Std. 12th

PHYSICS

PRACTICAL HANDBOOK

Instruction for Students :

1. L.H.S. means Left Hand Side (Blank page of practical record) and R.H.S. means Right Hand Side (line page of practical record)

2. L.H.S. page of each and every experiment should be written by pencil only.

3. R.H.S. page of each and every experiment should be written by blue/black pen.

4. Diagrams should be drawn neatly and should be properly labelled.

5. Graphs will be drawn on separate graph paper after noting observations on performing experiment.

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Experiment No. 1

Young's Modulus

Aim : To determine Young's Modulus (Y) of elasticity of the material of a given wire by Searle's method.

Apparatus : Searle's apparatus, two long identical wires of the same material and diameter, micrometer screw gauge, slotted weights, meter scale, etc. 7

Accuracy : Length of wire L is 2 to 3 m. Therefore, it can be measured correct up to mm using meter rod. Extension is measured with the help of micrometer screw correct up to (1/100)th of mm. Radius of wire appears as square of r which itself is a fraction of mm; therefore r should be measured very accurately with a fine micrometer of screw guage. It should be measured at a number of places or along with the length of the wire and average value should be taken.

Formula :

$$Y = \frac{MgL}{\pi r^{2} e} = \frac{gL}{\pi r^{2}} \frac{1}{(slope)}$$ [Slope of the graph of 'e' against 'M']

where, Y = Young's Modulus of the material of the wire.
M = Mass suspended to the experimental wire
g = Acceleration due to gravity = 980 cm/s^2
L = Original length of the experimental wire.
r = Radius of the experimental wire.
e = Elongation produced in wire by mass M
$\pi = 3.14$

Diagram :-

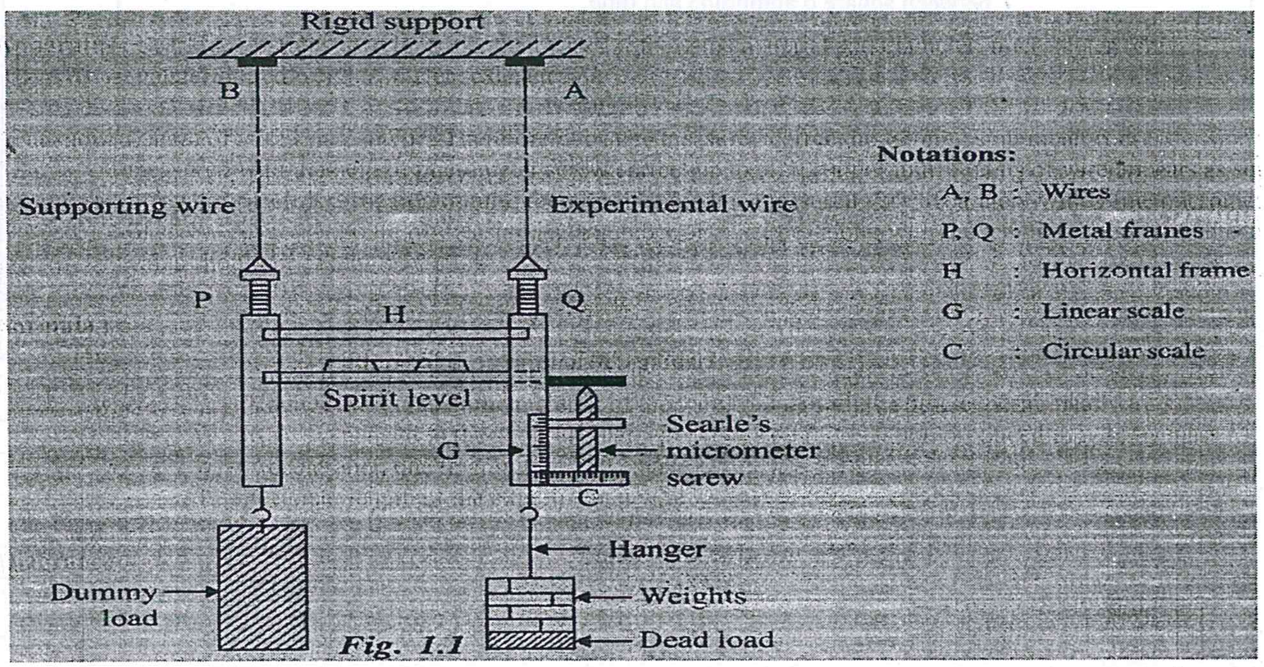

Fig. 1.1

Observations:

1) Original length of experimental wire. 'A' , L =............................ cm
2) **L.C. of micrometer screw:**
   i) Distance covered by the screw in 5 rotations on the linear scale, S =............. cm ii) Pitch of the screw, p $= \frac{S}{5} =$ .... cm
   iii) Number of divisions on the circular scale, n =............................. cm
   iv) Least count $= \frac{p}{n}$ = ... cm
3) Zero error = ...cm, Zero error correction = ... cm

Experiment No. 1

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Formula :

$$Y = \frac{MgL}{\pi r^{2e}} = \frac{gL}{\pi r^2}\frac{1}{(slope)} \text{[Slope of the graph of 'e' against 'M']}$$

where, Y = Young's Modulus of the material of the wire.
M = Mass suspended to the experimental wire
g = Acceleration due to gravity = 980 cm/s^2
L = Original length of the experimental wire.
r = Radius of the experimental wire.
e = Elongation produced in wire by mass M.
$\pi = 3.14$

Procedure:

1) Arrange the experimental set up as shown in Fig. 1.1. Attach dummy load and dead load (i.e. slotted hanger itself) to the frames of the supporting wire and experimental wire respectively so that the wires become free of kinks and remain vertically straight.
2) Adjust the spirit level so that the air bubble is at the centre.
3) Using meter scale measure the length L, of the experimental wire A from the point of support to the point fixed to the frame.
4) Using micrometer screw gauge measure the diameter of wire A at 3 different places. At each place measure the diameter in positions at right angles to each other. This is necessary to reduce error due to non uniformity of the wire.
5) Find the least count of micrometer screw gauge of Searel's apparatus and adjust it to bring the air bubble in the spirit level at the centre. Note the main scale and circular scale reading of Searle's micrometer screw gauge (spherometer). This is the reading for zero load.
6) Add a half kg-wt to the experimental wire A and wait for about one minute as the increase in length of the wire occurs rather slowly. Rotate the screw so that the air bubble in the spirit level is brought at the centre. The micrometer screw head should be rotated in one direction only to avoid error due to backlash.
7) Repeat the procedure described above by adding $^1/_2$ kg-wt to the hanger each time. Take six readings. Take care not to cross the elastic limit.
8) Suspend unknown load (M_x), if not available, treat one of the knowns as unknown load an as usual rotate the screw to bring the air bubble in the spirit level at the centre and take down the reading.
9) Take the readings for unloading. Decrease the load in steps of half kg-wt and wait for or minute. Rotate the screw in opposite direction so that the air bubble in the spirit level brought at the centre. Note the corresponding readings for a given load. Find the mean of two readings corresponding to loading and unloading.
10) Find the elongation `e' produced in the wire for different loads.
11) Plot a graph of extension (e) on Y-axis against load (M) on X-axis. Obtain slope of the graph and by using formula, find the value of Y. Also determine unknown mass from the graph.

Result:

1) Radius of the wire, r = ... cm
2) Mean elongation for 1000 gram wt., e' = ... cm
3) Young's modulus of the material of the given wire,
   (i) By calculation:
   Y = ...dynes/cm^2 = ...× 10^{-1} N/m^2
   (ii) By graph:
   Y = ... dynes/cm^2 =................ × 10^{-1} N/m^2
4) Unknown mass, M_x = ... g (by calculation)
   = ...g (by graph)

Observation Table :-

(A) For Diameter of the wire :-

Obs. No.	M.S.R. 'a' cm	C.S.D. 'b' div	C.S.R. cm (b×L.C)	Total reading cm [a+(b×L.C)]	Corrected reading cm	Mean diameter D (cm)
1.						
2.						
3.						

∴ Mean radius, $r = \frac{D}{2}$ = ...cm.

(B) For elongation of the wire :

L.C. of Searle's spherometer :

1) No of rotations given to circular scale (C.S.) either clockwise or anticlockwise = 5.
2) Distance travelled by the C.S. on the erect scale or linear scale in 5 rotations , X= ....cm
3) No. of divisions on the circular scale = N = ...
4) Pitch of the spherometer $p = \frac{X}{5}$ = ...cm
5) L.C. of the spherometer $= \frac{P}{N}$ = ...cm

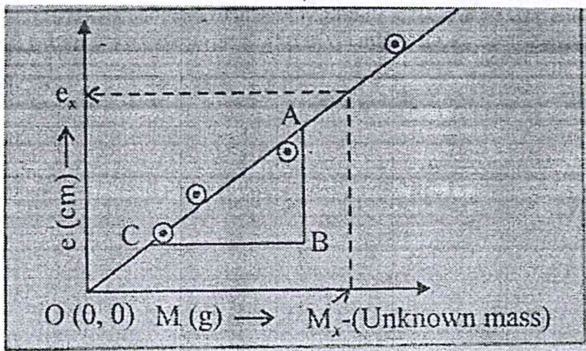
Obs. No.	Load M gm-wt	Loading M.S.R x cm	Loading C.S.R. y cm	Loading Total reading (x+y) cm	Unloading M.S.R. x' cm	Unloading C.S.R.y' cm	Unloading Total reading (x'+y') cm	Mean reading 'a' cm	Elongation for each load 'e' cm	Elongation for 1000 gm. 'e' cm
1.	0							a_0=..........	-----	-----
2.	500							a_1=	$a_1 - a_0$=	----
3.	1000							a_2=	$a_2 - a_0$=	$a_2 - a_0$= ....
4.	1500							a_3=	$a_3 - a_0$=	$a_3 - a_1$= ....
5.	2000							a_4=	$a_4 - a_0$=	$a_4 - a_2$= ....
6.	2500							a_5=	$a_5 - a_0$=	$a_5 - a_3$= ....
7.	Unknown							a_x=	$a_x - a_0 = e_x$ =........	-----

Mean elongation e =..............cm

Mean elongation for M'= 1000 gm, e' =......cm

Graph :-

Plot a graph of extension (e) on Y-axis against the load (M) on the X-axis with (0,0) origin



Scale:

For X-axis: ....

For Y-axis: ....

∴ Slope $= \frac{e}{M} = \frac{\text{AB (read on scale)}}{\text{BC (read on scale)}}$

= ....

Unknown mass, M_x = ... g

Fig. 1.2

Precautions :

1) Accurate measure of radius is to be taken.
2) Add weights to the hanger gently.
3) Turn the micrometer screw in one direction only while loading and unloading the experimental wire to avoid backlash error.
4) During loading and unloading wait for sufficient time so that full extension or contraction produced in the wire.
5) Dead load remains same throughout the experiment.
6) Take the readings only after adjusting the spirit level.
7) Total load should not be more than half the breaking strength of the wire.

Calculation :-

1) Young's modulus of the material of the wire :

(i) By Calculation,

$$Y = \frac{M g L}{\pi r^2 e} = \frac{g L}{\pi r^2} \times \left(\frac{M'}{e'}\right) = \frac{980 \times L}{\pi r^2}\left(\frac{1000}{Mean\ elongation\ for\ 1000\ gm.Wt.}\right) = \text{..............dynes/cm}^2$$

=

=

(ii) By Graph,

$$Y = \frac{M g L}{\pi r^2 e} = \frac{g L}{\pi r^2} \times \frac{1}{(Slope)} = \frac{980 \times L}{\pi r^2}\frac{1}{(Slope)} = \text{..............dynes/cm}^2$$

=

=

2) For unknown load (mass) :

Unknown mass $M_x = \frac{M'}{e'} \times e_x$

$$= \left(\frac{1000}{Mean\ elongation\ for\ 1000\ gm.wt.}\right) \times e_x = \text{...................... g}$$

Result:

1) Radius of the wire, r = ... cm
2) Mean elongation for 1000 gram wt., e' = ... cm
3) Young's modulus of the material of the given wire,
   (i) By calculation:
   Y = ...dynes/cm^2 = ...$\times 10^{-1}$ N/m^2
   (ii) By graph:
   Y = ... dynes/cm^2 =.................. $\times 10^{-1}$ N/m^2
4) Unknown mass, M_x = ... g (by calculation)
   = ...g (by graph)

R.H.S.

Experiment No. 2

Spring – Mass Oscillator

Aim : To find force constant and effective mass of a helical spring by plotting T^2 against m graph using method of oscillations.

Apparatus : Light spiral spring with clamping arrangement and attached pointer, meter scale, light pan, weight box, stop-watch, etc.

Formulae :

(1) $F = -kx$ where, F = restoring force
i.e. $(m-M)g = -kx$ x = extension in the spring
k = force constant

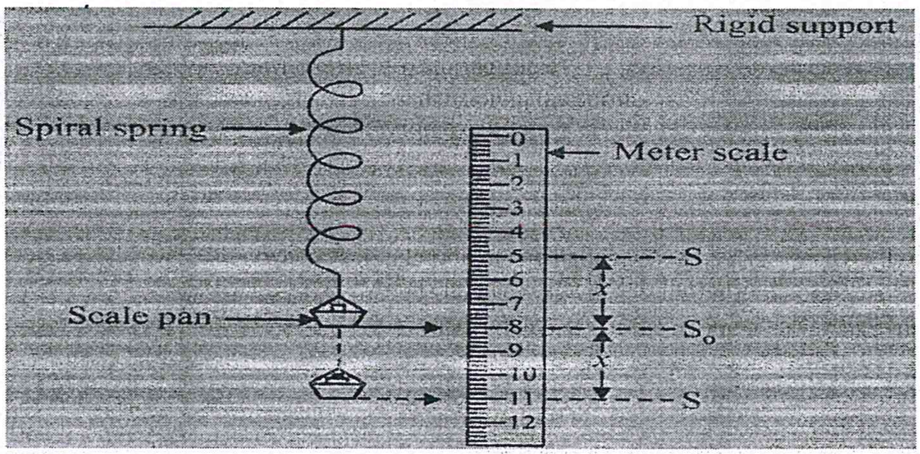
(2) $T = 2\pi\sqrt{\frac{M_1+(m_s/3)}{k}}$

where, T = Period of oscillation, k = Force constant
M_1 = Total mass attached to the spring
$\left(\frac{m_s}{3}\right)$ = Effective mass of the spring , m_s = mass of the spring

(3) $K = \frac{4\pi^2\left(M_1+\frac{m_s}{3}\right)}{T^2}$

(4) $k = \frac{4\pi^2}{slope}$ (Graph of T^2 against m)

Diagram :-



Observation :

(1) L.C. of vertical scale =.........................cm
(2) Mass of the scale pan, m_0....................gm
(3) Position of the pointer when the spring is stretched to about three times the upstretched length (S_0) = ...cm
(4) Mass attached for position S_0 is M =.................. + m_0 = ... g.
(5) Acceleration due to gravity g = 980 cm/s^2

Observations Table: Part A : For extenstion (x) :

Obs. No.	Total mass attached (m)g	F =(m−M)g g.wt	Position of the pointer 'S' cm	Extension X=(S_0-S)cm
1.	M + 150			
2.	M + 100			
3.	M + 50			
4.	M±.....	0	S_0 = ...	0
5.	M−50			
6.	M--100			
7.	M−150			

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where, T = Period of oscillation, k = Force constant
M_1= Total mass attached to the spring
$\left(\frac{m_s}{3}\right)$ = Effective mass of the spring, m_s = mass of the spring

(3) $K = \frac{4\pi^2\left(M_1+\frac{m_s}{3}\right)}{T^2}$

(4) $k = \frac{4\pi^2}{slope}$ (Graph of T^2 against m)

Procedure :

Part A : To determine force constant (k) :

(1) Find the mass of empty scale pan (m_0).
(2) Clamp the given helical spring to a rigid support and attach a scale pan with pointer to its lower end.
(3) Add suitable mass to the scale pan so that the spring is stretched to about three times of the upstretched length.
(4) Note the total mass attached to the spring (M) = m_0 + ... and also note the corresponding reading of pointer call it as S_0 i.e. mean position.
(5) Add 50 g weight in the scale pan and note the position of the of the pointer. Record the reading on the scale on the scale say 'S'. Repeat the procedure twice for 100 g and 150 g weights (Here total mass (m) attached is more than M).
(6) Remove the weights from scale pan and bring the pointer to its original position (S_0). Take three reading for three values of total mass attached to the spring (m) less than M.
(7) Determine the extension in each case.
$x=(S_0-S)$ cm.
(8) Plot the graph of F against x (Fig. 2.2) and determine the slope which is force constant (k)

Part – B : To determine the effective mass of spring :

(1) Suspend a light pan from the lower end of the spring. Note down its mass as m_0 and put a weight of suitable mass M in the pan in such a way that spring is stretched to about three times that of unstretched length under its own weight.
(2) Add suitable mass (m) to a spring and give small oscillations and note the time (t) required for 20 oscillations.
(3) Find the period of oscillation, T= t/20 and hence T^2 in each case.
(4) Repeat the same procedure for five more readings by increasing the mass in the pan by 20 gm.
(5) Plot a graph of T^2 versus total mass (M_1) and find the slope . From the slope find the force constant (k).
(6) Graph will intercept on X-axis (Fig.2.3). Find the point of intercept and calculate the mass of spring .

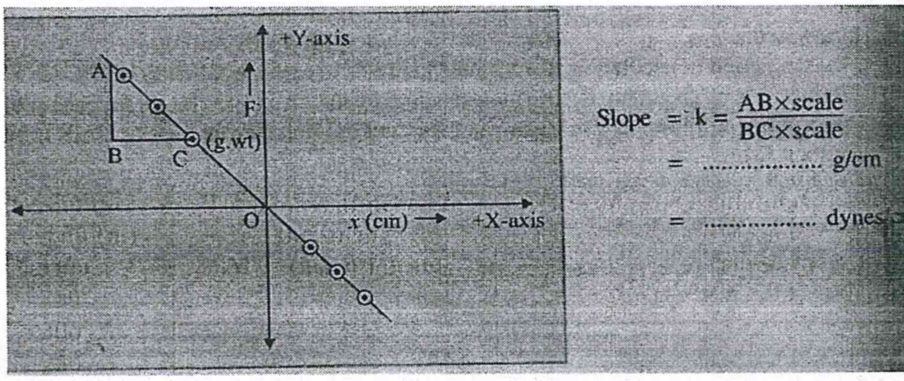
Result :

(1) Force constant (k) by graph (1) i.e. from fig 2.2 = ... dynes/cm
(2) Force constant (k) by graph (2) i.e. from fig 2.2 = ... dynes/cm
(3) Mass of given spring m_s = ... g.
(4) Effective mass of the spring = $\frac{m_s}{3}$ =.................... g

Obs. No.	Mass in the scale pan (m) gram	Total mass attached to the spring $M_1 = (m_0+m)$ gram	Time for 20 Oscillations			Period T=t/20 sec	T^2 Sec^2
			t_1 sec	t_2 sec	Mean t sec		
1.	350						
2.	300						
3.	250						
4.	200						
5.	150						
6.	100						

Graph :

(1) Plot a graph of F (on Y-axis) against extension x (on X-axis) and find the slope.



(2) Plot a graph of T^2 (on Y-axis) against M_1 (on X-axis) and find the intercept on X-axis. Also find the slope of the graph.

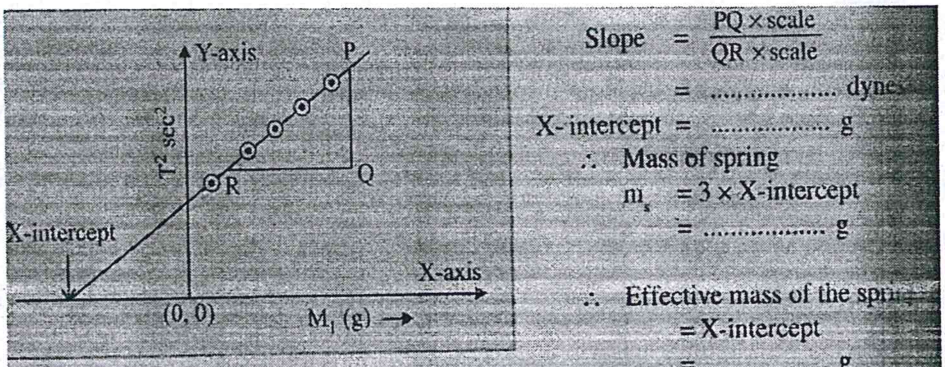


Fig. 2.3

Calculation :

1) Force constant (k) from graph 2 (Fig 2.3)

$$k = \frac{4\pi^2}{slope}$$

= ....

= ....

= .... dynes/cm

2) Mass of the given spring from graph , 2 (i.e. fig.2.3)

$m_s = 3\times$X-intercept = ...g

Result :

1) Force constant (k) by graph (1) i.e. from fig 2.2 = ... dynes/cm
2) Force constant (k) by graph (2) i.e. from fig 2.2 = ... dynes/cm
3) Mass of given spring m_s = ... g.
4) Effective mass of the spring = $\frac{m_s}{3}$ =.....................

Precautions :

(1) Spring should vibrate in a vertical plane.
(2) Take proper displacement of spring.
(3) Amplitude should be small.
(4) The spring and scale pan should not touch the scale.
(5) The helical spring should not be stretched beyond elastic limit.
(6) Oscillations should be in one plane only.

Experiment No. 3

Surface Tension

Aim : To determine the surface tension of a liquid (water) by capillary rise method.

Apparatus : Beaker, retort stand, travelling microscope, cork piece, wooden block, reading lens, capillary tube, thin needle or pin and liquid (water).

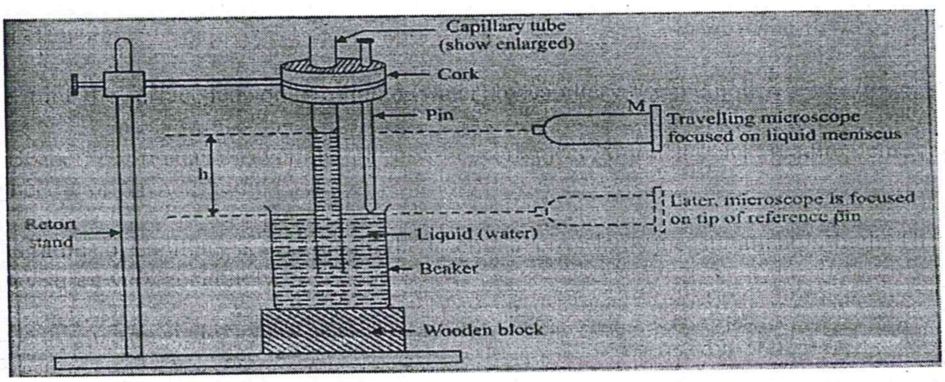
Accuracy : As radius of capillary is very small, the fractional error in its measurement is high. Therefore radius must be measured very accurately.

Formula :

$$T = \frac{rh\rho g}{2\cos\theta}$$

Where, T = Surface tension of water ; r = Radius of the capillary tube.
h = Height of water column ; ρ = Density of water = 1 g/cm^3
θ = Angle of contact between water and solid (glass) = 0° ; g = Acceleration due to gravity = 980 cm/s^2

Diagram :



Observations:

Least count of vertical scale of travelling microscope:

50 V.S.D. = 49 M.S.D. $\therefore$ 1 M.S.D.= $\frac{49}{50}$ M.S.D.

But 1 M.S.D. = $\frac{1}{20}$ of 1 cm as there are 20 divisions in 1 cm on the main scale.

$\therefore$ 1 M.S.D. = $\frac{1}{20} \times 1 = \frac{1}{20} = 0.050cm$ $\therefore$ 1V.S.D. = $\frac{49}{50} \times 0.050 = 0.049$ cm.

$\therefore$ L.C. of the travelling microscope
= 1 M.S.D − 1 V.S.D. = 0.050−0.049 = 0.001 cm

OR

L.C. of the travelling microscope

$$= \frac{\text{The value of the smallest division on the main scale}}{\text{Total number of the division on the vernier scale}} = \frac{0.05}{50} = 0.001\text{cm}$$

Observation table : (A) For the radius of the capillary tube :

Reading for	Obs. No.	Travelling microscope reading						Diameter D= (x-y) cm	Mean D cm	Radius diameter $r = \frac{D}{2}$ cm
		Position I			Position II					
		M.S.R. (a) cm	V.S.R. (b) cm	T.R. (a+b) x cm	M.S.R. (a) cm	V.S.R. (b) cm	T.R. (a+b) y cm			
Vertical cross-wires	1.									
	2.									
Horizontal cross-wires	1.									
	2.									

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Formula :

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Where, T = Surface tension of water ; r = Radius of the capillary tube.
h = Height of water column ; ρ = Density of water = 1 g/cm^3
θ = Angle of contact between water and solid (glass) = 0^0 ; g = Acceleration due to gravity = 980 cm/s^2

Procedure : First determine the least count of travelling microscope.

(A) To measure radius `r' of the capillary tube:

(1) Clean the capillary tube using dilute nitric acid followed by water. Dry the tube by passing a current of dry air through it.
(2) Hold the capillary tube horizontal in the clamp of a retort stand and focus the travelling microscope in its bore at one end. In case, if you find difficult to see the bore focused, pour one drop of blue ink in the bore. Adjust the travelling microscope to such a position that one of the cross wires (i.e. vertical cross wires) is tangential to the bore at one point [Fig. 3.2 Position I] Note this reading 'a'on the proper scale of microscope.
(3) Now move the travelling microscope in such a way that the cross-wire is tangential to diametrically opposite point on the bore [Fig. 3.2 Position II]. Note this reading 'b' on the same scale of travelling microscope.
(4) Thereafter move the travelling microscope in such a way that the horizontal cross- wire is tangential to the bore at one point [Fig. 3.3 Position I]. Note this reading 'c' on the proper scale of microscope.
(5) Now move the travelling microscope in such a way that the horizontal cross-wire is tangential to diametrically opposite point on the bore [Fig. 3.3 Position II]. Note this reading 'd' on the proper scale of microscope.

(B) To measure the height of water column 'h':

(1) Fix the capillary tube in a hole drilled in a piece of cork. A long thin needle or reference pin is passed through the cork so as to be very near to the capillary tube and parallel to it. The cork is then held firmly in the clamp of a retort stand.
(2) A clean beaker is filled with the water up to the brim and placed over a wooden bridge of proper height.
(3) Fix the cork in the clamp of the retort stand in such a way that the capillary tube and the needle remain vertical. Adjust the position of the clamp and beaker in such a way that capillary tube dips in and the water freely rises in the capillary while tip of the needle just touches the surface of the water (Fig. 3.1) (outside the capillary tube).
(4) Move the eye piece of the travelling microscope in or out until the cross-wires are seen distinctly i.e. focus on cross-wires.
(5) Focus the microscope on water in the capillary tube. Move the travelling microscope vertically until the horizontal cross-wire is tangential to the water meniscus. Note that due to refraction, the image meniscus in the capillary tube is convex but in reality the meniscus in the tube is concave for water. You are required to focus the horizontal wire of the cross wire on the upper part of the convex meniscus seen through the eye piece [Fig. 3.4 (a)]. Note the reading 'X' on the vertical scale of the travellingmicroscope.
(6) Remove the stand and take away the beaker carefully without disturbing the needle and the capillary tube. Bring the travelling microscope in front of the needle andlower it until the horizontal cross-wire touches the image of the tip of the needle [Fig. 3.4(b)], Note the travelling microscope reading 'Y' on the vertical scale.
(7) Take two or three more readings by dipping the capillary tube to different levels in the water.

Result :

(1) Radius of the capillary tube = r= ....cm
(2) Height of the water column = h = ...cm
(3) Surface tension of the water = T = ...dynes/cm = ...N/m

(B) For the height of the water column :

Obs. No.	Travelling microscope reading							
	Focused on the water meniscus			Focused on the tip of the reference pin			Height of the water column, h=(x-y)cm	Mean (h) cm
	M.S.R. (a) cm	V.S.R. (b) cm	T.R. (a+b) x cm	M.S.R. (a) cm	V.S.R. (b) cm	T.R. (a+b) y cm		
1.								
2.								
3.								

Calculations :

$T = \frac{r h \rho g}{2 \cos \theta}$

$= \frac{r h g}{2}$

[As for water $\theta \cong \cos 0°$ and $\cos \theta = \cos 0^{\circ} = 1$
Also, $\rho = 1$ g/cm^3]

= ……………………………………………………………
= […………………………………]
= […………………………]
= ………………………………… dynes/cm
= …………………………………N/m

Result :

(1) Radius of the capillary tube = r= ………….cm
(2) Height of the water column = h = …………………….cm
(3) Surface tension of the water = T = …………….dynes/cm = ………………..N/m

Precautions :

(1) Capillary should be clean and clamped vertically
(2) Capillary tube must be uniform, very fine and narrow bore.
(3) Turn the microscope screw in the same direction to avoid the back-lash error
(4) While measuring the rise of liquid, water should not be touched with fingers as that action will change the surface tension of water.
(5) There should not be air bubbles inside the capillary tube.

Experiment No. 4

Newton's Law of Cooling

Aim : To study the relationship between temperature of a hot body and time by plotting cooling curve.

Apparatus : A calorimeter, a double walled constant temperature enclosure, a thermometer, a stop watch, an arrangement of heating, water, stand, etc.

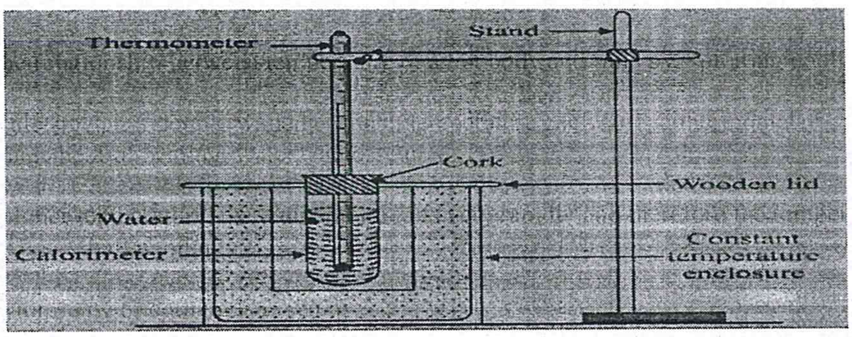
Accuracy : At higher temperature, the temperature falls very rapidly and therefore the temperature should be noted at least every half a minute.

Formula : Newton's law of cooling is given by

$$\frac{d\theta}{dt} \propto (\theta - \theta_0), \text{ when } (\theta - \theta_0), \text{ is small.} \therefore \frac{d\theta}{dt} = k(\theta - \theta_0)$$

where, $\frac{d\theta}{dt}$ = Rate of fall of temperature . ; θ = Temperature of hot body,
θ_0 = Room temperature (i.e. surroundings temperature),
$(\theta - \theta_0)$ = Excess of temperature; k = constant

Diagram :-



Observation:

1) L.C. of stop watch = ... sec.
2) L.C. of thermometer = ...°C
3) Room temperature = θ_0= .... °C

Observation Table :-

(A) **For temperature θ :**

Obs. No.	Time in minute (t)	Temperature of water in °C (θ)	Obs. No.	Time in minute (t)	Temperature of water (θ°C)
1.	0	70^0	21	10	
2.	½		22.	10 ½	
3.	1		23.	11	
4.	1 ½		24.	11 ½	
5.	2		25.	12	
6.	2 ½		26.	12 ½	
7.	3		27.	13	
8.	3 ½		28.	13 ½	
9.	4		29.	14	
10.	4 ½		30.	14 ½	
11.	5		31.	15	
12.	5½		32.	15 ½	
13.	6		33.	16	
14.	6½		34.	16 ½	
15.	7		35.	17	
16.	7½		36.	17 ½	
17.	8		37.	18	
18.	8 ½		38.	18 ½	
19.	9		39.	19	
20.	9 ½		40.	19 ½	
			41.	20	

Experiment No. 4

Newton's Law of Cooling

Aim : To study the relationship between temperature of a hot body and time by plotting cooling curve.

Apparatus : A calorimeter, a double walled constant temperature enclosure, a thermometer, a stop watch, an arrangement of heating, water, stand, etc.

Accuracy : At higher temperature, the temperature falls very rapidly and therefore the temperature should be noted at least every half a minute.

Formula : Newton's law of cooling is given by

$$\frac{d\theta}{dt} \propto (\theta - \theta_0), \text{ when } (\theta - \theta_0), \text{ is small.} \therefore \frac{d\theta}{dt} = k(\theta - \theta_0)$$

where, $\frac{d\theta}{dt}$ = Rate of fall of temperature . ; θ = Temperature of hot body,
θ_0 = Room temperature (i.e. surroundings temperature),
$(\theta - \theta_0)$ = Excess of temperature; k = constant

Procedure :

(1) Fill the calorimeter to nearly two third of its capacity, with hot water at about 70°C.
(2) Put the cork to the mouth of the calorimeter and place the calorimeter in the double-walled constant temperature enclosure. Insert the thermometer in the calorimeter, through the hole in the cork. (Fig 4.1)
(3) Note the initial temperature which is about 30°C above the room temperature.
(4) Start the stop-watch immediately.
(5) Note the temperature of water at regular intervals of half a minute till it falls by about 30°C.
(6) Plot a graph of temperature (0) of the water versus time (t). Draw smooth curve through the points.
(7) Find the slope $\left(\frac{d\theta}{dt}\right)$ of the cooling curve at various points on it by drawing normal and perpendiculars to the normal with a plane mirror at five different locations along the curve. The slope $\left(\frac{d\theta}{dt}\right)$ for a particular value of θ, gives the rate of fall of temperature at θ [See Fig. 4.2]. (The slope is negative because the temperature falls with time)
(8) Plot the graph of rate of fall of temperature $\left(\frac{d\theta}{dt}\right)$ versus temperatureθ Find the intercept on the + X-axis. The intercept on the x-axis used the room temperature of the surroundings (θ_0) (See fig. 4.3)
(9) Plot a graph of $\left(\frac{d\theta}{dt}\right)$ against, $(\theta - \theta_0)$ find the slope of this graph. It gives the value of K as this graph passes through the origin, Newton's Law of Cooling gates verifying,

Result:

(1) The nature of graph of temperature (0) against time (t) is a curve. It it known as Newton' cooling curve. This cooling curve will be steep at first, but will become less steep as the temperature approaches to temperature of the surrounding.
(2) As the graph of $\left(\frac{d\theta}{dt}\right)$ against $(\theta - \theta_0)$ is a straight line passing through origin, the rate of cooling is directly proportional to the excess of temperature over the surroundings. This verifies Newton's law of cooling.
(3) From the graph of $\left(\frac{d\theta}{dt}\right)$ against θ, room temperature or temperature of the surroundings, θ_0 = …………………… °C, (intercept on X-axis).
(4) (i) k = …………………………………………… per minute (by calculation).
(ii) k = …………………………………………… min-' (by graph)

Precautions:

(1) A large number of observations must be taken and consider all readings while plotting the graph.
(2) Allow the liquid (water) to cool to near surrounding temperature.
(3) Draw tangents and normal using a plane mirror or a capillary tube.
(4) Constant stirring must be done throughout the experiment to keep the temperature of water in the calorimeter constant.
(5) Make sure that the bulb of thermometer is well inside the water.
(6) The enclosure should have proper insulation to avoid loss of heat due to conduction or convection from hot water.

(B) for $\left(\frac{d\theta}{dt}\right)$: From cooling curve

Obs. No.	θ°C	(θ − θ)°C	$d\theta$° C	dt min.	$\left(\frac{d\theta}{dt}\right)$C/min	$K = \frac{(d\theta/dt)}{(\theta - \theta_\circ)}$
1.						
2.						
3.						
4.						
5.						

Mean k = ... min^{-1}

Graph :

(1) Graph of θ against t (cooling curve) :

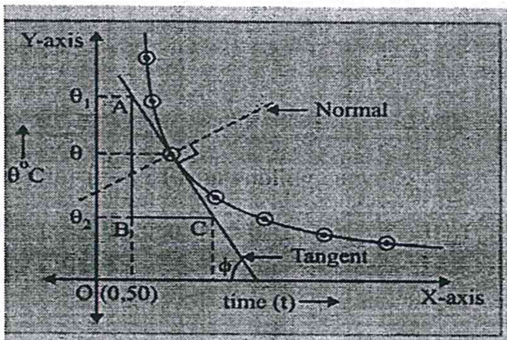


Fig. 4.2

Scale:
For X-axis: ....
For Y-axis: ....

For θ = ... °C,

$\tan\phi = \frac{d\theta}{dt} = \frac{AB}{BC} = \frac{\theta_2 - \theta_1}{t_2 - t_1}$

= ....°C

(2) Graph of $\left(\frac{d\theta}{dt}\right)$ against θ

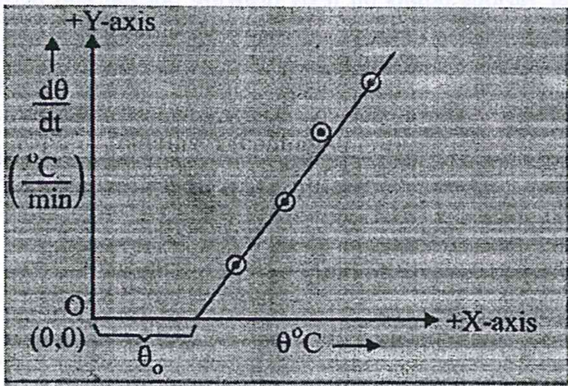


Fig. 4.3

Scale:
For X-axis: ....
For Y-axis: ....

From graph, Room temperature

θ_0 = ... °C

(3) Graph of $\left(\frac{d\theta}{dt}\right)$ against $(\theta - \theta_\circ)$

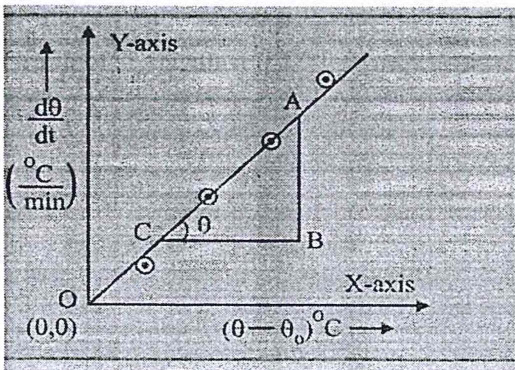


Fig. 4.4

Scale:
For X-axis: ....
For Y-axis: ....

Slope = tan θ

= $\frac{\text{AB (read on scale)}}{\text{BC (read on scale)}}$

= ....

∴ k = (slope)

= .... per minute

R.H.S.

Result:

1) The nature of graph of temperature (0) against time (t) is a curve. It it known as Newton' cooling curve. This cooling curve will be steep at first, but will become less steep as the temperature approaches to temperature of the surrounding.
2) As the graph of $\left(\frac{d\theta}{dt}\right)$ against $(\theta - \theta_0)$ is a straight line passing through origin, the rate of cooling is directly proportional to the excess of temperature over the surroundings. This verifies Newton's law of cooling.
3) From the graph of $\left(\frac{d\theta}{dt}\right)$ against θ, room temperature or temperature of the surroundings, $\theta_0 =$ ..... °C, (intercept on X-axis).
4) (i) k = ... per minute (by calculation).
   (ii) k = ... min^{-1}(by graph)

R.H.S.

Formula :

where T = Tension applied to the string (wire),

Diagram :

Observation Table:

Tension applied to the wire (string), T = ... kg-wt

Obs. No.	Frequency of ... Hz	Vibrating length, l cm					

Mean ... Hz-cm

Graph :

Plot a graph of reciprocal of the vibrating length $\left(\frac{1}{l}\right)$ ... against the frequency ... on X-axis. The graph will be straight line passing through origin.

Experiment No. 5

Sonometer I

Aim : To study the relation between frequency and the length of a given wire under constant tension using sonometer.

Apparatus : A sonometer, a hanger, slotted weights, tuning forks, a rubber pad, a meter scale, paper rider, etc.

Accuracy : Mass per unit length (m) should be same everywhere along the wire. Therefore the accuracy of the experiment depends upon the uniformity of the wire. A uniform wire must be used.

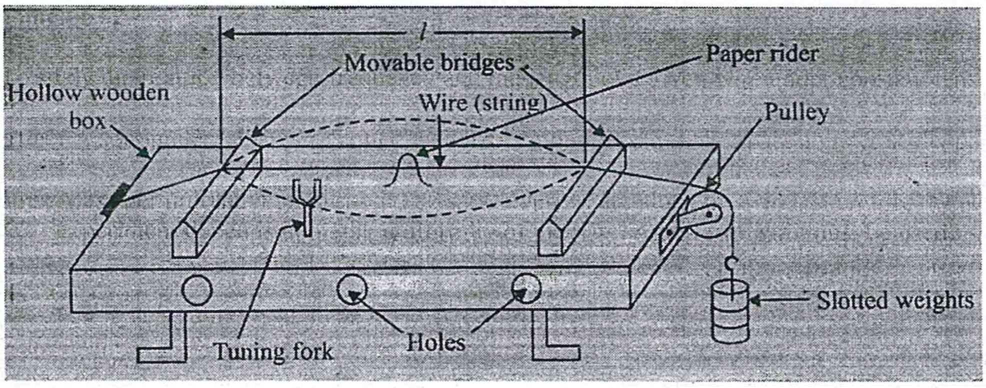
Formula :

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

$\therefore nl = \text{constant} = \left(\frac{1}{2}\sqrt{\frac{T}{m}}\right)$, if T and m are kept constant.

where, T = Tension applied to the string (wire); n = Frequency of tuning fork.
m = Mass per unit length or linear density of a wire, l = Vibrating length of a wire

Diagram :



Observation Table:

Tension applied to the wire (string), T =.. kg-wt

Obs. No.	Frequency 'n' Hz	Vibrating length 'l' cm				$\frac{1}{l}$ cm^{-1}	nl Hz-cm
		1	2	3	Mean l		
1.							
2.							
3.							
4.							
5.							
6.	Unknown'n'				l'= ....cm		-------

Mean nl = ...Hz-cm

Graph :-

Plot a graph of reciprocal of the vibrating length $\left(\frac{1}{l}\right)$on Y-axis against the frequency (n) on X-axis. The graph will be straight line passing through origin

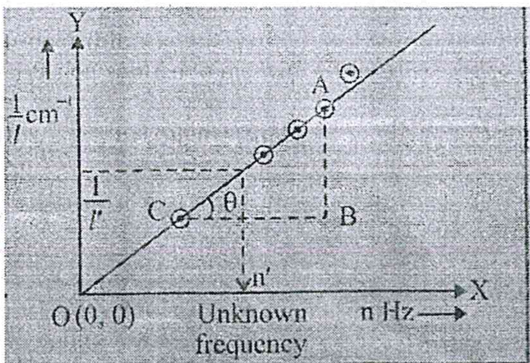


Fig. 5.2

Scale:

For X-axis: ....

For Y-axis: ....

Slope = tan θ

$= \frac{\text{AB (read on scale)}}{\text{BC (read on scale)}} =$ ....

$\therefore nl = \frac{1}{\text{Slope}} =$ ....

Unknown frequency n' = ... Hz

Experiment No. 5

Sonometer I

Aim : To study the relation between frequency and the length of a given wire under constant tension using sonometer.

Apparatus : A sonometer, a hanger, slotted weights, tuning forks, a rubber pad, a meter scale, paper rider, etc.

Accuracy : Mass per unit length (m) should be same everywhere along the wire. Therefore the accuracy of the experiment depends upon the uniformity of the wire. A uniform wire must be used.

Formula :

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

$\therefore nl$ = constant = $\left(\frac{1}{2}\sqrt{\frac{T}{m}}\right)$, if T and m are kept constant.

where, T = Tension applied to the string (wire); n = Frequency of tuning fork.
m = Mass per unit length or linear density of a wire, l = Vibrating length of a wire

Procedure:

(1) Measure the mass of 100 cm of sonometer wire and determine its mass per unit length. A sonometer is as shown in Fig. 5.1. Apply 2 kg wt including hanger to the sonometer wire (The given load is placed in the hanger suspended from the free end of the wire). Keep the tension same throughout the experiment.

(2) Initially the two movable knife edges are kept very close to each other and paper rider is placed on the wire mid-way between them.

(3) Arrange the given tuning forks in ascending order. The tuning fork of highest frequency is set into vibrations by striking one of its prongs on the rubber pad. Hold the tuning fork gently near the wire with its stem in contact with the box.

(4) The distance between the knife edges is slowly increased by taking the paper rider always at midway between them. For a particular length of the wire the paper rider flutters and falls off. This happened when natural frequency of the wire and that of tuning fork become equal, resonance takes place.

(5) Measure the vibrating length of a wire between two knife edges, using a meter scale. Take two more readings with the same tuning fork and find mean vibrating length (l).

(6) Repeat above step for four more tuning forks of known frequency and one of unknown frequency. Note the corresponding length of vibrating wire.

(7) Calculate '*nl*' for each tuning fork. Also find $\left(\frac{1}{l}\right)$ in each case.

(8) Plot a graph of reciprocal of vibrating length $\left(\frac{1}{l}\right)$ along Y-axis against frequency (n) along X-axis.

Result :-

(1) We observe that all *'nl'* values are same within experimental errors.
This verifies the law, $n \propto \frac{1}{l}$ (keeping m, T constant)

(2) Nature of the graph of $\frac{1}{l}$ against 'n' is a straight line.
This also verifies the law, $n \propto \frac{1}{l}$ (keeping m, T constant)

(3) Unknown frequency 'n' = ...Hz (by calculation)

(4) Unknown frequency 'n' = ...Hz (by graph)

(5) *nl* by calculation = ... Hz cm

(6) *nl* by graph = ... Hz cm

Precautions :

1) Start with the tuning fork of highest frequency.
2) Strike tuning fork gently on the rubber pad when setting it into vibrations.
3) Paper rider should always be placed on the wire mid-way between the knife edges.
4) Measure the vibrating length of wire directly with a scale.

Calculations :

(A) Log Calculation Table for *nl* :

∴ Mean nl = …………………….. Hz-cm

(B) *nl* by Graph : | **Log calculation**

$nl = \frac{1}{SLope}$ = ……………………………………………

= ……………………………………………

= ……………………………….. Hz. Cm.

(C) Unknown frequency n' :

(i) $n' = \frac{(Mean\ nl)}{l'}$ …………….(from calculation)

= ……………………………………….

= Antilog […………………….]

= ……………………………….. Hz

(ii) $n' = \frac{1}{(Slope)l}$ …………….(from graph)

= Antilog [log 1−log $(slop) - log\ l'$]

= Antilog [………………………]

= ……………………………….. Hz

Result :

(1) We observe that all 'nl' values are same within experimental errors.

This verifies the law, $n \propto \frac{1}{l}$ (keeping m, T constant)

(2) Nature of the graph of $\frac{1}{l}$ against 'n' is a straight line.

This also verifies the law, $n \propto \frac{1}{l}$ (keeping m, T constant)

(3) Unknown frequency 'n' = ………………………….Hz (by calculation)

(4) Unknown frequency 'n' = ………………………….Hz (by graph)

(5) nl by calculation = ……………………………………. Hz cm

(6) nl by graph = ……………………………………………. Hz cm

R.H.S.

The fundamental frequency of vibration (n) of a ... of length (l) under tension (T) is given by, ... other graph of ... against T is plotted.

... = constant ... are kept constant.

OR ... = constant ... kept constant.

... density of the material of the wire ...

Observations :

(1) Mass per unit length of wire, m = ... g/cm

(2) Frequency of fork used, n = ... Hz (Hz=Constant)

(3) Mass of hanger M_0 = ... g

Observation Table :

Obs. No.	Mass added to the hanger M (g)	Total Mass $M = M_0 + M$ (g)	Tension T = M×980 (dyne)	Vibrating length l (cm)			T (...)	...
				1	2	Mean l		

Experiment No. 6

Sonometer II

Aim : To study the relation between the length of a given wire and tension frequency using sonometer.

Apparatus : A sonometer, a hanger, slotted weights, a tuning fork, a rubber pad, a paper rider, etc.

Accuracy : Same as that of first law of vibrating. string (Expt. No. 5).

Formulae :-

The fundamental frequency of vibration (n) of a wire of length (l) under tension (T) is given by:

$n = \frac{1}{2l} \sqrt{\frac{T}{m}} = \frac{1}{2} \sqrt{\frac{(T/l^2)mean}{m}} = \frac{1}{2} \sqrt{\frac{1}{(Slop)\,m}}$, when graph of l^2 against T is plotted.

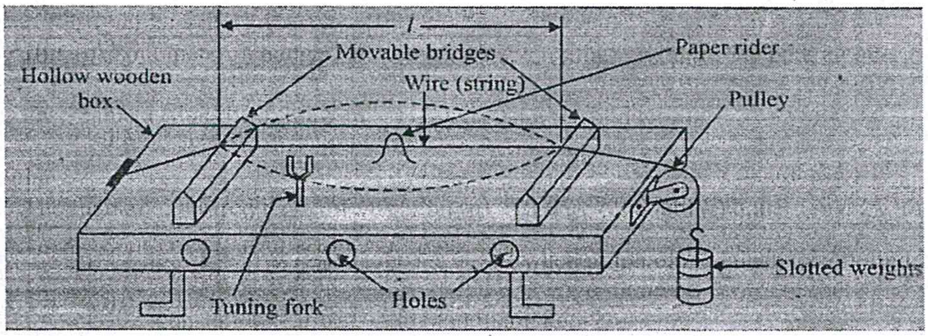
$\therefore \frac{\sqrt{T}}{l}$ = constant (= $2n\sqrt{m}$), if n and m are kept constant.

OR $\frac{T}{l^2}$ = constant (= $4n^2m$), if n and m are kept constant.

where, T = Mg = applied tension ; l = vibrating length of the wire
n = frequency of the given tuning fork
m = mass per unit length or linear density of the wire = $\rho\pi r^2$

where, ρ = density of the material of the wire, r = radius of the wire

Diagram :-



Observations :

(1) Mass per unit length of wire, m = ...gm/cm
(2) Frequency of fork used, n = ... Hz [Kept constant]
(3) Mass of hanger, M_0 = ... g.

Observation Table :

Obs. No.	Mass added to the hanger M'(g)	Total Mass $M=M_0+M'$ (g)	Tension T= M×980 (dynes)	Vibrating length l(cm) 1	2	Mean l	l^2 (cm^2)	$\frac{T}{l^2}$ $\frac{dynes}{cm^2}$
1.								
2.								
3.								
4.								
5.								
6.								
7.	Unknown Mass (M'_x)	Total mass (M_x)	Unknown Tension (T_x)	l_{x1} =.........	l_{x2} =.........	Mean l_x =.........	l_x^2 = ...	——

Experiment No. 6

Sonometer II

Aim : To study the relation between the length of a given wire and tension frequency using sonometer.

Apparatus : A sonometer, a hanger, slotted weights, a tuning fork, a rubber pad, a paper rider, etc.

Accuracy : Same as that of first law of vibrating. string (Expt. No. 5).

Formulae :-

The fundamental frequency of vibration (n) of a wire of length (l) under tension (T) is given by:

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1}{2}\sqrt{\frac{(T/l^2)mean}{m}} = \frac{1}{2}\sqrt{\frac{1}{(Slop)\, m}}$$, when graph of l^2 against T is plotted.

$\therefore \frac{\sqrt{T}}{l}$ = constant (= $2n\sqrt{m}$), if n and m are kept constant.

OR $\frac{T}{l^2}$ = constant (= $4n^2m$), if n and m are kept constant.

where, T = Mg = applied tension ; l = vibrating length of the wire

n = frequency of the given tuning fork

m = mass per unit length or linear density of the wire = $\rho\pi r^2$

where, ρ = density of the material of the wire, r = radius of the wire

Procedure :-

(1) Take one meter length of wire. Measure its mass using physical balance and calculate its mass per unit lengths.
(2) Keep sonometer wire under a tension (T) of about 1 kg-wt by adding slotted weights to the hanger.
(3) Adjust the length (l) of the wire between the two bridges so that it can vibrate in Unison with a given tuning fork. This can be done by paper rider method. {Refer Experiment 5]
(4) Measure the distance between two knife edges which is the vibrating length of wire. Take one more reading for the same tension. Find the mean value of vibrating length (l).
(5) Repeat the procedure for same tuning fork for five different tensions increased in steps of 0.5 kg-wt. Note the corresponding vibrating length (l)
(6) Calculate $\left(\frac{T}{l^2}\right)$in each case.
(7) Plot a graph of l^2 against T. The nature of graph is a straight line.

Result :

(1) The quantity $\frac{l^2}{T}$ is constant within experimental errors. This verifies the law of transverse vibrations.
$\therefore T \propto l^2$ i.e. $\frac{T}{l^2}$ or $\frac{l^2}{T}$ = constant.
(2) The graph of l^2 versus T is found to be straight line passing through the origin. This verifies that the square of the length of a wire vibrating in unison with a tuning fork is directly proportional to the tension in the string, if n and m are kept constant.
(3) From the graph the unknown tension = T_x = ... dynes Hence, unknown mass = M_x = ...g
(4) Mass per unit length of given wire
(iii) (i) m = ...g/cm (by calculation)
(iv) (ii) m = ...g/cm (by graph)
(v)

Precautions

(1) Strike tuning fork gently on the rubber pad when setting it into vibrations.
(2) Paper rider should always be placed on the wire mid-way between the knife edges.
(3) Measure the vibrating length of wire directly with a scale.
(4) Do not increase the load beyond the elastic limit of the wire.
(5) The stem of tuning fork should rest on the sonometer box.

Graph :-

Plot a graph of l^2 (on Y-axis) against T (on X-axis). The reciprocal of slope will give us the value of (T/l^2).

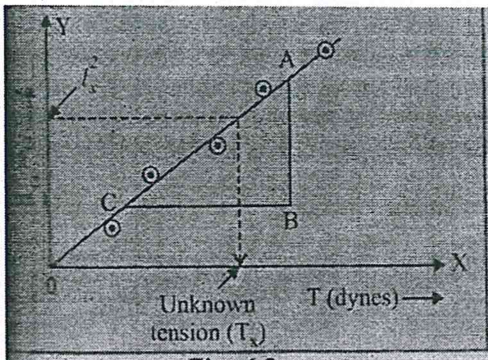


Fig. 6.2

Scale:
For X-axis: ....
For Y-axis: ....

$$\text{Slope} = \frac{AB}{BC} = \frac{l^2}{T}$$

= ....

$$\therefore \frac{1}{\text{Slope}} = \frac{T}{l^2} = \text{..........dynes/cm}^2$$

Unknown tension, T_x = ... dynes

Calculation :-

(1) Mean $\left(\frac{T}{l^2}\right)$ = ... Dynes/cm^2

(2) $\frac{1}{Slope} = \frac{T}{l^2}$ = ... dynes/cm^2

(3) Unknown Tension, T_x = ...dynes (by graph)

$\therefore$ Unknown mass, $M_x = \frac{(T_x)}{g} = \frac{(T_x)}{980}$

= ....

= [..........................]

= ....g

(4) Mass per unit length or linear density of wire = m

(i) **By calculation :** $m = \frac{1}{4n^2} \times \left(mean\ \frac{T}{l^2}\right)$

=..................g/cm

(ii) **By graph :** $m = \frac{1}{4n^2} \times \left(\frac{1}{Slope}\right)$

=..................g/cm

Result :

(1) The quantity $\frac{l^2}{T}$ is constant within experimental errors. This verifies the law of transverse vibrations.

$\therefore T \propto l^2$ i.e. $\frac{T}{l^2}$ or $\frac{l^2}{T}$ = constant.

(2) The graph of l^2 versus T is found to be straight line passing through the origin. This verifies that the square of the length of a wire vibrating in unison with a tuning fork is directly proportional to the tension in the string, if n and m are kept constant.

(3) From the graph the unknown tension = T_x = ... dynes Hence, unknown mass = M_x = ...g

(4) Mass per unit length of given wire

(i) m = ...g/cm (by calculation)

(ii) m = ...g/cm (by graph)

R.H.S.

Experiment No. 7

Resonance Tube

Aim : To determine the speed of sound in air at room temperature using a resonance tube

Apparatus : A tall glass jar filled with water, a metal tube (i.e. brass, aluminium etc.,) a set of tuning forks including the unknown fork, retort stand, two rubber pads, vernier calliper, meter scale, etc.

Accuracy : The length L is measured with the help of a meter scale which measures up to fraction of mm and therefore the diameter of the tube may be measured up to maximum of 0.1 mm accuracy. Hence a vernier calliper of least count 0.1 mm is used for measuring the diameter of the tube.

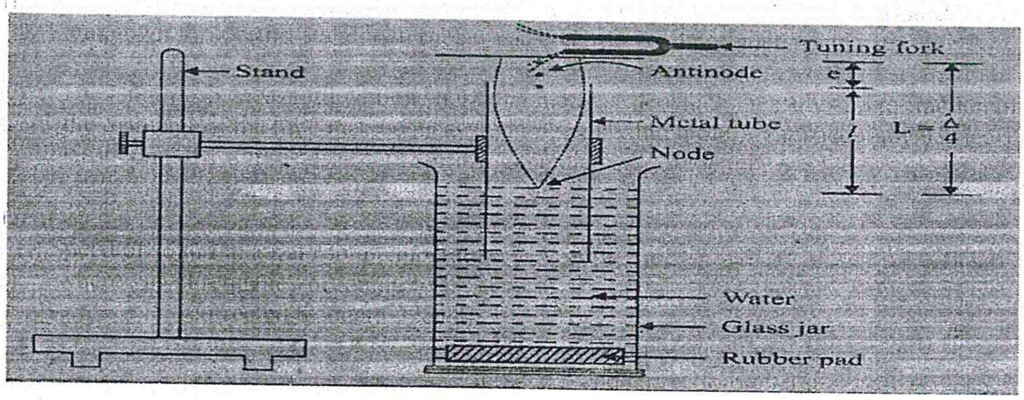
Formulae :-

1) (i) Speed of sound in air at room temperature = $V = 4nL$;
where , n = Frequency of tuning fork
L = corrected resonating length
$= l + e$ where l = length of air column
e = end correction = 0.3 d
where, d = diameter of metal tube

(iii) $V = 4 \times \frac{1}{Slope}$, if graph is $\frac{1}{L}$ against n

2) Unknown frequency $n_x = \frac{Mean\ (nL)}{\text{(Corrected resonating length for fork of unknown freqeuncy)}}$

Diagram:



Observations :

(1) Determination of least count of vernier callipers:

i) Smallest division on the main scale of the vernier calliper, x = ...cm
ii) Total no. of divisions on vernier scale, y = ... div.
iii) L.C. of vernier calliper, $\frac{x}{y}$; = ... cm
iv) Zero error = ... cm, Zero error correction = ... cm (2) End correction, e = 0.3 d = ... cm
(3) Room temperature = ... °C

Observation Table: (A) For inner diameter (d):

Obs. No.	M.S.R. 'a' cm	V.S.D. 'b' div.	V.S.R. (b×L.C.) cm	Diameter [a+(b×L.C.)] cm	Mean diameter 'd' cm
1.					
2.					
3.					

Experiment No. 7

Resonance Tube

Aim : To determine the speed of sound in air at room temperature using a resonance tube

Apparatus : A tall glass jar filled with water, a metal tube (i.e. brass, aluminium etc.,) a set of tuning forks including the unknown fork, retort stand, two rubber pads, vernier calliper, meter scale, etc.

Accuracy : The length L is measured with the help of a meter scale which measures up to fraction of mm and therefore the diameter of the tube may be measured up to maximum of 0.1 mm accuracy. Hence a vernier calliper of least count 0.1 mm is used for measuring the diameter of the tube.

Formulae :-

3) (i) Speed of sound in air at room temperature $= V = 4nL$;

where , n = Frequency of tuning fork

L = corrected resonating length

$= l + e$ where l = length of air column

e = end correction = 0.3 d

where, d = diameter of metal tube

(iv) $V = 4\times\frac{1}{Slope}$, if graph is $\frac{1}{L}$ against n

4) Unknown frequency $n_x = \frac{Mean\ (nL)}{\text{(Corrected resonating length for fork of unknown freqeuncy)}}$

Procedure :-

(1) Measure the inner diameter of a tube using vernier calliper. The diameter should be taken at different directions. Find the mean diameter (d). Hence calculate end correction (e) = 0.3d.
(2) Put one rubber pad in the glass jar (for safety of the jar).
(3) Fix the resonance tube vertically in the glass jar with the help of the retort stand. Pour water in the jar up to 85% of its height. The tube should rest on the rubber pad.
(4) Initially, the length of the air column is adjusted to be very small. Arrange the given tuning forks in the order of decreasing frequencies.
(5) Choose the tuning fork of highest frequency, strike it gently on the rubber pad so that the prongs start vibrating. Hold the tuning fork just above the open end of the resonance tube, so that the prongs vibrate in a vertical plane and raise the tube gradually together with the fork till a loud sound is heard. Clamp the tube in the positions in which loudness of the sound produced is maximum.
(6) Measure the length (1) of the air column in the tube from the water surface in the tube to open end.
(7) Repeat the procedure with other tuning forks in the decreasing order of frequencies. (You will find that 1 increases as the frequency (n) of a tuning fork decreases)
(8) In each case find the distance (L) between the node and the adjacent antinode ($L = l + e$).
(9) Plot the graph of '1/L' against 'n' .
(10) Find the speed of sound in air at room temperature and unknown frequency of given tuning fork.

Result :-

(1) Speed of sound in air column at room temperature .
(iii) V = ...cm/s = ...m/s (by calculation);
(iv) V = ...cm/s = ...m/s (by graph)

(2) Unknown frequency
(iii) n_x = ... Hz (by calculation)
(iv) n_x = ... Hz (by graph)

(3) (i) nL = ... Hz cm (by calculation)
(v) nL = ... Hz cm (by graph)

Precautions

(1) Strike tuning fork gently on the rubber pad.
(2) Hold the tube vertical in the glass jar.
(3) Tuning fork should not touch the resonance tube.
(4) The prongs of the tuning fork must vibrate in vertical plane.
(5) While adjusting the resonant length of air column, start with minimum length of the air column and the tuning fork of highest frequency.

(B) For nL :

Obs. No.	Frequency of tuning fork 'n' Hz	Resonating length 'l' cm			Corrected length L=(l+e) cm	$\frac{1}{L}$ cm^{-1}	nL Hz. cm
		1	2	Mean			
1.							
2.							
3.							
4.							
5.							
6.	Unknown	l_x = ………	l_x = ……	Mean l_x =……………	$L_x = l_x$+e =…………	$\frac{1}{L^x}$= ………	Unknown

Mean nL = …………………Hz.cm

Graph :

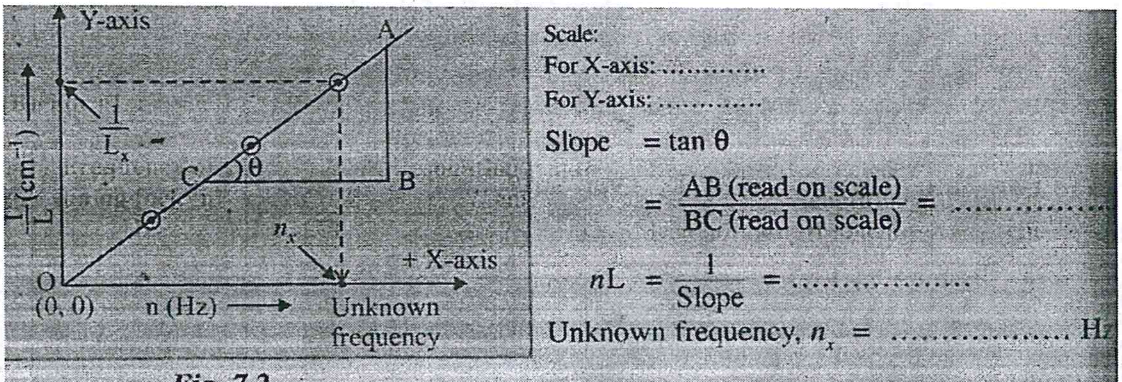


Fig. 7.2

Calculation :-

(A) Speed of sound in air at room temperature :

(i) By Calculation :- **Log Calculation**

V = 4 × (mean nL)

= …………… [………………………]

= …………… [………………]

= ………………………cm/s

(ii) By Graph :

V = 4 × $\frac{1}{Slope}$

= ……….. [……………………….]

= ……………… [……………..]

= ……………………..cm/s

(B) Unknown frequency :

(i) By calculation, $n_x = \frac{Mean\ (nL)}{L_x}$

= ……………… [………………………………..]

= Antilog [………………]

= ……………………Hz.

(ii) From graph; read the value of n_x corresponding to $1/L_x$

Result :-

(1) Speed of sound in air column at room temperature .

(i) V = …………………cm/s = …………………………m/s (by calculation);

(ii) V = …………………cm/s = …………………………m/s (by graph)

(2) Unknown frequency

(i) n_x = ………………………… Hz (by calculation)

(ii) n_x = ………………………… Hz (by graph)

(3) (i) nL = ………………………… Hz cm (by calculation)

(ii) nL = ………………………… Hz cm (by graph)

Formula :

$$\frac{X}{R} = \frac{l_1}{l_2} \qquad \rho = \frac{\pi r^2 X}{L}$$

where, L = Length of given resistance wire.

l_1 = Length of the bridge wire corresponding to X.

l_2 = Length of the bridge wire corresponding to R.

X = Unknown resistance introduced in resistance box.

R = Known resistance introduced in resistance box.

r = Radius of wire

ρ = Specific resistance of the material of wire. Known resistance

Circuit Diagram :

Observation :

1) Length of a resistance wire (L) = ... cm

2) Least count of micrometer screw gauge = ... cm

Observation Table :

(A) For diameter of a resistance wire :

Sr. No.	M.S.R. 'a' = cm	C.S.D. 'b' div.	C.S.R. (b×L.C.) = c cm	Total reading (diameter) = (a+c) cm	Mean (diameter) 'd' cm	Mean radius $r = \frac{d}{2}$ cm
1						
2						
3						
4						

(B) For resistance (X) of given wire :

1) With unknown resistance X in right gap

Obs. No.	Resistance from Resistance Box R Ω	Balancing length l_1 cm	Balancing length l_2 cm	Resistance $X = R\frac{l_1}{l_2}$ Ω	Mean X Ω

Experiment No. 8

Wheatstone's Meter bridge

Aim : To find resistance of given wire using Wheatstone' meter bridge and hence determine the specific resistance of its material.

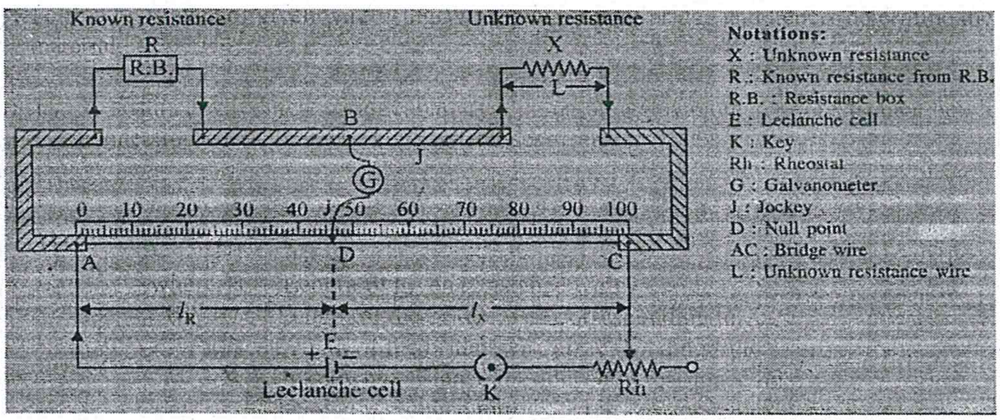
Apparatus : Resistance wire, meter bridge, battery eliminator, a galvanometer, a resistance boy jockey, a screw gauge, connecting wires, one way key, a meter scale, etc.

Formulae:

(1) $\frac{X}{R} = \frac{l_X}{l_R}$, (2) $\rho = \frac{\pi r^2 X}{L}$

where, L = Length of given resistance wire;
l_x = Length of the bridge wire corresponding to X.
l_R = Length of the bridge wire corresponding to R.
X = Unknown resistance introduced in resistance box.
R = Known resistance introduced in resistance box.
r = Radius of wire
ρ = Specific resistance of the material of wire. ~~Known resistanee~~

Circuit Diagram :



Observations :

1) Length of a resistance wire (L) = ...cm.
2) Least count of micrometre screw gauge = ...cm

Observation Table:

(A) For diameter of a resistance wire:

Obs. No.	M.S.R. 'a' = cm	C.S.D. 'b' div	C.S.R. (b×L.C.) = c cm	Total reading (diameter) = (a +c) cm	Mean (diameter) 'd' cm	Mean radius $r = \frac{d}{2}$ cm
1.						
2.						
3.						
4.						
5.						

(C) For resistance (X) of given wire:

(1) When unknown resistance wire in right gap :

Obs. No.	Resistance from Resistance Box R Ω	Balancing length		Resistance $X_1 = R\left(\frac{l_X}{l_R}\right)$ Ω	Mean X_1 Ω
		l_x cm	l_R cm		
1.					
2.					
3.					
4.					
5.					

Experiment No. 8

Wheatstone's Meter bridge

Aim : To find resistance of given wire using Wheatstone' meter bridge and hence determine the specific resistance of its material.

Apparatus : Resistance wire, meter bridge, battery eliminator, a galvanometer, a resistance boy jockey, a screw gauge, connecting wires, one way key, a meter scale, etc.

Formulae:

(1) $\frac{X}{R} = \frac{l_X}{l_R}$, (2) $\rho = \frac{\pi r^2 X}{L}$

where, L = Length of given resistance wire;

l_x = Length of the bridge wire corresponding to X.

l_R = Length of the bridge wire corresponding to R.

X = Unknown resistance introduced in resistance box.

R = Known resistance introduced in resistance box.

r = Radius of wire

ρ = Specific resistance of the material of wire. ~~Known resistance~~

Procedure :

(1) Mesure the length of a given resistance wire (L) in cm by using metre scale.
(2) Measure the diameter of the wire at least, at five places with the help of screw gauge.
(3) Find mean diameter of wire hence find radius of wire (r) cm.
(4) Connect the circuit as shown in Fig 8.1 with unknown resistance wire in the right gap and resistance box in the left gap of the meter bridge.
(5) Take some suitable resistance R from the resistance box.
(6) Switch on the circuit and check the connections as follows. Tap the jockey at one end of the meter bridge wire (say A) and note the direction of deflection shown by the galvanometer. Tap the jockey at other end (say C) of the wire and note the direction of deflection. If the two deflections are in the opposite directions, it means that the connections are correct. If the two deflections are in the same direction check the connections. Suppose that the two deflections are in opposite directions, bring the deflections within the scale of the glavanometer by adjusting the rheostat.
(7) Tap the jockey at various point on the wire, obtain the point D on the wire such that there is no deflection shown by the glavanometer when the jockey is tapped at D. The point D is called null point. Measure the lengths l_x = (AD) and l_R = (DC) of the bridge wire.
(8) Repeat the procedure for different values of the known resistance drawn from the resistance box.
(9) Repeat the expriment with R in the right gap and X in the left gap.
(10) Calculate the value X from the formula (1).
(11) Calculate the specific resistance of material of wire by using the formula (2).

Result :

(1) Unknown resistance of a give wire, X = ...Ω
(2) Specific resistance of material of wire, ρ = ...ohm-cm............ Ω m

Precautions

(1) Check all the connections and the keys in the resistance box are tight
(2) Move the jockey gently over bridge wire and do not rub it
(3) The plug in key K should be inserted only when the observations are to be taken.
(4) Null point should be brought between 45 cm and 55 cm.
(5) Remove the plug key after completion of the experiment.

(2) **When unknown resistance wire in left gap :**

Obs. No.	**Resistance from Resistance Box R Ω**	**Balancing length**		**Resistance $X_1 = R\left(\frac{l_X}{l_R}\right)\Omega$**	**Mean X_1 Ω**
		l_x cm	**l_R cm**		
1.					
2.					
3.					
4.					
5.					

Calculation :

(A) For unknown resistance 'X' :

(1) Unknown resistance in right gap

(2) Unknown resistance in left gap:

Mean X $= \frac{\text{Mean } X_1 + \text{Mean } X_2}{2} = \frac{\ldots\ldots\ldots\ldots}{2}$

= ……………………Ω

(D) For specific resistance

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

= ……………………[……………………………………]

=…………………… [……………………………………]

= …………………… [……………………….]

= ……………………ohm-cm.

Result :

(1) Unknown resistance of a give wire, X = ………………Ω

(2) Specific resistance of material of wire, ρ = ……………ohm-cm…………Ω

R.H.S.

Therefore X_1 and X_2 both should be large enough. This can be achieved by obtaining null point near the middle of the wire. The contact resistance if present, may be different on two sides of the wire. The errors introduced by contact resistances can be minimized by interchanging seats of X and R.

Formulae:

l = length of the bridge wire corresponding to X

l_2 = length of the bridge wire corresponding to R

X = unknown resistance

R = Known resistance introduced in R.B.

(2) When two resistances X_1 and X_2 are connected in series, the effective resistance of the combination is given by

$X_s = X_1 + X_2$

(3) When two resistances X_1 and X_2 are connected in parallel, the effective resistance of the combination is given by

$X_p = \frac{X_1 X_2}{X_1 + X_2}$

Circuit Diagram:

Observation Table:

(I) Unknown resistance in left gap :

Mean X Ω	Resistance $X = R\left(\frac{l_1}{l_2}\right)$ Ω	Balancing length		Resistance in Ω		Obs. No.	Unknown resistance
		l_2 cm	l_1 cm	Right gap R Ω	Left gap X		
						1	
						2	
						3	
						1	
						2	
						3	

Experiment No. 9

Laws of Resistances using Meter Bridge

Aim : To determine unknown resistances and to verify the laws of combination (series and parallel) of resistances using a meter bridge.

Apparatus : Wheatstone's meter bridge, resistance box, two unknown -resistances, a galvanometer, a cell, a plug key, a jockey, connecting wires, etc.

Accuracy : The length on bridge are measured correct up to mm. If l_x or l_x is very small, the errors will be large. Therefore lx_1 and lx_2 both should be large enough.This can be achieved by obtaining null point near the middle of the wire. The contact resistance if present, may be different on two sides of the wire. The errors introduced by contact resistances can be minimized by interchanging gaps of X and R.

Formulae :-

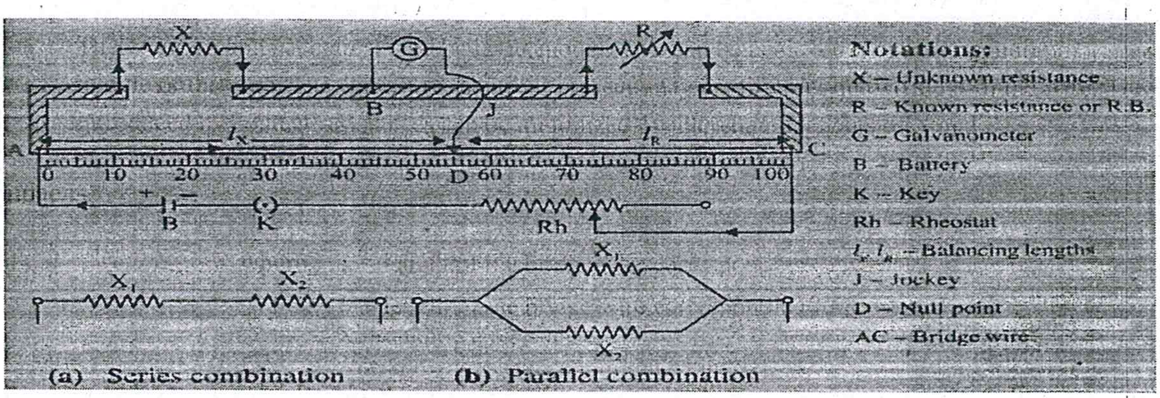
(1) $\frac{X}{R} = \frac{l_X}{l_R}$, where, l_x = length of the bridge wire corresponding to X
l_R = length of the bridge wire corresponding to R
X = unknown resistance
R = known resistance introduced in R.B.

(2) When two resistances X_1 and X_2 are connected in series, the effective resistance of the combination is given by $X_s = X_1 + X_2$

(3) When two resistances X_1 and $X_2$are connected in parallel, the effective resistance of the combination is given by

$$X_p = \frac{X_1 X_2}{X_1 + X_2}$$

Circuit Diagram :-



Observation Table:

(1) Unknown resistance in left gap :

Unknown resistance	Obs. No.	Resistance in Left gap Ω	Resistance in Right gap R Ω	Balancing length l_x cm	Balancing length l_R cm	Resistance $X \equiv R\left(\frac{l_x}{l_R}\right)$ Ω	Mean X Ω
X_1	1.	X_1					X_1
	2.	X_1					=............
X_2	1.	X_2					X_2
	2.	X_2					=............
X_s	1.	X_s					X_s
	2.	X_s					=............
X_p	1.	X_p					X_p
	2.	X_p					=............

Experiment No. 9

Laws of Resistances using Meter Bridge

Aim : To determine unknown resistances and to verify the laws of combination (series and parallel) of resistances using a meter bridge.

Apparatus : Wheatstone's meter bridge, resistance box, two unknown -resistances, a galvanometer, a cell, a plug key, a jockey, connecting wires, etc.

Accuracy : The length on bridge are measured correct up to mm. If l_x or l_x is very small, the errors will be large. Therefore lx_1 and lx_2 both should be large enough.This can be achieved by obtaining null point near the middle of the wire. The contact resistance if present, may be different on two sides of the wire. The errors introduced by contact resistances can be minimized by interchanging gaps of X and R.

Formulae :-

(1) $\frac{X}{R} = \frac{l_X}{l_R}$, where, l_x = length of the bridge wire corresponding to X
l_R = length of the bridge wire corresponding to R
X = unknown resistance
R = known resistance introduced in R.B.

(2) When two resistances X_1 and X_2 are connected in series, the effective resistance of the combination is given by $X_s = X_1 + X_2$

(3) When two resistances X_1 and $X_2$are connected in parallel, the effective resistance of the combination is given by

$$X_p = \frac{X_1X_2}{X_1+X_2}$$

Procedure:

(1) Connect the circuit as shown in the Fig. 9.1 with unknown resistance X_1 in the left gap of the Wheatstone's meter bridge.
(2) Take out some suitable resistance R from the resistance box.
(3) Switch on the circuit, check the connection as follows: Tap the jockey at one end of the meter bridge wire (say A) and note the direction of deflection shown by the galvanometer. Tap the jockey at the other end (say C) of the wire and note the directions of deflection. If the two deflections are in the opposite directions, it means that the connections are correct. If the two deflections are in the same direction check the connections Suppose that the two deflections are in opposite directions, bring the deflections within the scale of the galvanometer by adjusting the rheostat.
(4) Tap the jockey at various point on the wire, obtain the point D on the wire such that there i no deflection shown by the galvanometer when the jockey is tapped at D. The point D is called null point. Measure the lengths l_x = (AD) and l_R = (DC) of the bridge wire.
(5) Repeat the procedure for a different value of the known resistance drawn from the resistance box.
(6) Repeat the experiment with R in the left gap and X_1 in the right gap.
(7) Calculate the value of X_1 from the above formula.
(8) Repeat the experiment by replacing the resistance X_1 by the second unknown resistance to find the value of the resistance X_2.
(9) Repeat the experiment by connecting the resistance X_1 and X_2 in series. Find X_s
(10) Repeat the experiment by connecting the resistance X_1 and X_2 in parallel. Find X_P

Result :-

(1) Unknown resistance X_1 = ...ohms;
(2) Unknown resistance X_2 = ...ohms;
(3) Theoretical value of X_s = ...ohms
(4) Experimental value of X_s = ...ohms
(5) Theoretical value of X_p = ...ohms
(6) Experimental value of X_p = ...ohms
(7) Mean X_s (theoretically) = Mean X_s (experimentally)
Hence, series law of resistances is verified.
(8) Mean X_p (theoretically) = Mean X_p (experimentally)
Hence, series law of resistances is verified.

2) After interchanging (Unknown resistance in right gap)

Unknown resistance	Obs. No.	Resistance in Left gap RΩ	Balancing length			Resistance $X \equiv R\left(\frac{l_x}{l_R}\right)$ Ω	Mean X Ω
			Right gap Ω	l_x cm	l_R cm		
X_1	3.		X_1				X_1
	4.		X_1				=............
X_2	3.		X_2				X_2
	4.		X_2				=............
X_s	3.		X_s				X_s
	4.		X_s				=............
X_p	3.		X_p				X_p
	4.		X_p				=............

Calculation :

(A) Find X_1, X_2, X_s, X_p by using balancing condition formula,

$$X = R\frac{l_x}{l_R}$$

(B) Verification of Laws :

(1) Theoretical value of X_s is given as

$$X_s = X_{1(mean)} + X_{2(mean)}$$

= .... Ω

(2) Theoretical value of X_p is given as

$$= \frac{1}{X_p} = \frac{1}{X_{1(mean)}} + \frac{1}{X_{2(mean)}}$$

i.e $X_p = \frac{X_1 X_2}{(X_1+X_2)}$

= ....[.....................................]

= .... [...............................]

= .... Ω

Result :-

(1) Unknown resistance X_1 = ...ohms;
(2) Unknown resistance X_2 = ...ohms;
(3) Theoretical value of X_s = ...ohms
(4) Experimental value of X_s = ...ohms
(5) Theoretical value of X_p = ...ohms
(6) Experimental value of X_p = ...ohms
(7) Mean X_s (theoretically) = Mean X_s (experimentally)
Hence, series law of resistances is verified.
(8) Mean X_p (theoretically) = Mean X_p (experimentally)
Hence, parallel law of resistances is verified.

Precautions

(1) Check that all the connections and the key in the resistance box are tight.
(2) Adjust the known resistance R such that null point is obtained between 30 cm and 70 cm preferably one reading near or on the mid point of the bridge or in the middle one third of the meter bridge.
(3) Repeat the experiment by interchanging the resistances in the left gaps.
(4) Keep the circuit on only at the time of observation.
(5) Do not slide the jockey over the wire. Tap it on the wire lightly and momentarily to get exact position of mull point.

Experiment No. 10

Internal Resistance of a Cell

Aim : To determine the internal resistance of a given cell by using a potentiometer.

Apparatus : A potentiometer, a sensitive centre zero galvanometer, a cell whose internal resistance is to be determined, a rheostat, a jockey, two plug keys, an accumulator, a resistance box, connecting wires, etc.

Formula:

$$r = R\left|\frac{L_1 - L_2}{L_2}\right|$$

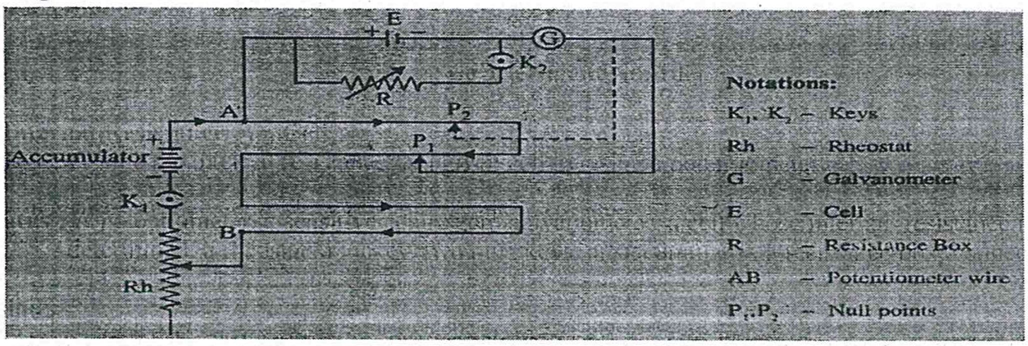
where; r = Internal resistance of the cell.

R = Resistance withdrawn from the resistance box.

L_1 = Balancing length on the potentiometer wire when the cell is on open circuit, (key K_2 open).

L_2 = Balancing length on the potentiometer wire when the cell is on closed circuit, (key K_2 closed).

Circuit Diagram:



Observation :

Balancing length for cell when key K_2 is open L_1 = ...cm

Observation Table : For length L_2 when key K_2 is closed;

Obs. No.	Resistance R Ω	Balancing length L_2 cm	(L_1-L_2) cm	$\frac{R}{L_2}$ $\frac{\Omega}{cm}$	Internal resistance r= $R\left\|\frac{L_1-L_2}{L_2}\right\|$ Ω
1.					
2.					
3.					
4.					
5.					

∴ Mean r = ...Ω

Graph :-

Plot a graph of R against $\frac{R}{L_2}$ as shown in Fig 11.2

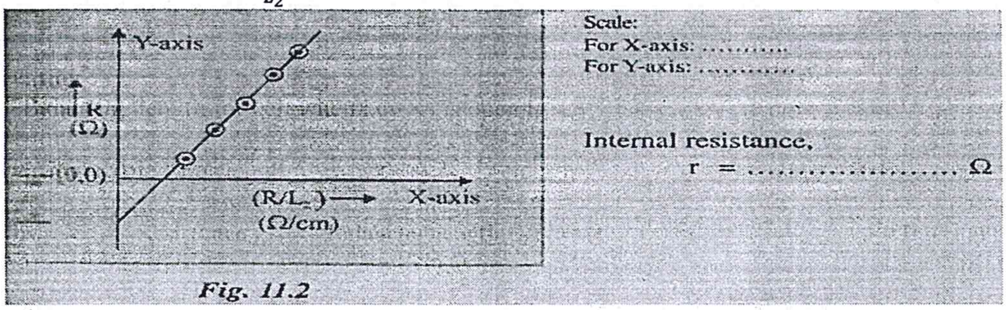


Fig. 11.2

Experiment No. 10

Internal Resistance of a Cell

Aim : To determine the internal resistance of a given cell by using a potentiometer.

Apparatus : A potentiometer, a sensitive centre zero galvanometer, a cell whose internal resistance is to be determined, a rheostat, a jockey, two plug keys, an accumulator, a resistance box, connecting wires, etc.

Formula :

$$r = R\left|\frac{L_1 - L_2}{L_2}\right|$$

where; r = Internal resistance of the cell.

R = Resistance withdrawn from the resistance box.

L_1= Balancing length on the potentiometer wire when the cell is on open circuit, (key K_2 open).

L_2 = Balancing length on the potentiometer wire when the cell is on closed circuit, (key K_2 closed).

Procedure :-

(1) Arrange the circuit as shown by the circuit diagram (see Fig. 11.1). Insert the plug in plug key K_1 connected in series with rheostat, keeping the other plug key K_2 open.
(2) Adjust the rheostat so that E of cell balances against an appreciable length L_1 of potentiometer wire, say the null point is obtained at P_1.
(3) Measure L_1 and leave the rheostat at this adjustment throughout the rest of the experiment.
(4) Now introduce resistance R in the resistance box and insert plug in plug key K_1 connected in series with the resistance box.
(5) Obtain a new balance point P_2 on the potentiometer wire and measure the length L_2 for balance.
(6) Repeat with different values of R in the resistance box.
(7) Calculate the value of 'r' in each find its mean value.
(8) Plot a graph of R(+ Y-axis) against $\frac{R}{L_2}$ (+X-axis) The intercept on Y-axis is the line which gives the internal resistance of the cell.

Result :

Internal resistance of a cell = r = ... Ω (by calculation)

= .... Ω (by graph)

Precautions

(1) The E.M.F. of the accumulator should be greater than the cell for which internal resistance is determined.
(2) The current should remain constant and passed through the circuit only at the time of observations
(3) Potentiometer wire should be uniform.

Calculation :-

Internal resistance of a cell,

$r = R\left|\frac{L_1 - L_2}{L_2}\right|$

Result :

Internal resistance of a cell = r = ... Ω (by calculation)

= .... Ω (by graph)

Experiment No. 11

Resistance of Galvanometer by Kelvin's Method

Aim : To determine the resistance of a galvanometer by Kelvin's method us Wheatstone's meter bridge.

Apparatus : Wheatstone's meter bridge, a rheostat, a cell, a galvanometer, a resistance box a jockey, connecting wires, a cell or battery, a plug key, etc.

Formula:

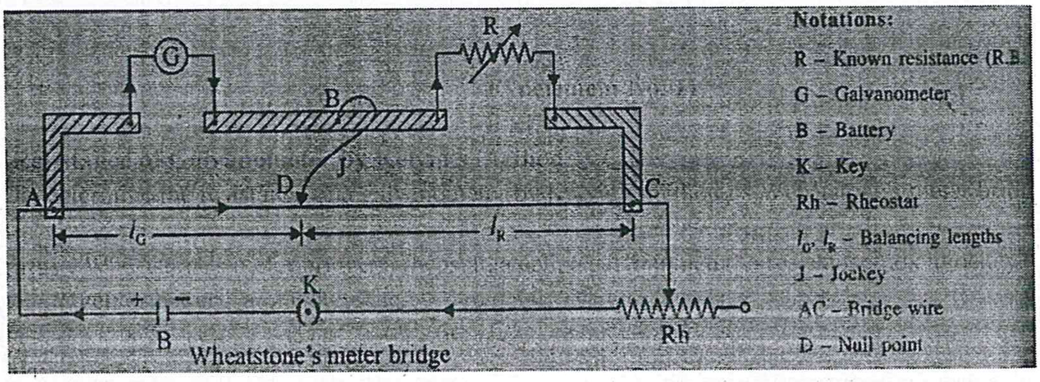
$G = R\frac{l_G}{l_R}$ where, l_G = length of the bridge wire corresponding to G.

l_R = length of the bridge wire corresponding to R.

G= resistance of galvanometer

R= resistance introduced in R.B.

Circuit Diagram:



Observation Table :

(1) Galvanometer in left gap :

Obs. No.	R ohm	L_G cm	L_R cm	$G = R.\frac{l_G}{l_R}$ ohm	Mean G ohm
1.					
2.					
3.					
4.					

(2) Galvanometer in right gap :

Obs. No.	R ohm	L_G cm	L_R cm	$G = R.\frac{l_G}{l_R}$ ohm	Mean G ohm
1.					
2.					
3.					
4.					

Calculation :

Log calculation Table $G = R.\frac{l_G}{l_R}$

∴ The resistance of the galvanometer

$$G = \frac{\text{Mean G (of left gap)+Mean G (of right gap)}}{2}$$

$$= \frac{\text{.....................}}{2} = \text{...........................}\Omega$$

Result :

The resistance of the galvanometer G = ...ohms

Experiment No. 11

Resistance of Galvanometer by Kelvin's Method

Aim : To determine the resistance of a galvanometer by Kelvin's method us Wheatstone's meter bridge.

Apparatus : Wheatstone's meter bridge, a rheostat, a cell, a galvanometer, a resistance box a jockey, connecting wires, a cell or battery, a plug key, etc.

Formula:

$G = R\frac{l_G}{l_R}$ where, l_G = length of the bridge wire corresponding to G.

l_R = length of the bridge wire corresponding to R.

G= resistance of galvanometer

R= resistance introduced in R.B.

Procedure:

(1) Connect the circuit as shown in Fig. 12.1.

(2) The galvanometer, whose resistance G is to be determined is connected in one arm, and a resistance box is connected in the other arm of the Wheatstone's bridge. A jockey is directly connected from a point between G and R. A suitable resistance R is introduced in the resistance box.

(3) The circuit is closed and the galvanometer deflection is noted. The rheostat is adjusted that the galvanometer shows nearly half the full scale deflection.

(4) When the jockey is touched on the wire; the galvanometer deflection either increases decreases. Move the jockey along the wire till the galvanometer deflection is restored original value. This is the null point or balance point. Thus in this position, the null constant when the jockey is touched or removed from the wire. Adjust R so that the point is between 30 cm to 70 cm preferably one reading near or in the mid of the bridge Measure l_G and l_R

(5) Take three more readings by changing the values of R.

(6) The positions of G and R are interchanged and four readings are obtained by adjusting R. Calculate the value of G in each case. Take mean G.

Result :

The resistance of the galvanometer G = ...ohms

Precautions :

(1) Make all the connections and the keys in the resistance box tight.

(2) Adjust the resistance R such that the point lies in the middle one third of the meter bridge wire or between 30 cm and 70 cm preferably one reading near or on the mid of the bridge wire.

(3) Keep the circuit on only at the time of observation.

(4) Do not slide jockey on the wire but tap it gently to get the exact null point.

Experiment No. 12

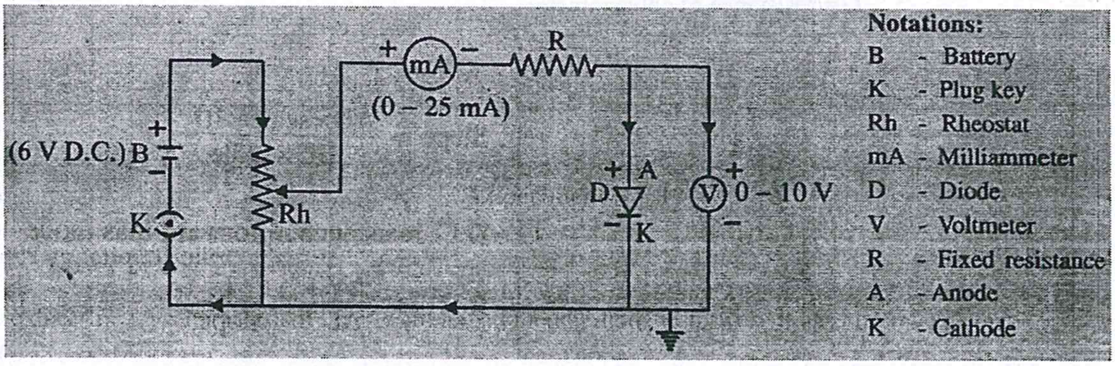
P-N Junction Diode

Aim : To draw the I-V characteristics curves of a p n junction diode in forward bias and reverse bias.

(A) Forward bias

Apparatus : PN Junction diode [DR 25 or AC 127, BY 126 transistor with collector removed], D.C. milliammeter (0 — 25 mA), D.C. voltmeter (0 — 10 V), power supply [6 V D.C.], rheostat, resistance (R) to limit the current in the circuit, connecting wires, etc.

Circuit Diagram:



Observation Table :

1) L.C. of voltmeter = ... V
2) L C. of milliammetre = ... mA

Obs. No.	Voltage V (in volt)	Current I (in mA)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Graph :-

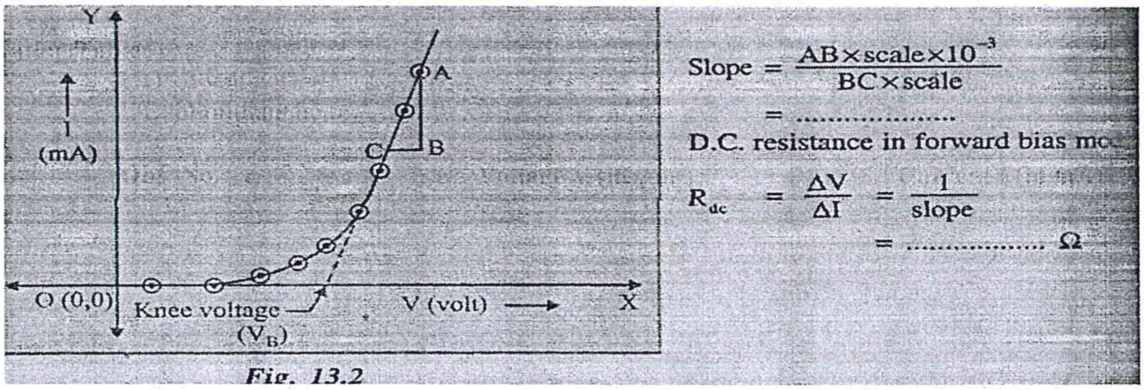


Fig. 13.2

Experiment No. 12

P-N Junction Diode

Aim : To draw the I-V characteristics curves of a p n junction diode in forward bias and reverse bias.

(A) Forward bias

Apparatus : PN Junction diode [DR 25 or AC 127, BY 126 transistor with collector removed], D.C. milliammeter (0 — 25 mA), D.C. voltmeter (0 — 10 V), power supply [6 V D.C.], rheostat, resistance (R) to limit the current in the circuit, connecting wires, etc.

Procedure :

(1) Keeping plug key open, connect the circuit as shown in Fig. 13.1 for forward bias.
(2) Adjust the rheostat so that the P.D. across the diode would be minimum or zero.
(3) Note down the L.C. of voltmeter and milliametre used.
(4) Close the plug key and note down the reading in voltmeter and milliametre.
(5) Increase the P.D. across the diode gradually and note down the corresponding readings shown by voltmeter and milliametre in each case
(6) Take at least ten readings.
(7) Plot a graph of current (I) versus voltage (V) applied. It is a curve as shown in
(8) Determine the knee voltage from graph.

(B) Reverse bias

Apparatus : Microammeter, 150 volt power supply.

Procedure :-

(1) Connect the circuit shown in Fig 13.3 for reverse bias. Make sure that the positive to of the battery is connected to the N-type section and negative terminal of the battery connected to the P-type section of the P-N junction diode.
(2) In this case microammeter is used in place of milliameter and a power supply of 150 volt place of 6 volt battery, as the electric current during the reverse bias is very small.
(3) Determine the least count of microammeter and voltmeter used.
(4) Starting from the zero value of reverse bias, increase the reverse voltage in step of 15 and record the observations of the micrometre till a particular reverse voltage at w current will rise very abruptly. This voltage at which the current increases at very high pace is called break-down voltage.
(5) Record the observations in a tabular form and plot a graph between voltage and current shown in Fig. 13.4. Determine the knee voltage from graph.

Result :-

(1) The nature of the I-V characteristic curves of a p - n junction diode in forward bias reverse bias are as shown in Fig. 13.2 and 13.4 respectively.
(2) D.C. resistance in forward bias mode, R_{dc} = ...Ω
(3) Knee voltage for forward bias = V_B = ... volt.
(4) Knee voltage for reverse bias = V_B = ... volt

Precautions :-

(1) To avoid unnecessary heating, keep the circuit on only at the time of observation.
(2) Don't apply a large D.C. voltage across the diode during forward bias.
(3) Connect the terminals of the meters properly.
(4) The readings should be taken starting from zero potential difference across the diode.
(5) The voltmeter used in this experiment must have high resistance.

(B) Reverse bias

Apparatus : Microammeter, 150 volt power supply,

Circuit Diagram :

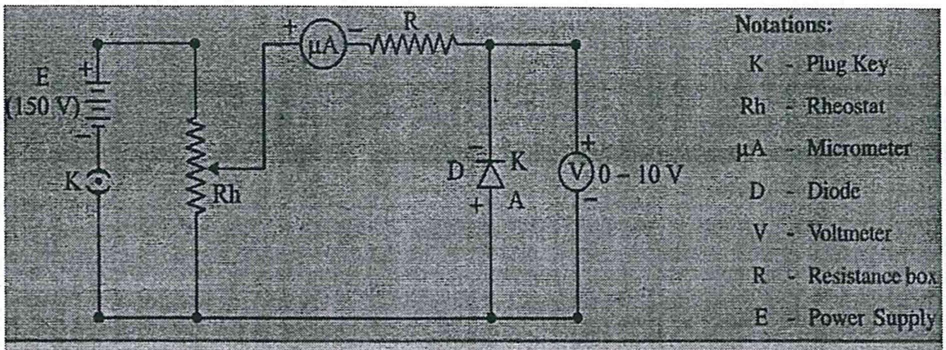


Fig. 13.3

Observation Table :

(1) L.C. of micrometre = ...μA

(2) L.C. of voltmeter = ...volt

Obs. No.	Voltmeter reading V(in volts)	Current I (in μA)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

Graph :-

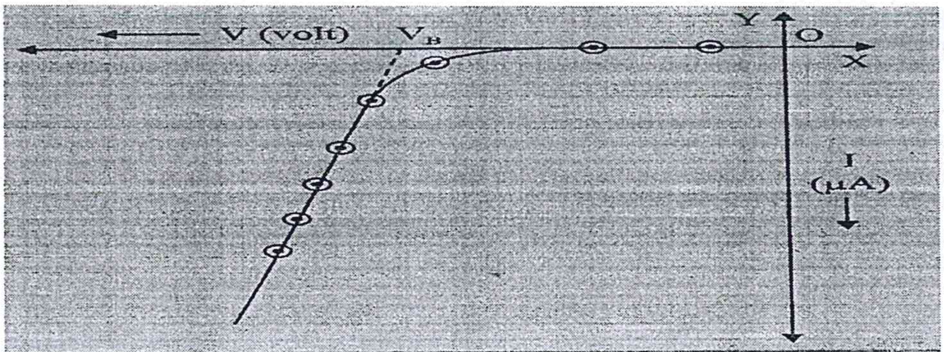


Fig. 13.4

Result :-

(1) The nature of the I-V characteristic curves of a p - n junction diode in forward bias reverse bias are as shown in Fig. 13.2 and 13.4 respectively.

(2) D.C. resistance in forward bias mode, R_{dc} = ...Ω

(3) Knee voltage for forward bias = V_B = ... volt.

(4) Knee voltage for reverse bias = V_B = ... volt

Experiment No. 13

Transistor Characteristics

Aim :- To study the characteristics of a common emitter npn or pnp transistor and to find out the values of current and voltage gain

Apparatus :-Two dc power sources (5V and 15 V), pnp transistor, dc microammeter (0-100μA), dc milliammter (0-10mA), resistances (10 kΩ, 1k Ω, 2.2kΩ ,220 Ω), variable resistors (commonly known as potentiometers) (100 Ω,1k Ω,10k Ω), a digital multimeter (DMM), connecting wires, etc.

Formulae :-

(1) Current gain $= \beta = \frac{\Delta I_C}{\Delta I_B}$

Circuit Diagram :

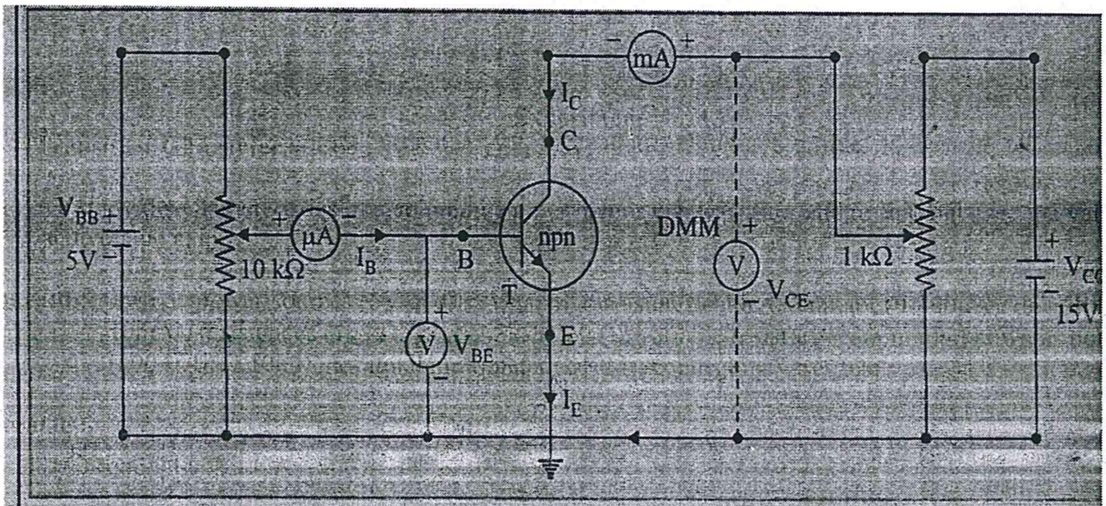


Fig. 14.1 Transistor characteristics in CE mode

Notations :

T	-	npn transistor
B.C.E.	-	Base, Collector, Emitter
V_{BB}	-	Base-emitter bias
V_{CC}	-	Collector – base bias
V_{BE}	-	Base potential
V_{CE}	-	Collector potential
I_B	-	Base current
I_C	-	Collector current
I_E	-	Emitter current

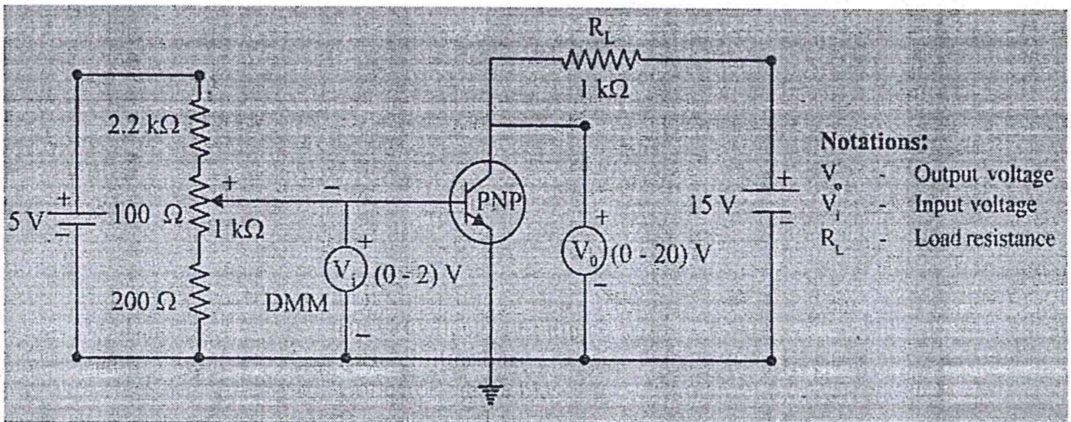


Fig. 14.2 Transistor amplifier in C-E mode

Experiment No. 13

Transistor Characteristics

Aim :- To study the characteristics of a common emitter npn or pnp transistor and to find out the values of current and voltage gain

Apparatus :-Two dc power sources (5V and 15 V), pnp transistor, dc microammeter (0-100μA), dc milliammter (0-10mA), resistances (10 kΩ, 1k Ω, 2.2kΩ ,220 Ω), variable resistors (commonly known as potentiometers) (100 Ω,1k Ω,10k Ω), a digital multimeter (DMM), connecting wires, etc.

Formulae :-

(1) Current gain $= \beta = \frac{\Delta I_C}{\Delta I_B}$

(2) Voltage gain $= Av = \frac{V_o}{V_i} = \frac{\Delta I_C R_L}{\Delta I_B R_i} = \beta \frac{R_L}{R_i}$

Procedure :-

(I) Input characteristics:

(1) Connect the circuit as shown in Fig. 14.1.
(2) Keep voltage V_{CE} to some fixed value. (Say $V_{CE} = 5V$)
(3) Using input potential divider vary VBE in small steps and note down the values of V_{BE} and I_B in each case.
(4) Repeat steps (2) and (3) for one more value of V_{CE}. (Say V_{CE} - 10 V).
(5) Plot a graph of I_B versus V_{BE} (Fig. 14.3) for each case, on the same graph paper.
(6) Determine the slope of the graph in linear portion for each case which will be input resistance R_i

(II) Output characteristics.

(1) Using the same circuit as in Fig. 14.1 adjust the input potential divider so that input current I_B is fixed at some suitable value (Say $I_B = 25\ \mu A$).
(2) Varying the value of V_{CE} in small steps, note down the values of I_c and V_{CE}.
(3) Repeat the same procedure by increasing IB in suitable step for two more values of I_B. (Say $I_B = 50\ \mu A$ and $75\ \mu A$).
(4) Plot the graph of Ic versus VcE (Fig. 14.4) on the same graph paper.
(5) Calculate the current gain (β) from the graph.

(III) Voltage gain:

(1) Connect the circuit as shown in Fig. 14.2 Note the value of R_L.
(2) Varying the input voltage in small steps, note down the output voltage V_0 corresponding to input voltage V_i,.
(3) Plot a graph of V_0 against V_i (Fig. 14.5).
(4) Find the slope of the graph in linear portion, which will give voltage gain.
(5) Compare it with the theoretical value $A_v = \beta \frac{R_L}{R_i}$

Result :-

(1) Input resistance, R_i = ... Ω
(2) Current gain, β = ...
(3) Voltage gain, A_v = ...(by graph)
= ....(by calculation)

Precautions :

(1) The collector voltage should not exceed the breakdown voltage of the junction.
(2) Heating of the transistor should be avoided.
(3) Note electric currents and voltages should be measured carefully.
(4) The polarities of power supply and meters should be properly connected.
(5) Do not pass large input current.

Observation Table :

(I) For Input characteristics :

Obs. No.	$V_{CE} = 5$ volt		$V_{CE} = 10$ V	
	V_{BE} (volt)	I_B (μA)	V_{BE} (volt)	I_B (μA)
1.				
2				
3.				
4.				
5.				
6.				
7.				
8.				

(II) For Output characteristics :

Obs. No.	$I_B = 25$mA		$I_B = 50$mA		$I_B = 75$mA	
	V_{CE} (volt)	I_C (mA)	V_{CE} (volt)	I_C (mA)	V_{CE} (volt)	I_C (mA)
1.						
2						
3.						
4.						
5.						
6.						
7.						
8.						

(III) For Voltage gain of transistor amplifier :

Obs. No.	Input voltage V_1 (volt)	Output voltage V_0(volt)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

Graphs :

(1) Input characteristics:

Plot a graph of base current I_B(on Y-axis) against base emitter voltage V_{BE} (on Y-axis) for two different values of V_{CE}

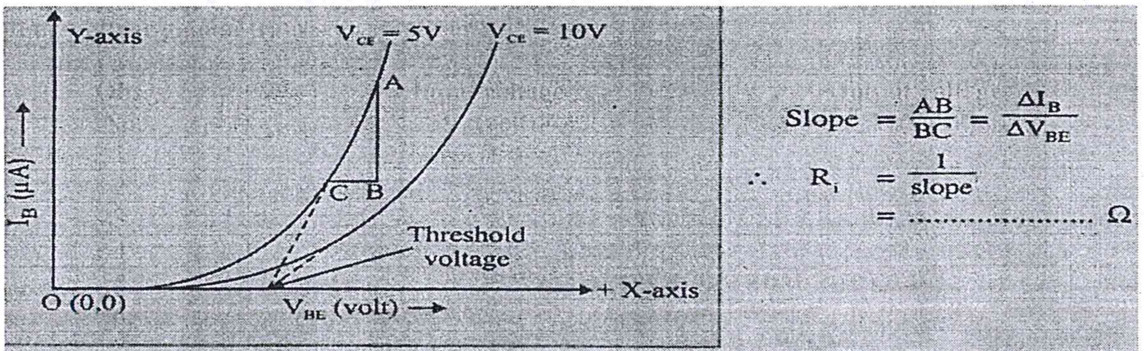


Fig. 14.3 Input characteristics

R.H.S.

(2) Output characteristics :

Plot a graph of I_c(on Y-axis) against V_{CE} (on X-axis) for three different constant values of I_B

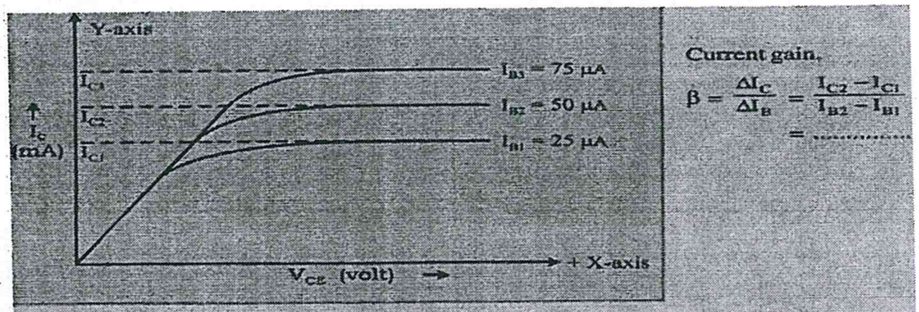


Fig. 14.4 Output characteristics

(3) **Voltage gain :** Plot a graph of output voltage V_0 (on Y-axis) against input voltage V_i (on X-axis), find the slope in linear portion .

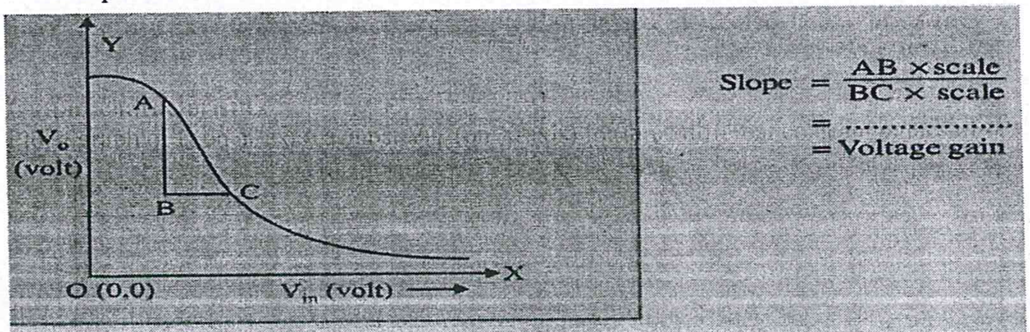


Fig. 14.5 Transfer characteristics

Calculation :-

(1) Input resistance (R_i)

From graph of input characteristics

Slope $= \left(\frac{\Delta I_B}{\Delta V_{BE}}\right) V_{CE=5\ volt}$

= ....

$\therefore$ Input resistance, $R_i = \frac{1}{Slope} = \frac{1}{..............}$

= ....Ω

(2) Current gain(β) :

From graph of output characteristics for fixed value of V_{CE}, find out the values of I_{c1}, I_{c2} corresponding to I_{B1} and I_{B2}

Current gain $\beta = \frac{\Delta I_C}{\Delta I_B}$

$= \frac{I_{C_2} - I_{C_1}}{I_{B_2} - I_{B_1}} = \frac{..........................}{....................}$

$= \frac{..........................}{....................}$

(3) Voltage gain (A_v) :

(i) From the graph of V_0 against Vi find the slope in linear portion

$\therefore$ Voltage gain $= \frac{V_0}{V_i}$

= Slope in linear portion

= ....

(ii) Theoretical value of voltage gain :

$A_v = \beta \frac{R_L}{R_i}$

Here, R_L = ...kΩ

R_i = ...Ω

β = ...

$\therefore A_v = \beta \frac{R_L}{R_i}$ = ...× $\frac{..................}{..................}$

Result :-

(1) Input resistance, R_i = ... Ω

(2) Current gain, β = ...

(3) Voltage gain, A_v = ...(by graph)

= ....(by calculation)

R.H.S.

Experiment No. 14

Characteristics Of Zener Diode

Aim : To draw the characteristics curve of Zener diode and to determine its reverse breakdown voltage.

Apparatus : Zener diode, D.C. power supply (0 to 9V) voltmeter, potentiometer (0 to 10 kΩ) microammeter (0 to 500 μA), rheostat, one way key,connecting wires, etc.

Circuit Diagram:

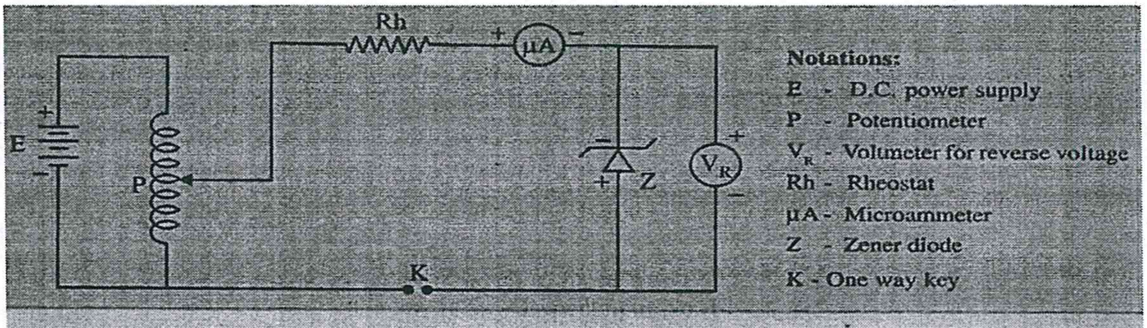


Fig. 15.1

Observations:

(1) L.C. of voltmeter = ... V

(2) L.C. of microammeter = ... μA

Observation Table :-

Obs. No.	Voltmeter reading V_R volt	Reverse current I_R in	
		μA	A
1.	0.0		
2.	0.5		
3.	1.0		
4.	1.5		
5.	2.0		
6.	2.5		
7.	3.0		
8.	3.5		
9.	4.0		
10.	4.5		
11.	5.0		
12.	5.5		
13.	6.0		
14.	6.5		
15.	7.0		
16.	7.5		
17.	8.0		
18.	8.5		
19.	9.0		
20.	9.5		
21.	10.0		
22.	10.5		
23.	11		
24.	11.5		
25.	12		

Experiment No. 14

Characteristics Of Zener Diode

Aim : To draw the characteristics curve of Zener diode and to determine its reverse breakdown voltage.

Apparatus : Zener diode, D.C. power supply (0 to 9V) voltmeter, potentiometer (0 to 10 kΩ) microammeter (0 to 500 μA), rheostat, one way key,connecting wires, etc.

Procedure :

(1) Note the L.C. of micrometer and voltmeter.
(2) Make the connections as shown in Fig. 15.1 for reverse bias.
(3) Using potentiometer increase the supply voltage in steps of 0.5 V. Note the corresponding voltage 'V_R' and current 'I_R'.
(4) Repeat step (3) till the breakdown of Zener diode occurs i.e. current I_R suddenly increases even if reverse voltage V_R is kept constant.
(5) This reading of voltmeter is known as zener breakdown voltage V_Z
(6) Plot the graph of reverse current I_R (on —ve Y-axis) against the corresponding reverse voltage V_R (on —ve X-axis) applied, it is a curve as shown in graph. From graph find the breakdown voltage V_z of Zener diode.

Result:

(1) Characteristics of Zener diode is as shown in graph (Fig 15.2).
(2) Reverse breakdown voltage for a given zener diode, V_z = ...volt.

Precautions:

(1) Identify the anode and cathode of the Zener diode correctly.
(2) Connect the voltmeter microammeter and zener diode with polarity as shown in circuit diagram.
(3) All connections should be tight.
(4) Use proper D.C. power supply
(5) Increase reverse voltage gradually.
(6) The reverse voltage across the zener diode should not exceed the rated breakdown voltage of the diode by more than 5%.

Graph:

Plot a Graph of V_R (on ve X-axis) against I_R (on —ye Y-axis). The nature of graph is as shown in Fig. 15.2

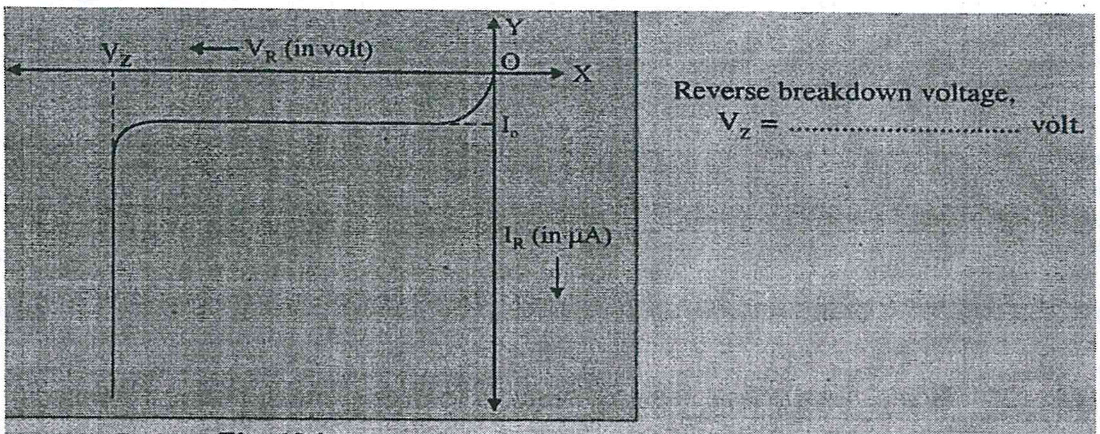


Fig. 15.2

Result:

(1) Characteristics of Zener diode is as shown in graph (Fig 15.2).
(2) Reverse breakdown voltage for a given zener diode, V_z = ... volt.

Activity – 1

Aim :- To study the dissipation of energy of a simple pendulum by plotting a graph between square o amplitude and time.

Apparatus : A pendulum bob, a split cork, thread, retort stand, stopwatch, meter scale, etc.

Formulae:

(1) $F = \frac{-mg}{l}x.$ where, F = Force acting on a pendulum

$\therefore F = -kx$ x = Displacement from mean position

$\therefore k = \frac{mg}{l}$ l = Length of pendulum

m = Mass of bob, k = Force constant

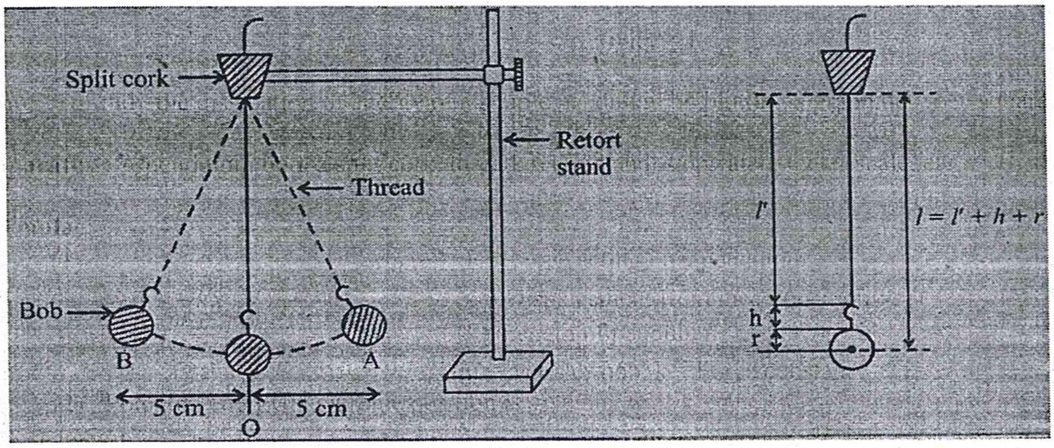
(2) Potential energy at extreme position is given by

$E_0 = \frac{1}{2} k A_0^2$ where, k = Force constant.

A_0 = Maximum displacement from mean position

(3) Energy dissipation, $E = E0 - E' = \frac{1}{2}k[A_0^2 - A^2]$ joule

Diagram:



Observations:

(1) Mass of the bob = m = ... g = ...$\times 10^{-3}$ kg
(2) L.C. of vernier callipers = ... cm
(3) Diameter of the bob = d = ...cm .
$\therefore$ Radius of bob = r =.................................... cm
(4) Least count of the stopwatch =......................sec.
(5) Effective length of the pendulum = l =....................... cm =.................. m
(6) Acceleration due to gravity, g = 9.8 m/s^2
(7) Force constant $k = \frac{mg}{l}$ = ...Nm^{-1}
(8) Initial amplitude, A_0 = ... cm
(9) Maximum energy, $E_0 = \frac{1}{2} k A_0^2$ ... ... joule.

Observation Table : For dissipation energy:

Obs. No.	Time t sec	Amplitude (A) cm^2	A^2 cm^2	$E = \frac{1}{2} kA^2$ joule	Energy dissipation $E = (E_0 - E)$ joule
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

Activity – 1

Aim :- To study the dissipation of energy of a simple pendulum by plotting a graph between square o amplitude and time.

Apparatus : A pendulum bob, a split cork, thread, retort stand, stopwatch, meter scale, etc.

Formulae:

(1) $F = \frac{-mg}{l}x.$ where, F = Force acting on a pendulum

$\therefore F = -kx$ x = Displacement from mean position

$\therefore k = \frac{mg}{l}$ l = Length of pendulum

m = Mass of bob, k = Force constant

(2) Potential energy at extreme position is given by

$E_0 = \frac{1}{2} k A_0^2$ where, k = Force constant.

A_0 = Maximum displacement from mean position

(3) Energy dissipation, $E = E0 - E' = \frac{1}{2}k[A_0^2 - A^2]$ joule

Procedure:

(1) Determine mass (m) of bob with the help of physical balance. Also measure diameter of bob of pendulum using vernier callipers.
(2) Take 150 cm long thread and tie bob to one end of the thread and pass the other end of thread through the split cork. Adjust the length of pendulum at 100 cm. Arrangement of experiment is as shown in Fig. A (1.1).
(3) Place meter scale behind the bob so that a full scale division lies at the centre of the bob.
(4) Find the least count of stopwatch. Bring its second hand at zero position.
(5) Displace the bob 5 cm away from the rest position (i.e. mean position). Set it for vibrating about the mean position and you will observe that its amplitude decreases as the time passes.
(6) Again take the bob along the meter scale of 5 cm away from the rest position 0 and release it so that it vibrate in the vertical plane.
(7) Start the stopwatch when the bob reaches to the extreme position and record this time as zero.
(8) Measure the amplitude of oscillation after every 20 second with the help of meter scale.
(9) Take at least 10 observations and record all observations in the table.
(10) Plot graph of amplitude square (A^2) on Y-axis against time (t) on X-axis. The graph shows dissipation of energy of simple pendulum with time,

Conclusion :

(1) Energy of simple pendulum is directly proportional to the square of amplitude, i.e. $E \propto A^2$
(2) Graph shows that square of amplitude decays with time and hence energy of pendulum dissipates with time.

Precautions :

(1) Amplitude should be small.
(2) Vibrations of pendulum should be in vertical plane.
(3) Length of pendulum should be sufficiently long.
(4) Pointer should be attached to the centre of the bob.

Calculation :

$$E = \frac{1}{2} k A^2$$

Graph :

Plot a graph between square of amplitude (A2) and time (t) taking t along X-axis and A2 along Y-axis. The graph shows dissipation energy of simple pendulum with time. [Fig. A (1.2)]

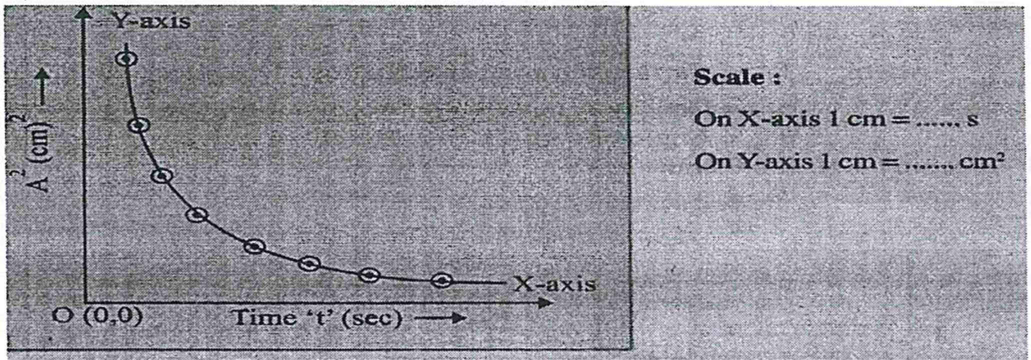


Fig. A(1.2)

Conclusion :

(1) Energy of simple pendulum is directly proportional to the square of amplitude, i.e. $E \propto A^2$

(2) Graph shows that square of amplitude decays with time and hence energy of pendulum dissipates with time.

R.H.S.

Activity – 2

Aim : To study the effect of detergent on surface tension by observing capillary rise.

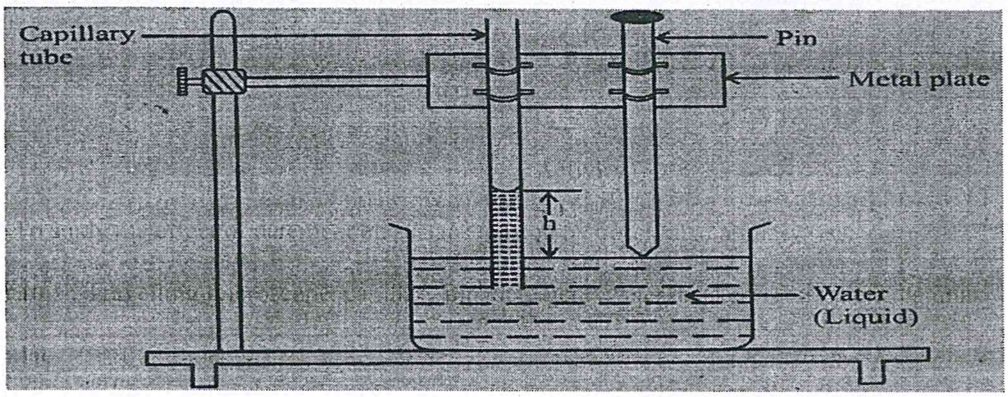
Apparatus : Travelling microscope, capillary pin, detergent, water, beaker, retort stand, capillary clamp with pointer.

Formulae :

1) $T = \frac{hr\rho g}{2\cos\theta}$ where, T = Surface tension, r = Radius of capillary tube
ρ = Density of liquid, g = Acceleration due to gravity
θ = Angle of contact, h = Height of liquid rise in capillary

2) $T \propto h$ (keeping r, g, and θ constant)

Diagram :



Observation Table :-

Obs. No.	Reducing For	Mass of detergent added 'm' g	Travelling microscope reading at		Rise of liquid in capillary tube (X-Y) cm
			Meniscus 'X' cm	Tip of the index pin 'Y'cm	
1.	Distilled water	0			h = ...
2.	Dilute detergent solution				h_1 = ...
3.	Concentrated detergent solution				h_2 = ...

Conclusion :

(1) The capillary rise decreases with addition of detergent in water.
(2) The addition of detergent in water reduces the surface tension, as it is directly proportional to capillary rise.

Activity – 2

Aim : To study the effect of detergent on surface tension by observing capillary rise.

Apparatus : Travelling microscope, capillary pin, detergent, water, beaker, retort stand, capillary clamp with pointer.

Formulae :

(1) $T = \frac{hr\rho g}{2\cos\theta}$ where, T = Surface tension , r = Radius of capillary tube
ρ = Density of liquid, g = Acceleration due to gravity
θ = Angle of contact, h = Height of liquid rise in capillary

(2) $T \propto h$ (keeping r, g, and θ constant)

Procedure :

(1) Set up the apparatus as in Experiment No. 3.
(2) Measure the rise of pure distilled water (h) through the capillary tube as in the Experiment No.3.
(3) Dissolve a known mass of detergent in the water. Find the rise of the solution (h_1) in s capillary tube. The rise will be less than that for pure water.
(4) Add double mass of detergent in same volume of water so as double concentration of solution is formed.
(5) Find the rise of the concentrated solution (h_2) in same capillary tube. The rise will be still lesser.
(6) Repeat the experiment with higher concentration solution of same detergent it will observe that rise decreases with increase in concentration.

Conclusion :

(1) The capillary rise decreases with addition of detergent in water.
(2) The addition of detergent in water reduces the surface tension, as it is directly proportional to capillary rise.

Activity 3

Aim : To study the effect of load of depression of a suitable clamped meter scale loaded (i) at its end (ii) in the middle.

Apparatus : A uniform wooden meter scale, G-clamp, pointer, pin, slotted weights of 50 gm each, vertical scale, clamp stand, thread, wax, etc.

Formula:

Depression δ produced in the rod of length l is given by

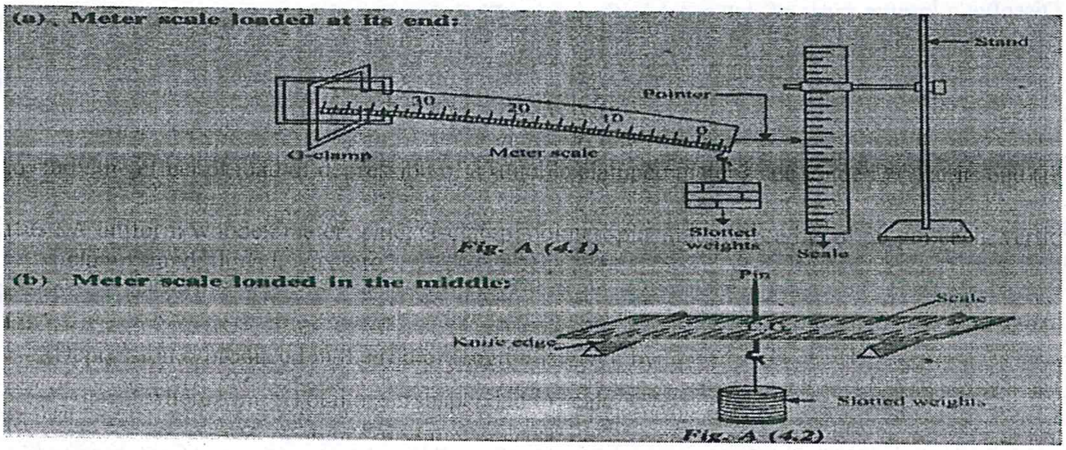
$\delta = \frac{mgl^3}{4Ybd^3}$ where, m = Total mass suspended to scale,

Y =Young's modulus of scale

b = breadth, d = depth.

For given scale $\delta \propto$ mg, i.e. depression is directly proportional to the load (weight) suspended from one end.

Diagram:



Observation Table:

(A) Load suspended at one end of meter scale:

Initial reading of pointer on vertical scale without loading at free end = x_0 =...... cm.

Obs. No.	Load suspended M(gm wt.)	Vertical scale reading (cm)			Depression $\delta = (x_0 - x)$ cm
		Loading (x_1)	Unloading (x_2)	Mean $x = \frac{x_1+x_2}{2}$	
1.	50				
2.	100				
3.	150				
4.	200				
5.	250				

(B) **Load suspended at the middle :**

Initial reading of pointer on vertical scale without loading in the middle = x_0 =...... cm.

Obs.No.	Load suspended M(gm wt.)	Vertical scale reading (cm)			Depression $\delta = (x_0 - x)$
		Loading (x_1)	Unloading (x_2)	Mean $x = \frac{x_1+x_2}{2}$	
1.	50				
2.	100				
3.	150				
4.	200				
5.	250				

Activity 3

Aim : To study the effect of load of depression of a suitable clamped meter scale loaded (i) at its end (ii) in the middle.

Apparatus : A uniform wooden meter scale, G-clamp, pointer, pin, slotted weights of 50 gm each, vertical scale, clamp stand, thread, wax, etc.

Formula:

Depression δ produced in the rod of length l is given by

$\delta = \frac{mgl^3}{4Ybd^3}$ where, m = Total mass suspended to scale,

Y =Young's modulus of scale

b = breadth, d = depth.

For given scale $\delta \propto$ mg, i.e. depression is directly proportional to the load (weight) suspended from one end.

Procedure:

(A) When meter scale loaded at its end:

(1) Clamp the meter scale in a given clamp at its ends on the corner of table, such that meter scale remains horizontal [Fig. A(4.1)].
(2) Pointer or needle is attached at free end of meter scale.
(3) Fix the vertical scale to a stand.
(4) Note the initial reading on vertical scale corresponding to the tip of the pointer when no weight is suspended.
(5) Suspend the hanger of slotted weights at the free end of meter scale and note the corresponding reading on the vertical scale.
(6) Take five sets of observations. Then start unloading the weights and again note the readings on the scale. Hence find the depression (δ) in each case.

(B) When Meter scale is loaded in the middle:

a. Locate the C.G of meter scale and pointer is attached at the midpoint of the scale with the help of wax.
b. Now place the meter scale on two knife edges such that the distance between the knife edges is about 85 cm [Fig. A(4.2)].
c. Meter scale should be in horizontal plane.
d. Focus the microscope on the tip of the pin. Place the hanger on the lower side. Adjust the position of the microscope so that the image of the tip is at the crossing point of crosswire. Note the reading.
e. When load M is placed on the hanger, the bar is bent at the centre and pin attached is also lowered.
f. Adjust the microscope on the image of pin as before and note the reading. Repeat procedure by adding weights in the step of 50 g.
g. Take five sets of observations. Then start unloading the weights and again note th corresponding readings.
h. Find depression (δ) in each case.

Conclusion :

The graph between load and depression is a straight line passing through origin which indicates that depression is directly proportional to the load i.e. $\delta \propto$ mg

Precautions :

(1) The metre scale should be uniform.
(2) Tip of pointer should not touch to vertical scale.
(3) Elastic limit of scale should no be exceeded.
(4) Reading on meter scale should be taken carefully.

Graph :

Plot a graph between load and depression(δ)against load (M) as shown in Fig A(4.3)

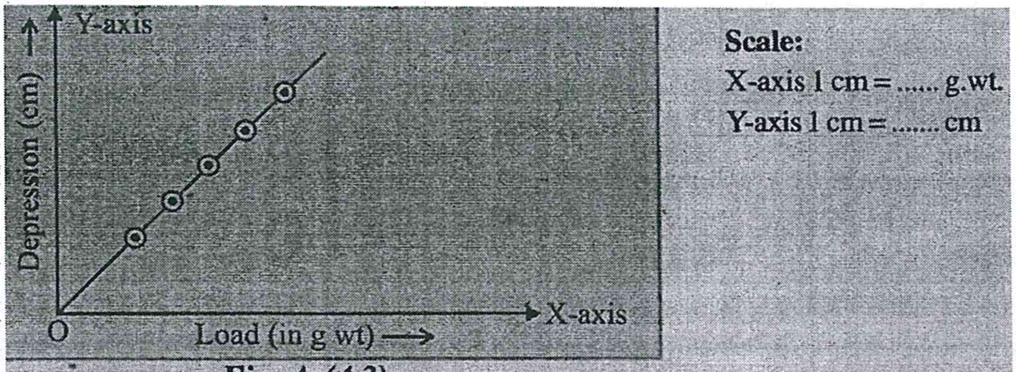


Fig. A (4.3)

Conclusion :

The graph between load and depression is a straight line passing through origin which indicates that depression is directly proportional to the load i.e. $\delta \propto mg$

R.H.S

Activity – 4

Aim : To study the variation in potential drop with length of a wire for a steady current.

Apparatus: A potentiometer, a battery eliminator of range 0 to 6 V, rheostat, voltmeter, ammeter, one way key, connecting wires, etc.

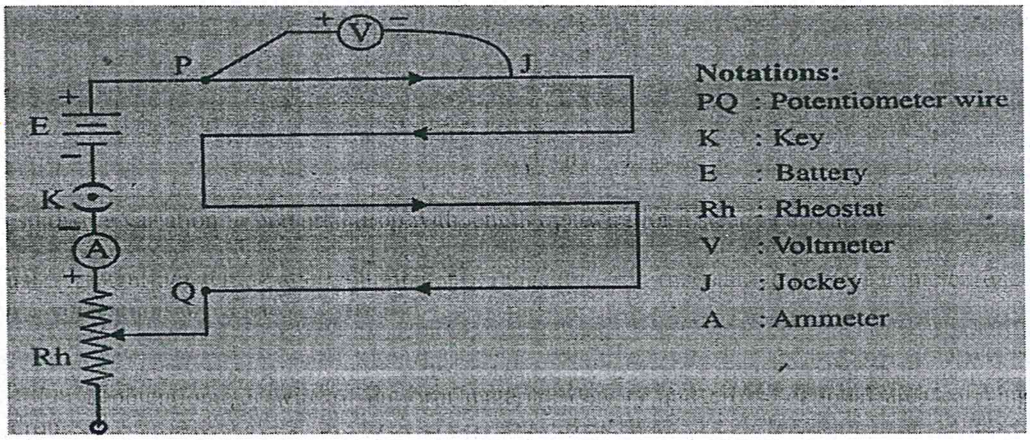
Formula:

For a potentiometer wire of uniform material, density and cross sectional area carrying a steady current, potential drop,

$V \propto l$

i.e. $V = \frac{\rho I l}{A}$

Circuit Diagram:



Observation :
The least count of voltmeter = ...volts.

Observation Table : For potential with length :

Obs. No.	Length of potentiometer wire l(cm)	Reading of voltmeter V(volt)	Ratio $\left(\frac{V}{l}\right)$
1.	50		
2.	100		
3.	150		
4.	200		
5.	250		

Calculation :-

$= \frac{V}{l} =$ .... V/cm. Calculate for each case.

Graph :

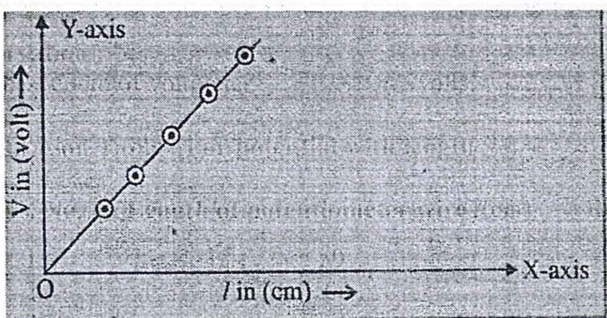


Fig. A (6.2)

Plot a graph of potential drop and leng
of the potentiometer wire. The graph
straight line as shown in Fig. A (6.2)

Scale:

X-axis 1 cm = ... cm

Y-axis 1 cm = ... volt.

Activity – 4

Aim : To study the variation in potential drop with length of a wire for a steady current.

Apparatus: A potentiometer, a battery eliminator of range 0 to 6 V, rheostat, voltmeter, ammeter, one way key, connecting wires, etc.

Formula:

For a potentiometer wire of uniform material, density and cross sectional area carrying a steady current, potential drop,

$V \propto l$

i.e. $V = \frac{\rho I l}{A}$

Procedure:

(1) Make the connections which are as shown in Fig. A (6.1)

(2) Connect the positive terminal of voltmeter to the end P and the negative terminal of t voltmeter to a jockey i.e. slide along the wire of the potentiometer.

(3) Place and touch the jockey at 50 cm mark on the wire PQ and note the voltmeter readings

(4) Now keep the jockey at the different lengths of wire away from its first end P. Note readings of voltmeter by touching the jockey at 100, 150, 200 and 250 cm length on potentiometer wire.

Conclusion :-

(1) From the observation table, since the ratio $\left(\frac{V}{l}\right)$ is almost constant known as potential gradient i.e. potential drop per unit length, for all readings, it implies that $V \propto l$

(2) From the graph, we conclude that the potential drop along the length of wire is directly proportional to the length of wire.

Conclusion :-

(1) From the observation table, since the ratio $\left(\frac{V}{l}\right)$ is almost constant known as potential gradient i.e. potential drop per unit length, for all readings, it implies that $V \propto l$

(2) From the graph, we conclude that the potential drop along the length of wire is directly proportional to the length of wire.

R.H.S.

Activity – 5

Aim : To draw the diagram of a given open circuit comprising at least a battery resistor/ rheostat, key, ammeter and voltmeter. Mark the components that are not connected in proper order and correct the circuit and also the circuit diagram.

Apparatus : A battery/cell/ power supply, a resistance, a rheostat, a milliammeter (0-500mA), a voltmeter (0-10 V), a plug key, connecting wires, etc.

Circuit Diagram:

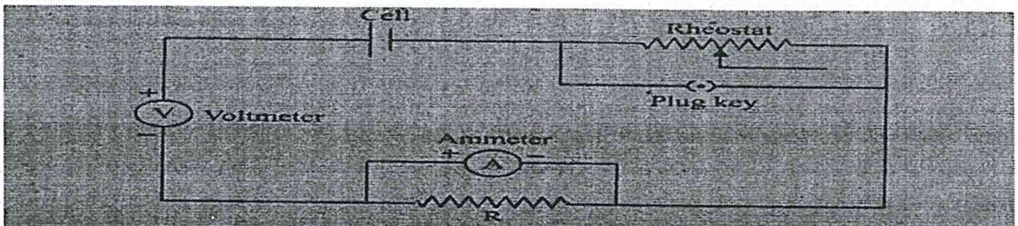


Fig. A (7.1) Given Open (faulty) circuit diagram

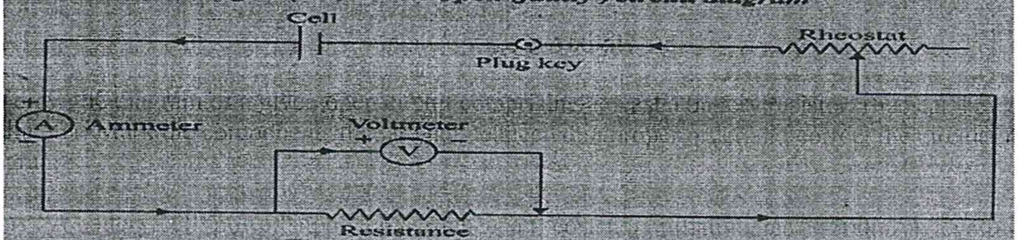


Fig. A (7.2) Correct circuit diagram

Observation :

After careful observation it is found that

Observations	Corrections
(1) Voltmeter is connected in series.	(1) Voltmeter should be connected in parallel across the resistance
(2) Ammeter is connected in parallel across the resistance.	(2) Ammeter should be connected in series.
(3) Plug key is in parallel across the rheostat.	(3) Plug key should be connected in series.
(4) Variable terminal of rheostat is not used or connected	(4) One fixed and other variable terminal should be connected.
(5) Direction of current not shown	(5) Direction of current should be shown properly.

Conclusion :-

The correct electric circuit diagram is obtained as shown in Fig. A (7.2)

Activity – 5

Aim : To draw the diagram of a given open circuit comprising at least a battery resistor/ rheostat, key, ammeter and voltmeter. Mark the components that are not connected in proper order and correct the circuit and also the circuit diagram.

Apparatus : A battery/cell/ power supply, a resistance, a rheostat, a milliammeter (0-500mA), a voltmeter (0-10 V), a plug key, connecting wires, etc.

Procedure :-

(1) Observe the open circuit diagram given to you [Fig. A. (7.1)]
(2) Observe the connections carefully and find out the components which are not connected in proper order.
(3) Mark the components and fault in the components or circuit diagram.

Conclusion :-

The correct electric circuit diagram is obtained as shown in Fig. A (7.2)

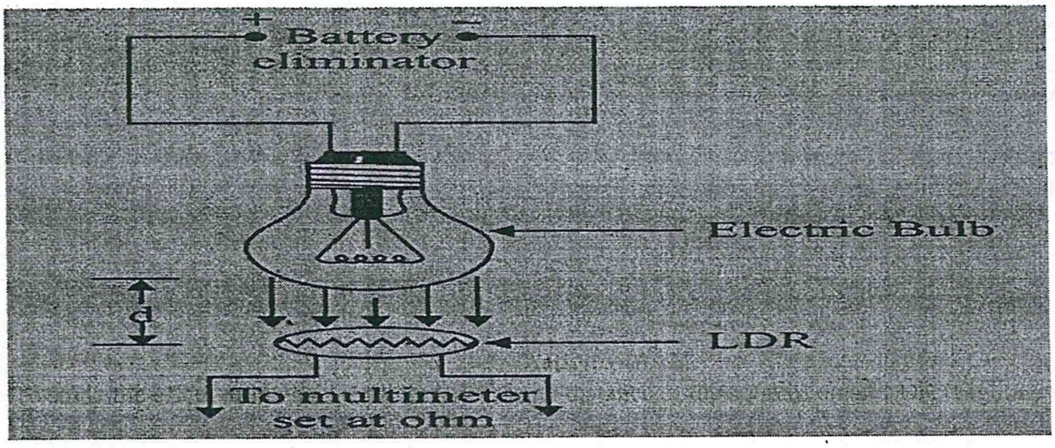
Activity - 6

Aim : To study the effect of intensity of light (by varying distance of the source) on an LDR (Light Dependant Resistor).

Apparatus:

LDR, intense light source (lamp), meter scale, Digital multimeter (DMM).

Circuit Diagram:



Observation Table :-

Obs. No.	Distance between LDR and lamp 'd' cm	d^2 cm^2	$\frac{1}{d^2}$ cm^{-2}	Resistance of LDR R_L kΩ
1.				
2.				
3.				
4.				
5.				

Graph :-

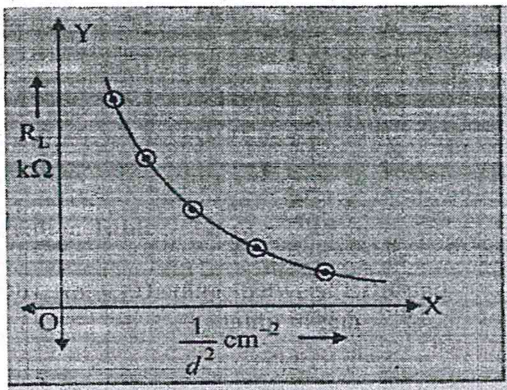


Fig. A (8.2)

Plot a graph of resistance of L.D.R. R_L (on Y-axis) against reciprocal of the square of distance between source of light and LDR, $\frac{1}{d^2}$ (on X-axis). The nature of the graph is as follows:

Conclusion :

(1) As the distance between LDR and source of light (lamp) increases, the resistance of LDR increases.

(2) As the intensity of light varies inversely as the square of distance, the resistance of LDR varies inversely as the intensity of light. i.e. as the intensity of light decreases, the resistance of LDR increases

Activity – 6

Aim : To study the effect of intensity of light (by varying distance of the source) on an LDR (Light Dependant Resistor).

Apparatus : LDR, intense light source (lamp), meter scale, Digital multimeter (DMM).

Procedure:

(1) Take a wooden box in which LDR is mounted in front of hole.
(2) Select the range of measurement of resistance in multimeter (say 20 kΩ).
(3) Connect the probes of DMM to the terminals of the LDR.
(4) Keep the lamp in front of LDR at suitable distance (5 or 10 cm) and make the lamp 'ON'.
(5) Note , the distance 'd' between LDR and lamp. Also note the resistance of 'R_L'LDR by using DMM.
(6) Increase the distance between LDR and lamp in steps of 5 cm / 10 cm and note the corresponding resistance 'R_L' of LDR
(7) Plot a graph of R_L (on Y-axis) versus $\frac{1}{d^2}$ (on X-axis).
(8) Write the conclusion from the graph.

Conclusion :

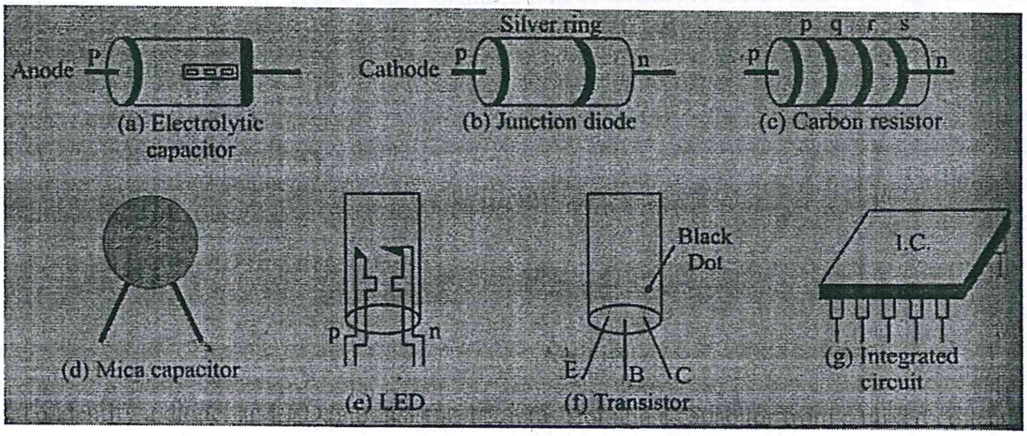
(1) As the distance between LDR and source of light (lamp) increases, the resistance of LDR increases.
(2) As the intensity of light varies inversely as the square of distance, the resistance of LDR varies inversely as the intensity of light. i.e. as the intensity of light decreases, the resistance of LDR increases.

Activity – 7

Aim : To identify a diode, an LED, a transistor, IC, a resistor and a capacitor from a mixed collection of such items.

Apparatus : Collection of components contains IC, resistor, capacitor, a diode, a transistor, etc., multimeter battery eliminator, key, etc.

Diagram:



Conclusion:

No.	Number of terminals	Name of components
1.	Two	Capacitor, Diode LED resistor
2.	Three	Transistor
3.	Four	IC
4.	Flow of current in one direction/emits no light	Diode
5.	Flow of current in one direction /emits light	LED
6.	Both direction flow of current/emits no light	Resistor
7.	Initially larger flow of current but decays to zero and no emission of light	Capacitor

Activity – 7

Aim : To identify a diode, an LED, a transistor, IC, a resistor and a capacitor from a mixed collection of such items.

Apparatus : Collection of components contains IC, resistor, capacitor, a diode, a transistor, etc., multimeter battery eliminator, key, etc.

Procedure:

(1) The component which has two terminals, may be diode or LED or a resistor or a capacitor.
(2) The component which has three terminals and it is not in the form of chip then it is a transistor.
(3) The component which has four or more terminal and flat shape chip, is an integrated circuits (IC).
(4) A resistor can be recognised by the colour bands marked on the item.
(5) A capacitor can be recognised by the positive and negative marked on the item and value capacity with the unit mentioned on it.
(6) LED can be recognised by the transparent coloured plastic envelope and having two unequal and parallel terminals.
(7) A diode can be recognised by the silver ring marked on it, which indicates its N-terminal

OR

To identify a diode, LED, capacitor and resistor, you can use multimeter in the following way

(1) To check whether two terminal component is a diode or a LED, or a resistor or a capacitor connect the battery eliminator, key to the components and the multimeter.
(2) Switch on the circuit.
  (i) If pointer of the multimeter shows deflection when component is in forward biased but it does not show deflection when it is in reverse biased and also does not emit light, the item is a **diode.**
  (ii) If the pointer of multimeter initially shows full deflection but it decays to zero whether it is in forward or reversed biased then the item is a **capacitor.**
  (iii) If the pointer of multimeter shows deflection when it is in forward biased but it does not show deflection in reverse biased and also it emits light, then the component is **LED.**
  (iv) If the pointer of multimeter shows deflection when it is forward or reverse biased the component is a **resistor.**

Conclusion:

No.	Number of terminals	Name of components
1.	Two	Capacitor, Diode LED resistor
2.	Three	Transistor
3.	Four	IC
4.	Flow of current in one direction/emits no light	Diode
5.	Flow of current in one direction /emits light	LED
6.	Both direction flow of current/emits no light	Resistor
7.	Initially larger flow of current but decays to zero and no emission of light	Capacitor

Activity – 8

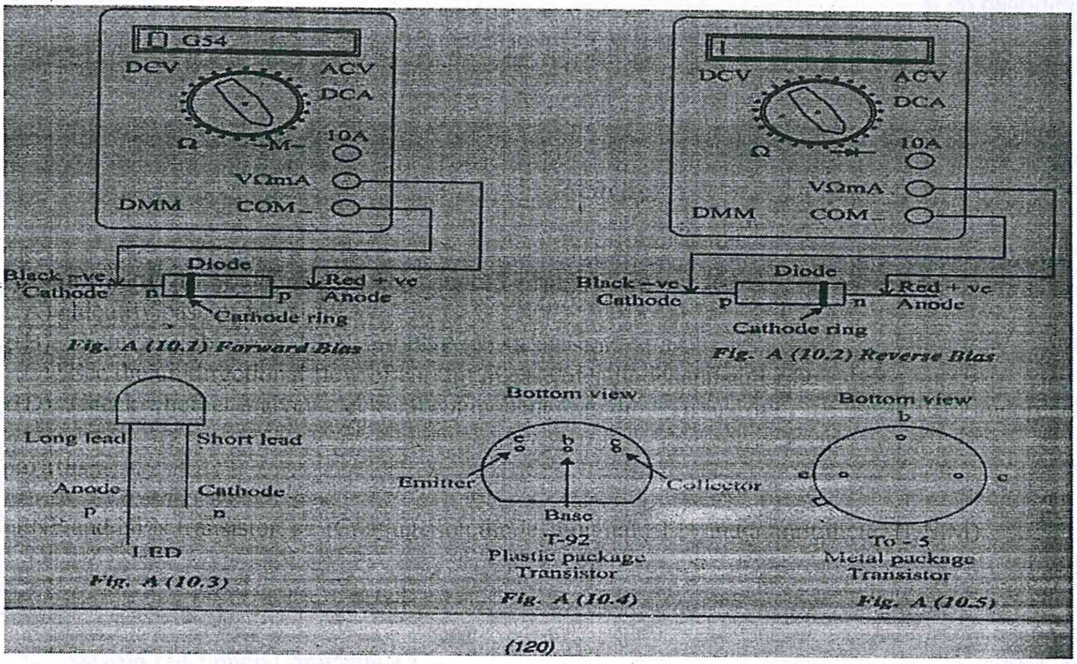
Aim :-

Use of multimeter to

(A) Identify base of transistor
(B) Distinguish between NPN and PNP type transistor
(C) See the unidirectional flow of current in case of a diode, and an LED.
(D) Check whether a given electrical component (e.g. diode, transistor or IC) is in working order.

Apparatus :-

PNP and NPN transistor, an IC, a junction diode, a digital LED and a multimeter (DMM).



Conclusion :-

(1) Base and types of transistor are identified.
(2) Terminals of an IC identified.
(3) Working of a junction diode is checked.

Activity – 8

Aim :-
Use of multimeter to

(A) Identify base of transistor
(B) Distinguish between NPN and PNP type transistor
(C) See the unidirectional flow of current in case of a diode, and an LED.
(D) Check whether a given electrical component (e.g. diode, transistor or IC) is in working order.

Apparatus :

PNP and NPN transistor, an IC, a junction diode,a digital LED and a multimeter (DMM)

Procedure:-

(A) To identify base of a transistor
(B) To distinguished between npn and pnp type transistors

(1) Make sure that red (positive) and black (negative) probes of DMM are in proper positions.
(2) Select the diode, check range of DMM
(3) Connect the positive probe of DMM to the centre terminal of any transistor (npn or pnp).
(4) Connect the negative probe in turn to other two terminals. If both the times forward bias is shown, it is an npn transitor and the centre terminal is 'base' .
(5) If the above condition is not satisfied, repeat with other two terminals until you find the 'base'
(6) If none of the three terminals satisfy the test for 'base' terminal, then this may be a pnp transistor.
(7) Connect the negative probe of DMM to the centre terminal of the trasistor and positive probe of DMM to remaining terminals in turn.
(8) If both the times forward bias is shown, then the selected centre terminal is 'base' and it is the pnp transistor. If the above condition is not satisfied, repeat with other two terminals, until you find the 'base' .

(C) To see the unidirectional flow of current in case of a diode and an LED.

(1) Select the diode-check range of DMM.
(2) Connect the two probes of DMM to the two terminals of a diode/an LED.
(3) **In case of a diode -** When the negative probe of DMM is conected to the cathode (i.e. (n) terminal adjacent to ring marked on diode) it will show forward bias. Thus current flows through diode.
(4) When the DMM probes are interchanged, it will show reverse bias or open circuit. That is, no current flows through diode. Thus there is unidirectional flow of current in a diode.
(5) **In case of an LED -** When positive probe of DMM is connected to anode (long terminal of LED) and negative probe of DMM is connected to cathode (short terminal of LED) DMM will show forward bias. LED lights up indicating flow of current.
(6) When DMM probes are interchanged, DMM will show reverse bias. LED does not light up, indicating no flow of current. Thus, there is unidirectional flow of current in LED.

(D) To check whether a given electronic component (diode, transistor) is in working order.

(1) Test the component using the above procedure.
(2) Diode/LED must satisfy both forward bias and reverse bias tests, then it is in working order.
(3) In case of a transistor, 'base' identification test should be checked, so that it is in working order. If 'base' is not identified, then transistor is not in working order.

Terminology used

a) **Forward Bias:** When positive of DMM is connected to p-terminal and negative of DMM is connected to n-terminal of a component, with selection of diode-check range of DMM, the reading shown in DMM will be between 0.3 V and 0.8 V, indicating forward bias.
b) **Reverse Bias :** When positive of DMM is connected to n-terminal and negative of DMM is connected to p-terminal of a component with selection of diode-check range of DMM, there will be no reading shown in DMM. It will indicate open circuit by vertical line(I) which is revers bias.
c) **npn transistor :-** When positive probe of DMM is connected to base terminal and negative probe of DMM is connected to either collector terminal or emitter terminal, it will show forward bias.
d) **Pnp transistor :-** When negative probe of DMM is connected to base terminal and positive probe of DMM is connected to either collector terminal or emitter terminal, it will show forward bias.

Conclusion :-

(1) Base and types of transistor are identified.
(2) Terminals of an IC identified.
(3) Working of a junction diode is checked.

Demonstration Experiments
Demonstration – I

Objective :-

To demonstrate the fact that for a metallic wire of uniform material density and thickness (area of cross section), the resistance increases directly as its length.

Apparatus :-

Resistance wire of uniform material density and thickness, metre scale, resistance measuring instruments (multimeter, etc.)

Formula :

For a resistance wire,

$R = \frac{\sigma l}{A}$ i. e. $R \propto l$

(For same material density, (σ)and cross- section area, A)

Observation Table :-

Obs. No.	Length (cm)	Resistance
1.	25	
2.	50	
3.	75	
4.	100	
5.	125	

Procedure :

(1) Take metallic wire pieces of the same material, density and same thickness.--
(2) Arrange the wires with increasing in length i.e. 25 cm, 50cm, 75 cm, 100cm, 125cm.
(3) Measure the resistance of each wire and note down in table.

Conclusion :

Resistance or wire increases in direct proportion to its length.
i.e. $R \alpha l$

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(1) Take metallic wire pieces of the same material, density and same thickness.--

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(3) Measure the resistance of each wire and note down in table.

Conclusion :

Resistance or wire increases in direct proportion to its length.

i.e. $R \alpha l$

Demonstration Experiments
Demonstration – II

Objective :-

To verify the truth table of logic gate

Apparatus :-

Power supply, Ic 7400,7402,7408,7432,7486, 2 LED s wire etc.

Formula :

$Y = \overline{A}$ (Not) gate

$Y = A.B$ (AND gate)

$Y = A+B$ (OR gate)

$Y = \overline{A.B}$ (NAND gate)

$Y = \overline{A+B}$ (NOR gate)

Circuit Diagram :-

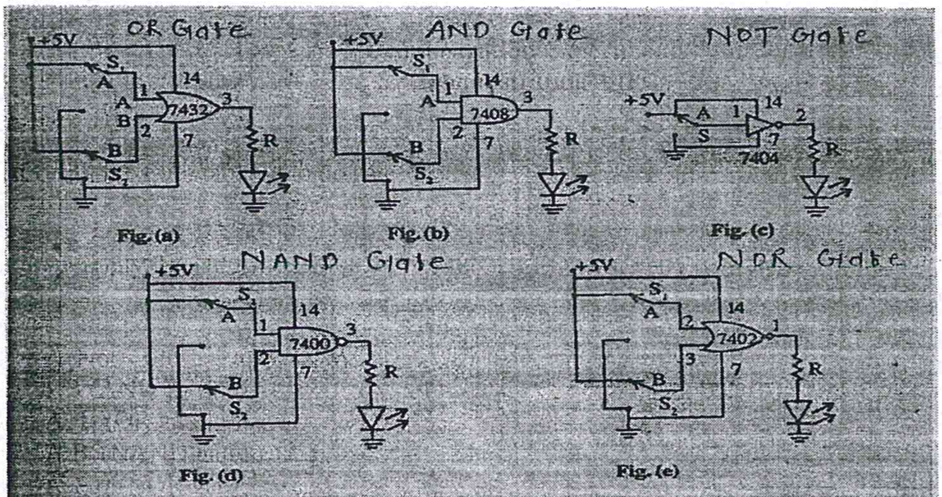

Fig. 1. 2 : *Circuit diagrams*

Observation :-

Not Gate

A	$Y=\overline{A}$
0	1
1	0

AND Gate

A	B	Y=A·B
0	0	0
0	1	0
1	0	0
0	1	1

OR gate

A	B	Y=A+B
0	0	0
0	1	1
1	0	1
1	1	1

ts

Objective :-

To ver·

Apparat·

.e etc.

Procedure :-

(1) Connect the Positive of VCC to pn ... egative of VCC to pin of.
(2) For logic circuit do connect the –Ve VCC to +ve input of the gate of L.E.D.
(3) Whether the regulated logic level the L.E.D. the output will show
(4) Connecting the truth table graph from the logic gate level L.E.D.

Result :-

(1) Truth table for logic gates are verified
(2) Not gate perform compliment of its output
(3) The truth table of NAND gate is inverse AND gate
(4) The Truth table of NOR gate is inverse of that of Or gate

NAND gate

A	B	$Y=\overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

NOR gate

A	B	$Y=\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

Result :-

(1) Truth table for logic gates are verified
(2) Not gate perform compliment of its output
(3) The truth table of NAND gate is inverse AND gate
(4) The Truth table of NOR gate is inverse of that of Or gate