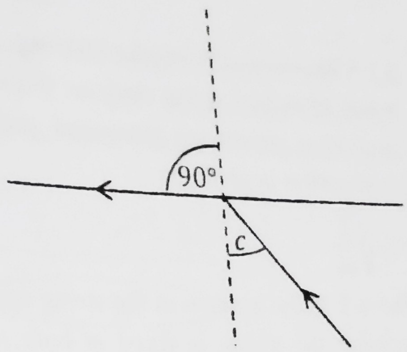


Fig 2.7b: Critical angle

For light traveling from glass (medium 1) to air (medium 2) and applying Snell's law:

$$n_1 \sin i = n_2 \sin r \qquad 2.9$$

That is $n_1 = n_2\, sinr/sini$

For critical incident angle r = 90 , sin90 = 1, n_2 = 1 for air and i = c, we obtain the equation:

$$n_1 = \frac{1}{.\sin c} \qquad 2.10$$

2.5 Properties of Lenses

There are two types of lenses, converging and diverging lenses. The converging lens gives real images. Parallel rays after refraction through a converging lens converge at the principal focus, F. The distance between F and the lens is equal to the focal length of the lens f. You can easily obtain the approximate focal length of a lens by focusing the image of a distance object on to a screen. f is equal to the distance between the screen and the lens.

The approximate focal length of diverging lens can be found as follows: Focus the image of a distant object with a combined converging and diverging lenses to obtain the focal length of the combination f_c. If the focal length of converging lens is f_1 and that of diverging lens is f_2

It can be shown that $1/f_c = 1/f_1 + 1/f_2$. We can then calculate f_2 since other quantities are known.

Chapter 3

SOUND WAVES

.1 Vibration of Stretched String

Vhen stretched string such as those of sonometer, guitar, violin, etc is plucked, ransverse waves are generated and propagated along the string. The speed of ropagation is given by:

$$v = \sqrt{\frac{T}{m}} \qquad 3.1$$

where T is the tension in the string and m, the mass per unit length. Because the string is fixed at both ends the waves reflect at the ends and the interference between the incident and reflected waves set up stationary or standing waves. The fundamental mode of vibration has nodes at the fixed ends of the string and antinode at the centre. This mode is usually obtained when the string is plucked at the middle.

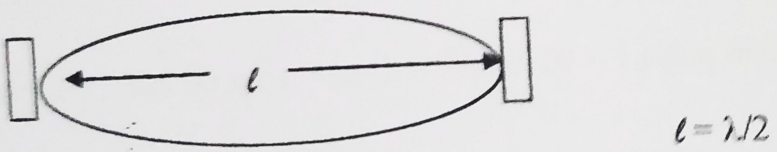


Fig. 3.1: Fundamental mode of vibration in stretched string.

Generally, wave velocity is given by

$$v = \lambda f \qquad 3.2$$

where f is the frequency of vibration defined by

$$f = \frac{v}{\lambda} \qquad 3.3$$

λ is the wavelength of the wave. For the fundamental vibration, $\lambda = 2\ell$

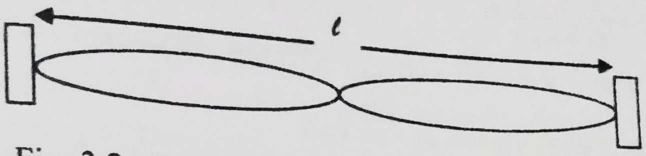
Hence,

$$f = \frac{1}{2\lambda}\sqrt{\frac{T}{m}} \qquad 3.4$$

Also

$$f=\frac{1}{2\lambda}\sqrt{\frac{T}{\pi r^2\rho}} \qquad 3.5$$

where r is the radius of the wire and ρ, the density of the material of the wire. The frequency is known as fundamental frequency, f_o. Higher frequencies which are integral multiples of the fundamental, $2f_o$, $3f_o$, $4f_o$, etc are known as Harmonics or overtones.



$\ell = \lambda$

Fig. 3.2: Second harmonics in stretched string.

Subsequent higher frequencies add a node to the previous number. It follows from equation 3.4 that

$f \propto \frac{1}{\ell}$ if T and m are constant

$f \propto \sqrt{T}$ if ℓ and m are constant

$f \propto \frac{1}{\sqrt{m}}$ if ℓ and T are constant 3.6

Example

A tension of 100N was created in a guitar string to produce fundamental note of 500Hz. Calculate

(i) the length of the string

(ii) the linear density of the string

(iii) the tension that will produce the third harmonic in the instrument (take v = 340ms^{-1})

Solution

(i) For a fundamental note on a string fixed at both ends, $\lambda = 2\ell$

From $v = \lambda f$

$\lambda = \frac{v}{f} = \frac{340\ ms^{-1}}{500\ hz} = 0.68\ m$ $\ell = \frac{\lambda}{2} = \frac{0.68}{2} = 0.34m$

The length of the string

(ii) The fundamental frequency f_o for a fundamental note is

$$f_o = \frac{1}{2\ell}\sqrt{\frac{T}{m}}$$

$$m = \frac{T}{4\ell^2 f_o^2} = \frac{100^2}{4x(0.34)^2 x500^2} = 0.09\ \text{kgm}^{-1}$$

(iii) From $f_2 = \frac{3}{2\lambda}\sqrt{\frac{T}{m}} = 3f_o$

$T = 4\ f_0^2\ \ell^2\ m = 4 \text{ x } 500^2 \text{ x } (0.32)^2 \text{ x } (0.09) = 936.4\text{N}$

3.2 Vibrations in Tubes closed at one end

When air vibrates inside a tube or pipe, waves generated reflect at the ends setting up a longitudinal stationary wave along the length of the tube. For a tube closed at one end, air is at rest at the closed end and vibrates freely at open end. Therefore, the fundamental vibration of the air column produces resonance of the column and has a node at the closed end and antinode at the open end. In stationary waves, the distance between a node and consecutive antinode is $\lambda/4$. Hence the length of the tube for the fundamental mode is a quarter of the wavelength i.e. $\ell = \lambda/4$ or

$$\lambda = 4\ell \qquad 3.7$$

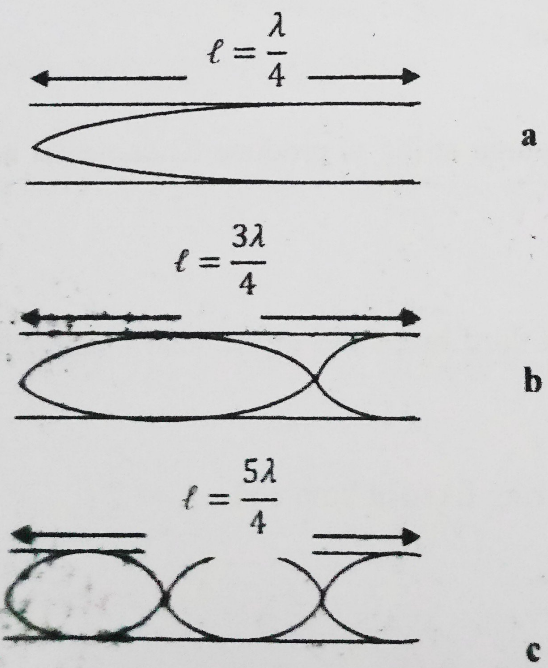


Fig. 3.3: (a) Fundamental (b) First overtone (c) Second overtone.

The fundamental frequency f_o then becomes

$$f_o = \frac{v}{\lambda} = \frac{v}{4\ell} \qquad 3.8$$

where v is the velocity of the waves. Waves of higher frequencies could be generated also. For first overtone (Fig. 3.7b),

$$\ell = \frac{3}{4}\lambda_1$$

This implies that $\lambda_1 = \frac{4}{3}\ell$

The frequency for this overtone is given by $f_1 = \frac{v}{\lambda_1} = \frac{3v}{4\ell} = 3f_o$ 3.9

Similar calculation shows the frequency of the second overtone to be $5f_o$ indicating that only odd numbers of harmonics are present as overtones (i.e. $3f_o$, $5f_o$, $7f_o$, etc) accompanying the fundamental notes.

End Correction

It has been observed that the antinode does not correspond exactly at the open end of the tube but a little distance c above the open end. This necessitates the addition of c to the length of the tube as an end correction. Resonance tube is a form of a tube closed at one end. The first and second positions of resonance correspond to fundamental mode of vibration and first overtone respectively. For the first position,

$$\ell_1 + c = \frac{\lambda}{4} \qquad 3.10$$

For the second position

$$\ell_2 + c = \frac{3}{4}\lambda \qquad 3.11$$

$$\ell_2 + c - (\ell_1 + c) = \frac{3}{4}\lambda - \frac{\lambda}{4} \qquad 3.12$$

$$\ell_2 - \ell_1 = \frac{\lambda}{2}$$

This shows that the wavelength could still be determined accurately despite the end correction using equation 3.2 and 3.12. The wave velocity could be written in terms of the end correction as $v = \lambda f = 4f(\ell_1 + c)$ 3.13

Example

In a resonance tube experiment, the first position of resonance was observed to be 25cm when a tuning fork of frequency 286Hz was sounded and brought near the

This constant ratio is therefore a characteristic of the conductor, termed the resistance R of the conductor.

Mathematically, Ohm's law is $V = IR$ 4.3

Potential difference (p.d) is measured in volts, current is measured in amperes, and resistance in ohms.

The current flowing round a circuit is given by.

$I = E/(R + r)$ 4.4

Where E is the e.m.f. of the cell, r is its internal resistance and R is total external resistance.

Temperature Coefficient of Resistance

The electrical resistance of a material varies with temperature. If the resistance of a wire is R_0 at 0° C and R_θ at temperature θ° C then it is found that

$R_\theta = R_0(1 + \alpha\theta)$ 4.5

α is the temperature coefficient of resistance. We may write that

$\alpha = \frac{R_\theta - R_0}{R_0 \theta}$ 4.6

α can be determined experimentally by measuring the resistance of the wire at ice temperature and steam temperature and using equation 4.6

Alternatively one can determine resistance R_θ at various temperatures and by plotting a graph of R_θ against θ, α can be obtained from the measurement of slope and intercept.

By considering the equation $(R_\theta = R_0\alpha\theta + R_0)$: Slope = $R_0\alpha$, intercept = R_0

4.3 Series and parallel connections of resistance

We want to remind you that resistances can be connected in series or in parallel

Without showing the proof which is in your theory books, we consider two or more resistances, $R_1, R_2, \ldots\ldots, R_n$

For series connections, the equivalent resistance $R_s = R_1 + R_2 + \ldots\ldots + R_n$ 4.7

For Parallel connections the equivalent resistance is $1/R_p = 1/R_1 + 1/R_{2+\ldots} + 1/R_n$ 4.8

4.4. Circuit Symbols

Electrical circuits are designed to perform specific functions such as lighting a lamp. An electric circuit is created by interconnecting electrical components.

A resistor and a battery are examples of electrical components. In its simplest form an electric circuit may contain one single source of electricity (e.g. a battery) and a resistor (e.g. a torch light bulb) and the wires that form the path of flow of electricity from the source through the resistor and back to the source. Circuit diagrams are used to represent a circuit on paper. To facilitate communication among scientists and engineers, the electrical components are represented in circuit diagrams by a standard set of symbols. For the experiments in this chapter below are the names and symbols of the electrical components involved.

(a) fixed resistor

(b) resistance box

(c) rheostat (variable resistor

(d) Key

(e) two-way switch

(f) ammeter

(g) voltmeter

(h) galvanometer

(i) galvanometer with a protective resistance, P

(j) Cell

(k) battery

(l) connecting wires

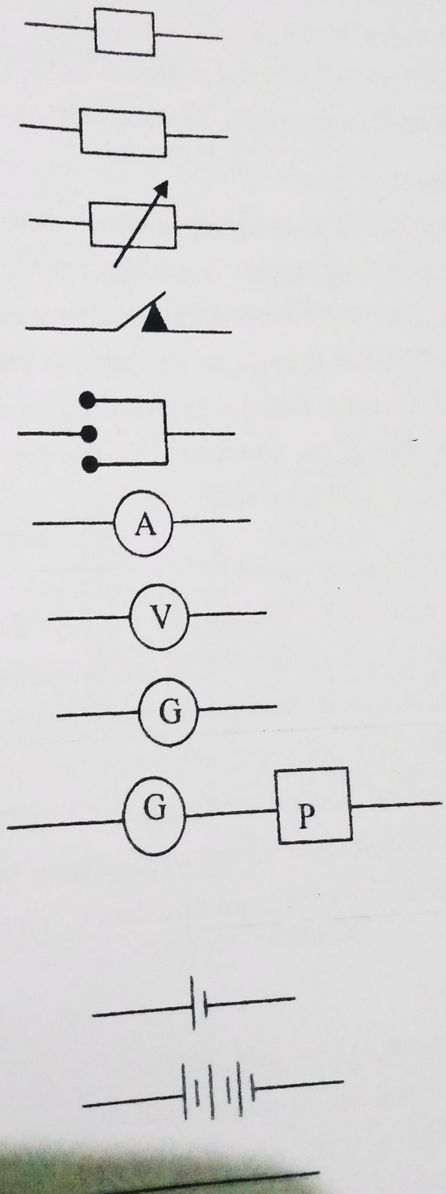


Fig 4.1 Diagram of electrical symbols

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$ 4.11

4.6: Meter Bridge

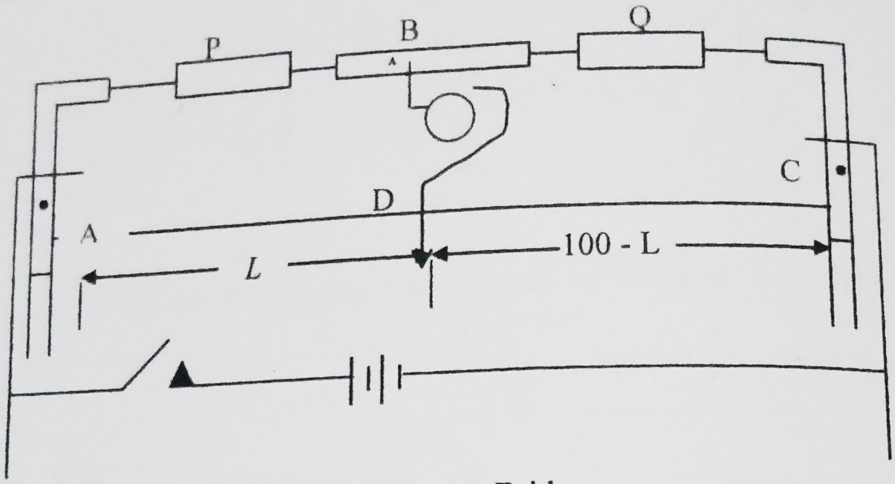


Fig .4.6: Meter Bridge

The meter bridge is one of practical arrangement of the Wheatstone bridge (figure 4.5).one branch ADC consists of a wire of uniform cross-section and of length 100 cm, stretched along a meter rule. The point D is located by a sliding contact. The unknown resistance P is placed in the left arm while the known resistance Q is placed in the right arm. For a balance

$$\frac{P}{Q} = \frac{L\sigma}{(100-L)\sigma}$$

Where σ is the resistance per unit length of wire, i.e.

$$\frac{X}{R} = \frac{L}{100-L}$$ 4.12

When using the meter bridge the following points should be remembered:

(1) Never press the sliding contact hard onto the wire, contact should be light so as not to make the wire non-uniform.

(2) Clean the wire properly with acetone if available and the jockey with emery cloth.

(3) The galvanometer will be damaged if too great a current is passed through it. A battery of $1.5 - 2$ V should be used. Make use of a high series resistor to protect to protect the galvanometer while trying to get a rough balance, and then short circuit it to get the final balance point.

4.7 Wheatstone Bridge with 'Fixed Ratio Arms'

This is slightly different way of arranging the Wheatstone bridge. Two of the four resistances R_1, R_2 have a known ratio R_1/R_2. The unknown resistances R_x are connected between A and D and a variable resistor R in the form of a resistance box is connected in the fourth arm. When there is a balance,

$$\frac{R_1}{R_2} = \frac{R_x}{R}$$

therefore

$$R_x = \frac{RR_1}{R_2} \qquad 4.13$$

4.8 Resistivity of a wire

Suppose the resistance R of a wire is found by the use of a Wheatstone bridge, the resistivity, ρ of the material of the wire is defined as

$$R = \rho\frac{l}{A} = \frac{\rho l}{\pi(d/2)^2} \qquad 4.14$$

Where d is the diameter and l is the length. Therefore

$$\rho = \frac{R\pi d^2}{4l} \qquad 4.15$$

4.9 The potentiometer and its applications

The potentiometer consists of a uniform resistance wire AB of length about 100 cm through which a source of constant e.m.f., viz. an accumulator, maintains a steady current I. The potentiometer like the metre bridge can easily be constructed in a workshop (see figure 4.10).

Since the wire is uniform, the resistance per unit length is constant, i.e. $R \propto L$

Therefore, for a constant current I, $V = IR \propto L$

Therefore $V = kL$

Several experiments can be done with the aid of a potentiometer, most notably:

(1) Comparison of e.m.f. of two cells

(2) Comparison of two resistances

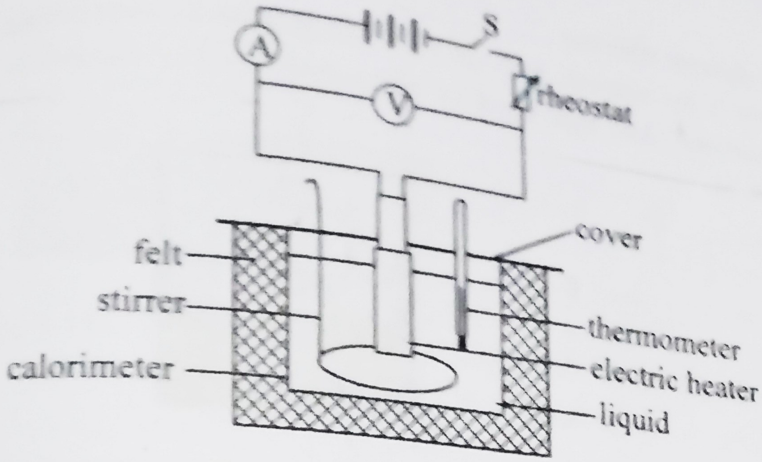


Fig. 4.11 Electrical heating devise

Then a graph of θ against t will be a straight line with slope equal to b and intercept equal to θ_i. Electrical heating has an important advantage in that uncertain heat loss during the transfer of a hot body to the calorimeter is eliminated.

4.11 Detection of electric current

The galvanometer is a sensitive instrument used for detecting electric current. The most commonly used type in our institutions is the centre zero galvanometer. The dial, showing the graduations is shown in Figure 4.12.

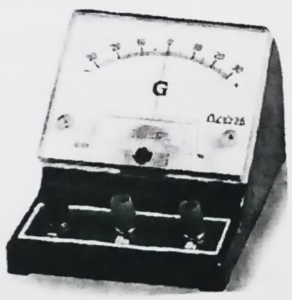


Fig 4.12 Galvanometer

Much current should not be passed through a galvanometer, otherwise it will be damaged. In Meter-Bridge and Potentiometer experiments, a protective resistor should be connected in series with it or a shunt should be connected across it. In these experiments, the galvanometer is always used to determine the balance point when no current is passing through it and so the pointer is not deviated to either side.

SECTION 2
EXPERIMENTS

LABORATORY EXPERIMENTS ON LIGHT

EXPERIMENT L .1

REFRACTION AT A PLANE SURFACE 1

Date. 12/07/2024

Aim

To determine the refractive index of a rectangular glass block

Apparatus

Drawing board, Drawing paper, Optical pins, Rectangular glass block, and a set of mathematical instruments.

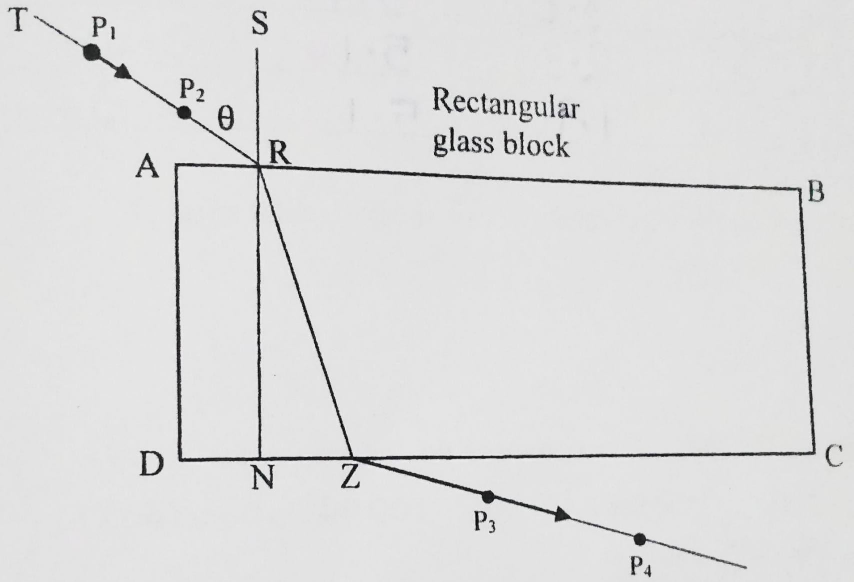
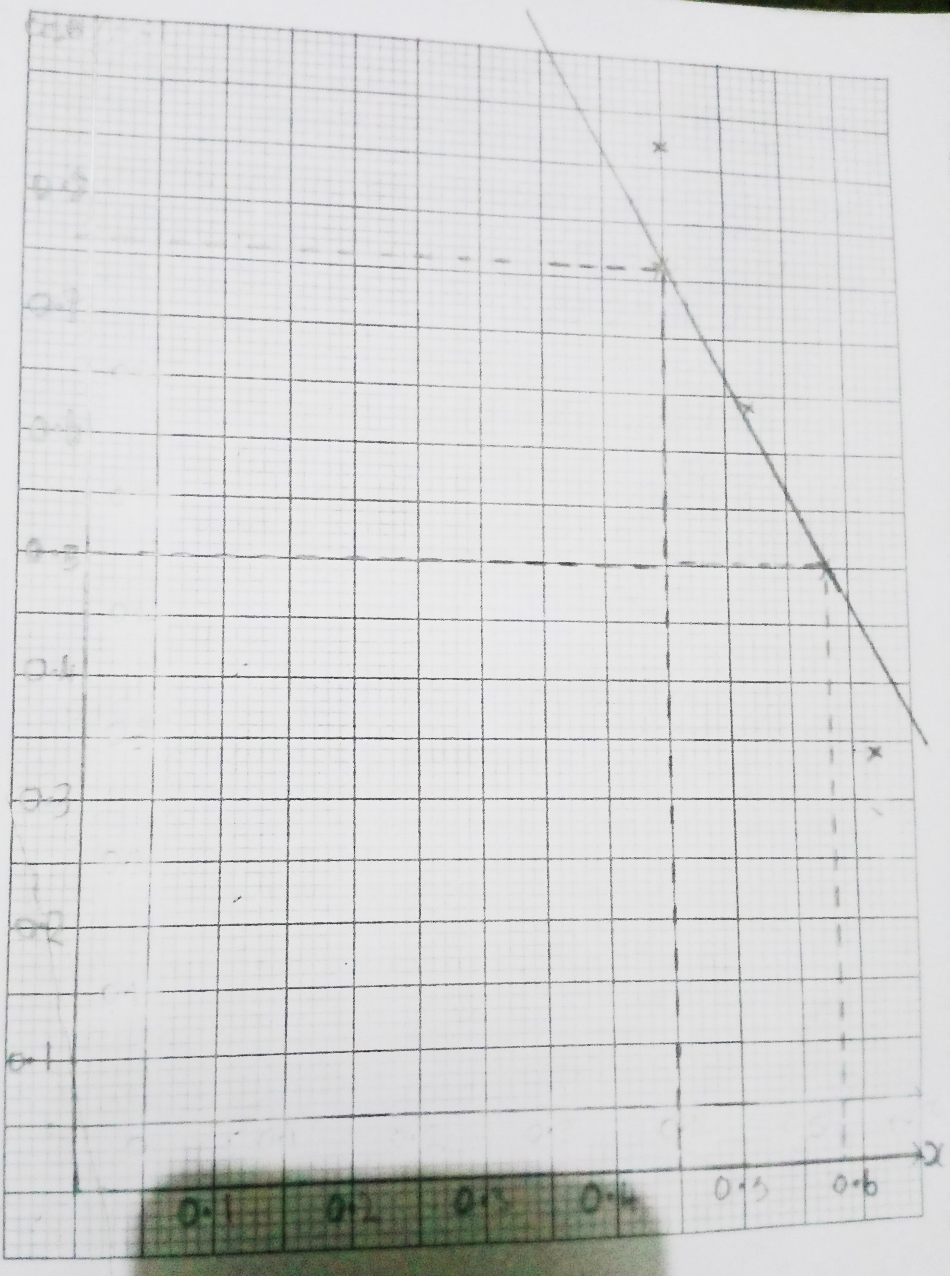


Fig L.1 Refraction through a glass block

Method

1) Label the outline of the glass block on the drawing paper ABCD.
2) Remove the glass block and mark a point R on AB about 3cm from A. Draw a normal SRN.
3) Draw a line TR so that it makes an angle $\theta = 70^\circ$ with AB.
4) Put two optical pins at P_1 and P_2.
5) Replace the glass block and fix 2 pins at P_3 and P_4 to be in a straight line with the images of P_1 and P_2.(Note that you should eliminate parallax)
6) Remove the glass block and join the points P_3 and P_4 to meet DC at Z. Join RZ.
7) Measure NZ, RZ.



0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.1
0.2
0.3
0.4
0.5
0.6
x

Li Solution

$$\text{Slope} = \frac{\Delta \cos\theta}{\Delta x}$$

$$= \frac{0.76 - 0.5}{0.58 - 0.45}$$

$$= \frac{0.26}{0.13}$$

$$= 2.00$$

EXPERIMENT L.2

Date 14/06/2024

REFRACTION AT PLANE SURFACE 2

Aim

To verify Snell's law using a parallel-sided glass block

Apparatus

Rectangular glass block, plain sheet of paper, drawing board, four optical pins, ruler

Method

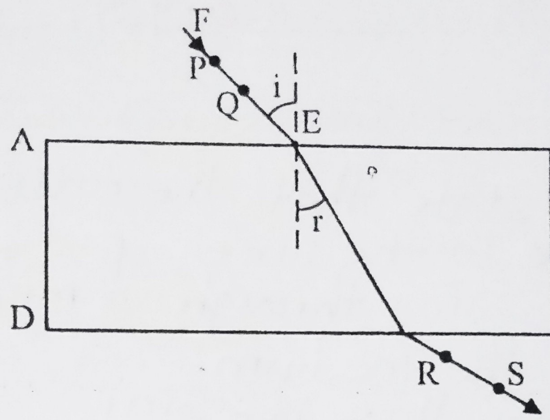


Fig. L.2 Refraction through glass block

1.Using the drawing pins, place the plain sheet of paper on the drawing sheet ensuring that it is firm with the glass block on it.

2.Trace its outline ABCD using pencil

3. Remove the glass block and draw the normal at E, then draw the incident ray FE with angle of incidence, i =20°.

4. Then put the optical pins at P and Q at exactly 5cm apart along the incident ray direction.

5. Next, replace the glass block; look through it along the path DC.

1. Then place the pins R and S in line with P and Q and measure the angle of refraction r. The procedure above should be repeated for other angles of incidence; i =30°, 40°, 50°, 60° and 70°. List your results in the table below.

Results

i^o	r^o	sin i	sin r
20	10	0.3420	0.1736
30	20	0.5000	0.3420
40	26	0.6428	0.4384
50	31	0.7660	0.5150
60	36	0.8660	0.5678
70	39	0.9397	0.6293

Questions

(i) State Snell's law and draw a suitable graph to deduce the refractive index of the glass block, n.

Snell's law state that the ratio of the sine of the angle of incidence to the sine of the angle of refraction of light passing through a medium is the refractive index of the medium.

Mathematically:- $n = \frac{\sin i}{\sin r}$

(ii) What are the precautions you took in the experiment?

1. It was ensured that the apparatus to be used was ensured to be in good condition.
2. It was ensured that the experiment was conducted in a location with sufficient light in order to accurately view for P_3 and P_4.
3. It was ensured that the appropriate instrument was used in obtaining the magnitude of certain para

(iii) List the possible sources of error

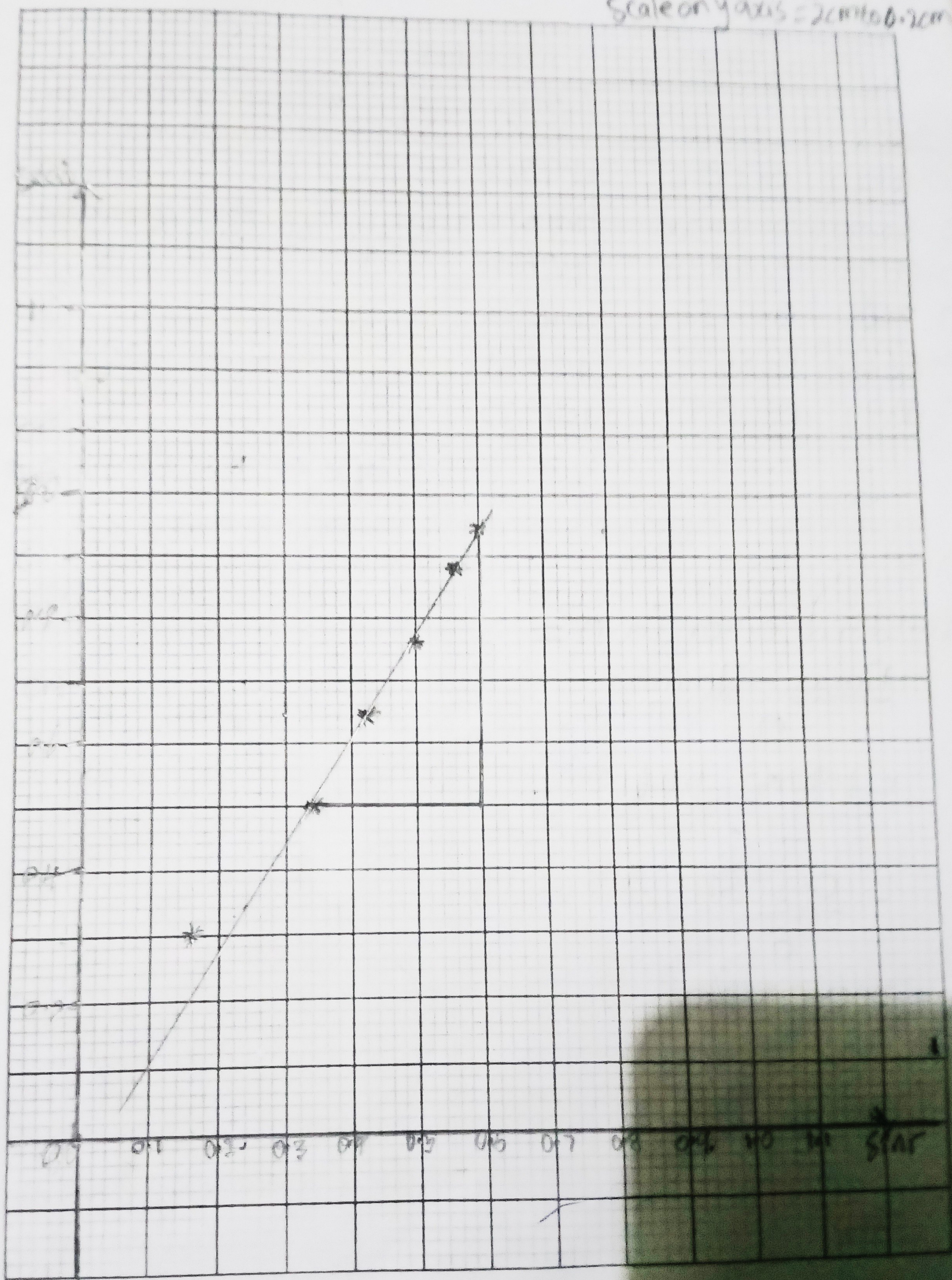
1. Eye defect
2. Paralax Error
3. Instrument

(iv) Compute the standard error in n.

Check worksheet

A GRAPH OF SIN I AGAINST SIN R

Scale on x axis = 2cm to 0.1cm
Scale on y axis = 2cm to 0.2cm



Sin i	Sin r	$\frac{\sin i}{\sin r}$
0.3420	0.1736	1.9700
0.5000	0.3420	1.4619
0.6428	0.4384	1.4662
0.7660	0.5150	1.4873
0.8660	0.5678	1.5251
0.9397	0.6293	1.4932

Slope of Graph $= \frac{\Delta \sin i}{\Delta \sin r}$

Slope of Graph $= \frac{0.93 - 0.50}{0.60 - 0.34}$

$= \frac{0.43}{0.26}$

Slope of the Graph = 1.65[illegible]

(iv)

Standard error in n =

$\frac{n_{max} - n_{min}}{n}$

$= \frac{1.9700 - 1.4619}{6}$

$= \frac{0.5081}{6}$

$= 0.0846$

EXPERIMENT L.3 Date 12/07/2024

REFRACTION THROUGH A PRISM

Aim: Determination of the refractive index of a glass prism

Apparatus:

Glass prism, drawing board, 4 optical pins, drawing pins, plain sheets of paper, protractor, and pencil.

Method

1) Trace the outline of the glass prism on a sheet of drawing paper.
2) Using a protractor and a ruler, draw the normal to the equilateral glass prism. (on the face AB)
3) Insert two object pins at F and G about 5cm apart to form an incident angle i with the normal.
4) Insert two more pins on the side AC of the prism at H and K so that they appear to be in line with the apparent positions of the object pins at F and G when viewed through the glass prism (Fig. L.3)
5) Remove the glass prism and measure the angle of deviation d and emergence e.
6) Repeat the experiment for values of i =30°, 40°, 45°, 50°, 55°, 60 and 65°.

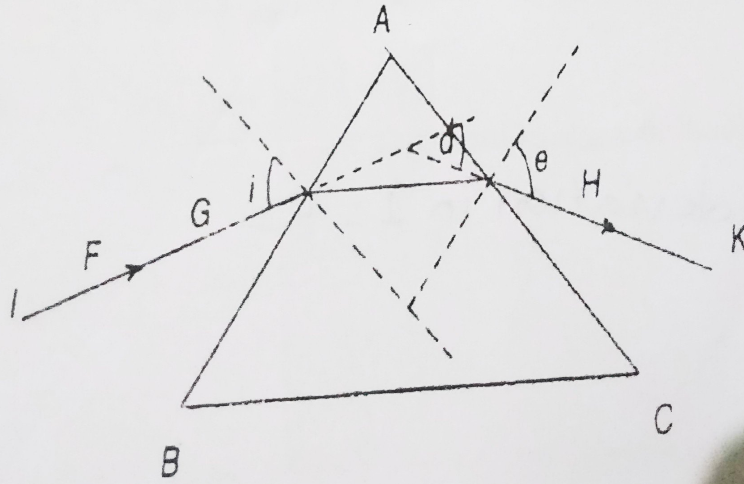


Fig. L3 Refraction of light through a prism

12-7.24

Results

i°	d°	e°
30	42	102
40	30	95
45	25	90
50	42	85
55		
60		
65	57	67

Questions

(i) Plot a graph of d against i.

(ii) From the graph determine (i) the minimum deviation, D

Minimum Deviation in D = 21

(iii) and the corresponding angle of incidence i_{Dmin}

Minimum deviation in I = 52

(iv) Comment on your results.

The minimum deviation (Dmin=)and its point of incident (iDmin) represents its minimum point at which rays of light passess through the prism refracts, ~~wise if it exceed~~.

(v) Calculate the refractive index of the glass of the prism material using the equation $n = \sin\left(\frac{A + D\min}{2}\right) / \sin\frac{A}{2}$ where A = 60°

$n = \sin\left\{\frac{A + D_{min}}{2}\right\} / \sin A/2$

$n = \sin\left[\frac{60 + 21}{2}\right] / \sin\frac{60}{2}$

$n = \frac{\sin 40.5}{\sin 30}$

$n = \frac{0.649}{0.500}$

$n = 1.298$

(vi) Determine the error in n

Error in n = standard value − experimental value

standard value = 1.500

Experimental value = 1.298

Error in n = 1.500 − 1.298

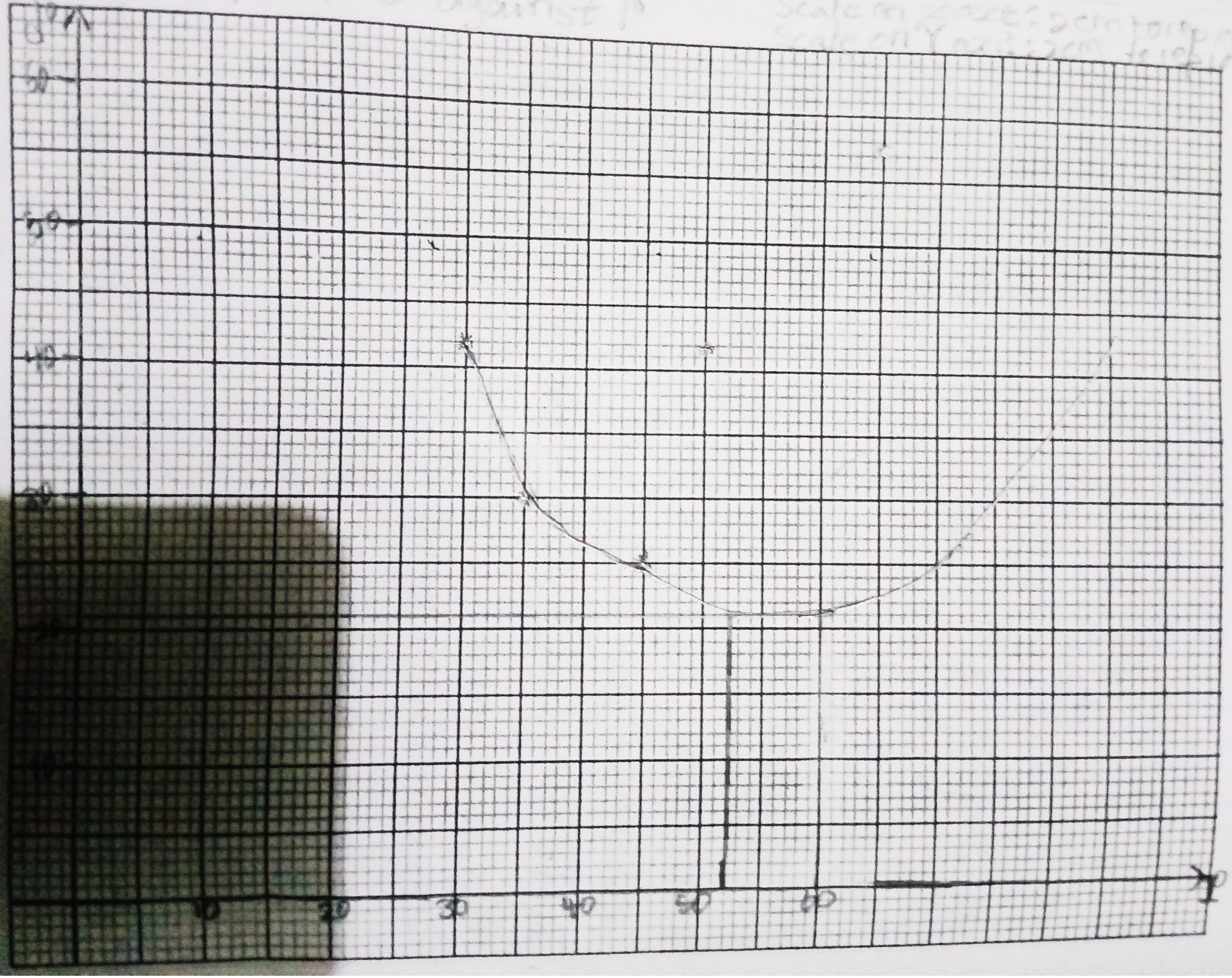
= 0.202

(vii) Explain why it is not advisable to use small values of i in performing this experiment.

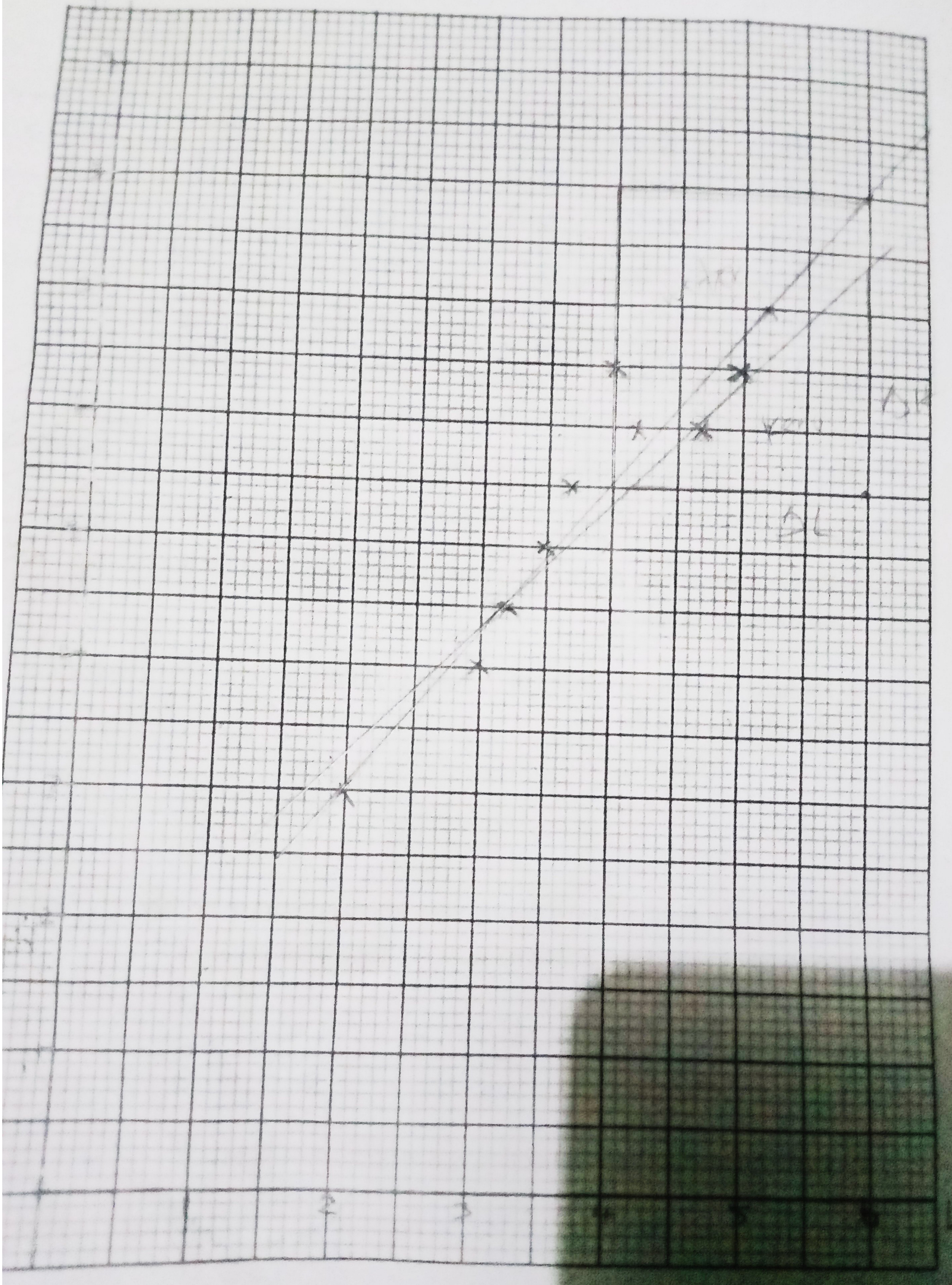
This is because if small value of i are use it will lead to corresponding small values of r which may be difficult to observe and this may affect the accuracy of our experiment

A GRAPH OF d^o against i^o

Scale on x axis: 2cm to 10 units
Scale on Y axis: 2cm to 10 units



WORKSHEET



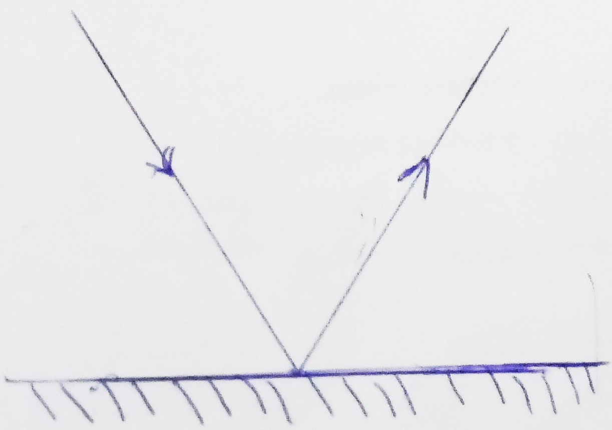
(3) Refractive index $= \frac{\text{Real depth (H)}}{\text{Apparent depth (L)}}$

$n = \frac{4}{3}$, $H = ?$, $L = 10$

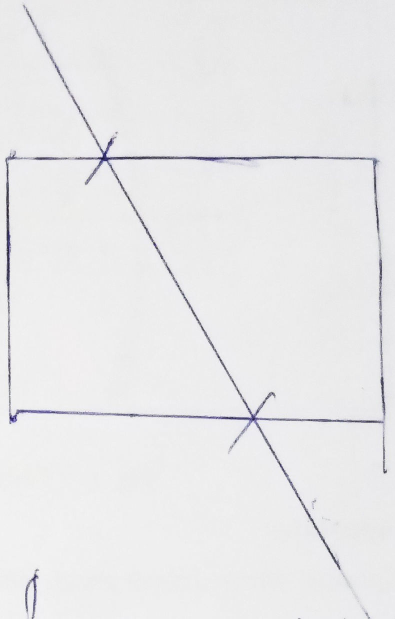
$$\frac{4}{3} = \frac{H}{10}$$

$$H = \frac{10 \times 4}{3} = 13.33m$$

(4) Reflection focus is the same medium while the refraction occurs when there is change in medium from air to glass.



Reflection of light



Refraction of light

Refraction of light repropagation of light while reflection is the slight change in the direction of light when it passes from one medium to another.

(2) For Kerosene

$$\text{Slope} = \frac{\Delta H}{\Delta L} = \frac{7.4 - 4.6}{6.0 - 4.2}$$

$$= 1.61$$

$$\text{Slope} = \frac{8.0 - 5.5}{6.0 - 4.0}$$

$$= 1.25$$

Questions

(i) Plot a graph of (D^2-d^2) versus D

(ii) What is the gradient of the graph.

$$\text{Slope} = \frac{\Delta[D^2-d^2]}{\Delta D} = \frac{4800-3000}{78-56} = \frac{1800}{22} = 81.8_{\text{//}}$$

(iii) Show that the gradient of the graph is related to the focal length of the lens.

$$\frac{D^2-d^2}{D} = 4f$$

(iv) Deduce the focal length of the lens from your slope

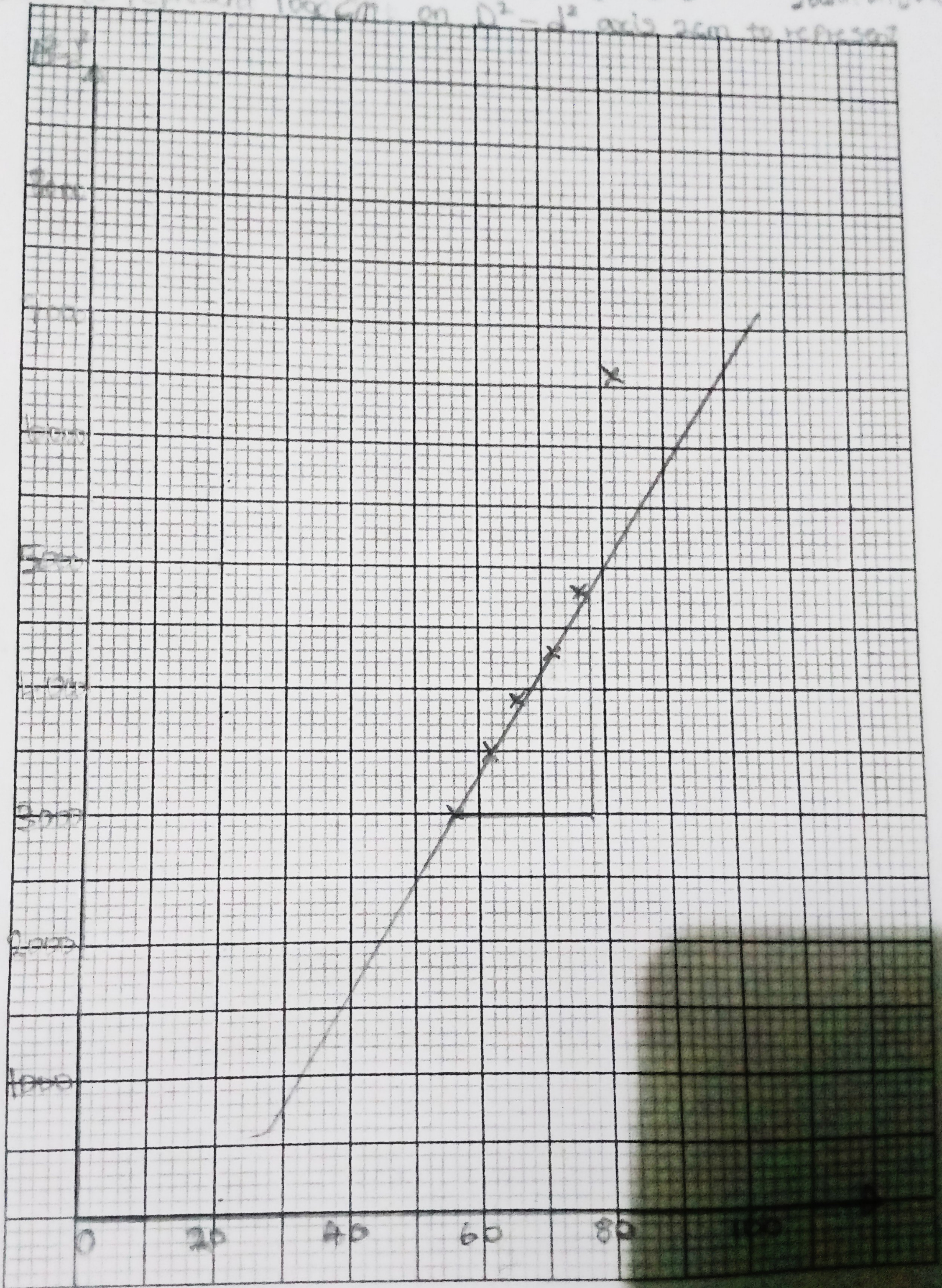
$$\text{Slope} = 4f$$

$$\therefore f = \text{Slope}/4 = \frac{81.8}{4}$$

$$f = 20.5$$

Graph of $(D^2 - d^2)$ Agains D

Scale : 2cm to represent 1000Cm on $D^2 - d^2$ axis 2cm to represent 20unit on D axis



LABORATORY EXPERIMENTS ON ELECTRICITY

EXPERIMENT E.1 Date 12th July 2024

OHM'S LAW

Aim

To illustrate Ohm's law

Apparatus

Battery, ammeter, voltmeter, a coil of wire of unknown resistance R, rheostat and a key

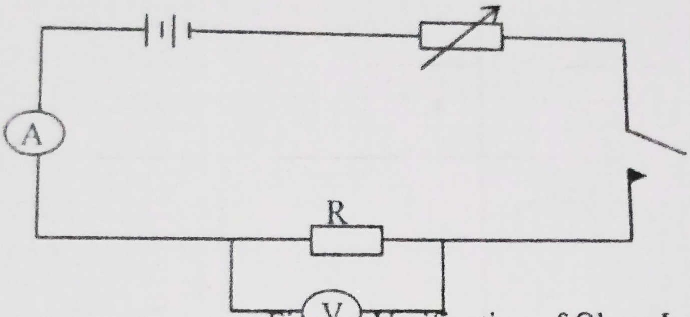


Fig. 1 Verification of Ohms Law

Method

Set up the circuit as shown in Fig. E.1

Set the rheostat to a large value and close the circuit

Take readings of the current and voltage

Reduce the value of the rheostat and take new readings of current and voltage

Proceed in this way until about five pairs of values have been obtained.

Tabulate your results

Results

V(V)	I (A)	V/I(Ω)
8.0	2.5	3.20
6.6	2.1	3.14
4.5	1.5	3.00
1.9	0.7	2.70
0.5	0.45	1.10

Plot a graph of V against I

Questions

1. Is the ratio in the last column of the table constant?

No, the ratio in the last column of the table is not constant

2. Determine the slope of the graph

$$\text{Slope} = \frac{\Delta V}{\Delta I} = \frac{8.0 - 1.9}{2.5 - 0.75} = \frac{6.1}{1.75} = 3.485$$

3. What conclusion can you draw from both V/I and the graph?

V/I represent the resistance experienced by the circuit at each point while the graph represents the overall resistance experienced by the circuit.

4. Why is this a less accurate method of measuring resistance ?

This is a less accurate method of measuring resistance because it cannot be used to measure very low resistance.

5. Suggest other more accurate methods

metre bridge
Wheatstone bridge.

EXPERIMENT E.2 Date 14.06.2024

COMBINED RESISTANCES

Aim

(a) To verify the law of combination of resistances in series.

Apparatus

Accumulator, key, variable resistance, ammeter, voltmeter, and two known resistances R_1 and R_2.

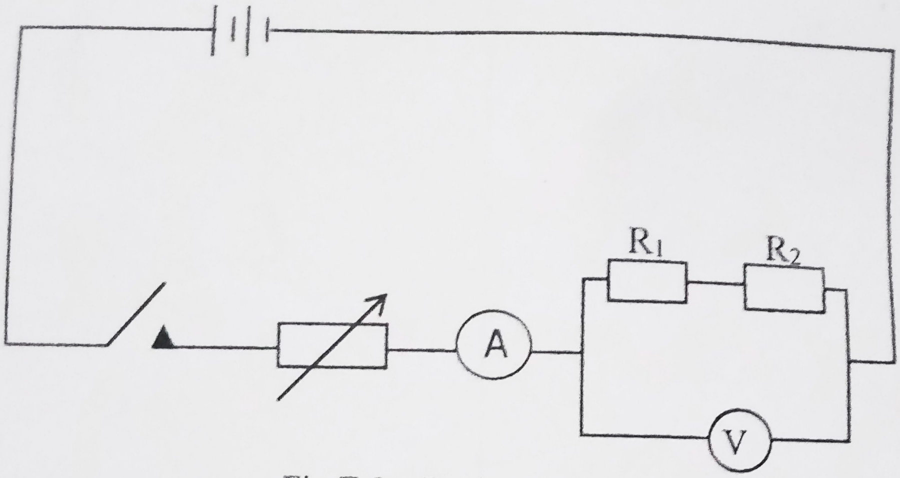


Fig E.2a Resistance in series

Method

et up the circuit of Figure E.2a

/ith the key closed adjust the variable resistance and determine the values of urrent I and corresponding potential difference V across R_1 and R_2 in series

t least five readings will be required.

ecord your results in the table provided

Results

R_1 = ...2...... Ω

R_2 = ...5...... Ω

Equivalent resistance $R_s = R_1 + R_2$ = ...7...... Ω

I (A)	V(V)	V/I (Ω)
0-3A	0-6V	2Ω
0.4A	0.9V	2.25Ω
0.6A	1.2V	2Ω
0.8A	1.8V	2.25Ω
1-15A	2.4V	2.08Ω

Questions

1. Obtain the average value of V/I in the third column of the table

Average value $= \frac{2+2.25+2+2.25+2.08}{5}$

$= \frac{10.58}{5} = 2.116$

2. Compare this average value with the value of R_s

Rs is the total resistance of the circuit while average of V/I is the effective resistance of the circuit when R1 & R2 are connected in series.

Date 14/06/21

EXPERIMENT E.4

METER BRIDGE

Aim

To determine the resistance of a wire using a meter bridge

Apparatus

A meter bridge, key, accumulator, sliding contact or 'jockey', galvanometer, know resistance Q and unknown resistance P.

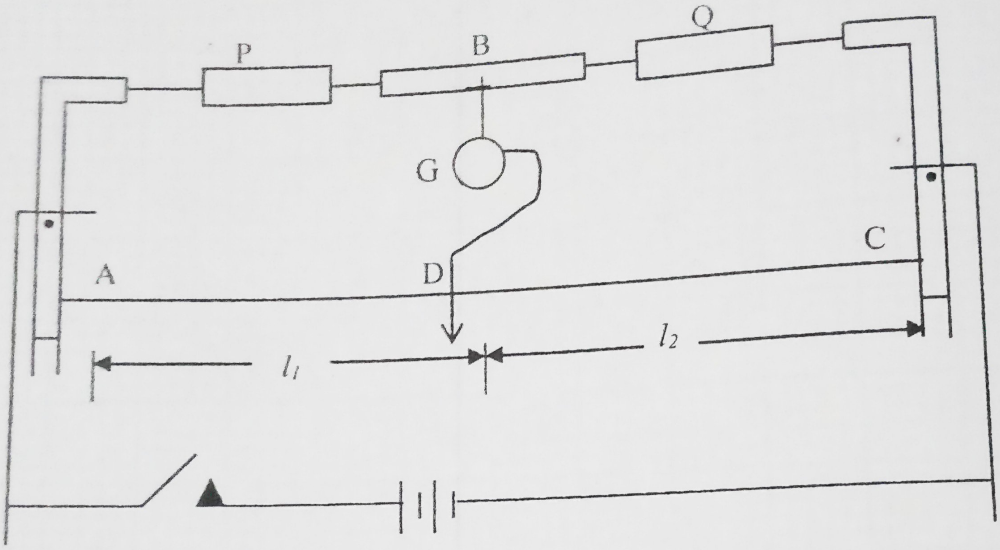


Fig. E 4 Measurement of Resistance with a metre bridge

Method

Set up the circuit in Fig. E 4

Close the key in the circuit

Press the sliding galvanometer contact Jockey slightly on the wire, and adjust the jockey D until there is no deflection (null deflection) of G

Read the lengths AD and DC from the meter scale mounted alongside the wire AC at null deflection.

Interchange P and Q

Determine the new balance point and note the new lengths AD and DC.

Results

Value of known resistance Q	=	20 Ohms
Value of resistance P (Unknown)	=	1.155 Ohms
Length AD (l_1)	=	85 cm
Length DC (l_2)	=	15 cm
Length l_1(after interchange of P and Q)	=	5.5 cm
Length l_2 (after interchange of P and Q)	=	94.5cm

Questions

D: 14/6/24

1. Determine the value of the unknown resistance P from your experiment (using metre bridge principle)

$X = R\left(\frac{100 - I}{I}\right)$ $R = 20\Omega$

$X_1 = 20\left(\frac{I_2}{I_1}\right) = 20(15/85) = 20(0.17)$

$= 3.52\Omega$

$X_2 = 20(5.5/94.5)$ $X = \frac{X_1 + X_2}{2}$

$X_2 = 1.16\Omega$ $X = \frac{3.54 + 1.16}{2} = X = 2.34\Omega$

2. How does your result differ from the known value of P?

$= 20 - 2.34$

$= 17.66$

3. What are possible sources of error?

- There might be a backlash error in the screwguage
- The wire might be of non-uniform diameter

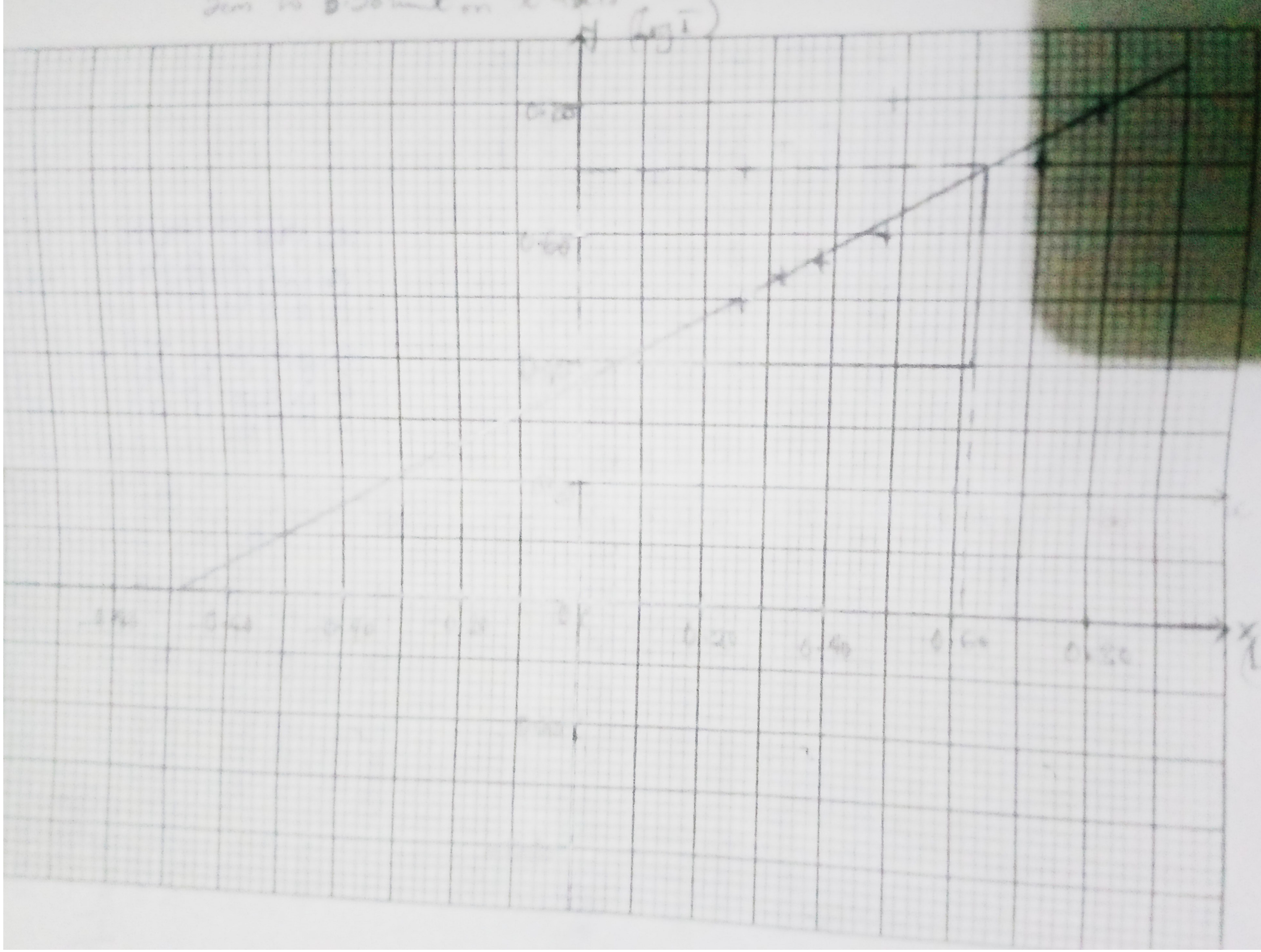
4. List the precautions used during the experiment

- It was ensured that the plugs were tightly connected in the resistance box
- It was ensured the the connection must be tight & clean.
- It was ensured that the key was inserted before observations were taken.

[illegible] of log I against log V

Scale = 2cm to 0.20 unit on the y axis

2cm to 0.20 unit on x axis



Chapter 2

GEOMETRICAL OPTICS

2.0 (Theoretical Background)

Many experiments in geometrical optics require the location of the image of an object. The behavior of lenses and mirrors towards light is shown most clearly if the object used is a white cardboard screen with a hole or slit in it and illuminated from behind by means of an electric light bulb. A similar vertical white cardboard can then be used for locating the real image of the illuminated object. A second less visual method is to use a pin as the object and another pin (the image pin) used to locate the image of the object pin (called the method of no-parallax). The advantage of this method is that because the very points of the pins are used as object and image, their position can be found with a greater precision of measurement.

To understand parallax, put your two fore-fingers in front of one eye, one behind the other. The near finger curs the more distant one and no separation between them can be seen. Now move the eye to the right, keeping the fingers still. You notice that there is a separation between the two fingers and that the more distant finger is now on the right of the near finger. In general, the object that is farther from the eye always appears to move in the same direction as the eye relative to the nearer object. This motion of one object relative to another is called parallax which is eliminated by making the object coincide with its images.
Finally, we use the 'real is positive' convention to determine any of the following: object distance, image distance, focal length, magnification.

The scientific study of light and optical materials is useful in the making of spectacles, cameras, projectors, binoculars, microscopes and telescopes. The most important of all optical materials are the various kinds of glass. Others such as plastics, polaroid, synthetic and natural crystals have useful applications.

A light wave normally spreads as it moves away from its source but in this section, we will treat light as a form of energy which travels in straight lines called rays. A collection of rays is called a beam. The ray treatment of light is called geometrical optics and involves:

(i) Rectilinear propagation, i.e, straight-line travel
(ii) The laws of reflection
(iii) The laws of refraction

2.1 Reflection at Plane surfaces

Laws of reflection: When light falls on a surface, it is partly reflected, partly transmitted and partly absorbed. For the reflected part, experiment shows that it is governed by two laws:

(1) The angle of reflection equals the angle of incidence is $i_1 = i_2$ (Fig. 2.1)

(2) The reflected ray is in the same plane as the incident ray and the normal to the mirror at the point of incidence.

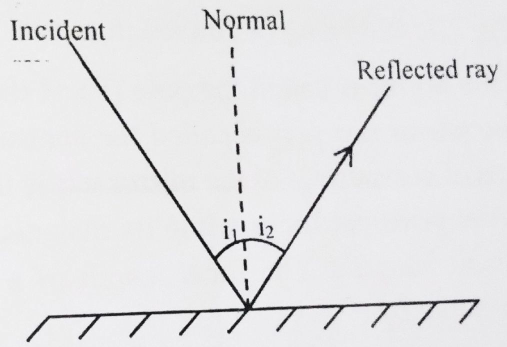


Fig. 2.1: Illustration of the laws of reflection

2.2 Curved Mirrors

Curved mirrors are used as car driving mirrors and as reflectors in car headlamps. searchlight and as flash lamps. There are 2 types of spherical mirrors: concave and convex.

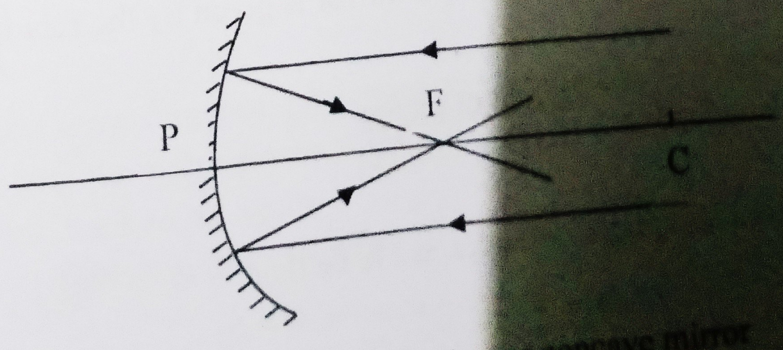


Fig 2.2: Converging or concave mirror

open end of the tube. If the wavelength of the wave was found to be 30cm, determine the second position of resonance.

Solution

For the first position

$$\ell_1 + c = \frac{\lambda}{4}$$

2^{nd} Position,

$$\ell_2 + c = \frac{3}{4}\lambda$$

Therefore

$$\ell_2 - \ell_1 = \frac{\lambda}{2}$$

$$\ell_2 = \frac{\lambda}{2} + \ell_1$$

$$= \frac{0.3}{2} + 0.25 = 0.4\,m$$

Exercise

1. A sonometer wire 70cm long and 1mm in diameter has a tension of 60N on it. If it produces a fundamental note of 400Hz, calculate (i) the linear density of the wire (ii) the density of the material of the wire.
2. In resonance tube experiment, the first position of resonance is 40cm and the second position is 130cm. Given that the velocity of waves in the air column in $340ms^{-1}$, calculate the frequency of the note and the end correction for the tube.

Chapter 4

ELECTRICITY AND MAGNETISM (THEORETICAL BACKGROUND)

4.1 Electric current

When a source of electrical energy, a battery, for example is connected to the two ends of a length of copper wire (an electrical conductor), an electric current made up of electrons flowing in one direction through the conductor is set up if the wire forms part of a closed conduction path called an electrical circuit. Each electron carries a definite amount of electric charge. If Q is the total charge transported past a point in the conductor in a time interval t, the electric current I is defined as

$$I = \frac{Q}{t} \quad 4.1$$

In the SI system of units current is measured in units of ampere (A). We also use a thousandth of an ampere (a milliampere) whose notation is mA. The 'driving force' for the current is provided by the battery and is called electromotive force or simply emf. In the SI system of units emf is measured in units of volts (V). Another term used to describe the driving force is voltage.

A quantity called potential, analogous to pressure in water flow, exists at each end of the copper wire. A potential difference V between the two ends of the wire is a measure of the amount of work W done in moving a charge Q from one point to another against the resistance R offered by the conductor to the flow of electrons (current).

As will be shown below the resistance R is defined as $R = \frac{V}{I}$ 4.2

The SI unit of resistance is the ohm (Ω).

Provided the temperature and other physical conditions of an electrical conductor do not change, the potential difference between its ends is directly proportional to the current through it. This statement is called Ohm's law. The constant of proportionality is the resistance of the conductor.

4.2 Ohms Law

Ohm's law states that the ratio of the potential difference V between the two ends of a conductor in an electric circuit to the current I flowing, is a constant. That is, it depends only on the form, dimensions and physical condition of the conductor.

Galvanometer

The galvanometer is a sensitive instrument for detecting current as mentioned earlier. Too much current should not be passed through it; for example in meter bridge potentiometer experiments, a protective resistor **P** is connected in series with it or a shunt is connected across it to divert some of the current.

Ammeter

The ammeter measures electric current. The resistance of the ammeter is always very small so that when it is placed in a circuit it will not diminish the current which it is intended to measure. The ammeter is always placed in series in the circuit.

Voltmeter

The voltmeter is an instrument which measures the p.d. two points in a circuit. The resistance of a voltmeter is always very high so that when placed across part of a circuit it does not divert an appreciable current the circuit. It is always placed in parallel with the resistance in order to measure the p.d. between the ends. It is important to note that in connecting an electric meter in a circuit the positive terminals should be connected to the positive side of the circuit, otherwise the pointer will read backwards.

Cells

There are different types of cell used in the laboratory – Daniell cell, with e.m.f. 1.1 v and internal resistance of a few ohms; Leclanche' cell, e.m.f. of 1.45 v and internal resistance of several ohms. These cells are used for supplying currents for a short time. The cells are emptied after use. The lead accumulator has an e.m.f. of 2 v and a low internal resistance; the nife cell has an e.m.f. 1.5v and also has a low internal resistance. Great care should be taken to avoid short circuiting these cells because of low internal resistance. There should be at least 1 – 2 ohms in the circuit.

Battery

A group of similar cells arranged in a series or in parallel is called a battery.

Cells in series

These are represented as in figure 4.2. if the e.m.f. and internal resistance of each cell is E volts and r ohms respectively and there are n cells in series we have:

E.m.f. of battery = nE volts;

Internal resistance = nr ohms.

Cells in parallel

These are represented as in figure 7.3. in this case: 4.9
The e.m.f. of the battery = E volts, i.e. the e.m.f. of one cell;

Internal resistance = n/r. 4.10

Figure 4.2

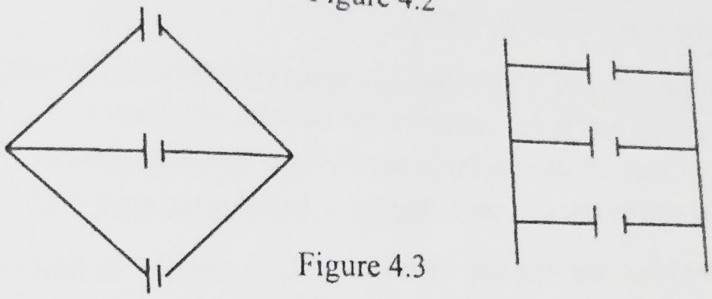


Figure 4.3

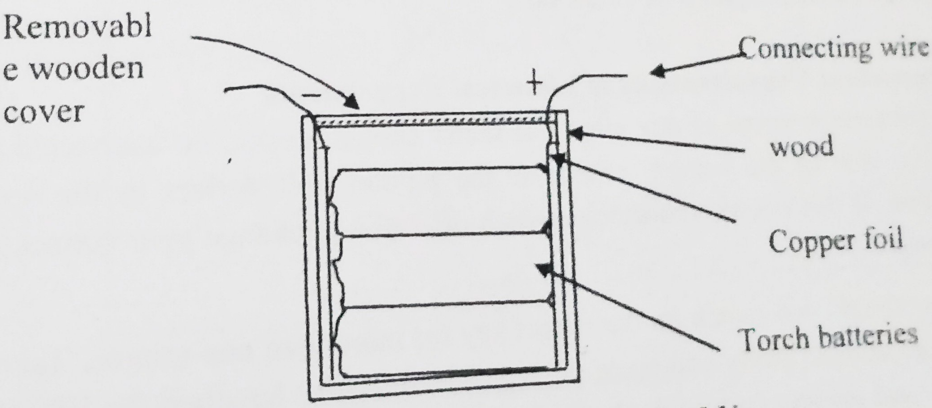


Fig. 4.4 OPN battery, e.m.f 1.5 V

Figs 4.2, 4.3 and 4.4 Cells in Series and Parallel

To Note

1. We observe that in some schools wet batteries and cells are not properly maintained since there are no chargers, and electrical experiment are not performed frequently and, moreover, there are so many students that it would be very expensive to provide enough batteries. For these reasons we have introduced a

battery which can supply current for quite some time, for ordinary simple electrical experiments such as the meter bridge experiments, which draw very small current from the cells. It is made from three or four ordinary torch batteries housed as shown in figure 4.4. we have named it the OPN battery. (meaning Okeke-PN battery).

2.Lab Technologists should be able to construct 100 of such batteries for their student's experiments.

3. Advantage of wet batteries over dry batteries is that wet batteries have a very low internal resistance, and a large current can be drawn from them without reducing the voltage across the terminals.

4. When n cells each of emf E volts and internal resistance r ohms are connected in series, the resulting emf is nE volts and the internal resistance of the cells is nr ohms. However, if they are connected in parallel, the resulting emf is E volts. This is the value of the emf of one cell only, and the internal resistance will be r/n ohms.

5. The usefulness of connecting two identical cells in parallel is that they provide twice the current capacity of either cell.

6. **Important Considerations in Electrical Experiments**

The positive terminal of any electrical meter should always be connected to the positive side of the battery, otherwise the pointer will deflect in the opposite direction. If this occurs you should switch off and interchange your connection to the meter.

7. You should not switch on the circuit key for more than one minute. Take your readings without delay and open the key. This helps to lengthen the life of your battery and prevent current fluctuations in your experiment.

8. The following important facts about measuring direct currents and voltages should be noted.

All dc ammeters and voltmeters have two terminals, one marked '+' (red in colour) and the other marked '-' (black in colour).

The red (+) terminal must be connected in a circuit so that it leads towards the positive terminal of the battery driving electric current in the circuit.

An ammeter must be connected in series with a component to measure the current through that component. A voltmeter must be connected in parallel with the component

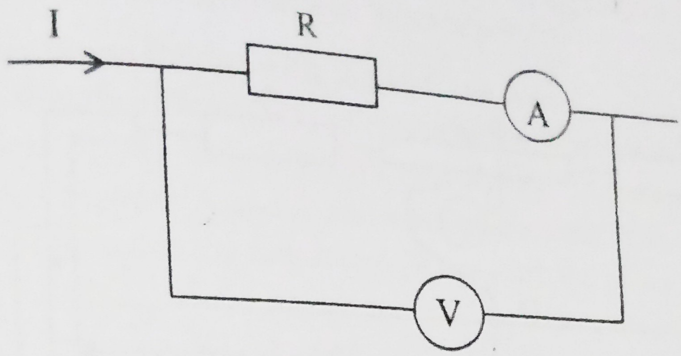


Fig.4.4b Connection of Ammeter and voltmeter in circuit

4.5 The Wheatstone Bridge

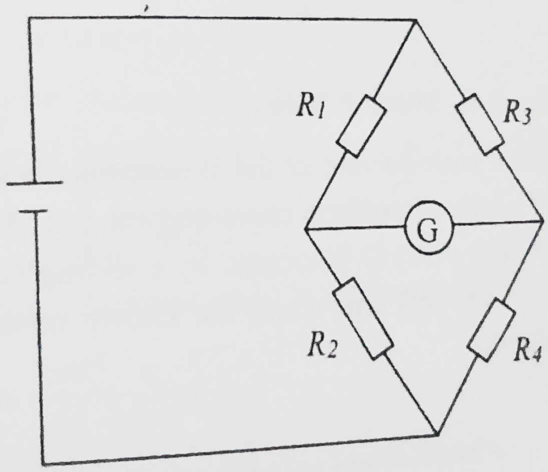


Fig.4.5: Wheatstone Bridge

The most convenient and accurate way of measuring resistance over a range of widely different values is by means of a Wheatstone bridge. Figure 4.4 shows the circuit diagram of a Wheatstone bridge. It consists of four resistances R_1 R_2, R_3, R_4 connected as shown. The current from the battery divides between the two branches ABC and ADC. By varying one of the resistances, a balance may be reached. This means that no current flows through the galvanometer. We can easily prove that when this occurs

(3) Measurement of internal resistances of cells.

4.10 Comparison of e.m.f.

Suppose the circuit is connected as in Figure 4.11 with E as a Daniell cell. Let balance occur at point C. This means that no current flows along AHC. That is, the potential at H = potential at C. then the p.d. across CA equals E (e.m.f of the cell), i.e.

$$kL = E \qquad 4.16$$

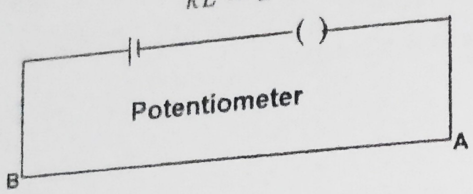


Fig 4.7

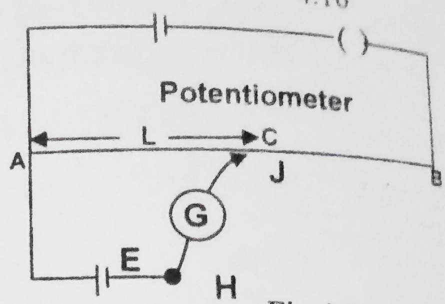


Fig 4.8

Fig 4.7 & 4.8: Principles of Potentiometer

Hence, the e.m.f. E is proportional to the balance length L.
Therefore, if a cell of e.m.f. E_1 gives a balance length L_1 and a cell of e.m.f. E_2 gives balance L_2, then since $E_1 = kL_1$ and $E_2 = kL_2$ we have that

$$\frac{E_1}{E_2} = \frac{L_1}{L_2} \qquad 4.17$$

Comparison of Resistances

Consider two accumulators C_1 and C_2 are connected as shown in Figure 4.9 together with resistances R_1 and R_2. Since the same current I is passing through the resistances R_1 and R_2 the ratio of the p.ds.is the ratio of the resistances, i.e.

$$\frac{VAB}{VBC} = \frac{IR_1}{IR_2} = \frac{R_1}{R_2}$$

If a balance L, is obtained with X connected to A and Y connected to B, and a balance L_2 when X is connected to B and Y to C then

$$\frac{VAB}{VBC} = \frac{L_1}{L_2} = \frac{R_1}{R_2}$$

Measurement of Internal Resistance of a Cell

In Figure 4.10 let the cell C_2 have an internal resistance r.

From Figure 7.10, let L_0 be the balance length with K_2 open and K_1 closed. Let L be the balance length when both keys are closed and R has some value. If E is the e.m.f. of C_2 and V is the p.d. across its terminals when K_2 is closed then.

$$I = \frac{E}{R+r} = \frac{V}{R}$$

Where I is the current through R. Therefore

$$\frac{V}{E} = \frac{R}{R+r}$$

Since $E = kL_0$ and $V = kL$

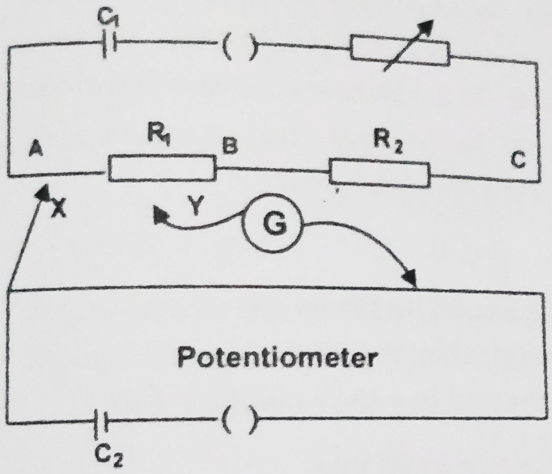


Fig. 4.9

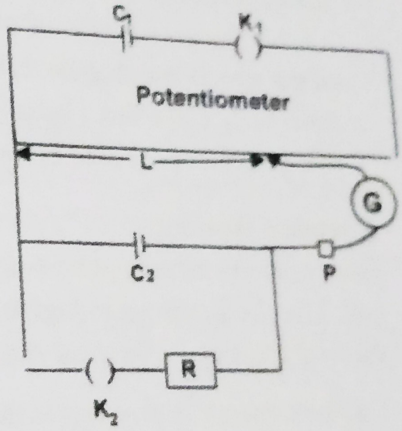


Fig 4.10

$$\frac{R}{R+r} = \frac{V}{E} = \frac{kL}{kL_0} = \frac{L}{L_0}$$

$$\therefore \qquad \frac{1}{L} = \frac{1}{L_0}\left(\frac{R+r}{R}\right) \qquad 4.18$$

Or

$$\frac{1}{L} = \left(\frac{r}{L_0}\right)\frac{1}{R} + \frac{1}{L_0}$$

Therefore, a graph of $1/L$ against $1/R$ as L and R vary will be a straight line with slope $= r/L_0$ and intercept $1/L_0$ from which r can be calculated.

Practical Precautions for Measurement of Internal Resistance of a Cell

(1) The accumulator C_1 must be fully charged. (Test by connecting a voltmeter across its terminals; a lead acid accumulator should give at least 2V, alkaline cell or O.I. battery 1.5 V).

(2) Since uniformity of wire is very important, the contact between the movable contact and the wire must be light to avoid making depressions on the wire.

(3) To protect the galvanometer, ensure that a high resistor is used to locate an approximate point of balance. To find a balance point, touch at the two ends of the wire with a jockey; the galvanometer should indicate opposite deflections. If it deflects in the same direction at both ends, then there are two possible reasons – either the wrong terminal of C_1 is connected to C_2 or the p.d. between the ends of the wire is less than the e.m.f. E of the cell. In the former case reversal of the leads to C_1 will allow a balance to be achieved. In the latter case, accumulator C_1 will need to be replaced by two or more accumulators in series.

Electrical Heating

One important method of heating up a liquid in a container is by use of a resistance coil. The circuit shown in Figure 4.3 is set up and when the current is switched on, the total amount of electrical energy given to the coil in a time t is $IVt = I^2Rt$.

This heat energy is given up to the liquid and container so that

$$IVt = I^2Rt = (\theta_f - \theta_i)(mc + m_c c_c) \qquad 4.19$$

where R is the resistance of the coil, θ_i is the initial temperature of liquid, m, c are the mass of the liquid and its specific heat capacity, m_c and c_c are the mass and specific heat capacity respectively of the container. θ is the temperature after a time, t.

From the above equation we can write

$$\theta - \theta_i = \frac{IVt}{(mc + m_c c_c)}$$

$$\therefore \theta = \frac{IVt}{(mc + m_c c_c)} + \theta_i \qquad 4.20$$

Or $\quad \theta = bt + \theta_i$

where $b = \dfrac{IV}{(mc + m_c c_c)}$ is a constant. θ_i, initial temperature, is also a constant.

4.11.1 Measurement of electric current

The unit of electric current is the ampere, and the instrument used for measuring electric current is the ammeter. And that used in measuring smaller current is milliameter. (Fig. 4.13 a & b).

Fig 4.13(a): Ammeter

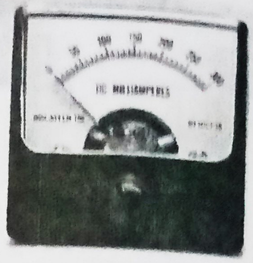


Fig 4.13(b): Milliammeter

The resistance of the ammeter should be very small, otherwise it will increase the resistance in the circuit, and reduce the current that it is meant to measure. It is important to note that in connecting electric meters which measure in one direction only in a circuit, the positive terminals of the meter should be connected to the positive side of the circuit, otherwise the pointer will read backwards. A centre zero instrument can measure a current in either direction so, it can be connected either way round. Some ammeters are calibrated in amperes while others are calibrated in mill-amps. They are also designed to measure more than one range. Some measure direct current while others measure alternating current. Any required range can be obtained by plugging into the appropriate socket in the ammeter.

4.12 Measurement of potential difference

The unit of potential difference (p.d.) is the volt, and the instrument used for measuring the p.d. between two points in a circuit is the voltmeter. (Fig. 4.14). Ammeter is always connected in series with the resistor while the voltmeter is always connected in parallel with a resistor, to measure the potential differences across the resistor or cell. The resistance of a voltmeter is always very high so that, when placed across part of a circuit, it does not divert an appreciable current from the main circuit. As, with the ammeter, if the voltmeter measures potential difference in one direction only, the positive terminal of the instrument should be connected to the positive pole of a cell or to the positive end of a resistor.

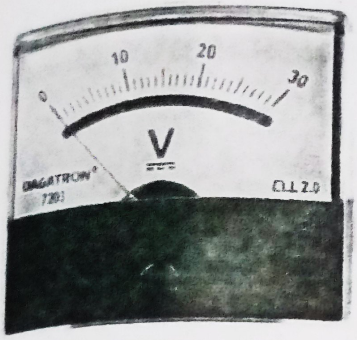


Fig 4.14: Voltmeter

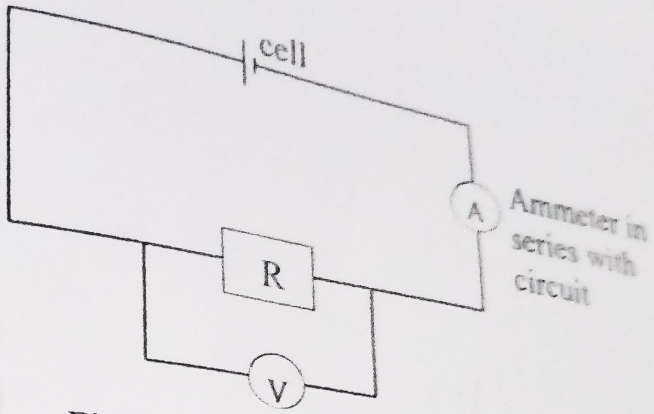


Fig. 4.15: Connections of ammeter and voltmeter in a circuit.

The common voltmeters used in our laboratories are calibrated in volts and milli-volts and there are various ranges.

8) Repeat the experiment for $\theta = 60°, 50°, 40°, 30°$, and measure the corresponding values of NZ, RZ. Tabulate your readings as follows:

Results

$\theta°$	$\cos\theta$	NZ	RZ	$X = \frac{NZ}{RZ}$
70	0.34	4.10	6.60	0.62
60	0.50	3.50	6.00	0.58
50	0.64	3.00	5.70	0.52
40	0.76	2.30	5.10	0.45
30	0.87	1.90	5.10	0.37

Questions

(i) Plot a graph of $\cos\theta$ on the y-axis against X on the horizontal axis.

(ii) Find the slope of the graph and comment on the parameter that the slope represents. The slope represents the refractive index of the rectangular glass block

(iii) State two precautions taken while performing the experiment.

i) I ensured the drawing papper and drawing board were smooth

ii) it was ensured ~~that~~ the experiment was conducted in a Location with suffient light, in order to accurately view P3 and P4

Hint: $\cos\theta = \sin(90 - \theta)$

Date 12th 9 July 2024

EXPERIMENT L 4:

Measurement of Refractive Index of liquid

Aim: To find the refractive index of a liquid by the real and apparent depth method.

Apparatus: Retort stand, search pin, object pin, measuring cylinder, and liquid of unknown refractive index (n).

Method

1) Place an optical pin at the bottom of a beaker.
2) Pour water into the beaker until it is about three-quarters full.
3) Attach a search pin horizontally to a sliding cork and move it up and down until it coincides with the apparent position of the pin as seen from above the liquid adjudged by no-parallax method.
4) Record the real and apparent depths, H and L respectively.
5) Repeat the procedure about 5 times by varying the quantity of water in the beaker and adjusting the location of object pin.
6) Find the refractive index of (i) water (ii) kerosene

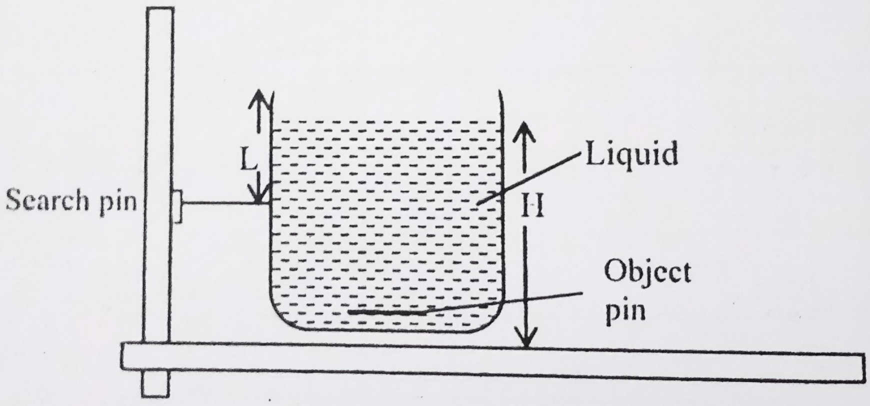


Fig. L.4 Real depth, H and apparent depth, L method of refractive index

Results:

Real Depth H(cm)		Apparent Depth L(cm)		n	
H2O	Kerosene	H2O	Kerosene	H2O	Kerosene
7.0	6.5	5.2	5.0	1.3	1.3
6.0	6.0	4.2	4.7	1.4	1.3
5.0	6.5	3.5	4.0	1.4	1.4
4.0	5.5	3.0	3.7	1.3	1.4
3.0	4.5	2.0	3.1	1.5	1.5

Questions

1) Plot a graph of real depth (H) versus apparent depth (L) for the two liquids on the same graph.

2) Deduce the refractive index of (i) water (ii) kerosene from your graph using the relation $n = \frac{H}{L}$.

3) What is the depth of a swimming pool which appears to be 10m deep when viewed directly from above its surface? Take n for water as $\frac{4}{3}$.

$R = \frac{H}{L} = \frac{4}{3} = \frac{H}{10} = \frac{40}{3} = 13.33$

4) Differentiate between reflection and refraction of light.

EXPERIMENT L 6: Date 14/06/2024

Focal Length of CONVEX LENS by the Displacement Method

Aim: To determine the focal length of a convex lens

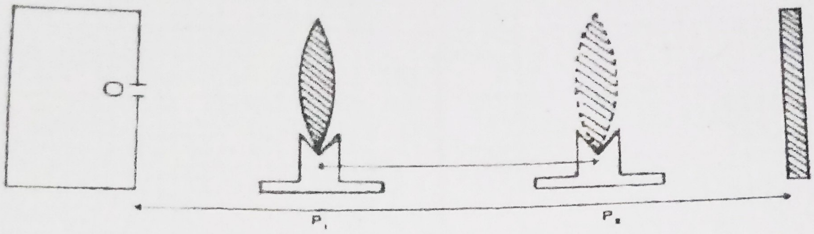


Fig. L 6 Determination of focal length of a converging lens

Apparatus: Illuminated Object O (e.g, "light box" or candle) Screen S, convex lens, lens stand, meter rule.

Method:

1) Measure and record the approximate focal length of the given lens by focusing the image of a distant object on the wall.

Approximate focal length, f_{app} = ~~14.0cm~~ 14 cm

2) Adjust the distance D, between illuminated object and screen to be about 4f.

3) Measure this distance, D accurately. D = 56 cm

4) Mount the lens in-between the screen & object.
5) Move the lens towards the screen until a clear image of the object (diminished & inverted) is obtained on the screen. Mark the position P_1
6) Move the lens away from the screen (towards the object) until, at a second position P_2 a magnified image is formed on the screen. Record the new reading P_2. The difference between the two readings is the displacement d of the lens.
7) Repeat the experiment for 5 more values of D .
8) Record the results in the table below.

Results

1st reading of mark P_1(cm)	2nd reading of mark P_2(cm)	Displacement D (cm)	Separation $P_1 - P_2 = d$ cm	$D^2 - d^2$ (cm^2)
36.00	23.00	56.00	13.00	2967
41.00	28.00	61.00	13.00	3552
46.00	25.00	66.00	21.00	3915
53.00	26.00	71.00	27.00	4312
58.00	26.00	76.00	32.00	4752
64.00	62.00	81.00	12.00	6557

(b) To verify the law of combination of resistances in parallel

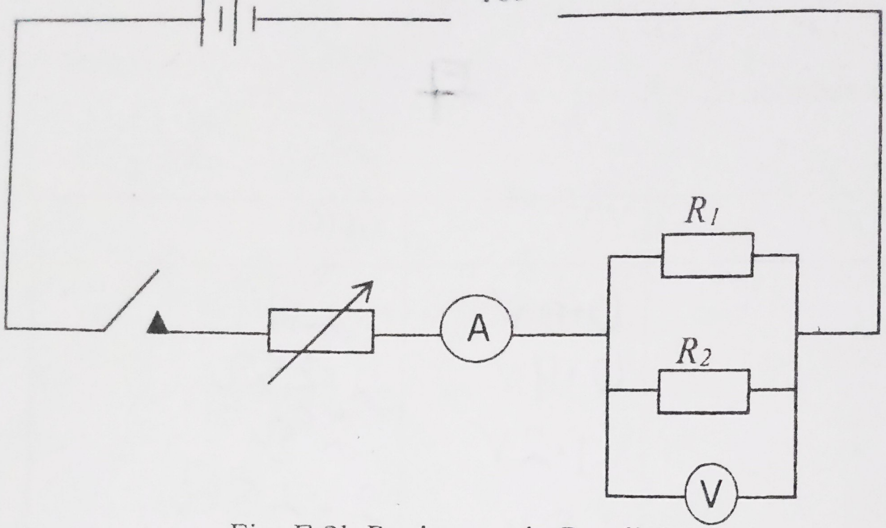


Fig. E 2b Resistance in Parallel

Method

Connect up the circuit of Fig. E 2b

With the key closed adjust the variable resistance to obtain the values of current I and potential difference V

Obtain a series of five pairs of readings of I and V

Record your results in the table provided

Results

R_1 = ...2...... Ω

R_2 = ...8...... Ω

I (A)	V(V)	V/I (Ω) = R_p
0.3 A	0.61 V	2.03
0.4 A	0.75 V	1.87
0.5 A	0.95 V	1.9
0.9 A	1.70 V	1.88
2.1 A	4.50 V	2.14

D., 14/6/24

R_p is the equivalent resistance of the parallel connections

Questions

1. Obtain the average value of *V/I* in the third column of the table = R_p

$$\frac{2.03+1.87+1.9+1.88+1.24}{5} = \frac{6.92}{5}$$

$$= 1.784$$

2. Compare this average value with the value of R_p obtained using the formular:

   $1/R_p = 1/R_1 + 1/R_2$

$$\frac{1}{Rp} = \frac{1}{2}+\frac{1}{5} = \frac{2 \times 5}{2+5} = 1.428\Omega$$

Rp is the total resistance of the circuit while average value of V/I is the effective resistance of the circuit when R_1 and R_2 are connected parallel.

EXPERIMENT E. 7: CURRENT AND VOLTAGE RELATIONSHIP IN A CAR LAMP

Date ..12/07/24....

Apparatus: A 12-volts d.c. power supply unit, rheostat, voltmeter of up to 12 volts full-scale deflection, ammeter of up to 3 amps full-scale deflection, car (tungsten) lamp (12v 36watts).

Method: Connect the circuit as shown in the Fig. E 7. Close the key k and adjust the sliding contact S gradually to obtain the corresponding current and voltage readings across the lamp L.

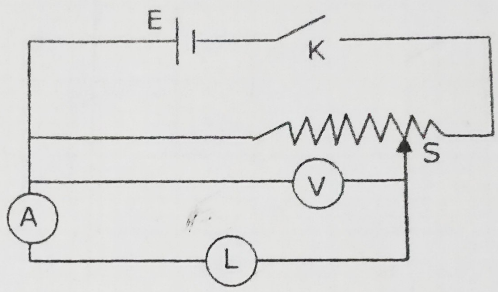


Fig. E 7 Current and voltage relation in car lamp

Record the current and voltage values when the lamp just lights. Obtain more readings of current I and voltage V up to 2 amps and 10 volts, respectively.

Theory: The current through the lamp is non-linear, and is of the form $I = KV^n$. So $\log I = n\log V + \log K$. So a graph of log I against log V will give a straight line with n as slope and log K as the intercept on the log I axis. Thus, n and K can be determined.

corresponding values of I and V. Obtain and tabulate the corresponding $\log_{10}I$ and $\log_{10}V$ values.

I	V	$\log_{10}I$	$\log_{10}V$
3.20	1.80	0.5	0.26 ~~0.3~~
3.40	2.10	0.53	0.32
3.60	2.40	0.56	0.38 ~~0.4~~
4.00	3.00	0.6	0.48 ~~0.5~~
5.20	4.50	0.71	0.65 ~~0.7~~
6.00	6.00	0.78	0.78 ~~0.8~~

Questions

1. Plot a graph of $\log_{10}I$ against $\log_{10}V$.
2. Record the values of the slope and the intercept on $\log_{10}V$ axis which is log K

Slope = 0.54 ; intercept = 0.68

3. Determine the value of n

4. Determine the value of K

5. Hence write down the equation for the current - voltage relationship for the car lamp