# INTERMEDIATE

PHYSICS LABORATORY MANUAL







TELANGANA OPEN SCHOOL SOCIETY, HYDERABAD



Laboratory Manual

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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 Laboratory Manual (312), encompassing a total of 15 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 Manual contains 15 experiments which are chosen based on text book so that the theoritical knowledge required to do the experiments are provided to the students before starting the lab sessions. In the introduction.

Objectives, lab report formal error calculations, drawing a graphs are provided. The experiments related to Waves, Sound, Optics, Electricity and Electronics are given with required procedure, formulae and tabler comomn. 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.

# A Note From the Director

# Dear Learner,

The Academic Department at the Telangana Open School Society, Hyderabad Telangana state tries to bring you new programmes in accordance with your needs and requirements. After making a comprehensive study, we found that our curriculum is more functional, related to life situations and simple. However, the task before us was to make it more effective and useful for you. We invited leading educationists of the country and under their guidance, we have been able to revise and update the curriculum in the subject of Physics in the light of the National Curriculum Framework. 2005.While updating the curriculum, we have also removed obsolete, outdated information and added new, relevant things and tried to make the learning material attractive and appealing for you.

I hope, you will find the new material interesting and exciting with lots of activities to do. Any suggestions for further improvement are welcome.

Let me wish you all a happy and successful future.

Sri. P.V.SRIHARI Director Telangana Open School Society, Hyderabad.

# A word with you

# Dear Learner,

I hope you must be enjoying studying Physics from Telangana Open School Society, Hyderabad Telangana state study material. Like any other branch of science, in Physics too you search for scientific truth by verifying the facts. Hence, learning by doing has an important role especially in Physics. The Telangana Open School Society, Hyderabad Telangana state Physics curriculum at Senior Secondary tag is designed to encourage development of such skills in order to make learning effective. Therefore, lots of activities have been incorporated even in the study material of Physics course. In Book I of Physics you will find a list of experiments in the end. Some of these experiments are indeed very simple and you will be able to perform them even on your own. But for others, you may require some guidance. In this Physics laboratory manual we have tried to incorporate all the required guidelines to perform the experiments. This book is in addition to three core books which help you to over the theory portion of the curriculum.

In the beginning the section. a few e of introduction have been given which discuss the importance and meaning of practical work in Physics, safety measures and precautions to be taken while in the laboratory, and the way you should maintain the Record Book. Each experiment in the manual has detailed instructions about how to perform the experiment and has observation tables in which you can record your data. Before starting an experiment, read the instructions given in the laboratory manual carefully and record the observations in the tables honestly.

I am sure, at the end of each experiment, you may like to assess our understanding about that experiment. For this purpose, a few questions have been given. For your convenience, the answers to these questions are also provided at the end of the manual in the appendix. Though the manual has the cope of recording your observations in the tables, you are required to maintain a record book as per the instructions given, as it carries weightage in the practical examination also. In case you have any doubts or problems while performing the experiments or otherwise, feel free to as our Physics Teacher or write to us.

We hope you will enjoy doing experiment. Wishing you an the success.

# (The Curriculum design and Course Development Team)



# 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 laboratory 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 laboratory Manual encompassing 15 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

# **Senior Secondary Course**

# **Physics Laboratory Manual (312)**

Course Coordinator KACHIRAJU SUBBA RAO



# **TELANGANA OPEN SCHOOL SOCIETY**

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# **INTRODUCTION**



Like any other science subject, physics is a subject which can be learnt better by doing. In fact, 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 covered 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  $1^{\circ}$  amplitude and then with  $20^{\circ}$  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. A practical course trying to familiarize you with too many instruments will be boring and too heavy. Through a few instruments, a practical course prepares you to use instruments in **general**. There is a certain **attitude of mind** that a researcher 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 in fine details how 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 can not be underestimated.

Pedagogically the third objective is, perhaps, the most important. Practical workdone honestly and properly trains you to be a good experimenter. It trains you inthe scientific method – the method of systematic experimentation to seek new knowledge. It is not only important for the researcher, but also for every one else.



Notes

We all face many situations in everyday 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:

- Aim: It defines the scope of the experiment. 1)
- 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.
- What you should know?: It highlights the concepts and background 3) 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.
- How to set up and perform the experiment?: The steps are given in a 5) 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 number6.
- 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 pitfalls 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.



Notes

# 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 a point 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 jointhe 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. 2). Slope of the graph:



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 the 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 slops 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.3).



#### Fig. 3: 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 meaningless to say "the current is *I*A", 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 = 0) 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  $30^{\circ}$  to  $60^{\circ}$  between the graph and the axes.
- (iii) For investigating the relation between two physical quantities, readings must be taken for atleast 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	Α		Conductor	В
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 be  $12 \text{ cm} \times 18 \text{ cm}$  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 for *V* as well as for *I* is same for both. Looking at the observations we find that *V*-scale needs to be of length 10 cm and *I*-scale of 12 cm. Thus we take *V*-axis along 12 cm side of graph and *I*-axis along longer side.

After plotting the points, it is clear that in case of conductor A (Fig. 2),  $V \propto I$ . In case of conductor B (Fig. 3), it seems that  $V \propto I$  only upto about I = 120 mA and then V 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 (240 mA, 1.70V) is rejected, being too far from the best graph.

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

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

 $\therefore$  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 the

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 its volume". Thus, if in an experiment we measure pressures (P) corresponding to various volumes (V) of a gas and then plot P against V, 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 straight line graph. So *whenever possible* we plot quantities which will yield a straight line 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 a 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.

**Example 5:** 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/cm <sup>3</sup>	50	40	35	30	25	22
P/mmHg	460	570	660	760	925	1050
<b>Solution:</b> 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

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The range of values is x = 0.0200 to 0.0454 for V<sup>-1</sup>/cm<sup>-3</sup> and y = 460 to 1050 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 = 0, y = 0). Hence the ranges have to be treated as x = 0 to .0454 and y = 0 to 1050. Let the graph paper have dimensions 18 cm × 24 cm. Let 5 cm along *x*-axis represent 0.01 and 3 cm along *y*-axis represent 200. Thus *x*-axis needs a length of about 23 cm and *y*-axis about 16 cm, which are respectively taken along length and breadth of graph paper.

After plotting the points (Fig. 4) 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.



#### 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 conductor 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 utilised. 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 involving 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**. Whereas 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  $\geq 10$ , 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 74.73 is 1

Characteristic of 7.473 is 0

Characteristic of 0.7473 is -1 or  $\overline{1}$  (read 'one bar')

Characteristic of 0.07473 is -2 or  $\overline{2}$ 

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

**Example 6:** Find log 7.4

**Solution:** 

In the column opposite the number 74 is mantissa 8692; the characteristic is 0. Hence  $\log 7.4 = 0.8692$ 



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### **Example 7:** Find log 74.7

#### Solution:

We find the first two figures 74 at the extreme left. Then move along 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  $\log 74.7 = 1.8733$ .

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**Example 8:** Find log 0.07473.

#### Solution:

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

Mantissa of log 747	= .8733	
Mean difference for 4th fig	gure 3 $= 2$	
Mantissa of log 7473	= .8735	
∴ log 0.07473	$= \frac{1}{2}.8735$	

#### A.4.1 Antilogarithms

The number corresponding to a given logarithm is found by using the table of antilogarithms. 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) Mean diff. for 7 = 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. Infact, 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 to be added.

**Example 10:** Multiply 47.45 × 0.006834 × 1063

#### **Solution:**

log 47.45 = 1.6763  $log 0.006834 = \overline{3.8347}$  log 1063 = 3.0265  $log (product) = 2.5375 \qquad \therefore Product = 434.8$ 

### A.4.3 Division

Whereas 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.

**Example 11:** Evaluate 0.4891 ÷ 256.8

#### **Solution:**

 $log 0.4891 = \overline{1.6894}$  log 256.8 = 2.4096  $log (quotient) = 3.2798 \qquad \therefore \text{ Quotient} = 0.001905$ 

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

	51-32×0-04971×1-021
Example 12: Evaluate	69-84 × 42-98× 3-982

### **Solution:**

log (numerator)	= 0.4158	log (denominator)	= 3.9/46
log 1.021	= 0.0090 - 0.4158	$\log 3.142$	= 0.4972
log 0.04971	= 2.6965	log 42.98	= 1.6333
log 51.32	= 1.7103	log 69.84	= 1.8441





Notes

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  $\overline{1}$ ; 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 its 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 stop watch 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 '*parallax error*'. 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 (5) for observing reading in a thermometer, with eye in position (a), you get correct reading  $65^{\circ}$ C. In position (b) you may get the reading as  $64^{\circ}$ C and in position (c) as  $66^{\circ}$ C. This so happens because whereas the scale is marked on the surface of the thermometer, the mercury thread is inside. The two can never be coincident.



Fig 5: Correct tine of sight

Fig. 6: Surface of liquid in a measuring jar

**PHYSICS** 

Referring to fig 6, 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 8: 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 8, which gives the correct reading 20.5 cm. 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 30 cm 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. 9). 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. Moreover, the markings themselves function to some extent as direction guides, by which you can keep your eye at the correct position.









Notes

In case 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, sometimes 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 alongside 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.1** GENERAL INSTRUCTION ON OPTICAL EXPERIMENTS

The eye and the ear, the two most important of our sense-organs, receive stimuli in the form of waves, viz. light (electromagnetic waves) and sound (mechanical waves). 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 and toys like kaleidoscopes. All those things, not only have given us a new insight into the microcosmos and macrocosmos, but also have improved quality of our life immensely.

All this has become possible through the study of light energy and its effect on matter. 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 at least 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.

# **B.2 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. 3 as the eye is moved from O to A, the pin X moves towards the left of X and oh moving the eye from O to B, 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. 4).



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.6 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 an oxide 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.



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. 4). 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 the terminal marked (-) on the battery. The flow of current in a circuit is actually drift of electrons only (except in electrolytes or semi-conductors). The terminal marked (-) n a cell provides electrons to circuit and (+) receives them back {Fig. 4). However, we state the direction 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.





In making electrical connections it is preferable to use wires insulated by a double layer of cotton (DCC wires). If wires of two different parts of the circuit happen to touch each other (Fig. 6a), still they do not get electrically connected due to this insulation. Even then it is a good precaution to lay out 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. 6b). In an a.c. circuit, such loose extra length of wire may be double-folded and then wound into a non-inductive coil.

### **D. 1 SAFETY IN THE PHYSICS LABORATORY**

In the physics laboratory, carelessness 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 paralyse 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 glass ware, etc. in the sink. Such things should be thrown into 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. Of course, 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 yourselves. 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 testerscrewdriver or/ a voltmeter of Appropriate range.
- (v) Whenever a sharp instrument is used, 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 steril 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 for 15 min. to 30 min. Then apply burnol.

# 7 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.

## 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	3 Marks
(ii)	Record Book	3 Marks
(in)	Two Experiments (7 marks each) (they should not be from the same group)	14 Marks





# **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.



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.

# **1.1 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.

# **1.2 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, say 10, are coincident 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: Vernier Callipers

### **1.3 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 under

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

Least count = 1 main scale division - 1 vernier scale division

= 1 main scale division  $-\frac{n-1}{n}$  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 vernier callipers 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 along 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 glass 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. Calculated 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.

### **1.4 OBSERVATIONS**

One small division of	main scale =mm
VS divisions	=MS divisions
1 VS division	=MS divisions
	=mm
Least count	= 1MS div $- 1$ VS div
	=mmmm
	=mm
	= cm
Zero error for diamet	er measurement = $(1)$ $(2)$

(3) .....

Mean zero error = ..... cm

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

#### Table 1.1: For internal diameter of calorimeter

S. No.	M.S. reading	Coincident	V.S. reading	Observed
	У	<i>V.S.</i> div. <i>n</i>	$x = n \times V.C.$	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.

**Table 1.2:** For depth of calorimeter (h)

S. No.	M.S. reading	Coincident V.S. div. n	V.S. reading $x = n \times V.C$ .	Observed value = y+x i
1				
2				
3				
4				
5				
6				

Mean observed diameter = ...... d = Mean corrected diameter = .....

# **1.5 RESULT AND DISCUSSION**

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

= .....

= .....

## Verification

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

# **1.6 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.

# 1.7 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.



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.

# 2.1 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. 2.3a). 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. 2.3b).





Fig. 2.3 (a): Negative zero error

Fig. 2.3 (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 the 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

# **2.2 HOW TO PERFORM THE EXPERIMENT**

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

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

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

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

- (iii) **Measuring zero error:** With the studs 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 neaerest 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 =  $pitch \times number of complete rotation + L.C. \times circular scale reading$ 



(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.

# 2.3 WHAT TO OBSERVE

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

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

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

Number of divisions on circular scale = .....

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

Mean zero error = .....

Mean zero correction = - (Mean zero error)

=.....to be added algebraically.

Table 2.1: Screw gauge readings for diameter

S. No.	Rea	adings	Observed diameter
	Linear Scale Circular Scale		$= m \times \text{pitch}$
	<i>m</i> (div)	<i>n</i> (div)	$+ n \times L.C.$
1.			
2.			
3.			
4.			
5.			

Mean observed diameter =..... cm

Mean corrected diameter = D =.....cm

# 2.4 SOURCES OF ERRORS

(i) If the instrument be screwed up tightly when finding zero error or taking reading of diameter of wire (perhaps on account of defective on hard ratchet cap) it may compress the wire out of shape.
- (ii) If the screw is 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 come a major error.

# 2.5 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 gauge?
(iv)	What is back-lash error and how it can be avoided?
(v)	What is the use of a ratchet arrangement in a screw gauge?
(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 0.005mm, 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.



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.

# 4.1 WHAT YOU SHOULD KNOW?

A simple pendulum is a small heavy 'bob' B hanging by a light and inextensible string S (fig 4.1). 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. 4.2):

$$T \propto \sqrt{l}$$

or 
$$T^2 \propto l$$

Thus graph between  $T^2$  versus l is a straight line passing through the origin. T 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.

**PHYSICS** 





# **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.

# 4.2 HOW TO SET UP AND PERFORM THE EXPERIMENT

- (i) Measure diameter of the bob with 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 4.1). The point P, where the thread comes out of the cork is thus a sharp point of suspension, whose position does not change as 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 suspension P (fig 4.2). 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 4,1). On a white strip of paper stuck at the vertical end face of the table, mark a vertical line. The thread coincides with this line in its vertical position, when you see it from the front.
- (v) Pull the bob to one side and release so that it oscillates with an amplitudes of less than 4° (Fig 4.3). 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' wnen thread crosses the central mark in the same direction, stop the watch. Take three consistent readings, lest there is an error in counting. Then calculate time of one oscillation *T*.



- (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 4.4) from this graph find the value of *I* for  $T^2 = 4 \text{ s}^2$

# 4.3 WHAT TO OBSERVE AND ANALYSIS OF DATA

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

Mean diameter = .....

Radius of the bob,  $r = \frac{1}{2}$  (diameter)

#### Table 4.1: Measurement of time period

S. No.	Length PH	l = PH + r	Time of 20 oscillations					
			(1)	(2)	(3)	Mean	Т	<b>T</b> <sup>2</sup>

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

PHYSICS

# 4.4 RESULT

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

# 4.5 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.

# 4.6 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 I/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) 1/81th 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.



After performing this experiment, you should be able to:

- set up a point in equilibrium under the action of three forces;
- recognize **tension** in strings;
- sec that bodies always hang vertically under the action of gravity;
- recognize **weight** as a force due to the earth on any body;
- understand that if a 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*.

# 5.1 WHAT SHOULD YOU KNOW

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



The weight due to a body of mass m = mg (Fig. 5.1). Therefore tension in the string is:

T = mg



- (ii) A fixed pulley only changes the direction of force and not its value (Fig. 5.2).
- (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 5.3(a)  $F_1$  and  $F_2$  are two forces acting simultaneously on point object at A at an angle 6. 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.

$$R = F_1 + F_2$$
$$|R| = F_1^2 + F_2^2 + 2F_1F_2Cos\theta$$

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

Where a is the angle which the direction of the resultant, R, makes with the direction of  $F_I$ 

If  $\mathbf{F}_1$  or  $\mathbf{F}_2$  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.

# 5.2 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. 5.4).





#### Fig 5.4: 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 a1m 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 *touch the 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.
- (vii) Knot the other end to the centre of 1m 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.

 $F_{I} = P$  (slotted weight + Weight of hanger)

 $F_2 = Q$  (slotted weight + weight of hanger}

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.* 



**Physics Laboratory Manual** 

- (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. 5.6).



due to 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 = 200g and their directions were recorded as shown in Fig. 5.7. Choose a scale 1cm = 50g



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.

# 5.3 WHAT TO OBSERVE

- (i) Weight of hanger .....g
- (*ii*) Scale for drawing the parallelogram, 50 g = 1 cm (or any other), 1 cm = n g.

S. No.	Forces weight	(slotted + hanger)	Diagonal AC y (cm)	Resultant force	Weight of the given
	Р	Q		$R = y \times \mathbf{n}(\mathbf{gwt})$	body
1.					
2.					
3.					

#### Table 5.1: Table for weight of the body

Average weight = .....g.

# 5.4 RESULT

Weight of the given body =.....g

# 5.5 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°. Find the resultant by drawing a suitable parallelogram. (Take 50 g = 1cm).
(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.



After performing this experiment, you will be 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.

## 7.1 WHAT YOU SHOULD 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  $\text{gr}^1 \circ \text{C}^{-1}$  or J kg<sup>-1</sup>  $\circ \text{C}^{-1}$  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  $\Delta t$ ,

Heat gained =  $ms \Delta t \{\Delta t - rise in temperature\}$ Heat

lost = ms  $\Delta t$  { $\Delta t$  - fall in temperature}.

 (iii) Heat-exchange takes place between solids, liquids and surroundings. Whatever 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.



## **Material Required**

surroundings.

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

### 7.2 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 60 mL 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 info 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** 7.1 : Shows careful heating of the brass bob before it is transferred to the water in the calorimeter.

**Fig** 7.2 : Shows the arrangement of calorimeter box thermometer, stirrer when the hot bob is transferred in to the calorimeter

#### **PHYSICS**

### 7.3 WHAT TO OBSERVE

(i)	Least count of measuring cylinder =
(ii)	Least count of spring balance =
(iii)	Mass of brass bob $m_b = \dots$
(iv)	Mass of calorimeter and stirrer = $m_c = \dots$
(v)	Least count of thermometer =
(vi)	Initial temperature of water in the calorimeter $= t_1 = \dots$
(vii)	Temperature of boiling water = $t_3$ =
(viii)	Final temperature of water and bob = $t_2$ =
(ix)	Specific heat of copper = $S_c$ (from the table) = 0.093 cal $g^{-1} \circ C^{-1}$ .
(x)	Volume of cold water in the calorimeter = $60 \text{ mL}$ (as given in the procedure) mass of cold water = $60\text{ g}$ (density of water $\approx 1 \text{ g/mL}$ ).

# 7.4 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 = 1 cal  $g^{-1}$  °C<sup>-1</sup>}
- (iii) 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

$$m_b \times S \times (t_3 - t_2) = \{60 + m_c \times S_c\} (t_2 - t_1)$$

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

**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. Of course you ignore the heat taken by plastic cup. You can avoid second thermometer by taking temperature of boiling water as roughly 100°C.

**PHYSICS** 





# 7.5 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 ml 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 0.215 cal  $g^{-1}$  °C<sup>-1</sup> or that of Aluminium is 900 J kg<sup>-1</sup> °C<sup>-1</sup>?

.....

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

.....

(ix) 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



. .

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. •

# 8.1 WHAT YOU SHOULD 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. 
$$Mg \propto l$$
  
 $\Rightarrow Mg = \mu l$   
or  $\mu = \frac{mg}{l}$ 
(8.1)

Here  $\mu$  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

$$\mu = \frac{\text{change in weight}}{\text{change in } l} = \frac{1}{\text{slope of graph}}$$
(8.2)

Eq (8.2) gives the value of  $\mu$  in the SI unit (Nm<sup>-1</sup>).

## **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.

# 8.2 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. 8.1). 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.





# 8.3 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 not been permanently strained by your maximum load, the pointer will return to its previous position for each load. There can be some observational error. Hence find the mean of the two readings and then extension for each load.
- (iv) Plot a graph between extension l (on y-axis) and load M (on x-axis) (Fig 8.2). 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  $\mu$ ,

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





Fig. 8.2: Graph between M and I

**Fig. 8.3:** *Graph between* M *and*  $T^2$ 

# 8.4 WHAT TO OBSERVE AND DATA ANALYSIS

S.No.	Load, M	Scale	Mean	Extension	
	M/kg	Load increasing		<i>I</i> /cm	

Table: Observations for extension versus load graph

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

Constant,  $\mu = (slope)^{-1} = \dots Nm^{-1}$ 

# 8.5 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  $\mu$  (weight suspended per unit extension) =.....Nm<sup>-1</sup>

## 8.6 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.

#### **PHYSICS**



(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.

# 8.7 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.



# **B.1 GENERAL INSTRUCTION ON OPTICAL EXPERIMENTS**

The eye and the ear, the two most important of our sense-organs, receive stimuli in the form of waves, viz. light (electromagnetic waves) and sound (mechanical waves). 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 and toys like kaleidoscopes. All those things, not only have given us a new insight into the microcosmos and macrocosmos, but also have improved quality of our life immensely.

All this has become possible through the study of light energy and its effect on matter. Moreover, the study of light energy is easy and interesting and requires very simple and low cost apparatus.

- (iv) While looking at the object and image-pins your eyes should be kept at least 25 cm away from the nearest pin.
- (v) The pins should be held vertical and parallax should be removed between the concerned pins, tip to tip.
- (vi) Line diagrams should be drawn for image formation indicating the rays with arrow-heads.

# **B.2 OPTICAL BENCH**

An optical bench is a 1 m, or 1.5 m, or 2 m long horizontal bed made of wood or iron (Fig. 1). The bench is supported on two levelling screws on either end and carries a metre-scale laid down along its length usually on one side. Three or four uprights are provided with the bench with a provision to hold a pin or a busholder in an upright. An upright can be fixed at any desired position on the bench and the position of the pin (or mirror/lens) held in it, can be read with the help of a line-mark in the middle of its base.





# Setting of Optical Bench Fig. B.1

- (i) Level the bench with the help of a spirit level and the levelling screws. For this, place the spirit level along the length, on the base of an upright and bring the bubble in the spirit level to its middle mark by adjusting the corresponding levelling screws. Then place the spirit-level transverse to the length of the bed and make the same adjustment again. Make sure by placing the spirit-level on other uprights also that the bed is thoroughly levelled.
- (ii) Fix the lens/mirror and pins in Uprights as per requirement of the experiment. Adjust their vertical heights such that the tips of the pins and the centre of the lens/mirror be on the same horizontal line parallel to the bed of thebench.

## **Bench Correction**

In making measurements with optical bench we measure the distance between the index lines on the uprights and take it as the distance between the tip of the pin and the pole of a mirror (or the optical centre of a lens). The index-line on the

upright may not give the exact position of the tip of the pin or the pole of the mirror. This causes an error in measurement called bench error. A correction for the error is to be done which is determined through a separate experiment and applied in all measurements.



Bench Correction = - (Bench error)

- (Measured distance – Actual distance)= Actual distance – Measured distance

To find bench correction the mirror (or lens) and the piri-tip are set at a fixed distance on the optical bench, making use of a knitting needle.

Length of the knitting needle, then, gives the actual distance between the pin and the mirror (or lens) and the observed distance can be read between the index lines of the corresponding uprights. For the setting in Fig B.2



### Bench Correction = AB - CD

quite often bench correction is also called 'index-correction'.

# **B.2 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. 3 as the eye is moved from O to A, the pin X moves towards the left of X and oh moving the eye from O to B, 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. 4).



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.



# **EXPERIMENT 7**

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



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.

# **10.1 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  $L_i$  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 the tube and an antinode at the open end (Fig 10.1).



Fig. 10.1: 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  $\lambda/4$  and therefore, resonance occurs when the length of the tube (air column) is nearly equal to an odd number of  $\lambda/4$  i.e.

$$L = \frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}, \dots \text{ etc}$$
  
Or, in general,  $L = \frac{n\lambda}{4}$  where  $n = 1, 3, 5, \dots$  (10.1)

where  $\lambda$  is the wavelength of the sound. You know that the relation between the wavelength and frequency of the sound source is

$$v = f\lambda \tag{10.2}$$

Combining (10.1) and (10.2) we get, for a closed pipe,

$$f_n = \frac{nv}{4L}, n = 1, 3, 5....$$
 (10.3)

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 (10.3) 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 (10.1) we see that the difference in the tube (air column) lengths for successive condition of resonance is

$$\Delta L = L_2 - L_1 = \frac{3\lambda}{4} - \frac{\lambda}{4} = \frac{\lambda}{2}$$
$$= \frac{L - L_2}{3} = \frac{5\lambda}{4} - \frac{3\lambda}{4} = \frac{\lambda}{2}$$

where  $L_1$  is the length of the air column at first resonance,  $L_2$  at second resonance and so on. Therefore,  $\lambda = 2 L$  (10.4)

We can determine the wavelength of sound waves by measuring  $\Delta L$ . 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:

$$\Delta v = f\lambda = 2f(L_2 - L_1)$$

(10.5)

Notes

## Material Required

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

#### **10.2 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 in Fig. 10.2. 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 otherwise it will overflow when you lower it. Practice lowering and raising the water level in the tube to get 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 fork horizontally slightly above the



Fig 10.2: The resonance tube apparatus.

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).

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

# **10.3 WHAT TO OBSERVE**

Temperature of air = .....

<b>Fable 10.1:</b>	Table	for	resonance	positions
--------------------	-------	-----	-----------	-----------

S. No.	No. Source First position of resonance			Second position of resonance					
	requency	1	2	3	Average	1	2	3	Average
	Hz	( <b>cm</b> )	( <b>cm</b> )	( <b>cm</b> )	$L_1$ (cm)	1 (cm)	2 (cm)	3 (cm)	$L_2$ (cm)
1									
2									
3									
4									

# **10.4 CALCULATIONS**

- (b) Velocity of sound in air =  $2f \Delta L$  = ..... ms<sup>-1</sup>.
- (c) Correct velocity of sound in air at room temperature (from tables) = .....
- (d) Percent error in the result =  $\frac{\text{observed value} \text{correct value}}{\text{correct value}} \times 100$

= .....%

#### **PHYSICS**

## 10.5 RESULT

- (i) Wavelength of waves in air column =.....m.
- (ii) The velocity of sound in air at temperature ...... is found to be ms<sup>-1</sup>. The correct value is ..... and percentage error is.....

# **10.6 CHEK YOUR UNDERSTANDING**

(i) A 128 Hz sound source is held over a resonance tube. What are the first and second lengths of air 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  $V_t = 331.4 + 0.6 t \text{ ms}^{-1}$  where *t* 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.

.....

(iii) 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 second resonance positions in a resonance tube.



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.

# 11.1 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  $\Delta L$  is the difference in the lengths of air column for successive conditions of resonance, then the wavelength of sound waves is given by

$$\lambda = 2 \Delta L \tag{11.1}$$

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

$$v = f\lambda \tag{11.2}$$

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

$$F_1 \lambda_1 = f_2 \lambda_2 \tag{11.3}$$

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

Combining this equation with equation (11.1), we get

$$\frac{f_1}{f_2} = \frac{\Delta L_2}{\Delta L_1} \tag{11.4}$$

## **Material Required**

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

## **11.2 HOW TO PERFORM THE EXPERIMENT**

- (i) Follow the procedural steps (i) to (viii) given in experiment No. 11. (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 table.
- (iv) For each length of resonating air column, calculate the average of the three readings taken.
- (v) Calculate the difference  $(\Delta L)$  between length of resonating air column for the second and the first position for the two tuning forks.
- (vi) Calculate the ratio of  $\Delta L$ 's for the two tuning forks.

# **11.3 WHAT TO OBSERVE**

S. No.	<b>Tuning fork</b>	First	t posi	tion o	of resonance	Second position of resonance			
		1	2	3	Average	1	2	3	Average
1									
2	First								
3									
1									
2	Second								
3									

## 11.4 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 I!nd tuning fork = ...... cm.

(iii) 
$$\frac{f_1}{f_2} = \frac{\Delta L_2}{\Delta L_1^4} \cdots$$



11.5 RESULT

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

# **11.6 CHECK YOUR UNDERSTANDING**

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

.....

(ii) For a resonance tube apparatus with a total tube length of 1m, 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 =  $347 \text{ ms}^{-1}$ ).

.....

(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 t in degree celsius, is  $V_t = 331.4 + 0.6 t \text{ ms}^{-1}$ .

.....



# **EXPERIMENT 9**

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.



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 values of *u*;
- plot a graph between 1/u and 1/v;
- interpret the graph and compute the focal length of the given concave mirror.

# **13.1 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)

$$\frac{1}{1} = \frac{1}{1} + \frac{1}{1} \Longrightarrow \frac{1}{1} = -\frac{1}{1} + \frac{1}{1}$$

$$f \quad v \quad u \quad v \quad u \quad f$$

$$13.1)$$

Comparing equation (13.1) with standard equation of a straight line, namely, y = mx + c we find that graph between 1/v and 1/u should be a straight line with a slope of (-1) and intercepts on y-axes equal to (1/f), 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.



**Notes** 

# **13.2 HOW TO SET-UP THE EXPERIMENT**

- Fix an upright at zero cm mark on the optical bench and put mirror holder (i) 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. 13.1).



Fig 13.1: Experimental set-up

# **13.3 HOW TO PERFORM THE EXPERIMENT**

#### **Determination of bench-correction (a)**

- *(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*.
- Using knitting needle, adjust the (ii) 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 arid 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. 13.2: 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,  $f_1$  and  $2f_1$  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 13.1,
- (xiii) Find the values of 1/u and 1/v for each observation, by taking u and v in metres.
- (xiv) Plot a graph with 1/u on x-axis and 1/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.

#### **13.4 WHAT TO OBSERVE**

#### (a) Determination of bench correction

Observed separation between the mirror and pin A

on optical bench scale, when they are separated by l i.e.,  $l_1 = \dots$  cm.

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

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





#### (b) Rough focal length of the mirror

Mean value of rough focal length = ..... cm.

<b>Table 13.1:</b> Observations for u and	v
---	---

SI.		Position of Object distance			Ima				
No.	Mirror cm	Object Needle A	Image Needle B	Observed Value	Corrected value (u)	Observed value	Corrected value (v)	1/u	1/v
		cm	cm	cm	cm	cm	cm	<b>m</b> <sup>-1</sup>	<b>m</b> <sup>-1</sup>
1.									
2.									
3.									
4.									
5.									
6.									

# 13.5 ANALYSIS OF DATA

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

y coordinate of point D - OD =  $\dots m^{-1}$ 

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

*x*-coordinate of point  $C = OC = \dots m^{-1}$ 

 $Slope = -OD/OC = \dots$ 

# **13.6 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.

# **13.7 SOURCES OF ERROR**

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

## **13.8 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.

.....

PHYSICS





**EXPERIMENT** 11

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



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<sub>m</sub>);
- determine the refractive index of the glass of the prism.

# **17.1 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 in ( $v_2$ ) in the substance.

$$\frac{Sin i}{Sin r} = \frac{v_1}{v_2} = n \tag{17.1}$$

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





If a ray MN of light (Fig 17.1) 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 surface. 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, 17.1. The angle of deviation,  $\delta_m$ , is then called the angle of minimum deviation. For this angle of minimum deviation  $\delta_m$ , there is a simple relation between the refracting angle A, the angle of minimum deviation  $\delta_m$ , and the .refractive index *n*. The relation is

$$n = \frac{Sin \ i(A + \delta m)}{(17.2)}$$

Sin(A/2)

### **Material Required**

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

## **17.2 HOW TO PERFORM THE EXPERIMENT**

- (i) Fix a sheet of a white paper on the drawing board.
- (ii) Draw a 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 and P<sub>2</sub> appear to be one behind the other. Now fix two pins P<sub>3</sub> and P<sub>4</sub> in line with  $P_1$  and P<sub>2</sub> 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  $P_2 P_1$  and  $P_4 P_3$  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  $30^\circ$  and  $60^\circ$  at intervals of  $5^\circ$

## **17.3 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.			

## **17.4 ANALYSIS OF DATA**

Plot a graph betwen *i* and  $\delta$  keeping  $\delta$  along *y*-axis. From the graph, find the angle of minimum deviation,  $\delta_m$  from the graph. Calculate the refractive index of the glass of the prism using these values in Equation (17.2).

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

δ*m* .....degree

## 17.5 RESULT

The refractive index of glass of the prism = .....

## **17.6 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.

# **17.7 CHECK YOUR UNDERSTANDING**

(i) A prism made of glass { $\mu = 1.5$ } and refracting angle 60° 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  $60^{\circ}$  prism that produces minimum deviation of  $50^{\circ}$ .

.....

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

.....

.....

(v) A prism, n = 1.65, has a refracting angle of  $60^{\circ}$ . Calculate the angle of minimum deviation.

Notes



# **EXPERIMENT 12**

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



After performing the experiment, you should be able to:

- find the least count of a screw gauge;
- 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 precautions to be taken while performing an experiment;
- find the position of balance point on the wire; and
- know the sources of error in an electrical circuit

## 22.1 WHAT SHOULD YOU KNOW

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

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

*P* and *Q* are called ratio arms *R* is adjustable and S is the unkn resistance. For a wire of uniform area of cross-section, if null point obtained at length l (Fig. 22.1),

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

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

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

#### **Materials 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.

#### 22.2 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. 22.1: 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  $\Omega$  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.



#### **PHYSICS**

- (vii) Repeat the above steps two times more by selecting the suitable values 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 terminals. Straighten it by stretching and remove 3 kinks.
- (ix) Measure the diameter of the wire by a screw guage atleast the 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 mater

# 22.3 TO OBSERVE

#### (i) Measurement of resistance S :

No. of	Resistance	Position of null point	BC =	$S = \frac{(100-l)}{l}R$
obsv.	R (ohm)	$\mathbf{AB} = l \; (\mathbf{cm})$	100– <i>l</i> (cm)	ohm
1.				
2.				
3.				

Mean value of the resistance of the wire -

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

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

Number of divisions on circular scale = 100.

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

Zero enor (e) = .....cm.

(iv)

Sl. No.	Reading along one direction			Reading along mutually perpendicular direction			Mean Obs. dia	Corrected diameter
	MSR	CSR	Obsd. dia	MSR CSR Obsd.		$d_{o} = (d_{1} + d_{2})/2$	$d = d_o - e$	
	<b>S</b> <sub>1</sub>	<b>n</b> <sub>1</sub>	$d_1 = s_1 + n_1 a$	<b>S</b> <sub>2</sub>	<b>n</b> <sub>2</sub>	$d_2 = s_2 + n_2 a$		
1								
2								
3								

Notes

**Note:** In another identical table record observations to find diameter d' 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  $\rho = S \frac{\pi d^2}{4l} = \dots$  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-

 $\rho_0 = \dots$  ohm metre

 $\rho'_{o}$  =..... ohm metre.

# 22.4 CONCLUSION

The specific resistance of the material of the given wires —

 $\rho = \ldots \ldots ohm \; m$ 

 $\rho^{\,\prime}\!=\!....ohm\ m$ 

#### 22.5 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 crossectional area.

#### **PHYSICS**



Notes

# 22.6 CHECK YOUR UNDERSTANDING

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

.....

- (iii) What is null point?
  - .....
- (iv) Why is it advised to keep the null point between 30 cm and 70 cm?
  - -----
- (v) Why should the moving contact of Jockey not be pressed too ha or should not be scratched along the wire?

.....

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

.....

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

.....



**EXPERIMENT 13** 

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



After performing this experiment, you should be able to:

- identify the cathode and anode of a 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; and
- choose meters of proper range for the experiment.

## **26.1 WHAT SHOULD YOU KNOW**

A *pn* junction diode consists of p-type and n-type materials forming a junction as shown in Fig. 26.1 (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 V group element which gives rise to free electrons in it. The current flows in it due to motion of these electrons.





**Fig. 26.1(b)** : Due to recominination of holes and electrons P-region becomes negatively changed an N- region becomes (positively very charged).

Fig. 26.1(a) : pn junction diode

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. 26.1(b). 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. 26.2. 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 26.2:** *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 a straight line as is seen in Fig. 26.3. It is called the 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 or  $R_{dc}$  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  $\Delta_{pq}$  and current  $\Delta I_{pq}$  from the curve as shown in Fig. 26.4, then R dynamic or  $R_{ac}$  is defined as





**Fig. 26.3** :  $R_{pc}$  at  $P = V_{p}/IP$ , which is the slope of line OP. It will have different values for different positions of P.

**Fig. 26.4** :  $R_{AC} = \Delta V_{PQ} / \Delta I_{PQ}$ , 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 it's value is 0.7 V and for Germanium diode it's value is 0.3V.

The commonly used diodes in the laboratory are OA79 and 1N4007J OA79 is Ge diode which is sealed in a glass tube. 1N4007 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. 26.5(a) and Fig. 26.5(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 OA79 is 30 *ma* at 1.5V. For 1N4007,  $I_{max}$  is 1 amp at 1.5 V. The symbol of the diode is given in Fig. 26.5(c).



### **Material Required**

A Ge diode OA79, O-1.5V voltmeter, O-30 *ma* meter, 25 ohm rheostat, 2V lead accumulator, one-way key and connecting wires etc.

## **26.2 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 26.6.



#### Fig. 26.6

- (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 and voltmeter. 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. 26.3.

#### **26.3 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.Voltmeter<br/>Divn.Reading<br/>VmA meter<br/>Divn.Reading<br/>mA1.................2.................15.................

## 26.4 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?

## 26.5 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.

## 26.6 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 two points near the point A for B or C) on the graph for finding dynamic resistance be at equal distances from A?

.....





# **EXPERIMENT 14**

To draw the characteristics of an NPN transistor in common emitter mode. From the characteristics find out (i) the current gain ( $\beta$ ) of the transistor and (ii) the voltage gain  $A_{\nu}$  with a load resistances of 1k  $\Omega$ .



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 ( $\beta$ ) of a transistor;
- define the voltage gain  $(A_v)$ ; and
- know the factors on which  $A_v$  depends.

## 27.1 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. 27.1. In some transistors there is a coloured dot marked on the casing. The lead near this mark is collector The other two leads taken in anti clockwise order are respectively base and emitter leads as shown in Fig. 27.2.



While using a transistor the collector is always reverse biased. Normally no current flows in the collector emitter circuit as shown in fig 27.3. But on passing a small base current by forward biasing the base emitter junction as shown in Fig. 27.4, a strong  $I_c$  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 27.4, we see that the emitter is included in both the base and the collector circuits. Hence it is called a common emitter circuit.



The incremental ratio  $\delta I_c / \delta I_b$  is the current amplification factor ' $\beta$ ' of the transistor. We have to find out '/3' from the characteristics curves as explained later. To keep  $I_c$ , constant, that is independent of variation of  $I_c$  a high resistance of 20k ohm or more is included in series with the base as shown in the circuit given in Fig. 27.5.



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 gain  $A_v$  from a transistor a load resistance  $R_o$  is to be connected in series with the collector and a suitable resistance  $R_i$  in series with the base. To determine the voltage gain a circuit shown in Fig. 27.6 is used. Briefly, the voltage gain  $A_v$  produced by the transistor can be found as given below.

If  $\delta V_i$  is the change in input voltage, then change in base current produced by it is given by  $\delta I_i = \delta I_b = \delta V_i / R_i$ 



Therefore, corresponding change in collector current  $\delta l_c$  is given by

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

The output voltage  $\delta V_{o}$  will be the change in voltage drop across the load resistance  $R_{o}$ . Therefore,

$$\delta V_o = \delta I_o \times R_o = \beta \times \delta V_i \times R_o / R_i, \text{ or}$$
$$A_v = \frac{\delta V_o}{\delta V} = \beta \times R / R_o$$
$$_i$$

From this expression we see that the value of  $A_v$  the voltage gain produced depends on  $\beta$ ,  $R_a$  and  $R_r$ .

 $\beta$  for CL100 is around 150, so to keep the value of  $A_{\nu}$  practically measurable that is around 20, the value of  $R_{0}$  is taken as 1000 ohm or 500 ohm and  $R_{i}$  used is 4000 ohm.

#### **Material Required**

One 1.5 V and one 9 V batteries or stabilised battery eliminator with 9 V and 1.5V output terminals, medium power NPN transistor CL100 or equivalent mounted on board for making connections, 0-30 mA DC meter, 0-300 micro amp DC meter, 0-10 V DC voltmeter, 0-1.5 V DC voltmeter, two 1000 ohm rheostats, two one way keys, 20 k ohm, 4 k ohm, 2 k ohm, 1 k ohm and 0.5 k ohm carbon resistors with terminals and connecting wires or leads.

### **27.2 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. 27.5 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 collector current will be zero. Now move the wiper of 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.





## 27.3 HOW TO PERFORM THE EXPERIMENT TO FIND THE CURRENT GAIN

(i) Note the least count of the meters.

Least count of micro ammeter =.... $\mu$ 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 position. Move the wiper of rheostat-1 so that the  $I_o$  becomes 100 µA. Leave it there. Now move the wiper of rheostat-2 slowly in small steps, take the readings of  $V_{ce}$ and  $I_c$  and record them in table No. 1 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  $I_o$  set to 150 and 200 µA and record the observations in table No. 2 and 3.

#### Table 1:

### $I_{b} = 100 \ \mu A$

<i>V<sub>ce</sub></i> ( <i>V</i> )	0	-1	-2	-3	-5	-75	1	2	3	4	5	6	9
$I_{c}(mA)$													



wiper of rheostat at zero. Keep  $R_i = 4$  k ohm.

(ii) Insert key K<sub>2</sub>, to apply voltage of 9V to collector. Then insert K<sub>1</sub>, and move the wiper of rheostat slowly upward till the reading of  $V_{ce}$  say 5V. Now increase or decrease V. by say 0.05 V, or 0.1V, or 0.2 V. For this least count of voltmeter  $V_i$  should be small. This gives the change in input voltage that is  $\delta V_i$ , Note the corresponding change in  $V_{ce}$ , which gives  $\delta V_o$ . Record the readings in table 4 given below. Repeat this process five or six times and record the observations in table 4.

#### Table 4:

Load resistance  $R_0 = \dots \dots \dots \dots \dots$  ohm.

Input resistance  $R_i = \dots$  ohm.

$\delta V_i(\mathbf{V})$	
$\delta V_o(\mathbf{V})$	
$A = \delta V_o / \delta V_i$	

- (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 =  $\beta \frac{R_o}{R_i}$

#### 27.5 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 CLIOO 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  $R_o$  is 10k ohm and  $R_i$  is 500 ohm? How many readings of  $\delta V_i$  with your meter having a L.C. of .01 V/div. can be taken? Given that  $\beta$  is 200.

.....

(iv) From your experimental curves (Fig. 27.7) find out how will  $\beta$  change with  $V_{ce}$ .

.....

.....

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

Notes

**PHYSICS** 



# **EXPERIMENT 15**

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



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; and
- place a bar magnet in proper orientation.

## 28.1 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 (Fig. 28.1)



Fig. 28.1: Frely 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 fields 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 field. 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. 28.2). 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 lines of force.





#### **Material Required**

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

## **28.2 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. 28.3. For the II part of the experiment line will have to be drawn parallel to long edge as shown in Fig. 28.4.



- (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 it is 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 chalk on the table, as shown in two cases in Figures 28.3 and 28.4.



# **28.3 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.
- (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 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. 28.6.



(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.



Fig. 28.7

(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. 28.7.

These lines will not cut each other. You will get two regions on the equatorial line shown by small circles in Fig. 28.7, 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 these points will be equi-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. 28.4.



Fig. 28.8

(ii) Now follow the same procedure as in the last experiment. The lines of force will look as shown in Fig. 28.8 above.

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

#### **28.4 WHAT TO OBSERVE**

- a) N-pole of magnet towards north
- (i) In this case, each, of the two neutral points is equi-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.



# 28.5 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.

# **28.6 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?

# **Answers to Check Your Understanding**

# **Experiment** 1

(1) 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.

(i) 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 much precision.

(ii) 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 precision of a fraction ( or 1/10 or 10/20 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 outside depth using the lower jaws. Substract the former from the latter to get the thickness of the

bottom.

# $\sqrt{\text{Experiment 2}}$

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

(1) 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 itsaxis 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**

(1) 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 is 20 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 2 s.

# **Experiment 4**

(1) 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**

(1) 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  $100^{\circ}$ 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 cal g°C Let the specific heat of brass = S

Heat lost by brass piece =  $200 \times S \times (100-23)$ 

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. Similarkg 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 mat 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.

(ii) 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**

(1) 0.67 m and 2.01 m.

(ii) Equation (1) says that from 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 I, but is I + 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= n2/4. Hence, if the temperature is 5°C more, length of air column for each resonance will increase.

# **Experiment 8**

(1) 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**

(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 sideways.

(ii) As we move an object away from a concave mirror between its pole and focus the size of its virtual image increases. On placing it at a point beyond focus the image formed is real and the size of 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 10**

(ii)  $\frac{1}{f} = (\mu - 1) \left(\frac{1}{R}\right) = 0.5/R = 1/2R$ =f=2R (iii) a) P= -2.5 m<sup>-1</sup>, 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.

$$(v) \frac{1}{f} = (1.5 - 1) \left( \frac{1}{R_{1}} + \frac{1}{R_{2}} \right)$$
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. 14.4). Hence if the lens is backed by a plane mirror the rays will retrace their path and hence the real and inverted

# **Experiment** 11

(1) In minimum deviation A = 2r  $\Rightarrow r = \frac{60}{2} = 30^{\circ}$   $\mu = \frac{\sin I}{2} \Rightarrow \sin i = \mu \sin r$   $\sin r$  = 1.5 x1/2 = 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 wavelength (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 wavelengths 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 for different frequencies!(for different colours).

(v) 51.2°

# **Experiment 12**

the wire.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 / & (100-1) 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 in its 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** 13

(1) 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 Ais their mid-point, even in the case when slope of the graph is changing along the graph.

# **Experiment** 14

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

(ii) The transistor can withstand 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 8V, of 0.01 V can be taken as SV can be at the most 4 V.

(iv) "You have to take several vertical lines, say at V=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

(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, 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.

# **Experiment 15**

- (i) Resistance of 1000 ohms in series.
- (ii) A shunt resistance of 0.1 ohm in parallel.
- (iii) In parallel.
- (iv) In series.
- (v) Entire circuit, only the device across-which shunt is connected.

