EXPERIMENTAL PHYSICS FOR ENGINEERS

For 1st year B.E / B.Tech

Department of Physics
P.S.G. College of Technology
Coimbatore - 641004

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Roll No	:

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INSTRUCTIONS TO STUDENTS

<u>Objectives</u> of the Laboratory Course:

- To provide an opportunity for learning through doing, observing and testing.
- To become familiar with the instruments and gain experience in handling them.
- To acquire the skill of making the optimum use of the given apparatus.
- To establish for yourself the working of physical principles.
- To become aware of limitations of the accuracy with which measurements can be made.
- Generally to relate text book information to the behavior of the physical world around you.

As scientists and technologists you will be dealing with instruments and apparatus of various kinds throughout your career. You will greatly benefit from the beginning if you take a serious and enthusiastic attitude towards experimental work. There is no substitute for the experience that you gain by carrying out even simple laboratory measurements.

(1) Laboratory work is the heart of physics and it should be taken seriously. Your grades in this course are based on your performance in the weekly sessions, the reports you write and on how well you do in the examinations.

(2) Preparation: Before coming to the laboratory session you must carefully read the instructions given for performing the experiment of the day. Unless you come fully prepared with this background material you will not be able to complete the required work and, what is more, you will miss the opportunity of learning all aspects of the experiment. Lack of background often makes the experiment uninteresting and much more time has to be spent later for an understanding of the points missed. Thus, for your own benefit, prior study of the instructions sheets is very important. Also, if you are unprepared, you will not do well in the viva/quiz conducted, by your instructor during the session. If you wish, you may visit the lab to look at the apparatus, prior to your lab, [Between 3.00 p.m. to 5.00 p.m] on any working day. [In some cases you may find it helpful to go to the website of Phywe, <u>(www.phywe.de)</u> who has supplied some of the experiments. Short video clips of some of the experiments are available on link **http://172.2837.65/PHY101A/videos.php.** In case you find difficulty in opening these videos, you may take help from Mr. A.S.Rathaur.]

(3) Physics observation notebook is available in the book store. **All work must be done in ink.** <u>You must get at least one observation of each kind checked and signed by your instructor, failing which your report will not be graded.</u> You must complete all experimental work, during the session. Every observation made must be recorded directly on the on the observation notebook. <u>No rough record is allowed.</u> The completed observation must be submitted within the specified time limit.

(4) Equipment needs your care: On reaching the laboratory you should check the apparatus provided and ascertain if there are any shortages or malfunctions. Set up the equipment in accordance with the instructions. Proceed carefully and methodically. Remember that scientific equipment is expensive and quite susceptible to damage. So handle it carefully. If the apparatus is complicated, consult the teacher before you proceed with the actual performance of the experiment. Make the required measurements and record them neatly in tabular form. Double-check to make sure that you have recorded all the necessary data.

(5) Acceptable results with given apparatus: It is more important to see what result you get with given apparatus rather than what is the 'correct' result. The apparatus given to you is capable- of certain accuracy and your result may be completely acceptable even if it differs from 'correct' results. You must learn to do things on your own even if you might make mistakes some time.

(6) Graphs: Each graph should occupy one complete sheet; the information as to quantities plotted, scale chosen and units should be mentioned clearly on the graph in ink.

(7) Following is the **Format of the Record Note**

- Date, title of the experiment.
- **Aim :** A clear statement of what is to be done.
- Apparatus Required.
- Procedure.
- Essential diagram of the experiment and the formulae used.
- Well-tabulated observations (Tables should be neat and self-explanatory).
- Relevant substitutions; and results expressed with the estimated error and units.
- Conclusions including what you learnt from the experiment.
- Precautions you took to do the experiment. Measure sources of error. Criticism of the design. Suggestions for improving the experiment.
- Answers to questions given at the end in the instruction sheets of each experiment.

(8) YOU MUST BRING WITH YOU manual, observation and record notebook, pen, pencil, eraser, Clark's table, calculator and transparent ruler.

(9) YOU MUST KEEP YOUR WORK PLACE NEAT AND CLEAN AND LEAVE THE LAB, NEAT AND TIDY.

(10) Laboratory Courses (CA — 100%) **Total: 100 Marks**

- **CA Distribution:**

(I Attendance		05 Marks
(ii) Test /Record		40 Marks
Test I / Record	15 Marks	
Viva I	05 Marks	
Test II / Record	15 Marks	
Viva II	05 Marks	
(iii) Final Test (Full Portion) [scheduled by faculty concerned]		40 Marks
(iv) Viva by External Examiner		15 Marks

(11) PUNCTUALITY:

- Record note book should be submitted on the day of your experiment. There is heavy penalty if you don't.
- Please come to the lab on time; as being late may mean deduction of marks.

LIST OF EXPERIMENTS

For 1st year B.E / B.Tech

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For 1st year B.E / B.Tech

PRECISION INSTRUMENTS Page No

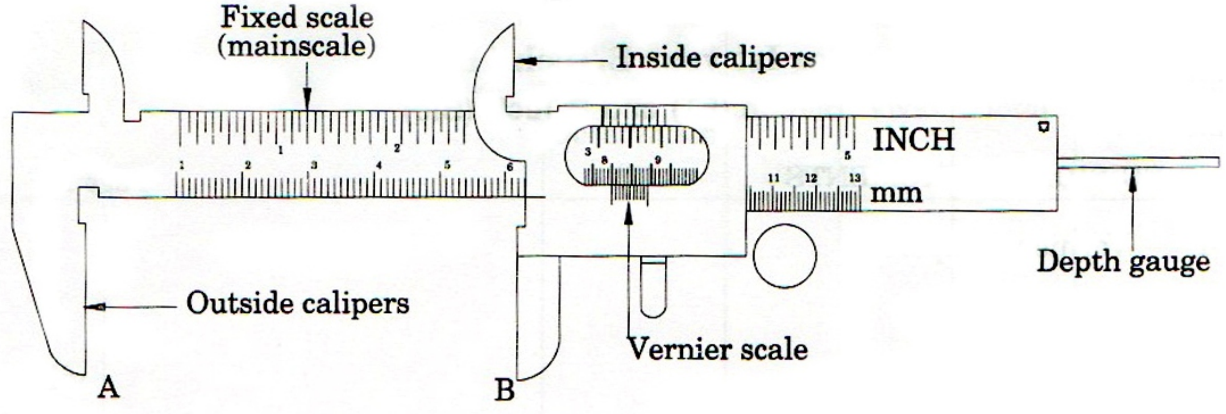
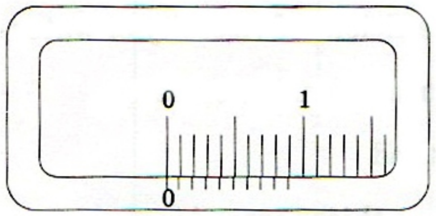
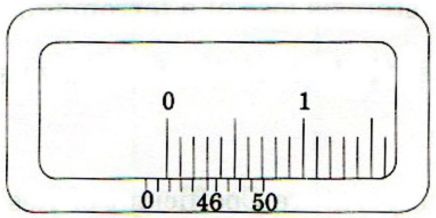


Fig. 1 Vernier Caliper



Z.C. : Nil

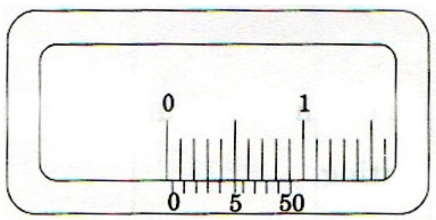
Fig. 1.1



Z.E. : – 4 div

Z.C. : + 0.08 mm

Fig. 1.2



Z.E. : + 5 div

Z.C. : – 0.10 mm

Fig. 1.3

PRECISION INSTRUMENTS

I. Vernier caliper

The Vernier caliper consists of a main scale (fixed scale) and a moving vernier, In a metric vernier the main scale is marked in millimeters. The vernier is divided into 50 divisions.

Before taking a reading with the Vernier Calipers the least count and zero error have to be determined.

Least count:

L.C. = 1MSD-1VSD

1MSD = 1mm

Total number of divisions on vernier Scale = 50.

50 Vernier Scale Divisions (VSD) = 49 Main Scale Division (MSD)

Value of 1 VSD = 49/50 MSD

Value of 1MSD = 1mm

Hence value of 1VSD = 49/50x1mm = 0.98mm

Least count (LC) = 1MSR -1VSR

= 1 – 0.98

= 0.02mm

Least count (LC) = 0.02mm

When the two jaws A&B of the vernier calipers touch each other and if the zero of the vernier coincides with zero of the main scale division there is no zero error (Fig 1.1).

When the two jaws are in contact and if the zero of the vernier is to the right of the zero of the main scale the error is positive. In this case let 5th vernier division coincide with definite main scale division (Fig 1.3)

Value of zero correction = ±(ZE x Least Count) **Z.E = +5 div**

= 5x0.02mm = 0.1mm

When the two jaws are in contact and if the zero of the vernier is to the left of the zero of the main scale the error is Negative. Let 46th vernier scale division coincides with definite main scale divisions (Fig 1.2).

ZE = -(50-41)div

= -4 div

Then value of zero correction = + 4 x 0.02mm

= + 0.08mm

Determination of Length

The object whose length to be measured is held between the two jaws. the main scale reading and the vernier scale coincidence are noted.

Now VSR (OR) = VSC x Lc

Total reading (TR) = MSR +(VSR $\pm$ ZC)

Length of the given object is measured at different places and the observations are tabulated in Table (1) and mean value is taken.

Table 1:

Least count = 0.02mm

Zero error = ____________________div

Zero correction = __________________mm

S.No.	MSR $\times 10^{-3}$m	VSC div	VSR = (VSC x L.C.) $\times 10^{-3}$ m	TR = MSR + (VSR ±ZC) $\times 10^{-3}$ m
1.				
2.				
3.				
4.				
5.				

Mean = $\times 10^{-3}$m

II. Screw Gauge

A screw gauge can measure distances with more precision than a Vernier Calipers. The screw gauge consists of a barrel (Pitch Scale) moving within a Head scale (Sleeve). The Head Scale is divided into 50 divisions. The head scale moves over the pitch scale, which is graduated in 1mm. A ratchet knob is provided for closing the Screw gauge on the object being measured without exerting too much force.

To make a measurement with the screw gauge, the pitch, least count and zero error have to be determined.

Total number of divisions on head scale = 50

$$\text{Least Count} = \frac{\text{pitch}}{\text{Total number of head scale divisions}}$$

$$\text{Pitch} = \frac{\text{Distance moved by the head scale on the pitch scale}}{\text{Total number of rotations given to the head scale}}$$

$$= \frac{0.5\text{ mm}}{1} = 0.5\text{ mm.}$$

$$\therefore \quad \text{L.C} = \frac{0.5\text{ mm}}{50} = 0.01\text{ mm.}$$

When the tip of the screw and the stud are in contact and if the zero of the head scale exactly coincides with the zero of the pitch scale (Fig 2.1), there is no zero error. If the zero of the head scale is below the reference line on the pitch scale, the error is positive. In the case let 5^{th} head scale division coincides with the reference line (Fig. 2.2).

Z.E = +5 div

Z.C = -5 x L.C

= -5 x 0.01 mm

= -0.05 mm

If the zero of the head scale is above the reference line then the zero error is Negative. Let 45^{th} head scale division coincides with the reference line, in this case (Fig.2.3).

Z.E = -(50-45)div

Z.E = -5 div

Z.C = +5 x L.C

= +5 x 0.01 mm

= -0.05 mm

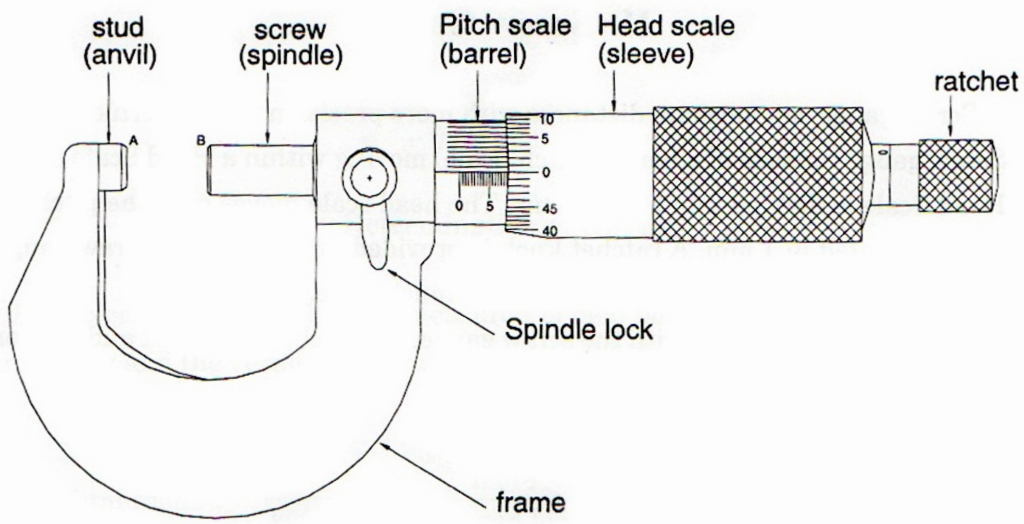
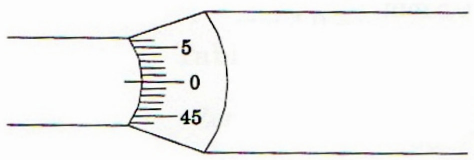
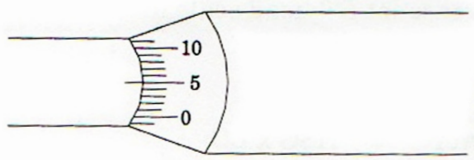


Fig. 2 Screw Gauge



Z.C. : Nil

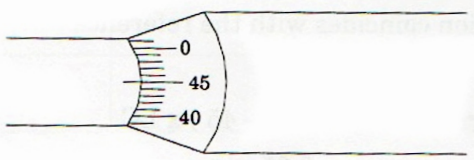
Fig. 2.1



Z.E. : + 5 div

Z.C. : – 0.05 mm

Fig. 2.2



Z.E. : – 5 div

Z.C. : + 0.05 mm

Fig. 2.3

Determination of thickness of an object

The object whose thickness is to be measured is held tightly between A and B. The head scale coincidence divisions and the pitch scale reading are noted.

The head scale reading (HSR) = HSC x L.C

∴ Total Reading TR = PSR + (HSR ± ZC)

Observations are repeated for different places on the object. The readings are tabulated in Table (2) and mean value is found.

Table 2:

Least count = 0.01mm

Zero error = ____________________div

Zero correction = __________________mm

S.No	PSR $\times 10^{-3}$m	HSC div	HSR = (HSC x L.C.) $\times 10^{-3}$ m	TR = PSR + (HSR $\pm$ ZC) $\times 10^{-3}$ m
1.				
2.				
3.				
4.				
5.				

Mean = $\times 10^{-3}$m

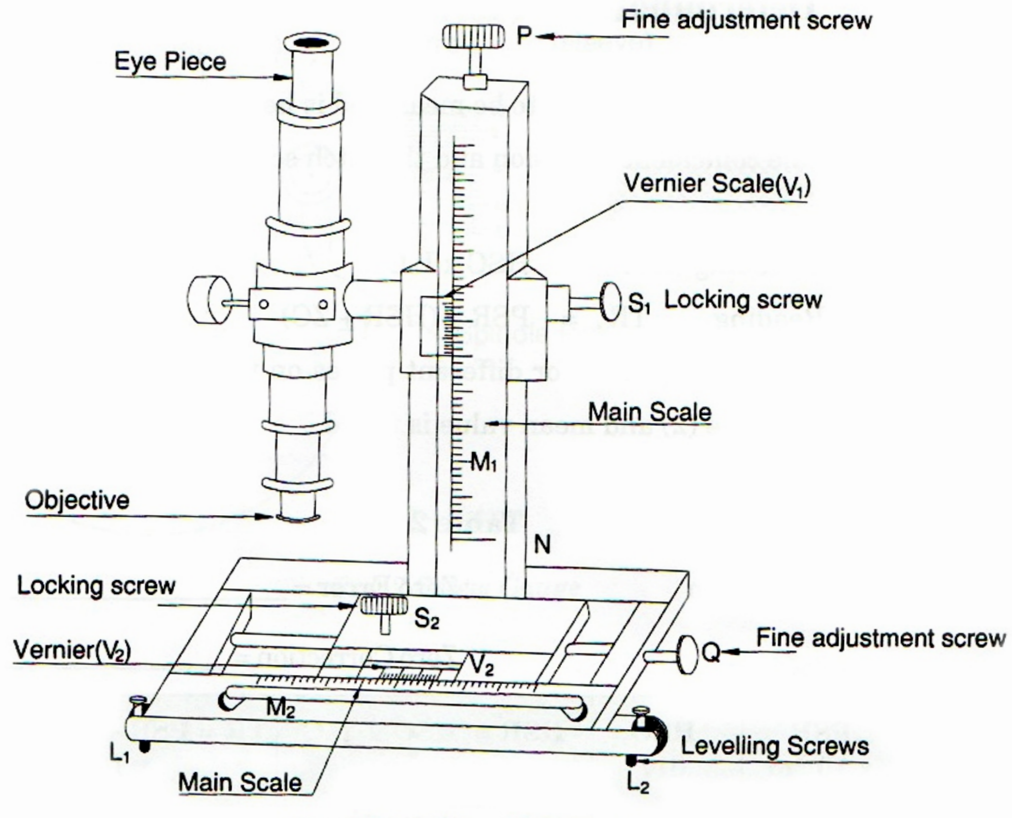


Fig. 3 Travelling Microscope

Table 3:

Least count = 0.001cm

Position	Microscope Reading			Diameter $\times 10^{-2}$ m
	MSR $\times 10^{-2}$ m	VSC div	TR = MSR + (VSC x LC) $\times 10^{-2}$ m	
V_1				$V = V_2 - V_1$
V_2				
H_1				$H = H_2 - H_1$
H_2				

Mean = $\times 10^{-2}$m

III. Travelling Microscope

The Travelling Microscope consists of a compound microscope that is capable of independent vertical and horizontal movements fitted with main scales (M_1 and M_2) and verniers (V_1 and V_2). The microscope attached with verniers V_1 can be raised or lowered along M_1 by a screw S_1/P. Similarly V_2 is moved to and fro horizontally with a screw S_2/Q. two screws (L_1 and L_2)at the base of the microscope are used for its leveling. The main scale is marked in millimeters and half millimeters. The vernier is divided into 50 divisions.

Least Count

L.C = 1MSD- 1VSD

20 MSD = 1 cm

1MSD = 1/20cm= 0.05cm

Total no.of divisions on the vernier scale = 50

50 VSD coincides with 49 MSD

$\therefore$ 50 VSD = 49 MSD

1VSD = 49/50 MSD

= 49/50x 0.05 cm = 0.049 cm

$\therefore$ LC = 1MSR – 1VSR

= (0.05-0.049) cm

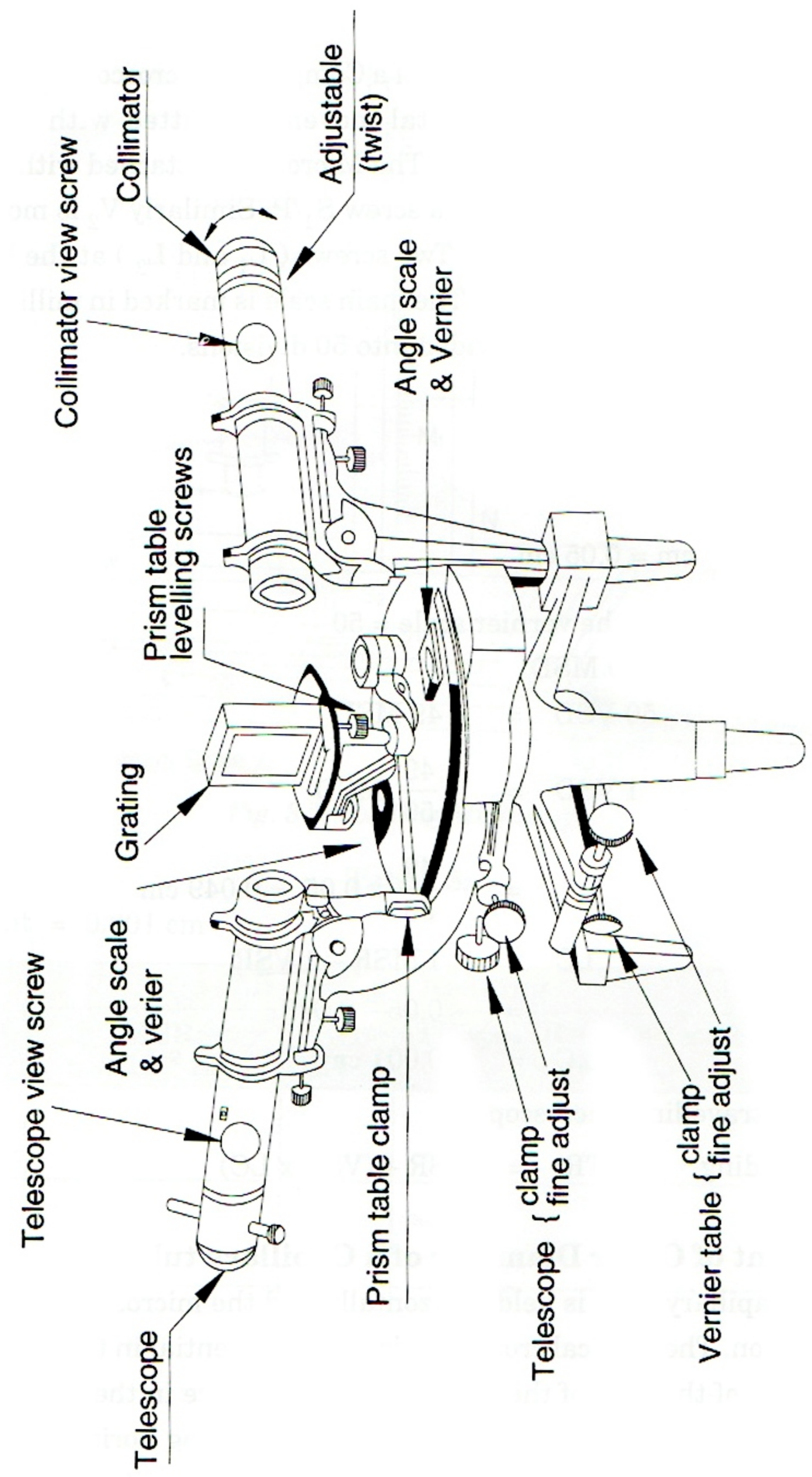
$\therefore$ L.C = 0.001 cm

In the case of travelling microscope

Total Reading (TR) = MSR = (VSC x LC)

Measurement of Outer Diameter of a Capillary tube

The capillary tube is held horizontally and the microscope is focused on the cross section. The vertical cross wire is made tangential in two diametrically opposite points of the bore of the tube and the difference in the horizontal scale readings is taken. The experiment is repeated by making horizontal cross wire tangential to the bore and the difference in vertical scale reading is taken and the observations are recorded in table 3.



IV. Spectrometer

The essential parts of a spectrometer are the Collimator, Prism table and the Telescope. A circular graduated disc (Main scale) is attached to the telescope and hence rotates with it. The telescope can be fixed at any desired position by a clamping screw while finer adjustments can be made with a tangential screw.

The prism table is made up of two circular platforms one above the other Connected together by three leveling screws, a circular disc with two verniers 180^0 apart is mounted coaxially with the main scale.

Before taking measurements using spectrometer , it is essential to make the following preliminary adjustments.

i) Eye piece is adjusted to get a clear image of the cross wires.

ii) The telescope is turned to a distant object and is focussed to get a clear image of the object.

iii) The slit of the collimator is illuminated with monochromatic light and image of the slit is viewed through the telescope. The collimator screw is adjusted to get the sharp image of the slit.

iv) The leveling of the prism table is done with a sprit level.

Least count

The main scale is graduated in half degree. There are 30 divisions in the vernier.

Least count = 1MSD – 1 VSD

1MSD = $\frac{1}{2}^0$=30'

Total no. of divisions on vernier scale = 30

30 VSD coincides with 29 MSD

30 VSD = 29MSD

$\therefore$ 1 VSD = 29/30 MSD

i.e., 1 VSD = (29/30) x 30'=29'

$\therefore$ LC = 1 MSD – 1 VSD

= 30'-29'

L.C = 1'

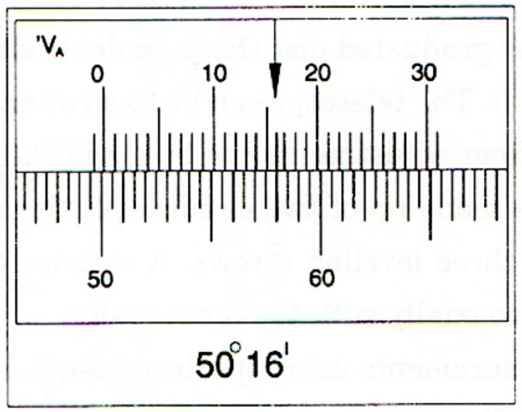


Fig. 4.1

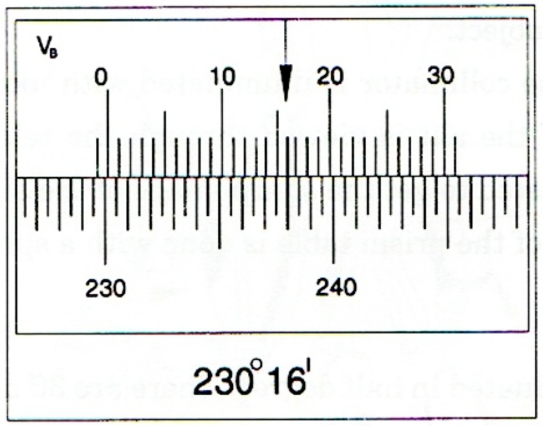


Fig. 4.2

Table 4:

Least count = 1’

MSR	VSC	TR = MSR + (VSC x LC)
50^0	16'	$50^0 16'$

Illustration For Measurement

The telescope is turned and the vertical cross wire is coincided with sharp images of the illuminated slit. The main scale reading immediately before vernier zero is notices. The vernier coincidence division with definite main scale reading is also taken. The reading is taken making use of both the verniers.

Let one of the Vernier is called vernier. If the 50° of the main scale reading (MSR) lies immediately before zero of the vernier, and the 16th division of vernier scale coincide with one of the MSR (Fig 4.1). Then total reading on vernier A is,

Total Reading (TR) = MSR + (VSC X LC)

TR = 50° + (16 X 1′)

TR = 50° 16′

Similarly in Vernier B, 230th MSR lies immediately before zero of the vernier and the 16th division of the vernier scale coincides with one of the MSR fig (4.4) then,

TR in vernier B= 230° + (16 X 1′)

TR = 230° 16′

If 50° of main scale reading (VA) coincides exactly with zero of the vernier scale, then

MSR = 50°

VSC = 0

TR in vernier A = 50° + (0 X 1′)

= 50°

If 230° of main scale reading (VB) coincides exactly with zero of the vernier scale, then

MSR = 230°

VSC = 0

TR in vernier B = 230° + (0 X 1′)

= 230°

ABBREVIATION OF THE TERMS:

Screw Gauge :

PSR = Pitch Scale Reading

HSC = Head Scale Coincidence

HSR = Head Scale Reading

Vernier Calipers:

MSR = Main Scale Reading

VSC = Vernier Scale Coincidence

VSR = Vernier Scale Reading

EXPERIMENTS

Diagram

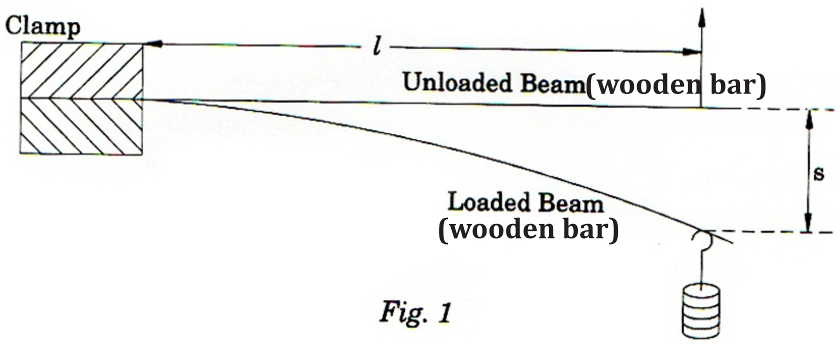


Fig. 1

OBSERVATIONS

Length of the cantilever l = m
Breadth of the bar b = m
Thickness of the bar d = m

OBSERVATIONS

Least count of the travelling microscope = 0.001 cm

Table - 1

To determine the depression for M kg:

S.No.	Load (10^{-3} kg)	Reading of the microscope							Depression for M (kg) $x10^{-2}$ m (s)
		Increasing Load $x10^{-2}$ m			Decreasing Load $x10^{-2}$ m			Mean $x10^{-2}$ m	
		MSR	VSC (div)	TR	MSR	VSC (div)	TR		

Mean = 10^{-2}m

1. Determination of Young's Modulus of a wooden bar - Cantilever method

Aim

To determine the Young's modulus of a wooden bar by measuring the depression of a cantilever .

Apparatus

A rectangular wooden bar , travelling microscope, vernier calipers, pin and clamp.

Formula

The Young's modulus of a wooden bar,

$$Y = \frac{4Mgl^3}{sbd^3} \text{ N m}^{-2}$$

where M – mass for the depression 's' (metre)

g – acceleration due to gravity (9.8m / sec^2)

l – length of the bar (metre)

b – breadth of the wooden bar (metre)

d – thickness of the wooden bar (metre)

s – mean depression for M kg.(metre)

principle

When a load is applied to one edge of the wooden bar where the other end fixed on to a table then it acts as a cantilever.

A cantilever is a wood bar. fixed at one end and held free at other end comprises a cantilever.

Procedure

A wooden bar is rigidly fixed at one end of the table. A pin is vertically stuck to the other end (free end) of the bar. A loop of cotton string is attached to this end and a weight hanger is suspended. A travelling microscope is focused on to the tip of the pin end (Fig.1)

The horizontal cross wire of the microscope is made to coincide with the tip of the image of the pin and the reading on the vertical scale is noted. Loads are added in steps of 50 gm to the hanger. Every time the microscope is focused on to the pin and readings are noted. This is repeated for seven units with an increment of 50 gm. Now the loads are decreased in the same steps and reading are measured again.

Table - 2

To determine the breadth of the wooden bar (b)

Least count: 0.02mm

Vernier Calipers

S.No.	Main scale Reading (MSR) (x 10^{-3}m)	Vernier Scale Coincidence (division)	Total Reading MSR +(VSC x LC) (x 10^{-3}m)

Mean = 10^{-3}m

Table - 3

To determine the thickness of the wooden bar (d): Z.E = ______________div

Least count : 0.01mm Z.C =_____________mm

Screw Gauge

S.No.	PSR (x 10^{-3m})	HSC (division)	HSR = HSC x LC (x 10^{-3m})	OR=HSR +PSR (x 10^{-3}m)	CR = OR ± ZC (x 10^{-3}m)

Mean = 10^{-3}m

Experimental Physics

The mean depressions (s) for a definite load say 'm' kg is found (Table1). The length(1) of the cantilever from the point of clamping to the position of the pin is noted. The breadth (b) and thickness (d) of the bar are found using vernier calipers and screw gauge respectively. (Table 2 and Table 3).

Result

Young's modulus of the wooden bar = N m^{-2}

Questions

1. State Hooke's law.
2. What is modulus of elasticity?
3. Define Young's modulus.
4. What is normal stress?
5. What is shearing stress?

Diagram

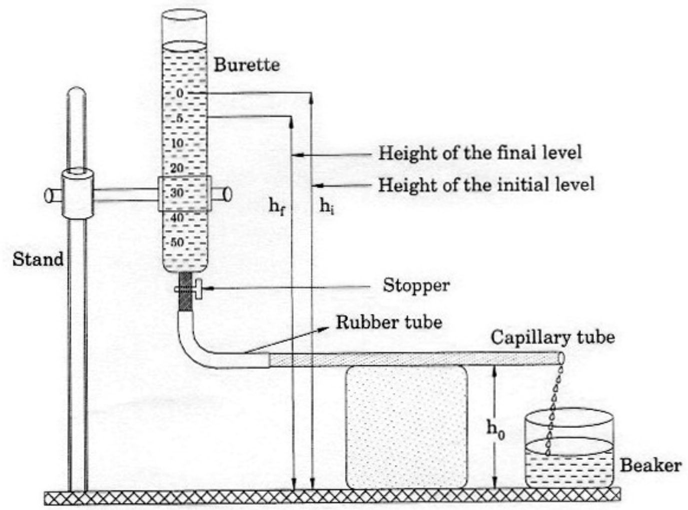


Fig. 1

OBSERVATIONS

Density of the liquid ρ = kg m^{-3}
Acceleration due to gravity g = 9.8 m s^{-2}
Radius of capillary tube a = m
Length of the capillary tube l = m

Table - 1

To determine ht

S.No.	Liquid Level	Time (sec)	Range x 10^{-6} m^3	Time difference(t) (s)	h (x 10^{-2}m)	ht (ms)

2. Determination of coefficient of viscosity of water-poiseuille's flow method

Aim

To determine the coefficient of viscosity of liquid by poiseullie's flow method.

Apparatus

Graduated burette, wooden stand, capillary tube, beaker, stop clock, liquid, meter scale.

Formula

The coefficient of viscosity of the liquid,

$$\eta = \pi \rho g a^4 (h t) / 8 l v \ \ \mathrm{Nsm^{-2}}$$

where
ρ - density of the liquid (kg/m^3)
g - acceleration due to gravity (m/sec^2)
a - radius of the capillary tube (m)
l - length of the capillary tube (m)
v - volume of water flowing out of the tube in t sec.(m^3)
h - average height of h_1 and h_2 (m)
h_1 - height of initial level from the axis of the capillary tube (m)
h_2 - height of final level from the axis of the capillary tube (m)

Procedure

A clean burette is mounted vertically in the stand. One end of the rubber tube is connected to the bottom of burette and the other to a capillary tube. The capillary tube is placed in a horizontal position. As shown in the figure the liquid is poured into the burette and the height is adjusted so that there is a steady flow. When the liquid level comes to zero mark, a stop clock is started. The time for the liquid to reach 5cc is noted. Similarly time at 10, 15, 20, 25 and 30 cc are noted (table 1). The height of the axis of the capillary tube (h_0) above the table is measured. Let h_1 and h_2 be the heights of water level at initial and final position of liquid from the capillary tube. respectively the volume v of fluid between h_1 and h_2 flowing through the capillary tube in t secs under the pressure is calculated. By knowing 'r' and 'l' the coefficient of viscosity is calculated. using the above mentioned formula.

Table - 2

To determine h :

Height of the capillary above the table $h_0 =$ _______________ x 10^{-2}m

S.No.	Range $\times 10^{-6} m^3$	Height of the initial level from the table $(h_i) \times 10^{-2}$m	Height of the final level from the table $(h_f) \times 10^{-2}$m	$h_1 = h_i - h_0$ $(\times 10^{-2}m)$	$h_2 = h_f - h_o$ $(\times 10^{-2}m)$	$h = \frac{h_1 + h_2}{2}$ $(\times 10^{-2}m)$

Table - 3

To determine the radius of the capillary tube (a)

S.No.	Position	Microscope reading x 10^{-2} m			Diameter x 10^{-2} m	Radius x 10^{-2} m
		MSR	VSC (div)	TR		
1.	H_1				$H_2 - H_1 =$	
2.	H_2					
3.	V_1				$V_2 - V_1 =$	
4.	V_2					

Mean = 10^{-2}m

Result

The coefficient of viscosity of the given liquid, η = Nsm^{-2}

Questions

1. What is laminar flow?
2. What is viscous drag?
3. What is viscosity?
4. What is coefficient of viscosity?
5. What is critical velocity?

Table - 1

(I) To determine the value of 'h' Least count = 0.001cm

S.No.	Microscope readings (x 10^{-2}m)						h= (A-B) ($x10^{-2}$m)
	Meniscus A			Pointer B			
	MSR	VSC	TR	MSR	VSC	TR	
1.							
2.							
3.							
4.							
5.							
6.							

Mean = 10^{-2}m

Table - 2

To determine the radius of the capillary tube (r)

S.No.	Position	Microscope reading x 10^{-2} m			Diameter x 10^{-2} m	Radius x 10^{-2} m
		MSR	VSC (div)	TR		
1.	H_1				H_2 - H_1 =	
2.	H_2					
3.	V_1				V_2 - V_1 =	
4.	V_2					

Mean = 10^{-2}m

3. Determination of surface tension of water – Capillary rise method.

Aim

To determine the surface tension of a liquid by capillary rise method.

Apparatus

A uniform capillary tube, Travelling microscope, Beaker with given liquid, Pointer.

Formula

The surface tension of liquid $T = \frac{(h+r/3)\, r\rho g}{2}$ Nm^{-2}

Where h - height of the liquid rise in the capillary tube (metre)

r - radius of the capillary tube (metre)

ρ - density of the liquid (kg/m^3)

g - acceleration due to gravity. ($9.8 m/sec^2$)

M - microscope
a - capillary tube
b - pointer
c - water

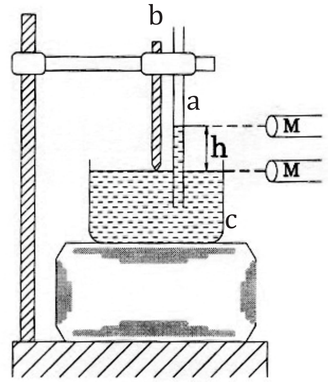


Fig. 1

Procedure

A capillary tube of uniform cross sectional area is clamped vertically to a stand. The tube is dipped into a beaker containing the liquid whose surface tension T is to be measured. Due to surface tension, the liquid rises to a certain level (Fig. 1). A pointer is mounted such that its tip just touched the surface of the liquid in the beaker. A travelling microscope is adjusted such that the horizontal cross wire is tangential to the lower meniscus of the liquid and the microscope is focused on the tip of pointer and the corresponding reading are noted. The difference between the two reading gives the rise value 'h' of liquid in the capillary tube (Table 1).

The inner diameter of the capillary tube is measured with the microscope and the radius 'r' is calculated. Then knowing ρ and g, surface tension of the liquid is determined.

Result

The surface tension of liquid = Nm^{-2}

Questions

1. What is surface tension?
2. What is surface energy?
3. Explain cohesion and adhesion.
4. Why camphor move rapidly on water?

Diagram

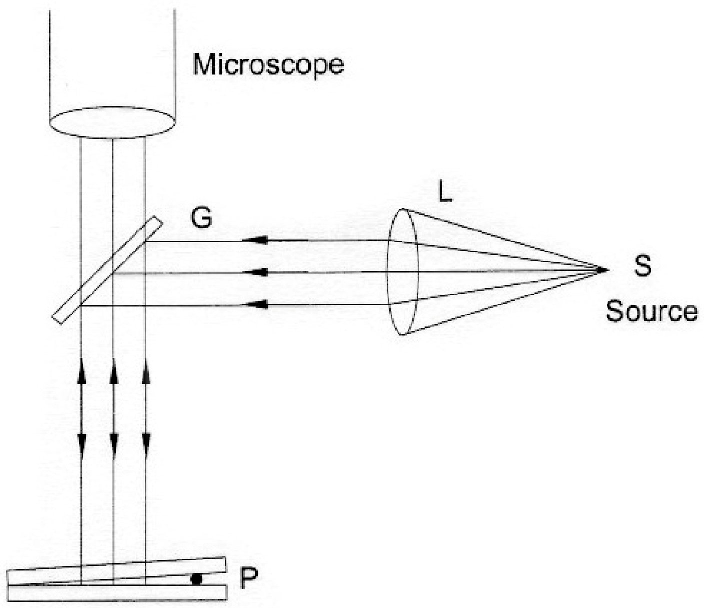


Fig. 2.1

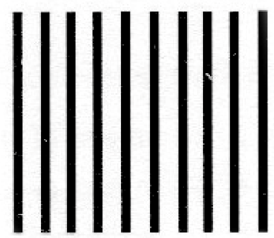


Fig. 2.2

Table - 1

To determine the band width (β): Least count = 0.001cm

S.No.	Order of the fringes	Microscope Reading $x10^{-2}$m			Width of 12 fringes $x\ 10^{-2}$m	Band width β $x\ 10^{-2}$m
		MSR	VSC (div)	TR		
1	n					
2	n+3					
3	n+6					
4	n+9					
5	n+12					
6	n+15					
7	n+18					
8	n+21					
9	n+24					
10	n+27					

Mean β= 10^{-2}m

4. Determination of fibre thickness – Air wedge method

Aim

To determine the thickness of fibre by forming interference fringes using an air wedge arrangement.

Apparatus

Two optically plane rectangular glass plates, Sodium vapour lamp, thin wire and travelling microscope.

Formula

Thickness of thin fibre

$$t = \frac{l\lambda}{2\beta} \text{ (metre)}$$

Where λ - Wave length of monochromatic light (589.3nm)
β - Band width (metre)
l - Distance between the edge of the contact and the fibre (metre)

Principle

When a wedge shaped air film is viewed by a normally reflected monochromatic light through a microscope, the field of view is crossed by a number of alternate dark and bright interference bands of equal thickness.

Procedure

An air wedge is formed by keeping two optically plane glass in contact along one of the edges and keeping a thin fibre near the other end parallel to the edges of contact of the glass plate (Fig.1). this arrangement is placed on the bed of the travelling microscope.

A parallel beam of light is reflected down on the air wedge by a glass plate kept inclined at an angle of 45^0 to the horizontal, interference takes place between the light reflected at the top and bottom surfaces of the air film between the two plane glass plates. Interference pattern (Fig.2) consisting of a series of bright and dark bands of equal width is viewed by a travelling microscope arranged above the air wedge.

Microscope is focused on these fringes and the vertical cross wire is made to coincide with the n^{th} dark fringe near the edge of contact of the glass plates. The reading on the horizontal scale of the microscope is taken. Cross wire is made to coincide with successive 3^{rd} fringes (n+3,n+6,n+9,-----------n+27) and the corresponding microscope reading are noted. The reading are recorded in Table 1

Experimental Physics

Using the travelling microscope the distance 'l' between the edge of the contact and the wire is measured.

The thickness of the wire is found out using the formula.

$$t = \frac{l\lambda}{2\beta}$$

Result

Thickness of the given thin fibre = m

Questions

1. What are coherent sources?
2. Give examples for monochromatic sources.
3. How can the thickness of insulation on a wire be measured by forming air wedge?
4. Can you determine the thickness of a very thick fibre? Give reasons.
5. What is the effect of length of air wedge on band width?

Diagram

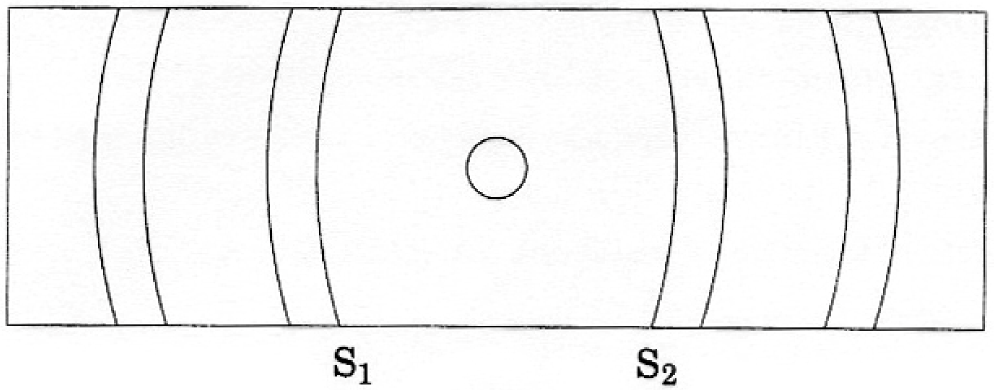


Fig. 1

Table - 1

Radius of camera (R) = _________x 10^{-2}m

Wave length of monochromatic X-ray (λ) ______________x 10^{-10}m

To determine the K for _________________Film

S.No.	Film used	Scale reading (x 10^{-2}m)			θ = S/(4R) (degree)	sin θ	$\sin^2 \theta$	$K = \frac{\sin^2 \theta}{h^2+k^2+l^2}$
		Left s_1	Right s_2	$s = s_2 - s_1$				
1.								
2.								
3.								
4.								
5.								
6.								

5. Determination of lattice constant using X-ray powder photograph

Aim

To determine the lattice constants of FCC and BCC crystals using powder photograph

Apparatus

X-ray powder photograph, microscope

Formula

$$\sin^2\theta = \frac{\lambda^2}{4a^2}(h^2+k^2+l^2) \quad \text{....(1)}$$

$$K = \frac{\lambda^2}{4a^2} = \frac{\sin^2\theta}{(h^2+k^2+l^2)} \quad \text{....(2)}$$

$$a = \frac{\lambda}{2\sqrt{k}} \text{ m}$$

K - Constant

a - Lattice constant (metre)

λ - Wave length of X-rays (metre)

h,k,l - Miller indices

θ - Diffraction angle (degree)

Principle

The crystal powder consist of large number of tiny single crystal oriental in different direction. when X-rays undergo Bragg Reflections from certain selected crystal plains, they give rise to constructive interference fringes which from arcs of circles on X-rays film .

Procedures

The print of the X-ray diffraction film is used for the measurement of lattice constant.

The distance between any two corresponding arcs of the spread out film is termed as 'S'. if R is the radius of the camera then the glancing angle θ = S/4R here S is measured using a microscope.

The microscope is focused on the left extreme arcs of the circle on the spread out film and the crosswire is made tangential to it. the horizontal scale of the microscope is read. The microscope is moved so that the crosswire is tangential to the successive arcs and the readings are noted on the horizontal scale. The process is repeated on the right side, the difference between the reading of the corresponding arcs gives the value the of S. the reading are recorded in table 1.

The above procedure is repeated for the FCC film also. The readings are tabulated as in table 2.

For BCC crystals, all allowed refections are from planes for which $(h^2+k^2+l^2)$ ratio is 2:4:6:8:10:12:14:16: for f.c.c. crystal $(h^2+k^2+l^2)$ ratio 3:4:8:11:12:16. For SC crystal $(h^2+k^2+l^2)$ ratio 1:2:3:4:5:6:8:9. So using these $(h^2+k^2+l^2)$ value K is calculated. Using this value of K in the formula a = $\lambda/2\sqrt{k}$ the lattice constant 'a' is determined

Table - 2

To determine the K for ____________________Film

S.No.	Film used	Scale reading (x 10^{-2}m)			$\theta = S/(4R)$ (degree)	$\sin\theta$	$\sin^2\theta$	$K = \frac{\sin^2\theta}{h^2 + k^2 + l^2}$
		Left s_1	Right s_2	$s = s_2 - s_1$				
1.								
2.								
3.								
4.								
5.								
6.								

Experimental Physics

Result

Lattice constant for BCC crystal = Å

Lattice constant for FCC crystal = Å

Questions

1. What is a single crystal?
2. What is a lattice constant?
3. What are miller indices?
4. What are the differences between FCC and BCC crystals?
5. Mention the Miller indices of the crystal planes that give rise to constructive interference of x-rays for BCC and FCC crystals.

Diagram

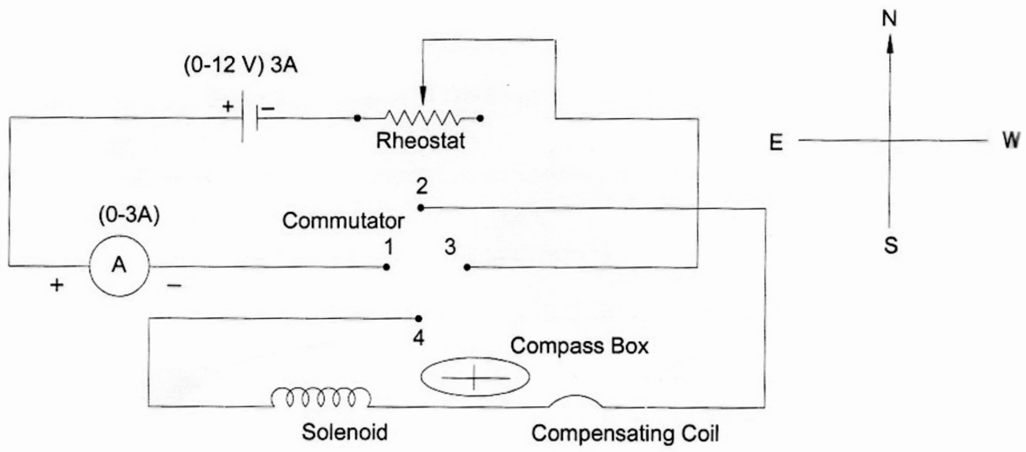


Fig. 1

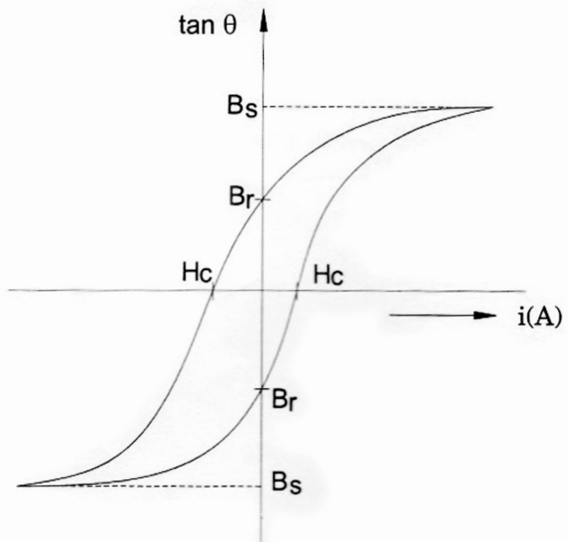


Fig. 2

6. Determination of Hysteresis loss of a ferromagnetic material

Aim

To draw the Hysteresis curve for the given sample of ferro magnetic material and hence to determine the energy loss.

Apparatus

Solenoid, compensating coil, rheostat, magnetometer, commutator, battery and ferro magnetic material in the form of a rod.

Formula

$$\text{Hysteresis loss of the material of the sample} = \frac{(i\ \tan\theta).\, x.\, y.\, n.\, B_e (d^2 - l^2)^2}{R^2\, Ld}\ \mathrm{J/m^3} - \text{cycle}$$

Where $(i \tan\theta)$ = area of the hysteresis loop (m^2)

x and y = the scale factors on x, y axes.

n = number of turns per metre in the solenoid

B_e = horizontal component of earth's magnetic induction . ($40X10^{-6}$Tesla)

L = the length of the specimen . (m)

R = radius of the specimen. (m)

D = The distance between the centre of the magnetometer and the centre of the solenoid. (m)

l = Semi length of the rod (m) (l=L/2)

Principle

When a ferro magnetic material is subjected to a cycle of magnetisation, there is an expenditure of energy. this energy generally appears in the from of heat in the specimen. The energy loss due to the lagging of magnetic induction (B) with respect to the magnestising field (H) is called 'Hysteresis'. The closed loop of B versus H graph is known as Hysteresis loop.

The magnetic dipoles are oriented or reoriented when the material is passed through a cycle of magnetization and this molecular motion results in the production of heat.

Procedure

The solenoid is kept along the east-west direction perpendicular to the magnetic meridian. The connections are made as shown in the (Fig.1.) A magnetometer is kept between the solenoid and the compensating coil. The circuit is closed and the rheostat is adjusted so that a maximum current 3.0 amp., flows in the circuit , Under this condition, the position of the compensating coil is adjusted so that the deflection in the magnetometer become zero, the circuit is then kept open. The given iron sample I demagnetized by dropping it a few times. It is then inserted into the solenoid. (Even with zero current there will be a deflection in the magnetometer which is due to residual magnetization.)

First the rod is taken through a complete cycle of magnetization, the cycle of operation changing the current from +3 amp. to -3amp. And back again form +amp, to +amp, is repeated four or five

Table - 1

To determine tan θ :

S.No.	I (Ampere)	θ_1 (degree)	θ_2 (degree)	Mean θ (degree)	tan θ

Table - 2

To determine the radius of the specimen (R):

Least count = 0.01mm

Zero error - ______________div

Zero correction = ____________mm

S.No.	Pitch scale Reading $x10^{-3}$ m	Head scale Coincidence (division)	Head scale Reading (HSC x LC) $x10^{-3}$ m	Observation Reading (PSR+HSR) $x10^{-3}$ m	Correct Reading =O.R ± Z.C $x10^{-3}$ m

Mean Diameter = 10^{-3} m

times before the readings are finally taken in order to insure the saturation states is reached in going through the cycle the rheostat must be worked all in one way without bushing the sliding contact backward and foreword. Now the sliding contact of the rheostat is set for a current of three amp. In the circuit. The current is then decreased in steps of 0.5amp. Till 0.0amp.is reached nothing the magnetometer readings in each case . Now the commutator is reversed and the current is increased by the same steps up to -3.0amp. the current is then decreased till 0.0amp.is reached noting the magnetometer readings in each case . Again the commutator is reversed is and the current is increased successively to 3.0amp.noting the magnetometer reading .

Observations of deflections (θ) at different currents (I) for the whole cycle are noted in the Table 1.

The length (L) of the road is noted. The radius (R) of the road is accurately determined as the mean of a few readings with the screw gauge. The values are noted in Table 2.

The distance (d) between the center of the magnetometer and the solenoid is measured. A graph (Fig. 2) is drawn connecting the current (i) and tan θ and its area is calculated. The hysteresis loss of the given specimen rod is calculated using the formula.

$$\text{Hysteresis loss of the given specimen rod} = \frac{(i\ \tan\theta).\ x.\ y.\ n.\ B_e (d^2 - l^2)^2}{R^2\ Ld}\ \text{J/m}^3 - \text{cycle}$$

Result

Hysteresis loss of the material of the given sample= ------------------- J/m^3-cycle

Questions

1. Explain ''magnetic Hysteresis''
2. Explain the terms 'Coercivity' and 'retentivity'.
3. Explain the practical significance of magnetic Hysteresis,
4. What are soft and hard magnetic materials?
5. Mention few applications of soft and hard magnetic materials.

Diagram

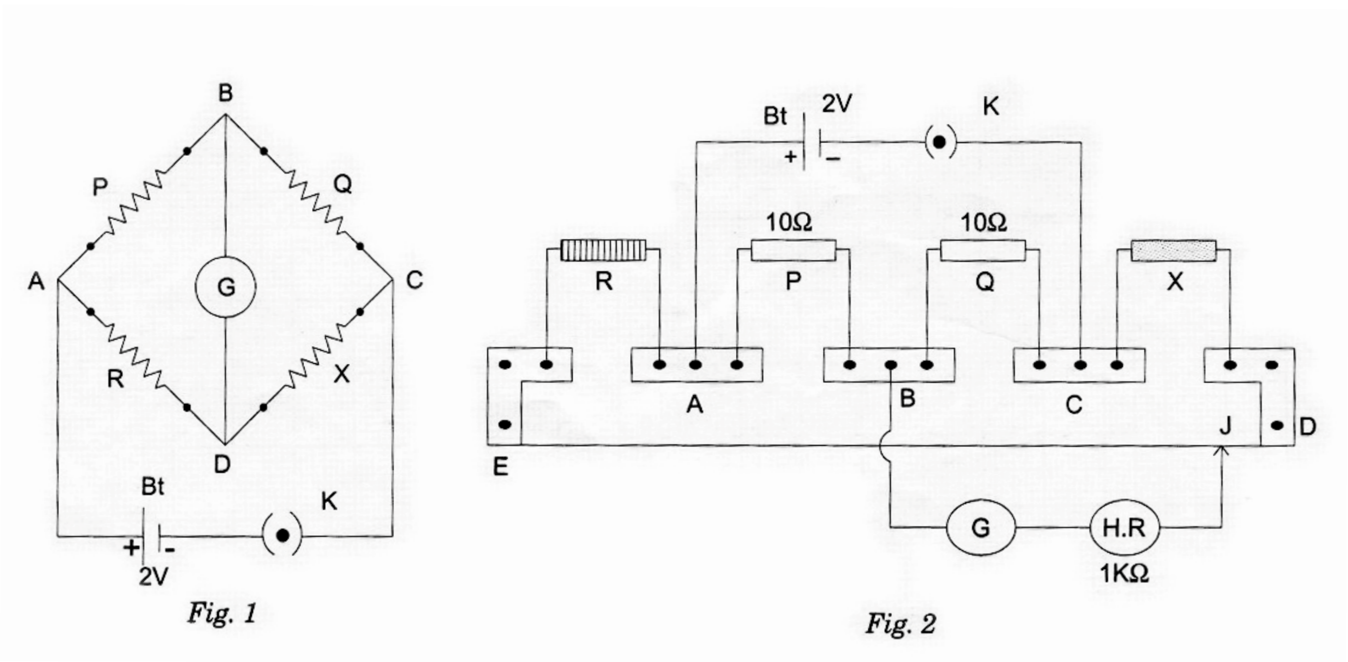


Fig. 1 *Fig. 2*

Table - 1

To determine the resistance per meter length of the Carey Fasters bridge wire (x):

S.No.	R (ohm)	l_1 (x10^{-2} m)	l_2 (x10^{-2} m)	$X = \frac{R}{(l_1 \sim l_2)}$ (ohm m^{-1})

Mean =

7. Determination of resistivity of metal and alloy using Carey foster bridge

Aim

To determine the resistivity of a metal (Copper) /alloy.

Apparatus

A Carey Foster's bridge, two equal (10 ohm) resistances, standard resistance box, 2V battery, key, jockey, high resistance, galvanometer, metal and alloy wires and screw gauge.

Formula

The resistance per meter of the Carey foster's bridge wire $X = \frac{R}{(l_1 \sim l_2)}$ (ohm)/m ....(1)

The unknown resistance $X = (R\text{-}X(l_2\text{-}l_1)X)$ ohm ....(2)

The specific resistance of the material of the wire $S = \frac{\pi r^2 X}{L}$ (ohm. metre) ....(3)

Where R = the resistance in the standard resistance box (ohm)

X = resistance per metre of the Carey foster's bridge wire.(ohm)

l_1 = balance length when X is on the right gap and R is in the left gap. (metre)

l_2 = balance length when X and R are interchanged (metre)

r = radius of wire.(metre)

L = length of the wire (metre)

S = specific resistance of the wire (ohm metre)

Principle

Carey Foster Bridge is a modified version of meter bridge which gives high accurate measurements. This is based on wheatstone's principle.

Accordingly, when 4 resistance, namely P, Q the standard resistance, R, the variable resistance and X the unknown resistance are connected as a wheatstone's bridge network, and the bridge is balanced by varying the resistance in R, for a condition of i_G=0. when the galvanometer current is zero,

then $$\frac{P}{Q} = \frac{R}{X}$$

When all the other 3 resistance are know the 4th unknown resistance X is found,

$$X = R\frac{Q}{P} \text{ in R.}$$

for a Carey Foster's Bridge, two additional gaps are provides to include the end resistance, and hence no additional correction is required. End resistance is the small resistance offered by the thin metalic strip welded with the bridge wire, this is specially used for determining the difference between two nearly same resistance.

Table - 2

To determine the specific resistance of the material of a wire (S):

S.No.	R (ohm)	l_1 (x10^{-2} m)	l_2 (x10^{-2} m)	X = R-x[(l_2–l_1)] ohm

Mean =

Table - 3

To determine the radius of the Wire (r):

Least count = 0.01mm

Zero error - _______________div

Zero correction = _____________mm

S.No.	Pitch scale Reading x10^{-3} m	Head scale Coincidence (division)	Head scale Reading (HSC x LC) x10^{-3} m	Observation Reading (PSR+HSR) x10^{-3} m	Correct Reading =O.R ± Z.C x10^{-3} m

Mean Diameter = 10^{-3} m

Radius = 10^{-3} m

Experimental Physics

In the CF Bridge, the two standard while resistance P, Q are connected in the inner gaps the standard resistance R and the unknown resistance X is connected in the outer two gaps in left and right respectively on series with the wire of the bridge .

Now the wheatstone principle for this combination of resistance,

$$\frac{P}{Q} = \frac{R + \alpha + xl_1}{X + \beta + xl_2}$$

Where α and β are the end resistance at left and right gaps respectively, and by interchanging R and X,

$$\frac{P}{Q} = \frac{X + \alpha + xl_2}{R + \beta + xl_1}$$

Thus the unknown resistance can be found by

X=[R - x (l_2-l_1)]

where 'x' is resistance/m of the bridge wire

Procedure:

The experiment is carried out in two parts. The first part to determine the resistance per meter(x) of the bridge wire and then, the second part is done to determine the resistance of the unknown wire.

Part I:

The connections are made as per the circuit diagram given in fig 2, but for the 'X' unknown resistance. The right gap, is short circuited by a connection wire, to give zero resistance. The circuit is powered and checked for the connectivity by placing the jockey on extreme points of the bridge wire, to observe opposite deflections on either sides.

Now the variable resistance R is varied in suitable steps and the bridge is balanced to measure l_1. The resistance R and the connecting wire are now interchanged and the same procedure is done for various of R, and now the balancing length l_2 is obtained when the bridge is balanced.

All the reading in the Carey Foster's Bridge are always measured from the left end of the scale.

Based on the reading of Table1, the resistance per unit length of bridge wire is calculated by,

$$x = \frac{R}{(l_1 \backsim l_2)} \text{ ohm/m}_1$$

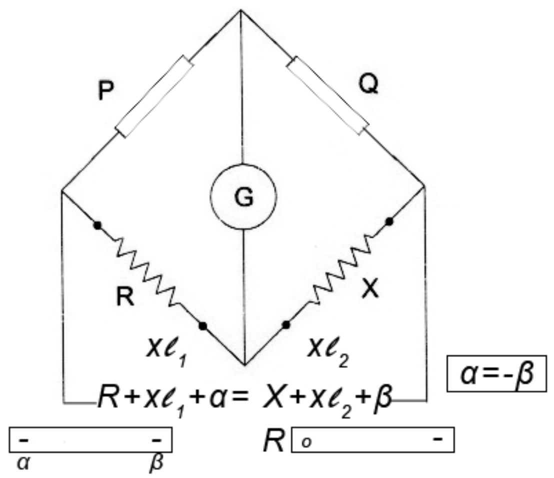
Part II:

The circuit connection remains the same as the above, but for the inclusion of X, the unknown resistance in the right gap and R in the left gap.

For various values of R, balancing length l_1 is measured, and later interchanging R and X, balancing length l_2 is measured.

Note: Whenever R is connected in the left gap the balancing length one measures is l_1 and when R is connected in the right gap the balancing length is l_2.

Diagram



The value in table 2 is used to calculate X,

$$X= [\,R - x\,(l_1\text{-}l_2)]R$$

The radius of the unknown wire is measured using a screw gauge wire provided for the same.
The specific resistance of the unknown wire is calculated by the formula.

$$\rho = \frac{X.\pi r^2 A}{L}$$

Result

Resistivity of metal (copper)/alloy = ohm.m

Questions

1. What is the deference between a meter bridge and a Carey Foster's Bridge ?
2. Explain the effect of alloying on resistivity of a metal
3. On what Factors to the sensitiveness and accuracy of a carry Foster's Bridge depend ?
4. Explain magneto resistance
5. Explain the principal of a strain gauge

Diagram

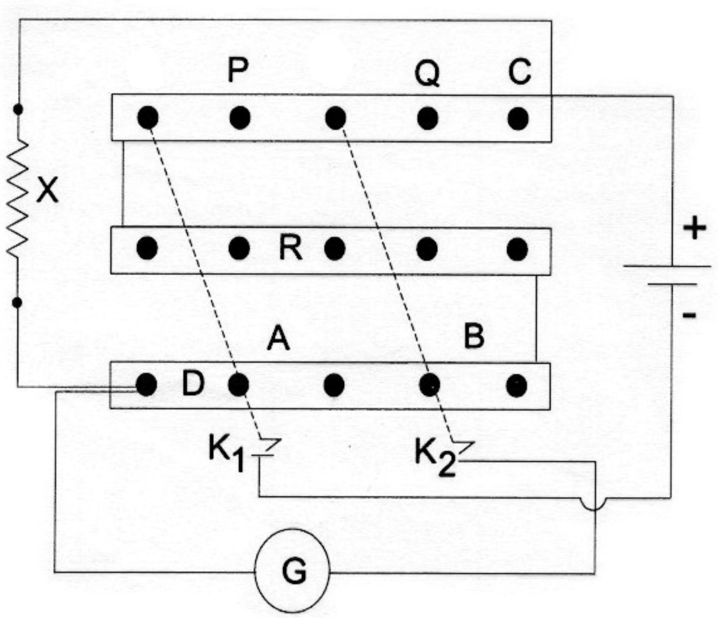


Fig. 1

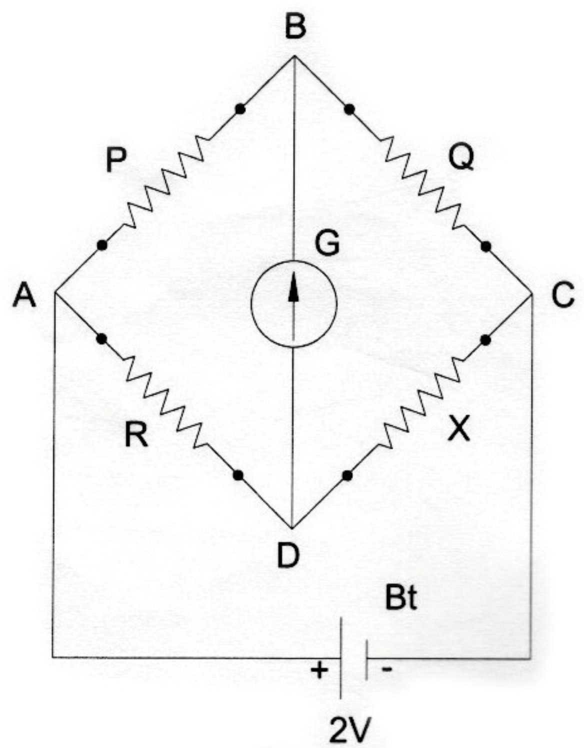


Fig. 2

8. Determination of Temperature Coefficient of Resistance of metallic wire using Post office box

Aim

To determine the resistance of metallic wire at different temperatures and to calculate the temperature coefficient of resistance (TCR) of the conductor.

Apparatus

Metallic wire, Post office box, Heater, Thermometer, Galvanometer, 2 volts battery.

Formula

Temperature Coefficient of Resistance (TCR)

$$\alpha = \frac{X_2 - X_1}{X_1 T_2 - X_2 T_1} \ /^{0}C$$

X_1 - Resistance of the conductor at temperature T_1 (ohm)
X_2 - Resistance of the conductor at temperature T_2 (ohm)

Principle

The resistance of a metallic conducted increase with increase of temperature when the temperature increases, lattice vibration increases and this cases an increase in resistence in the conductor. The variation of resistance with temperature is governed by the relation $X_{1=} X_0 (1+\alpha t)$ where X_1 is the resistance of the conductor at t^oC and X_0 in the resistance at 0^0c.

The post office box works on the wheatstone Bridge principle , namely P/Q = R/X when the bridge is balanced.

Procedures

The connection are given as per the fig 1. P and Q are the standard resistances, R the variable resistance and X is the coil of unknown resistance.

The connectivity is checked before proceeding with the experiment. Firstly P and Q are included with 10 Ω of resistance each.

Thus $\frac{P}{Q} = 1 = \frac{R}{X}$ ie $\boxed{R=X}$

In order to find the unknown resistance X, suitable values are included in the variable resistance R. This is done by including resistance in steps of 1Ω in R. The value of resistance must be kept increasing till the galvanometer changes the direction of reflection. For instance, between 9 and 10, there is different in the direction of deflection then, the same range 9-10 is noted down in the table 1, under colomn R.

Secondly, P is included with 100Ω and Q with same 10Ω. The ratio P/Q is now 10. R= 10x. So, R is now included in steps of 10Ω, to find out the range of resistance value which shows two different directions of deflection say between 140 and 150 then the range of resistance is noted as 140-150 in the table.

Table - 1

To determine the resistance of a metallic wire (X):

S.No.	Temperature ^{0}C	P (ohm)	Q (ohm)	R (ohm)	X=(Q x R) / P (ohm)
	Room temp	10	10		
		100	10		
		1000	10		

Table - 2

S.No.	T_1	T_2	X_1	X_2	$\alpha = \frac{X_2 - X_1}{X_1T_2 - X_2T_1}$ /°C

Experimental Physics

Finally P is included with 1000Ω and Q still with QΩ. now the ratio of P/Q=100m, R=100x, resistance in R is included in steps of hundreds. Now that high value of resistance is included in the circuit, the deflection is the galvanometer will be small. The opposite direction diflection is noted, for two values of R values carefully. For instance between 800-900, there is opposite deflection, it is understood the resistance of X lies in this range. Thus resistance in R is now added in steps of 10s, and again the opposite direction deflection is noted, say between 810-820, it is noted, it means the value of X has be narrowed done. Now R values are added in steps of ones, and for one exact value the bridge gets balanced. The galvanometer shows null deflection. The sum of the resistances in R is noted using the values of P, Q and R, X is calculated.

The procedure is repeated for higher temperature. The unknown coil of wire in the test tube is put in the constant temperature bath and heated. Resistance of x is calculated, by the similar procedure at boiling point, and few other high temperature.

For calculating the 'α', value few combinations of T_1,T_2 and X_1, X_2 values are chosen from Table1. t is the high temp and X_1 is its associated resistance is X_2.

$$\alpha = \frac{X_2 - X_1}{X_1T_2 - X_2T_1} \ /^{o}C$$

is used to calculate the Temperature coefficient of resistance of the given metallic wire.

Result

The temperature coefficient of resistance of the material is } α = /° C

Questions

1. What is the principle of post office Box?
2. How does the resistance of a metal vary with temperature? Why?
3. What is the difference between resistance and resistivity?
4. What type of metals do we choose for making precision resistors?
5. What type of metals do we choose for making resistance thermometers?

Diagram

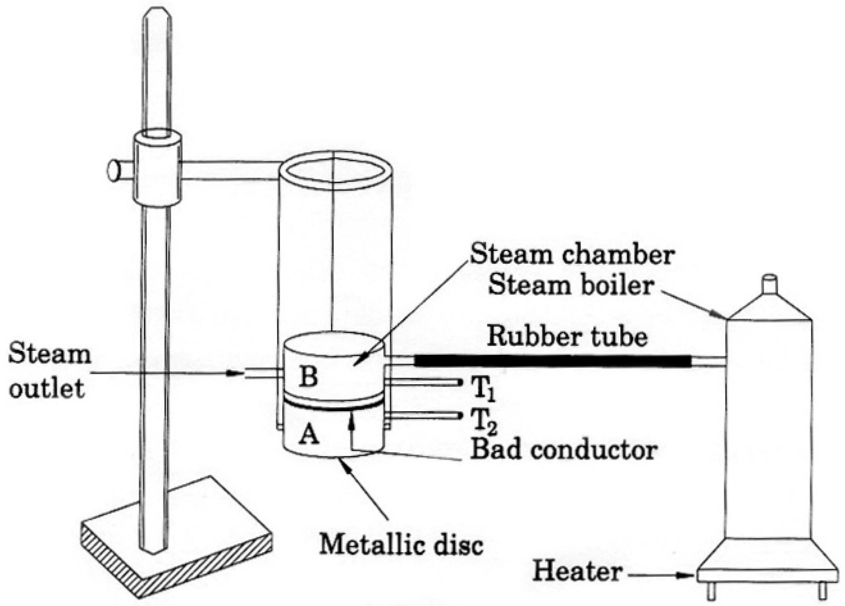


Fig. 1

Table - 1

T_1 = ...K T_2 = ...K

S.No.	Temperature (kelvin)	Time (s)	Range (dT) (Kelvin)	Time(dt) (s)	$R=\left(\frac{dT}{dt}\right)$

Mean =

9. Determination of thermal conductivity of bad conductor using Lee's Disc method

Aim

To determine the thermal conductivity of a bad conductor using Lee's disc method.

Apparatus

Lee's disc set-up, thermometer (2 numbers), vernier calipers, screw gauge, steam source.

Formula

Head conducted by the cardboard $= KA\,(T_1 - T_2)\ /\ d$ ....(1)

Head lost by the disc $= MSR\,(2h+r\ /\ 2h+2r)$ ....(2)

At the steady state $KA\ (T_1 - T_2)\ /\ d = MSR\,(2h+r\ /\ 2h+2r)$

$$K = \frac{MSR\ d\ (2h+r)}{A\ (T_1 - T_2)\ (2h+2r)}\ \ (W/mK) \qquad ....(3)$$

Where,

K-thermal conductivity of card board (W/ mK)

M-mass of the (kg)

S-Specific heat of the material of disc (370 J/kg/s)

R-rate of fall of temperature (Kelvin/sec)

h- thickness of the lower disc (m)

r-radius of the lower disc(m)

d-thickness of the card board(m)

A-area of cross section of card board (m^2)

Procedure

The cardboard is placed in between a stream chamber B and a brass disc A. The whole arrangement is suspended by means of strings attached to hooks in A. The thermometers T_1 and T_2 are inserted into the holes in B and A to record the temperature.

Steam is admitted into the chamber. The head conducted through the cardboard disc is imparted to the brass disc A which raises the temperature gradually and finally attains a steady temperature $T_2\ ^0c$. When steady state is reached the head conducted by the disc A by conduction through the cardboard is just lost by radiation from the surface of the disc. Temperatures of the brass disc A and B are noted at intervals of 5 or 10 minutes. When the temperature indicated by T_1 and T_2 remains steady it means the whole arrangement has reached the steady state. Now the temperature T_1 and T_2 are noted.

Table - 2

To determine the thickness of the brass disc (h)

Least count = 0.01mm

Zero error - _______________div

Zero correction = _____________mm

S.No.	Pitch scale Reading $x10^{-3}$ m	Head scale Coincidence (division)	Head scale Reading (HSC x LC) $x10^{-3}$ m	Observation Reading (PSR+HSR) $x10^{-3}$ m	Correct Reading =O.R ± Z.C $x10^{-3}$ m

Table - 3

To determine the thickness of the card board (d)

Least count = 0.01mm

Zero error - _______________div

Zero correction = _____________mm

S.No.	Pitch scale Reading $x10^{-3}$ m	Head scale Coincidence (division)	Head scale Reading (HSC x LC) $x10^{-3}$ m	Observation Reading (PSR+HSR) $x10^{-3}$ m	Correct Reading =O.R ± Z.C $x10^{-3}$ m

Experimental Physics

To Find the rate at which heat is radiated by the disc A, it is brought directly into contact with the steam chamber after removing the cardboard disc and its temperature is allowed to rise about $10^{0}C$ above the steady temperature $T_2\,^{0}C$. the metal disc A is removed and then suspended from a stand. With a stop clock the time is recorded for every one degree fall of temperature as it cools from $(T_2 +5)\,^{0}C$ to $(T_2-5)\,^{0}C$ (i.e.82.5 to $72.5^{0}C$) when the steady temperature is (say $77.5\,^{0}C$). if 't' is the time (in sec.) taken by the disc to cool from $(T_2+1/2)\,^{0}C$ to $(T_2-1/2)\,^{0}C$, then rate of all of temperature of the brass disc at the mean temperature $T_2\,^{0}C$ is equal to 2/t deg./sec.

Similar calculations are made with the other reading average value of the rate of fall of temperature R at $T_2\,^{0}C$ is found (table 1). The thickness of the cardboard disc and brass disc is determined with a screw gauge (table 2 and table 3). Radius of the brass disc is measured with a vernier calipers. Knowing A, mass of the disc and S, the specific heat capacity of brass, thermal conductivity k of the cardboard is determined from the formula,

A graphical method can also be used to calculate R. First a cooling curve is drawn taking time on the x-axis and temperature $T_2\,^{0}C$ the corresponding rate of fall of temperature of the brass disc A at the $T_2\,^{0}C$ can be found and used in calculating the value of K.

Result

The thermal conductivity of the given material = ___________________W/mK.

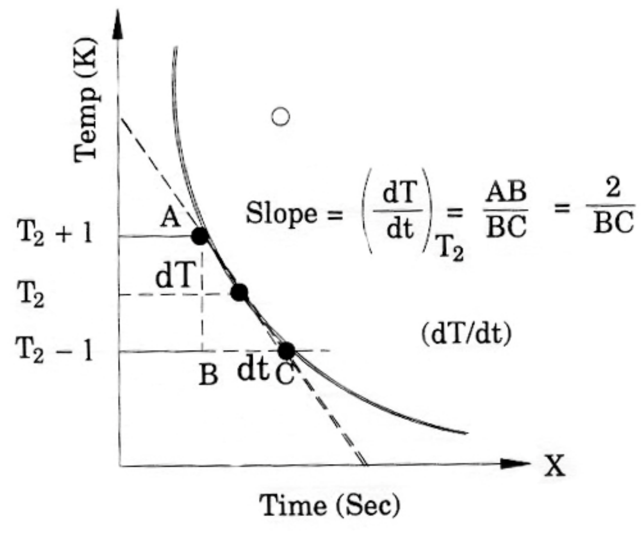


Fig. 2

Diagram

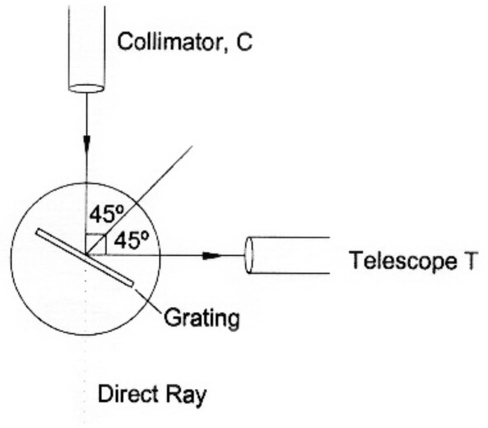


Fig. 1 Adjustment for normal incidence

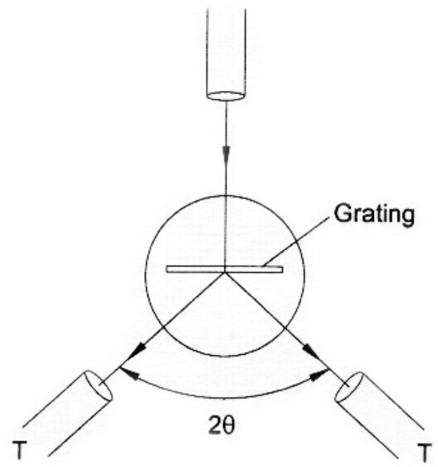


Fig. 2 Determination of wavelength of Hg Spectrum

Experimental Physics

10. Determination of wavelength of mercury spectrum using transmission grating

Aim

To determine the wavelength of the various spectral lines of mercury spectrum using a grating by normal incidence method.

Apparatus

Spectrometer, Plane transmission grating, Mercury vapour lamp, reading lens.

Formula

(1). The number of lines per metre on the grating

$$N = \frac{\text{Sin}\theta_g}{m\lambda_g} \quad \text{metre}^{-1}$$

where θ_g - angle of diffraction for green line of Hg spectrum (degree)
λ_g - wavelength of the green line of Hg spectrum. (degree)
m - Order of the spectrum

(2). Wave length of the prominent line of Hg Spectrum.

$$\lambda = \frac{\sin\theta}{mN} \quad \text{metre}$$

where θ - angle of diffraction of the given spectrum line (degree)
m - Order of the spectrum.
N - Number of lines ruled per meter on the grating.

Principle

Diffraction

When light falls on obstacles or small apertures whose size comparable to the wavelength of light, the light bends round the corners of the obstacles or apertures. This bending of light is called diffraction.

Fraunhofer diffraction

The light source and the screen are placed effectively at infinity. In the grating experiment, lens systems are used (collimator, telescope) to obtain this condition.

Grating Spectrum

When the light emits radiation of different wavelengths (eg. Hg vapour lamp), then the beam gets dispersed by the grating and in each order a spectrum of the constituent wavelength is observed.

Procedure

The preliminary adjustments of the spectrometer are made. are noted.

Normal incidence setting

The grating is adjusted for normal incidence (Fig.1). for this, the slit of collimator is illuminated by mercury vapour lamp. The telescope is placed in line with the collimator. The white slit image is

Table - 1

Wavelength of mercury spectrum (λ):

L.C = 1'

Colour	Telescope Reading: Left (Degree) V_A MSR	V_A VSC (div)	V_A TR	V_B MSR	V_B VSC (div)	V_B TR	Right (Degree) D_A MSR	D_A VSC (div)	D_A TR	D_B MSR	D_B VSC (div)	D_B TR	$2\theta_A = V_A - D_A$ (degree)	$2\theta_B = V_B - D_B$ (degree)	$\theta = \left(\frac{2\theta_A + 2\theta_B}{4}\right)$ (degree)	$\lambda = \frac{\sin\theta}{mN}$
Violet - I																
Violet - II																
Blue																
Bluish																
Green																
Green																
Yellow - I																
Yellow - II																
Red - I																
Red - II																
Red - III																

made to coincide with the vertical wire of the telescope. the direct reading is taken. The telescope is rotated through 90^0 and fixed in this position. the grating is mounted on the grading table and the table is rotated until the reflected slit image, reflected by the surface of the grating, coincides with vertical cross wire of the telescope. the grating table is fixed in this position. The vernier table is now rotated in the appropriate direction through 45^0 ,so that the rays of light from the collimator incident normally on the grating.

Angle if diffraction measurement

The telescope is brought in line with collimator and the central image is observed. on either side of the white image, grating spectra of different orders are obtained. The telescope is turned to the right of the central white image and the first order spectrum is viewed. The vertical cross- wire is made to coincide successively with the prominent lines of the spectrum. The readings are taken . the Telescope is rotated to the other side to view the first order spectrum in the left. The telescope readings are taken for the prominent lines in the spectrum. The reading are recorded in Table 1.

The difference between the two reading of left and right for each spectral line gives 2θ for that line. Hence the angle of diffraction θ is obtained for each spectral line.

Standardization of grating

The angle of diffraction for the prominent green line of the Hg spectrum is noted as θ_g ., The wave length of the green line λ_g is assumed. Since it is the first order spectrum, m=1. The number of line rules per metre on the grating is calculated using the relation,

$$N = \frac{\sin\theta_g}{m\lambda_g}$$

wavelength measurement

wave length of each prominent line 'λ' is calculated by substituting the angle of diffraction 'θ' of that line in the relation.

$$\lambda = \frac{\sin\theta}{mN}$$

Here m - Order of the spectrum (m=1)

N - Number of lines per metre on the grating.

Result

The wavelength of the various lines of mercury spectrum is compared with standard wavelength.

Questions

1. What is an optical grating?
2. Distinguish between prism spectra and grating spectra,
3. Distinguish between Fresnel and Fraunhofer diffraction.
4. Can we use an optical grating to dittract X-rays? Give reason
5. What are the wavelength of the yellow doublets of mercury spectrum and sodium spectrum?

Diagram

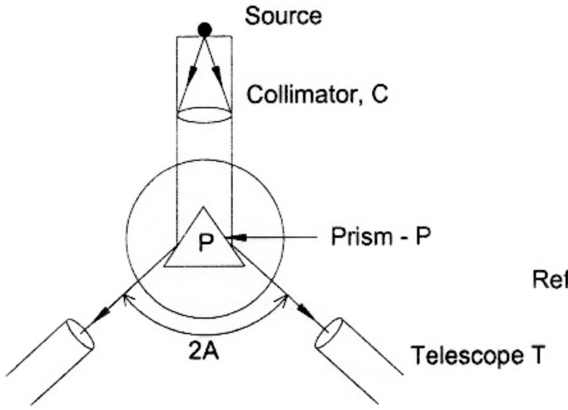


Fig. 1

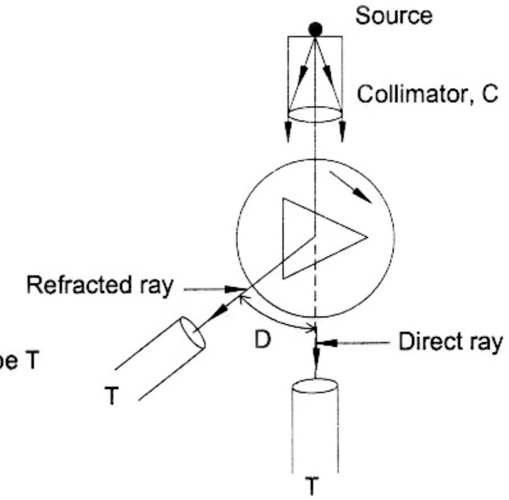


Fig. 2

Table - 1

To determine the angle of prism (A) : LC = 1’

Vernier	Telescope Reading						2A = a-b (degree)	Mean of 2A (degree)	A (degree)
	Face I (a)			Face II (a)					
	MSR	VSC (div)	TR	MSR	VSC (div)	TR			
Ver A									
Ver B									

11. Determination of dispersive power of a glass prism using spectrometer

Aim

To determine the refractive indices of glass prism for various colours of mercury spectrum and hence to find the dispersive power of the material of the prism.

Apparatus

Spectrometer, mercury vapour lamp , glass prism , reading lens.

Formula

The refractive index of the material of the prism.

$$\mu = \frac{\text{Sin}\,(A+B)/2}{\text{Sin}\,A/2} \qquad \text{---- (1)}$$

Where, A – Angle of the prism (degree)

D –Angle of minimum deviation (degree)

$$\omega = \frac{\mu_2 - \mu_1}{\left(\frac{\mu_2+\mu_1}{2} - 1\right)} \qquad \text{----- (2)}$$

where μ_1 and μ_2 are the refraction indices of the prism for two different colours.

ω = Dispersive power of the material of the prism

Principle

When a composite light passes through a prism, it gets dispersed into its constituent colours according to their refractive indices.

Procedure

Adjustment of spectrometer

The eye piece of the telescope T is adjusted so that the cross wires are sharply focussed. The telescope is focussed for parallel light using a distant object. There should be no parallax between the image seen in the telescope and the cross wires seen through the eye piece. The mercury vapour lamp is placed near the slit. The collimator is adjusted for a sharp slit image. The slit is now adjusted for a narrow slit image.

Measurement of Angle of the prism

Prism is mounted on the prism table and the prism is leveled by adjusting the leveling screws. Prism is arranged symmetrically on the prism table with its refracting edge almost bisecting the collimating lens (Fig.1.) The image of the slit as reflected by one of the polished faces is viewed, first with the naked eye and then through the telescope. The telescope is moved by working the fine

Table - 2

To determine the angle of minimum deviation (D) :

Direct Reading V_A = V_B=

Colour	Telescope Reading at Min. Dev.												Angle of Min. Dev. (degree)		D = $\left(\frac{D_A + D_B}{2}\right)$ (degree)	μ
	Left (Degree)						Right (Degree)									
	V_A			V_B			D_A			D_B			D_A	D_B		
	MSR	VSC (div)	TR	MSR	VSC (div)	TR	MSR	VSC (div)	TR	MSR	VSC (div)	TR				
Violet - I																
Violet - II																
Blue																
Bluish																
Green																
Green																
Yellow - I																
Yellow - II																
Red - I																
Red - II																
Red - III																

adjustment screw until the vertical cross wire coincide with slit image. The reading of both the verniers are taken. Similarly, the slit image as reflected by the other face is viewed and the reading are taken and recording in Table 1. The difference between the two sets readings gives twice the angle of the prism. Thus the angle of the prism 'A' is found.

Measurement of Angle of minimum deviation

The prism table is turned such that one reflecting face of the prism faces the collimating lens. The telescope is rotated to view the spectrum. The prism table is rotated in a suitable direction such that the spectrum moves towards the direct ray direction. The spectrum is followed with the telescope . at one stage , the spectrum stops and just starts to retrace its path. the prism table is fixed at this position which is the minimum deviation position. By working the fine different spectral lines. Each time, the telescope reading is recorded in Table 2.

The prism is removed and the telescope is set to receive the direct ray .The vertical cross wire is made to coincide with the direct white image. The direct reading is recorded. The difference between the two sides of reading for each vernier gives the angle of minimum deviation 'D' for the different spectral lines.

The refractive indices of the material of the prism for the various spectral lines (colours) are found out by using the relation.

$$\mu = \frac{\text{Sin}\,(A+D)/2}{\text{Sin}\,A/2}$$

The dispersive power of the material of the can be calculated using the formula

$$\omega = \frac{\mu_2 - \mu_1}{\left(\frac{\mu_2 + \mu_1}{2} - 1\right)}$$

μ_1 and μ_2 the refractive indices for two different colours.

Result

(1). Refractive indices of the prism for two different colours are determined. It is found that the refractive index decreases with of wave length of light.

(2). Dispersive power of the material of the prism =

Questions

1. Define refractive index
2. Define dispersive power of the prism
3. How does the refractive index of the material of the prism vary wavelength?
4. How does the angle of deviation vary of incidence?

Diagrams

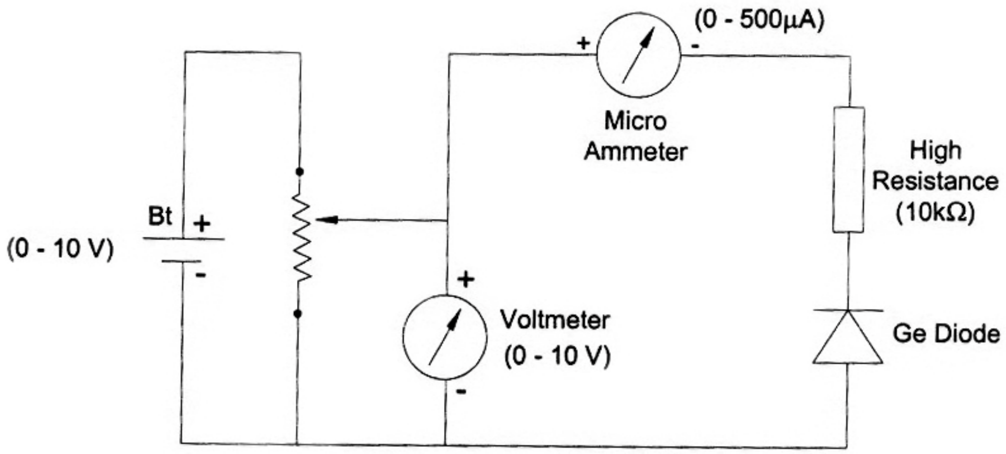


Fig. 1

Model graph

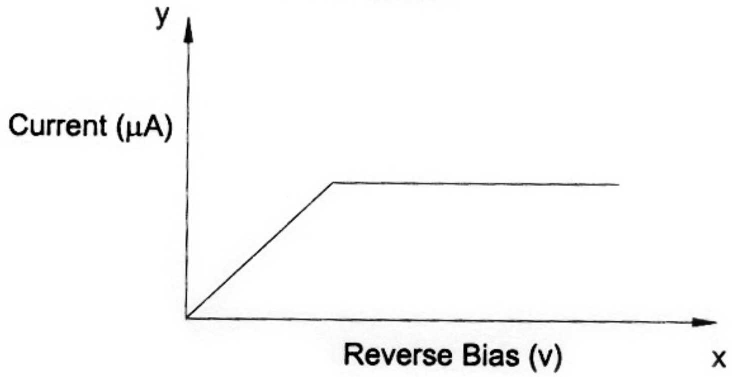


Fig. 2

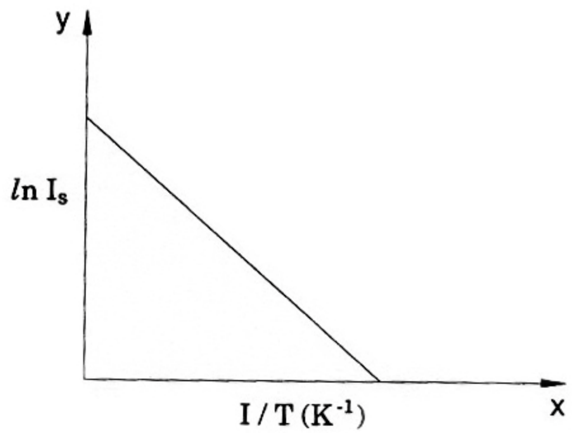


Fig. 3

Experimental Physics

12. Study of reserve bias characteristics of Germanium diode and determination of band gap of Ge

Aim

To determine the band gap of germanium diode by finding the reserve saturation current at different temperatures.

Apparatus

Germanium diode, 10V battery, key, rheostat, 10V voltmeter, microammeter, thermometer, high resistance and hot water bath.

Formula

$$\text{Band Gap Eg} = k\left(\frac{d(ln\, I_s)}{d\, T^{-1}}\right) \text{(eV) joules} \qquad .....(1)$$

where k = Boltzman's constant

= 1.38×10^{-23} Joule kelvin^{-1}

$\frac{d(lnI_s)}{dT^{-1}}$ = slope of the graph ($ln\ I_s$ Vs 1/T)

I_s = Reverse saturation current (Ampere)

T = Temperature (K)

principle

Forbidden energy gap is one of the key intrinsic parameters of a semiconductor and a number of methods can be employed to determine it experimentally. The saturation current in the reverse bias at a temperature T kelvin in terms of forbidden band Eg and Boltsmann's constant K is given by

$$Is = (\text{constant})\ T^m \exp(-Eg/nKT) \qquad .....(2)$$

Where m=2 and n=1 for Germanium

From equation (2) it is obvious that In (Is / T^m) VS T^{-1} plot is a straight line whose slope yields the forbidden energy gap. If the temperature covered is not very wide, variation caused T^{-1} could be ignored relative to the greater contribution of the exponential factor and in this case of the slope of the InlsVs T^{-1} can be conveniently employed to estimate Eg.

$$Eg = nk\ [d(lnI_s) / d(T^{-1})]$$

For Ge, n=1

$$Eg = k \text{ slope of } (lnI_s \text{ Vs } T^{-1}) \text{ graph}$$

Table - 1

To determine the reserve saturation current for different voltages

S.No :	Voltage (V)	Current (μA)

Table - 2

To determine the reserve saturation current at different temperature's

V_s =______________________volt

S.No :	T(K)	I_s(μA)	$\frac{1}{T}$ (k^{-1})	$ln I_s$

Procedure

The germanium diode is placed in a test tube and immersed in a water bath. The temperature of water is varied by placing the water bath on a heater. The temperature is measured using a thermometer. The diode is reserved biased and connections are made as shown in (fig.1).

A regulated power supply is employed as source of emf and a microammeter is used to read the reverse current.

To draw the reverse bias characteristics of the given germanium diode keep the diode at room temperature. Now for different reserve voltages the current values are noted in table 1. The reserve bias characteristics (Fig.2) is drawn.

To determine the band gap of the diode material the reverse voltage is kept at 3V. the reverse saturation current is noted for the diode keeping at room temperature, 35° ,45° , 55° and 65° C the value are tabulated in table 1.

A graph is drawn between 1/T and $ln\, I_s$ (Fig .3.) the slope of the straight line is found out. Using the relation 8.1, the band gap is calculated.

Result

Band gap of Germanium = -----------------J

= ---------------- eV

Questions

1. Define band gap
2. Explain in the effect of biasing on depletion layer.
3. Which carriers are responsible for the reverse current flow?
4. Explain the concept of 'hole'
5. Distinguish between conductors, semiconductors and insulators based on band theory.

Diagrams

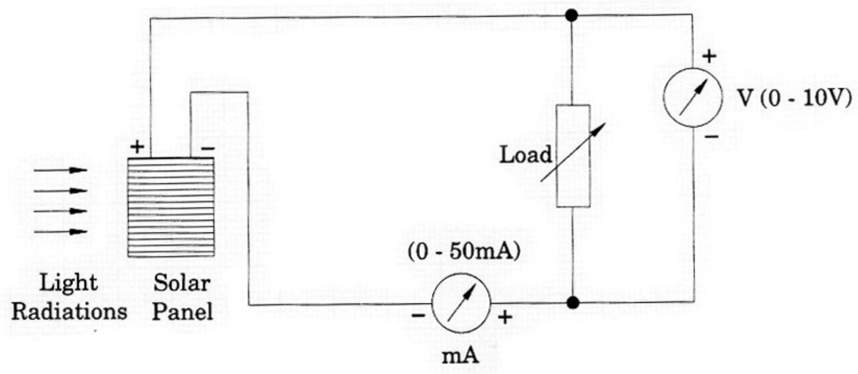


Fig. 1

Model Graph

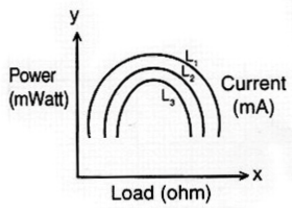


Fig. 2

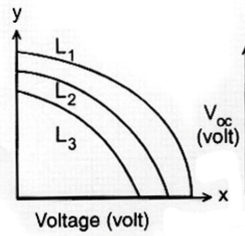


Fig. 3

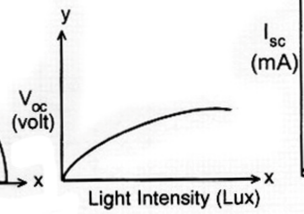


Fig. 4

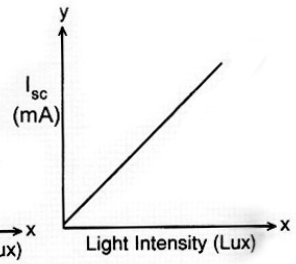


Fig. 5

Table - 1

Intensity = ____________________Lux

S.No :	Load (ohm)	Current (mA)	Voltage (V)	Power (mW)

13. Study of I-V characteristics of solar cell and determination of its efficiency

Aim

To determine the efficiency of a silicon solar cell and study its and characteristics.

Apparatus

Solar panel, Milliammeter ,60 W lamp, Rheostat, Luxmeter, Voltmeter.

Formula

$$\text{Efficiency } \eta = \frac{P_{max}}{\text{Light power input}} \times 100\%$$

P_{max} = Maximum Electrical power output (watt)

Solar cell is a semiconductor device which converts solar energy into electrical energy. It is also called photovoltaic cell or solar battery. The solar cell is essentially a PN junction device (Fig .1). When solar radiation falls on the top P type silicon semiconductor, it will reach near the PN junction since P layer is very thin. The incident photons produce electron – hole pairs at or near the junction. They are separated without recombination by the electric field of the batter potential V_B. The electron are swept to N side and holes are swept to P side by the potential V_B. on the P side , there is accumulation of positive charges and on the N side there is accumulation of negative charges. These accumulated charge of opposite sign give rise to an emf which sends current through an external load. The performance of a solar cell is characterised by the following two parameters.

$$\text{Quantum efficiency} = \frac{\text{No.of electron-hole pairs produced}}{\text{No.of photons incident}}$$

$$\text{Efficiency } \eta = \frac{\text{Electric power output}}{\text{Light power input}}$$

Procedure

Solar panel consists of several solar cells connected in series or parallel, to get the required voltage or power. The solar panel is connected in series with a milliammeter and a load resistance. A voltmeter is connected parallel to the load. Light rays from a 60 Watts lamp is allowed to fall on the panel (Fig.1.) the voltmeter an ammeter readings are noted for varies load resistance and tabulated (Table 1).

Table - 2

Intensity = ____________________Lux

S.No :	Load (ohm)	Current (mA)	Voltage (V)	Power (mW)

Table - 3

Intensity = ____________________Lux

S.No :	Load (ohm)	Current (mA)	Voltage (V)	Power (mW)

Table - 4

S.No :	Light Intensity (Lux)	Open circuit voltage (V_{oc}) (volt)	Short circuit current (I_{sc}) (mA)

Experimental Physics

The input light power is measured using a lux meter. The experiment is repeated for 2 different light intensities (table 2 &3).

A graph is plotted connecting power and load (Fig.2) From (Fig.2) maximum power output from the cell is noted. Knowing the area of the solar panel, the light power input is measured using lux meter and efficiency is determined. Current - Voltage characteristics are drawn for three intensity values as shown in (Fig.4). the open circuit Voltage V_{oc} Vs intensity graph is drawn ass shown in (Fig.4). It is found that V_{oc} remains constant beyond certain, light intensity. I_{sc} Vs intensity graph is plotted as in (Fig.5). It is found that the short circuit current increases linearly with light intensity.

Light Intensity = --Lux

$$\eta = \frac{P_{max}}{\text{Light input}} \times 100\%$$

Light input = Luxmeter reading x 0.001 x area of the panel in cm^2

(since 1 Lux = 0.001m W/cm^2)

Here both output and input powers are in mW

The efficiency of any solar cell is found to be very small (around 15%). Mora power can be produced by increasing the area of the solar panel. This will increase the cost involved. From the graph we understand that the voltage remains constant beyond certain light level irrespective of light fluctuations. This enables the solar cell to be used for charging batteries at constant voltage. The current produced increasing linearly with light level and this principle is employed in the construction of light meter, It is also found that only at a particular load, maximum power is delivered at a particular light intensity.

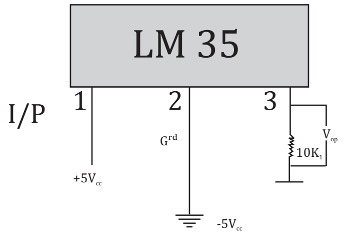
Result

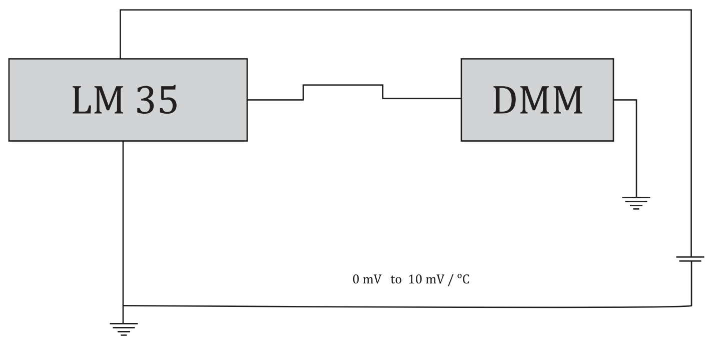
The efficiency of the given solar cell = ____________

Questions

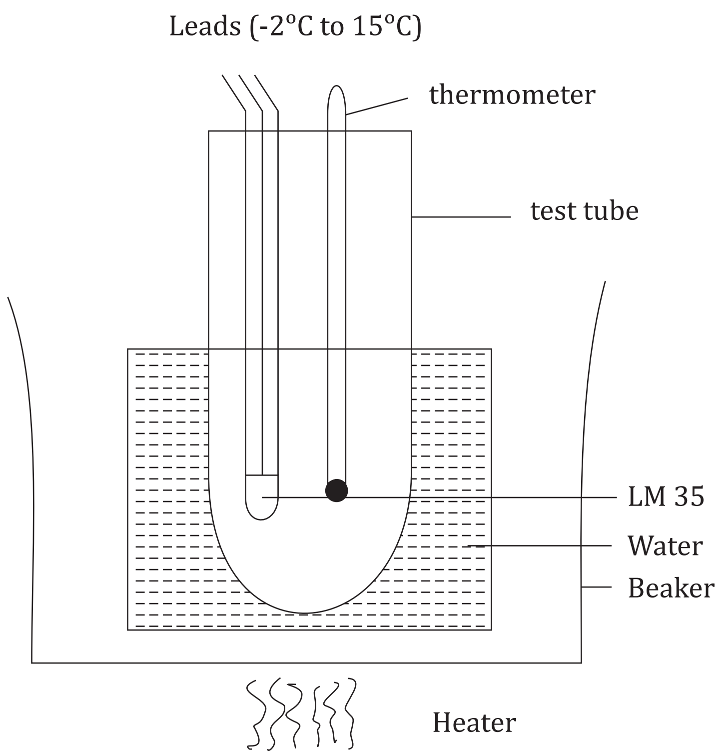
1. What is photo voltaic effect?
2. Define ' efficiency ' and ' quantum efficiency ' as related to solar cell?
3. Explain how a voltage develops in a solar cell?
4. Explain how the open circuit voltage V_{oc} varies with light intensity?
5. Explain how the short circuit current Isc varies with light intensity?

Diagrams





Basic centigrade temperature sensor



14. Measurement of temperature using LM35

Aim:

To determine the temperature of the given sample using LM-35 and to measure the hysteresis in the measurement.

Apparatus

LM-35, 6V DC regulated power supply, Digital Multi meter, Beaker, Test tube, Thermometer.

Formula

$$\text{Hysteresis Em} = \frac{(\text{Tupper} - \text{Tlower})}{2\ \text{Tmid}} \times 100$$

Procedure:

Hysteresis in temperature measurements during thermal equilibrium exist in a system when the temperature is constant.

Measured Temperature T = Output Voltage (V) X 100° C

$$\text{Mid range temperature Tmid} = \frac{\text{Tmax} + \text{Tmin}}{2}$$

Tmax = Boiling point of water from thermometer.
Tmin = 35° C

The percentage of mid range of hysteresis error is X 100

$$\text{Er} = \frac{(\text{Tupper} - \text{Tlower})}{2\ \text{Tmid}} \times 100$$

% mid error is measured.

$$\text{Em} = \frac{(\text{Tupper} - \text{Tlower})}{2\ \text{Tmid}} \times 100$$

Further the system is said to be in internal equilibrium with surrounding of the system. The temperature of the system and surrounding is same. In each such case, there is no net heat flow between the different parts of the system.

Uses of LM 35:

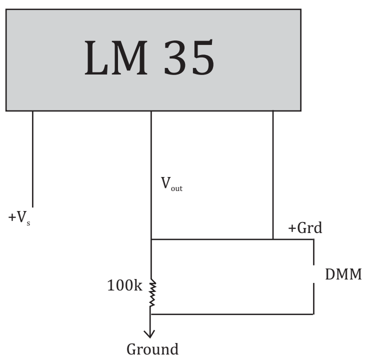
We can measure the temperature which is more accurate than thermistor.
Sensor circuitry is sealed and no subject to oxidation etc.

Procedure:

The connections are made as shown in the figure. The two types of sample are taken in a test tube and melted. The test tube containing the molten sample is in contact with LM35 and he output voltage (Vout) is noted. The variation in Vout for every 30 second is noted and the temperature corresponding to Vout is calculated using the formula and the readings are tabulated.

Table - 1

Heating Cycle			Cooling Cycle		
Thermometer reading	V_{out} in mV	Measured temperature (°C)	Thermometer reading (°C)	V_{out} in mV	Measured temperature (°C)



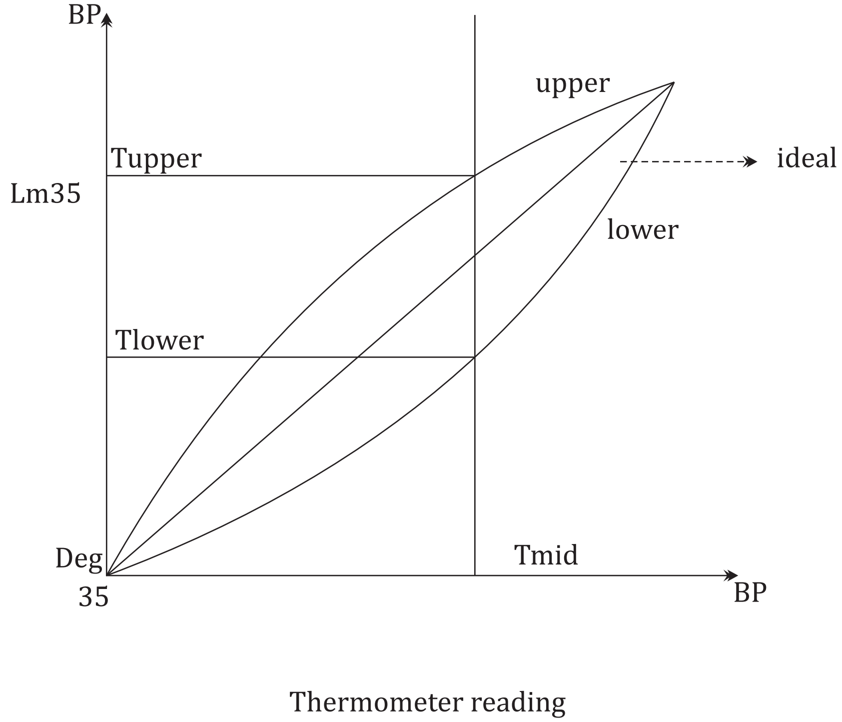
Result:

The mid-range hysteresis error and the mid range error were measured.

Em =

E % =

Model graph



Diagrams

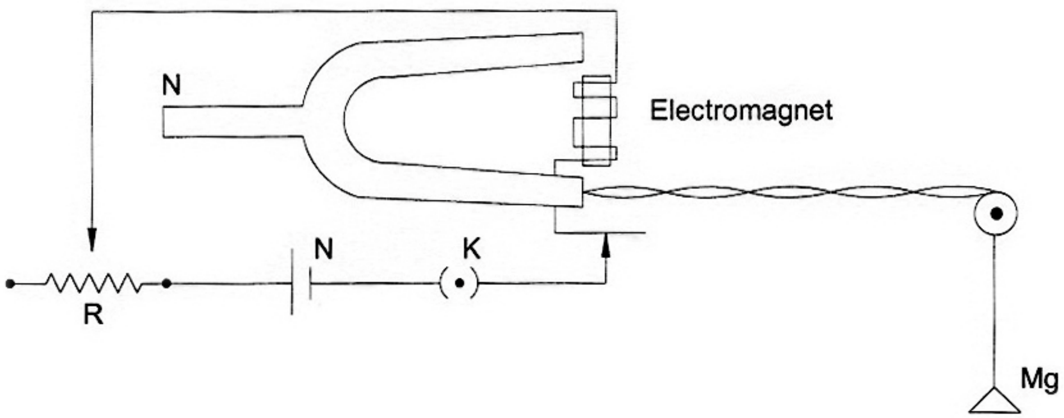


Fig. 1 Melde's Apparatus - Transverse Mode

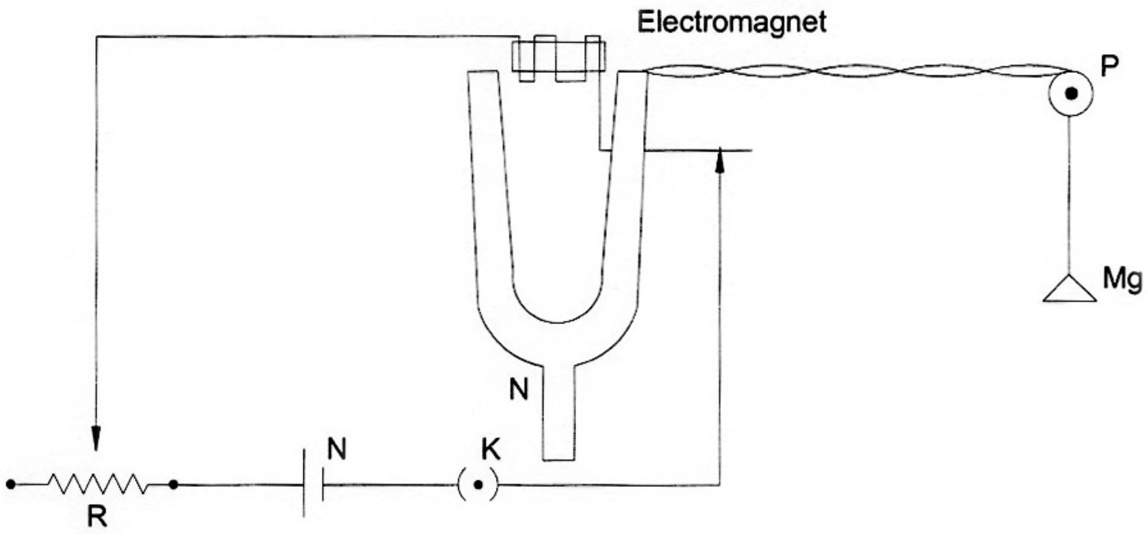


Fig. 2 Melde's Apparatus - Longitudinal Mode

15. Measurement of vibration frequency using Melde's apparatus

Aim

To determine the frequency of the given electrically maintained tuning fork.

Apparatus

Electrically maintained tuning fork, weights string and power supply.

Formula

(i) Frequency of the tuning fork by transverse mode of vibration

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \qquad \text{when} \qquad T = Mg$$

(ii) Frequency of the tuning fork by longitudinal mode of vibration

$$n = \frac{1}{l}\sqrt{\frac{T}{m}} \qquad \text{when} \qquad T = Mg$$

l = length of single loop in meter

M = mass suspended in the string in kg.

m = linear density of the string in kg/m^3

principle

When the electrically maintained tuning fork vibrates, the string attached to it vibrates with a frequency equal to the frequency of the fork in the transverse mode of vibration and twice the frequency of the fork in longitudinal mode of vibration.

Procedure

(i) Transverse mode of vibration of string

Electrically maintained tuning fork is arranged as shown in Fig.1., with the length of the string parallel to the prong of the tuning fork to which one end of the string is attached. The other end of the string passes over a pulley to which a known mass M is suspended. When excited, the fork vibrates in a direction perpendicular to the length of the string.

A mass of about 10g is suspended from the string. The circuit connection is made as shown in the figure. The tuning fork is set into vibration and the fork sets the stretched string to vibrate transversely and hence transverse stationary waves are produced in the string. The length of the string is adjusted so that the string vibrates in certain number of well defined loops. The total length of a definite number of loops is measured. From this, the length of single loop l is calculated. The experiment is repeated for masses 15g ,20g and 25g. The reading are recorded in Table 1. The mean value of $\frac{\sqrt{T}}{l}$ is calculated.

Table - 1

S.No :	Mass Suspended 'M' kg	Tension T = Mg N	No . of loops	Total length of loops m	length of Single loops 'l' m	$\frac{\sqrt{T}}{l}$

Mean =

Table - 2

S.No :	Mass Suspended 'M' kg	Tension T = Mg / N	No . of loops	Total length of loops m	length of Single loop 'l' m	$\frac{\sqrt{T}}{l}$

Mean =

Experimental Physics

The linear density m of the string is calculated by measuring the mass of 10m length of the string.

$$m = \frac{\text{mass of 10m length of string}}{10} \text{ Kg m}^{-1}$$

The frequency of vibration of electrically maintained tuning fork by transverse mode of vibration is calculated using the formula.

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

$$n = \frac{1}{2\sqrt{m}}\left(\frac{\sqrt{T}}{l}\right) \text{ Hz}$$

(i) Longitudinal mode of vibration of string:

Electrically maintained tuning fork is arranged as shown in Fig.2., with the length of the string perpendicular to the fork. The experiment is repeated by suspending masses 2g, 3g and 5g and readings are recorded in Table 2 and the mean value of $\frac{\sqrt{T}}{l}$ is found out.

The frequency of vibration of electrically maintained tuning fork by longitudinal mode of vibration is calculated using the formula.

$$n = \frac{1}{l}\sqrt{\frac{T}{m}} \text{ Hz}$$

$$n = \frac{1}{\sqrt{m}}\left(\frac{\sqrt{T}}{l}\right) \text{ Hz}$$

Result :

The frequency of the tuning fork

(i) By transverse mode of vibration = Hz

(ii) By longitudinal mode of vibration = Hz

Questions :

1. How are the vibrations maintained in an electrically maintained tuning fork?
2. How will you set Melde's apparatus for transverse mode of vibration and longitudinal mode of vibration?
3. What is a stationary wave?
4. What are node and anti-nodes?
5. How will you find the relative density of a solid using Melde's apparatus?
6. On which factors do the frequency of electrically maintained tuning fork depend?

Diagrams

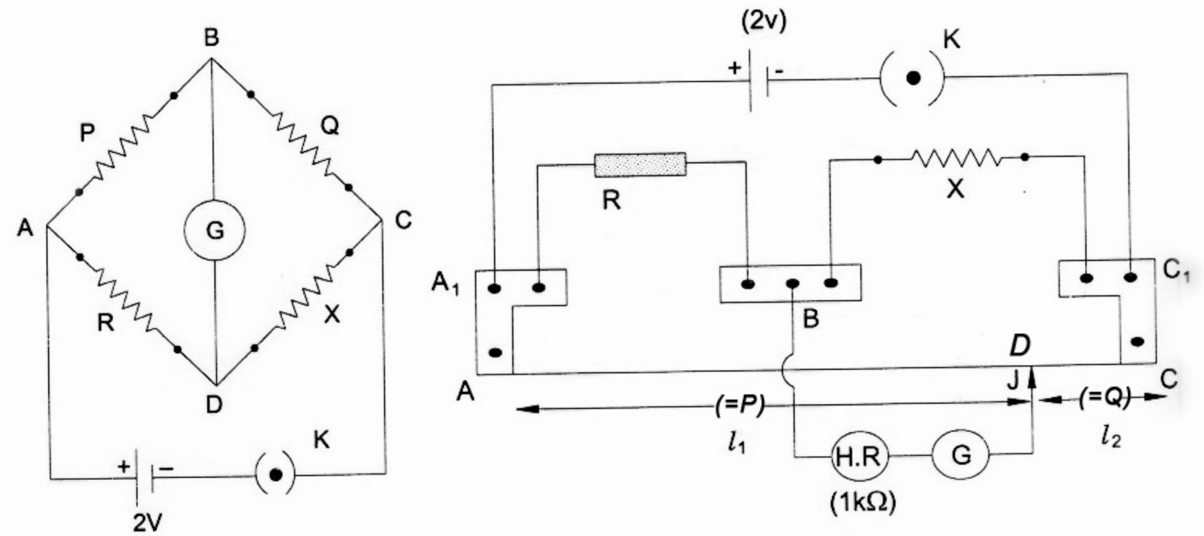


Fig. 1 **Wheatstone's bridge** *Fig. 2* **Metre bridge**

Table - 1

To determine the resistance of copper wire (X) :

S.No :	R (Ω)	l_1 for R (x 10^{-2}m)	l_2 for X (x 10^{-2}m)	X & R interchanged		Average		$X=R\frac{l_2}{l_1}$
				l_1 for R (x 10^{-2}m)	l_2 for X (x 10^{-2}m)	l_1 (x 10^{-2}m)	l_2 (x 10^{-2}m)	

Mean (X) =

16. Determination of thermal conductivity of a metallic material using Wiedemann Franz law

Aim

To determine the thermal conductives of a metallic material (copper / alloy) using wiedemann Franz Law

Apparatus

Metre bridge , metallic material (in the form of uniform wire), standard resistance box, 2V D.C power supply, galvanometer, jockey and plug key

Formula

The thermal conductivity of the given material of the wire

$WM^{-1}K^{-1}$ ....(1)

$\sigma = 1/\rho$ ....(2)

$\rho = X\pi r^2 / l$ ....(3)

where K = Thermal conductivity of the copper (w/mK)

σ = Electrical conductivity of the copper (ohm^{-1} m^{-1})

L = Lorentz Number = 2.23 x 10^{-8} WΩk^{-2}

T = Room temperature (kelvin)

ρ = Electrical Resistivity of the copper (ohm m)

X = Resistance of the given copper (ohm)

r = Radius of the copper wire (metre)

l = length of the copper wire (metre)

Principle

Metre bridge is a simple form of wheatstone's network. and hence works on wheatstone's principle

As per wheatstone's equation , at the point of balance

$$\frac{P}{Q} = \frac{R}{X} \quad .....(4)$$

At null deflection drive balance condition, if P, Q, and R are known, the value of unknown resistance (X) - the copper can be determined. From the resistance of material of the wire and knowing its length and radius the electrical conductivity can be determined. Applying Wiedemann Franz Law the thermal conductivity of the material wire can be determined from its electrical conductivity.

Table - 2

To determine the radius of the Copper Wire (r):
Least count = 0.01mm

Zero error - _______________div
Zero correction = _____________mm

S.No.	Pitch scale Reading $x10^{-3}$ m	Head scale Coincidence (division)	Head scale Reading (HSC x LC) $x10^{-3}$ m	Observation Reading (PSR+HSR) $x10^{-3}$ m	Correct Reading =O.R ± Z.C $x10^{-3}$ m

Experimental Physics

Procedure

A resistance box R is connected in the left gap and unknown resistance X in the right gap. circuit established as in (Fig.2)One portion (AD) of the wire may be used as P and the other portion (DC) as Q. Thus we have four resistances P, Q, R and the X connected in a closed network as in (Fig.2.).

Starting with a known value of resistance in R (say 2 ohms) the bridge is balanced by moving the jockey on the wire so that there is no deflection in the galvanometer. The balancing length l_1 for R and $(100-l_1)= l_2$ for X are determined.

Then $$\frac{R}{X} = \frac{l_1}{l_2}$$

$$X = R\frac{l_2}{l_1} \qquad .....(5)$$

The experiment is repeated for four different values of R. Now R and X are interchanged and again l_1 and l_2 are determined for the same values of R. the observed values are tabulated in table 1. The mean value of X is determined.

The radius of the wire is found with a screw gauge at least of four differing points. The values are tabulated as shown in table2. The length of the wire is determined using a metre scale. Then substitute in equation.3 X, r and l, the specific resistance of the material is determined substitute in equation.2 From resistivity, our conductivity of the material of the wire is found out substitute wiedemann Franz Law K = σLT the thermal conductivity (K) of the material of the wire L & T equation.1. the thermal conductivity of the material is computed.

Result

The thermal conductivity of the given material of the wire = ------------W/mK

Questions

1. Define the terms ' Electrical resistivity ' 'Electrical conductivity' and 'Thermal conductivity' of a metal.
2. State Wiedemann Franz Law.
3. How do you make sure that the connections are current in this experiment?
4. What is the function of High resistance in the circuit used in this experiment?
5. Explain the principle of the metre bridge

Diagram

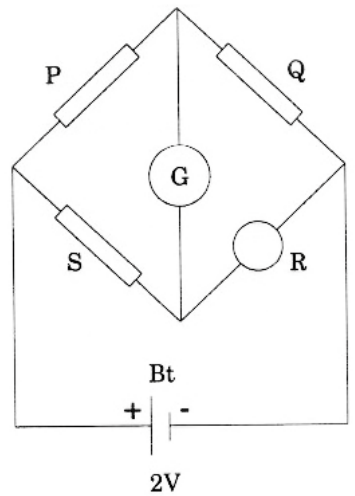


Fig. 1

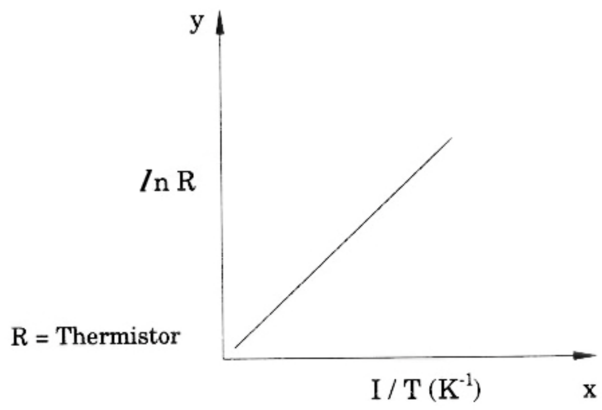


Fig. 2

Table - 1

To determine the resistance of the thermistor at different temperature

S.No :	T (K)	P (ohm)	Q (ohm)	S (ohm)	R = SQ / P (ohm)

17. Thermistor measurement of temperature and band gap

Aim

To determine the band gap of the thermistor material and using thermistor to measure an unknown temperature.

Apparatus

Thermistor, temperature bath , post office Box, Galvanometer, thermometer. connecting wire, D.C power supply,

Formula

Band gap of the thermistor is

Eg = (Slope of ln R vs 1/T graph) 2k (eV)

k = Boltzmann constant (1.380×10^{-23})

T = Absolute temperature (K)

R = Resistance of the thermistor (ohm)

Principle

With an increase in temperature.

$$l\text{n}\,R = l\text{n}\,C + \frac{E_2}{2kT}$$

$$R = C_e\left(\frac{E_g}{2kT}\right)$$

A graph is drawn connecting In R and 1/T

$$l\text{n}K = l\text{n}C + \frac{E_g}{2kT}$$

Procedure

The connections are made as shown in (Fig.1.) The thermistor is connected in one of the arms of the wheatstone's bridge as shown in the figure. The thermistor is enclosed inside a glass tube. and thermometer is inserted inside the tube to measure temperature near the thermistor. The tube is kept immersed in a water bath which can be heated to different temperature. The resistance of thermistor is determined at room temperature and then 5° rise until 70° C. and the readings are recorded in table 1 and 2.

A graph is drawn between R versus 1/T. It will be a straight line ass shown in (Fig.2). The slope of the straight line is determined. And substitute in equation (2) the band gap is calculated. Energy value will be in joules. This is converted into electron volts by dividing it by 1.6×10^{-19}

(Fig.2) is also called calibration graph, which could be used to measure unknown temperature. The thermistor is placed in the bath whose temperature is to be measured and the corresponding resistance is measured. From the calibration graph, the unknown temperature can be determined.

Table - 2

S.No :	T (K)	1/T (K^{-1})	R (ohm)	lnR

Result

i) . The band gap of thermistor material -------------------e V.
ii). Temperature calibration graph is determined & unknown temperature is determined.

Questions

1. What is a thermistor?
2. What is a bolometer?
3. What are the uses of thermistor?
4. What are the materials used for making thermistor?
5. How does the electrical conductivity of a semiconductor vary with temperature?

Circuit Diagram

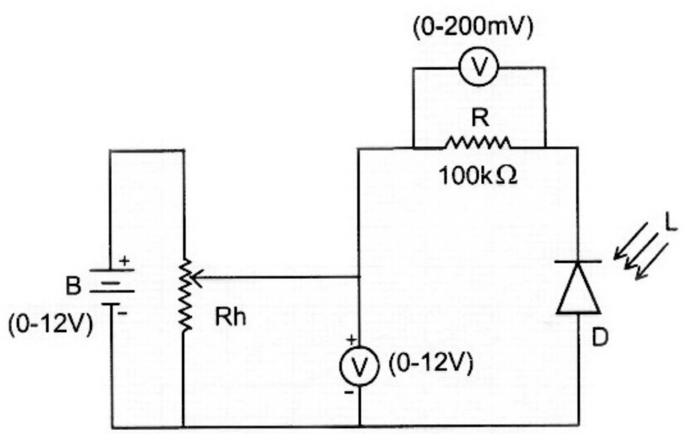


Fig. 1

Model Graph

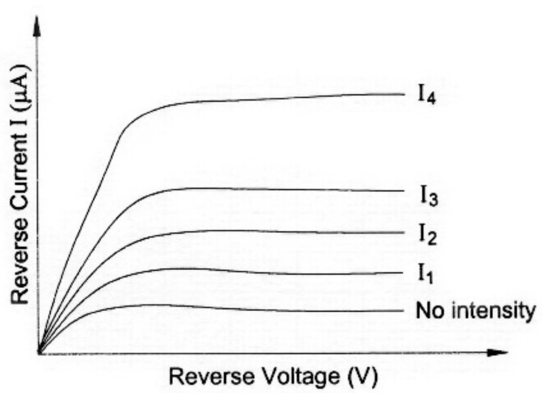


Fig. 2

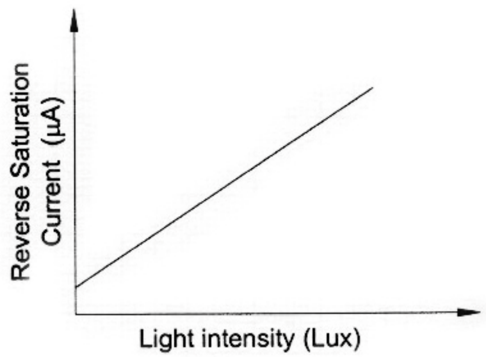


Fig. 3

18. Study of characteristics of Photo diode

Aim

To determine the characteristics of the given photo diode.

Apparatus Required

Photo diode, 100 KΩ resistor, Voltmeter (0-200 mV) (0-12V), 12 V battery, rheostat, key, Lux meter, scale, 40W table lamp and connecting wires.

Procedure

The connections are made as shown in the circuit diagram (Fig. 1). The light source is placed 5 cm away from the photo diode, the intensity is measured in Luxmeter. Now, 0.5V is kept I the voltmeter and the corresponding current is calculated by measuring the voltage across the know resistance noted. Now the voltage is increased to 1.0, 1.5, 2.0, 2.5, ...10V and the corresponding current reading is tabulated (Table 1) .

Similar procedure is followed for distance of source places at 10, 15, 20 cm an for no intensity. The result obtained is plotted I n the graph of reverse voltage Vs reverse current (Fig. 2) and a second graph of light intensity Vs reverse saturation current (Fig, 3).

Using the graph, the characteristics of the photo diode are studied.

Graph - I

Reverse voltage vs Reverse current.

Graph - II

Reverse saturation Current (I_s) vs Light Intensity (Lux)

x - axis-----> Light Intensity

y - axis-----> Reverse saturation current.

Result

The characteristics of the given photo diode were studied using the graphs drawn,

i, Reverse voltage vs Reverse current

ii, Light intensity vs Reverse Saturation Current.

Table - 1

Observation

To determine the reverse saturation current at different voltages

S.No :	Voltage (V) Volt	Reverse Saturation Current (A)				
		___________Lux	___________Lux	___________Lux	___________Lux	No intensity

Experimental Physics

Questions

1. What are the similarities and differences between a photo diode and photo voltaic cell ?
2. What are the applications of a photo diode?
3. What are the differences between LED and photo diode?
4. What are the differences between photo diode and photo transistor?

Diagram

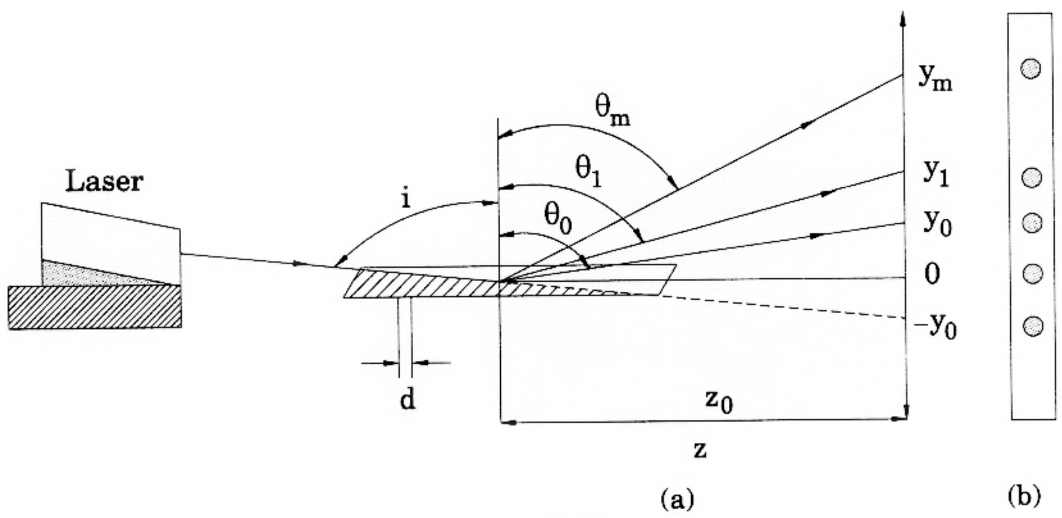


Fig. 1

Table - 1

Observation

Distance between the screen and the caliper Z_0=

Order	Position of the spot from O : Y_m cm	Y^2m	Y^2m -Y^2o	(Y^2m -Y^2o) / m

19. Determination of Wave length of He-Ne laser using reflection grating

Aim

To measure the wavelength of He-Ne laser beam.

Apparatus

He-Ne laser, Photo multiplier tube, sharp knife edge, Micro - positioner.

Wavelength of HE-Ne Laser-Reflection grating

The steel vernier calipers with close engravings acts as a reflection grating for a coherent laser source. The vernier caliper is placed on a horizontal table, and the laser is alight such that the un expanded beam is incident at the grazing angle ($i=87^0$) on the scale as shown in Fig.1(a).

The diffraction pattern is observed at a distance of 3-4 meter from the scale. The beam can be aligned so that the diffraction pattern is at its best as shown in Fig.1 (b). The pattern arises due to the diffraction at the engraving on the scale and is governed by the grating equation

$$d(\sin i - \sin \Theta_m) = m\lambda \qquad .....(1)$$

Where i is angle of incidence

Θ_m is the angle of incidence

d is the grating constant (equal to the least count of the Vernier Scale)

m is the order

The wavelength of the light is given by

$$\lambda = \frac{d}{2z_0^2}\left(\frac{Y_m^2 - Y_0^2}{m}\right) \qquad .....(2)$$

The distance are measured from the horizontal plane. The intersection of the plane of the grating with the screen lies halfway between the stops of the direct beam (at-Y_0) and the zero order diffracted beam which is specularly reflected (at Y_0). Z_0 is the distance between the vernier and the screen. (Fig.1a)

Procedure

The laser is mounted on an inclined platform, which can be adjusted with leveling screws. The vernier caliper is placed on a rotatable mount. The height of the platform is adjusted so that the laser light falls at a grazing ($i=87^0$). This can be done using the three levelling screws provided at the bottom of the platform. The diffraction is observed at a distance 3-4 meters away from the calipers. The position of the various order and the direct spot are market on the screen . The laser is switched off and the distance of the spots from the intersection point 'O' are measured fig.1(b). Also between the screen and the calipers Z_0 is noted. The least count of the scale gives d. The wave length is calculated using equation (2).

Result

Wavelength of the Laser = nm

Fundamental physical constants

Avagadro's number	N = 6.022045 x 10-23 molecules / mol
Boltzmann's constant	K = R/N = 1.380662 x 10-23J/K
Electric permittivity of evacuated free space	ε_0 = 8.85418782 x 10-12F /m or C2 J-1 m-1
Electron charge mass ratio	$^e/m^e$ = 1.7588047 x 1011 c/kg
Elementary charge	^{e} = 1.6021892 x 10-19 C
Faraday constant	F = Ne = 9.648456 x 104 C /mole
Gravitational constant	G = 6.672 x 10-11N.m2/kg2
Magnetic permeability	μ = 4π x 10-7 H/m -12.5663706 x 10-7 Wb / A.m
Normal acceleration due to gravity	g= 9.80665 m/s2 = 9.81 m / s2
Normal atmospheric pressure	P = 1.0129 x 105 N/m2
One Atomic mass unit	1 a.m.u = 1.6605655 x 10-27 kg
Plank's constant	h = 6.622176 x 10-34 j.s.
Rest mass of electron	m^e = 9.106534 x 10-31 kg
Rest mass of neutron	mn = 1.6749543 x10-27kg
Rest mass of proton	mp = 1.6726485 x 10-27 kg
Rydberg constant	Rα = 10.973,731 m-1
Solar constant	= 1370W/m2
Stefan-Boltzman constant	σ = 5.67032 x 10-8 Wm-2 . k-4
Universal gas constant	R = 8.31 J/mole/ k
Velocity of light in vacuum	C = 2.997958 x 108 m/s = 3 x 108 m/s
Volume of one mole of ideal gas at NTP	V = 22.41383 x 10-3m3/mole
Wien's constant	= 0.00289782 m.k.

Densities of Substances

Substance	Density in kg /m^2	Substance	Density in kg /m^2
Aluminium	2.7×10^3	Germannium	5.32×10^3
Aluminium chloride	1.5×10^3	Glass	2.5×10^3
Brass	8.5×10^3	Gold	1.93×10^4
Brick	1.8×10^3	Graphic	2.1×10^3
Coal	1.4×10^3	Ice (0°C)	0.9×10^3
Constantan	8.9×10^3	Iridium	2.24×10^4
Copper	8.9×10^3	Iron, cast iron	7.4×10^3
Copper sulphate	2.2×10^3	Iron, steel	7.8×10^3
Cork	2.4×10^2	Lead	1.14×10^4
Diamond	3.5×10^3	Magnanim	8.5×10^3
Ebonite	1.2×10^3		

INTRODUTION

Substance	Density in kg /m^3	Substance	Density in kg /m^3
Mico	2.8 x 103	Salt common	2.1×10^3
Nicrome	8.3 x 103	Silver	1.05×10^4
Nickel	8.9 x 103	Tin	7.3×10^3
Nickeline	8.8 x 103	Tungsten	1.93×10^3
Paraffin	9.0 x 102	Uranium	1.87×10^4
Platinum	9.28 x 103	Zine	7.1×10^3
Porcelain	2.3 x 103		

LIQUIDS AT 20ºC

Alcohol ethy1	7.9 x 103	Oil, Mineral	9.2 x 103
Benzene	9 x 102	Oil, Olive	9.2 x 102
Glycerin	1.20 x 102	Petrol	7.0 x 102
Kerosene	8.0 x 102	Trpentine	8.7 x 102
Mercury at 0oC	1.36 x 104	Water at 227 K	1.0 x 103
Nitrobenzene	1.2 x 103	Water at 373 K	0.958 x 103

GASES AT N.T.P.

Acetylene	1.17	Hydrogen	0.09
Air	1.29	Krypton	3.74
Ammonia	0.77	Methane	0.72
Argon	1.78	Neon	0.90
Carbon dioxide	1.98	Nitrogen	1.25
Chlorine	3.21	Oxygen	1.43
Helium	0.18	Xenon	5.85

GASES AT N.T.P.

Substance	Young's modulus 10^{10} N/m^2	Rigidity – n 10^{10} N/m^2	Bulk modulus k 10^{10} N/m^2	Poisson's Ratio
Aluminium	7.2 - 7.5	2.5 - 3.4	7.46	0.84
Brass	9.7 - 10.1	3.5	10.6	0.34 - 0.40
Copper	10.5 - 12.5	3.5 - 4.5	14.3	0.26
Glass	5.1 - 7.1	3.1	3.75	0.13 - 0.32
Iron(cast)	10 - 13	3.5-5.3	9.6	0.23 - 0.31
Lead	1.6	5.6	5	-
Rubber	.00015 - .0005	0.00005	-	0.46 - 0.40
Silver	7.1	2.5	10.9	-
Steel	20.9	8.12	16.4	0.29

Coefficient of Linear Expansion of Solids

Substance	α in K^{-1}	Substance	α in K^{-1}
Aluminium	2.3×10^{-5}	Iron Steel	1.2×10^{-5}
Brass	1.9×10^{-5}	Lead	2.9×10^{-5}
Cast iron	1.8×10^{-5}	Nickel	1.28×10^{-5}
Copper	1.7×10^{-5}	Platinum	$9. \times 10^{-5}$
Ebonite	7.0×10^{-5}	Tin	2.1×10^{-5}
Glass	9.0×10^{-6}	Tungsten	4.0×10^{-5}
Gold	1.4×10^{-5}	Zinc	2.9×10^{-5}
Invar	6×10^{-7}		

Coefficient of volume Expansion of Liquids

Substance	β In K^{-1}	Substance	β In K^{-1}
Aceton	1.2×10^{-3}	Petrol	1.0×10^{-3}
Alcohol-ethyal	1.1×10^{-3}	Pelroleum	1.0×10^{-3}
Ethylether	1.6×10^{-3}	Suphuric acid	5.7×10^{-4}
Glycerin	5.0×10^{-4}	Transformer oil	6.0×10^{-4}
Kerosene	1.0×10^{-3}	Water (10-20oC)	1.5×10^{-4}
Mercury	1.8×10^{-4}		

Surface Tension (at 293 K)

Substance	T in N/m	Substance	T in N/m
Aceton	0.024	Kerosene	0.024
Alcohol-ethyal	0.022	Mercury	0.470
Castor oil	0.033	Petrol	0.029
Ethylether	0.017	Turpentine	0.027
Glycerin	0.059	Water	0.072

Specific heats

Substance		C in (J/kg-K)	
SOLIDS			
Aluminium	880	Copper	380
Brass	380	Glass	840
Brick	750	Gold	125
Cement	750	Ice	2090
Concrete	880		
LIQUIDS			
Iron(cast)	55	Silver	250
Iron steel	460	Sulphur	712
Lead	120	Tin	250
Naphthalene	1300	Zinc	400
Paraffin	3200	Wood	2700
Platinum	125	Alcohol ethyl	2430
Sand	970	Glycerin	2430

LIQUIDS			
Iron	830	Oil transformer	2093
Kerosene	2140	Sauphate	2330
Mercury	125	Water	4187
Oil machine	2100		
GASES (at constant pressure)			
Air	1000	Hydrogen	14300
Ammonia	2100	Nitrigen	1000
Carbon dioxide	830	Oxygen	920
Helium	5200	Water vopour	220

INTRODUCTION

Dielectric Constants

Substance	Relative Permittivity -no nuits	Substance	Relative Permittivity -no nuits
Air (at 1 atm)	1.0006	Kerosene	2.0
Air (at 100 atm)	1.055	Paraffin	2.2
Amber	2.8	Paraffined paper	2.0
Aniline	84.0	Petrol	2.3
Ebonite	2.7	Porcelain	4.7
Glycerin	39	Vacuum	1
Hydrogen	1.0003	Wax	5.8
Ice (at -18oC)	3.2	Water	81.0

Specific Resistance

Substance	S in Ω - m	Substance	S in Ω - m
Aluminium	2.7×10^{-8}	Mercury	9.54×10^{-7}
Brass	6.3×10^{-8}	Nichrome	1.05×10^{-6}
Constantan	4.7×10^{-7}	Nickel	7.3×10^{-8}
Copper	1.60×10^{-8}	Platinum	1.05×10^{-7}
Gold	2.2×10^{-8}	Silver	1.58×10^{-8}
Iron	9.9×10^{-8}	Tin	1.13×10^{-7}
Lead	2.07×10^{-7}	Tungsten	5.3×10^{-8}
Magnanin	3.9×10^{-7}	Zinc	5.95×10^{-8}

Temperature Coefficents of Resistance

Substance	α In k^{-1}	Substance	α In k^{-1}
Constantan	0.000005	Nickeline	0.0001
Magnanin	0.000008	Rheotan	0.0004
Nichrome	0.0002	Tungsten	0.00050

Electrochemical

Substance	Z in kg/C	Substance	Z in kg/C
Aluminium	9.32×10^{-8}	Magnesium	1.26×10^{-7}
Clacium	2.077×10^{-7}	Nickel	3.04×10^{-7}
Chlorine	3.67×10^{-7}	Oxygen	8.29×10^{-8}
Copper	3.294×10^{-7}	Potssium	4.052×10^{-7}
Gold	6.81×10^{-7}	Silver	1.118×10^{-6}
Hydrogen	1.044×10^{-8}	Sodium	2.383×10^{-7}
Lead	1.074×10^{-8}	Zinc	3.388×10^{-7}
Mercury	2.072×10^{-6}		

Refractive Indices

Substance	μ	Substance	μ
Alcohol ethyl	1.36	Quartz	1.54
Alcohol methyl	1.33	Salt (Rock)	1.54
Acetone	1.36	Sugar	1.56
Air	1.0003	Turpentine	1.51
Aniline	1.59	Water	1.33
Carbon bisulphide	1.63		
Carbon tetrachloride	1.46		
Diamond	2.42		
Glass (crown glass)	1.5		
Glycerin	1.47		
Ice	1.31		
Petrol	1.5		

OBJECTIVE TYPE QUESTIONS

1. Write the S.No of the dimensional formula against the physical quantities listed below :

Q.No.	Listed physical Quantities	S.No.	Dimensional Formula	Q.No.	Ans.
1.	Area	1.	L^1MT^{-2}	1.	(5)
2.	Volume	2.	$L^0M^0T^0$	2.	(14)
3.	Density	3.	$L^0M^0T^{-2}$	3.	(15)
4.	Specific gravity	4.	L^{-1}	4.	(2)
5.	Velocity	5.	L^2	5.	(6)
6.	Acceleration	6.	LT^{-1}	6.	(16)
7.	Momentum	7.	L^0MT^{-2}	7.	(13)
8.	Force	8.	L^2MT^{-1}	8.	(12)
9.	Work-Energy	9.	L^2MT^{-3}	9.	(11)
10.	Impulse	10.	L^2M	10.	(13)
11.	Power	11.	L^2MT^{-2}	11.	(9)
12.	Pressure	12.	LMT^{-2}	12.	(1)
13.	Stress	13.	LMT^{-1}	13.	(1)
14.	Strain	14.	L^3	14.	(2)
15.	Modulus of elasticity	15.	ML^{-3}	15.	(2)
16.	Torque	16.	LT^{-2}	16.	(20)
17.	Angular displacement	17.	$L^{-1}MT^{-2}$	17.	(2)
18.	Angular velocity	18.	$L^{-1}MT^{-1}$	18.	(2)
19.	Angular acceleration	19.	$L^3M^{-1}T^{-2}$	19.	(3)
20.	Frequency	20.	L^2MT^{-2}	20.	(21)
21.	Radius of gyration	21.	$L^0M^0T^{-2}$	21.	(4)