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PHYSICS PRACTICAL MANUAL(312)

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TELANGANA OPEN SCHOOL SOCIETY, HYDERABAD

312

PHYSICS

LABORATORY MANUAL

3

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FOREWORD

Providing education to children is a fundamental right and is essential for the overall development of society. The Government of Telangana plays a crucial role in ensuring that education is accessible to all, often establishing institutions like the Telangana Open School Society (TOSS) to serve children who may face challenges in accessing formal education due to various reasons.

In order to deliver quality education to students studying Intermediate Education in the Telangana Open School Society, starting from the 2023 academic year, we have undertaken the task of revising our textbooks to align them with the changing social landscape and to incorporate the fundamental principles of the National Education Policy 2020. The guidelines outlined in this policy aim to enhance the overall learning experience and cater to the diverse needs of our students. Unlike the earlier textbooks that primarily contained questions and answers, TOSS has taken a student-centric approach in designing these textbooks, taking into consideration the various learning styles and needs of our students. This approach encourages active engagement and participation in the learning process.

This Physics Laboratary Manuel encompassing a total of 16 experiments. It has been thoughtfully crafted to foster the understanding and appreciation of this remarkable discipline. This as a gateway to the intriguing and multifaceted realm of practical physics.

The manuel contains 16 experiements which are choose based on text book. So that the theoritcal knowledge required to do the experiemtns are provided to the students before starting the lab sessions. In the introduction, objectives, lab report formal error calculations drawing of graphs are provided. The experiments relted to waves, sound, optics, electricity and electronics are given with requires procedure, fromula and tabuluar coloun. The precausions are also listed in the experiments. Basic requirements for doing optical and electricity experiments were given in the introduction it self.

We are indeed very grateful to the Government of Telangana and the Telangana State Board of Intermediate Education. Special thanks go to the editors, authors, co-coordinator, teachers, lecturers, and DTP operator who tirelessly contributed their services to create this textbook.

Director,
TOSS, Hyderabad.

Date : 2023
Place : Hyderabad.

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A Word With You

Dear Learner

We are delighted to welcome you to the world of open and distance learning through TOSS. Your decision to embark on this educational journey as an Open and Distance learner is commendable, and we are thrilled that you have chosen physics as one of your subjects of study.

With great pleasure and enthusiasm, we present to you this comprehensive physics labour manual meticulously designed for senior secondary course in open and distance learning. Physics is a subject that unveils the mysteries of the universe, offering profound insights into the fundamental laws governing the cosmos. Our lab manual encompassing 16 chapters, has been thoughtfully crafted to foster your understanding and appreciation of this remarkable discipline.

As you set out on this educational voyage, you will explore the captivating domains of mechanics, heat and thermodynamics, optics, electricity and magnetism, atoms and nuclei, semiconductors, and communication systems. Each volume serves as a gateway to the intriguing and multifaceted realm of physics.

Volume-1, consisting of 14 chapters, lays the essential foundation for your journey into the world of physics. Mechanics, with its principles of motion, forces, and energy, provides the framework for comprehending how objects interact with one another. Heat and thermodynamics delve into the fascinating world of temperature, heat transfer, and the laws governing energy transformations.

Volume-2, with 15 chapters, will lead you through the enigmatic universe of light, exploring topics like reflection, refraction, and the formation of images, delves deeper into the enigmas of the physical world. Electricity and magnetism will electrify your imagination as you explore the principles of electric circuits, magnetic fields, and electromagnetic waves. Atoms and nuclei will unveil the intricacies of the atomic realm, from quantum mechanics to nuclear physics. Semiconductors and communication systems will introduce you to the technology that drives our modern world, from transistors to telecommunications.

Our textbook is tailored with your unique learning journey in mind, recognizing the distinctive challenges and opportunities that open and distance learning offers. Clear explanations, illustrative diagrams, and practical examples have been incorporated to make physics accessible and engaging, even when you are learning independently. Each chapter acts as a stepping stone, building upon previously introduced concepts, ensuring a coherent and structured learning experience.

Physics transcends being a mere subject; it is a path to discovery. It empowers you to explore the universe, from the vast expanses of space to the tiniest particles that constitute matter. Physics nurtures critical thinking, problem-solving abilities, and a profound appreciation for the natural world's beauty.

As you progress through these pages, remember that physics is not just a collection of equations and theories; it is a tool that equips you to understand and shape the world around you. Embrace the challenges, ask questions, and never cease to wonder. Your journey through these volumes will not only equip you with the knowledge and skills to excel academically but also inspire a lifelong passion for the marvels of physics.

We extend our heartfelt best wishes as you embark on this educational odyssey. May this textbook be your trusted companion and guide on your quest for knowledge. If you encounter any difficulties or have suggestions, please do not hesitate to reach out to us.

Sincerely,

The Curriculum Design and Course Development Team

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INTRODUCTION

Like any other science subject, physics is a subject which can be learnt better by doing. Infact, the experiments form an integral part of the physics course at senior secondary stage.

A.1 THE OBJECTIVES OF PRACTICAL PHYSICS

We may start by asking "What are the objectives of laboratory work; why do it? "Laboratory work may serve to:

- demonstrate the principles coverd in your study material in physics;
- provide familiarity with apparatus and enable them to handle the instruments and apparatus with purpose;
- learn how to do science experiments;
- develop an attitude of perfection in practical tasks.

Seeing something demonstrated in practice is often a great help in understanding it. For example, intuitively one may feel that if a pendulum oscillates with 1^0 amplitude and then with 20^0 amplitude, the time period in the latter case will be much larger - if not 20 times, at least 2 or 3 times. For Galileo it was a great fascination when he discovered, using his heart beats as a clock, that time period does not change with amplitude and this lead to development of pendulum clocks.

The second objective is perhaps more important. In any practical course you handle a number of instruments. In your later career you may be involved in scientific research, or in an industry. No practical course at senior secondary stage, or even at university stage, can include all instruments that different students may later use in such careers. Apractical course trying to familiarize you with too many instruments will be boring and too heavy. Through a few instruments, apractical course prepares you to use instruments in general. There is a certain attitude of mind that are searcher or technician should adopt while handling any instrument, and this is what the course tries to instill, besides some basic skills.This is the attitude of perfection - an attitude of trying to know infinede tail show the instrument in hand works, how to handle it properly and then making genuine effort to handle it properly with all the relevant precautions. In the context of Indian industry, now poised to compete internationally, the importance of this objective cannot be under estimated.

Pedagogically the third objectiveis, perhaps, the most important. Practical work done honestly and properly trains you to be a good experimenter. It trains you in the scientific method – the method of systematic experimentation to seek new knowledge. It is not only important for there searcher, but also for every one else.We all face many situations in every day life when we have to seek information through, what in everyday life is called 'trial and error'.

A.2 THE FORMAT OF THIS MANUAL

The experiments are presented in this manual in the form of self-instructional material in the following format:

1) **Aim:** It defines the scope of the experiment.
2) **Objectives:** The objectives of an experiment give you an idea about the skills or the knowledge that you are expected to develop after performing that experiment.
3) **What you should know?:** It highlights the concepts and background knowledge related to the experiment, which you must understand in order to do the experiment in a meaningful way.

4) **Material required:** It gives an exhaustive list of apparatus and other material required to perform the experiment.

5) **How to set up and perform the experiment?:** The steps are given in a sequential manner for setting up the apparatus and performing the, experiment. The precautions, wherever necessary, are incorporated while describing various steps.

6) **What to observe?:** A proper format of recording the observations, is suggested in each experiment.

7) **Analysis of data:** How to analyse your data, is suggested in each experiment; Quite frequently, it is combined with the previous heading, at serial number 6.

8) **Result:** It is the outcome of the observations and supports the aim set in the beginning.

9) **Sources of error:** Since all the experiments in physics involve measurements, your attention; is drawn in each experiment to major pit falls specific to that experiment, if any, which may cause error in your measurements.

10) **Check your understanding:** At the end of each experiment, a few questions have been incorporated to consolidate what has been done and to check your own understanding about it.

Before starting any experiment, you are advised to go through the detailed instructions given under it and plan your work accordingly. In case of any doubt, consult your tutor and get the clarification needed.

A.3 GRAPHS IN PRACTICAL PHYSICS

Majority of experiments in physics require drawing of a graph showing how a physical quantity changes with changes in another.The former is called the dependent variable and the latter the independent variable. For example, you may have measured voltages that develop across a conductor when various currents are passed through it. Here the current I, being the independent variable,is plotted along horizontal axis (i.e. x-axis, or abscissa). The voltage V which develops across the conductor, being the dependent variable, is plotted along vertical axis (or y-axis, or the ordinate). Each pair of values is represented by apoint on the graph. Points are marked as cross (×or+) or as a dot surrounded by a circle(•). Then a smooth line is passed closest to the points. Never simply join the points by a zig-zag line, which will indicate as if there was no error in any of the observations.

If the graph is a straight line passing through the origin, it indicates that the variable are proportional to each other. Relation between V and I for an eureka wire whose temperature does not significantly change during the experiment is such a relation (Fig.1). Slope of the graph:

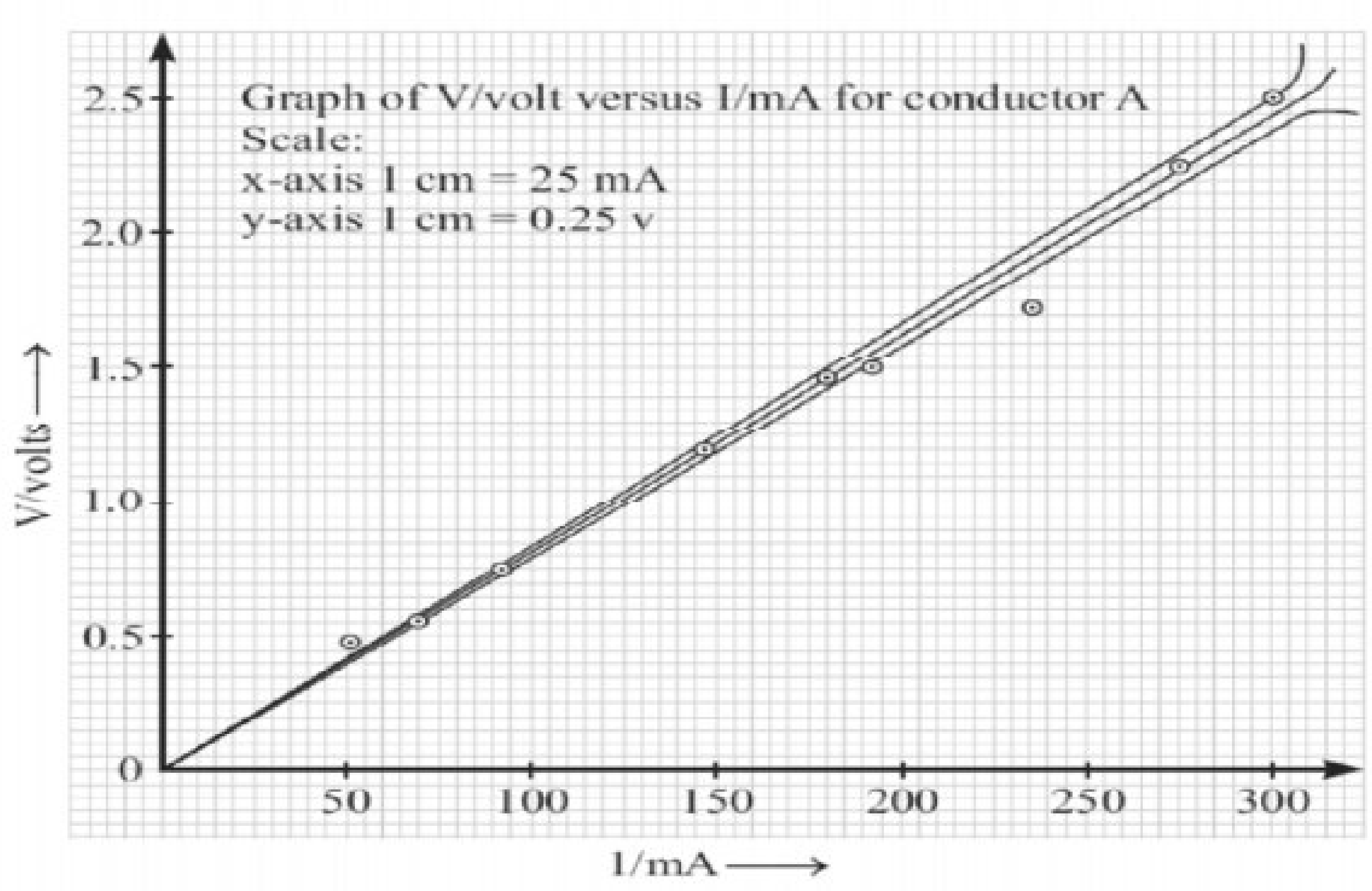


Fig.1: Graph between v and t

$$\frac{\Delta V}{\Delta l} = \frac{change\ in\ voltage}{change\ in\ current} = R$$

gives the resistance of the wire. Value of slope thus found from the graph averages all the readings. Graph is also a good means of detecting there a readings which need to be rejected, which may be widely off the smooth graph. Graph also provides a good means of estimating the error in the slope thus found. Draw two lines close to each other so that most of the points lie between them. Mean of their slopes is the best estimate of slope and half the difference between their slopes is an estimate of the error in this slope.

Graph is often the best method to find out the kind of relation that exists between two variables. For example, a study of relation between V and I for a torch bulb may indicate that V is not proportional to I. The smooth graph is curved in which V increases much faster at higher values of current(Fig.2).

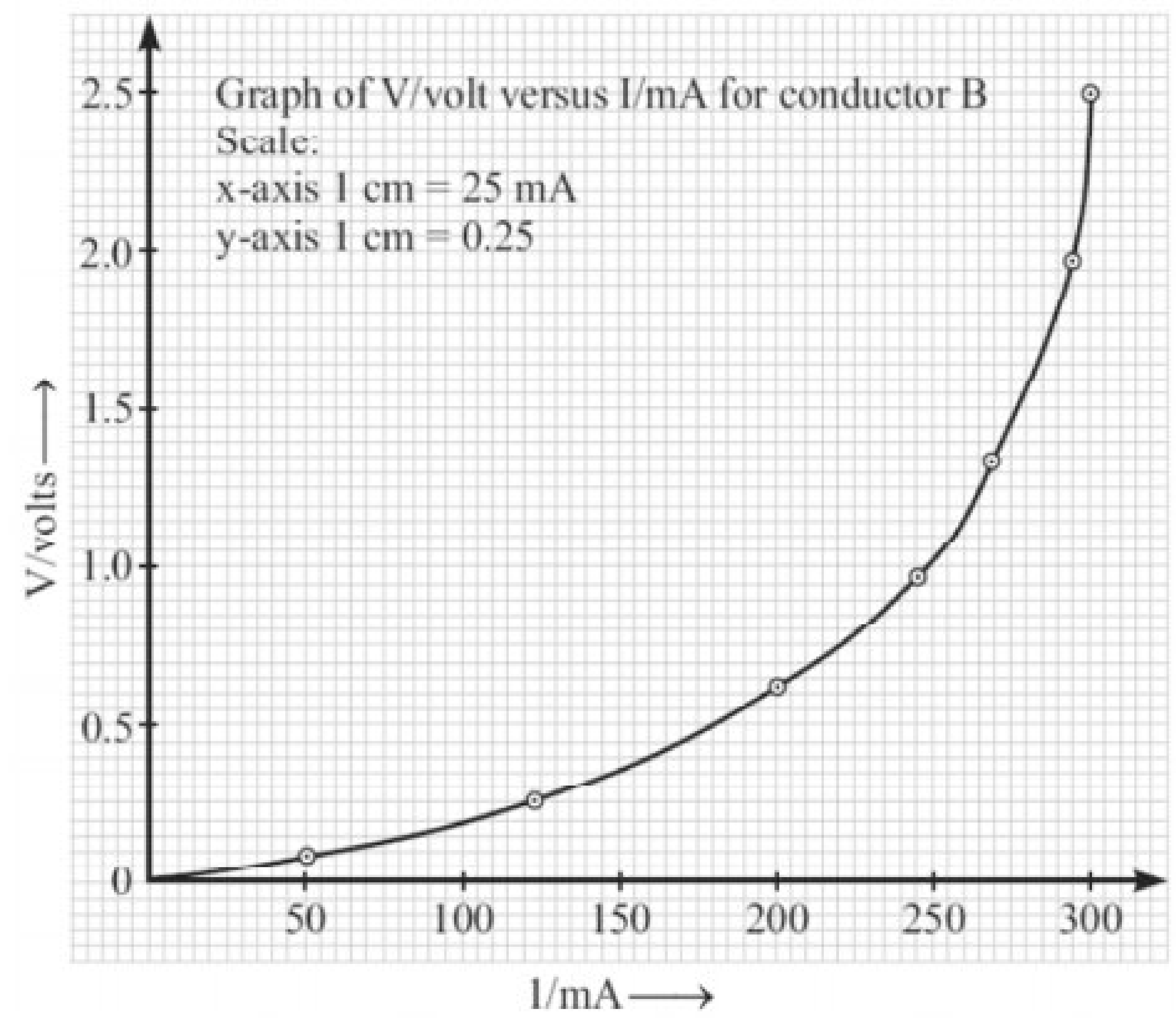


Fig.2: Curved Graph between V and I

For plotting a graph of observations already taken, following points should be noted:

(i) Graphs are plots of numbers, rather than physical quantities. In physics, a symbol represents a physical quantity, with an appropriate unit. For example, the statement" the current is 1.5 ampere" can be expressed using symbols as" I=1.5A". It would be meaning less to say" the current is IA", since I includes the unit ampere. So I/A,, or I/mA, or V/volt, or V/mV is a pure number. These numbers are plotted on the graph.

(ii) When choosing the scales for the two axes, the following points must be considered

   (a) Choose scales so that the points are distributed as widely as possible; this means choosing a suitable scale and deciding on the numbers at the beginning of the scales, i.e. whether to choose the true origin (x-b,y= o) or a false origin, e.g. (x= 5,y= 15).

   (b) Choose simple scales to make calculations straight forward, e.g. don't choose 4 small divisions on X-axis to represent 9 mA. A better choice close to it is let 5 small divisions represent 10 mA.

   (c) If the slope of the graph is to be measured, try to obtain an angle of 30^0 to 60^0 between the graph and the axes.

iii) For investigating the relation between two physical quantities, readings must be taken for at least

7 or 6 pairs of values of the two quantities. For taking these readings, the values of the independent variable should be spread over the entire range that the instruments given to you can provide.

Example 4: Following are readings of voltages across two conductors for various values of currents passing through them. State in which case the voltage is proportional to current, and find the resistance of this conductor.

Conductor A			Conductor B		
S.No.	**I/(mA)**	**V(volt)**	**S.No.**	**I/(mA)**	**V/(volt)**
1	0	0.00	1	0	0.00
2	50	0.45	2	50	0.10
3	100	0.75	3	80	0.15
4	130	1.00	4	120	0.20
5	150	1.20	5	160	0.35
6	180	1.45	6	200	0.60
7	200	1.55	7	240	1.00
8	240	1.70	8	260	1.30
9	70	0.55	9	280	1.70
10	270	2.15	10	290	2.00
11	300	2.45	11	300	2.50

Solution: Let the mm graph paper available for each conductor be12cm×18cm in size. We may choose 20 mm to represent 50 mA on the I-axis and 20 mm to represent 0.50 volt on V-axis for both graphs, as the range forV as well as for I is same for both. Looking at the observations we find that V-scale needs to be of length10cm and I- scale of 12- cm. Thus we takeV-axis a long12cm side of graph and I-axis a long longer side.

After plotting the points, it is clear that in case of conductor A (Fig.1), $V \propto I$.Incase of conduct or B (Fig.2), it seems that $V \propto I$ only upto about I = 120mA and thenV increases faster and faster as I increases.

In trying to find the slope of the best line through points plotted for conductor A, we find that most of the points lie between lines OA and OC. The reading (240mA,1.70V) is rejected, being too far from the best graph.

Slope of straight line $\frac{2.45 volt}{300 mA} = 8.17 \text{ohm}$

Slope of straight line OC= $\frac{2.30 volt}{300 mA}$ =7.67ohm

$\therefore$ R, the resistance of conductor. A= $\frac{8.17 + 7.67}{2}$ =7.92 ohm. Estimated error in the value of

$R = \frac{8.17 - 7.67}{2} = 0.25$ ohm. Rounding off to one digit after decimal, which is the first unreliable figure, we can write the result as $R = 7.9 \pm 0.3$ ohm.

A.3.1 Converting a Curved Graph to a Straight Line

Not all graphs are straight lines. For example Boyle's law states that," pressure of a fixed mass of a gas at constant temperature is inversely proportional to itsvolume". Thus, if in an experiment we measure pressures (P) corresponding to various volumes (V) of a gas and then plot P againstV, a curve will be obtained by which it will be difficult to assert that the curve obtained verifies the Boyle's law for that gas.

A curved graph sometimes gives valuable information, but in general much more information is revealed from a straightline graph. So whenever possible we plot quantities which will yield a straightline graph. In the above example we may say that" pressure is directly proportional to reciprocal of its volume". Thus we may plot values of P against corresponding values of 1/V and see whether experimental points so obtained yield as straight line graph passing through the origin. If such a graph is obtained, the Boyle's law can be said to have been verified for that gas. Such conversion to straight line graph may, perhaps, not be possible for V versus I plot for a torch bulb, fig.3.

Example5:Following data was obtained for pressure and volume of an enclosed sample of air at constant temperature.Check graphically if this data verifies the hypothesis that" pressure is proportional to reciprocal of volume for air".

V^{-1}/cm^3	50	40	35	30	25	22
P/mmHg	460	570	660	760	925	1050

Solution: First we calculate values of V^{-1} and rewrite the data as under:

$V{-}1/cm^3$	0.02	0.0250	.02860	.0333	0.0400	.0454
P/mmHg	460	570	660	760	925	1050

The range of values is x = 0.0200 to 0.0454 for $V^{-1}/cm^{-3}$and y= 46 0to1050 for P/mmHg. Thus to make a well spread out graph one may like to take a false origin at (x = .02, y = 450). However, we have to check whether or not the straight graph is obtained, and if so whether it passes through the true origin (x=O, y = O). Hence the ranges have to be treated as x = O to .0454 and y = O to1050. Let the graph paper have dimensions18cm×24cm. Let 5cm along x-axis represent 0.01 and 3cm along y-axis represent 200. Thus x-axis needs a length of about 23cm and y-axis about 16cm,which are respectively taken along length and breadth of graph paper.

After plotting the points (Fig. 3) we find that they indeed lie on a straight line,which passes through the origin (x = O, y = O). Hence the given hypothesis is verified for air.

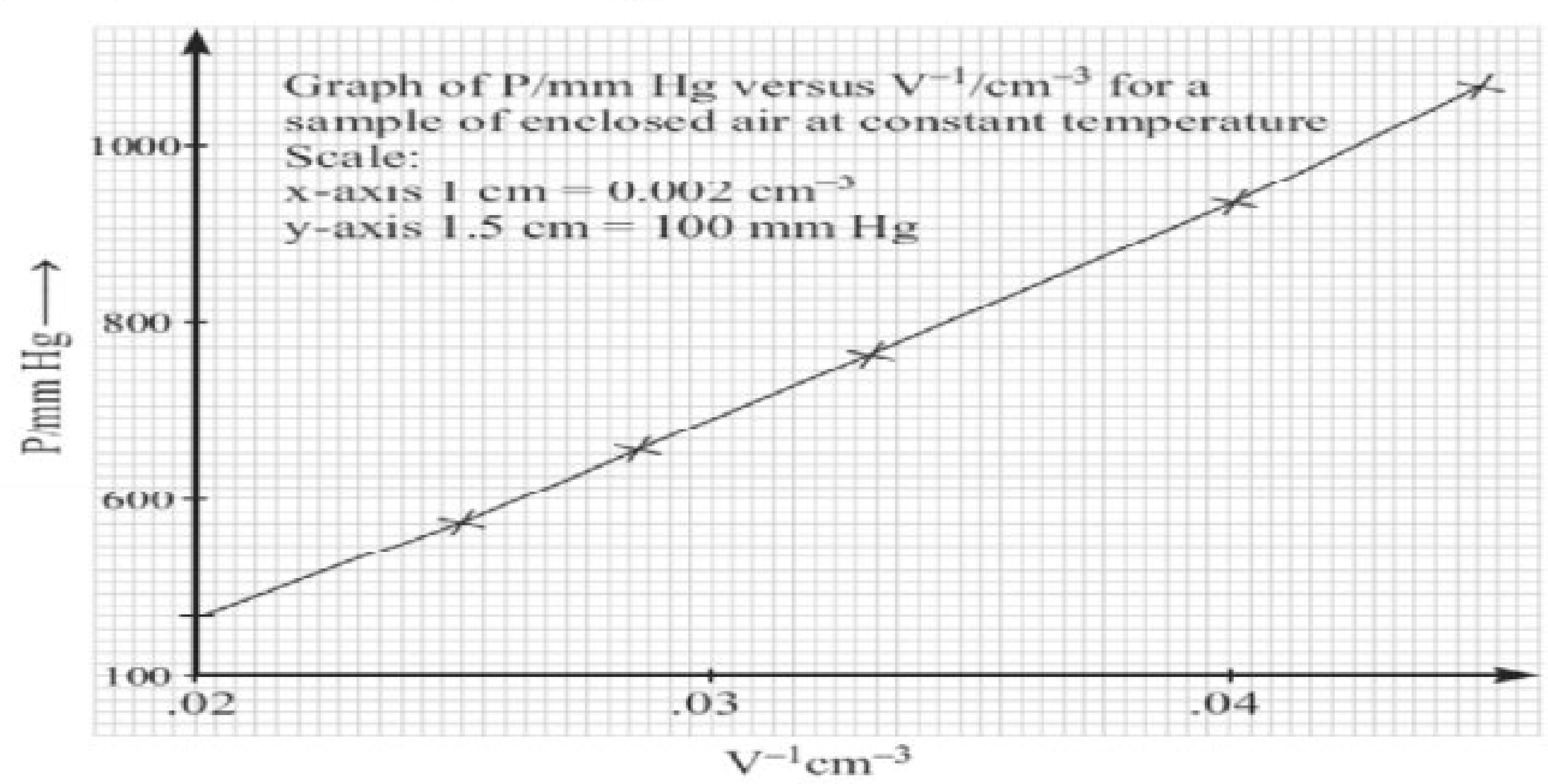


Fig. 3

A.3.2 Which is the Independent Variable?

In the above discussions we have considered current I as the independent variable for study of relation between V and I. In actual performance of the experiment, choice of independent variable is often arbitrary.Thus instead of measuring voltages developed when current of your chosen values passes in the conductor, you may measure currents passing in the conduct or when you apply your chosen voltages across it. This consideration applies to study of relation between p and v of a gas at constant temperature also and to almost all similar experiments.

For plotting a graph also, the choice of variable to be treated as independent variable is often arbitrary. More important is the choice of scales for the two variables so that maximum portion of the area of the graph paper is utilized.

You can always make either the length or the breadth as the horizontal axis.

A.4 USE OF LOGARITHMS FOR CALCULATIONS IN PHYSICS

In order to obtain the final result from your observational data, you have often to do calculations in volving multiplications and divisions.

Such calculations can be done quickly and with less chance of a calculation error by using the logarithms.

To find the logarithm of a number you use a "4 - figure table of logarithms". The logarithm of a number consists of an integral part, called characteristic, and a decimal part called the mantissa.Where as the characteristic can be a positive or negative integer or zero, the mantissa is always positive.

If you look at a table of logarithms, it will be seen that rows of four figures are placed against each of the numbers from 10 to 99. These four figures form in each case the mantissa of a logarithm; the characteristic has to be supplied by you.

The characteristic of logarithm of any number between 1 and 10 is zero. For any number Rs. 10, it is a positive integer which is less by one than the number of figures to the left of the decimal point. For any number <1, it is a negative integer whose magnitude is one more than the number of zeros which follow the decimal point. Thus:

Characteristic of 7,47,300 is 5

Characteristic of 7,473 is 3

Characteristic of 74.73is1

Characteristic of 7.473 is 0

Characteristic of 0.7473 is 1 or $\bar{1}$ (read 'onebar') Characteristic of 0.07473 is - 2 or $\bar{2}$

Characteristic of 0.007473 is - 3 or $\bar{3}$

Example 6: Find log 7.4

Solution:

In the column opposite the number 74 is mantissa 8692; the characteristic is 0.Hencelog7.4=0.8692

Example 7: Find log74.7

Solution:

We find the first two figures 74 at the extreme left. Then move a long the horizontal line to the number in the vertical column headed by the third figure 7 to obtain the mantissa 8733. The characteristic is 1, Hence log 74.7 = 1.8733.

Example 8: Find log 0.07473.

Solution:

This number consists off our figures. To obtain the logarithm of a number consisting off our figures, it is necessary to use the mean difference columns at the extreme right of the page.

Mantissa of log747 =.8733

Mean difference for 4th figure 3= $\overline{3}$

Mantissa of log7473 =.8735

$\therefore$ log 0.07473 = $\overline{2}$.8735

A.4.1 Antilogarithms

The number corresponding to a given logarithm is found by using the table of anti logarithms. First we use only the mantissa to find the figures of the required number. Then we locate the decimal point with the help of the characteristic.

Example 9 : Find the number whose log is 2.6057.

(For first 3 digits of mantissa) Antilog .605 = 4027

(For 4th digit of mantissa) Meandiff.for7=7

= 4034

Hence, the number whose log is 2.6057 is 403.4

Similarly, the number whose log is 0.6057 is 4.034

the number whose log is $\overline{1}$.6057 is 0.04034 the number whose log is $\overline{2}$.6057 is 0.4034

A.4.2 Multiplication

To multiply two or more numbers together, add the logarithms of the numbers; the sum is the logarithm of the product.While adding the logarithms care has to be taken that mantissa is always positive. Only the characteristic, which is the integer to the left of decimal point, is positive or negative. In fact, this convention makes the addition of logarithms easier than common positive and negative numbers, because four figures of each mantissa are added as positive numbers. Then in the characteristic only we have some positive and some negative integers tobe added.

Example10: Multiply 47.45×0.006834×1063

Solution:

log 47.45 = $\overline{1}$.6763

log 0.006834=3.8347

log 1063 =3.0265

log (product) = 2.5375 $\therefore$ Product=434.8

A. 4.3 Division

Where as for multiplication we add the logarithms, for division we subtract the logarithm of the divisor from logarithm of the dividend. Then the difference obtained is the logarithm of the quotient.

Example11: Evaluate 0.4891÷256.8

Solution:

log 0.4891 =1.6894

log 256.8 =2.4096

log (quotient) = 3.2798 $\therefore$ Quotient=0.001905

Notice that characteristic 2 subtracted from $\bar{1}$ gives $\bar{3}$, like the usual operation with positive and negative integers.

Example12: Evaluate $\dfrac{51.32 \times 0-.04971 \times 1.021}{69.84 \times 42.98 \times 3.982}$

Solution:

log 51.32	=1.7103	log 69.84	=1.8441
log 0.04971	= $\bar{2}$.6965	log 42.98	=1.6333
log 1.021	=0.0090	log 3.142	=0.4972
log(numerator)	= 0.4158	log(denominator)	=3.9746
		3.9746	
log (result)	= $\bar{4}$.4412	$\therefore$ Result=0.0006446	

Notice that while subtracting log (denominator) from log (numerator), mantissas are treated as positive numbers. To subtract 9 from 3, we borrow 1 from characteristic 0 to make it T; then 13-9 gives 4 in the first figure after decimal point.

A.5 PRECAUTIONS FOR READING SOME COMMON INSTRUMENTS

When you make a measurement with any instrument, it usually has a scale on which you read the position of end of an object, or a level, or a pointer, etc. For example:

(a) You have thermometer on the scale of which you observe the position of upper end of mercury thread inside.

(b) You have a metre scale on which you read the positions of the tips of a knitting needle to find length.

(c) You have a graduated cylinder in the scale of which you read the position of the surface of a liquid filled inside it to find its volume.

(d) You have an ammeter, or a voltmeter, or a galvanometer, or a multimeter, or a stopwatch on the circular scale of which you read the position of a pointer.

The most general precaution in all the cases is that you keep your line of sight perpendicular to the scale of the instrument in order to eliminate 'parallaxerror'. It requires a little practice to observe the reading with one eye, keeping the other eye closed. Then you have to keep the open eye in such a position that line joining the eye and the point whose reading is to be taken (i.e. your line of sight) is perpendicular to scale.

Referring to figure(4)for observing reading in a thermometer,with eye in position (a), you get correct reading 65^{0}C. In position (b) you may get the reading as 64^{0}C and in position (c) as 66^{0}C. This so happens because where as the scale is marked on the surface of the thermometer, the mercury thread is inside.The two can never be coincident.

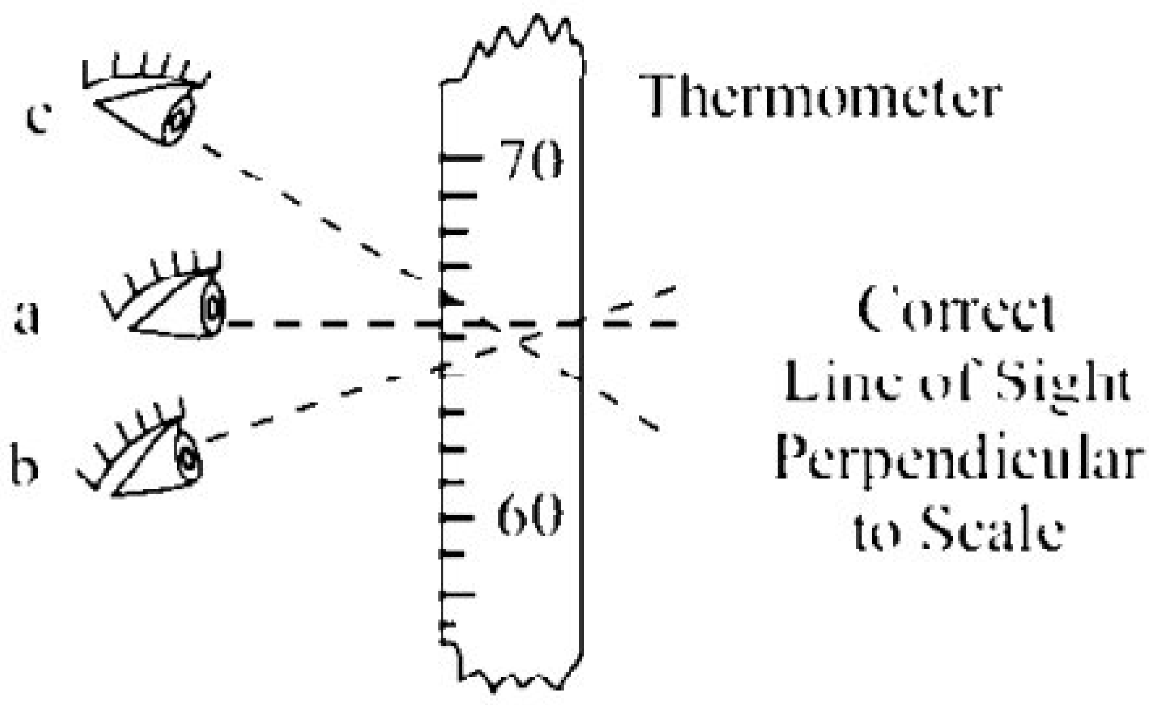


Fig 4 : Correct line of sight

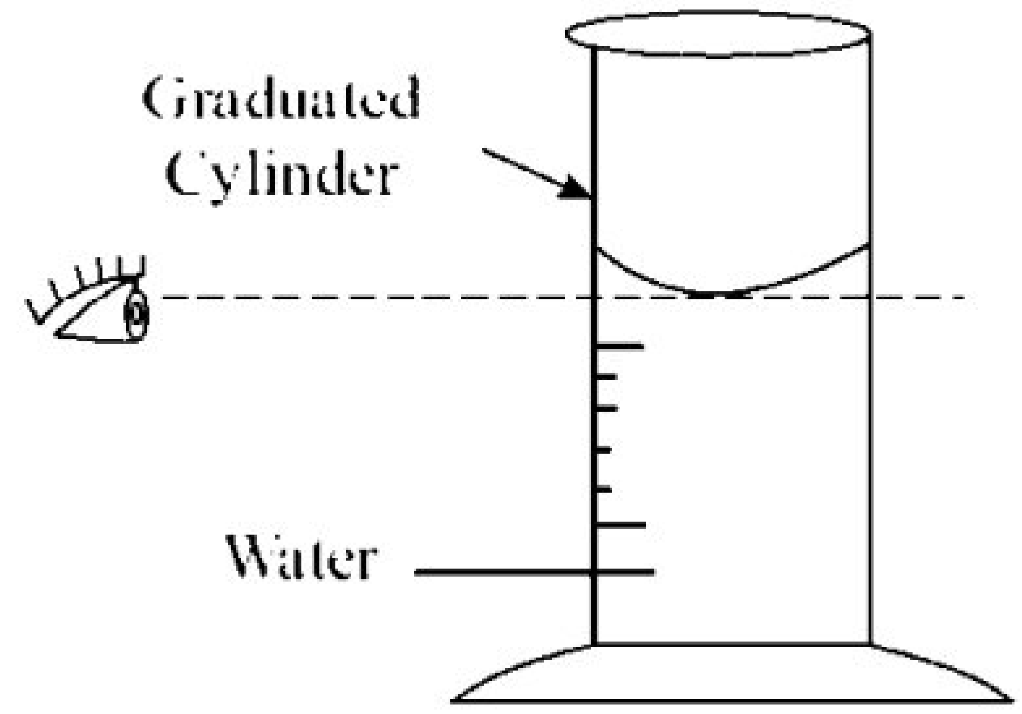


Fig 5 : Surface of scale in a measuring jar

Referring to fig 5, the surface of a liquid in a measuring jar or in a burette is never plane. It is concave upwards for water and most other liquids.You want to read the position of centre of the surface on the scale. Being lower than boundry, it is called lower miniscus.Your line of sight has to be horizontal and the length of the cylinder has to be vertical. If the cylinder is inclined to left in the diagram, you may get a too high reading. If it is inclined to right, you may get a too low reading. In similar manner for mercury filled in a glass burette or water filled in certain plastic vessels, where the surface is convex (fig.7), you want to read the position of centre of the surface, called the upper miniscus.

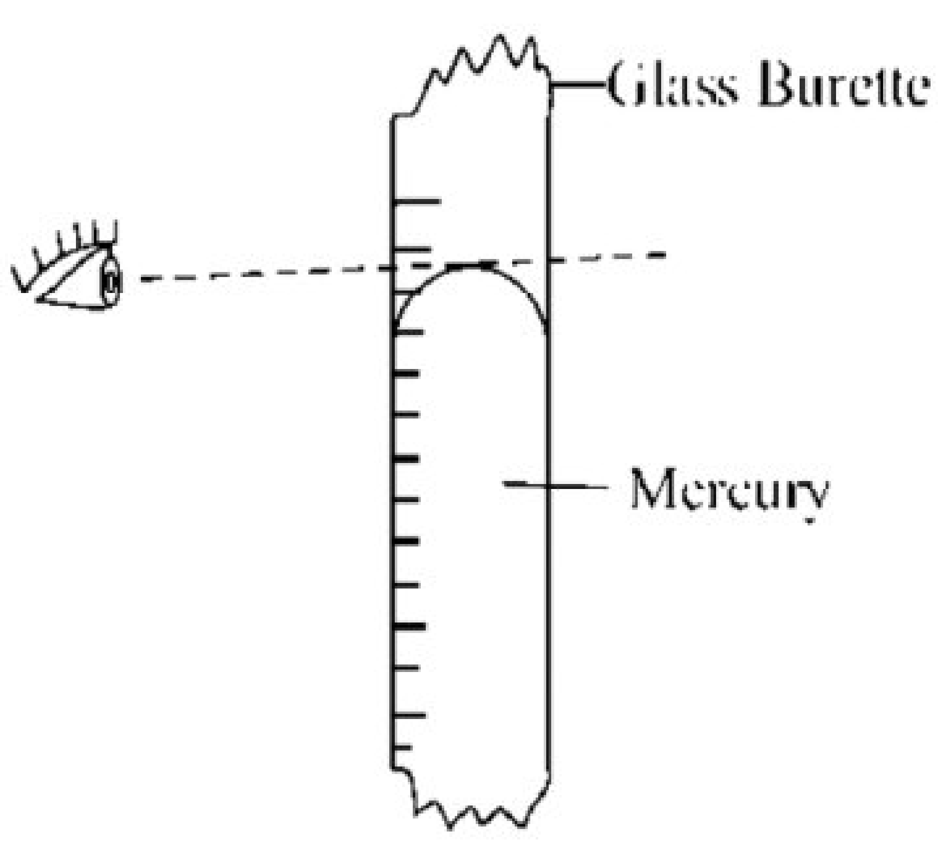


Fig 6 : Surface of mercury in a vessel

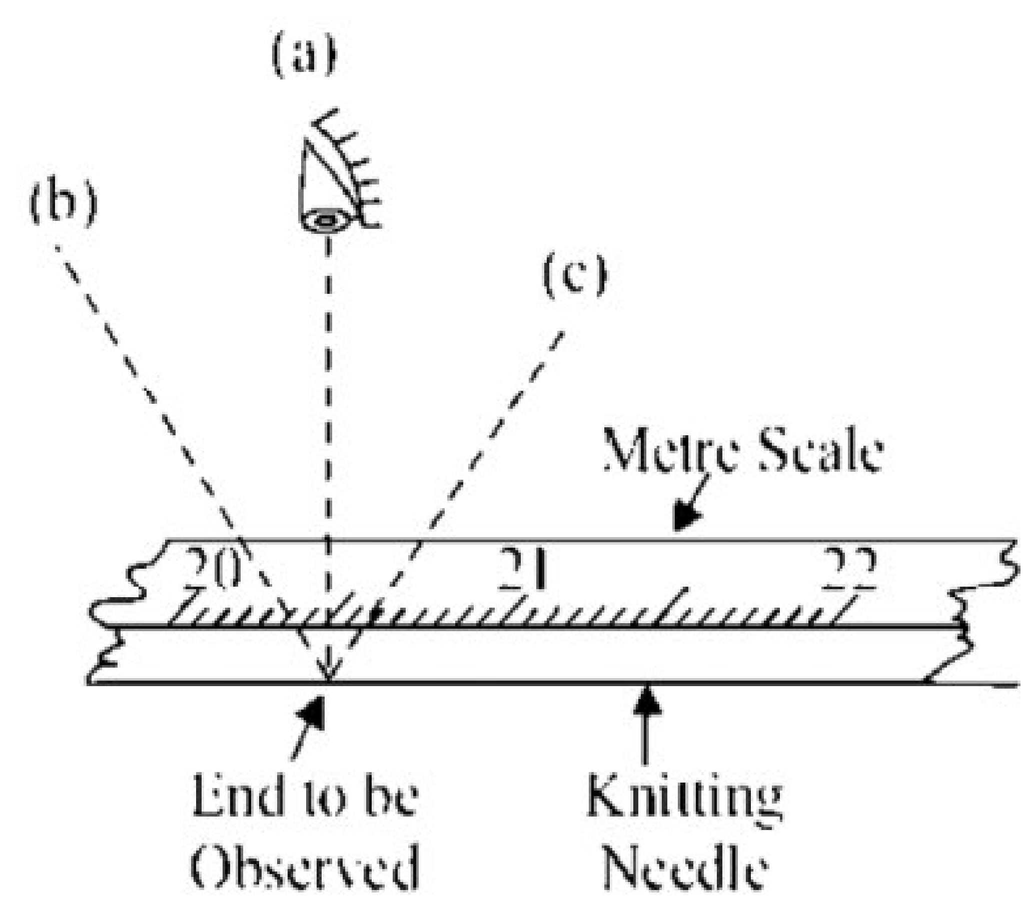


Fig 7 : Taking reading on metre scats

While observing the position of end of the knitting needle on the metre scale,again, you have to keep the. observing eye in a line perpendicular to scale, i.e. position (a) in fig 7, which gives the correct reading 20.5cm. Positions of eye at (b) or at (c) will give you a wrong reading. The thinner is the edge of the scale, the smaller is this parallax error in positions (b) or (c) of the eye. Hence in some 30cm scales, the edge is made quite thin.

A better method to use the metre scale with a thick edge is to keep it standing on the edge (Fig. 8). In this manner the end to be observed is quite close to the markings, thus making the parallax error small in case your line of sight is not perpendicular to scale. More over, the markings themselves function to some extent as direction guides, by which you can keep your eye at the correct position.

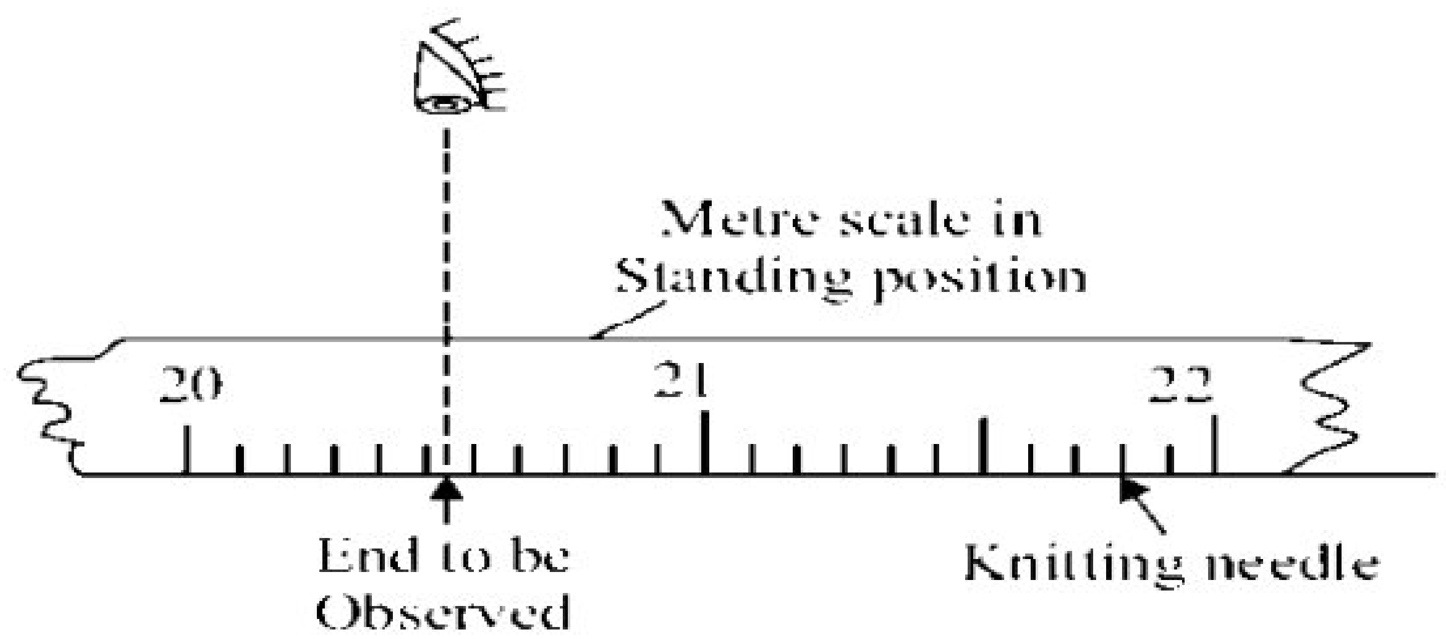


Fig 8 : Metre scale in standing position

Incase of a stop watch or a galvanometer, there is a pointer moving a little above the scale. In order to keep your line of sight perpendicular to the scale, some times you can see the image of your observing eye in the front glass of the instrument functioning as a partially reflecting mirror. In good electrical instruments, a mirror strip is built-in a long side the scale. Thus you see the image of the pointer in this, mirror strip.You keep your observing eye in such a position that the pointer and its image coincide.

B. GENERAL INSTRUCTIONS ON OPTICAL EXPERIMENTS

The eye and the ear, the two most important of our sense-organs, receive stimuliin the form of waves, viz. light (electromagnetic waves) and sound (mechanicalwaves). The study of wave-phenomena is, therefore, of utmost importance.Optics, the study of light energy, has provided us with tools like spectrometers;aids of vision like microscopes, telescopes, spectacles, photographic camera andtoys like kaleidoscopes. All those things, not only have given us a new insightinto the microcosmos and microcosmos, but also have improved quality of ourlife immensely.All this has become possible through the study of light energy and its effect onmatter. Moreover, the study of light energy is easy and interesting and requires very simple and low-cost apparatus.

(i) While looking at the object and image-pins your eyes should be kept atleast 25 cm away from the nearest pin.

(ii) The pins should be held vertical and parallax should be removed between the concerned pins, tip to tip.

(iii) Line diagrams should be drawn for image formation indicating the rays with arrow heads.

METHOD OF PARALLAX

Relative shift in the position of a body, with respect to another body, on viewing it from two different positions is called parallax. More is the separation between the bodies more is the parallax between them. In Fig. 9 as the eye is moved from O to A, the pin X moves towards the left of X and on moving the eye from O toB, it moves towards the right. But when X and Y are one above the other, no parallax is observed as we look at them from different positions. (Fig. 10).

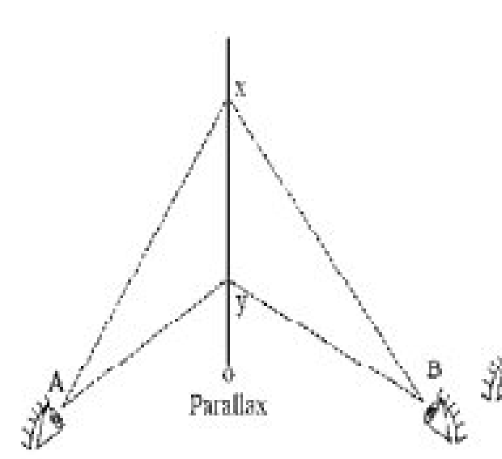


Fig 9

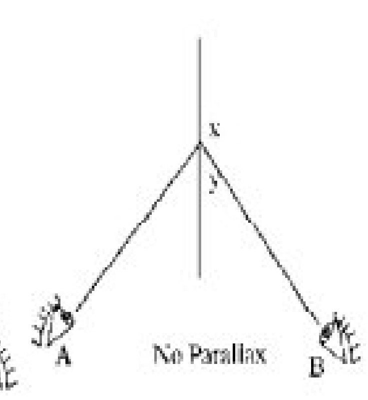


Fig 10

Method of parallax is used to locate the position of a real image. When on moving the eye from one side to other the tip of image pin is found to remain coincident with the tip of the image we say that there is no parallax between them and hence the image - pin gives the position of the real image.

C. GENERAL INSTRUCTIONS FOR MAKING CIRCUIT CONNECTIONS.

In electricity experiments, you often have a circuit diagram. You are required to connect various pieces of apparatus by copper wires according to that diagram for performing the experiment. The ends of copper wire may have anoxide layer on them. Thus on connecting an end to a terminal, resistance of this oxide layer may add an extra resistance in the circuit. To eliminate this contact resistance, ends of each copper wire should be cleaned by sand paper, to remove the oxide layer. Check whether the surfaces of the screws of the terminals are also clean. If not, clean them by a liquid cleaner (e.g. Brasso). Sand paper does make the surface of wires rough. But copper being a soft metal, when screw presses on the wire, contact is established over a substantial area.

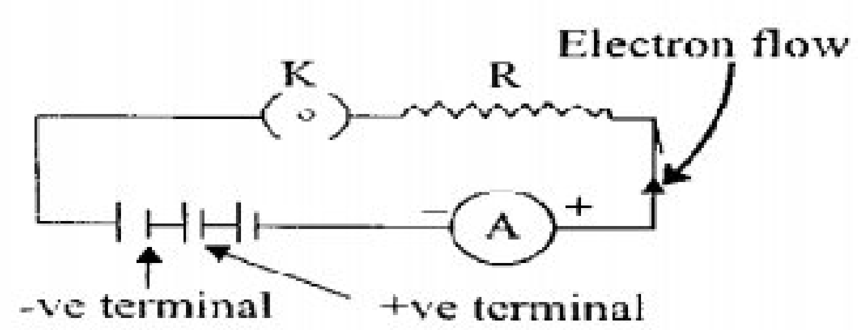


Fig.11

When you connect a few cells in series to obtain an e.m.f. more than what one cell can provide, then positive of each cell connects to negative of the adjacent cell(Fig.11). But in case of a circuit element like ammeter or voltmeter, the situation is the exact opposite. The terminal marked (-) is to be connected to he terminal marked(-) on the battery

.

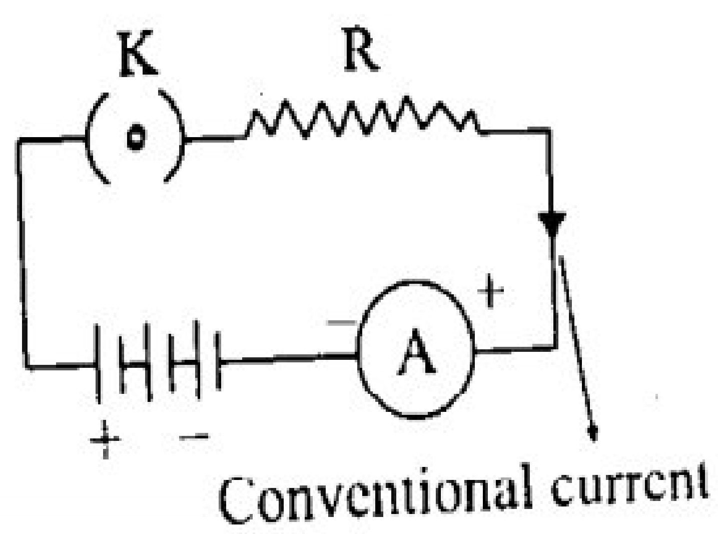


Fig.12

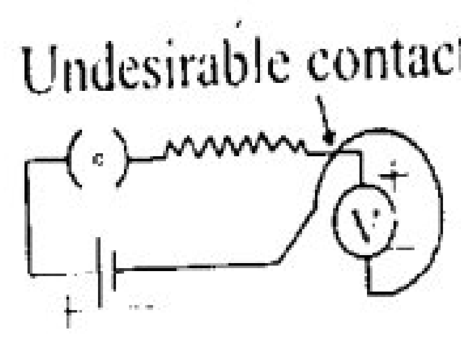


Fig. 13(a)

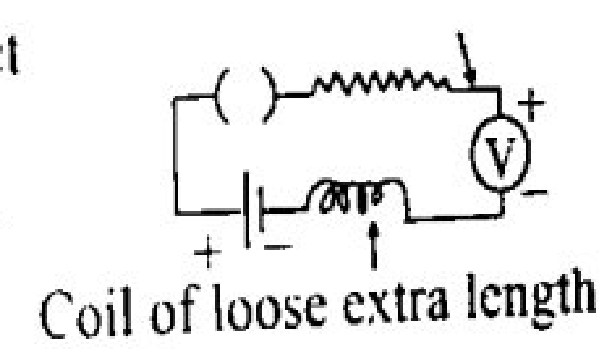


Fig. 13(b)

The flow of current in a circuit is actually drift of electrons only (except in electrolytes or semi conductors), The terminal marked(-) in a cell provides electrons to circuit and (+) receives them back (Fig.11). However, we state the direction of current to be opposite to the direction of electron flow. i.e. we find it convenient to talk in terms of the conventional current, in which we imagine positive charge flowing in the circuit(Fig.12).

In making electrical connections it is preferable to use wires insulated by a double layer of cotton(DOC wires). If wire of two different parts of the circuit happen to touch each other(Fig.13a) still they do not get electrically connected due to this insulation. Even then it is a good precaution to layout your circuit in such a way that such undesired contact of wires does not take place.If there is a loose extra length of wire in some part of the circuit, it may be wound into a coil (Fig. 13b) in an a.c. circuit, such loose extra

D. SAFETY IN THE PHYSICS LABORATORY

In the physics laboratory, care lessness can lead to accidents causing injury to you or to your neighbour. Some instruments are costly. If such an instrument is damaged in an accident, it can paralyze the work of the whole class. Proper handling of apparatus and other materials can prevent majority of accidents. Remember the following points and act on them, while working in the physics laboratory.

(i) Put off the gas to extinguish the flame of a burner. Do not use any solid or liquid for this purpose (like putting a cap or pouring water as for extinguishing burning coal).

(ii) Do not throw any broken glassware, etc. in the sink. Such things should be thrown in to the waste basket.

(iii) Do not talk to other students in the laboratory while performing the experiment. In case you have any difficulty, consult your tutor. Ofcourse,if you are a team of two or three students working on same experiment on the same apparatus, you can talk about the experiment among your selves. Each member of the team should take turns to take observations.

(iv) Never test whether a wire is carrying current by touching it, Use a tester-screwdriveror/a voltmeter of appropriate range.

(v) Whenever a sharp instrument isused, be careful not to cut or puncher your skin, e.g. while using a pair of blades to make a narrow slit.

(vi) While using a delicate instrument, e.g. a sensitive galvanometer, be careful not to pass a high current in it,which may burn it out. While using it to find a null point, use a low resistance shunt or a high series resistance initially. When you approach the null point, then remove it to make the instrument sensitive and make fine adjustment of the null point.

(vii) Take care not to wet any instrument, unless it is part of the experiment itself.

Cuts and Burns

- For wound caused by a broken glass or any sharp edge, remove the glass piece from the wound, control the bleeding by pressing a clean cloth or handkerchief or by a sterile surgical dressing. Apply a little dettol, or spirit, or burnol, or savlon and cover it with bandage.
- For wounds due to heat of a flame or due to touching a hot object, put the burnt portion under cold water for15min. to 30min. Then apply burnol.

E. MAINTENANCE OF RECORD BOOK

Now, you are surely interested to know how to maintain the record book for experiments done by you. While performing an experiment, most probably you have acted on the steps as given in this manual. In some situations you may have followed a procedure a little different from that described in this manual, on the advice of your tutor. For writing the experiment in the record book, you may use the format having following sections:

- Aim of the experiment.
- Apparatus and material used for the experiment.
- Procedure followed, if it is slightly different from the one described in this manual.
- Observations which you take during the experiment.
- Calculations that you do after taking observations.
- Result, the final conclusion that you get on the basis of observations and calculations.
- Precautions taken by you during performing the experiment.

F. SCHEME OF PRACTICAL EXAMINATION

Duration : 3 hours

There will be a practical examination of 20 marks apart from the theory examination.

The distribution of 20 marks is as follows:

(i)	Viva	3Marks
(ii)	RecordBook	3Marks
(in)	Two Experiments (7 marks each) (they should not be from the same group)	14Marks

EXPERIMENT 1

Determine the internal diameter and depth of a cylindrical container (like tin can, calorimeter) using a vernier calipers and find its capacity. Verify the result using a graduated cylinder.

1.1 OBJECTIVES

- After performing this experiment, you should be able to:
- determine the least count and zero error of a vernier callipers
- determine the least count of a graduated cylinder
- determine the internal diameter and depth of a cylinderical vessel by a vernier callipers
- determine the capacity of a cylinder by a graduated cylinder.

1.2 WHAT SHOULD YOU KNOW

The volume of a cylinder is given by the relation

$$V = \pi r^2 h = \pi\left(\frac{d}{2}\right)^2 h = \frac{1}{4}\pi d^2 h$$

where d = internal diameter of cylinder

r = internal radius of the cylinder

h = depth of cylinder

Material Required

A vernier callipers, a calorimeter, a graduated cylinder, a glass slab.

1.3 HOW TO SET UP THE EXPERIMENT

You would have studied about vernier callipers. It consists of a pair of calliper having a vernier and main scale arrangement. The instrument has two jaws A and B.

The vernier scale can easily slide along the edge of the main scale. The graduations of the vernier scale are so designed that a certain number of divisions of vernier scale, say10, are co incident to 9 number of division of main scale.

The difference between one smallest division of the main scale and one division of the vernier scale is known as vernier constant and is also the least count of the vernier device.

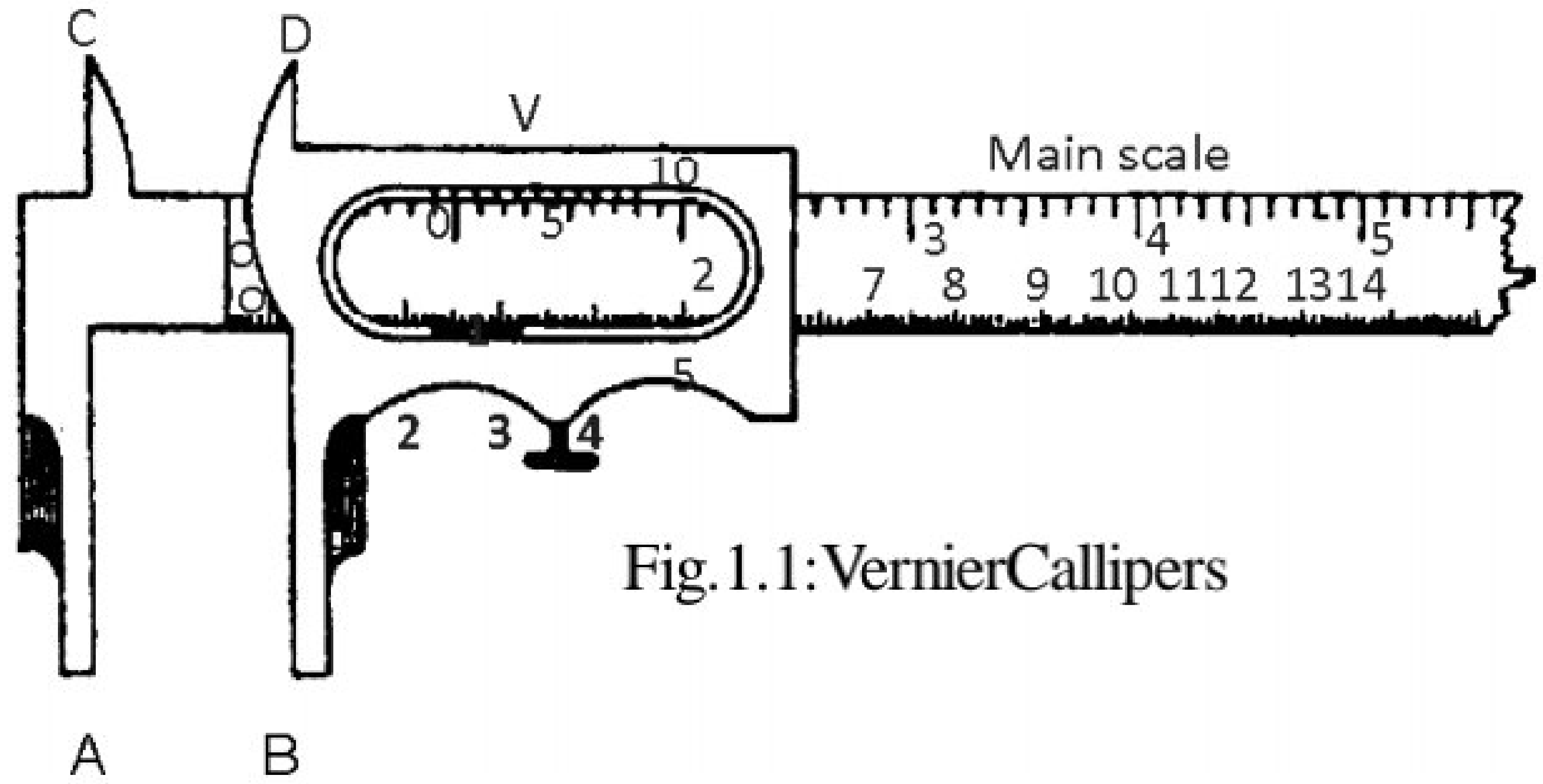


Fig.1.1:VernierCallipers

1.4 HOW TO PERFORM THE EXPERIMENT

(a) Finding least count or vernier constant

(i) Observe the divisions on the vernier scale are smaller than those on the main scale. The difference between one main scale division and one vernier division is called vernier constant or least count of the vernier callipers.

(ii) Observe the number of vernier divisions (n) which match against one less number of divisions of main scale(n-1).

(iii) Calculate the least count as follows

$$1 \text{division of vernier scale} = \frac{n-1}{n} \text{ division of main scale}$$

$$\text{Least count } = 1 \text{ main scale division} - 1 \text{ vernier scale division}$$

$$= 1 \text{ main scale division - } \frac{n-1}{n} \text{ main scale division.}$$

= 1/n main scale division

(b) To find the zero error of the vernier scale

(iv) With the jaws of the callipers closed, if the zero marks of the main scale does not coincide with the zero mark of the vernier scale, the instrument has a zero error. If the zero mark of the vernier scale is on the left of the main scale's zero mark then the zero error is negative as shown in Fig.1.2(a) and when it is on the right of the main scale's zero mark, the zero error is positive[Fig.1.2(b)].

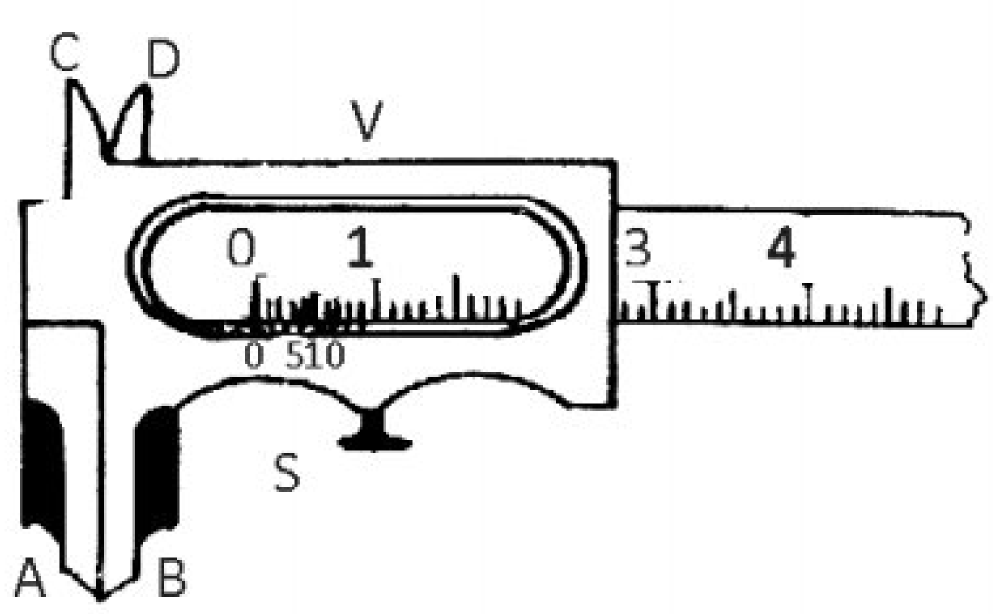


Fig.1.2(a): Negative zero error

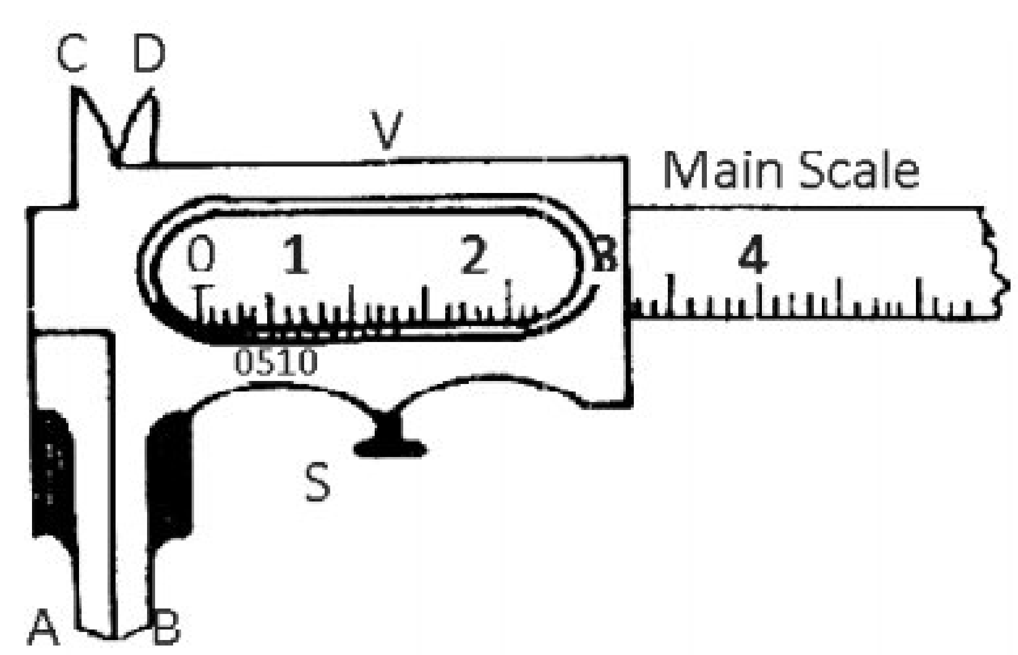


Fig.1.2(b): Positive zero error

(v) If there is zero error, observe which vernier scale (v.s.) division best coincides with any main scale (ms) division with jaws of the callipers closed. The value of the zero error is the product of the best coinciding vernier division and least count of the vernier callipers when zero error is positive. On the other hand when zero error is negative, the coinciding vernier division is to be seen from the end of the vernier scale, backwards.

(vi) While observing which vernier scale division coincides with a main scale division, it may happen that none coincides. For example, 5th may be a little ahead and 6th may be a little before a main scale division. Observe,which one is closest to a main scale division.

(c) To find the zero correction of the vernier scale

(vii) It is the negative of the zero error.

Zero correction = - (zero error)

Zero correction is added algebraically in the observed diameter to get the corrected diameter.

(d) Measuring internal diameter

(viii)To measure the internal diameter of the calorimeter, place the vernier callipers with the upper jaws inside the calorimeter as shown in the diagram (Fig.1.1).The upper jaws of the verniercallipers should firmly touch the ends of a diameter of the calorimeter, but without deforming the calorimeter.

(ix) Note the main scale reading immediately before the zero mark of the vernier and also note the division of the vernier which coincides with any of the main scale divisions.

(x) Since the calorimeter may not be of precisely circular shape, take one more observation a long a diameter perpendicular to previous one.

(xi) Repeat the pair of observations at least three times and record them.

(e) Measuring depth

Next, let the end of the vernier callipers stand on its end on a glass slab, push down its depth gauge (the central moving strip), so that it also firmly touches the glasss slab. Then note the zero error of its depth gauge.

(xiii) Next, set the vernier callipers with its end resting on the upper edge of the calorimeter and its depth gauge touching the bottom inside.Thus note the observed depth of the calorimeter. Calculate corrected depth by applying zero correction.

(f) Verification

(xiv) Next, in order to verify the capacity of calorimeter measured by vernier callipers, fill it completely with water. Pour this water in to an empty graduated cylinder and observe the volume of this water. Both values should be in agreement within experimental error.

1.5 OBSERVATIONS

One small division of main scale=................... mm

..........VS divisions =……………. MS divisions

1VSdivision= …………….MS divisions

= …………….mm

Leastcount =1MS div–1VS div

=...............mm.………........mm

=…………… mm

=……………. cm

Zero error for diameter measurement=(1)........... (2)..............(3)...........

Mean zero error= ....cm

Mean zero correction=–(Mean zero error)= ....mm

Table1.1: For internal diameter of calorimeter

S.No.	M.S.reading y	Coincident V.S. div. n	V.S. reading x=n×V.C.	Observed value=y+x
1 (a)				
(b)				
2 (a)				
(b)				
3 (a)				
(b)				

Mean observed diameter=................

d = Mean corrected diameter=………..

Zero error for depth measurement

Zero Error=(1)................. (2)................ (3)...............

Mean zero error= cm.

Mean zero correction=–(Mean zero error)= cm.

Table1.2: For depth of calorimeter(h)

S.No.	M.S.reading y	Coincident V.S. div. n	V.S. reading x=n×V.C.	Observed value=y+xi
1				
2				
3				
4				
5				
6				

Mean observed diameter=…………

d = Mean corrected diameter = ………

1.6 RESULT AND DISCUSSION

Internal valume of cylinder $\frac{1}{4}\pi^2 dh$

= ……………………………..

= ……………………………..

Verification

Volume of calorimeter as measured by graduated cylinder=………..

1.7 SOURCES OF ERRORS

(i) None of the vernier divisions may be exactly coincident with a main scale division.

(ii) The vernier scale may be loose,.and the caliberation may not be uniform. Similarly, vernier jaws may not be at right angles to its main scale. These are common small defects in cheaper instruments.

1.8 CHECK YOUR UNDERSTANDING :

(i) What is vernier scale and why is it so called?

....

(ii) What is meant by vernier constant?

....

(iii) If the zero of V.S. is on the left of the zero of M.S. the zero error is positive or negative?

....

(iv) How is zero error determined?

....

(v) What is the advantage of the vernier?

....

(vi) If zero error is – 0.03 cm, what is the value of zero correction?

....

(vii) How can you find the thickness of the bottom of a hollow cylinder by using vernier callipers?

....

EXPERIMENT 2

Determine the diameter of a given wire using a screw gauge

2.1 OBJECTIVES

After performing the experiment you should be able to:

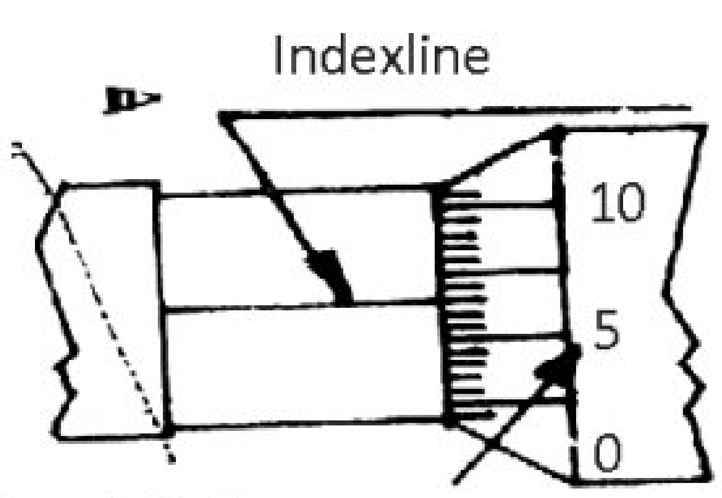
- determine the least count of a screw gauge;
- determine the zero error of a screw gauge.
- determine the diameter of a wire using a screw gauge.

2.2 WHAT SHOULD YOU KNOW

(i) **Pitch:** The pitch of the screw is the distance through which the screw moves along the main scale in one complete rotation of the cap on which is engraved the circular scale.

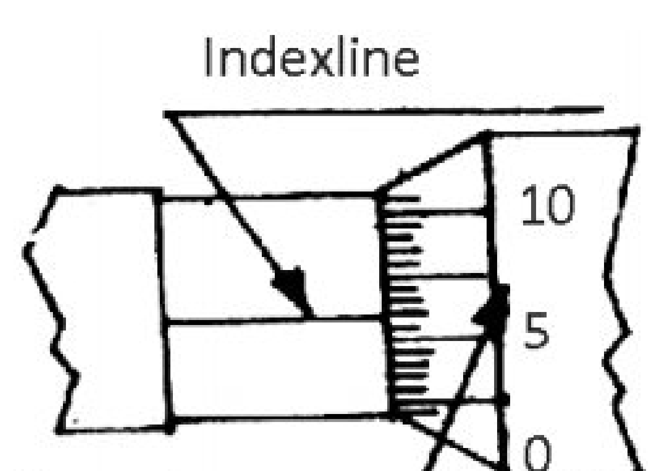
(ii) **Least Count:** The least count of the screw gauge is the distance through which the screw moves when the cap is rotated through one division on the circular scale.

(iii) **Zero error and correction:** When the zero mark of the circular scale and the main scale do not coincide on bringing the studs in contact the instrument has zero error. The zero of the circular scale may be in advance or behind the zero of the main scale by a certain number of divisions on circular scale. If the zero of the circular scale is ahead of the zero of main scale the zero error is negative (Fig. 2.1a). On the other hand if the zero of the circular scale is behind the zero of the pitch scale, the zero error is positive (Fig. 2.1b).



Zero is below
The index Line By 3 Div

Fig. 2.1(a): Negative zero error



Zero has crossed over
The index Line By 3 Div

Fig. 2.1(b): Positive zero error

(iv) **Back-lash error:** Owing to ill fitting or wear between the screws and the nut, there is generally some space for the play of the screw, the screw may not move along its axis for appreciable rotation of the head (or cap, on which circular scale is marked). The error so introduced is called back-lash errors. To eliminate it you must advance the screw, holding it by the ratched cap, when making final adjustment for finding zero error or the diameter of the wire.

Material Required
Given wire, screw gauge

2.3 HOW TO PERFORM THE EXPERIMENT

(i) **Measuring pitch:** To measure the pitch, give several rotations to its cap and observe the distance through which screw moves. Calculate the pitch using the following formula.

$$\text{Pitch} = \frac{\text{distance moved}}{\text{No. of complete rotations}}$$

(ii) **Measuring least count:** To measure the least count note the number of divisions on the circular scale and calculate

$$\text{Least count (L.C.)} = \frac{\text{Pitch of the screw}}{\text{No.of divisions on the circular scale}}$$

(iii) **Measuring zero error:** With the study in contact observe the numbers of divisions by which zero of the circular scale deviates from the zero of the main scale. This number multiplied by the least count gives the required zero error.

(iv) **Calculate the zero correction:** It is negative of zero error.

Zero correction = - zero error

Zero correction is added algebraically in the observed diameter of wire to get the corrected reading

(v) **Measuring diameter:** To measure the diameter of the wire move the screw back to make a gap between the studs. Insert the wire between the studs. Turn the screw forward by holding it from the ratchet cap and wire should be held gently between the two studs.

(vi) Read the nearest division on the circular scale in line with the main scale and also find the complete rotations of the cap with the help of the main scale. Calculate the observed diameter.

Observed diameter = pitch x number of complete rotation
+ L.C.x circular scale reading

(vii) Repeat the experiment for 5 observations at different points of the wire along its length. Find the mean observed diameter and apply the zero correction to obtain correct diameter.

2.4 WHAT TO OBSERVE

Linear distance covered in 4 complete rotations = ...mm

Linear distance covered in 1 complete rotation = ...mm

$\therefore$ Pitch of the screw = ... mm = ... cm

Number of division on circular scale = ...

$$\text{Least count} = \frac{\text{pitch}}{\text{Number of division on circular scale}}$$ = ... cm

Zero error = (1) .... (2) .... (3) ....

Mean zero error = ...

Mean zero correction = - (Mean Zero error)

= .... to be added algebrically.

Table 2.1: Screw gauge readings for diameter

S.No.	Readings		Observed diameter = m x pitch + n x L.C.
	Linear Scale m (div)	Circular Scale m (div)	
1			
2			
3			
4			
5			

Mean observed diameter = ... cm

Mean corrected diameter= D = ... cm

2.5 SOURCES OF ERRORS

(i) If the instrument be screwed up tightly when finding zero error or taking reading of diameter of wire(perhap on account of defective on hard ratchet cap)it may compress the wire out of shape.

(ii) If the screw it not turned by holding the ratchet cap then the screw may compress the wire out of shape.

(iii) As mentioned earlier, to eliminate the back-lash error, the screw should always be turned in the same direction (i.e. in forward direction) when making the final adjustment Negligence of this procedure can rise a major error.

2.6 CHECK YOUR UNDERSTANDING

(i) Why is this instrument called a screw gauge ?

....

(ii) What do you understand by pitch of a screw gauge?

....

(iii) What do you understand by least count of a screw guage?

....

(iv) What is back-lash error and how it can be avoided?

....

(v) What is the use of ratchet arrangement in a screw guage?

....

(vi) If the zero of circular scale is ahead of the zero of main scale by 7 divisions of circular scale and least count is 0.005 mm. what is the zero error and the zero correction ?

....

EXPERIMENT 3

To find the time period of a simple pendulum for small amplitudes and draw the graph of length of pendulum against square of the time period. Use the graph to find the length of the second's pendulum.

3.1 OBJECTIVES

After performing this experiment you should be able to:

- set up a simple pendulum swinging freely about a sharp point of suspension and measure its time period accurately;
- measure the length of the pendulum in hanging position;
- draw a graph between square of time period versus length of the pendulum and thus find the length of second's pendulum;
- comprehend that length of second's pendulum is specific to a certain place.
- appreciate that time period increases as length increases, and is proportional not to length but to square root of length.

3.2 WHAT SHOULD YOU KNOW

A simple pendulum is a small heavy 'bob' B hanging by a light and inextensible string S(fig. 3.1). In'equilibrium position ' string is vertical. While oscillating, the 'amplitude of oscillation' is the maximum angle that thread makes with the vertical (or sometimes the maximum horizontal displacement of the bob). Its time period T, i.e., time taken for one oscillation depends on its length i.e. distance from point of suspension to C.G. of bob B (fig. 3.2):

$$T \alpha \sqrt{l}$$

or $T^2 \alpha l$

Thus graph between T^2 versus *l* is a straight line passing through the origin. *l* also increases if amplitude is large, but for small amplitudes it is constant.

Second's pendulum is one which takes one second to move from one end of the swing to other.Thus its time period is 2 s.

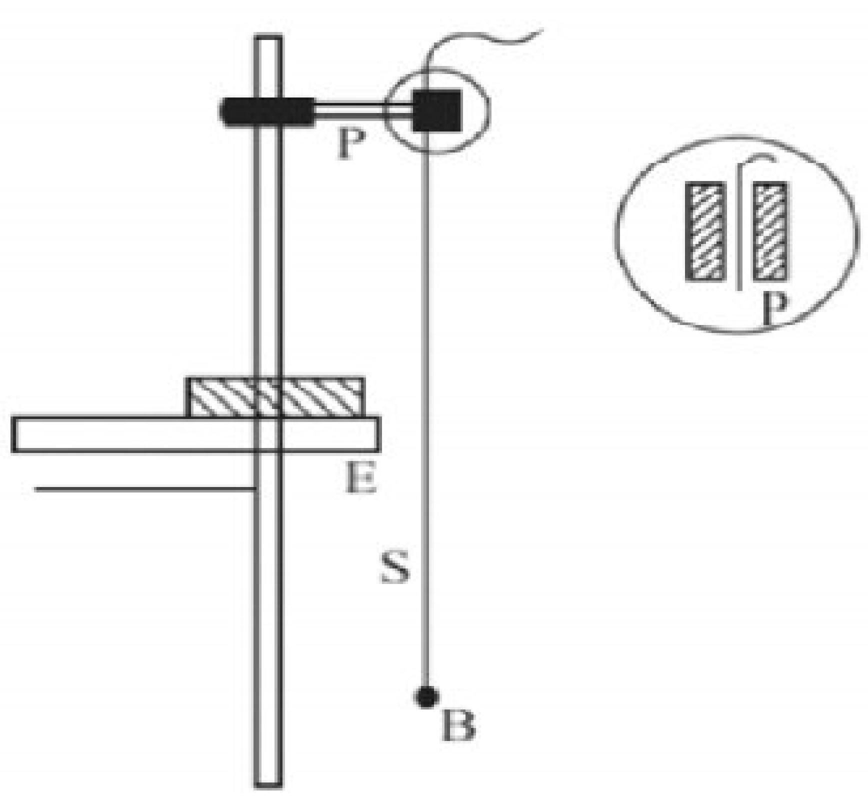


Fig. 3.1

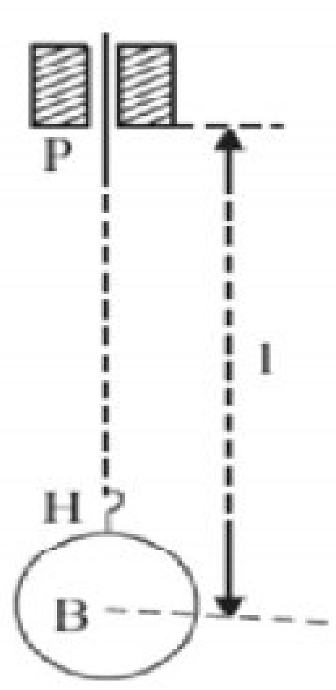


Fig. 3.2

Material Required

A spherical bob; stop watch (with least count of 0.1 second or less), tall laboratory stand with clamp, split cork, fine thread, two small wooden blocks. metre scale.

3.3 HOW TO SET UP AND PERFORM THE EXPERIMENT

(i) Measure diameter of the bob with the help of the metre scale and the two wooden blocks. Then tie one end of thread in the hook of the bob.

(ii) Pass the other end of the thread between two pieces of the split cork and clamp it in the clamp of the stand (Fig 3.1). The point P, where the thread comes out of the cork is thus a sharp point of suspension, whose position does not change the pendulum swings. To ensure this, check up that two pieces of the split-cork have sharp lower edges at P.

(iii) Make a length of about 125 cm of this pendulum for the first set of readings. Measure the length from foot of the hook H to point of uspension P (fig 3.2), Add to it half the diameter of the, bob to obtain l . the length of the pendulum. Length PH must be measured with bob suspended, as the thread may have some elastic extension by the weight of the bob.

(iv) Adjust position of stand to bring this pendulum close to edge E of the table (Fig 3.1). On a white strip of paper stuck at the vertical end face of the table, mark a vertical line. The thread coincide with this line in its vertical position, when you see it from the front.

(v) The bob to one side and release so that it oscillates with an amplitude of less than 4°(Fig 3.3). If height of P above table is about 60 cm, then maximum displacement of thread from central mark is not more than about 4 cm.

(vi) With the help of stop watch, measure time of 20 oscillation. You should start the watch when thread crosses the central mark in a given direction and count 'zero'. At the count 'twenty' when thread crosses the central mark in the same direction, stop the watch. Take three consistant readings, lest there is an error in counting. Then calculate time of one oscillation T.

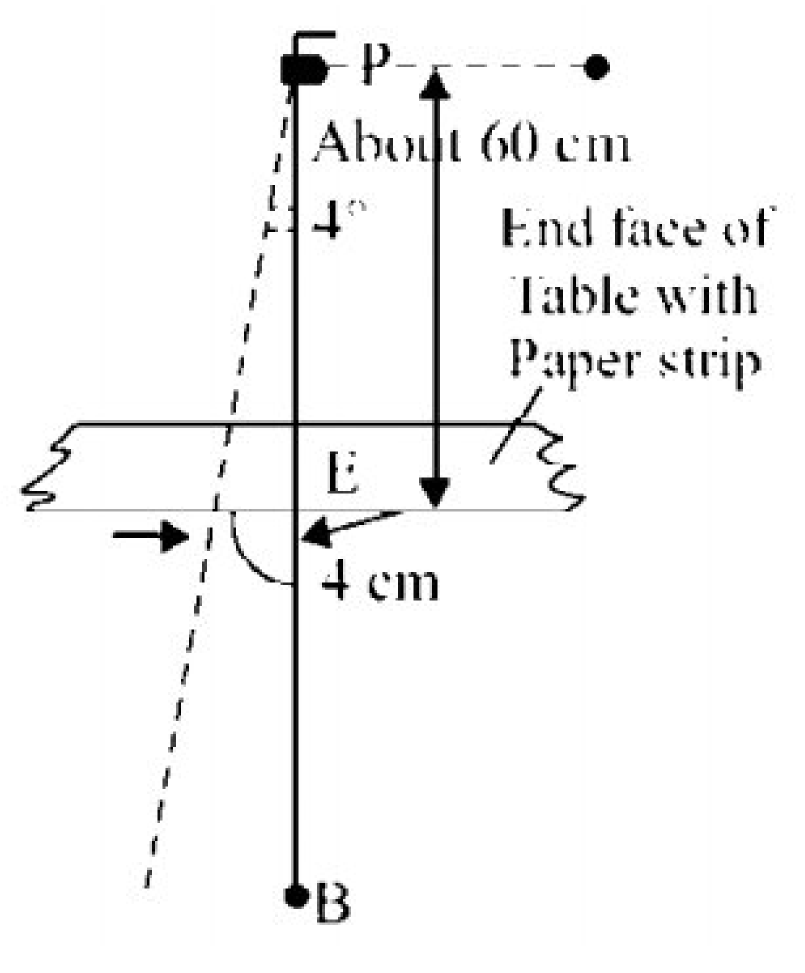


Fig 3.3

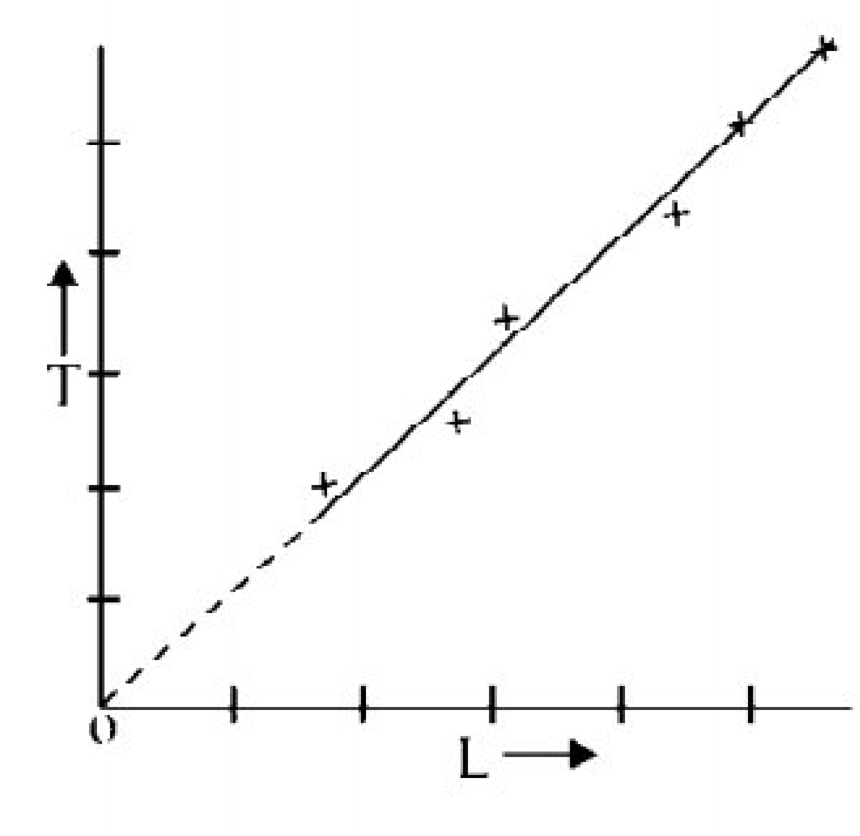


Fig. 3.4

(vii) Repeat steps (3) to (6) making shorter lengths of the pendulum upto about 20 cm.

(viii) For each length calculate T^2 and plot a graph between T^2 versus l (Fig. 3.4) from this graph find the value of l for $T^2 = 4s^2$.

3.4 WHAT TO OBSERVE AND ANALYSIS OF DATA

Diameter of the bob = (1) .... (2) .... (3) ....

Mean diamter = ...

Radius of the bob l = 1/2 (diameter)

Table 3.1 : Measurement of time period

S.No.	Lenghth PH	l = PH +r	Time of 20 oscillations				T	T^2
			(1)	(2)	(3)	Mean		

From T^2 versus l graph, l for $T^2 = 4s^2$ is ....

3.5 RESULT

i) T^2 versus -l graph is found to be a straight line passing through origin. Hence, $T \alpha \sqrt{l}$

ii) Length of second's pendulum at the place of the experiment is

a) by graph

b) by calculation (T= $2\pi\sqrt{l/g}$ for seconds pendulum T=2s and obtain value of g at your place of experiment from a table of physical constants).

3.6 SOURCES OF ERROR

i) If the stand is not quite rigid, it may cause horizontal movement of the point of suspension while the pendulum swings. This may affect the time period.

ii) Elasticity of thread may result in error in measurement of length of pendulum.

3.7 CHECK YOUR UNDERSTANDING

i) Time period is defined as the time interval in which the pendulum makes one oscillation. To measure it why you are advised the indirect approach of first measuring time of 20 oscillations and then calculate time of one oscillation, instead of simply measuring the time of 1 oscillation by the stop watch?

....

ii) How does it help in making accurate measurement of time period if you measure time of 50 oscillations instead of 20 oscillations?

....

iii) If length of a pendulum is (a) decreased to 1/9th (b) increased to 9 times its previous length. Then its time period becomes (Choose the correct answers in the two cases).

i) 1/9th ii) 9 time iii) 1/8 th iv) 81 times

v) 1/3rd vi) 3 times

....

iv) Without changing the length of your pendulum, you carry it to another place where acceleration due to gravity is larger.

a) Does its time period change? If so how ?

b) Does the length of seconds pendulum change ? If so how?

....

EXPERIMENT 4

To find the weight of a given body using law of parallelogram of vectors.

4.1 OBJECTIVES

After performing this experiment, you should be able to:

- set up a point in equilibrium under the action of three forces;
- recognise tension in strings;
- see that bodies always hang vertically under the action of gravity;
- recognise weight as a force due to the earth on any body;
- understand that if number of forces act on a body simultaneously it is possible to find a single force which will produce the same effect is the resultant force.

4.2 WHAT SHOULD YOU KNOW

(1) According to Newton's Third Law of motion, tension in a string supporting a body is equal to the weight of the body.

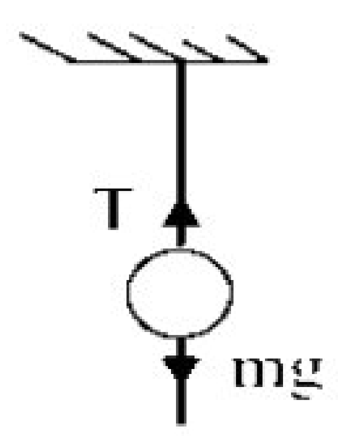


Fig. 4.1

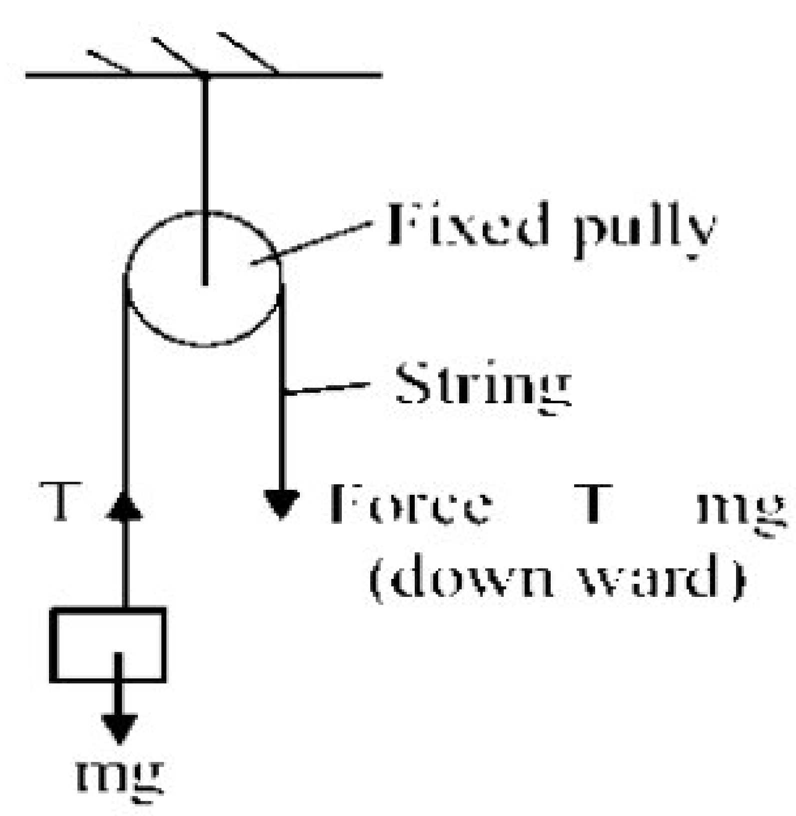


Fig. 4.2

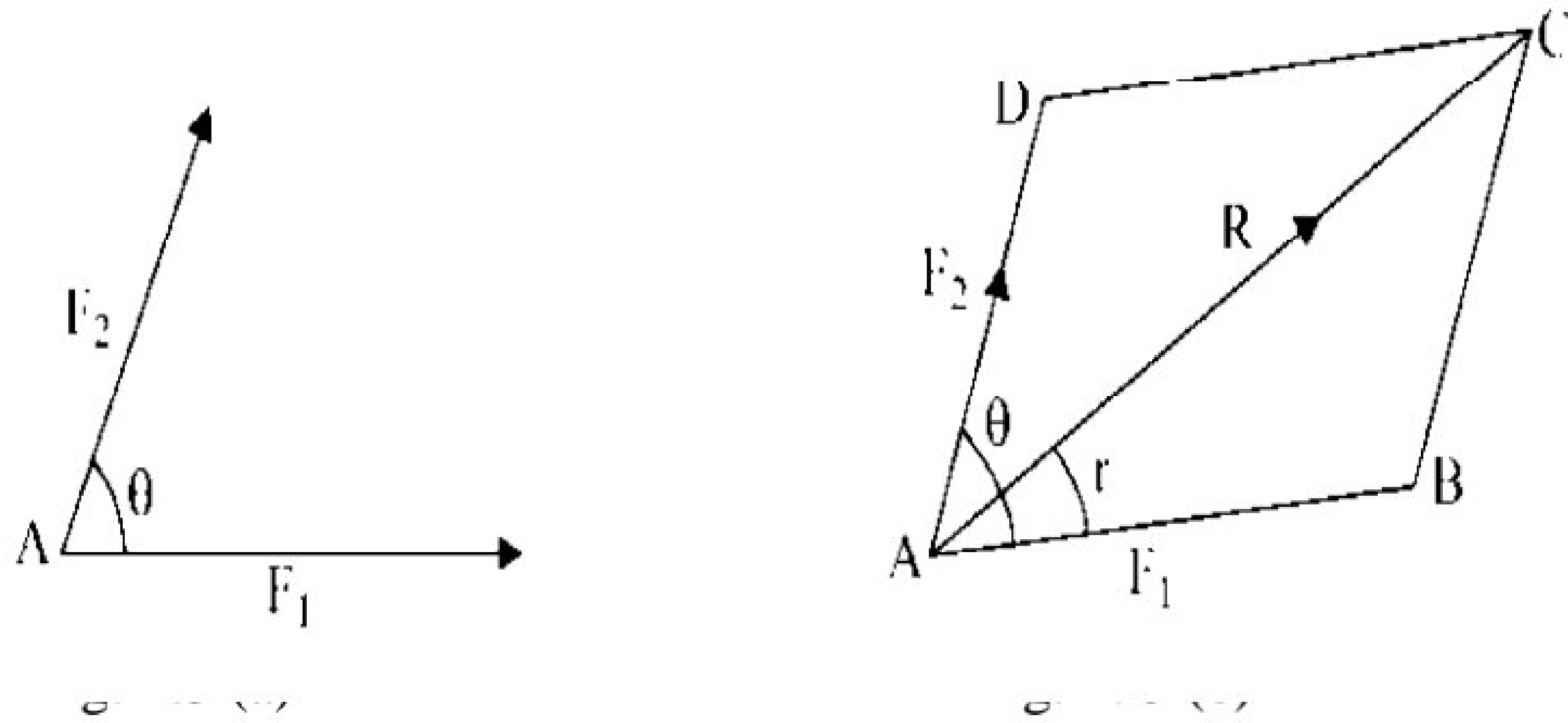
(i) The weight due to a body of mass m = mg (Fig. 4.1). Therefore tension in the string is :

T= mg

(ii) A fixed pulley only changes the direction of force and not its value (Fig. 4.2).

(iii) Forces are vectors and they cannot be added arithmetically. Resultant force is a single force that produces the same effect as a combination of two or more forces. A body is said to be in equilibrium if the resultant force on it is zero.

(iv) **Law of parallelogram of vectors:** If two vectors acting simultaneously on a particle be represented in magnitude and direction by the two adjacent sides of a parallelogram drawn from a point, then their resultant is completely represented in magnitude and direction by the diagonal of that parallelogram drawn from that point.



In Fig 4.3(a) F_1, and F_2, are two forces acting simultaneously on point object at A at an angle θ. They are represented in magnitude and direction by sides AB and AD of the parallelogram ABCD.

The diagonal AC will represent R the resultant force.

$$R = F_1 + F_2.$$

$$|R| = F_1^2 + F_2^2 + 2F_1F_2 \,\mathrm{Cos}\,\theta$$

$$\text{Also tax } \alpha = \frac{F_2 Sin\theta}{F_1 + F_2 Cos\theta}$$

Where r is the angle which the direction of the resultant, R, makes with the direction of F_1

If F_1 or F_2 change in magnitude or direction R will also change.

Material Required

Parallelogram law of forces apparatus (Gravesand's apparatus), plumb line, slotted weights,thin strong thread, white drawing, paper sheet, drawing pins, mirror strip, pencil, set square/protractor, a body whose weight is to be determined.

4.3 HOW TO PERFORM THE EXPERIMENT

i) Set up the Gravesand's apparatus with its-board vertical arid stable on a rigid base. Check this with the help of a plumb line (Fig. 4.4)

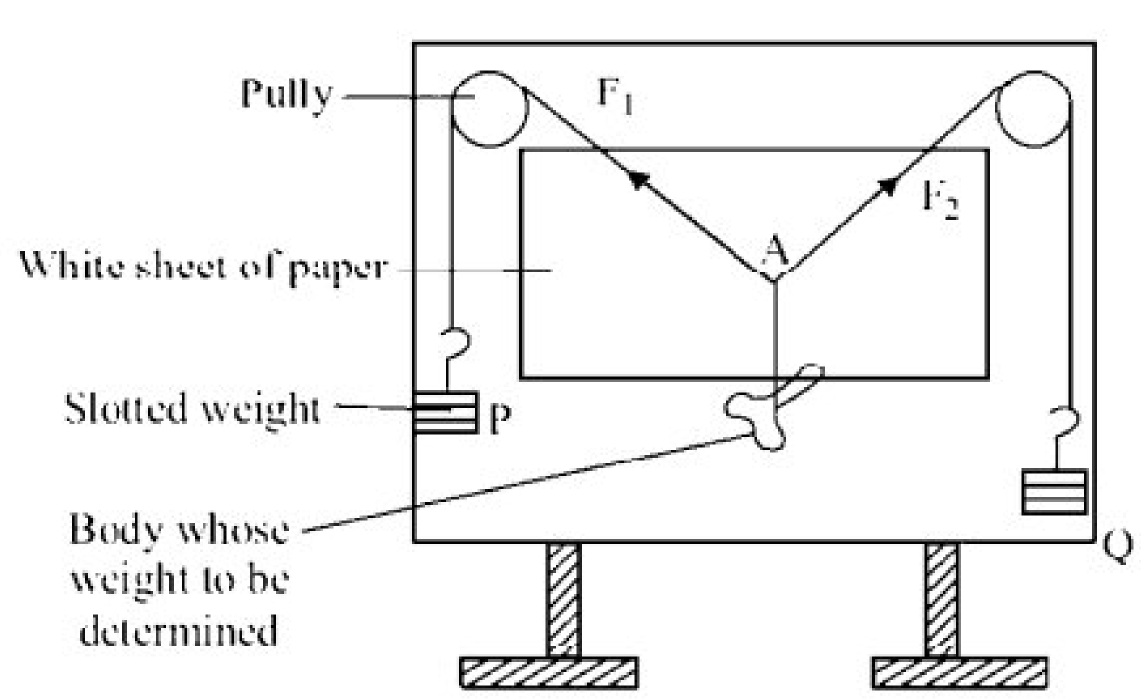


Fig. 4.4: Grayesand's apparatus

(ii) Oil the axle of pulley so as to make them move freely.

(iii) Fix the white drawing sheet on the board with the help of pins.

(iv) Cut a l m long thread. Tie the hooks of the slotted weights at its ends.

(v) Pass the thread over the two pulleys. The hangers must hang freely and they should not touchthe board or pulley or ground.

(vi) Cut 50 cm long thread. Tie the body whose weight is to be determined at one end of the string.

(vi) Knot the other end to the centre of l m thread at A.

(viii) Adjust the three weights such that the junction A stays in equilibrium slightly below the middle of the paper. The three forces are:

F_1-due to slotted weights P.

F_2 - due to slotted weights Q.

R- due to the weight of the body.

F_1 =P (slotted weight + Weight of hanger)

F_2 = Q(slotted weight + weight of hanger)

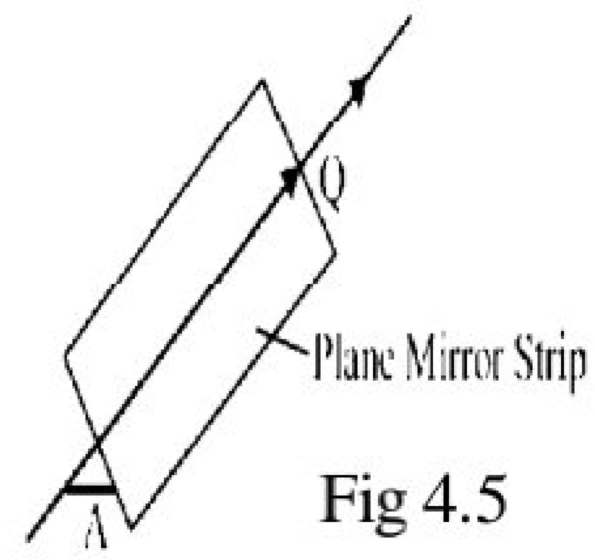


Fig 4.5

Perhaps with a given set of weights P and Q and body of unknown weight you find that central junction A can stay anywhere within a circle. Try to locate the centre of this area and bring the junction A there.

(ix) To mark the direction of the forces, place the plane mirror strip lengthwise under each thread in turn. Mark two points one on either ends of mirror strip by placing your eye in such a position that the image of the thread in strip is covered by the thread itself. The points should be marked only weights are at rest.

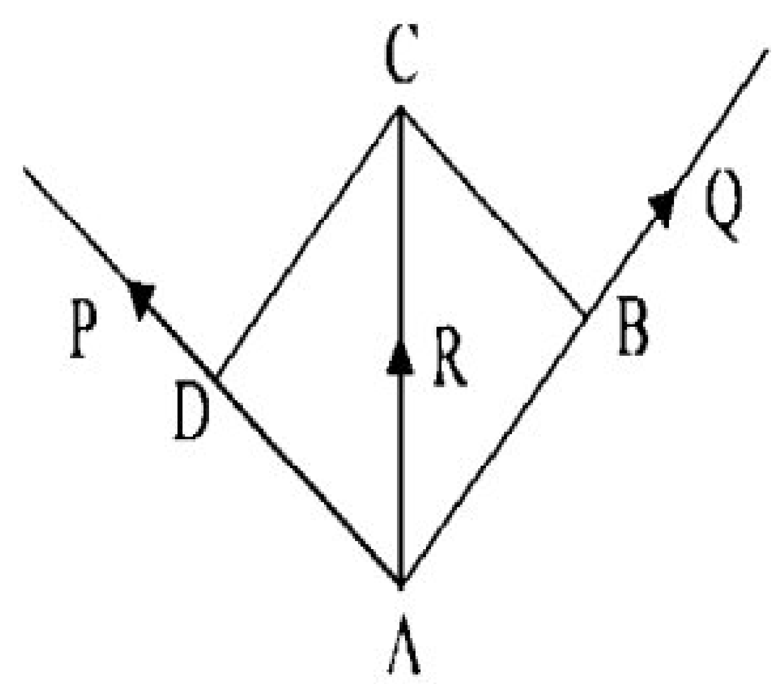


Fig 4.6

x) Note the value of the weights P and Q. Do not forget to add the weight of the hanger along with each. Find weight of hanger by spring balance.

xi) Remove the sheet of paper. Join the marked points to show the direction of forces (Fig. 4.6).

xii) Choose a suitable scale to indicate the forces, so as to get a large parallelogram.

From A mark off B such that AB = $\frac{Q}{n}$ and

D such that AD = $\frac{p}{n}$ to represent forces due to

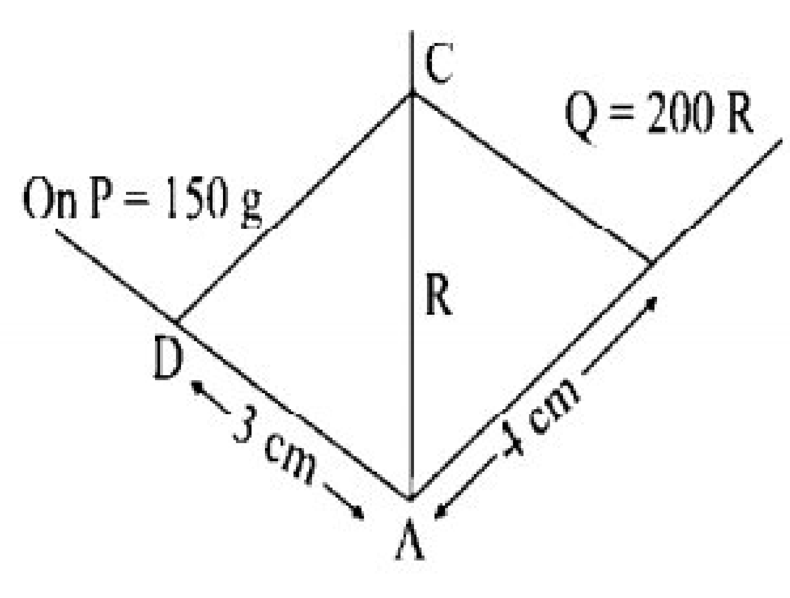


Fig 4.7

n the weights and hanger. Here, n grown weight is represented by 1 cm.

The number n should be so chosen that the lengths AB and AD are accommodated in the drawing sheets.

An example will make these points clearer. In an experiment P= 150g and Q=200 g and their directions were recorded as shown in Fig. 4.7. Choose a scale 1 cm = 50 g

$$\therefore \text{ AD } \frac{150}{50} = 3 \text{ cm}$$

$$\text{and AB} = \frac{200}{50} = 4 \text{ cm}$$

completing the parallelogram we measure and find that

$\therefore$ R = 4.4 x 50 = 220.0 g

or 220 g.

The diagonal AC gives the value of resultant and hence in our case the unknown weight of the body.

xiii) Repeat the experiment twice again by changing weights in the hangers. Find the average value of the unknown weight.

4.4 WHAT TO OBSERVE

i) Weight of hanger .... g

ii) Scale for drawing the prallelogram, 50 g = 1 cm (or any other), 1cm=ng.

Table 4.1: Table for weight of the body

S.No.	Forces (slotted weight + hanger)		Diagnoal AC y (cm)	Resultant force R = y x n (gwt)	Weight of the given body
	P	Q			
1					
2					
3					

Average weight = ...g.

4.5 RESULT

Weight of the given body = ...g.

4.6 CHECK YOUR UNDERSTANDING

i) When do we say a body is at rest ?

....

ii) Why the thread junction does not come at rest at the same position always ?

....

iii) Why the suspended weights are kept away from board or table?

....

iv) A student has value of P=200 g. Q=250 g and angle between them is (a) 90°, (b) 60°. (c)= 30^0 Find the resultant by drawing a suitable parallelogram. (Take 50 g=1 cm)

....

v) For pulling down a tall tree why ropes are pulled in two different directions making an acute angle between them?

....

EXPERIMENT 5

Determine the specific heat of a solid using the method of mixtures.

5.1 OBJECTIVES

After performing this experiment, you wil lbe able to:

- understand the principle of heat exchange;
- verify heat is lost to the surrounding whenever hot bodies are placed in cooler surroundings i.e. heat flows from higher temperatures to lower temperatures;
- appreciate that energy is always conserved and, therefore, heat energy is also conserved;
- recognise that different materials have different specific heats; and
- determine the specific heat of a solid.

5.2 WHAT SHOULD YOU KNOW

(i) **Specific heat:**The amount of heat required for a unit mass of substance to raise its temperature by 1°C is defined as specific heat.

The unit of specific heat is cal $g^{10}C^{-1}$ or J $kg^{-1°}C^{-1}$ and it is read as calory per gram per degree celcius or Joule per kilogram per degree celcius.

(ii) **Heat lost or gained by a body:** For a body of mass, specific heat s and change in temperature Δt,

Heat gained = ms Δt { Δt - rise in temperature}

Heatlost = ms Δt { Δt-fall in temperature}.

(iii) Heat-exchange takes place between solids, liquids and surroundings. What ever heat is lost by a hot body is taken up by the cooler ones in its contact because energy is conserved. This is known as principle of heat exchange which states that,

Heat gained by a cold body = heat lost by a hot body

This can be used to find the specific heat of solids and liquids.

(iv) **Method of Mixture:** States that if a hot solid is placed in a cold liquid with which it has no chemical reaction then the heat lost by the solid body is equal to heat gained by the liquid, assuming there is no loss of heat to the surroundings.

Material Required

Calorimeter with insulated box and stirrer, heating arrangement, brass bob, two thermometers, measuring glass cylinder thread, spring balance to find the mass of bob.

5.3 HOW TO PERFORM THE EXPERIMENT

(i) Clean and weigh the calorimeter and stirrer using the spring balance.

(ii) Place the calorimeter in its insulated box.

(iii) Measure 60mL of water using the measuring cylinder and pour it carefully in the calorimeter.

(iv) Fix the thermometer in the stand and note the temperature of this cold water.

(v) Tie a thread to the brass bob; heat it in boiling water for a few minutes. Note the temperature of boiling water by second thermometer already fixed in it, in another stand.

(vi) Quickly transfer the brass bob into the water in the calorimeter; cover the lid; and stir.

(vii) The temperature of water will rise and then become steady. Thereafter it slowly falls on account of loss of heat to the surrounding.

(viii) Note the steady, final temperature of water.

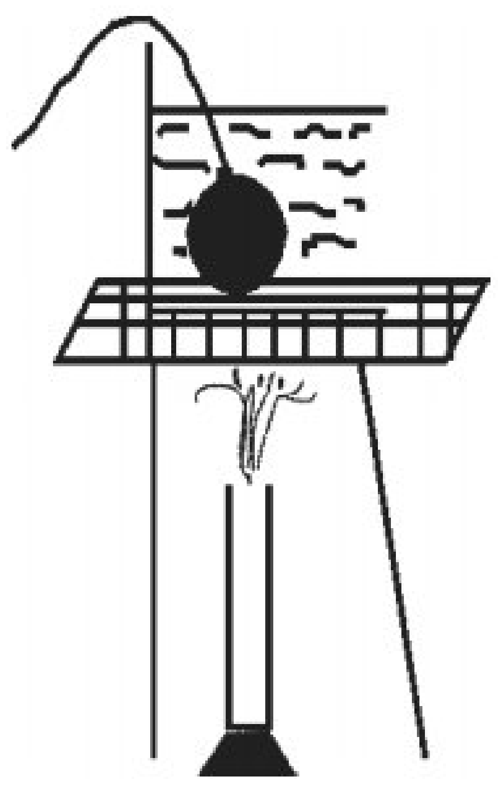


Fig 5.1: Shows the careful heating of the brass bob before it is transferred to the water in the calorimeter

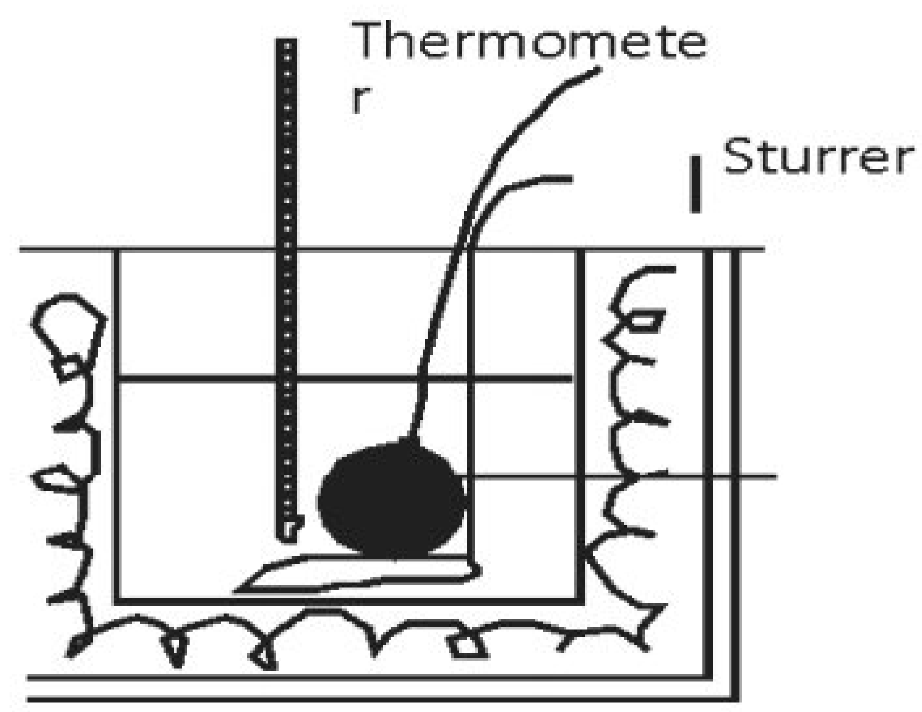


Fig 5.2 : Shows the arrangement of calorimeter box thermometer, stirrer when the hot bob is transferred in to the calorimeter

5.4 WHAT TO OBSERVE

(i) Least count of measuring cylinder=..

(ii) Least count of spring balance=..

(iii) Mass of brass bob m_b=...

(iv) Mass of calorimeter and stirrer=m_c=..

(v) Least count of thermometer=..

(vi) Initial temperature of water in the calorimeter=t_1=...............................

(vii) Temperature of boiling water=t_3=..

(viii) Final temperature of water and bob=t_2=..

(ix) Specific heat of copper=S (from the table)=0.093 calg^{-1}° C^{-1}.

(x) Volume of cold water in the calorimeter = 60mL (as given in the procedure) mass of cold water = 60g (density of water=1g/mL).

5.5 HOW TO CALCULATE

(i) Heat given by hot brass bob =$m_b \times S \times (t_3 - t_2)$cal.

(ii) Heat taken by water in calorimeter=$60 \times 1 \times (t_2 - t_1)$cal.

{Specific heat of water=1calg^{-1}°C^{-1}}

Heat taken by calorimeter = $m_c \times S_c \times (t_2 - t_1)$ cal.

We have from method of mixtures,

Heat given by hot body = heat taken by cold body

$m_b \times S \times (t_3 - t_2) = \{60 + mc \times Sc\}\ (t_2 - t_1)$cal

$$S = \frac{(60 + m_c S_c)(t_2 - t_1)}{m_b (t_3 - t_2)} = \text{..........................cal g}^{-1}\,{}^0\text{C}^{-1}$$

Note: It is interesting that this method can be adapted to do simple experiments at home. You can use a plastic cup to perform your experiment instead of a calorimeter. Take marble pieces for finding the specific heat of marble. You will need a laboratory thermometer to note temperatures. Weighing of the marble piece can be done at any grocery shop near your house. Amount of water can be worked out with an empty medicine bottle. Try, it is a lot of fun. Ofcourse you ignore the heat taken by plastic cup. You can avoid second thermometer by taking temperature of boiling water as roughly100°C.

5.6 CHECK YOUR UNDERSTANDING

(i) Can you find the specific heat of the brass bob by putting the cold brass bob in hot water in the calorimeter? Explain! Can you still find the final steady temperature? Why?

....

(ii) Can you use this method to determine the specific heat of a wooden bob? Explain.

....

(iii) Why does the tap water not boil at 100°C?

....

(iv) How do you measure the final temperature of the mixture?

....

(v) Why should the mixture be stired continuously?

....

(vi) A brass piece of 200 g at 100°C is dropped into 500 m*l* of water at 20°C. The final temperature is 23°C. Calculate the specific heat of brass.

....

(vii) What is meant by the statement specific heat of marble is 0.215calg^{-1}°C^{-1} or that of Aluminium is 900J kg^{-1}°C^{-1}?

....

(viii) Can you use this 'method of mixtures' for finding the specific heat of a liquid? Explain.

....

Is it necessary that the solid bob should be spherical in shape?

....

Suggested Activity:

Use this method to find the specific heat of any oil.

Hint: Use given oil instead of water and repeat the experiment in the same way as you have done using brass-bob and water.

EXPERIMENT 6

To measure extensions in the length of a helical spring with increasing load

6.1 OBJECTIVES

After performing this experiment, you should be able to:

- suspend a spring vertically and set up the arrangement for measuring length corresponding to different loads;
- measure the extension produced in the spring by a load suspended on it;
- draw a graph between load versus extension of the spring;
- calculate spring constant from the graph.

6.2 WHAT SHOULD YOU KNOW

It follows from Hooke's law that the gravitational force of load M suspended in a spring and extension/ produced in it by the load are proportional to each other:

i.e. $Mg \; \alpha \; l$

$\Rightarrow mg = \mu \, l$

$$\text{or } \mu = \frac{mg}{l} \qquad (6.1)$$

Here μ is the force in newton required to produce unit extension and is called spring constant of the spring. If we plot a graph between extension produced l (on y-axis) and load suspended Mg (on x-axis) then

$$\mu = \frac{\text{(Change in weight)}}{\text{(change in l)}} = \frac{1}{\text{(slope of graph)}} \quad \text{.........................} \quad (6.2)$$

Eg. (6.2) gives the value of μ in the SI unit (Nm^{-1})

Material Required

The spring, a pan which can be suspended below the spring, weight box, half-metre scale, laboratory stand, light aluminium strip with a pointer.

6.3 HOW TO SET UP

Attach the scale in the laboratory stand in a vertical position. On the same stand suspend the spring.

Suspend a light aluminium strip below it at which is stuck a light paper pointer (Fig. 6.1). At the lower end of the strip suspend the pan. When weights are added in the pan and spring extends, tip of the pointer moves down on the scale, without touching it. Position of the tip of the pointer can be read on the scale.

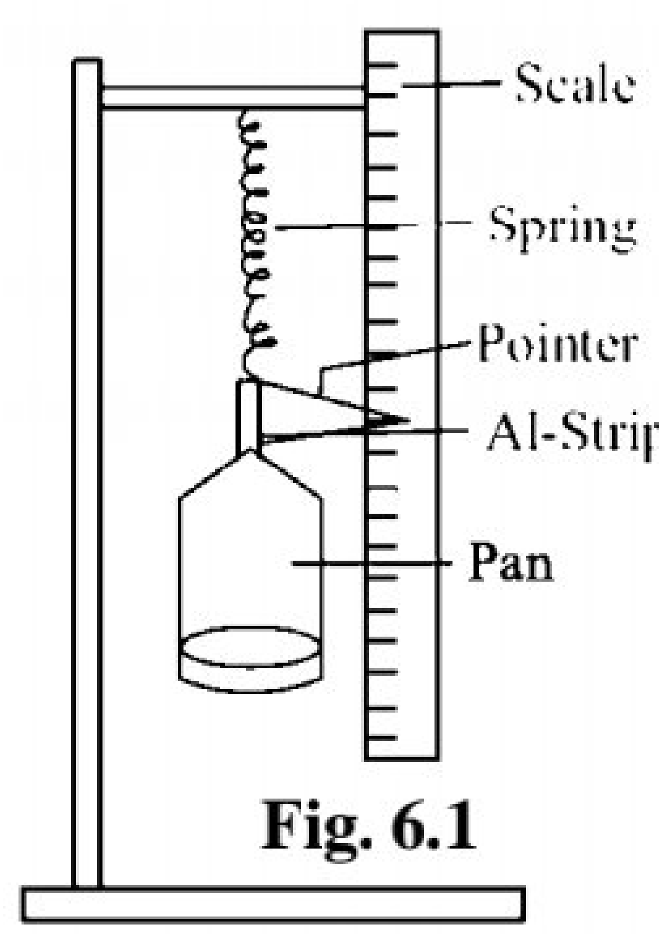


Fig. 6.1

6.4 HOW TO PERFORM THE EXPERIMENT

(i) Note the zero reading of pointer on the scale with no weights in the pan. Add a suitable weight, M, in the pan and note the new reading on the scale. Difference of the two readings gives extension, I, of the spring due to the weight M.

(ii) Gradually increase in steps the weights in the pan and note the position of pointer for each load.

(iii) After an appropriate maximum load is reached, reduce the weights in same steps. Again note the position of pointer for each load. If the spring has notbeen permanently strained by your maximum load, the pointer will returnto its previous position for each load. There can be some observational error. Hence find the mean of the two readings and then extension for eachload.

(iv) Plot a graph between extension l (on y-axis) and load M (on x-axis) (Fig6.2). Draw the best straight line through the points plotted and the origin, which is also an observation - zero extension for zero load.

(v) Find the slope of the graph and then the constant μ

$$\mu = \frac{\text{Change in M}}{\text{change in l}} = \frac{1}{\text{slope of graph}}$$

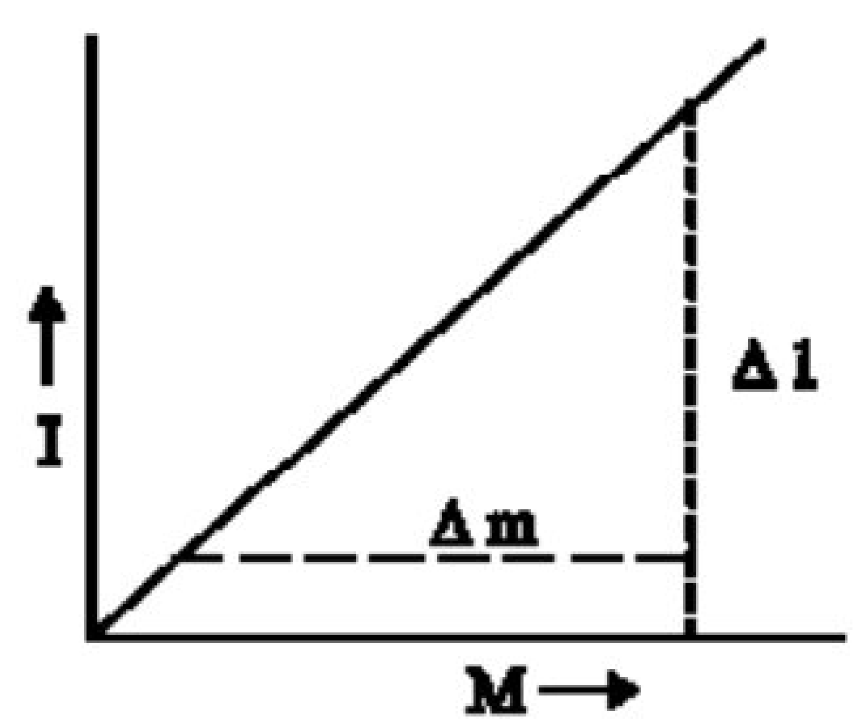


Fig. 6.2: Graph between M and I

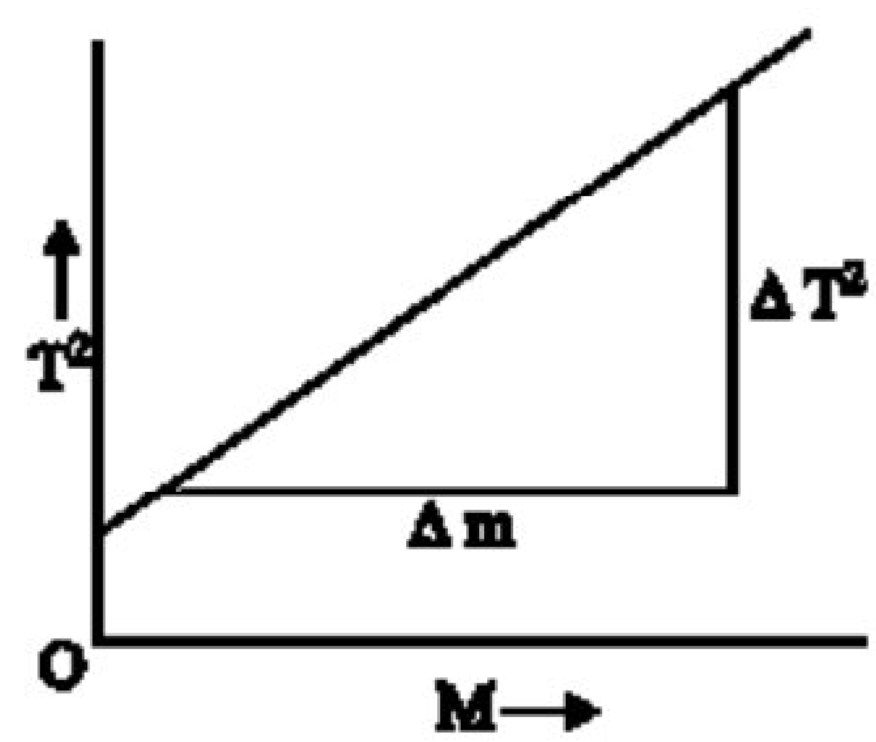


Fig. 6.3: Graph between M and T^2

6.5 WHAT TO OBSERVE AND DATA ANALYSIS

S.No.	Load, M M/kg	Scale reading		Mean	Extension I/cm
		Load Increasing	Load decreasing		

Slope of extension versus load graph = $\frac{\Delta l}{\Delta M}$ .... m kg^{-1}

Constant, μ = $(slope)^{-1}$ = ...Nm^{-1}

6.6 RESULT

(i) Extension versus load graph is a straight line passing through origin. Thus extension is proportional to load, i.e. Hook's law is found valid.

(ii) Constant μ (weight suspended per unit extension) = …........….. Nm^{-1}

6.7 SOURCES OF ERROR

(i) If pointer positions for equal loads for load decreasing are lower than those for load increasing, then a permanent extension of spring has occurred by the maximum load applied. At that load, Hook's law breaks down.

(ii) There can be friction between the pointer and the scale if they touch each other and their contact is not light enough. Then, for a given load, the pointer will come to rest in several positions.

6.8 CHECK YOUR UNDERSTANDING

(i) Why should the oscillations be small?

....

(ii) Why should oscillations be only vertical?

....

(iii) How will the time period of large vertical oscillations, but within the elastic limit compare with that for small vertical oscillations?

....

(iv) A spring, with a certain load suspended on it, is carried to the Moon. Thus the load decreases due to less gravitation of the Moon. What change occurs in its extension. Give reasons for your answer.

....

EXPERIMENT 7

To determine (i) the wave length of sound produced in an air column, (ii) the velocity of sound in air at room temperature using a resonance column and a tuning fork.

7.1 OBJECTIVES

After performing this experiment, you should be able to:

- set the resonance tube apparatus
- determine the first and second positions of resonance:
- determine the wavelength of sound waves in air.
- calculate the velocity of sound waves in air, and
- understand the phenomenon of resonance.

7.2 WHAT SHOULD YOU KNOW

You know that air columns in pipes or tubes of fixed lengths have their specific natural frequencies. For example, in a closed organ pipe (closed at one end) of length L_t when the air column is set into vibration with a tuning fork of a particular frequency, it vibrates in resonance with the tuning fork. The superposition of the waves travelling down the tube and the reflected waves travelling up the tube produce (longitudinal) standing waves which must have a node at the closed end of thee and an antinode at the open and (Fig 7.1).

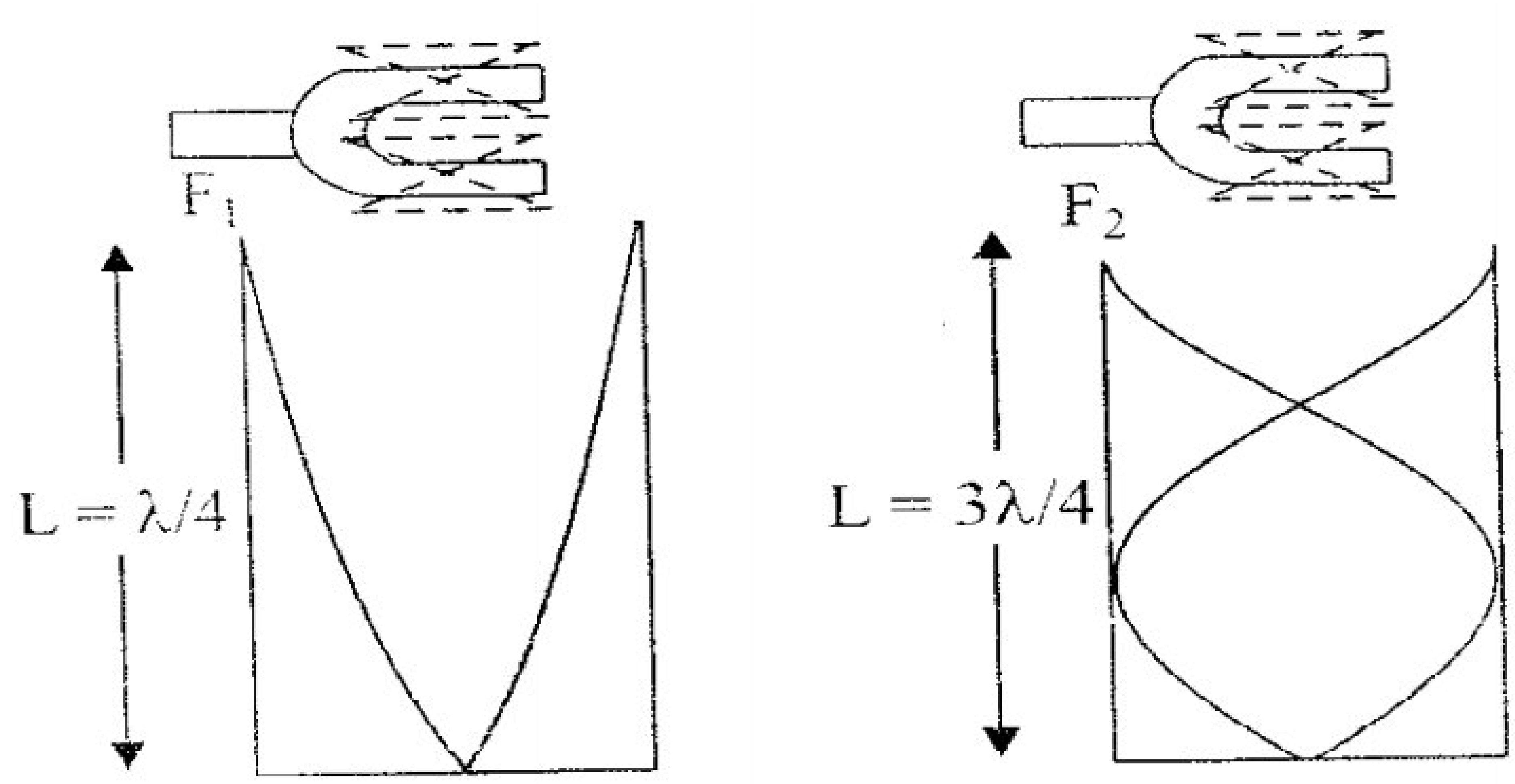


Fig. 7.1: Longitudinal standing waves of different frequencies in a tube

The resonance frequencies of a pipe or tube (air column) depend on its length L. Only a certain number of wavelengths can be "fitted" into the tube given the condition that there should be a node at the closed end and an anti-node at the open end. But you know that the distance between a node and an anti-node is λ/4 and therefore, resonance occurs when the length of the tube (air column) is nearly equal to an odd number of $\frac{\lambda}{4}$ i.e.

$$L = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4} \text{...... etc}$$

or, in general, $L = \frac{n\lambda}{4}$ when n = 1,3,5................ (7.1)

Where λ is the wavelength of the sound. You know that the relation between the wavelength and frequency of the sound source is

$$v = f\lambda \text{ .... (7.2)}$$

Combining (7.1) and (7.2) we get, for a closed pipe,

$$f_n = \frac{nv}{4L} \text{, n = 1, 3, 5... (7.3)}$$

The lowest frequency of (n = 1) is called the fundamental frequency and higher frequencies are called overtones. Hence, an air column of length L has particular resonance frequencies and will be in resonance with the corresponding driving frequencies.

It is clear from equation (7.3) that the three parameters involved in the resonance condition of an air column are f, v and L. To study resonance in this experiment, the length L of the air column will be varied for a given driving frequency (the wave velocity in air is relatively constant).

From condition (7.1) we see that the difference in the tube (air column) lengths for successive condition of resonance is

$$\Delta L = L_2 - L_1 = \frac{3\lambda}{4} - \frac{\lambda}{4} = \frac{\lambda}{2}$$

$$L = L_3 - L_2 = \frac{5\lambda}{4} - \frac{3\lambda}{4} = \frac{\lambda}{2}$$

where L_1 is the length of the air column at first resonance, L_2 at second resonance and so on.

$$\lambda = 2 L \quad \text{.................. (7.4)}$$

We can determine the wavelength of sound waves by measuring ΔL. Then by knowing frequency f of the driving tuning fork, the velocity of sound in air at room temperature can be calculated using the relation:

$$\Delta \; v = f\lambda = 2f(L_2 - L_1) \text{ ....(7.5)}$$

Material Required

Resonance tube apparatus, tuning forks, rubber mallet or block, meter stick (if measurement scale not on resonance tube) and thermo meter.

7.3 HOW TO PERFORM THE EXPERIMENT

(i) Note the room temperature.

(ii) Note the frequency of the tuning forks.

(iii) The resonance tube apparatus is shown inFig. 7.2. Set it in vertical position with the help of levelling screws attached to its base and spirit level. Fill the reservoir with water and raise it to adjust the water level in the long tube to a point near the top. Do not overfill the reservoir other-wise it will overflow when you lower it. Practice lowering and raising the water level in the tube toget the "feel" of the apparatus.

iv) With the water level in the tube near the top, take the tuning fork and set it into oscillations by striking it with a rubber mallet or on a rubber block, whichever is available. Never strike the tuning fork on a hard object (e.g. a table). This may damage the fork and cause a change in its characteristic frequency. Hold the vibrating the fork horizontally slightly above the opening of the tube so that the sound is directed down the tube. (Note that a tuning fork has directional sound-propagation characteristics. Experiment with a vibrating fork and your ear, to determine these directional characteristics).

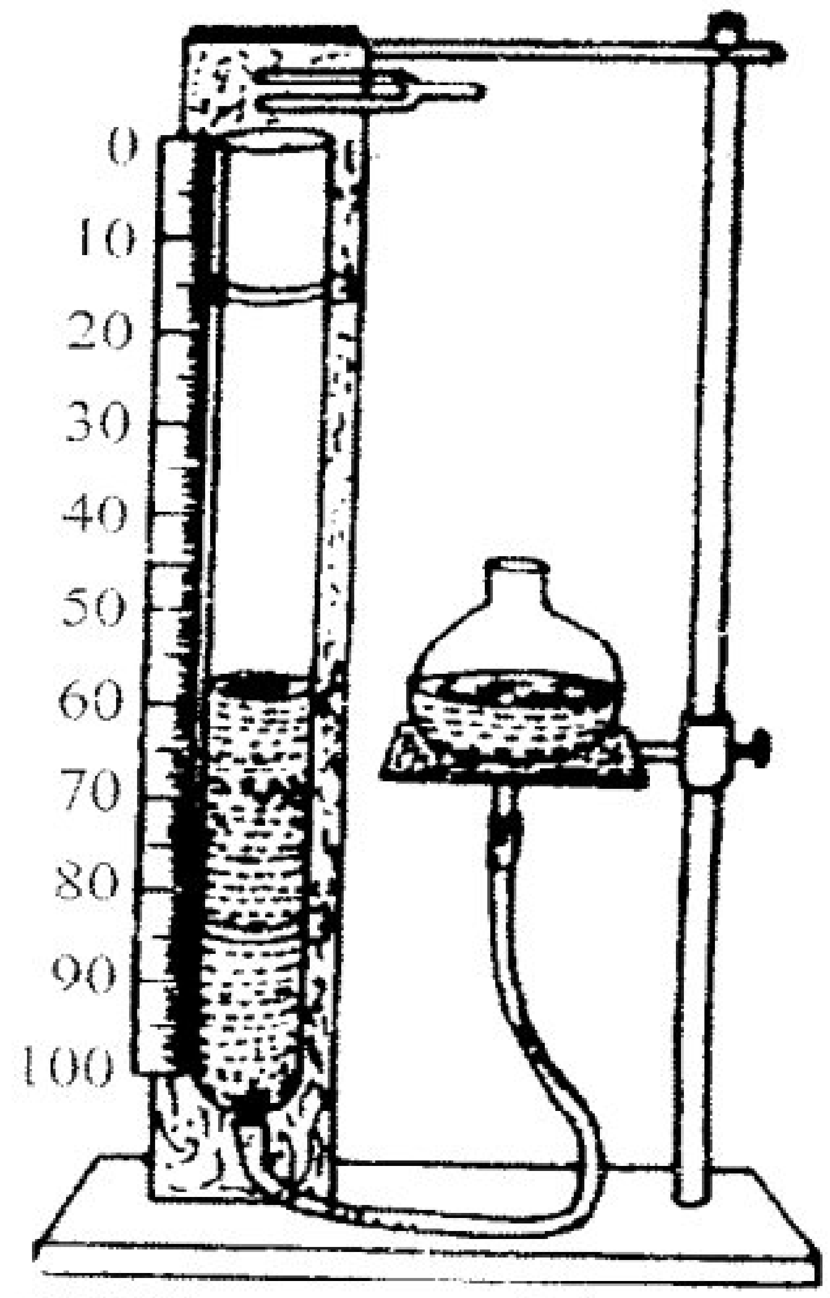


Fig 7.2 The resonance tube apparatus

(v) Lower the reservoir to a low position on the support rod. Adjust the water level in the tube to fall in steps of 1 cm, controlling it with the help of pinch cork. Bring the tuning fork at top of the tube each time. Continue till a loud sound is heard.

(vi) Now raising and lowering the water level in steps of 1 mm try to locate the position at which maximum sound is heard. This is first resonance position.

(vii) Determine the exact position of the water level on the scale, (while noting the position, measure the length from the top of the tube) for the first resonance. Repeat the experiment thrice.

(viii) Repeat this procedure for the second resonance position, at around three times the length of aircolumn for first resonance.

(ix) Compute the average lengths of air column for first and second resonances. Then compute wave length from the difference between them. Using the known frequency of the fork, calculate the velocity of sound.

7.3 WHAT TO OBSERVE

Table 10.1 Table for Resonane Position

S.	Source frequency Hz	First position of resonance				Second position of resonance			
		1	2	3	Average	1	2	3	Average

Temperature of air =……………………

7.4 CALCULATIONS

(a) Length of air column for 1st resonance L, ... cm

Length of air column for IInd resonance L_2 =... cm

$\Delta L = L_2 - L_1$ = ... cm = ...m

(b) Velocity of sound in air = 2f ΔL = ...ms^{-1}.

(c) Correct velocity of sound in air at room temperature (from tables) = ...

(d) Percent error in the result $= \dfrac{\text{observed value - correct value}}{\text{correct value}} \times 100$

=…..............................……%

7.5 RESULT

(i) Wavelength of waves in air column= ....m.

(ii) The velocity of sound in air at temperature .... is found to be ms^{-1}. The correct value is .... and percentage error is..................

7.6 CHECK YOUR UNDERSTANDING

(i) A 128 Hz sound source is held over a resonance tube. What are the first and second lengths ofair column at which resonance will occur at a temperature of 20°C? (The velocity of sound in air is temperature-dependent and is given by the relationship V1 = 331.4 +0.61 ms^{-1} where is the air temperature in degree Celsius?

....

(ii) Why do you use the difference in lengths, of resonating air column for the first and second position, for calculating the wavelength and the velocity of sound? Explain.

....

(ii) Suppose that the laboratory temperature were 5° C higher than the temperature at which you prepared this experiment, what effect would this have had on the length of the resonating air column for each reading? Explain.

....

EXPERIMENT 8

To compare the frequencies of two tuning forks by finding the first and secondresonance positions in a resonance tube.

8.1 OBJECTIVES

After performing this experiment, you should be able to.

- use the resonance tube apparatus
- determine the first and second position of resonance,
- compare the frequencies of the given tuning forks.

8.2 WHAT SHOULD YOU KNOW

From the previous experiment, you know that an air column can be driven to resonance using a vibrating tuning fork. Resonance occurs when the length of the air column is equal to an odd multiple of $\lambda/4$, We found that if ΔL is the difference in the lengths of air column for successive conditions of resonance, then the wavelength of sound waves is given by

$$\lambda = 2\,\Delta L \qquad ...(8.1)$$

If f is the frequency of the sound source, the velocity of sound is

$$v = f\lambda \qquad ...(8.2)$$

Since the velocity of sound is constant in a given condition, for two tuning forks of frequencies f_1 and f_2 we have

$$f_1\lambda_1 = f_2\lambda_2 \qquad ...(8.3)$$

$$\text{Or}\quad \frac{f_1}{f_2} = \frac{\lambda_2}{\lambda_1}$$

Combining this equation with equation (8.1), we get

$$\frac{f_1}{f_2} = \frac{\Delta L_2}{\Delta L_1} \qquad ...(8.4)$$

Material Required

Resonance tube apparatus, tuning forks, robber mallet or block, meter stick (if measurement scale not attached to the resonance tube).

8.3 HOW TO PERFORM THE EXPERIMENT

(i) Follow the procedural steps (i) to (viii) given in experiment No. 7.

(ii) Repeat the experiment for the second tuning fork.

(iii) Record the position for the first and second resonance for the two tuning forks in the observation

(iv) For each length of resonating air column, calculate the average of the three readings taken.

(v) Calculate the difference (ΔL) between length of resonating air column for the second and the first position for the two tuning forks.

(vi) Calculate the ratio of ΔL's for the two tuning forks.

8.4 WHAT TO OBSERVE

S. No.	Tuning fork	First position of resonance				Second position of resonance			
		1	2	3	Average	1	2	3	Average
1 2 3	First								
1 2 3	Socond								

8.5 CALCULATIONS

(i) Difference between the positions of first and second resonance for the first tuning fork = ... cm.

(ii) Difference between the positions of first and second resonance for the second tuning fork = ... cm.

(iii) $\frac{f_1}{f_2} - \frac{\Delta L_2}{\Delta L_1} =$ ....

8.6 RESULT

The ratio of frequencies of the given tuning forks is found to be.

8.7 CHECK YOUR UNDERSTANDING

(i) Should a tuning fork be set into oscillation by striking it with a rubber mallet/block or any otherobject? Explain.

....

(ii) For a resonance tube apparatus with a total tube length of 1 m, how many resonance positions would be observed when the water level is lowered through the total length of the tube for a tuning fork with a frequency of (a) 500 Hz, (b) 1000 Hz? (Velocity of sound in air = 347 ms^{-1}).

....

(iii) A sound source is held over a resonance tube, and resonance occurs when the surface of the water in the tube is 10 cm below the source. Resonance occurs again when the water is 26 cm below the source. If the temperature of the air is 20°C, calculate the source frequency. Velocity of sound in air at temperature in degree Celsius, is V_t = 33 1.4+0.6 ms^{-1}.

....

EXPERIMENT 9

To draw the lines of force due to a bar magnet keep (i) N-pole pointing to magnetic north of the arth (ii) S-pole pointing to magnetic north of the earth. Locate neutralpoints.

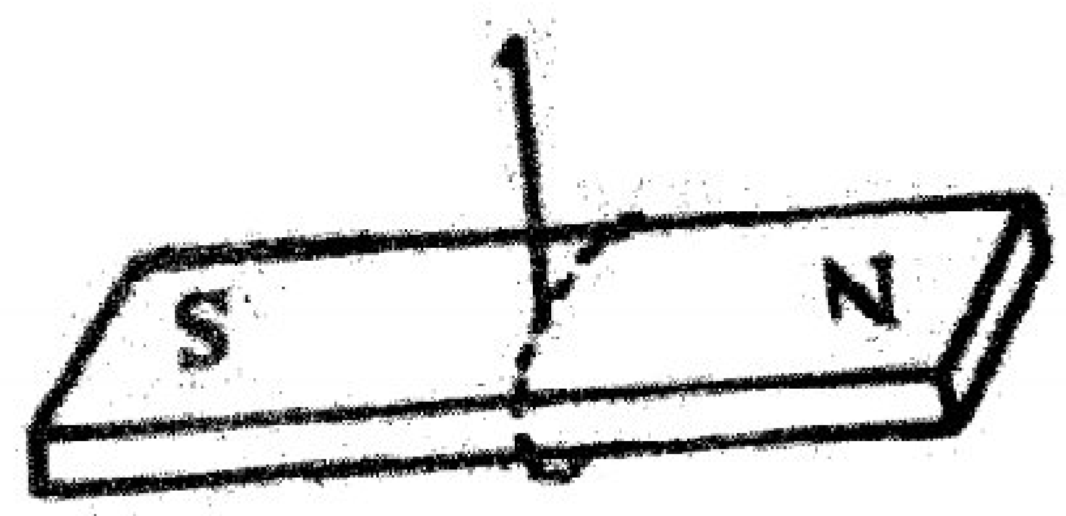
9.1 OBJECTIVES

After performing this experiment you should be able to:

- find the N and S-pole of a bar magnet
- define magnetic meridian
- locate the position of poles in a bar magnet
- know the condition for getting a neutral point;
- place a bar magnet in proper orientation.

9.2 WHAT SHOULD YOU KNOW

The common bar magnet is a magnetised piece of iron. It has maximum attracting power near the ends. These are called the poles. To find which end is N and which is S, it is suspended freely with the help of a thread tied in the middle



Freely suspended magnetic needle

After some time it will come to rest in N-S direction. The end which points toward geographic North is called N-pole and the other is S-pole The line joining N and S passing through the middle of magnet is usual its magnetic axis.

At a point in space around the bar magnet, where there are two equal opposite magnetic field cancelling each other, there is a neutral point Here there will be no magnetic field. In our experiment,

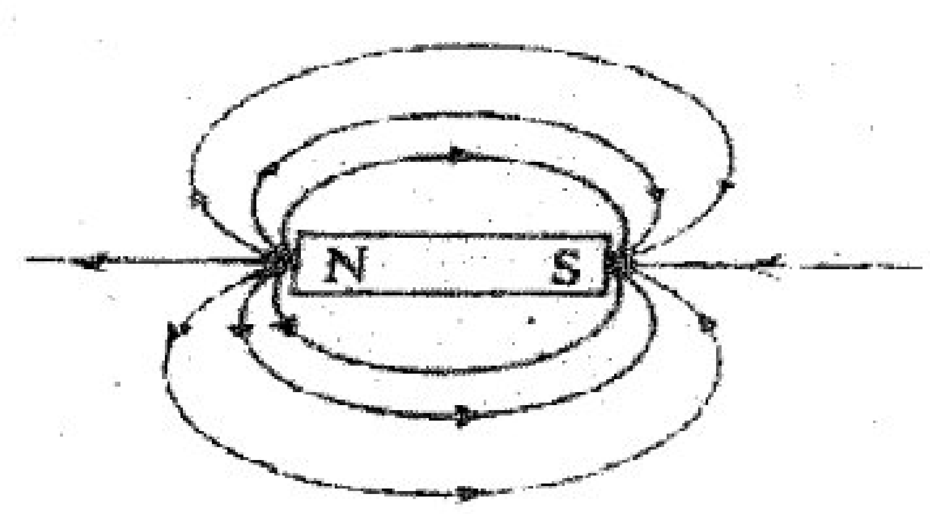
one of the two fields is produced by the bar magnet and the other is earth's horizontal magnetic feild.These two combine together to give the neutral point.The lines of force are the paths on which a hypothetical N-pole set free will move in the given magnetic field. These are supposed to come out of N-pole and enter the S-pole and form closed lines.

These are curves around the bar magnet (Fig. 9.2). The line of symmetry AB, which is a straight line of force passing through the poles is the magnetic axis of the magnet.

Earth's magnetic field being uniform in the small region of your laboratory, gives parallel linesof force.

MATERIAL REQUIRED

Two bar magnets, compass needle, white paper, drawing board, drawing pins, pencil, chalk.



9.3 HOW TO SET UP THE EXPERIMENT

(i) Find the N-pole of the bar magnet and mark the end with ink.

(ii) Fix a white paper on the drawing board.

(iii) Draw a line in pencil through the middle of paper along the short edge for performing the I part of experiment i.e. N-pole of magnet toward north as shown in Fig. 9.3. For the II part of the experiment line will have to be drawn parallel to long edge as shown in Fig. 9.4.

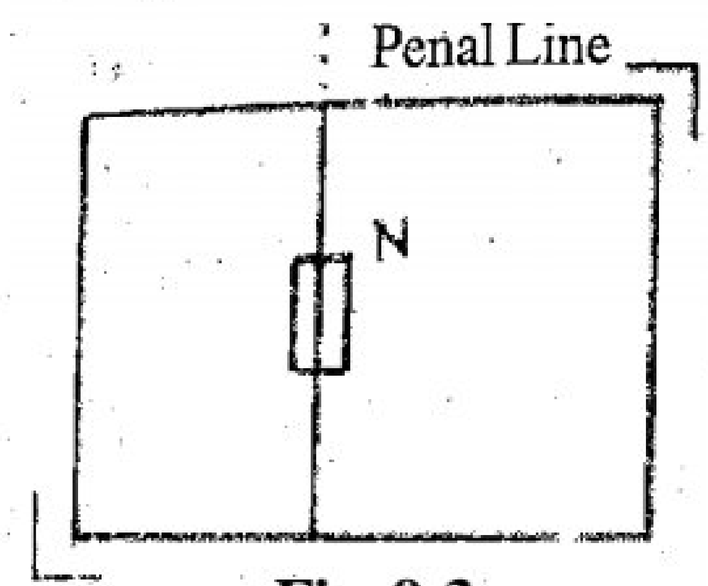


Fig 9.3

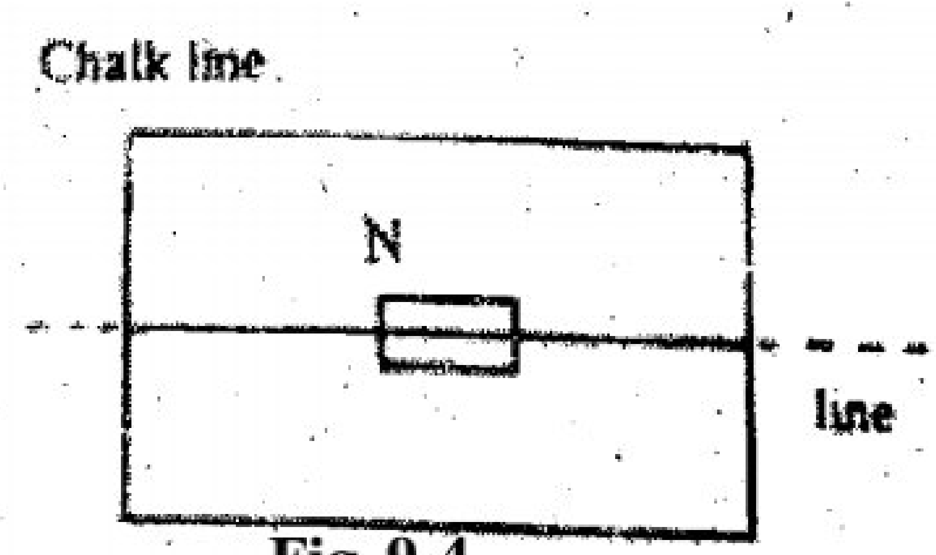


Fig 9.4

(iv) Place the magnet in the middle of line also shown above.

(v) Take a small compass box and place it on a wooden table. Place a metre rod beside it so that itis parallel to the needle. Remove the compass and draw a line with a chalk. This line gives the magnetic meridian at the place.

(vi) Place the drawing board such that the line on paper in pencil is parallel to the line drawn in chalkon the table, as shown in two cases in Figures 9.3 and 9.4.

9.4 HOW TO PERFORM THE EXPERIMENT

a) N-Pole facing North

(i) After placing the magnet as shown in Fig. 28.3 mark the boundary of board in chalk, so that its position is not displaced during the experiment. If at all it accidentally gets displaced, it can be put back in its original position.

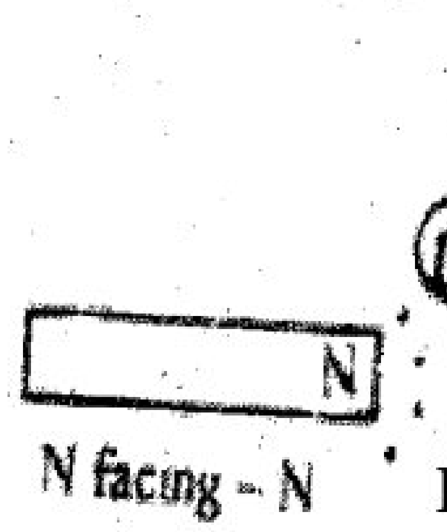


Fig. 9.5

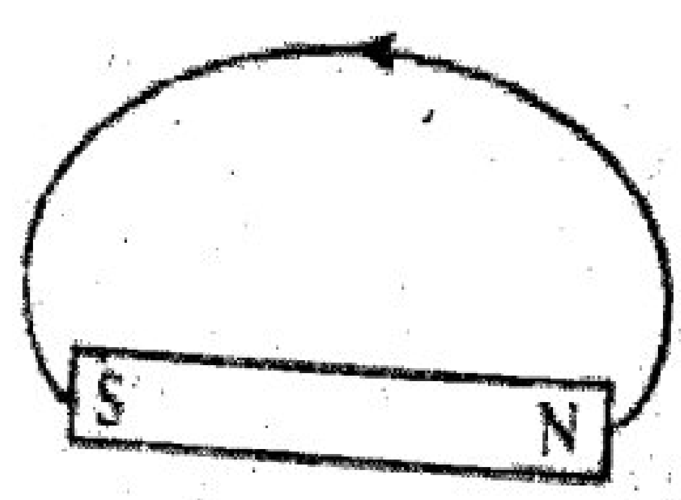


Fig. 9.6

(ii) Take a .small compass box. Place it near the N-pole of the bar magnet with it pointer pointing towards the pencil dot marked near the N-pole (Fig. 28.5). Mark the dot on the other side of

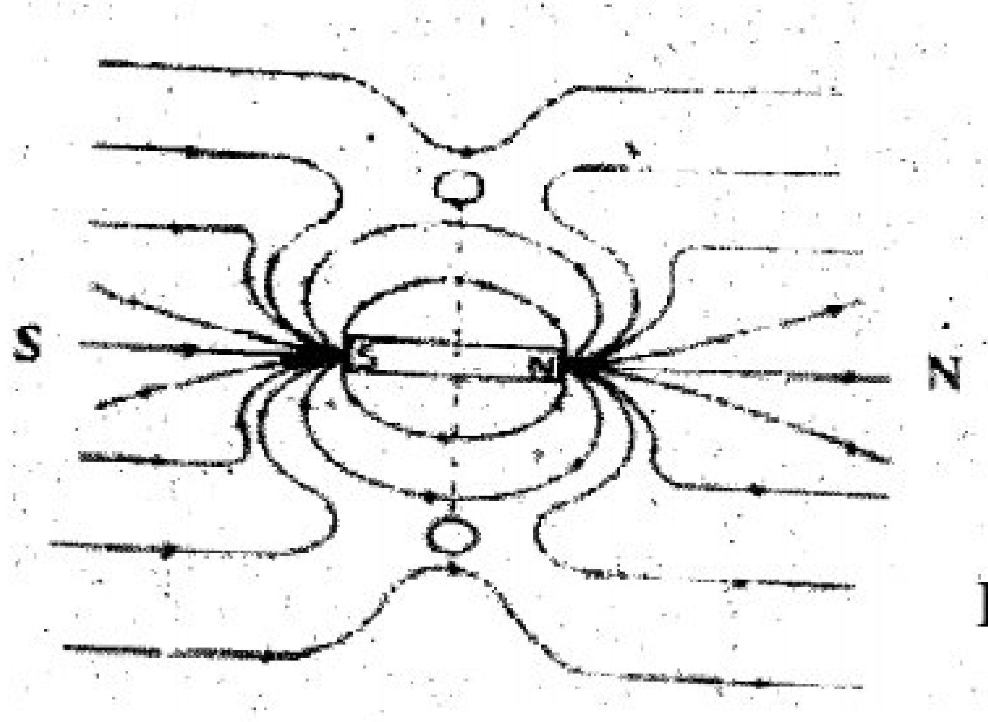


Fig. 9.7

needle. Move the compass box to the second marked dot, again mark a dot near the far end of needle. Repeat this process till you reach the S-pole. You will get a chain of dots which can be joined by a smooth curved line, as shown in Fig. 9.6.

(iii) Join these dots with free hand. This gives the line of force. Mark arrow head on it pointing away for N-pole as shown.

(iv) Draw such lines for different starting points and you will get large number of lines of force around the magnet. Their shape will be as shown in Fig. 9.7.

These lines will not cut each other. You will get two regions on the equatorial line shown by small circles in Fig. 9.7, where there will be no line of force. These are the neutral points. There are two neutral points, one on each side of the magnet. If you place the compass here in the circle with its centre at the neutral point, the needle wire not point in any fixed direction. It can come to rest in any orientation. That shows that no force is acting on it If magnet is properly placed, each of

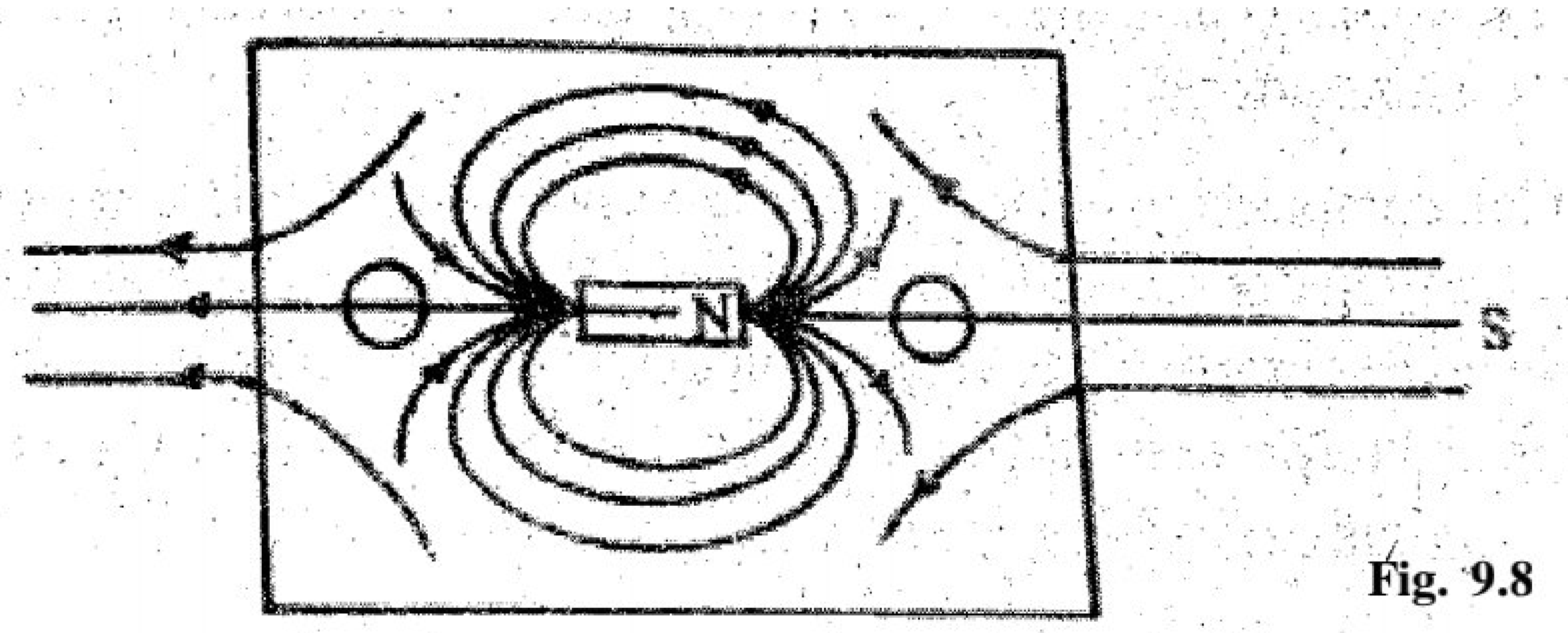


Fig. 9.8

these points will be equal-distant from the two poles and lie exactly on equatorial line.

b) N-facing South

(i) For drawing the magnetic field in this case and locating neutral points place the drawing board with pencil line on paper parallel to long edge of board, along the N-S line of earth, as shown in the Fig. 9.4.

(ii) Now follow the same procedure as in the last experiment The lines of force will look as shown in Fig. 9.8 above.

Here we see that the two neutral points are located on the axial line of the magnet. Because it is at the sepoints where the earth's horizontal fleld and the magnetic field of magnet balance each other.

9.5 WHAT TO OBSERVE

a) N-pole of magnet towards north

(i) In this case, each, of the two neutral points is equal-distant from the poles.

(ii) They are symmetrically located on the equatorial line.

(iii) On the neutral points, the compass needle come to rest in every position. It does not align itself in any fixed direction.

(iv) The directions of lines here are opposite.

b) N-pole of magnet towards south

(v) In this case the neutral points lie on the axial line. They a symmetrically located.

Other things are same as in (a) part.

9.6 SOURCES OF ERROR

(i) The magnet may not be placed symmetrically not the line in pencil on paper.

(ii) The N-S line drawn on the table may not be correct.

Due to both these errors the field drawn is not symmetrical about the line in pencil drawn on the paper.

9.7 CHECK YOUR UNDERSTANDING

(i) What is magnetic equator of earth?

....

(ii) What type of magnetic pole is located at geographic north pole of the earth?

....

(iii) Can you get a neutral point in a single magnetic field?

....

EXPERIMENT 10

To find the value of v for different values of u in case of a concave mirror and find its focal length (f) by plotting graph between 1/u and 1/v.

10.1 OBJECTIVES

After performing this experiment, you should be able to:

- set up an optical bench;
- determine bench correction;
- determine approximate focal length of the mirror,
- determine 'v for different value of u:
- plot a graph between1/u and 1/v.
  interpret the graph and compute the focal length of the given concave mirror.

10.2 WHAT SHOULD YOU KNOW

You know that for a concave mirror the reciprocal of its focal length (f) is equal to the sum of the reciprocals of image distance (v) and the object distance (u)

$$\frac{1}{f}=\frac{1}{v}+\frac{1}{u} \Rightarrow \frac{1}{v}=\left(-\frac{1}{u}+\frac{1}{f}\right) \qquad (10.1)$$

Comparing equation (10.1) with standard equation of a straight line, namely, y=mx+c we find that, the graph between $\frac{1}{v}$ and $\frac{1}{u}$ should be a straight line with a slope of (-1) and intercepts on y- axes equal to $\left(\frac{1}{f}\right)$: From this we can find the focal length of the given mirror.

Material Required

Concave mirror, optical bench with three uprights, mirror holder, two pins, knitting needle,metre rod, spirit level.

10.3 HOW TO SET-UP THE EXPERIMENT

(i) Fix an upright at zero cm mark on the optical bench and put mirror holder in it.

(ii) Place the other two uprights holding pins on the optical bench at different positions.

(iii) Level the optical bench with the help of spirit level and levelling screws.

(iv) Fix the mirror in mirror-holder and adjust the tips of the pins so that they are in the same horizontal line as the pole of the mirror (See Fig. 10.1).

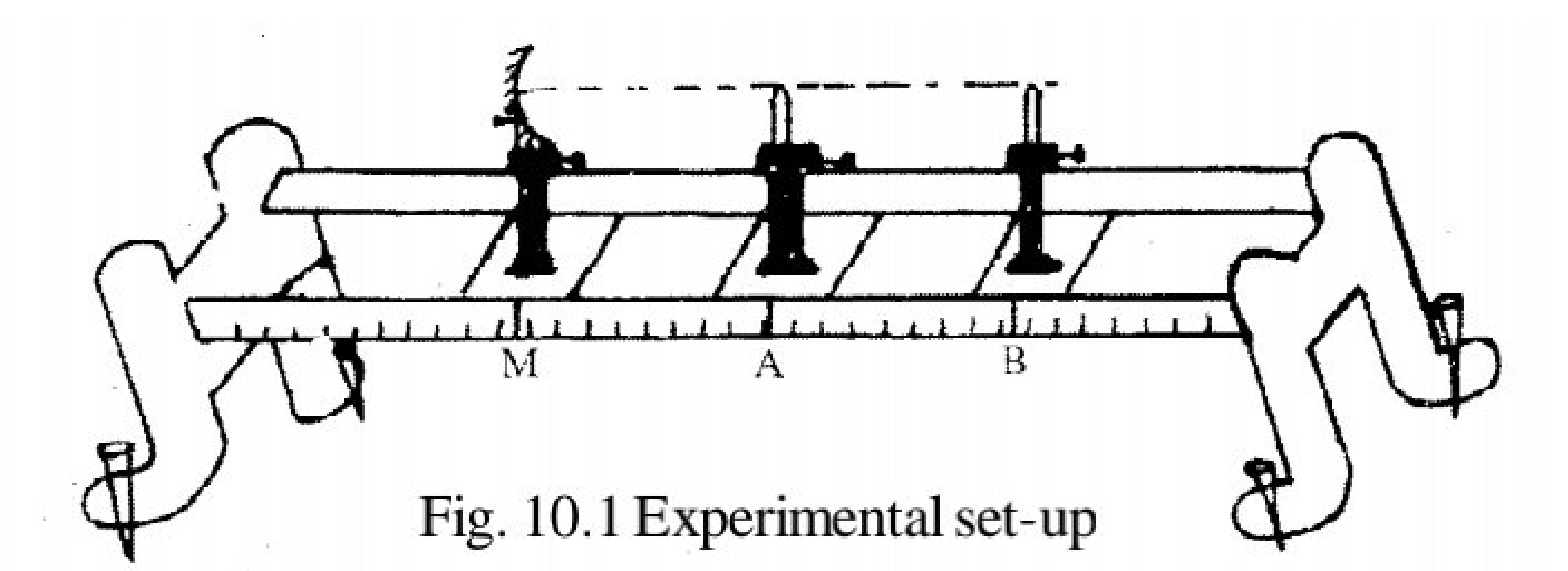


Fig. 10.1 Experimental set-up

10.4 HOW TO PERFORM THE EXPERIMENT

(a) Determination of bench - correction

(i) Place the knitting needle along the metre scale. Read the position of its two ends, avoiding error due to parallax. Find the length of the knitting needle *l*.

(ii) Using knitting needle, adjust the object-pin, so that the distance between the pole of the mirror and the tip of the pin is *l*. Now read the position of the mirror and the object-pin A, on the scale of the optical bench. Find the observed length of knitting needle as measured on the optical bench-scale l_1

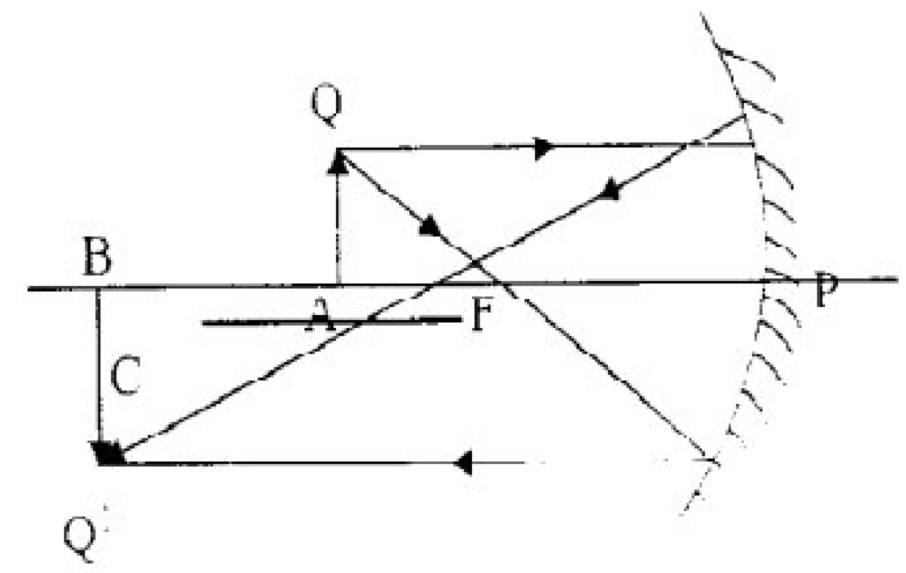


Fig. 10.2 Ray diagram

(iii) Find bench correction $(l-l_1)$ for pin A.

(iv) Repeat the same procedure for image pin 'B' also.

(b) Determination of approximate focal length of the mirror

(v) Take out the mirror from mirror-holder and hold it in such a way so that a clear distinct image of a distant object is obtained on the wall.

(vi) Measure the distance between the mirror and the wall with the help of a metre scale. This gives the approximate focal length, f_1 of the mirror.

(C) Determination of v for different values of u

(vii) Fix the mirror again in the mirror - holder.

(viii) Fix the object-pin A at a point between, f, and 2f, but so that looking into the mirror, you will see a clear real, inverted and highly enlarged image of A.

(ix) Position the image - pin B beyond $2f_1$ so that there is no parallax between the tip of B and the tip of image of A.

(x) Fix pin B.

(xi) Repeat the procedure (ii) and (iii) for different positions of pin A between f_1 and $2f_1$ and seeing that it is enlarged.

(xii) Record the observations in tabulated form as shown in table 10.1.

(xiii) Find the values of *l*/u and *l*/v for each observation, by taking u and v in metres.

(xiv) Plot a graph with *l*/u on x-axis and *l*/v on y-axis, taking scone scale on both axes and start from zero on either axes,

(xv) Read the intercept on y-axis. Reciprocal of it gives the focal length.

10.5 WHAT TO OBSERVE

(a) Determination of bench correction

Length of the knitting needle *l*=………….. cm.

Observed separation between the mirror and pin A on optical bench scale, when they are separated by l i.e., l_1=........ cm.

Observed separation between the mirror and P in B, l_2 = ……….. cm

Bench correction for u = $(l-l_2)$ cm = x_1=……….. cm.

Bench correction for v = $(l-l_2)$ cm = x_2 =………… cm.

(b) Rough focal length of the mirror

f_1 =…….cm,………..cm,………cm.

Mean value of rough focal length =…………………. Cm.

Table 10.1 : Observations for u and v

Sl. No.	Position of			Object distance		Image distance		1/u m^{-1}	1/v m^{-1}
	Mirror cm	Object Needle A cm	Image Needle B cm	Observe Value cm	Corrected value (u) cm	Observed value cm	Corrected value (v) cm		
1.									
2.									
3.									
4.									
5.									
6.									

10.6 ANALYSIS OF DATA

The graph between $\frac{1}{u}$ and $\frac{1}{v}$ is shown in the adjoing diagram.

y coordinate of point D - OD = ... m^{-1}

$\Rightarrow f = \frac{1}{OD}$ = ...m =

x-coordinate of point C = OC = …….m^{-1}

Slope = – OD/OC = ...

10.7 CONCLUSIONS

(i) Graph between $\frac{1}{u}$ and $\frac{1}{v}$ is a straight line with a slope = ………

(ii) Focal length of the given concave mirror = ……….. m.

10.8 SOURCES OF ERROR

(i) Most often error in measurement occurs due to error of parallax. So parallax should be removed carefully.

10.9 CHECK YOUR UNDERSTANDING

(i) What do you mean by parallax? How is it removed between the tips of a pin and the real image of another pin?

....

(ii) How does the size of the image change as the object is moved away from a concave mirror?

....

(iii) When will you get a virtual image of an object in a concave mirror?

....

(iv) What is the importance of determining rough focal length before starting the actual experiment?

....

(v) You are given a round piece of mirror. How will you identify whether the mirror is plane, concave or convex.

....

(vi) Why do we use small spherical mirror?

....

(vii) Can you determine the focal length of a convex mirror using this method? Explain.

....

(viii) Suggest any other alternative graphical methods for the determination of 'f' in this experiment.

....

(ix) In this experiment if you are given a candle and a screen in place of the two pins. Can you still perform this experiment? Explain.

....

(x) If you are given only one pin in this experiment. Can you find the focal length of the mirror? Explain.

....

EXPERIMENT 11

To find the focal length (f) of a convex lens by plotting graph between 1/u and 1/v

11.1 OBJECTIVES

After performing this experiment you should be able to:

- set up an optical bench;
- determine bench correction;
- determine approximate focal length of the lens;
- determine 'v' for different values of 'u';
- plot a graph between 1/u and 1/v and ; and
- interpret the graph and compute the focal length of the lens.

11.2 WHAT SHOULD YOU KNOW

You know that the relation between the object distance u and the image distance v for a convexlens placed in air is

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \Rightarrow \frac{1}{v} = -\left(\frac{1}{u}\right) + \frac{1}{f} \quad \text{...... (11.1)}$$

Comparing equation (11.1) with the standard equation of a straight line, i.e., y=mx+ C, we find that on plotting a graph between $\frac{1}{u}$ and $\frac{1}{v}$ we will get a straight line with slope (-1) and intercept $\frac{1}{f}$ on y-axis.

Material Required

Convex lens, optical bench with uprights, lens holder, two pins, three knitting needle, metre rod, spirit level.

11.3 HOW TO SET-UP THE EXPERIMENT

(i) Fix an upright at 50 cm mark and put lens holder and lens in it.

(ii) Place the other two uprights holding pins on the optical bench, one on either side of the lens.

(iii) Level the optical bench with the help of spirit level and levelling screws,

(iv) Adjust the centre of the lens and the tips of the pins in the same horizontal line as shown in the diagram 11.1.

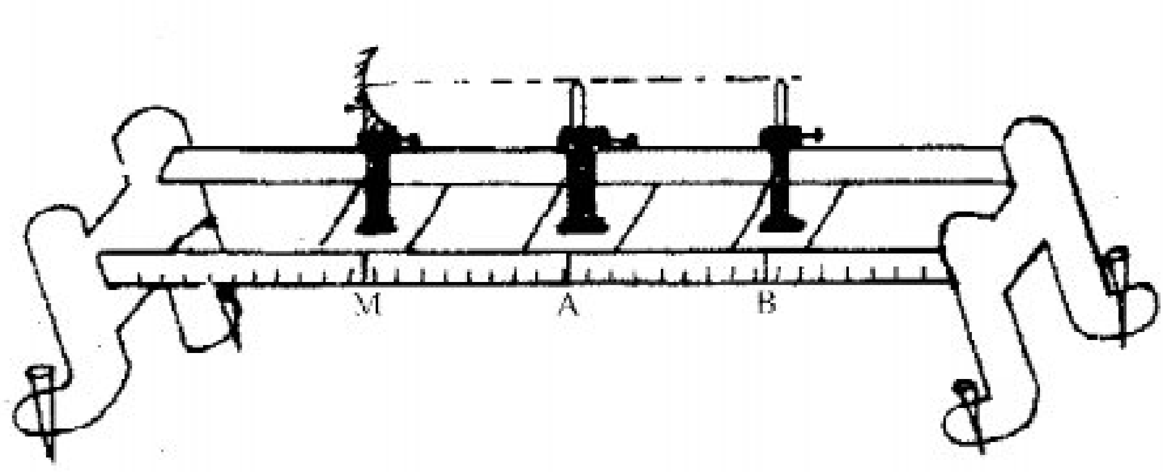


Fig. 11.1 Experimental setup

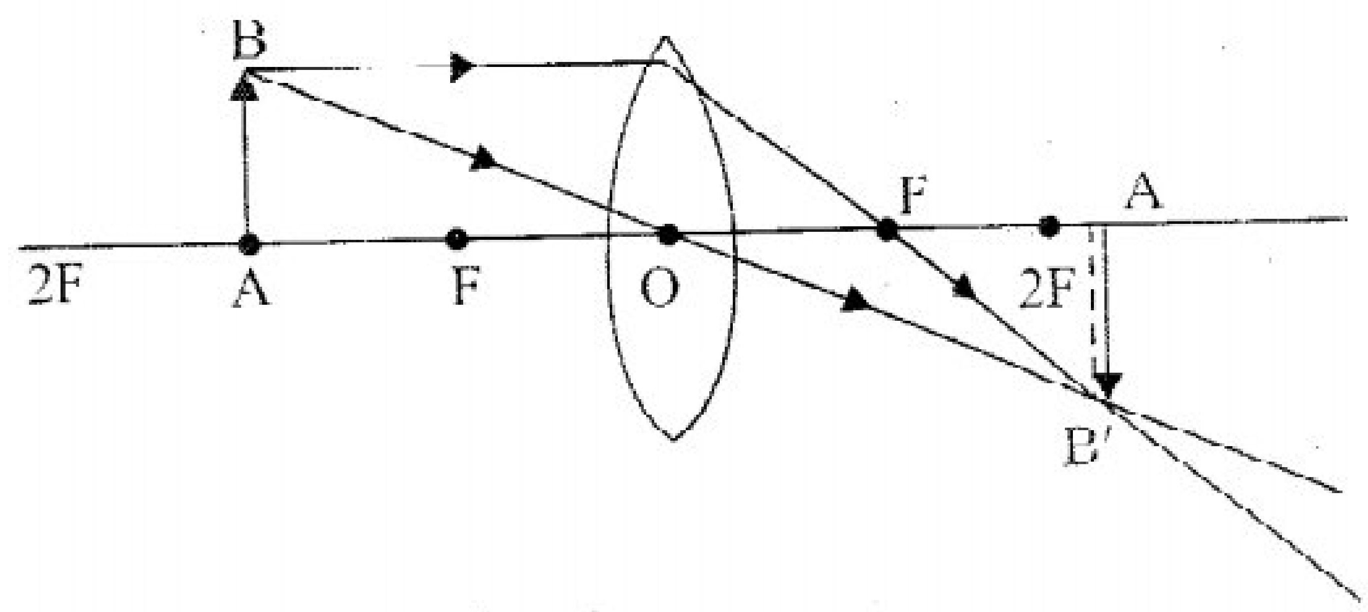


Fig. 11.2 Ray diagram

11.4 HOW TO PERFORM THE EXPERIMENT

(A) Determination of bench correction

(i) Place the knitting needle along the metre scale. Read the position of its two ends, avoiding error due to parallax. Find the length of the knitting needle 'l'

(ii) Adjust the position of the object pin O, so that the distance between the centre of the lens and the tip of the pin is l. Read the position of the lens and the object pin O on the scale of the optical bench.

Find the observed length of the knitting needle on the optical bench scale l_1.

(iii) Determine bench correction (l-l_1) for the object pin O.

(iv) Repeat the same procedure for image pin I also and find the bench correction (l-l_2) for it.

(B) Determination of approximate focal length of the lens

(v) Take out the lens from lens holder and hold it in such a way so that a clear distinct image of a distant object is obtained on the wall.

(vi) Measure the distance between the lens and the wall with the help of a metre scale.

(vii) Record the approximate focal length f_1 of the lens.

(C) Determination of v for different values of u

(viii) Fix the lens again in the lens holder on optical bench.

(ix) Fix the object pin O between f_1 and $2f_1$ with respect to the lens. See from the other side of the lens so that a clear, real, inverted enlarged image of O is formed by the lens.

(x) Move the image - pin I, beyond $2f_1$ and remove parallax between the tip of the image of O and the tip of I by moving your eyes to the left and then to the right side of the image and seeing that the two tips remain in contact as you move your eye. Also observe on other side of the lens that parallax between the tip of pin O and tip of inverted image of pin I has been removed, (i.e. I functions as object).

(xi) Fix pin I also. Measure the separation between the uprights of L and O(i.e. u) and L and I (ie. v) on the scale of optical bench.

(xii) Repeat the steps (ii) to (iv) for different positions of object pin O five or six times. Keep it beyond f, every time and see that the image formed is inverted.

(D) Plotting the graph and calculation of f

(xi) Calculate the value of $\frac{1}{u}$ and $\frac{1}{v}$ for each observation by taking u and v in metres

(xiv) Plot graph with $\frac{1}{u}$ on x-axis and $\frac{1}{v}$ on y-axis. Take same scale for both axes. Start from zero on either axes. In this graph plot also the points with values of u and v interchanged, because you observed removal of parallax on other side of the lens as well, when pin I functions as object.

(xv) Read the intercept on any axis. Reciprocal of it gives the focal length.

11.5 WHAT TO OBSERVE

(A) Determination of Bench Correction

Length of the knitting needle l =......................cm.

Observed separation between the lens and object - pin O on optical benched scale when they are separated by I, i.e. l_1 =.......................... cm.

Observed separation between the lens and the image - pin when they are separated by l, i.e., I_2 =.......................... cm.

Bench correction for object distance x = $(1-l_1)$ cm. Bench correction for image distance y=$(1-l_2)$ cm.

(B) Rough focal length of the mirror

f_1=……….cm, ………….cm,…………cm

(C) Observations for u and v.

Sl. No.	Position of			Object distance		Image distance		1/u m^{-1}	1/v m^{-1}
	Lens O cm	Object Needle A cm	Image Needle A cm	Observed Value OA cm	Corrected value OA' cm	Observed value OA' cm	Corrected value OA' cm		
1.									
2.									
3.									
4.									
5.									
6.									

11.6 ANALYSIS OF DATA

The grah between 1/u and and 1/v is shown in Fig. 11.3 x-coordinate of point C,

OC = = ... m^{-1} f = $\frac{1}{OC}$ m = a

y coordinate of point D, OD = ...m^{-1}

f = $\frac{1}{OD}$ m = b

Mean f = $\frac{a+b}{2}$ m

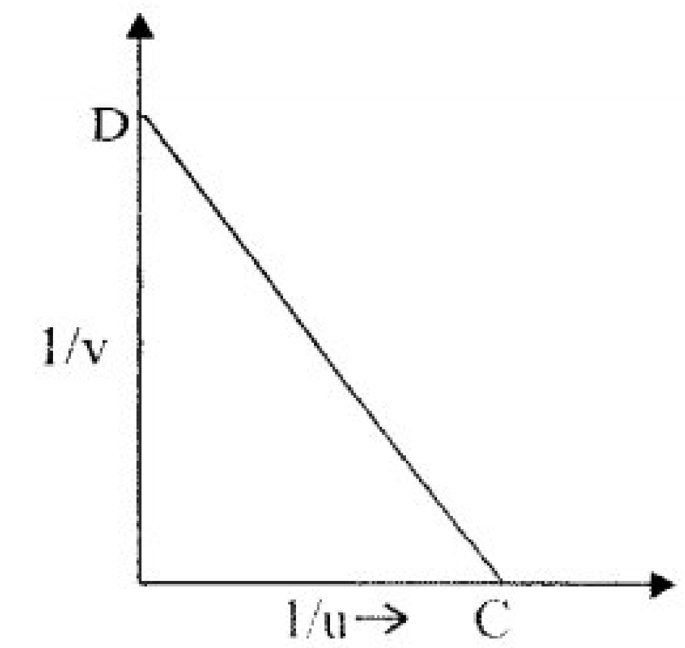


Fig. 11.3

11.7 CONCLUSIONS

(i) Graph between $\frac{1}{u}$ and $\frac{1}{v}$ is a straight line with a slope = -1 (because a $\approx$ b)

(ii) Focal length of the given convex lens f = ... cm.

11.8 SOURCES OF ERROR

(i) Lens has some thickness which has been neglected in this experiment.

11.9 CHECK YOUR UNDERSTANDING

(i) Give some practical uses of lenses.

....

(ii) You have a plano - convex lens having μ = 1.5 and R the radius of curvature of its spherical surface. What is the value of its focal length in terms of R.

....

(iii) Power of a lens is - 2.5 Dioptre (a) what is the focal length of the lens ? (b) Is it a converging or a diverging lens.

....

(iv) Can you perform the experiment using a candle and a screen. How?

....

(v) If a lens of u = 1.5, be immensed in water $\left(\mu = \frac{4}{3}\right)$, how will its focal length change?

....

(vi) What is the position of the object for which image formed by a convex lens is of the same size as the object?

....

(vii) Is the image formed by a convex lens always real?

....

(viii) How will you determine the focal length of a convex lens using one pin and a plane mirror?

....

EXPERIMENT 12

To draw a graph between the angle of incidence (i) and angle of deviation (δ) is for a glass prism and to determine the refractive index of the glass of the prism using this graph.

12.1 OBJECTIVES

After performing this experiment, you should be able to:

- draw emergent rays corresponding to rays incident on the face of a prism at different angles:
- determine the angle of deviation (δ) for various values of angle of incidence (i);
- determine the angle of prism;
- plot the variation of angle of deviation (δ) with angle of incidence (i) and hence determine the angle of minimum deviation (δ_m)
- determine the refractive index of the glass of the prism.

12.2 WHAT SHOULD YOU KNOW

You know that when light travels from one medium to another in which its speed is different, the direction of travel of the light is, in general, changed, when light travels from the medium of lesser speed to the medium of greater speed, the light is bent away from the normal. If light travels from a medium of greater speed to one of lesser speed, the light is bent towards the normal. The ratio of the sine of the angle of incidence in vacuum (i) to the sine of the angle of refraction (r) in a substance is equal to the ratio of speed of light (v_1) in the vacuum to the speed of light (v_2) in the substance.

$$\frac{Sin\ i}{Sin\ r} = \frac{v_1}{v_2} = n \qquad (12.1)$$

where the constant n is called the refractive index of the substance.

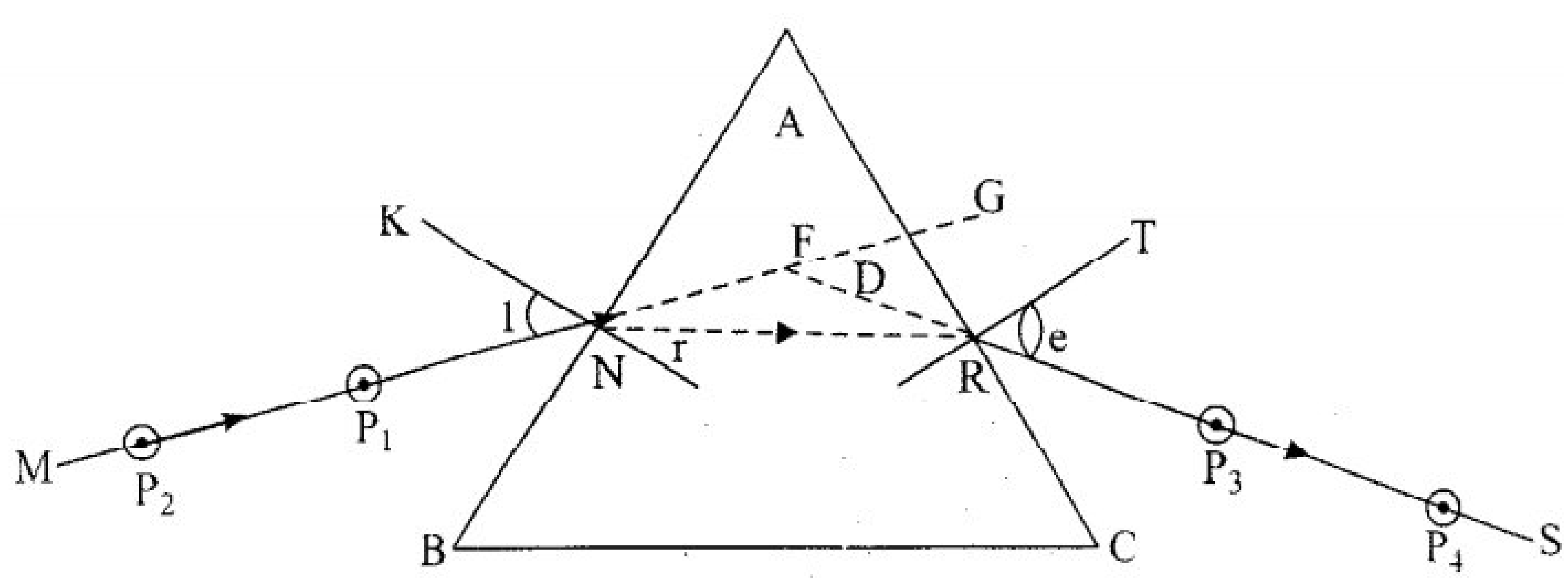


Fig. 12.1 Refraction through glass prism

If a ray MN of light (Fig 12.1) is incident on one surface of a prism ABC, the ray is bent at both the first and the second surface. The emergent ray RS is not parallel to the incident ray but is deviated by an amount that depends upon the refracting angle A of the prism the refractive index n of its material and also on the angle of incidence (i) at the first sufrace. As the angle of incidence is, say, decreased from a large value, the angle of deviation decreases at first and then increases and is minimum when the ray passes through the prism symmetrically as in Fig. 12.1. The angle of deviation, δ_m is then called the angle of minimum deviation. For this angle of minimum deviation δ, there is a simple relation between the refracting angle A, the angle of minimum deviation δ_m there is a simple relation between there fracting angle A, the angle of minimum deviation δ_m and the refractive index n. The relation is

$$n = \frac{Sini(A+\delta m)}{Sin(A/2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (12.2)$$

Material Required

Drawing board, white paper, prism, pins, pencil, scale, protractor, drawing pins.

12.3 HOW TO PERFORM THE EXPERIMENT

(i) Fix a sheet of a white paper on the drawing board.

(ii) Draw line AB representing a face of the given prism. At a point N on this line, draw normal KN and a line MN at angle z representing an incident ray. Do not keep i less than 30° as the ray may get totally reflected inside the prism.

(iii) Place the prism on the sheet so that its one face coincides with the line AB. Refracting edge A of the prism should be vertical.

(iv) Fix two pins P_1 and P_2 on the line MN. Looking into the prism from the opposite refracting surface AC. position your one-eye such that feet of P_1 and P_2 appear to be one behind the other. Now fix two pins P_3 and P_4 in line with P_1 and P_2 as viewed through the prism.

(v) Remove the pins and mark their positions. Put a scale along side AC, remove the prism and then draw a long line representing surface AC. Draw line joining P_3 and P_4. Extend lines P_2P_1 and P_4P_3 so that they intersect at F. Measure the angle of incidence i (angle MNK), angle of deviation D (angle RFG) and angle of prism (angle BAG).

(vi) Repeat the experiment for at least five different angles of incidence between 30^0 and 60^0 at intervals of $5^{0.}$

12.4 WHAT TO OBSERVE

Table : Variation of angle of deviation with angle of incidence

S. No.	Angle of incidence (i) Degrees	Angle of deviation (d) degrees	Angle of prism (A) degrees
1			
2			
3			
4			
5			

12.5 ANALYSIS OF DATA

Plot a graph between i and δ keeping δ along y-axis. From the graph, find the angle of minimum deviation, δ_m from the graph. Calculate the refractive index of the glass of the prism using these values in Equation (12.2).

$$n = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin(A/2)} = \frac{\sin\ .....}{\sin\ .....} = \frac{.....}{.....} = ...$$

m = ... degree

δ_m ....degree

12.6 RESULT

The refractive index of glass of the prism =

12.7 PRECAUTION

Common prisms are usually quite small with sides of 2.5 cm or 3 cm. So drawing the boundary of the prism and then measuring angle A does not lead to accurate value of A. Therefore, it is suggested that you draw a long line for faces AB and AC with a ruler and place the prism touching the ruler.

12.8 CHECK YOUR UNDERSTANDING

(i) A prism made of glass (μ = 1.5) and refracting angle 60^0 is kept in minimum deviation position. What is the value of angle of incidence ?

....

(ii) What is the condition for the angle of minimum deviation? In particular, what is the relation of the transmitted ray to the base of the prism?

....

(iii) Find the index of refraction of a 60^0 prism that produces minimum deviation of 50^0.

....

(iv) Is the refractive index of glass prism different for different wavelengths ? Explain.

....

(v) A prism, n-1.65, has a refracting angle of 60^0. Calculate the angle of minimum deviation.

....

EXPERIMENT 13

Determine the specific resistance of the material of two given wires using a metrebridge.

13.1 OBJECTIVES

After performing the experiment, you should be able to:

- find the least count of a screw guage;
- know the difference between resistance and specific resistance;
- identify the factors on which resistivity of a wire depends;
- make the connections of an electrical circuit;
- know the connections of an electrical circuit;
- find the position of balance point on the wire; and
- know the sources of error in an electrical circuit

13.2 WHAT SHOULD YOU KNOW

Metre bridge is the practical form of Wheatstone's bridge where

$$\frac{P}{Q} = \frac{R}{S}$$

P and Q are called ratio arms R is adjustable and S is the unknown resistance. For a wire of uniform area of cross-section, if null point obtained at length l (Fig. 13.1)

$$\frac{P}{Q} = \frac{1\sigma}{(100-l)\sigma} = \frac{1}{(100-l)}$$

as the total length of the wire of metre bridge is 100 cm, where σ is resistance per unit length of the bridge wire. Therefore,

$$S = \frac{(100-l)}{l} R$$

Material Required

A metre bridge, a galvanometer, a jockey, a Leclanche cell, a one way key, a resistance box, a metre scale, sandpaper, connecting wires and screw gauge.

13.3 HOW TO PERFORM THE EXPERIMENT

(i) Draw the circuit diagram given below in your notebooks and make the connections according to the circuit diagram.

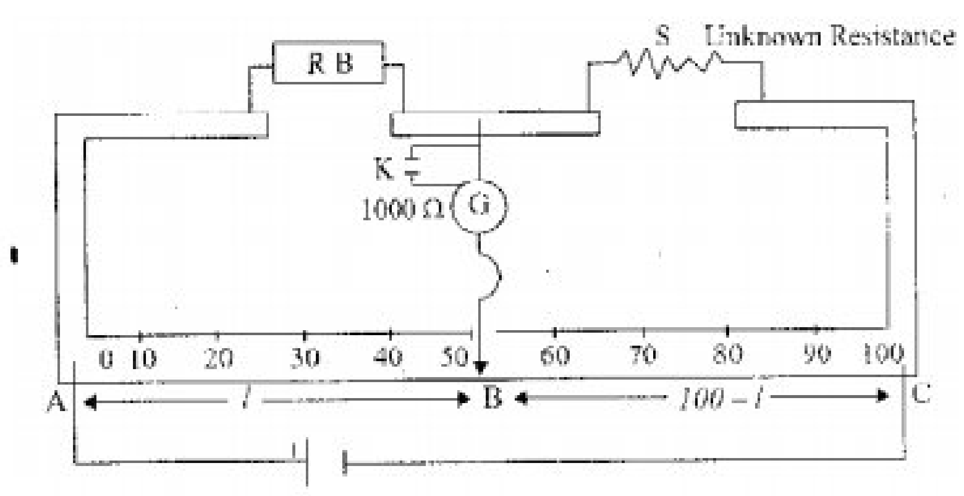


Fig. 13.1: Null position on the meter bridge wire

(ii) Remove the insulations from the ends of the connecting wires with the help of sand paper and make neat, clean and tight connections.

(iii) Make sure that the resistance in the resistance box is of same order of magnitude as the unknown resistance S.

(iv) To check whether the connections of the circuit are correct, take out a plug from the resistance box to introduce suitable resistance in the circuit. Open the key K. Now the 1000 Ω resistor makes galvanometer safe. Touch the jockey gently, first at the left and then at the right end of the metre bridge wire. If the deflections in the galvanometer are in opposite directions, the connections are correct.

(v) Now choose an appropriate resistance R from the resistance box. This is the rough position of null point. Now close the key K and then make fine adjustment of null point. Slide the jockey on the metre bridge wire gently by touching and lifting it again and again till the galvanometer reads zero nearly in the middle of the wire.

(vi) Record the lengths of both parts of the wire in the observation table.

(vii) Repeat the above steps two time more by selecting the suitable value of R for getting null point between 30 cm and 70 cm.

(viii) Now cut the resistance wire S at the points where it leaves binding tenninals. Straighten it by stretching and remove 3 kinks.

(ix) Measure the diameter of the wire by a screw guage atleast at different points. At each point, the diameter should be measured in two mutually perpendicular directions.

(x) Repeat the whole experiment for second wire of different material.

13.4 WHAT TO OBSERVE

i) Measurement of resistance S:

No. of obsv.	**Resistance R (ohm)**	**Position of null point AB = *l* (cm)**	**BC = 100-*l* (cm)**	$S = \frac{(100-1)}{l} R$
1.				
2.				

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Mean value of the resistance of the wire -

S = ... ohm.

Note : In another identical table record observations to find resists S^1 of your second wire.

(ii) Length of the second wire (L) = ... cm

Length of the second wire (L') = ... cm

(iii) Pitch of the screw gauge (P) =............................ cm

Number of divisions on circular scale = 100.

Least count (a) = $\frac{P}{100}$ =.............................. cm.

Zero error (e) =.............................. cm.

Zero correction (-e) = ... cm.

(iv)

Sl. No.	Reading along one direction			Reading along mutually perpendicular direction			Mean Obs. dia $d_v = (d_1+d_2)/2$	Corrected diameter $d = d_v - e$
	MSR s_1	**CSR** n_1	**Obsd.** $d_1=s_1+n_1a$	**MSR** s_2	**CSR** n_2	**Obsd.** $d_2=s_2+n_2a$		
1								
2								
3								

Note: In another identical table record observations to find diameter d^1 of second wire.

Mean corrected diameter (d) of first wire = ... cm.

(d^1) of second wire = ... cm.

(v) Specific resistance of the material of the given wires -

For first wire $\rho = S\frac{\pi d^2}{4l}$ = ...ohm metre

For second wire $\rho = S^1\frac{\pi d^2}{4l}$ ....ohm metre

Standard value of specific resistance of the material of the given wires -

ρ_0 = ... ohm metre.

ρ^1 = ... ohm metre.

13.5 CONCLUSION

The specific resistence of the material of the given wires -

ρ = ... ohm m

ρ^1 = ... ohm m

13.6 SOURCES OF ERROR

(i) The instrument screws may have much contact resistance.

(ii) The plugs may not be clean and tight enough giving rise to contact resistance.

(iii) The wire of the metre bridge may not have uniform cross sectional area.

13.7 CHECK YOUR UNDERSTANDING

(i) Why should the metre bridge wire have uniform thickness? What are end resistances?

....

(ii) What is null points?

....

(iii) Why is it advised to keep the null point between 30 cm and 70 cm?

....

(iv) Why should the moving contact of Jockey not be pressed too hard should not be scratched along the wire?

....

(v) Why should the current be passed only while taking an observation?

....

(vi) It has been advised to connect a high resistance (1000 ohm) series with the galvanometer while trying to find the null point. Why?

....

EXPERIMENT 14

To draw the characteristic curve of a forward biased pn junction diode and to determine the static and dynamic resistance of the diode.

14.1 OBJECTIVES

After performing this experiment, you should be able to:

- identify the cathode and anode of pn Junction diode;
- find from the data sheet the maximum safe current that can be passed through the diode being used;
- know the difference between static and dynamic resistances of a diode;
- know the knee voltage of the diode;
- choose meters of proper range for the experiment.

14.2 WHAT SHOULD YOU KNOW

A p-n junction diode consists of p-type and n-type materials forming a junction as shown inFig. 14.1(a)

In the p-type material there is an impurity of a III group element which gives rise to holes in it.The current flows in it due to motion of these ! holes. In the n-type material there is an impurity of a V157group element which gives rise to free electrons in it. The current flows in it due to motion of these electrons.

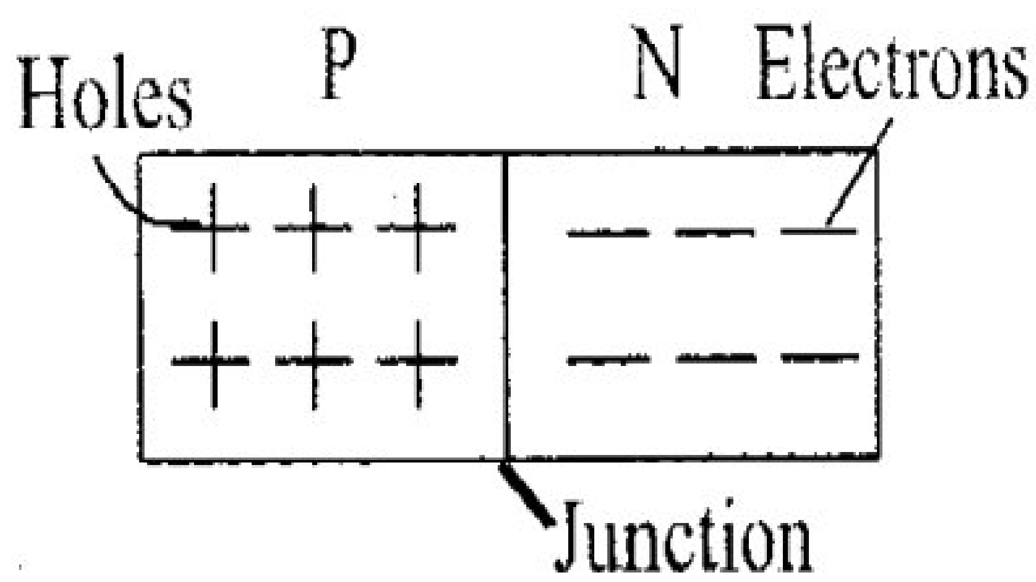


Fig. 14.1(a) p-n junction diode

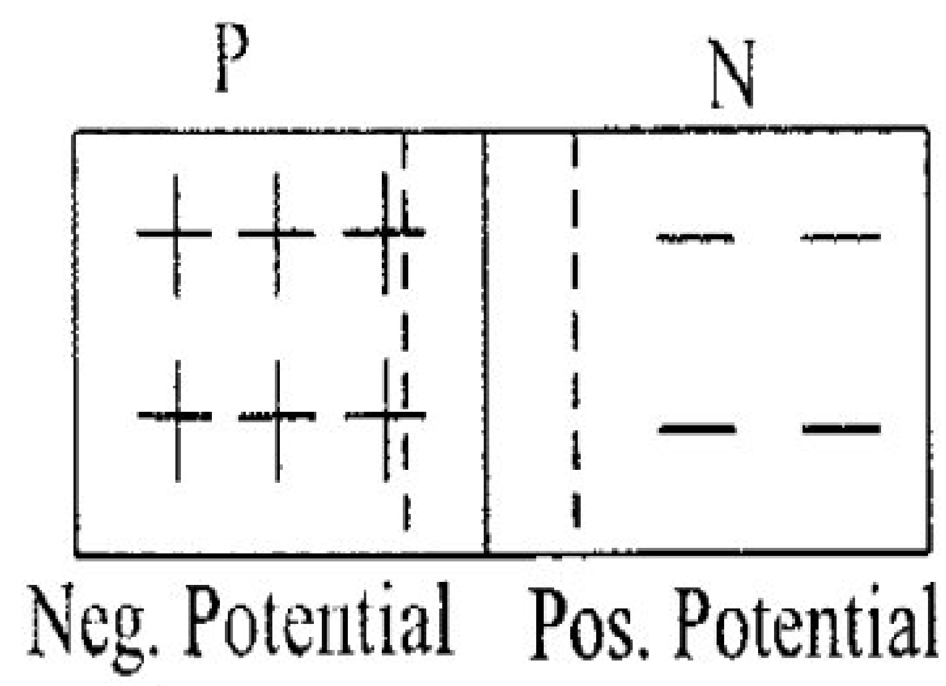


Fig. 14.1(b) Due to recombination of holes and electrons P-region becomes negatively changed an N-region becomes (positively very charged)

Both the materials are electrically neutral. Holes from p-type and electrons from n type, being free, combine with each other" at the junction. Due to this combination of holes and electrons, the p-type material develops a negative potential and n-type acquires positive potential as shown in Fig. 14.1.. This potential difference across the junction pulls the holes and electrons apart and stops their further combination.For forward biasing the diode, p-type side of the junction called the 'Anode' is connected to the positive pole of the battery and n-type side called the 'Cathode' is connected to the negative pole of battery as shown in Fig. 14.2. Under the-effect of this external applied potential difference- the holes and electrons are 'pushed towards each other. When the applied voltage exceeds the contact PD across, the junction, they start combining with each other and current starts flowing. It rises rapidly with increase of applied voltage. If the polarity of battery is reversed the holes and electrons are pulled still apart and no current flows in the diode.

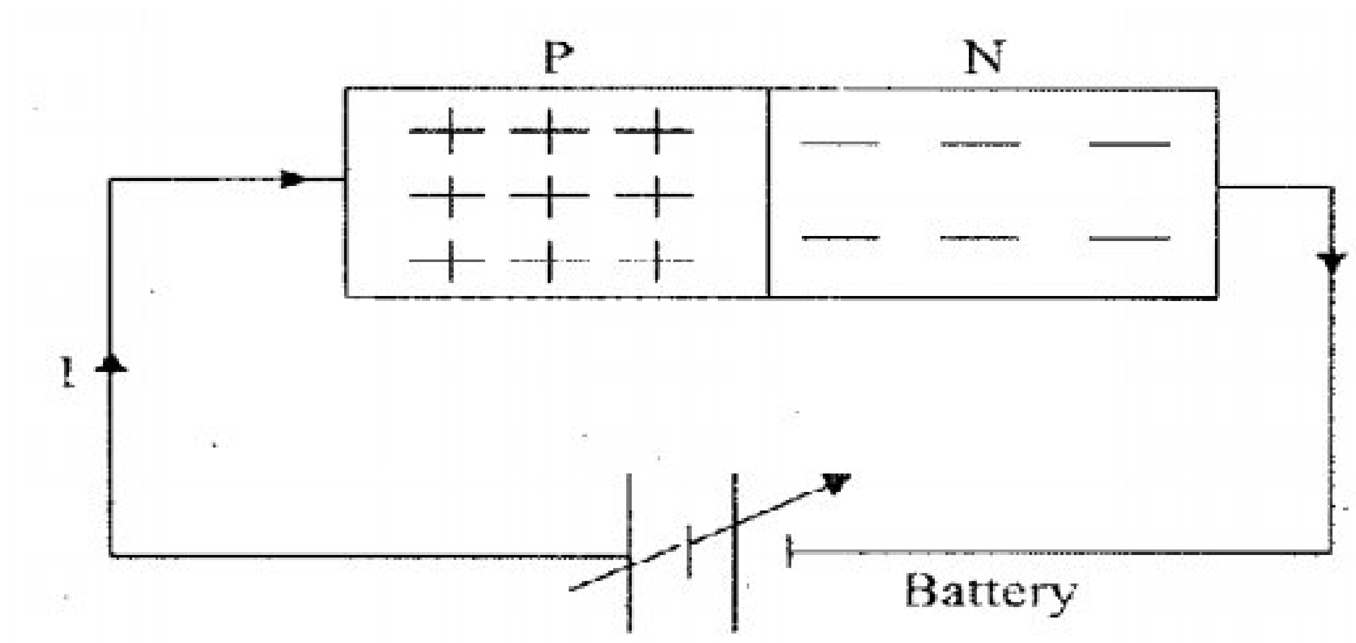


Fig 14.2: pn-junction is forward biased by the battery. The positive pole of battery supplies positive charge to P-region and negative pole supplies negative charge to N-region which combine at the junction and a current starts flowing.

In this experiment we have to study, how the current varies with the applied voltage. Here, we shall see that the current remains zero till the applied voltage approaches contact PD called the `knee' voltage. On increasing the applied voltage beyond this point, the current flowing through the diode increases rapidly. A graph plotted between `V and I' is not straight line as is seen in Fig. 14.3. It is called characteristics of the diode. In such cases where the (V vs 1) graph is not a straight line, we define two resistances. The static resistance or DC resistance and dynamic resistance or AC resistance. If we take a point P on the curve and note the applied voltage V_p and current I_p corresponding to this point, then the static resistance of R_{dc} at point P is defined as

$$R = \frac{V_P}{I_P}$$

The value of this resistance varies from point to point and is not constant.

If we take two points P and Q close to each other on the straight part of the curve and find the corresponding incremental voltage Δ_{pq} and current ΔI_{pq} from the curve as shown in Fig. 14.4, then R dynamic or R_{ac} is defined as

$$R_{ac} = \frac{\Delta V_{pq}}{\Delta I_{pq}}, \quad R_{ac} = \frac{\Delta V_{PQ}}{\Delta I_{PQ}}$$

$$K_{ac} = \Delta I_{pq} \qquad \Delta I_{pq}$$

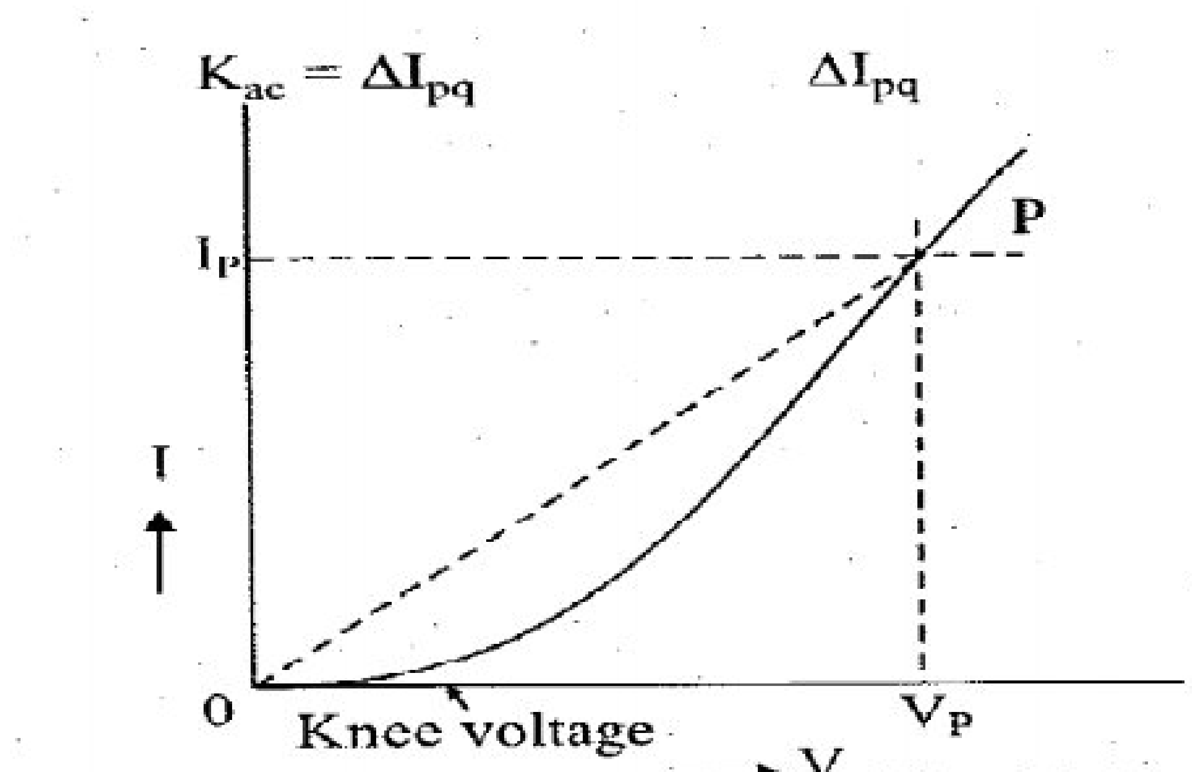


Fig. 14.3

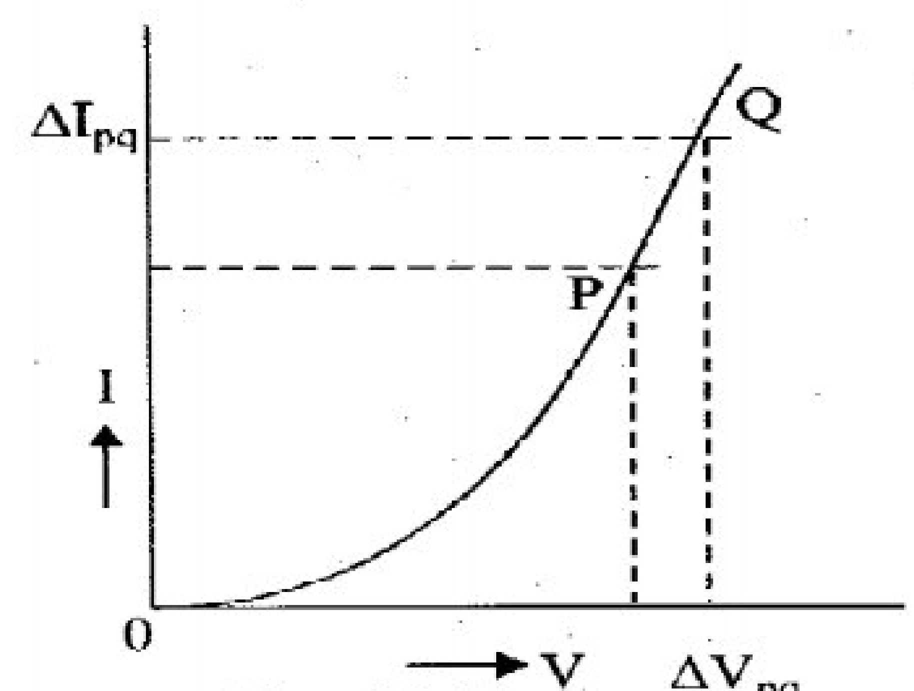


Fig. 14.4

Fig. 14.3 : *R_α at $P = Vp/IP$, which is the slope of line OP. ft. will have different values for different positions of P.*

Fig. 14.4 : *R_{AC} at $\Delta V_{pc}/\Delta I_{pq}$ this will be nearly constant for straight part of the curve. It is much less than R_{DC}*

This resistance is nearly constant for the straight part of the curve. The dynamic resistance of a diode is much lower than the static resistance. It is this resistance which a diode offers to AC when it is used as a rectifier to convert AC into DC.

The knee voltage of a diode depends on the material used for id fabrication. For Silicon diode its value is 0.7 V and for Germanium diode it's value is 0.3V.

The commonly used diodes in the laboratory are OA 79 and IN4007JOA79 is Ge diode which is sealed in a glass tube. IN4007 is a Silicon diode sealed in plastic casing. The distinguishing No. is printed on their casing. There are two axial leads. On one side there is a coloured ring as shown in Fig.14.5(a) and Fig. 14.5(b). This ring indicates the cathode lead which is connected to the n-type material in the diode. The other lead connected to p-type material is anode. From the data sheet we find that I_{max} for OA 79 is 30 ma at 1.5V. For IN4007, 1_{max} is 1 amp at 1.5V. The symbol of the diode is given in Fig. 14.5(c).

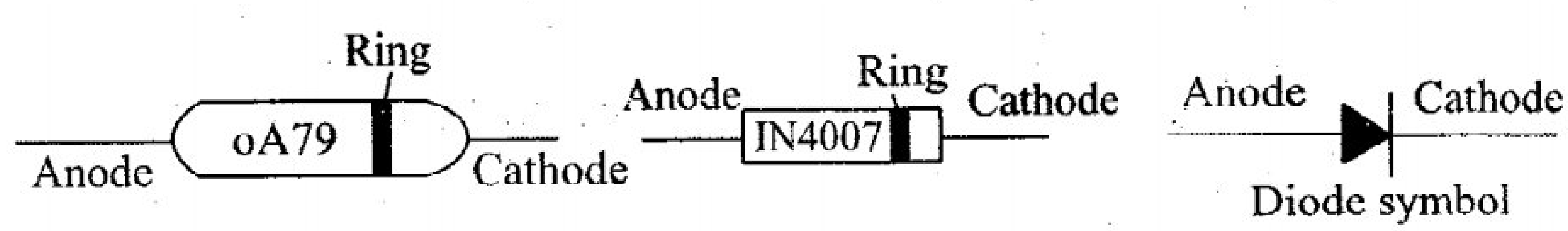


Fig 14.5 (a) Fig. 14.5(b) Fig. 14.5 (c)

Material Required

A Ge diode 0A79 0-1.5V voltmeter, 0-30 ma meter, 25 ohm rheostat, 2V lead accumulator, one-way key and connecting wires etc.

14.3 HOW TO PERFORM THE EXPERIMENT

(i) Set the zero of both the meters

(ii) Record the least count of both the meters.

(iii) Make the connections as shown in diagram 14.5.

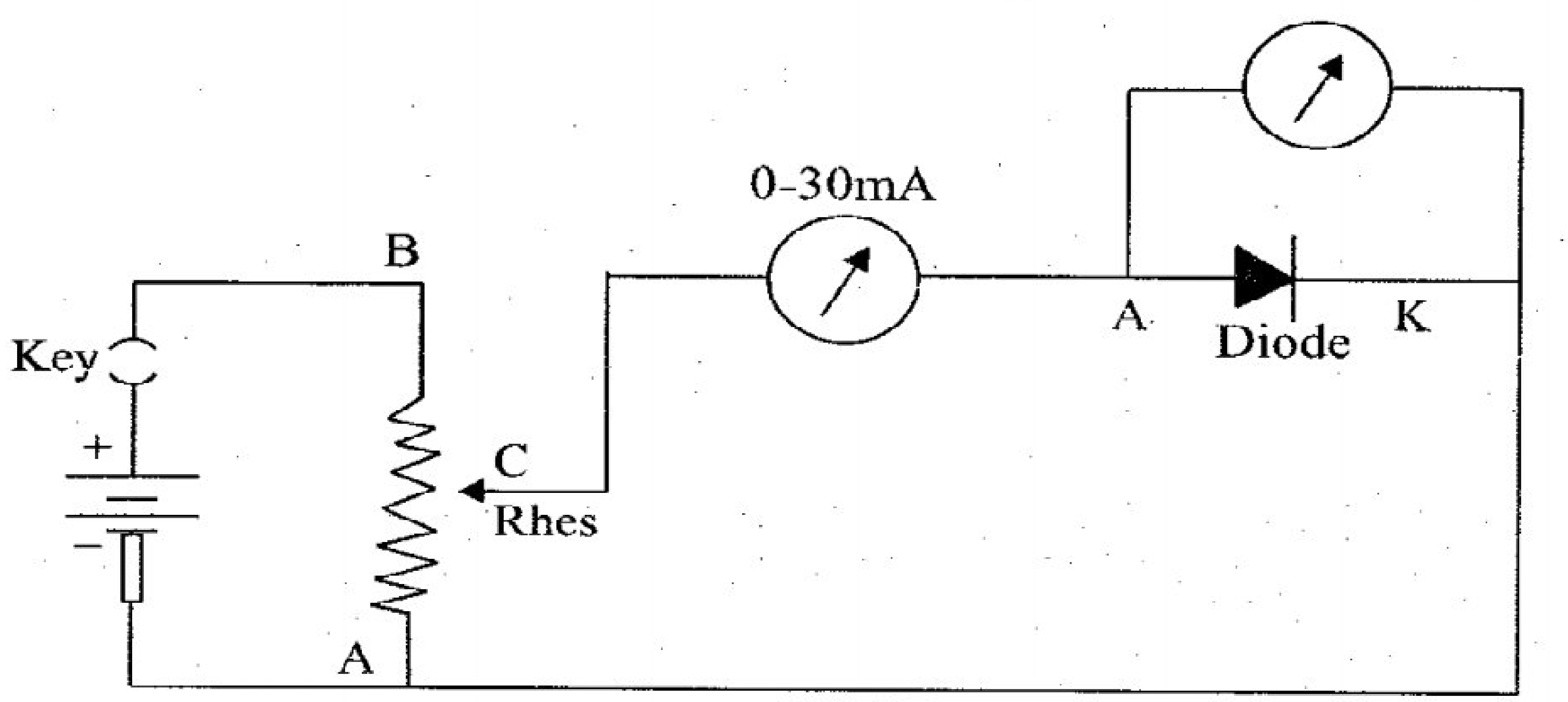


Fig. 14.6

(iv) Bring the movable point C of the rheostat nearest to the point A and insert key. Readings in both the meters will be zero. Now move point C slowly towards B so that the reading in the volt meter is on a scale mark and record the readings of mA and volt meter in the observation table.

(v) In this manner move point C towards B in small steps and each time take readings of mA andvoltmeter. Take the readings in steps of say 0.1 volt till the current passing through the diode is around 25 to 30 mA.

(vi) Now plot a graph from these readings, which will look like the one given in Fig. 14.3.

14.4 WHAT TO OBSERVE

Zero error in voltmeter = Nil

Zero error in mA meter = Nil

Least count of voltmeter = V/div.

Least count of mA meter = mA/div

S.No	Volmeter Divn.	Reading V	mA meter Divn.	Reading mA
1.				
2.				
....				
15.				

14.5 ANALYSIS AND CONCLUSION

(i) From the graph plotted from the observations recorded in the table, you will find that the current through the diode is zero while potential difference across it is low. Find the voltage (the knee voltage) at which the current just starts flowing.

(ii) Take 3 points A, B and C on the graph. Find the voltage and current corresponding to these points and calculate the value of static resistances at these points. Are they equal?

(iii) Take three pairs of points close to A, B and C. Points near A should be at equal distances on either sides of A. and so on. Find the incremental voltage and currents at these points. From these values of incremental voltage and currents find dynamic resistances at these points. Are they equal?

(iv) What conclusions do you draw about the static and dynamic resistances at different points on the graph?

14.6 SOURCES OF ERROR

(i) They may be contact resistances particularly if any connections remains loose.

(ii) Zero error of the meters may not be accurately eliminated.

(iii) Starting deflection may be too small and more than 70% of full scale.

(iv) Each time the pointer of ammeter may not be on a scale mark.

(v) Ammeter is measuring current of voltmeter and diode.

14.7 CHECK YOUR UNDERSTANDING

i) Which of the two resistances of a diode is higher and why?

....

ii) Why the dynamic resistance is nearly constant while the static resistance is different at different points of the V-I characteristic ?

....

iii) Why should a sensitive voltmeter be used in this experiment?

....

iv) Why should the points near the point A or B or C on the graph for finding dynamic resistance beat equal distances from A?

....

EXPERIMENT 15

To draw the characteristic of an NPN transistor in common emitter mode. From the characteristics find out (i) the current gain (β) of the transistor and (ii) the voltage gain Av, with a load resistance of 1K Ω.

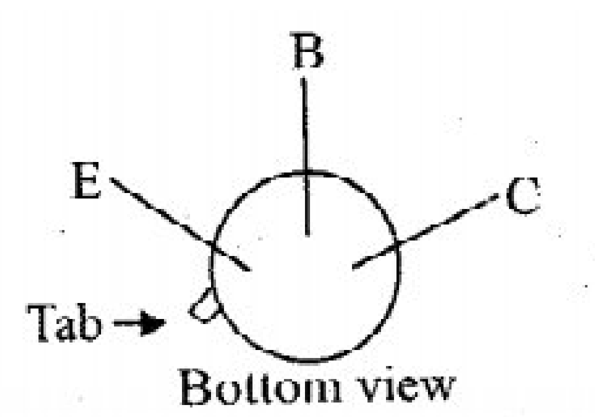
15.1 OBJECTIVES

After performing this experiment, you should be able to

- understand how to forward bias a p-n junction and how to reverse bias it;
- identify the leads of the transistor,
- find out from data sheet the type of transistor, the maximum safe current voltage and maximum power dissipation for the transistor,
- know what is meant by CE mode;
- know that the transistor is a current operated device;
- define current gain (β) of a transistor;
- define the voltage gain (A_v); and
- know the factors on which A_v depends.

15.2 WHAT SHOULD YOU KNOW

You have already learnt in theory that a transistor has three leads. To identify them hold it up side down.There is a small tab projecting out of the casing. The lead adjacent to this tab is emitter lead. The other two leads taken in clock wise direction are respectively base and collector leads as shown in Fig. 15.1. Some transistors there is a coloured dot marked on the casing. The lead near this mark is collectorThe other two leads taken in anti clockwise order are respectively base and emitter leads as shown in 15.2.



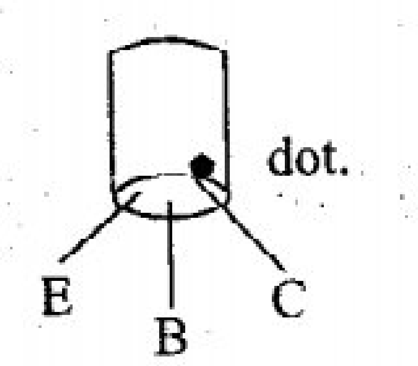
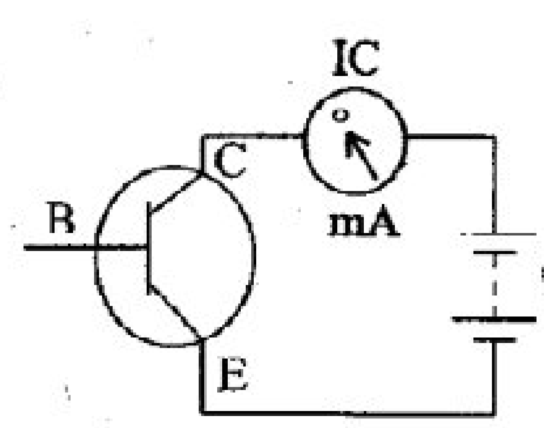


Fig. 15.1 Fig. 15.2

While using a transistor the collector is always reverse biased. Normally no current flows in the collect for remitter circuit as shown in fig15.3. But on passing a small base current by forward biasing the baseemitter junction as shown in Fig. 15.4. a strong I starts flowing. Thus we see that a transistor is a current operated device and a small base current gets amplified in the collector circuit. In fig. 15.4, we see that the emitter is included in- both the base and the collector circuits. Hence it is called a common emitter circuit.



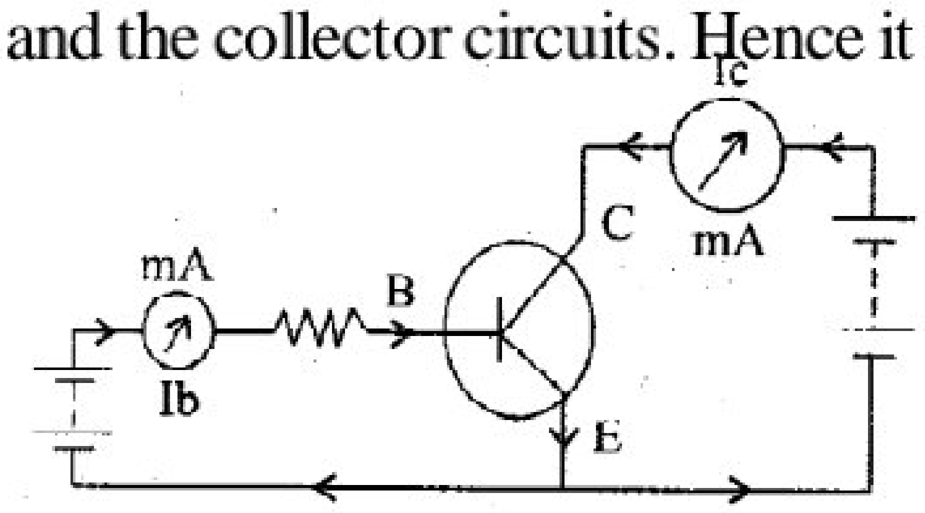


Fig. 15.3 Fig. 15.4

The incremental ratio $\delta I_c / \delta I_b$, is the current amplification factor β of the transistor. We have to find out β from the characteristics curves as explained later, To keep I_C constant, that is independent of variation of I_c high resistance of 20k ohm or more is included in series with the base as shown in the circuit given in Fig. 15.5.

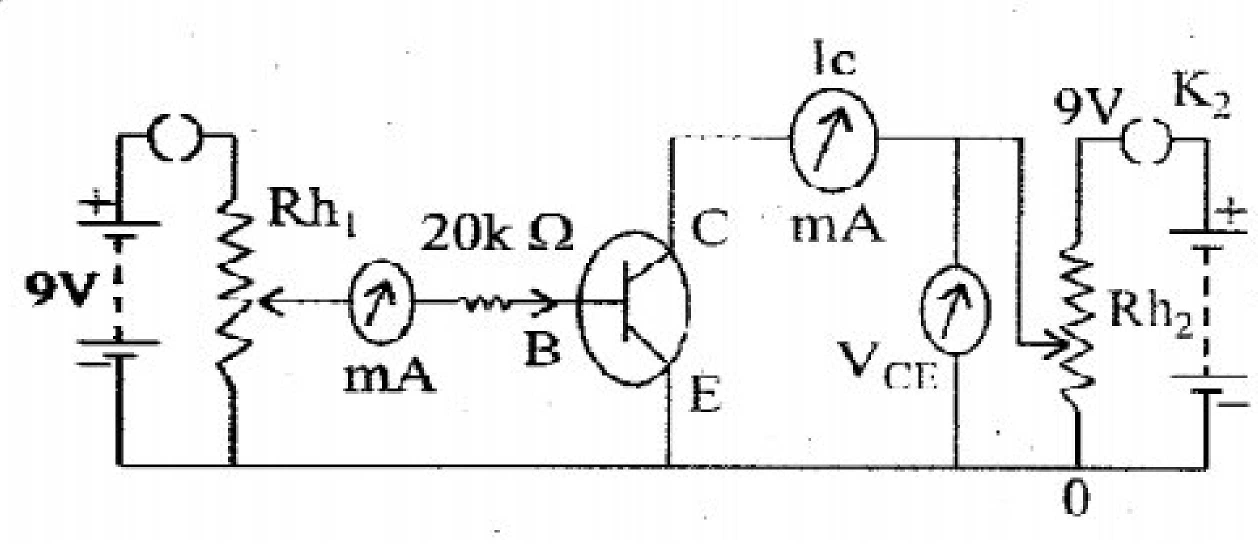


Fig. 15.5

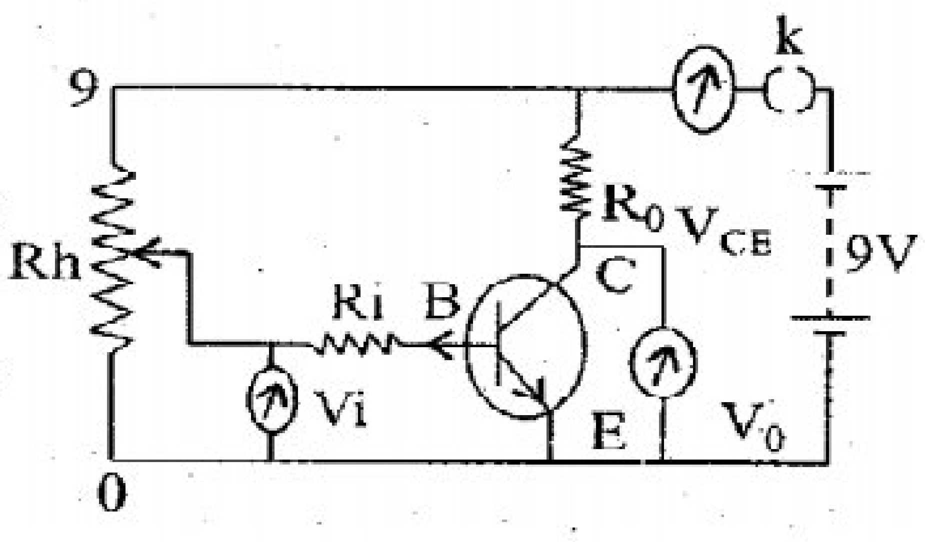


Fig. 15.6

When the input signal supplied to a transistor changes by a small amount, it produces a large change in output The ratio of change in output voltage to the corresponding change in input voltage is called voltage gain A_v produced by the transistor.

To obtain voltage gainA_v from a transistor a load resistance R_0 is to be connected in series with the collector and a suitable resistance R_1 in senes with the base. To determine the voltage gain a circuit shown in Fig. 15.6 is used. Briefly, the voltage gain A, produced by the transistor can be found as given below.

If δV_1 is the change in input voltage, then change in base current produced by it is given by

$$\delta I_i = \delta 1_b = \delta V_i/R_i$$

Therefore, corresponding change in collector current δI_c is given by

$$\delta I_c = \beta \times \delta I_b = \beta \times \frac{\delta V_i}{R_i}$$

The output voltage δV_0 will be the change in voltage drop across the load resistance R_0, Therefore,

$$\delta I_0 = \delta I_0 \times R_o = \beta \times \delta V_1 \times R_0/R_i, \text{ or}$$

$$A_v = \frac{\delta V_0}{\delta V_1} = \beta \times R_0/R_i$$

From this expression we see that the value of A_v the voltage gain produced depends on β, R_0 and R_i.

β for CL100 is around 150, so keep the value of A, practically measurable that is around 20, the value of R_0 is taken as 1000ohm or 500 ohm and R_1 used is 4000 ohm.

Material Required

One 1.5 V and one 9 V batteries or stabilised battery eliminator with 9V and 1.5V output terminals, medium power NPN transistor CL 100 or equivalent mounted on board for making connections. 0-30 mA DC meter, 0-300 micro amp DC meter, 0-10V DC voltmeter, 0-1.5 VDC voltmeter, two 1000 ohm rheostats. two one way keys, 20 k ohm, 4 k ohm. 2 k ohm. I k ohm and 0.5 k ohm carbon resistors with tenninals and connecting wires or leads.

15.3 HOW TO SET UP THE EXPERIMENT

Select a medium power transistor so that it can withstand a high current without damage. Here.the CL100 has been recommended for the experiment. Identify it's leads and see that they are correctly connected to the three terminals on the board. Draw the diagram Fig. 15.5 on your copy and place all the required equipment on the table as shown in the diagram. Then complete the connections with the wire. Move the wipers of rheostats to 0 end and insert the keys. All the meters should indicate zero reading.

Now set the wiper of rheostat-2 to the middle. The collector voltmeter will show 4 volt and current will be zero. Now move the wiper of the rheostat-1 slowly upward. The base current will increase uniformly as indicated by the micro ammeter and the collector current will also rise. Take care that it does not go beyond 30 mA. The circuit has been set correctly

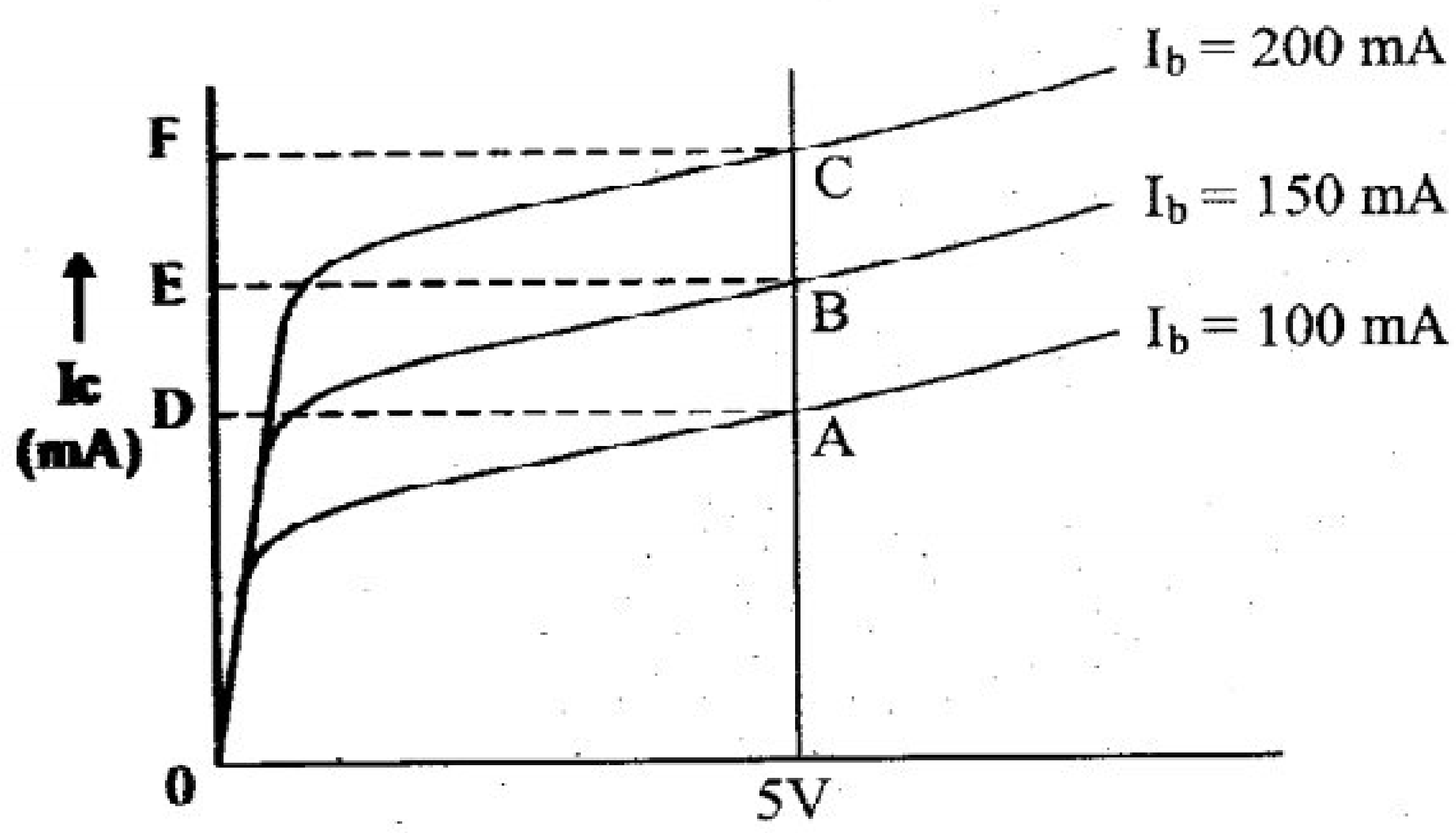


Fig. 15.7

15.4 HOW TO PERFORM THE EXPERIMENT TO FIND THE CURRENT GAIN

(i) Note the least count of the meters.
Least count of mircro ammeter = ... μ A/div.
Least count of volt meter =.............................. V/div.
Least count of milli-ammeter =................ A/div

(ii) To start with, the wipers of both the rheostats are at zero ion. Move the wiper of rheostat-1 so that the I_0 becomes 100 µA. Leave it there. Now move the wiper of the rheostat-2 slowly in small steps, take the readings of V_{ce} and I_c, and record them in table No given below. You will note that at first I_c rises rapidly and then it becomes nearly constant against variation of V_{ve} , Take the readings up to 9 V. Similarly repeat the observations with 1_0 set to 150 and 200 µA and record the observations in table No.2 and 3.

Table 1:

$I_b = 100\ \mu$ A

V_{ce}(V)	0	.1	.2	.3	.5	.75	1	2	3	4	5	6	9
I_c (mA)													

Table 2:

$I_b = 150\ \mu A$

$V_{ce}(V)$	0	.1	.2	.3	.5	.75	1	2	3	4	5	6	9
I_c (mA)													

Table 3:

$I_b = 200\ \mu A$

$V_{ce}(V)$													
I_c (mA)													

(iii) Plot graphs from the data recorded in above three tables. The graphs obtained and shown in fig. 15.7. These are the characteristics of CL100 in CE mode. At low V_{ce} a fraction of charge carriers injected into the base region are collected by the collector and hence I_c, is small. As V_{ce} increases more and more carries get collected, hence I_c rises rapidly. When all the carriers have been collected I_c becomes nearly constant. This explains the shape of the characteristics curves.

(iv) To find the current amplification factor β of the transistor draw a vertical line perpendicular to V_{ce} axis at say -5V point. Let it cut the three curves at A, B and C as shown in Fig. 15.7. Now from points A,B and C draw perpendiculars on the l_c axis. Let these meet the axis at points D, E and F as shown in Fig. 15.7.

(v) In going from points A to B the base currect changes by

$\delta I_b = 150 - 100 = 50\ \mu A = 50 / 1000$ mA

(vi) The collector current changes by DE mA, therefore,

$\delta I_c =$ DE mA

$\beta = (DE \times 1000) / 50$

(vii) Similarly calculate β for variation of currents from B to C and A to C. Find the mean value of β.

15.5 TO FIND THE VOLTAGE GAIN

(i) To determine the voltage gain A produced by the transistor with Ik ohm load resistance R_0, connect the circuit as shown in Fig. 15.6. Keep the wiper of rheostat at zero. Keep R_i=4kohm.

(ii) Insert key K_2, to apply voltage of 9V to collector. Then insert K_1, and move the wiper of rheostat slowly upward till the reading of V_{ce} say 5V. Now increase or decrease V. by say 0.05V, or 0.1 V, or 0.2 V. For this least count of voltmeter V_i should be small. This gives the change in input voltage that is δV_i Note the corresponding change in V_{ce} , which gives δV_0. Record these readings in table 4 given below. Repeat this process five or six times and record the observations in table 4.

Table 4 :

Load resistance R_0 = ... ohm.

Input resistance R_i = ... ohm.

δV_i (V)	
δV_0 (V)	
$A = \delta V_0 / \delta V_i$	

(iii) Calculate the voltage gain for all the sets of readings recorded in table 4. You will see that A_v is about the same for all the sets. The deviation occurs when the output voltmeter readings are near 0 or 9 volts.

(iv) You can also verify that the experimental value of A_v is = $\beta \frac{R_0}{R_i}$

15.6 CHECK YOUR UNDERSTANDING

i) What happens to the transistor, when we pass 30 mA current for a long time with 9V V_{ce}?

....

ii) From the data sheet we find that CL100 can pass I_c = 150 mA and it can safely withstand 50 V between collector and emitter. Can we pass 150 mA at 50 V through it? If not, why?

....

iii) What will happen if R_0 is 10k ohm and R_i is 500 ohm? How many readings of 8V_1 with your meter having a L.C. of .01 V/div. can be taken? Given that β is 200.

....

iv) From your experimental curves (Fig. 15.7) find out how will β change with V_{ce}.

....

v) Is it possible to do this experiment without a separate battery of 1.5V base circuit? If so how?

....

Answers to Check Your Understanding

Experiment 1

(i) A vernier scale is a scale with divisions slightly smaller than those on the main scale and is moveable along the main scale. It is no named after the name of its inventor Pierr- Vernier.

(ii) Vernier constant is the difference between the length of one main scale division and one vernier division. It is the least count of the instrument, because we can measure a length with this muchprecision.

(iii) Negative

(iv) By adjusting the lower jaws for zero thickness (or the depth gauge for zero depth), observe the vernier reading and multiply it by vernier constant.

(v) Vernier scale enables is to observe the position of its zero mark on the main scale with a precisionof a fraction (or1/10 or 1 /20 or 1/50) of the main scale division,

(vi) + 0.03 cm.

(vii) First measure the inside depth of the hollow cylinder by using its depth gauge. Next measure its out side depth using the lower jaws. Substract the former from the latter to get the thickness of the bottom.

Experiment 2

(i) Because it measures the fraction of smallest division on the main scale accurately with the help of a screw.

(ii) Pitch of a screw gauge is the distance through which the screw move along its axis in one complete rotation.

(iii) Least count is the distance through which the screw moves along its axis in a rotation of one Pitch of the screw Least Count=No.of divisions in the circular scale

(iv) Back-lash error is the error in circular scale reading caused by no movement of screw along its axis while we rotate it. It is due to play in the screw. It can be avoided by taking care to only advance the screw every time final adjustment is made for finding zero error or the diameter of the wire.

(v) Ratchet arrangement prevents you from accidentally pressing hard on the fixed stud by the screw while measuring zero error, or on the wire while measuring diameter of the wire.

(vi) Zero error = -0.035 mm

Zero correction = + 0.035 mm.

Experiment 3

(i) Chance error of measuring a time interval by stop watch, which depends on your personal skill,remains the same whatever is the length of the time interval. By taking 20 oscillations, the fractional error (i.e. percentage error) in the measurement is smaller by a factor 1/20, as the time interval is20 times longer.

(ii) When you measure time of 50 oscillations, instead of 20 you measure a time interval 2.5 times longer. Thus percentage error in measuring this time interval (and also the calculated time of one oscillation) is smaller by a factor 1/2.5,

(iii) (a) 1/3rd (b) 3 times.

(iv) (a) Time period changes. Because bob accelerates faster, T decreases. (b) Length of second's pendulum also changes. It increases - a longer pendulum will be required for same time period of 2s.

Experiment 4

(i) A body is said to be at rest if it does not change its position relative to its surroundings with the passage of time.

(ii) The junction may not come to rest at the same position due to friction.

(iii) The weights are kept away from the table or board so as to avoid effect of friction.

(iv) (a) 320 g wt.

(b) 390 g wt. (c) 443 g wt.

(v) The resultant force is almost equal to sum of the individual forces and when it falls down, it does not fall on any of the workers.

Experiment 5

(i) Yes. This method-can be used. In this case hotter water and calorimeter will give heat to colder solid brass hob. However, it will be (difficult to find the stead) final temperature of the mixture.Because, the temperature of water with bob dipped in it, will keep on falling continuously.

(ii) No, Wood is bad conductor of heat. It can not acquire uniform temperature throughout.

(iii) The pure water boils at 100°C only when the atmospheric pressure is 76 cm of mercury.

(iv) The temperature of the water during stirring initially rises; becomes maximum and steady for some time and then starts falling again due to heat losses by radiation. This steady maximum temperature of the water is the final temperature of the mixture.

(v) The mixture is stirred continuously to keep the temperature uniform

(vi) Specific heat of water = 1 calg°C Let the specific heat of brass = S

Heat lost by brass piece = 200 x S x (100-23)

Heat gained by water = 500 x 1x (23-20). Assuming no loss of heat to the surrounding.

$S = 500 \times 3/200 \times 77 = 15/157$

= 0.098 Cal/g-1/°C-1

(vii) For marble of 1 gm to raise its temperature by unity, 0.215 cals of heat are required. Similarly 1 kg of Aluminium requires 900 J of I heat to raise its temperature by one degree celcius.

(viii) Yes. Instead of water, the given liquid is used. In this case, however, the specific heat of the material of solid bob is taken as known.

(ix) No. It can be of any shape.

Experiment 6

(i) If the oscillations are too large, maximum extension of the spring during a downward swing be beyond the elastic limit.

(ii) We are concerned with oscillations which occur in the suspended mass M due to elastic force spring only? If there is a horizontal component of motion, somewhat like a pendulum, gravitational force makes the motion complicated.

(iii) These will be equal. The oscillations are S.H.M. If these are within elastic limit, i.e. maximum extension during a downward swing is within elastic limit of the spring. For a simple harmonic motion, time period is independent of amplitude.

(iv) Extension decreases due to smaller, gravitational force pulling down the spring.

Experiment 7

(i) 0.67 m and 2.01 m.

(ii) Equation (1) says that fro m even one length, we can determine the wavelength and hence the velocity of sound. But the antinode does not occur exactly at the open end of the tube. It is at a slight distance above it. This is approximately equal to 0.3 D where D is the internal diameter of the tube. Therefore, the real length of the resonating air column is not equal to length of air column l, but is $l + e$. Taking the difference in the lengths of resonating air columns for two positions this end correction.

(iii) For a given source of sound, frequency is constant and hence wavelength is directly proportional to the velocity of sound. Since the velocity increases with temperature, wavelength will also increase accordingly. Now length of resonating air column $L = \frac{n\lambda}{4}$. Hence, if the temperature is 5°C more, length of air column for each resonance will increase.

Experiment 8

(i) A tuning fork should be set into oscillation by striking it with a rubber mallet/ block whichever is available. Striking the tuning fork with any hard object may damage the fork and cause a change in its characteristic frequency.

(ii) (a) 3 (b) 6

(iii) 1073 Hz.

Experiment 9

(i) It is a locus of the points on the surface of earth which are equidistant from the two magnetic poles of the earth.

(ii) Magnetic S pole is located near the geographical North pole of the earth.

(iii) Neutral points cannot be found in a single magnetic field.

Experiment 10

(1) Relative shift in the position of a body with respect to another body, on viewing it from two different stand-points, is called parallax. Parallax between the tip of the real image of a pin and the tip of another pin is removed by moving the image-pin on the optical bench till we find that their tips remain coincident as we see them from different positions by moving our head side-ways.

(ii) As we move an object away from a concave mirror between its pole and focus the size of itsvirtual image increases. On placing it at a point beyond focus the image formed is real and the sizeof the real image decreases as we move the object from focus to infinity.

(iii) We will get a virtual image from a concave mirror when the object is positioned between the two focus and the pole of the mirror.

(iv) Rough focal-length is determined so that the object pin may be placed between f and 2f. Thus we will manage to keep our image-pin beyond 2f and the real image of object pin may be formed on it.

(v) Place an object very close to the mirror. If its image in the mirror is enlarged, the mirror is concave if the image is diminished in size, the mirror is convex.

(vi) We use spherical mirrors of aperture (diameter) small in comparison to focal length, because the mirror formula is applicable only for paraaxial rays.

(vii) No. Because the image formed by a convex mirror is always virtual.

(viii) We could also determine f by plotting graphs between (i) on y-axis (uv) and (ii) on x-axis(u+v). Slope of this straight line graph passing through origin is the focal length.

(ix) Yes. Because the real image of candle may be obtained on screen and thus the value of u and v may be accurately determined.

(x) Yes. We can obtain the real image of a pin on itself when it is placed at the centre of curvature.Thus we can determine R.

Then f =-R/2

Experiment 11

(i) Lenses ae used in (i) spectacles, (ii) microscopes, (iii) telescopes, (iv) Photo-camaras etc.

(ii) $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R}\right) = 0.5/R=1/2R$

=f=2R

(iii) a) P= -2.5 m^{-1}, f= $\frac{1}{p}$

=-1/2.5, m = -40m.

(b) Negative sign of focal length indicates that the lens is a diverging (concave) lens.

(iv) Yes. Because the image formed by a convex lens in this experiment is real, we can use a candle in place of object pin and a translucent screen in place of image-pin.

(v) When in air

$$\frac{1}{f} = (1.5\text{-}1) \quad \left(\frac{1}{R1} + \frac{1}{R2}\right)$$

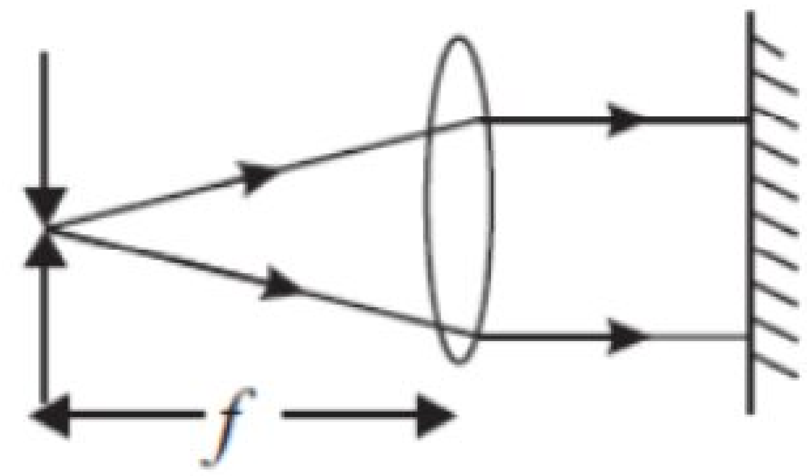


Fig. 11

When in water $\frac{1}{f_1} = \left(\frac{1.5}{\frac{4}{3}} - 1\right) \left(\frac{1}{R^1} + \frac{1}{R^2}\right)$

$$= \left(\frac{9}{8} - 1\right) \left(\frac{1}{R^1} + \frac{1}{R^2}\right)$$

$$= \frac{f_1}{f} = \frac{0.5}{1/8} = 4$$

$= f_1 = 4f$

i.e. in water the focal length will be four-times the value in air.

(vi) The image is same size as object when the object is placed at 2f

(vii) No. The image will be virtual when the object is placed between focus and optical centre of the lens.

(viii) If the object pin is placed at the focus of the lens,rays from any point of it will emerge out as parallel beam (Fig. 11.4). Hence if the lens is backed by a plane mirror the rays will retrace their path and hence the real and inverted image of the object pin will be formed at the same position. Thus f can be measured.

Experiment 12

(1) In minimum deviation

A = 2r

$$\Rightarrow r = \frac{60}{2} = 30^0$$

$$\mu = \frac{Sini}{Sinr}$$

Sin i = 1.5 x 1/2 = 0.75

i = Sin^{-1} (0.75)

(ii) The angle of minimum deviation occurs for a particular wavelength when a ray of that wavelength passes through the prism symmetrically, i.e. parallel to the base of the prism.

(iii) 1.64

(iv) The index of refraction is slightly different for different wavelengths. When the incident beam is not monochromatic, each wave length (colour) is refracted differently because the wave velocity is slightly different for different wavelengths in a material medium. Here different wavelengths for different colours refers to their wave lengths in air (or in vacuum). But the frequencies of the waves are unchanged, when they enter from one medium to another. Thus we can also take of different n for different frequencies n (for different colours).

(v) 51.2^0

Experiment 13

(i) In the derivation of the formula S = [100-l/l]R it has been assumed that resistance per unit length of the metre bridge wire is constant throughout. For a wire of varying crossectional area,this will not be true.

(ii) Usually a small contact resistance in series with the wire exists at each end due to loose fixing, of the ends of wire to the screws. This is called end resistance.

(iii) When position of jockey on the wire of metre bridge has been so chosen that potential difference across galvanometer in zero, this position is called null point.

(iv) So that the lengths l& (100-l) are comparable. The wheat stone bridge is more sensitive when all the four resistances are of the same order of magnitudes.

(v) It may cause variation in the cross sectional area, thereby using a variation in the resistance per unit length of the metre-bridge wire.

(vi) If the current through the wire is passed continuously, it would get heated causing an increase inits resistance. This may change the value of the ratio $\left(\frac{l}{100-l}\right)$ thus changing the null-point.

(vii) Galvanometer is a sensitive instrument. Initially when jockey is far from the null point then current through the galvanometer may be high causing deflection beyond the maximum deflection mark on-the scale. A sudden flow of high current may damage the galvanometer. To allow a small and safe value of current to flow through the galvanometer when it is far from the null point, a high series resistance is connected. Alternatively, a shunt is connected across the galvanometer to by-pass a major portion of the current.

Experiment 14

(i) Dynamic resistance of a diode is much smaller and DC resistance is much higher. It is because for some initial voltage across the diode, no current flows through it. When current starts flowing then for a small incremental voltage, there is a large incremental current.

(ii) Dynamic resistance is reciprocal of the slope of the V-I characteristic (I being plotted along y-axis). The slope is constant along straight portion of the characteristic and so is the dynamic resistance. Static resistance keeps changing along the graph because slopes of lines from origin to different points on the graph are different.

(iii) Current drawn by voltmeter is an error in current reading of the mA -metre, which measures total current passing in the voltmeter and the diode. Hence voltmeter should be sensitive and draw very small current.

iv) The ratio of incremental current/incremental voltage gives average slope of the graph between the two points. This will be equal to slope of the graph at A, if A is their mid-point, even in the case when slope of the graph is changing along the graph.

Experiment 15

(i) The transistor heats up and can be damaged.

(ii) The transistor can with stand either Ic= 150 mA or V=50V. If both are simultaneously applied,the transistor will damage immediately.

(iii) Voltage gain will be very large, roughly about 4000. No reading with δv_i of 0.01 V can be taken as δv_{ce} can be at the most 4 V.

(iv) "You have to take several vertical lines, say at V_{ce}=4V, 5 V, 6 V, 7 V, 8 V, and 9V. Then work according to steps 27.4 (iv) and (v) for each value of V_{ce}

(v) Yes, it is possible to do this experiment without a separate battery for base circuit. We can take a fraction of P.D. of the 9V battery of collector circuit by a rheostat RG_1 of 1000 ohm in series with a resistance of 5 k ohm and feed it to the base through R This can be done for finding current gain as well as for finding voltage gain.