Veer Bahadur Singh Purvanchal University

Instruction Manuals
For
B. Sc. I & II Semester
Laboratory Experiments

Department of Physics

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Contents

SPRING CONSTANT

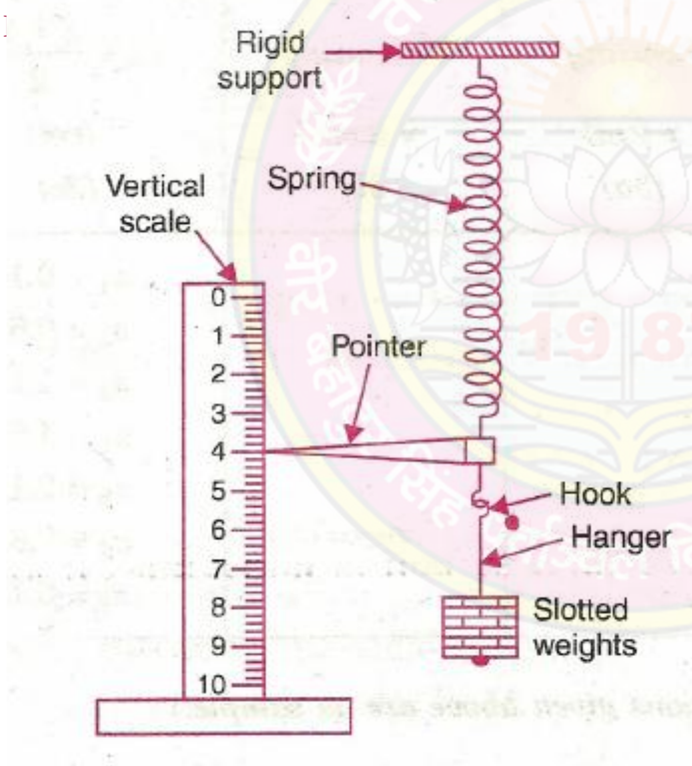
Object: T*o find the force constant of a helical spring by plotting graph between load and extension.*

APPARATUS

Spring, a rigid support, slotted weights, a vertical wooden scale, a fine pointer, a hook.

THEORY

When a load F suspended from lower free end of a spring hanging from a rigid support, it increases its length by amount x,
then $F \alpha x$
or $F= k x$,
where k is constant of proportionality.
It is called the force constant or the spring constant of the spring.



PROCEDURE

1. Suspend the spring from a rigid support. Attach a pointer and a hook from . free end.
2. Hang a 20 g hanger from the hook.
3. Set the vertical wooden scale such that the tip of the pointer comes over the the scale.
4. Note the reading of the position of the tip of the pointer on the scale. Record the reading in loading column against zero load. .
5. Gently add a 20 g slotted weight to the hanger. The pointer tip moves down.

6. Wait for few minutes till the pointer tip comes to rest. Repeat step 4.
7. Repeat steps 5 and 6 till five slotted weights have been added.

8. Now remove one slotted weight. The pointer tip moves up. Repeat step 6. Record the reading in unloading column.
9. Repeat step 8 till only hanger is left.
10. Record your observations as given below.

OBSERVATIONS

Least count of vertical scale = 0.1 cm.

Table for load and extension

Serial No.	**Load (g)**	**Reading of the scale while**		**Extension x (cm)**
		Loading	unloading	

CALCULATION

S From graph,
k =……………… gwt per cm.

RESULT

The force constant of the given spring is …………. g wt per cm.

PRECAUTIONS

1. Loading and unloading of weight must be done gently.
2. Reading should be noted only when tip of pointer comes to rest.
3. Pointer tip should not touch the scale surface.
4. Loading should not be beyond elastic limit.

SOURCES OF ERROR

1. The support may not be rigid.
2. The slotted weights may not have correct weight (20g).

Y by bending of beam

OBJECT: To determine the Young's modulus of the material of a given beam supported on two knife edges and loaded at the middle point.

Apparatus used: Two parallel knife edges on which the beam is placed, a hook to suspend weights, a meter scale, Spherometer, 500gm weights, d.c. source, bulb or galvanometer, wires, screw gauge, vernier callipers and a meter scale.

Formula: The following formula is used for the determination of Young's modulus (Y) for a beam material.

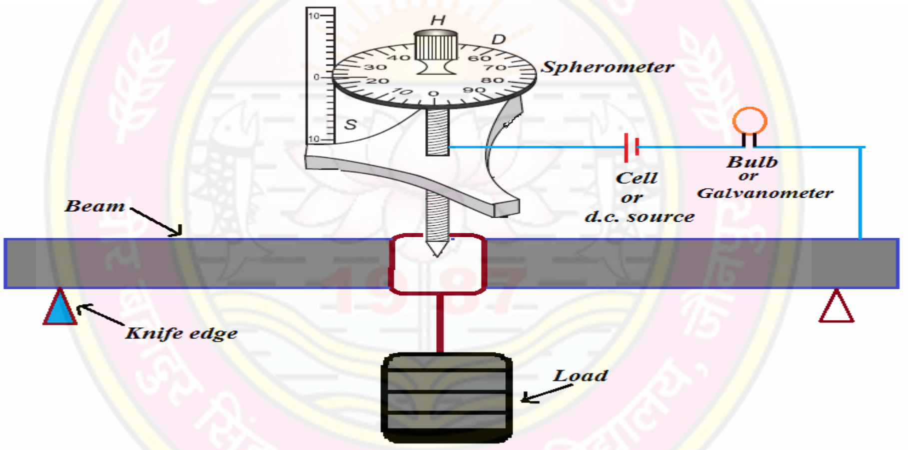
$$Y = \frac{Mgl^3}{4bd^3\delta} = \frac{gl^3}{4bd^3}\frac{M}{\delta}$$

Where M = load suspended from the beam, g = acceleration due to gravity,

l = length of the beam between the two knife edges, b = breadth of the beam,

δ = depression of the beam in the middle d = thickness of the beam

Figure:



Procedure:

(1) Measure the length of bar between knife edges using meter scale. This will give you value of l.

(2) Find out the least count of screw gauge and zero error in it.

(3) Using screw gauge, measure the thickness of bar/beam. It will provide the value of d.

(4) Find out the least count and zero error of Vernier calipers.

(5) Using Vernier calipers, measure the breadth of beam. It will provide the value of b.

(6) Find the least count of spherometer.

(7) Suspend the hanger with a graduated scale attached to it, on the mid-point of the beam. Now rotate the spherometer. As soon as it touches the beam, the bulb glows. Stop the rotation of spherometer and note its reading. This gives zero mass depression.

(8) Now load 500 gm on hanger. At this position, the bulb will not glow. Further rotate the spherometer till the bulb just glows. Stop the rotation of spherometer and note its reading. This gives depression for 500gm.

(9) Increase the mass on hanger till 2500gm in interval of 500gm and note the spherometer readings at the situation of bulb glow. This will give you the depressions at different masses.

(10) Note the same reading of depression, for M=2500gm in case of decreasing load.

(11) Now remove the 500gm mass from hanger and rotate the spherometer in opposite direction till the bulb just becomes off. Note the spherometer readings at the situation. This provides you the value of depression for 2000gm mass at load decreasing case.

(12) Similarly decrease the load up to zero mass in steps of 500gm and note the spherometer readings at the just off situation of bulb. This will give you the depressions at different masses in case of load decreasing.

(13) In the process of (7)-(12), you have recoded the depressions (spherometer reading) for different masses in case of load increasing and decreasing. Take the mean of spherometer readings for load increasing and decreasing for each masses.

(14) Now calculate the difference of mean spherometer reading of each mass with zero mass reading. This will provide the relative depression for each masses with respect to zero mass.

(15) Find out depression for 1500gm. This can be obtained by taking difference among 1st& 4th, 2nd&5th and 3rd and 6th. Put all the values in given formula and calculate the value of ***Y***.

(16) Plot graph in mass and relative depression and find out its slop. The slop of graph gives the value of $\tan\theta=\delta/M$. Put all the value in the given formula and calculate the value of ***Y***.

(17) Take mean of both calculated values of *Y*. This provides the final value of Young modulus of material of beam.

Observations:

(1) Length of beam between knife edges (l)=……..cm

(2) Least count of screw gauge= $\dfrac{pitch}{Number\ of\ \text{divisions on circular scale}}$ =…….cm

(3) Zero error in screw gauge=……..gm

(4) Table for thickness (d) of beam:

Sr. no.	M.S. (cm)	C.S. (div)	un-corrected diameter (T= MS + CS x LC) (cm)	Mean un-corrected diameter (T: cm)	corrected diameter (d=T± zero error) (cm)
1.					
2.					
3.					
4.					

(5) Least count of Vernier calipers $= \frac{value \text{ of one division on main scale}}{Number\ of \text{ divisions on vernier scale}}$ ……..cm

(6) Zero error in Vernier calipers=……..cm

(7) ***Table for breadth of beam:***

Sr. no.	M.S. (cm)	V.S. (div)	un-corrected breadth (T= MS + VS x LC) (cm)	Mean un-corrected breadthr (d: cm)	corrected breadth (b=T± zero error) (cm)
1.					
2.					
3.					
4.					
5.					

(8) ***Table for mass and depression:***

Sr. no.	Mass M (gm)	Spherometer reading			Depression δ (cm)	Depression (δ) for M=1500gm (cm)	Mean δ for M=1500gm (cm)
		For load increasing y_1 (cm)	For load decreasing y_2 (cm)	Mean y (cm)			
1.	0			A	δ_1=A-A	δ_4-δ_1	
2.	500			B	δ_2=B-A		
3.	1000			C	δ_3=C-A	δ_5-δ_2	
4.	1500			D	δ_4=D-A		
5.	2000			E	δ_5=E-A	δ_6-δ_3	
6.	2500			F	δ_6==F-A		

Calculation: $Y = \frac{gl^3}{4bd^3}\frac{M}{\delta}$

(Using table and graph data of M/ δ, calculate the two values of Young Modulus with log method and find out their mean.)

Results: The Young Modulus of material of beam= ……….N/m^2

Maximum possible error: Taking log and differentiating formula of Y, we get

$$\frac{\partial Y}{Y} = \frac{3\partial l}{l} + \frac{\partial b}{b} + \frac{3\partial d}{d} + \frac{\partial \delta}{\delta}$$

So, Maximum possible error= $\frac{\partial Y}{Y} x100$

Precautions:

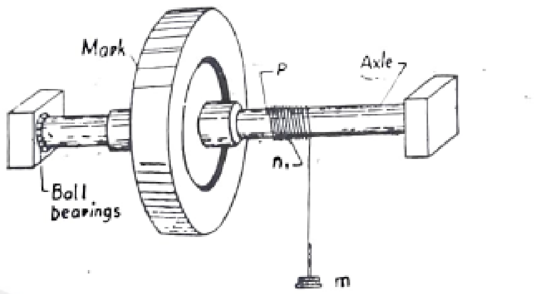
1. The knife edges should be rigid and fixed on rigid support.
2. The knife edges should be at equal distances from the center of bar/beam.
3. The weights should be placed and removed gently on the hanger.
4. The load on beam should not exceed the elastic limit of beam.
5. To avoid the backless error, the circular scale of screw gauge and spherometer should be moved in one direction.

Moment of inertia of a Flywheel

OBJECT: To determine the moment of inertia of a flywheel about its own axis of rotation.

Apparatus used: Flywheel, a few masses, a strong and thin string, stop watch, vernier callipers.

Formula used: The moment of inertia of a flywheel is given by following formula:



$$I = \frac{2mgh - mr^2\omega^2}{\omega^2\left(1+\frac{n_1}{n_2}\right)} = \frac{\frac{2mgh}{\omega^2} - mr^2}{\left(1+\frac{n_1}{n_2}\right)}$$

$$Since \quad \omega = 2\times\frac{2\pi n_2}{t} \; and \; h = 2\pi r\, n_1$$

$$I = \frac{\frac{2mg(2\pi r\, n_1)t^2}{(4\pi n_2)^2} - mr^2}{\left(1+\frac{n_1}{n_2}\right)}$$

$$\boxed{I = \frac{mr\left(\frac{gt^2\, n_1}{4\pi n_2^2} - r\right)}{\left(1+\frac{n_1}{n_2}\right)}}$$

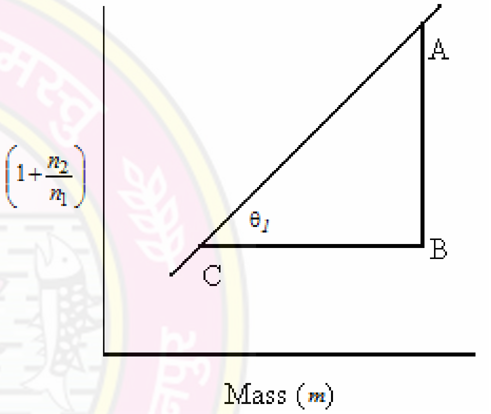
$$Since \quad \frac{gt^2\, n_1}{4\pi n_2^2} >> r$$

$$I = \frac{mrgt^2\, n_1}{4\pi n_2^2\left(1+\frac{n_1}{n_2}\right)} = \frac{m\,g\,r\,t^2}{4\pi\, n_2\left(1+\frac{n_2}{n_1}\right)}$$

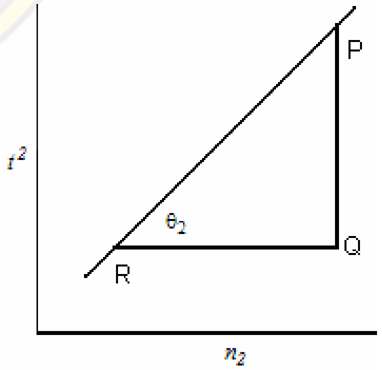
$$\boxed{I = \frac{g\,r}{4\pi}\,\frac{m}{\left(1+\frac{n_2}{n_1}\right)}\,\frac{t^2}{n_2} = \frac{g\,r}{4\pi}\,K\,C}$$

Where $K = m\Big/\left(1+\frac{n_2}{n_1}\right)$; $C = t^2\big/n_2$;

g = gravitational acceleration.
r = radius of flywheel axis.
m = mass suspended through string / thread.
n_1 = Number of turns of string wrapped on axis.
n_2 = Number of oscillation up to flywheel stopped after detaching the mass.
t = time of oscillation up to flywheel stopped after detaching the mass.



$$\tan\theta_1 = \frac{1}{K} = \frac{\left(1+\frac{n_2}{n_1}\right)}{m} = \frac{AB}{BC}$$



$$\tan\theta_2 = C = \frac{t^2}{n_2} = \frac{PQ}{QR}$$

Procedure:

1. Measure the diameter of the axle with vernier calipers at different points and find the mean.
2. Attach the mass with string.
3. Wrap the string or thread axle of flywheel for allotted number of turns (n_1=4 or 6 or 8).
4. Allow to fall the mass.
5. After fall of the mass, note the number of oscillation of flywheel (n_2) and corresponding time (t_2) till the flywheel stopped.
6. Repeat procedure from 2-5 at fixed n_1 for different masses (e.g. m=100, 150, 200, 250, 300gm)
7. Draw the graphs between mass (m) and $(1+\frac{n_2}{n_1})$ and between n_2 and t^2. The graph should be separate for each n_1.

Observation:

A. For radius of axle

$$Least\ count\ of\ vernier\ callipers = \frac{value\ of\ one\ division\ on\ main\ scale}{Number\ of\ division\ on\ vernier\ scale} = ...cm$$

Sr. No.	Main scale reading	Vernier scale reading	Total
1			
2			
3			
4			
5			

Diameter of axle (D=Mean of Total = ……………………………………

Radius of axle (*r=D/2*) = …………………………………………………

B. For n_2 and t

Sr. no.	n_1	m	n_2	t	$1+\frac{n_2}{n_1}$	t^2
1						
2						
3						
4						
5						

Calculation:

The moment of inertia can be calculated with following formula:

$$I = \frac{g\,r}{4\,\pi} K\,C = \frac{g\,r}{4\,\pi}\frac{tan\,\theta_2}{tan\,\theta_1}$$

Least count error: $\frac{\Delta I}{I} = \left\{\frac{\Delta r}{r} + 2\frac{\Delta t}{t}\right\} \Rightarrow \frac{\Delta I}{I} x100 = \left\{\frac{\Delta r}{r} + 2\frac{\Delta t}{t}\right\} x100$

Result:

The moment of inertia of fly wheel is …………….. ± …………..(unit).

Precautions:

1. There should be least friction in flywheel.
2. The length of string should be less than the height of axle from floor.
3. There should be no kink in string.
4. The string should be thin and should be wound evenly.
5. The stop watch should be started just after detaching the loaded string.

Acceleration due to gravity ‘g’ by Bar Pendulum

OBJECT: To determine the value of acceleration due to gravity and radius of gyration using bar pendulum.
Apparatus used: Bar pendulum, stop watch and meter scale.
Formula:
A. The general formula of the time period for bar pendulum is given by following equation:

$$T = 2\pi\sqrt{\frac{\frac{k^2}{l}+l}{g}} = 2\pi\sqrt{\frac{l_2+l_1}{g}}$$

$$\boxed{g = \frac{4\pi^2(l_1+l_2)}{T^2} = \frac{4\pi^2 L}{T^2}} \qquad (1)$$

Where l: distance between C.G. and suspension point, L: distance between suspension and oscillation points, $L = l_1 + l_2 = l + \frac{k^2}{l}$, g: acceleration due to gravity, T: time period.

B. The time period is minimum when $l = \pm k$, in this situation the equation (1) becomes as:

$$T_{min} = 2\pi\sqrt{\frac{2k}{g}}$$

or
$$\boxed{g = \frac{8\pi^2 k}{T_{min}^2}} \qquad (2)$$

where, k: radius of gyration, T_{min}: minimum time period.
The value of ‘g’ can be calculated using equations (1) and (2).
The values of L, T, k and Tmin are obtained using graph between T and L for bar pendulum which is shown in following figure.

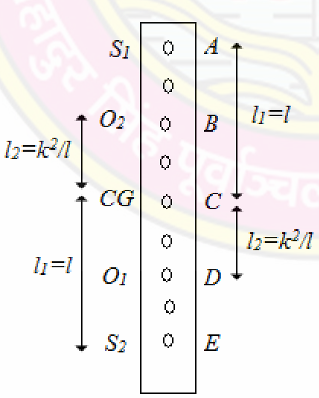


Fig.1

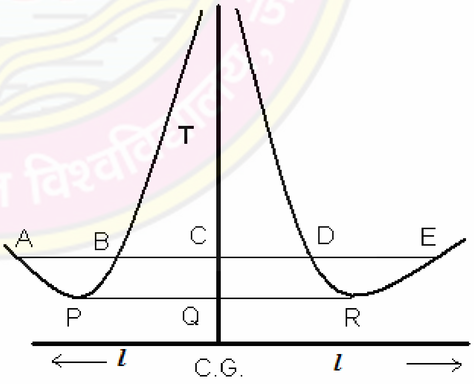


Fig. 2

From Figures (1) and (2),

(a) $L_1 = AC+CD$, $L_2 = EC+CB$ *and* $L = (L_1+L_2)/2$, *T=time at C*
(b) k =(PQ+QR)/2 and T_{min}= time at Q

C. The radius of gyration can be obtained with following formula

$$\boxed{k = \sqrt{l_1 l_2}} \qquad (3)$$

Where $l_1 = (AC+CE)/2$, $l_2 = (BC+CD)/2$

Procedure:

(1) Place the knife-edges at the first hole of the bar.
(2) Suspend the pendulum through rigid support with the knife-edge.
(3) Oscillate the pendulum for small amplitude ($\theta = 3 \sim 4^0$).
(4) Note the time taken for 20 oscillations and measure the distance of the hole from the C.G. of the bar.
(5) Repeat the observations (2)-(4) for knife-edges at first half side holes of bar.
(6) Repeat the process (1)-(5) for the second half side of the bar.
(7) Plot the graph between T and L.

Observations:

1. Least count of the stop watch = ….. sec
2. Least count of the meter scale =…… cm
3. *Table for l and T*

S. No.	*l* (cm)	t (time taken for 20 oscillations)	T = t/20
For first half side of the bar			
1	45		
2	40		
3	35		
4	30		
5	25		
6	20		
7	15		
8	10		
9	5		
For second half side of the bar			
10	-5		
11	-10		
12	-15		
13	-20		
14	-25		
15	-30		
16	-35		
17	-40		
18	-45		

Calculations: *from graph,* *L=(AD+EB)/2=….,* *T=…sec,*
k=PR/2=… $T_{min=}$*…sec*
l_1*=(AC+CE)/2=….,* l_2*=(BC+CD)/2*

1. $g_1 = \dfrac{4\pi^2 L}{T^2}$ 2. $g_2 = \dfrac{8\pi^2 k}{T_{min}^2}$ 3. $g = \dfrac{g_1 + g_2}{2}$ 4. $k = \sqrt{l_1 l_2}$

Results: The acceleration due to gravity (g) = ……….m/s^2
Radius of gyration (k) =………cm (from calculation)
=………cm (from graph)

Precautions:

1. The motion of the pendulum should be in a vertical plane. While taking the time, start taking observations after two oscillations to avoid any irregularity of motion.
2. The amplitude of oscillation should be small.

Experiment : To find Young's modulus , modulus of rigidity and poisson's ration for material of a wire by searl's method

Apparatus. Searle's apparatus thread,

Required

Stop watch, a telescope, a metre rod vernier callipers and screw gauge.

Procedure.

1 Fasten the wire under test to the identical bars *LM* and *PQ* at their middle point as shown in fig 5.13. Suspend the two bars from a rigid support, by two threads of suitable lengths so that when the system is at rest, the two bars and the wire lie in the same horizontal plane.

2. mark a vertical reference line at the centre of the end of each bar. Focus the telescope on this line on one of the bars so that the vertical cross-wire coincides with this mark.

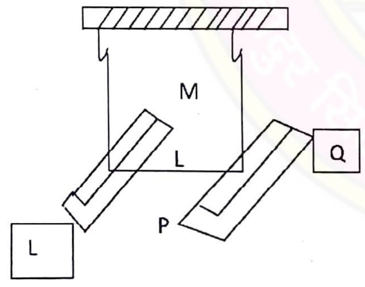


Fig 5.13

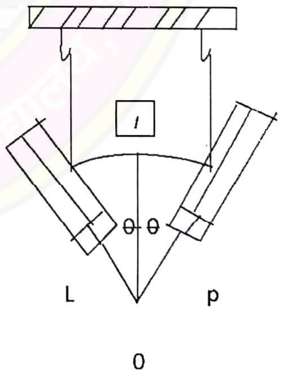


Fig 5.14

3. Draw the two bars slightly together by a loop of him cotton thread slipped at the ends *L* and *P* and carefully bring the system to rest. Burn the thread of the loop to release the bars which will begin to oscillate with a small amplitude.

Look thread the telescope and find the time for 25 vibrations. Repeat four time and calculate the mean time period t_1

4. Measure the length of the bar with a metre rod and its breadth with a vernier callipers. Find its mass by weighing it. Measure the length of the wire under test with a metre rod and its diameter with a screw gauge accurately at a number of places and at each place in two mutually perpendicular direction.

Observation and calculations.

(a) Determination of Y.

Time for 25 vibrations = 1. 2. 3. 4.

Mean = second

Time period t_1 = sec.

Length of the bar L = m

Vernier constant = 0· mm

Breadth of the bar = 1. 2. 3.

Mean breadth b = cm = m

Mass of the bar m = kg.

Moment of inertia of bar $I = m \, \dfrac{L^2 + b^2}{12}$ kg- m^2

Length of the wire l = m

Diameter of the wire

Least count of screw gauge = mm

Zero correction = $\pm$ mm

	Observed diameter							
	1	2	3	4	5	6	7	8
(a)								
(b)								

Mean observed diameter = mm

Corrected mean diameter d = mm = m

Corrected radius r = m

Young's modulus $$Y \quad \frac{8\pi l\ I}{r^4\ t_1^2} = \quad N/m^2$$

(b) **Modulus of rigidity** **η**

Time for 25 vibration = 1. 2. 3. 4.

Mean = sec

Time period t_2 = sec

Co-efficient of rigidity $$\eta = \frac{8\pi I l}{r^4\ t_2^2} \quad N/m^2$$

(c) **Poisson's ratio** $$\sigma = \frac{t_2^2}{2t_1^2} - 1$$

It is clear from the expression for the poisson's ratio that the value of this important constant can be determined from the measurement of the two time periods alone, which can be determined with sufficient accuracy. It is not necessary to find the value of Y and η to find the value of σ.

η by Maxwell Needle

OBJECT: To determine the modulus of rigidity of material of given wire by dynamical method using Maxwell needle.

Apparatus used: Maxwell needle, stop watch, screw gauge, meter scale.

Formula: The following formula is used for the determination of modulus of rigidity (η).

$$\eta = \frac{2\pi l}{r^4}\frac{(m_s - m_H)L^2}{\left(T_1^2 - T_2^2\right)}$$

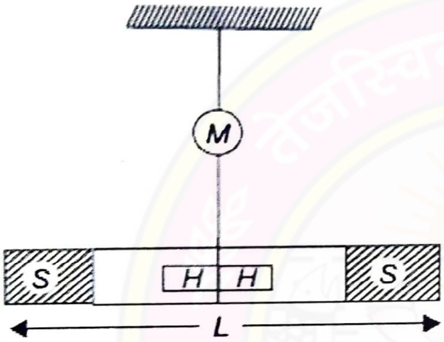
Where l: length of wire, L: length of Maxwell needle, r: radius of wire,

m_S: mean mass of solid cylinders, m_H; mean mass of hollow cylinders,

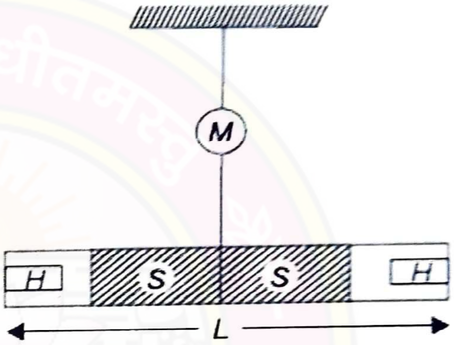
T_1: time period of oscillation when solid masses are out side,

T_2: time period of oscillation when solid cylinders are inside

Figure:



Arrangement 1: Solid cylinders at outside



Arrangement 2: *Solid cylinders at inside*

Procedure:

(1) Measure the length of wire using meter scale through which the Maxwell needle is hanged. This will give you value of l.

(2) Measure the length of Maxwell needle using meter scale. This will give you value of L.

(3) Measure the mass of both solid cylinders using balance and do its half, this will provide the value of m_S.

(4) Measure the mass of the both hollow cylinders and do its half, this will provide the value of m_H.

(5) Find out the least count of screw gauge and zero error in it.

(6) Using screw gauge, measure the diameter of wire. Its half will provide the value of radius of wire.

(7) Find out the least count of stop watch.

(8) Now put the hollow cylinders at inside and solid cylinders at out side of the Maxwell needle. Oscillate it in horizontal plane about vertical axis. Note the time for 10, 20 and 30 oscillations. Divide the time with number of oscillations and find its mean. This will provide the value of T_1.

(9) Now place solid cylinders at inside and hollow cylinders at out side of the Maxwell needle. Oscillate it in horizontal plane about vertical axis. Note the time for 10, 20 and 30 oscillations. Divide the time with number of oscillations and find its mean. This will provide the value of T_2.

(10)Put all the value in given formula and solve it with log method.

Observations:

(1) Length of wire (l)=……..cm

(2) Length of Maxwell needle (L)=…….cm

(3) Mean mass of solid cylinders (m_S)=……..gm

(4) Mean mass of hollow cylinders (m_H)=……gm

(5) Least count of screw gauge= $\frac{pitch}{Number\ of\ \text{divisions on circular scale}}$ =……..cm

(6) Zero error in screw gauge=………..cm

(7) ***Table for diameter of wire***

Sr. no.	M.S. (cm)	C.S. (div)	un-corrected diameter (d= MS + CS x LC) (cm)	Mean un-corrected diameter (d: cm)	corrected diameter (D=d± zero error) (cm)
1.					
2.					
3.					
4.					
5.					
6.					

(8) *Radius of wire (r)=D/2=…….cm*

(9) Least count of stop watch=……sec

(10) Table for T_1 and T_2:

Sr. no.	Number of oscillations (N)	For outside solid cylinders			For inside solid cylinders		
		t_1 (sec)	$T_1=t_1/N$ (sec)	MeanT_1 (sec)	t_2 (sec)	$T_2=t_2/N$ (sec)	MeanT_2 (sec)
1.	10						
2.	20						
3.	30						

Calculation: $\eta = \frac{2\pi l\,(m_s - m_H)L^2}{r^4\,(T_1^2 - T_2^2)}$

(Put all the values in the above formula and solve it with log method)

Results: The modulus of rigidity of given wire material = ………N/m^2

Precautions:

1. There should be no kink in the wire.
2. The Maxwell needle should remain horizontal and should not vibrate up and down.
3. The amplitude of vibration/oscillation should be small so that wire is not twisted beyond the elastic limit.
4. To avoid the backless error, the circular scale of screw gauge should be moved in one direction.

Experiment : To find the moment of inertia of an irregular body about an axis through its centre of gravity with a torsion pendulum.

Apparatus. Moment of inertia table, a right circular cylinder (a regular body), an irregular body, a spirit level, a vernier callipers, stop watch

Required

Telescope with inverted scale with zero mark in the middle, a stop watch, a balance and a weight box

Procedure

1. Suspend the moment of inertia table by means of a copper wire if a suitable length and thickness from a rigid support. Place a spirit level along the diameter ab and see that the table is horizontal. If is not, then adjust the nuts provided at the ends of the rods A and B below the disc or adjust the position of the lead weights in the groove. Test again by placing the spirit level along the diameter cd.

2. Place a telescope with an inverted centimetre scale clamped to its stand at a distance not less than one meter towards the mirror fixed to the torsion head.

   Place the eye just above the telescope and the position of the scale so that the image of the scale division are see in the mirror. Now place the telescope in the position of the eye.

   Adjust the eye-piece of the telescope so that the cross-wire are clearly visible. Focus the telescope on the centimetre scale division as seen in the mirror but on the mirror. It may be remembered that the image lies as far behind the mirror as the scale in front of it.

   Observe the reading of a division mark in the centre of the scale image and adjust the vertical cross-wire with it Let this be the reference mark.

3. Give a slight twist to the table so that it begins to executed torsional vibration in the horizontal plane alone. When the image of the reference line on the scale just passed the vertical cross-wire, start the stop-watch and count zero.

Count one when the image of the same mark passes in the same direction and so on. Find the time 10 vibrations. Repeat three time.

4. Place the solid cylinder in the centre of the table. Adjust its position so that table is again horizontal. Test with a spirit level. Find the for 10 vibration of the system three times

5. Remove the cylinder and place the irregular body in the centre of the table. Adjust the position so that the table is horizontal. In this case the axis of the wire passes the C.G. of the body. Find the time for 10 vibrations of the system three time again.

6. Weight the solid cylinder and find its diameter with a vernier callipers.

Observation

Sl no		Time for 10 vibrations			Time period
		1	2	3	
1	Table alone				$t=$
2	With cylinder				$t_1=$
3	With irregular body				$t_2=$

Mass of the solid cylinder m = kg

Diameter of the solid cylinder = 1. 2. 3.

Mean diameter d = cm

Radius of the cylinder r = cm = m

$$\text{Moment of inertia } I_1 = \frac{1}{2} mr^2 = \text{kg-m}^2$$

Calculation.

M. I. of the irregular body $I_2 = I_1 \times \dfrac{t^2_2 - t^2}{t^2_1 - t^2} = \text{kg} - \text{m}^2$

VERIFICATION OF STEPHEN LAW

(BY DIODE VALVE EZ81)

Introduction :- This experimental set up is designed to verify the Stephen law of 4th power by diode valve type EZ81. The set up consist one diode valve EZ81, one low voltage dc regulated power supply (0 - 6.3V @ 1Amp) with two meters and valve base upon panel.

Brief :- The set up is similar to the experiment designed upon tungston lamp taken as black body radiator. In this experiment a diode valve EZ 81 used as for same purpose. The valve is heated up using a dc source (inbuilt 0 - 6v) and two meters connected in heater circuit read the current and voltage. Applying Ohm's law we obtain the resistance RT for the given votage (current) as V/I, and same time we evaluate the value of power P = V.I. Neglecting the loss due to convection of heat in surrounding air the Stphen's law is written as

$$P = \sigma C T\alpha$$

or $$\text{Log } P = \text{Log } (\sigma C) + \alpha \text{ Log } T$$

where P = V.I, σ is Stephen's constant 5.67 x10^{-8} $\omega m^{-3}K^{-4}$, a is slope quite close to 4 and C is physical constant for radiator given 2.42 x 10^{-4} m^2 for EZ81 and emissivity for cathode of EZ81 is given as $\varepsilon = 0.239$.

Thus plotting a graph between Log T v/s Log P equal to slope of curve gives value α close to 4 (3.8) which verify the law. From the plot the value of Log (σC) as an in-

- tercept on Log P axis which gives the value of σ, and C is known as given.

Experiment procedure

1. Insert the valve EZ81, in given base. Keep the Heater supply control to minimum i.e. fully counter - clockwise direction.

2. Switch on power.

3. Very slowly adjust the heater supply to few mV say 0.05V. Note the heater current for corrosponding heater voltages. Calculae the heater resistance at room temperature using Ohm's law as rersistance R = V/I.

4. Note the room temperature. Add it with 273 to evaluate the absolute temperature at room temperature T_R.

5. Adjust heater voltage to 3V. Note the heater current after 3 minute. Adjust heater voltage furthur with 0.5V increament say 3.5V,4V and so. note the heater current for each heater voltage setting. Calculate the resistance R at different heater voltage setting.

6. Now calculate the temperature T at different heater voltage using emperical relation as given below. Calculate power P = V.I

$R/R_R = [T/(273 + T_R)]'$, in ^{0}K, an emperical relation

7. Calculate Log P, and Log T.

8. Plot a curve between the Log P and Log T. The slope of the curve (nearly 3.78) verify the stephen law.

Verification of stephens law by EZ81 - 3.

Probability of error : The probable source of error may be temperature determination. Note the heater current after get stablization after 3 to 5 minutes. The heater resistance may be directly measure between pin 4 and 5 of valve by good quality digital multimeter (nearly 1.5 Ohms at 20^{0}C)

Specific Heat of Solid

Aim:- To determine the specific heat of various solids by the method of heat transfer.

Setup Contains:-

- Joule`s Calorimeter assembly with heating wire & stirrer .
- Digital Regulated Power Supply with range (0-30)V, (0-2)A.
- Connecting Wire.
- Digital Stop Watch
- Thermometer
- Different types of metal blocks.
- Digital Weighing Machine.
- Glycerin

Formula Used:-

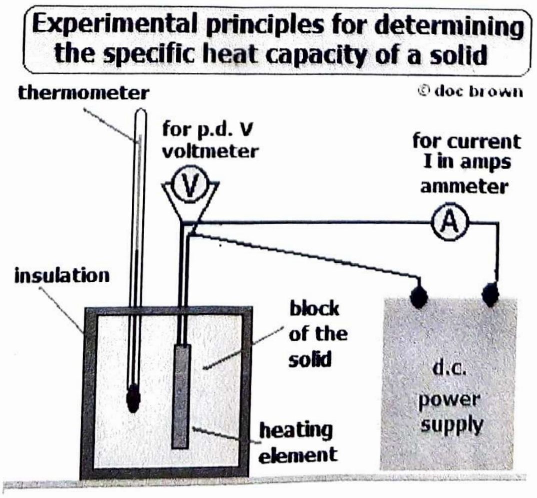
Mass of the solid (metal) in kg = m
Specific heat of the metal = c
Initial temperature of (hot) solid = T_1
Mass of calorimeter with stirrer = m_1
Mass of cold water = m_2
Initial temperature of cold water = T_2

Final equilibrium temperature of mixture = T_3
Specific heat of calorimeter(Aluminum) = $c_1 = 900$ J/kgC°
Specific heat of water = $c_2 = 4186$ J/kgC°
Heat lost = -Heat gained

Heat lost by the solid = $(m)(c)[(T_2 - T_1)]$

Heat gained by water + (calorimeter & stirrer) = $(m_2)(c_2)(T_3 - T_2) + (m_1)(c_1)(T_3 - T_2)$

Required Diagram:-



Useful Theory:-

Heat capacity of a body is the quantity of heat required to raise the temperature of the body by 1°C. The *specific heat* of a substance is the heat capacity per unit mass. Thus, heat capacity = mass x specific heat. The specific heat is essentially a measure of how thermally insensitive a substance is to the addition of energy. The *water equivalent* of a body is the mass of water, which would require the same amount of heat as the body in order to raise the temperature through one degree Celsius.

The method of mixtures makes use of the principles that when two bodies at different temperatures exchange heat, the quantity of heat lost by the warmer body is equal to the heat gained by the cooler body, and some intermediate equilibrium temperature is finally reached. This is true provided no heat is lost or gained from/to the surroundings. The purpose of the calorimeter is to prevent heat lose to the surroundings. There are three methods of heat transfer: conduction, convection and radiation.

In this experiment, a heated solid of known mass and temperature is dropped in the calorimeter containing known mass of cold water. The equilibrium temperature is then measured. The magnitude of the heat lost by the solid must be equal to the magnitude of the heat gained by the water, and calorimeter with stirrer.

Procedure for observation:-

1. First connect the power supply to joule calorimeter assembly with DCC Wire.
2. Take the mass of Calorimeter, Strrier and Sample Solid Block.
3. Fill the calorimeter with glycerin.
4. Switch ON the power supply Set Some Voltage Around 20 V, Note their respectively current .
5. Wait till the rising heat of liquid become steady note the steady temperature if liquid. T1.
6. Switch off the power supply and put the sample block into liquid note the temperature at every 60 sec. till it become steady and note in the table as T2.
7. Repeat above two steps for another solid sample..

Observations:-

- Mass of Calorimeter-.............
- Mass of Strrier:-...........
- Mass of Solid Blocks:-..........
- Least Count of Thermometer:-............
- Applied Voltage :-.................
- Output Current:-..................
- Specific Heat of Colarimeter:-..........
- Specific Heat of Liquid:-..............
- Mass of Liquid:-..................

Sample Metal.	**Steady Temp of Liquid T_1 (°C)**	**Steady Temp of Solid T_2 (°C)**	**Specific Heat (S)** $J kg^{-1} K^{-1}$

substance	$\frac{c}{\frac{kJ}{K \cdot kg}}$	$\frac{c}{\frac{kJ}{K \cdot kg}}$
	experiment	literature
lead	0.133	0.1295
copper	0.367	0.385
glass	0.656	0.746

To find the co-efficient of thermal conductivity of a bad conductor by Lee's method.

Apparatus. Lee's disc apparatus, two $1/10^\circ C$ thermometers, circular disc of the specimen of a bad conductor, (ebonite or card board), a stop watch, steam boiler

Theory. On passing steam through the cylindrical vessel a steady state is reached soon. In this condition the rate at which heat is conducted across the specimen disc is equal to the rate at which heat is emitted through the exposed surface of the lower disc. If K is the co-efficient of thermal conductivity of the material of bad conductor, d its thickness and r its radius; θ_1 and θ_2 the constant readings of the thermometers T_1 and T_2 in the steady state, then rate at which heat is conducted across the disc of the material

$$Q = \frac{K\pi r^2(\theta_1 - \theta_2)}{d}$$

If M is the mass of the metal disc, s the specific heat of its material, then rate of cooling at θ_2 is equal to

$$= Ms\frac{d\theta}{d}$$

Where $\frac{d\theta}{d}$ is the rate of fall of temperature at θ_2.

$$\therefore \quad \frac{K\pi r^2(\theta_1 - \theta_2)}{d} = Ms\frac{d\theta}{d}$$

Or

$$K = \frac{Msd}{\pi r^2(\theta_1 - \theta_2)} \quad \frac{d\theta}{dt}$$

Thermal Conductivity

The rate of cooling is found by heating the metal disc to a temperature about $10^\circ C$ above the steady temperature θ_2, it is then allowed to cool and temperature is noted after every 30 seconds till the temperature falls about $10°C$ below θ_2. A graph is then plotted between the temperature and time. A tangent is drawn at a point P corresponding to θ_2. The slope of the tangent gives the value of $\frac{d\theta}{dt}$ corresponding to temperature θ_2.

Procedure.

1. Set the apparatus as shown Fig.9.4 so that the flat surface of the disc is horizontal. Insert the disc of the material in between this disc and the cylindrical vessel. Place the thermometers T_1 and T_2 in position.

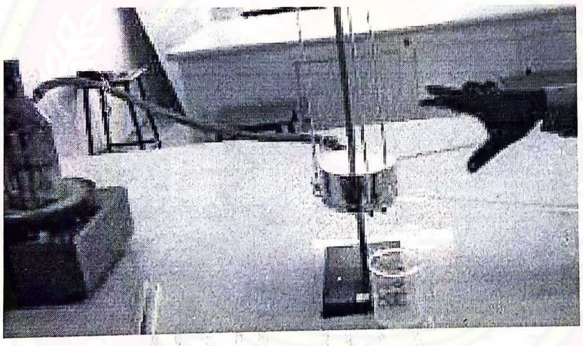
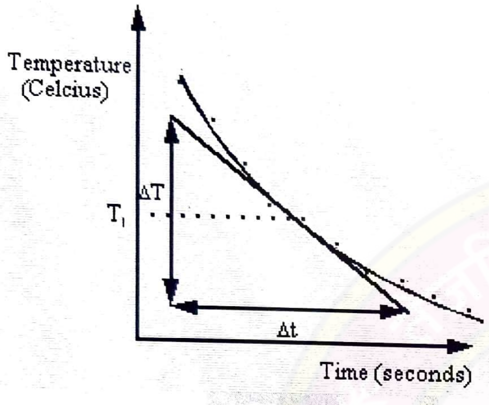


Fig 9.4

2. Pass steam from the inlet of the cylindrical vessel and wait till the steady state is reached. This will take 30-40 minutes. When the temperatures indicated by the thermometers T_1 and T_2 and again note down the temperatures.

3. Remove the cylindrical vessel as also the disc of the material and heat the disc A till its temperature is about $10°C$ above the steady temperature indicated by T_2. Allow it to cool and note the temperature at intervals of about 30 seconds, till its temperature falls to about $10°C$ below θ_2. Plot a graph between temperature and time.

4. Measure the diameter of the disc with a vernier calipers along two diameters mutually perpendicular to each other and measure its thickness with a screw gauge at different points. Also find the mass of the disc when cooled.



Observations.

Mass of the metallic disc M = gm = kg

Specific heat of metal s = kilo-cal/kg

Diameter of the disc = 1. 2.

Mean diameter D = cm =∴

∴ Radius of the disc r = cm = m

Thickness of the disc d = 1…., 2…., 3…., 4…

Mean thickness = cm= m

Steady temperature of the thermometers

T_1 = (i) (ii)

T_2 = (i) (ii)

Mean Temperature $\theta_1 = {}^\circ C$

Mean Temperature $\theta_2 = {}^\circ C$

Readings for cooling curve.

No. of Obs.	1	2	3	4	5	6	7	8	9
Time in seconds	30	60	90	120	150	180	210	…	…
Temp. of disc									

To find the rate of cooling $\frac{d\theta}{dt}$. Draw a graph taking time *t* along *X*-axis and temperature *t* along the *Y*-axis. Draw a tangent to the graph at a point P corresponding to the steady temperature t_2 as shown in Fig.9.6 cutting the *X*-axis at A. Draw *PM* perpendicular to *OA*.

The rate of fall of temperature $\frac{d\theta}{dt}$ at the temperature θ_2 is given by

$$\frac{d\theta}{dt} = \tan a = \frac{PM}{MA}$$

∴ Rate of cooling $\frac{d\theta}{dt}$ from the graph corresponding to steady temperature $\theta_2 = {}^\circ C$ /sec.

Calculations. $K = \frac{Msd}{\pi r^2(\theta_1 - \theta_2)} \times \frac{d\theta}{dt}$

Precautions.

1. Thickness d of the disc the material should b measured at a number of places on its surface.

2. The diameter of the disc should be equal to that of the cylindrical vessel and the metallic disc and should be measured in two perpendicular directions.

3. The thermometers should be placed close to the face of the disc of the specimen.

4. There should be a good thermal contact between the disc of material and the lower surface of the cylindrical surface and the upper surface of the circular metallic disc, if necessary glycerin may be applied between the surfaces.

5. The steady state temperatures should be recorded only when the readings of T_1 and T_2 remains constant after an interval of above five minutes.

Experiment . **To determine the thermal conductivity of rubber in the form of a tube** .

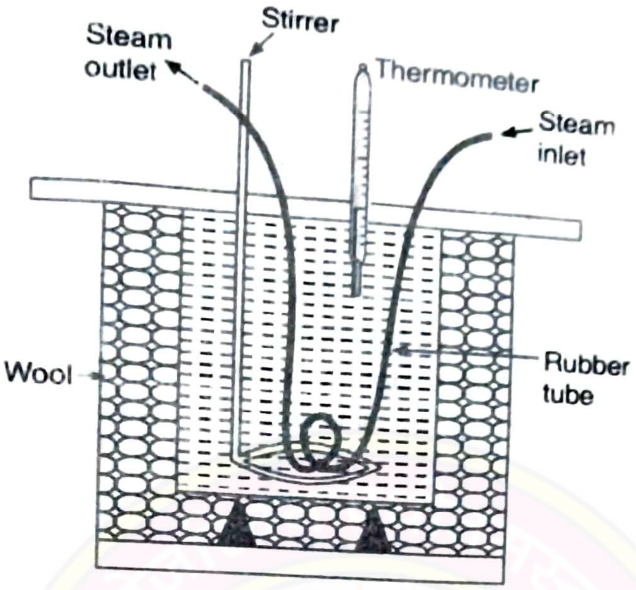
Apparatus. Rubber tube of sufficient length, , calorimeter with stirrer, thermometer,

Requited accessories : Travelling microscope, balance, weight box, meter scale, stop-watch, etc .

Formula . $$k = \frac{(m + w)(\theta_2 + \theta_1 + \delta)\log_{10}\left(\frac{r_2}{r_1}\right)}{2\pi L\left(\theta_3 - \frac{\theta_1 + \theta_2}{2}\right)t}$$

Procedure.

1. Make two marks on the rubber tube at a distance of 10 to 15 cm. Note the exact distance between these two marks.
2. Measure the mass of calorimeter with stirrer. Fill the calorimeter half with water. Again measure the mass of colorimeter, stirrer and water.
3. Allow the given experiment rubble tube to pass through one hole on the lid of the calorimeter and pass it out through the other hole on the lid.
4. Insure that both marks on rubber tube on just on the surface of water taken in calorimeter and there is no twist or fold of rubber tubing inside the water.



5. te the temperature of water.
6. One end of the rubber tube is connected to the boiler through a cock. The other end is kept in air for let off the stream.
7. Allow the steam to pass through the tube and immediately start the stop-watch. Stir the water in calorimeter and when the temperature of water in calorimeters rises by about 7^0 to 8^0C, cut off the steam and simultaneously stop-watch and record the maximum temperature. Record the time t for which the steam is allowed.
8. To calculate the radiation correction, start the stop-watch again when the water attains maximum temperature and allow the water to cool for exactly t sec. The radiation correction δ = half the fall in temperature in time t sec.
9. Record the temperature of the steam by inserting a thermometer in the boiler.
10. For calculation internal and external radii r_1 and r_2, five ink marks of the end of the tube or specimen are taken on a white paper n which microscope is focussed. Vertical and horizontal diameter are measured for each mark (inner and outer) . Average of each is found separately.

Observations.

1. Mass of calorimeter with stirrer =m = ...gm
2. Mass of water + calorimeter with stirrer = M_1 = ...gm
3. Specific heat of material of calorimeter = s = ...cal/ gm ^{0}C
4. Mass of water = m = $M^1 - m$ = ...gm
5. Water equivalent of = W = Ms = ...cal/ ^{0}C.
   Calorimeter and stirrer
6. Initial temperature of
   Water = $\theta^0{}_1$ c.
7. Temperature of steam = $\theta^0{}_3$ c.
8. Final temperature of calorimeter = $\theta^0{}_2$ c.
9. Time for which steam is passed = t sec.
10. Temperature of water after it cools for the same time t = θ '
11. Inner and outer diameter.
    Least count of microscope vernier -

No. of ink marks	Inner diameter position of microscope at							
	P	Q	R	S	Hor. Dim .PQ	Vert. Diam. RS	Mean	Mean inner Diameter for all ink marks
1.								
2.								
3.								
4.								

No. of ink marks	Inner diameter position of microscope of							
	O	T	M	N	Hor. Diam. OT	Vert. Diam. MN	Mean	Mean inner Diameter for all ink marks
1.								
2.								
3.								
4.								

Calculations .

$$\text{Radiation correction} = \frac{\theta_2 - \theta'}{2}$$

$$k = \frac{2.303\,(m + w)\,(\theta_2 + \delta - \theta_1)\,\log_{10}\dfrac{r_2}{r_1}}{2\pi L\left(\theta_3 - \dfrac{\theta_2 - \theta_2}{3}\right)t}$$

$$= \text{Cal. Cm}^{-1}\,\text{gm.}^{-1}\,\text{sec.}^{-1}$$

Result. *The coefficient of thermal conductivity of the rubber was found to be ... cal cm^{-1} sec^{-1} ^{0}C^{-1}.*

Experiment :

(i) **Study of energy meter or watt-hour meter.**

(ii) **Objective** – To study the working of energy meter or watt-hour and to use it in determining the power consumption of several house-hold appliances.

Apparatus- Energy meter, appliances to be tested (such as bulb, heater, electric iron etc.) A.C. voltmeter (0-300V). A.C. Ammeter (0-4A) ,3 switches, 1 sockets , 3 bulb holders

Method; -

(1) There are four wires leading from the base of the meter. Two wires are for the input A.C. and two for the load. Check the circuit before the connection of the main supply- Better consult your teacher in the lab before you connect the meter to the power line. The appliance, the ammeter and voltmeter are connected as shown in the circuit. Fig. 1. If a wattmeter is available then connect it to measure power consumed by inductive loads. Remember voltmeter and Ammeter donot measure power factor.

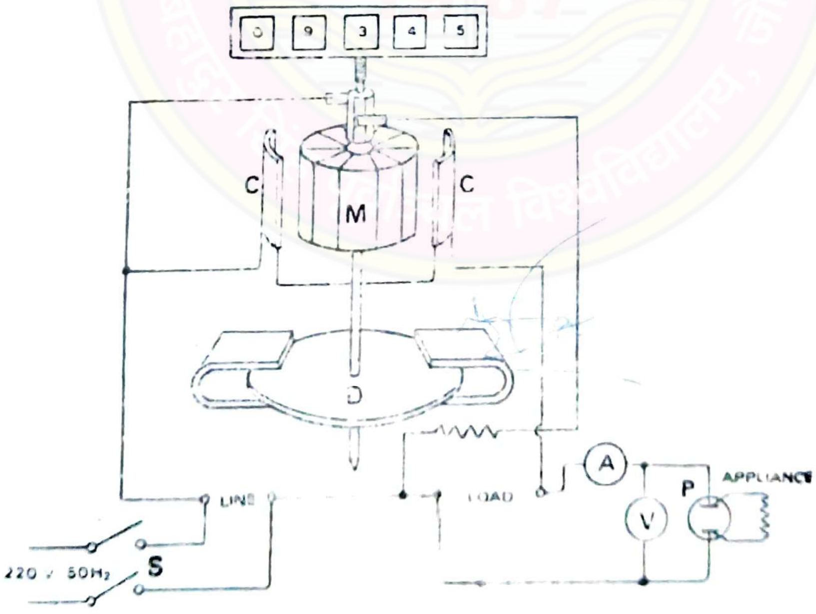


FIG.1

(2) After proper connection switch on the circuit. Count the number of rotation of the disc for about three minutes. Record the time and number of rotation. Note the energy-meter constant. It gives the energy in watt-hour per rotation of the aluminium disc. It is usually stamped near the disc D or under the plate covering the lead connection.

(3) Repeat the procedure for different appliances you get. It is important that the range of ammeter and various connection must be got checked before switching on the circuit.

(4) Record the Observations and do required calculation.

Observations.

I. Name of appliance used=

Time for which appliance is used=t=

Number of rotation of the disc D=n=

Energy meter constant =x=WH/rotation

Ammeter reading =I=

Voltmeter reading =V=

Analysis and Discussion ;-

(I) Electric energy recorded by watt-hour meter

$$= n.x \text{ kWH}$$

$$= \frac{nx}{1000} \text{ KWH}$$

Electric power recorded $= \frac{nx}{1000t}$

Calculated the power in watts.

Electric power as recorded by voltmeter and Ammeter

$$W = VI$$

%Error in the meter=

(2) Local power consumption rate = Rs. 0.35 per KWH

Calculation the cost of electric power consumed for the month for all the appliances used over a month.

Kind of appliance	P.D.V	Current I	Number of rotation of disc n	Time for Rotation	Power From meter	Power = VI	Error in meter

Total energy per month for all appliances=KWH.

SEMICONDUCTOR (P - N) JUNCTION DIODE CHARACTERISTICS

A p - n junction can be formed either by point contact or by diffusing donor impurity in p - type substrate in n - type substrate. In forward bias mode when the supply is connected such that the positive terminal of the supply is connected with p - side and the negetive terminal with the n - side the junction is called forward - biased. When the potential increased across the junction the holes are repelled from the positive end of supply and are compelled to move towards the junction. In similar way the electrons are repelled from the negetive side of the supply and drifts towards the junction. because of the acquired energy some of the holes and electrons penetrate the depletion region. This reduces the potential barrier and the width of the depletion region is reduced. as result of this more majority carriers diffuse across the junction. This results in an increased current through the p - n junction.

When the supply teminals are reversed such that the positive terminal with n - type and negetive with p - type get connected the junction is called reverse - biased. Increase in potential across the junction the holes in the p - region are attractedtowards the negetive side of the supply and the electrons in n - region attracted towards positivwe side of supply. Thus the majority carriers are drew away from the junction and this increases the barrier potential. The increased barrier potential makes more difficult to diffuse the majority carriers across the junction. But this position does not exsists for the minority carriers and they drifts across the junction. The quantity of these minority carriers depends upon the temperature of the junction. If the temperature of the junction is fixed the generated minority carriers will be fixed in quantity. Thus a little current flows across the junction called the reverse saturation or leakage current. It is generally lies in nanoamps for silicone diffused junctions and in µamps for germenium diffused or contact junctions. Increase in applied potential across junction does not more effect upon this reverse current till a voltage level called the breakdown voltage approaches where the current increases abruptly. At breakdown region the temperature of the junction also inreased quickly which helps to flow more current through the junction. In normal application this situation is avoided.

To draw the volt - ampere (v - i) characteristics of (GE)p - n junction diode, circuit shown in fig 1 and 2 are used. In fig 1, the +dc supply is connected with the anode of the diode and -dc with the cathode, where the voltmeter is in parallel and current meter in series. This is called the forward - biased diode. In fig 2, the supply is shown in reverse order, where the +dc is now connected with the cathode and vice - versa. This is called the reverse - biased diode. In forward - biased mode a low potential supply used and in reverse - biased mode a higher current limited supply is used to prevent permanat breakdown of the diode. Typical plottings of the curves are shown in fig 3.

Note :- There are two miniature toggle switches given to select the desired range for volt and current. The given dc supplies are selected by these switches. So when diode is made FORWARD - biased select the **forward** bias mode for both switches and **reverse** bias mode to bias the diode in REVERSE bias mode. In the meantime the connections are made according to given circuits.

Experiment procedure

object : To draw the forward and reverse - biased p - n junction diode characteristics.

a. Forward - biased diode.

1. Connect the diode with the supply sockets as shown in fig 1.

2. Select 1.5V range for supply. Select mA range for ammeter. Select 20 V range for voltmeter.

3. Switch on the power. Gradually increase the forward bias supply in small steps. Note the volt and current readings from the panel meters as forward voltage $\mathbf{V_F}$ and corrosponding current $\mathbf{I_F}$ in mA.

4. Take the readings till the mA meter approaches near maximum deflection. Switch off the power, turn supply control back to minimum. Prepare the table between $\mathbf{V_F}$ and $\mathbf{I_F}$ from the observations.

5. Plot the forward - biased diode graph taking $\mathbf{V}_F$ readings along the x - axis and $\mathbf{I}_F$ readings along the y - axis. Find the slope of the line from the linear part of the curve as shown in fig 3a. Calculate the dynamic forward resistance of the diode

$$R_F = \frac{\delta \ \mathbf{V}_F}{\delta \ \mathbf{I}_F}$$

b. Reverse - biased diode.

1. Keep both meters range select switches towards the 200V for voltmeter and uA range for current meter. Connect diode as shown in fig 2, such that its cathode is connected with the + dc socket of the supply.

2 Switch on the power. Increase the reverase bias supply in small steps and note reverse voltages as -ve volts and corrosponding current from the current meter.

3. Plot the reverse biased diode characteristics as shown in fig 3 in 3rd quadrent. Find out the slope of the curve before breakdown. From the slope

$$R_R = \frac{\delta \ \mathbf{V}_R}{\delta \ \mathbf{I}_R}$$

Conclusion : The forward resistance of a diode is very low while its reverse resistance is high, thus it allows to pass the current to one direction only.

Forward biased diode

Sr No.	V_F	I_F
1	..V	..mA
2	"	"
3	"	"
4	"	"
5	"	"
6	"	"
n	"	"

Reverse biased diode

Sr No.	V_R	I_R
1	..V	..mA
2	"	"
3	"	"
4	"	"
5	"	"
6	"	"
n	"	"

Sem (p -n) diode ch 2d-4

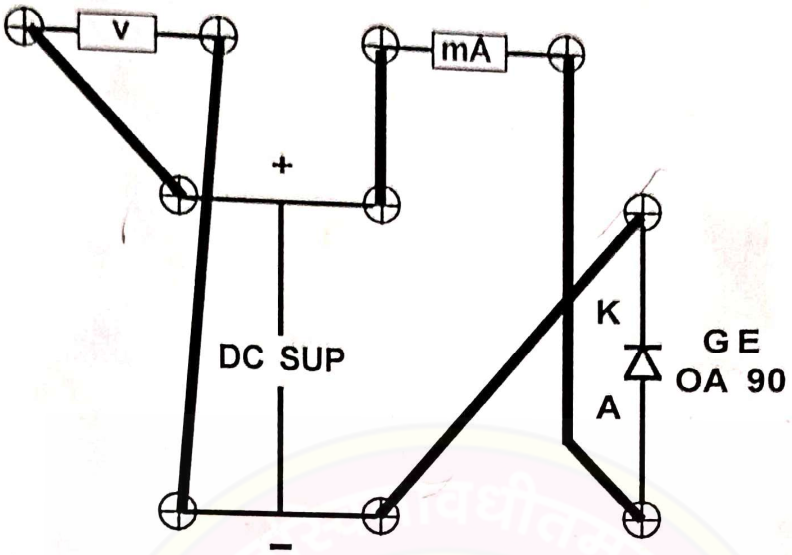


FIG 1, FORWARD - BIASED DIODE CIRCUIT. CURRENT LIMIT RESISTANCE INCLUDED.

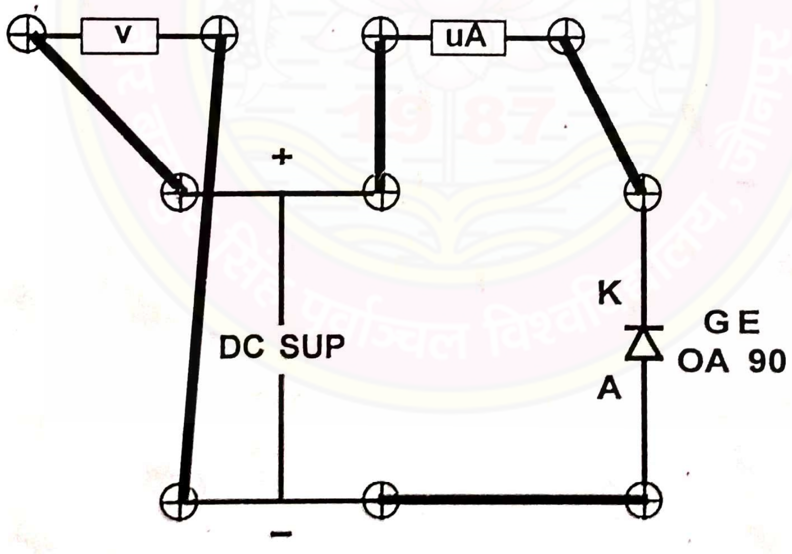


FIG 2, REVERSE - BIASED DIODE CIRCUIT. CURRENT LIMIT RESISTANCE INCLUDED.

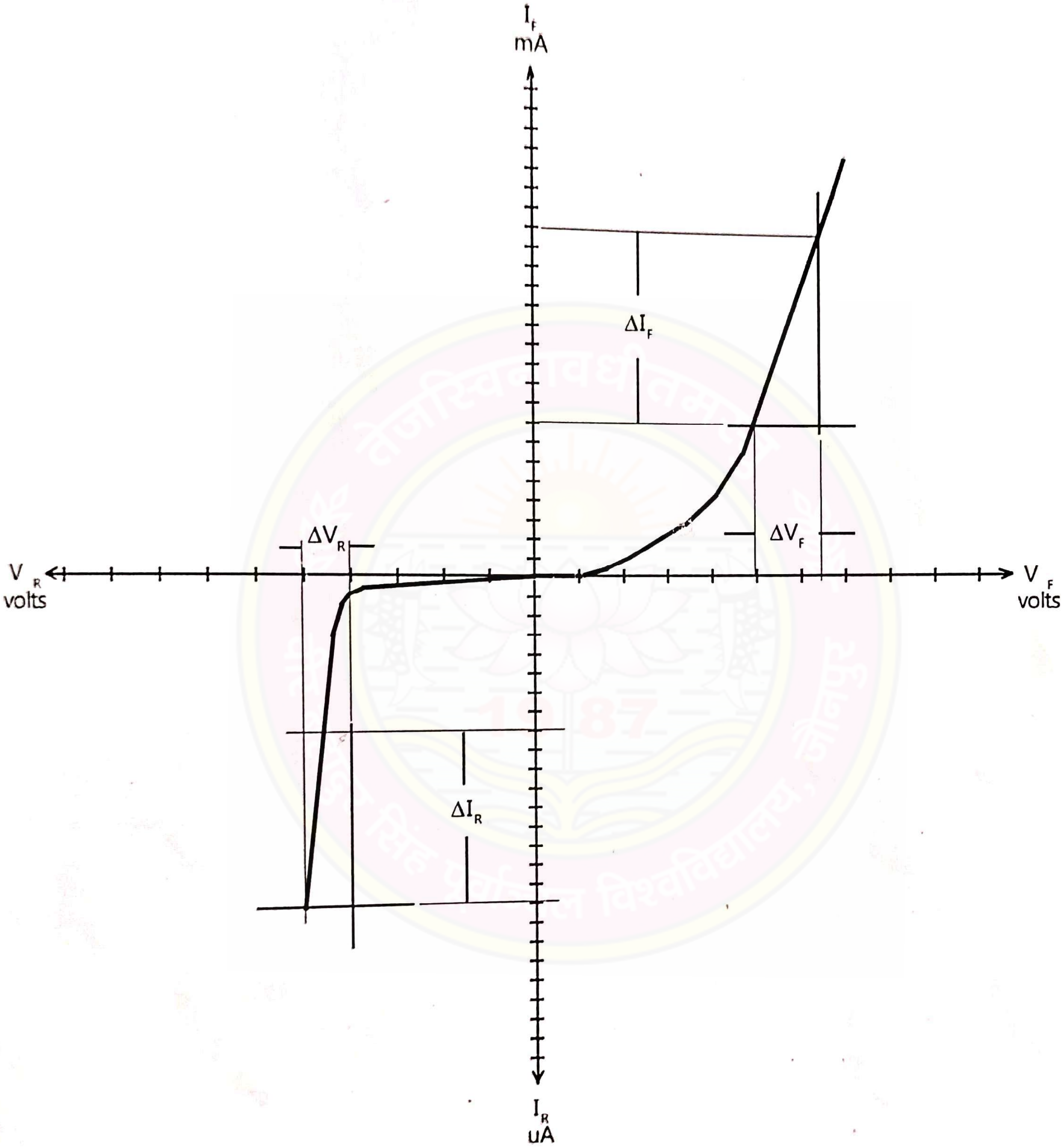


FIG 3, TYPICAL V - I CHARACTERISTICS CURVES FOR GE P - N JUNCTION DIODE.
(Shown for example changed device to device)

TRANSISTOR CHARACTERISTICS

Common - emitter configuration

The transistor is a three layer (electrode) semiconductor device. the three electrode are the collector, the emitter and the base. The emitter injects the charge carrier into the base, which in turn controls the number of these carriers that are gathered by the collector. Whenever a transistor is to be used in electrical circuits, its electrical performance are viewed. The electrical perfomances are found from the volt - ampere (V - I) charactristics of the transistor.

The transistor is biased such that its base - emitter junction is made forward biased and collector - emitter is made reverse biased. In common emitter configuration the emitter terminal is kept common for input - output. The voltage applied at input , between base - emitter becomes instantaneous voltage *Vbe* and at output *Vce*,applied between collector - emitter. Similarly two instantaneous currents *Ib* at input and *Ic* at output obtained. To determine the electrical properties two set of graphs are plotted. In each graph two variables are dependent and other are constant. The plots are called input and output charactricstics curves.

The input characteristics.

To draw input characteristics the input supply *Vbe* is varied and corrosponding current *Ib* is noted with each increamental step, while the output supply is kept constant throughout the step. Atleast set of three curves are plotted from the observations and input impedance is evalated from the curves as,

The input impedance **Ri =** $\dfrac{\Delta \mathbf{Vbe}}{\Delta \mathbf{Ib}}\Bigg|$ **Vce constant** .... (1)

The output characteristics.

To draw output characteristics the output supply *Vce* is varied and corrosponding current *Ic* is noted with each increamental step, while the input current Ib is kept constant throughout the step. Atleast four to five curves are plotted from the observations and output impedance ,current gain β is evaluated from the curves as,

The output impedance **Ro =** $\dfrac{\Delta \mathbf{Vce}}{\Delta \mathbf{Ic}}\Bigg|$ **Ib constant** .... (2)

The current gain **β** = $\dfrac{\Delta \mathbf{Ic}}{\Delta \mathbf{ib}}\Bigg|$ **Vce constant** .... (3)

EXPERIMENT PROCEDURE

Object : To plot the input and output characteristics of given transistor in common emitter configuration.

(a) The input characteristics. (Fig 1)

1. Keep Vce supply at dc 5volt, i.e. Vce = 5V.

2. Slowly increase Vbe supply in small steps. Note Ib and Vbe for each increamental step.

3. Tabulate all observations.

4. Plot the Input characteristic curve from the observations, between Ib and Vbe. Find out the slope of the curves as given in relation (1) see fig 2.

(b) The output characteristics. (Fig 1)

1. Keep Vce = 0. Adjust Ib = 40 uA.

2. Slowly increase Vce supply in small steps. The mAmmeter deflects back as the Vce get increased. This is due to reverse saturation current Iceo. Recorrect Ib to determined value 40 mA. Note IC and Vce with each increamental step.

3. Repeat step 2 for different values of Ib, say 80 uA increament for each step. Care should be taken to recorrect Ib throughout the steps.

4. Tabulate the observations.

5. Plot the output characteristics curves from the observations, between Ic and Vce. Fix an operating point in the middle of the curves,find out the slope of the curve as given in relation (2) and (3) see fig 3.

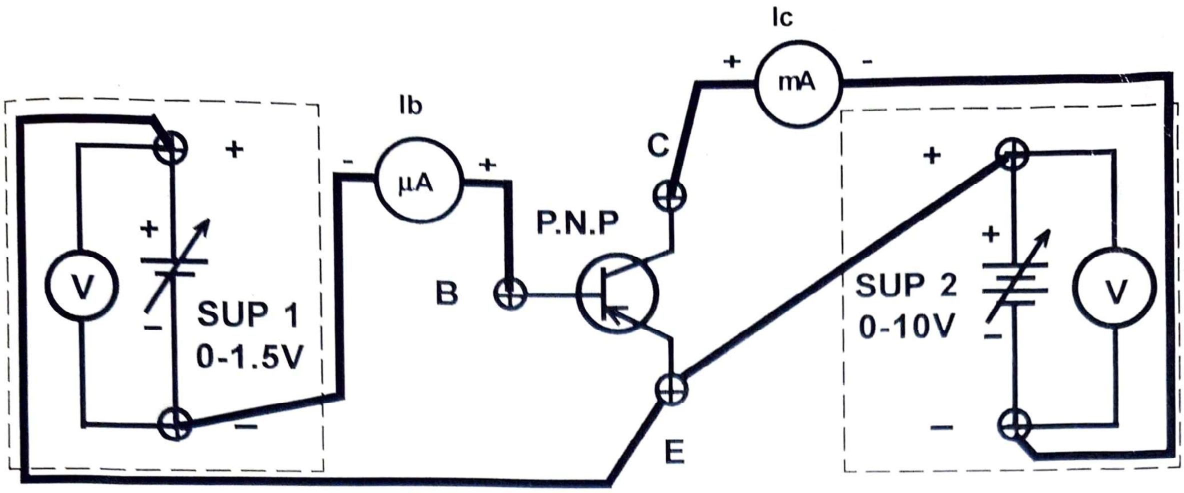
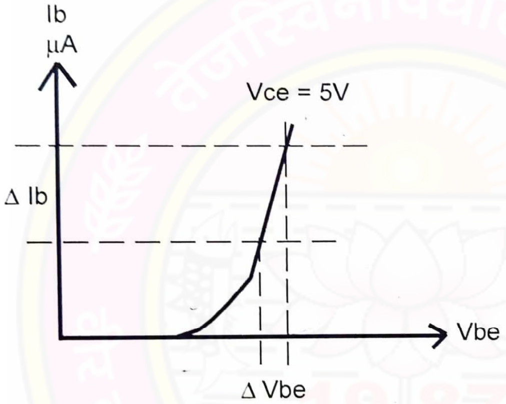


FIG 1

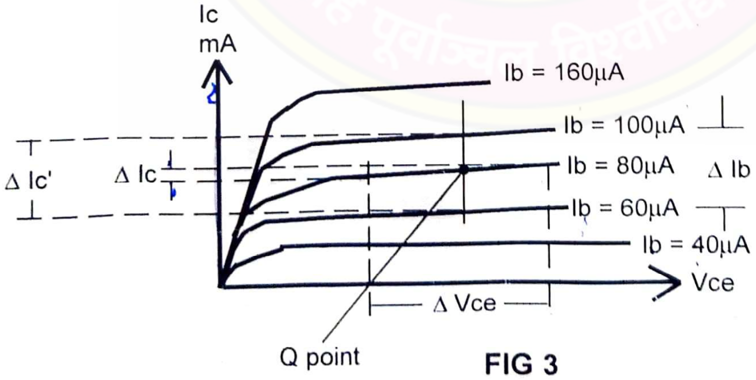
Transistor P.N.P. in common - emitter biasing



$$R_i = \frac{\Delta V_{be}}{\Delta I_b}$$

FIG 2

Typical input characteristics curve



$$R_o = \frac{\Delta V_{ce}}{\Delta I_c}$$

$$\beta = \frac{\Delta I_c'}{\Delta I_b}$$

FIG 3

Typical output characteristics curve

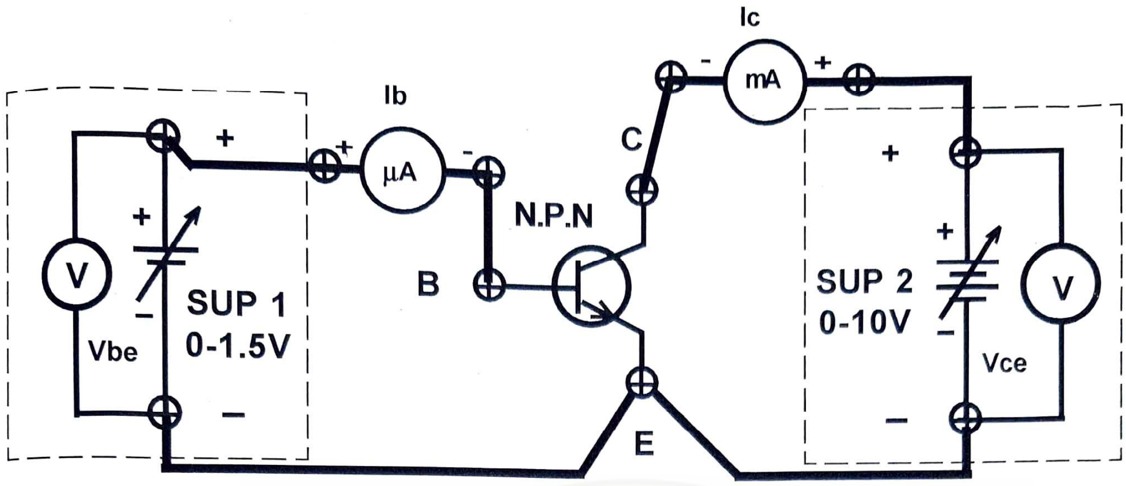
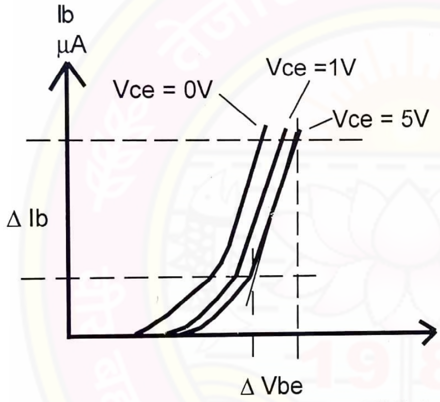


FIG 1

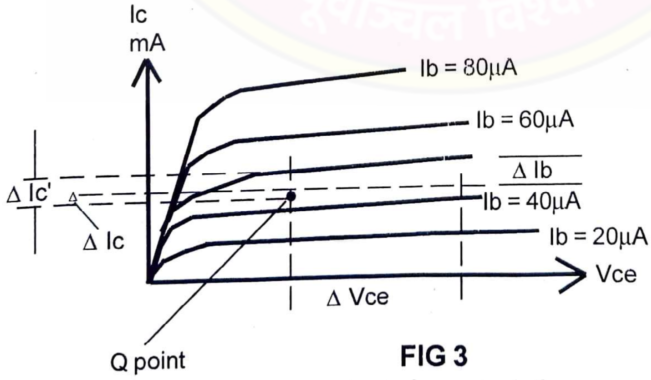
N.P.N Transistor in common - emitter biasing



$$R_i = \frac{\Delta V_{be}}{\Delta I_b}$$

FIG 2

Typical input characteristics curve



$$R_o = \frac{\Delta V_{ce}}{\Delta I_c}$$

$$\beta = \frac{\Delta I_c'}{\Delta I_b}$$

FIG 3

Typical output characteristics curve

TRANSISTOR CHARACTERISTICS

Common - base configuration

The transistor is a three layer (electrode) semiconductor device. the three electrode are the collector, the emitter and the base. The emitter injects the charge carrier into the base, which in turn controls the number of these carriers that are gathered by the collector. Whenever a transistor is to be used in electrical circuits, its electrical performance are viewed. The electrical perfomances are found from the volt - ampere (V - I) characteristics of the transistor.

The transistor is biased such that its base - emitter junction is made forward biased and collector - emitter is made reverse biased. In common base configuration the base terminal is kept common for input - output. The voltage applied at input , between emitter - base becomes instantaneous voltage *Veb* and at output *Vcb*,applied between collector - base. Similarly two instantaneous currents *Ie* at input and *Ic* at output obtained. To determine the electrical properties two set of graphs are plotted. In each graph two variables are dependent and other are constant. The plots are called input and output charactericstics curves.

The input characteristics.

To draw input characteristics the input supply *Veb* is varied and corrosponding current *Ie* is noted with each increamental step, while the output supply is kept constant throughout the step. Atleast set of three curves are plotted from the observations and input impedance is evaluated from the curves as,

$$\text{Input impedance } \mathbf{Ri} = \frac{\mathbf{D\ Veb}}{\mathbf{D\ Ie}}\Bigg| \ \mathbf{Vcb\ \ constant} \ldots\ldots\ldots (1)$$

The output characteristics.

To draw output characteristics the output supply *Vcb* is varied and corrosponding current *Ic* is noted with each increamental step, while the input current *Ie* is kept costant throughout the step. Atleast five to six curves are plotted from the observations and output impedance ,current gain a is evaluated from the curves as,

$$\text{Output impedance } \mathbf{Ro} = \frac{\mathbf{D\ Vcb}}{\mathbf{D\ Ic}}\Bigg| \ \mathbf{Ie\ constant} \ldots\ldots\ldots\ldots (2)$$

$$\text{The current gain } \mathbf{a} = \frac{\mathbf{D\ Ic}}{\mathbf{D\ Ie}}\Bigg| \ \mathbf{Vcb\ constant} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

EXPERIMENTAL PROCEDURE

Object : To plot the input and output characteristics of given transistor in common base configuration.

(a) The input characteristics. (Fig 1)

1. Keep Vcb supply at 5volt, i.e. Vcb= 5V.

2. Slowly increase Veb supply in small steps. Note Ie and Veb for each increamental step.

3. Tabulate the observations.

4. Plot the Input characteristics curves from the observations, between Ie and Veb. Find out the slope of the curves as given in relation (1) see fig 2.

(b) The output characteristics. (Fig 1)

1. Keep Vcb = 0. Adjust Ie = 5 mA

2. Slowly increase Vcb supply in small steps. The mAmmeter deflects back as the Vcb get increased. This is due to reverse saturation current Icbo. Recorrect Ie to determined value 5 mA. Note IC and Vcb with each increamental step.

3. Repeat step 2 for different values of Ie, say 5 mA increament for each step. Care should be taken to recorrect Ie throughout the steps.

4. Tabulate all results.

5. Plot the output characteristics curves from the observations, between Ic and Vcb. Fix an operating point in the middle of the curves,find out the slope of the curve to evaluate ro as given in relation (2). To calculate a take both side curves for D Ie and D Ic

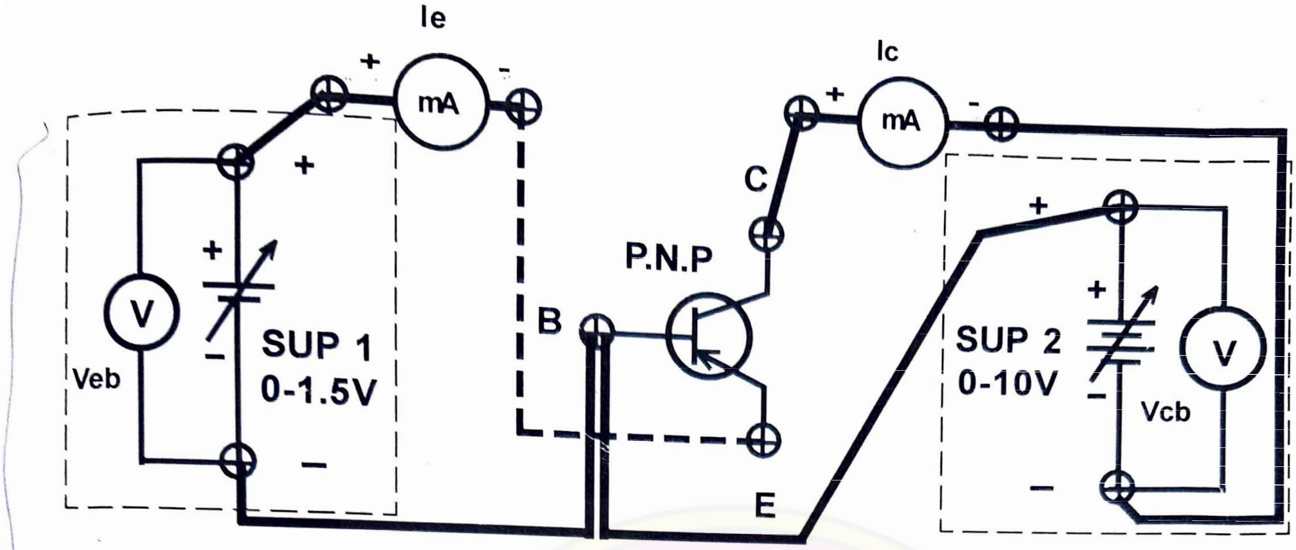


FIG 1

P.N.P Transistor in common - base biasing

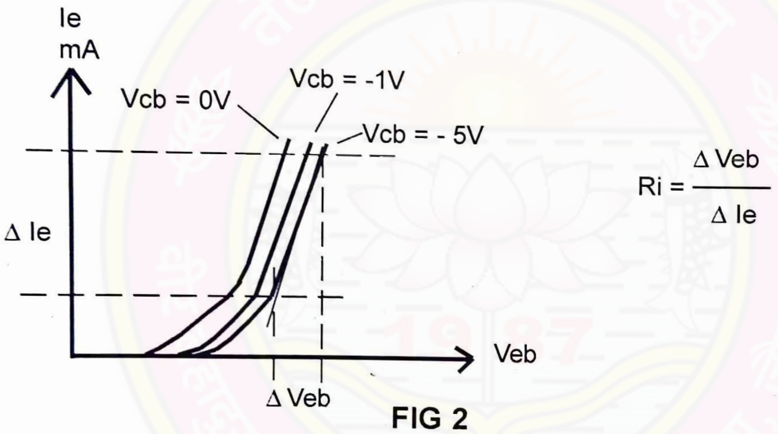


FIG 2

Typical input characteristics curve

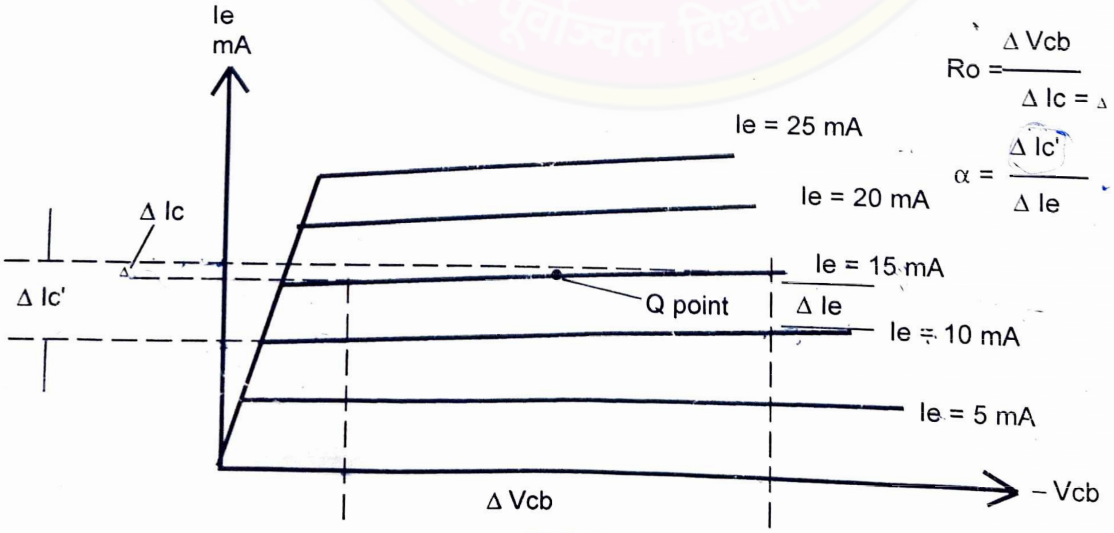


FIG 3

Typical output characteristics curve

Transistor ch C B - 4

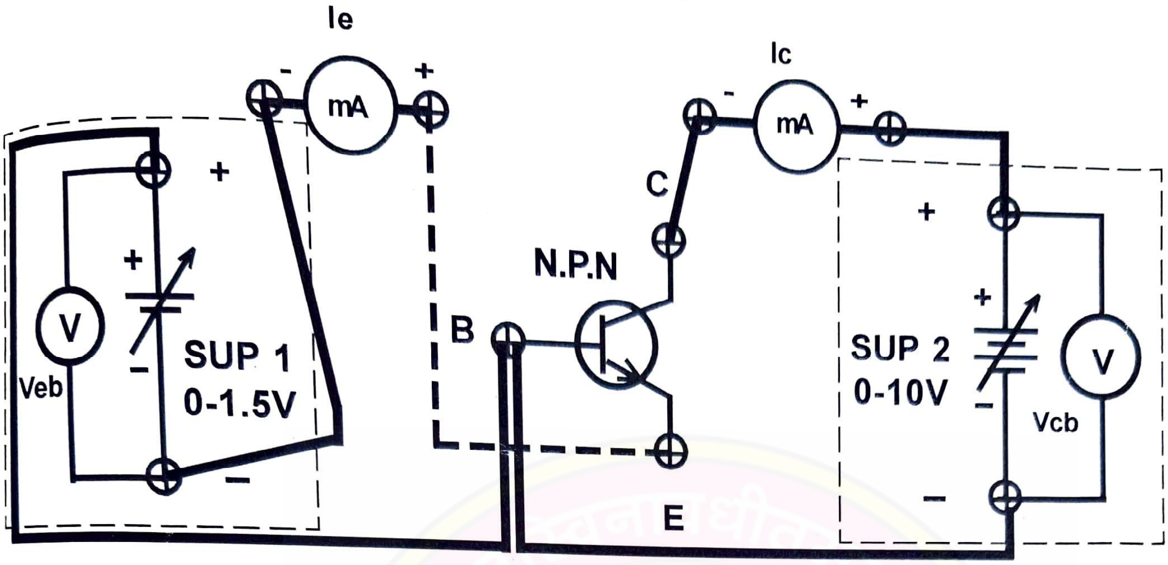


FIG 1

N.P.N Transistor in common - base biasing

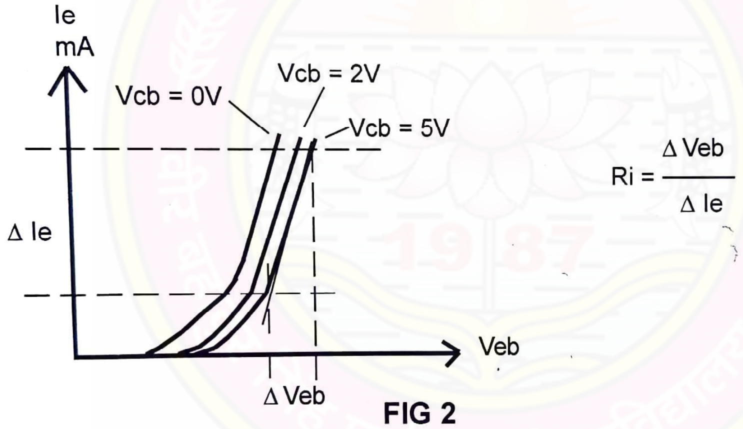


FIG 2

Typical input characteristics curve

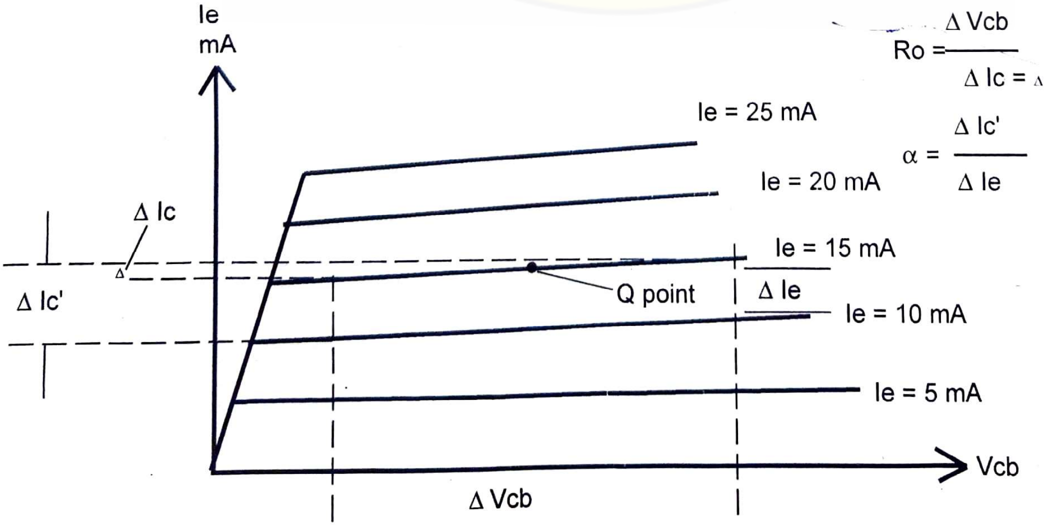


FIG 3

Typical output characteristics curve

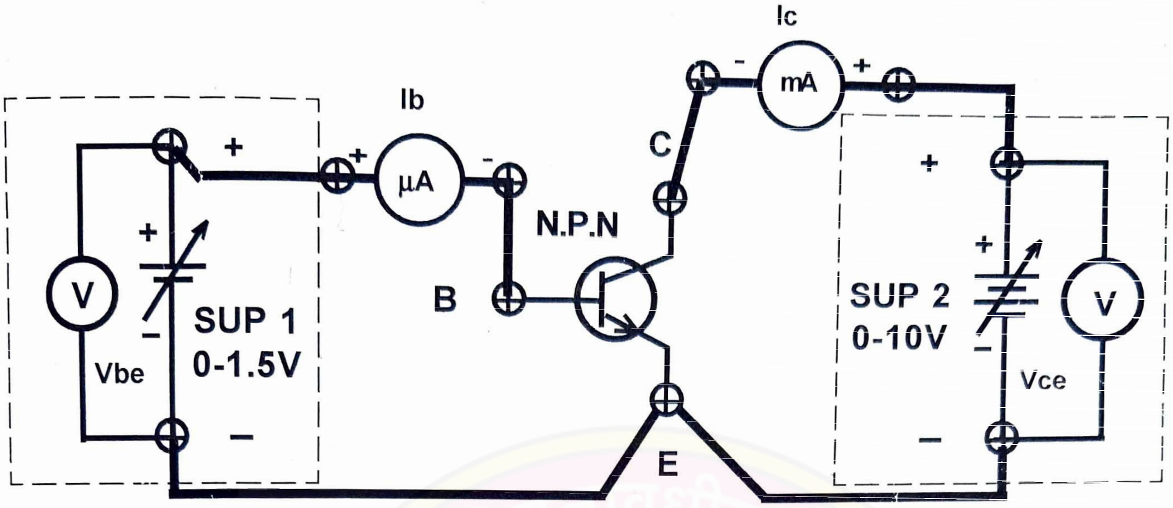
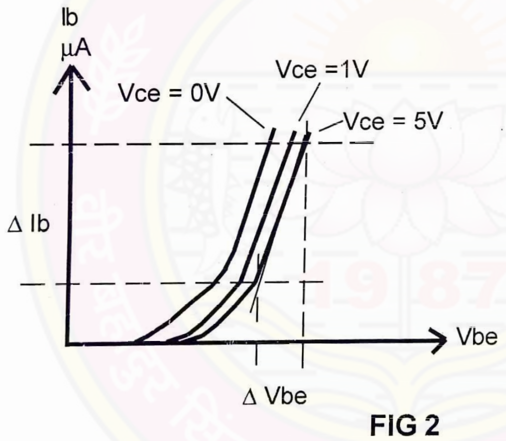
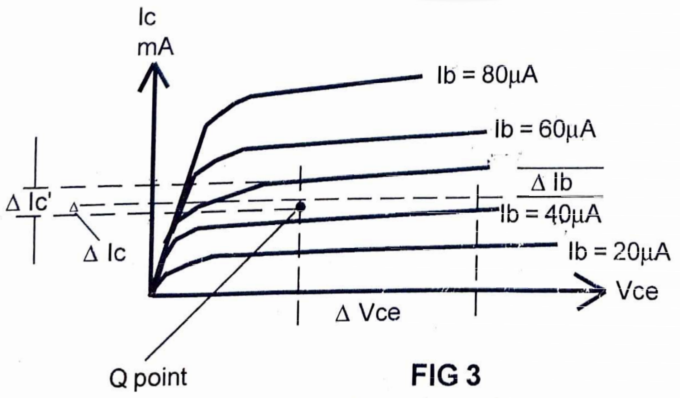


FIG 1
N.P.N Transistor in common - emitter biasing



$$R_i = \frac{\Delta V_{be}}{\Delta I_b}$$

FIG 2
Typical input characteristics curve



$$R_o = \frac{\Delta V_{ce}}{\Delta I_c = \Delta}$$

$$\beta = \frac{\Delta I_c'}{\Delta I_b}$$

FIG 3
Typical output characteristics curve

V-I characteristic of Zener Diode

Object: To draw the V-I characteristic of Zener diode and to determine Zener breakdown voltage.

Apparatus used: Zener diode, voltmeter (0-2volt), voltmeter (0-30 volt), mili-ammeter, micro-ammeter, variable source (0-2 volt and 0-30 volt).

Theory:

Zener Diode: Zener diode is a heavily doped PN junction diode. Due to heavily doped, its depletion layer is very thin and is order of micrometer. The forward bias characteristic of Zener diode is same as the normal PN junction diode but in reverse bias it has different characteristic.

Initially, a negligible constant current flow through the zener diode in its reverse bias but at certain voltage, the current becomes abruptly large. This voltage is called as zener voltage. This sudden and sharp increase in zener current is called as zener breakdown.

Circuit diagramme:

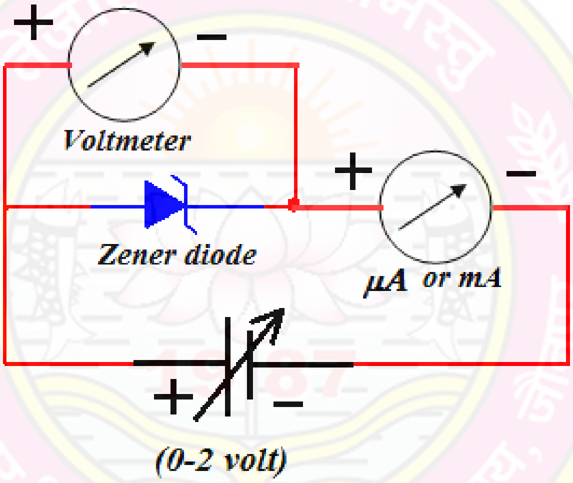


Fig 1: Zener Diode in FB

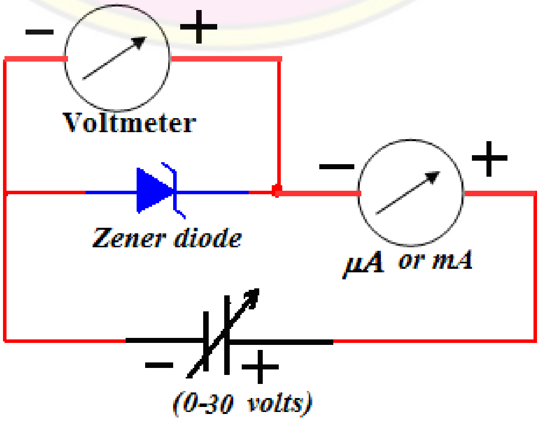


Fig 2: Zener Diode in RB

Observation:

1. Least count of voltmeter (0-2volt) =0.02 volt
2. Least count of voltmeter (0-30volt) =0.5 volt
3. Least count of miliammeter =0.2 mA
4. Least count of micro-ammeter =5 μA
5. *V_F and I_F for PN junction Diode in FB*

Sr. No.	*V_F (Volt)*	*I_F (mA)*
1.	*0*	*0*
2.	*0.1*	*0*
3.	*0.2*	*0*
4.	*0.3*	*0*
5.	*0.4*	*0*
6.	*0.5*	*0*
7.	*0.6*	*0.2*
8.	*0.62*	*0.2*
9.	*0.64*	*0.4*
10.	*0.66*	*0.6*
10.	*0.68*	*0.8*
11.	*0.70*	*1.2*
12.	*0.72*	*2.2*
13.	*0.74*	*3.2*
14.	*0.76*	*5.2*
15.	*0.78*	*7.0*
16.	*0.80*	*9.4*

6. *V_R and I_R for PN junction diode in RB*

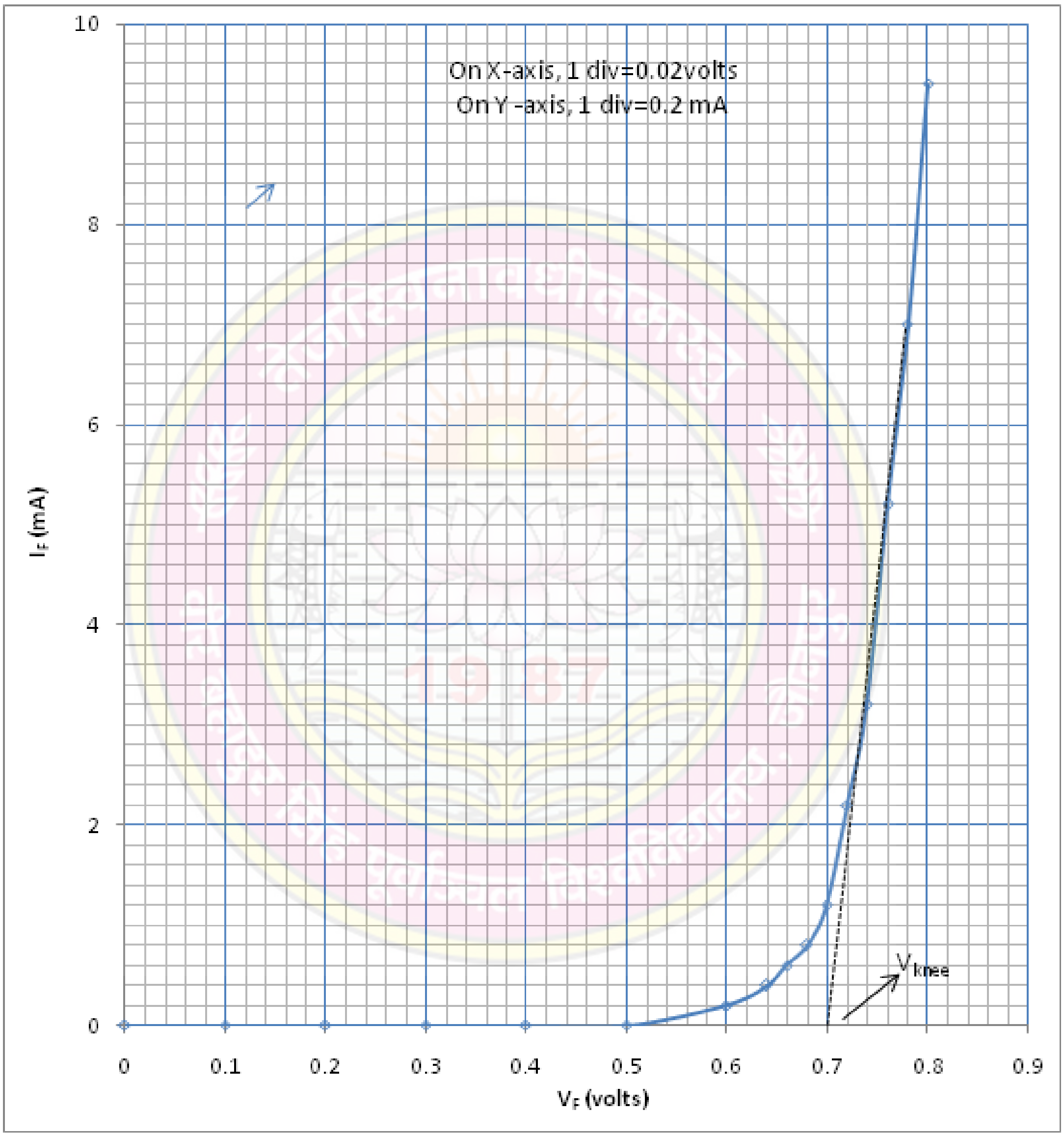
Sr. No.	*V_R (Volt)*	*I_R (mA)*
1.	0	0
2.	1	0
3.	2	0
4.	3	0
5.	4	0
6.	5	0
7.	6	0
8.	7	0
9.	8	0
10.	8.8	0.2
10.	9	0.4
11.	9.2	3.0

Result:

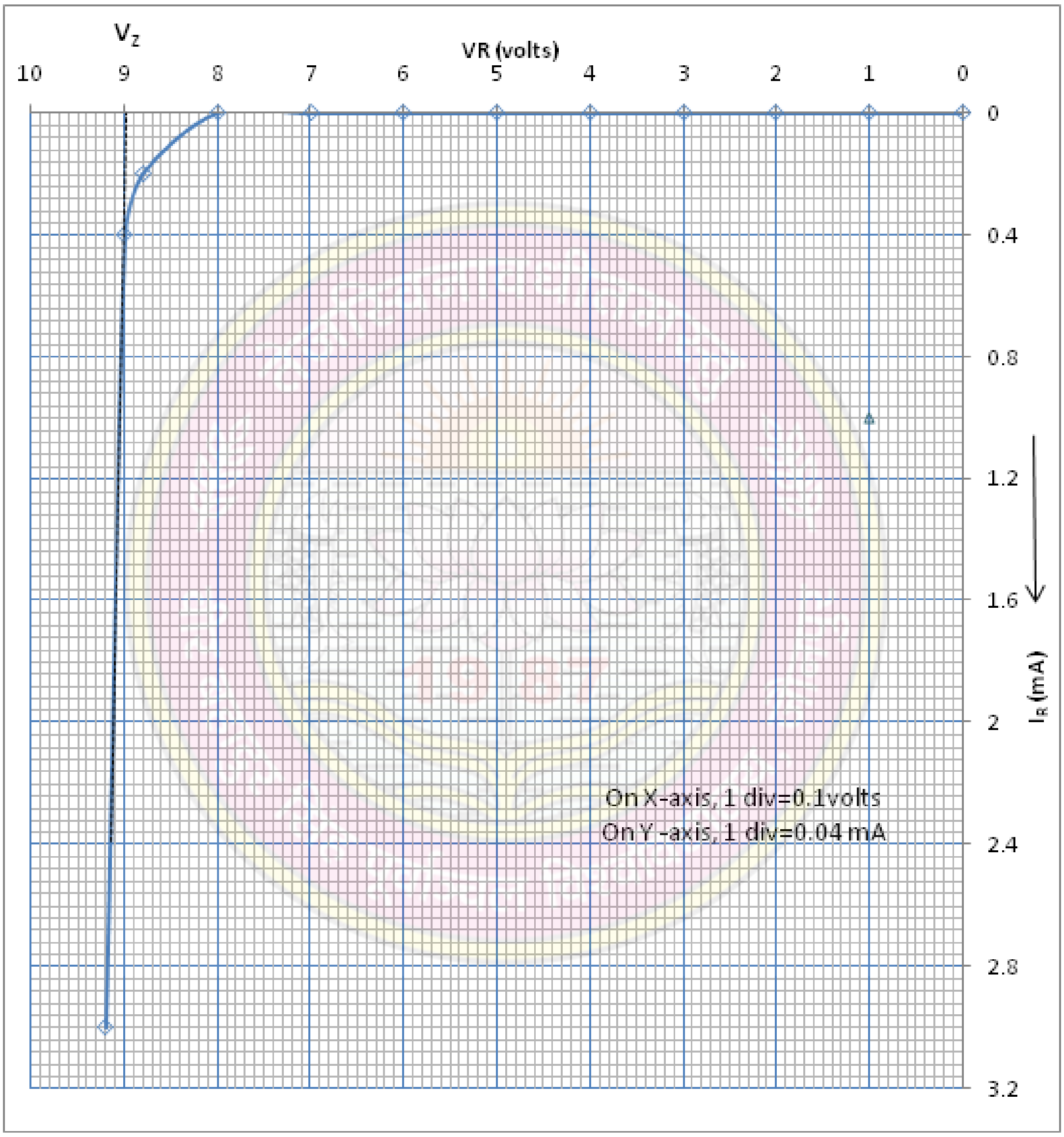
The V-I characteristic of Zener diode indicates that characteristic of Zener diode in forward bias is same as PN junction diode. In reverse bias, a negligible constant current flow through the zener diode but the current becomes abruptly large at certain voltage. This voltage is called as zener voltage. This sudden and sharp increase in zener current is called as zener breakdown. V_{knee}=0.7 volt and V_Z= 9 volt.

Precautions:

1. The connection should be tight otherwise fluctuation in voltage and current will happen.
2. At the turning point of curve, more reading should be taken.
3. For the plot of Graph, current should be taken mA for both forward and reverse biased diode.
4. The reading should be in multiple of least count.



V-I Characteristic Curve for Zener Diode in FB



V-I Characteristic Curve for Zener Diode In RB

Boltzmann Constant

Object: To find the value of the Boltzmann constant from the *V-I* characteristics of a p–n junction diode.

> **Apparatus Required**
>
> A *p-n* junction diode, a DC power supply, a rheostat, milliammeter (0–20 mA), a digital voltmeter (least count of 0.05 V) and connecting wires.

Before beginning the experiment, let us briefly discuss the basic underlying concepts.

THEORETICAL CONCEPTS

Shockley Diode Equation

IThe general *V-I* characteristics of a semiconductor diode in forward and reverse bias is described by the following Shockley diode equation (named after the co-inventor of the transistor William Shockley, of Bell Telephone Laboratories):

$$I_D = I_S\left(e^{V_D/\eta V_T} - 1\right) \tag{1}$$

where

I_D is the diode current

I_S is the reverse saturation current

V_D is the applied voltage across the diode

V_T is the thermal voltage

η is an ideality factor, which is a function of operating condition and physical construction; it has a range between 1 and 2 depending upon a variety of factors.

$\eta = 1$ (for Ge) and $\eta = 2$ (for Si).

For $\eta = 1$, Eq. (1) is called the Shockley ideal diode equation. The thermal voltage V_T is defined by :

$$V_T = \frac{k_B T}{e} \tag{2}$$

where

k_B is the Boltzmann constant (= 1.38 X 10^{-23} JK^{-1})

T is the absolute temperature in Kelvin (= temperature in °C + 273) e is the magnitude of electronic charge (= 1.6×10^{-19} C)

A typical plot of Eq. 1 is shown in Fig. 1.

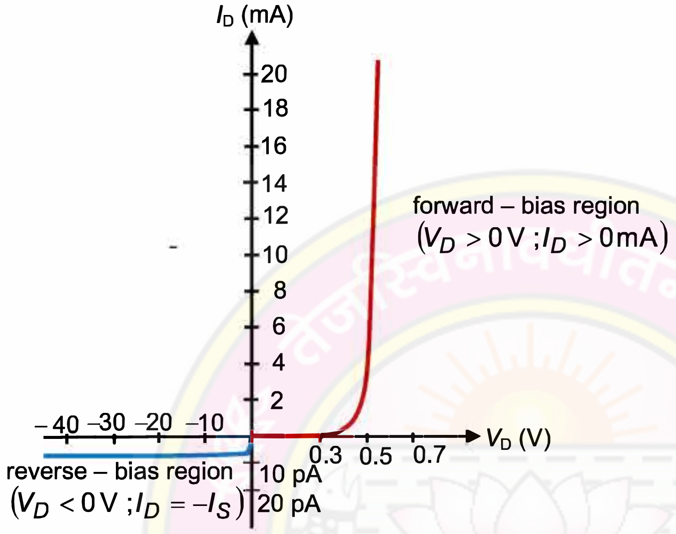


Fig. 1: Typical plot of the Shockley diode equation.

For positive values of V_D, (forward bias), the first term of Eq.(1) i.e. $I = I_S e^{V_D/\eta V_T}$ will grow very quickly and is much larger than the second term i.e. I_S so the second term can be easily neglected in comparison the first term thus reducing Eq.(1) to

$$I_D \cong I_S e^{V_D/\eta V_T} \qquad (3)$$

With negative values of V_D, (reverse bias), the first term (exponential term) dies off very quickly, giving the following equation

$$I_D \cong -I_S \qquad (4)$$

Boltzmann constant from Shockley Diode Equation

Substituting for V_T from Eq. (2) into Eq. (1) we get

$$I_D = I_S\left(e^{V_D e/\eta k_B T} - 1\right) \qquad (5)$$

Taking log on both the sides of Eq. (5) we get

$$\log_{10} I_D = \log_{10} I_S + \frac{V_D e}{2.303 \eta k_B T} \qquad (6)$$

As the slope from a graph between $\log_{10} I_D$ versus V_D gives $e/2.303\eta k_B T$ which the Boltzmann constant k_B can be evaluated:

$$Slope = \frac{e}{2.303\eta k_B T} \Rightarrow k_B = \frac{e}{2.303\eta T(Slope)} \qquad (7)$$

With this preliminary knowledge you can now perform the experiment.

Procedure

Follow the procedure described below to perform the experiment.

1. Make the connections as per the Fig. 2. Connect the *p-n* diode in the forward bias mode. Connect the voltmeter across the diode and a milliammeter in series with the circuit.

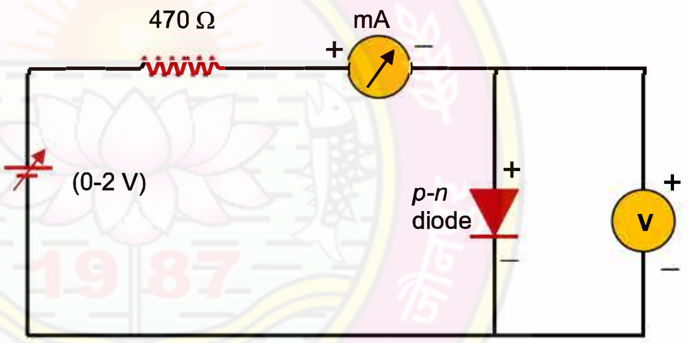


Fig. 2: **Circuit diagram for the determining Boltzmann constant from the *V-I* characteristics of a *p-n* diode**

2. Increase the input voltage from 0 V in small steps. The voltmeter will measure the voltage (*V*) across the diode and the ammeter will measure the current (*I*) flowing in the circuit.

3. Note down the reading of the voltage and current in Observation Table 1.1. A digital voltmeter and ammeter, preferably with low least count will ensure maximum number of readings and also reduce the possibility of error.

4. Take the readings till the current reaches a value of say 20mA. Note the room temperature.

5. Draw a graph with the voltage along the *x*-axis and $\log_{10} I$ along the *y*-axis. A typical graph is shown in Fig. 1.3 Since the values of $\log_{10} I$ are negative so the graph is plotted in the fourth quadrant. A straight line is obtained.

Observation Table 1: Variation of current with voltage

Temperature, T =……K
Least count of Voltmeter, V =…… V
Least count of Ammeter, I =…… A

S.No.	Voltage *V* (Volts)	Current *I* (mA)	Current *I* (A)	$\log_{10} I$
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				

DETERMINATIOIN OF BOLTZMANN’S CONSTANT

Calculate the slope of the straight line as shown in Fig. 3 (the slope is positive):

$$Slope = \frac{AB}{BC}$$

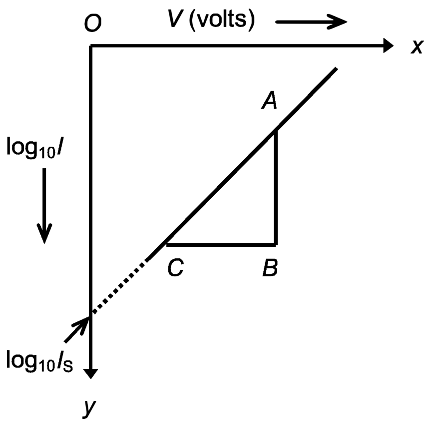


Fig. 3: Plot of *V* versus $\log_{10} I$.

Boltzmann’s constant k is calculated as

$$k_B = \frac{e}{2.303\eta T} \times \frac{1}{Slope}$$

Using the values of e and T, and inserting the value of *eta*(At 300 K, for a Silicon diode the value of *eta* is 2) we can calculate k_B as

$$k_B = \frac{11.59 \times 10^{-23}}{Slope} = ...\mathrm{JK}^{-1}$$

Result:

Boltzmann Constant = $.......\mathrm{JK}^{-1}$

Standard Value = $1.38 \times 10^{-23}\,\mathrm{JK}^{-1}$

Percentage error = ...%

PRECAUTIONS AND SOURCES OF ERRORS

- The value of ideality factor η is equal to 1 for germanium diode and is equal to 2 for Silicon diode. The values are taken as per the p-n junction diode used in the experiment.
- *p-n* junction diode is connected in forward bias condition.
- The supply voltage is to be increased slowly and should not be increased to high value else it may damage the diode.

Vernier Calipers

OBJECT: *To determine the radius of a cylinder using Vernier calipers*

Apparatus used: *Cylinder, Vernier calipers.*

Formula: *Radius =diameter/2* *or* $r = D/2$

Theory - ***Vernier calipers-*** *It is a device to measure the length or width of any small object with greater precision than with a normal cm scale. While the least count of a cm scale is one mm. The least count of Vernier calipers is normally 0.1 mm or even lesser. Different Vernier calipers have different least counts.*

Vernier calipers consist of a rectangular steel bar graduated in inches on one side and centimeters on the other side. This is known as the main scale. Over this scale, another small scale slides called Vernier scale (fig.1). The instrument has two jaws A and B. The jaw A is fixed at the end of the main scale, while the jaw B is movable. It is a part of the sliding Vernier scale. Each jaw is at right angles to the main scale. Usually when the two jaws are touching each other, the zero of the Vernier scale coincides with the zero of the main scale. If it is not so then the instrument has a zero error.

It has also the jaws protrude upwards as P and Q. These projecting jaws are used to measure the internal diameter of the tubes. The movable jaw also carries a thin rectangular rod R that is used to measure the depth of a vessel.

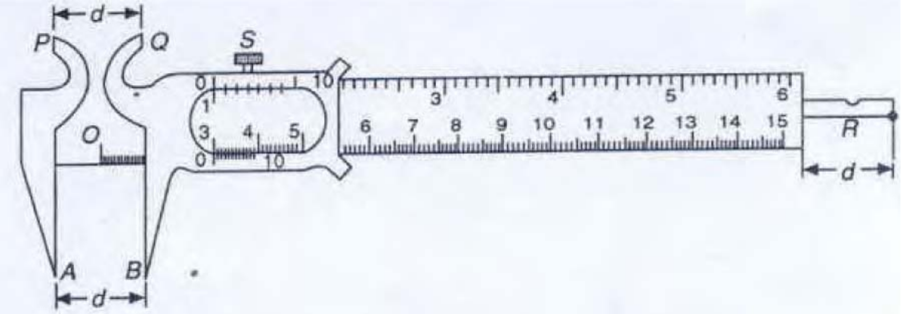


Fig.1

Procedure:

A. Least count of Vernier calipers or Vernier constant: *First of all find out the least count of Vernier calipers. The least count of Vernier can be determined by two methods.*

First method:

1. *Find out the value of one division of main scale.*
2. *See how many division of main scale is equivalent to Vernier scale divisions.*
3. *The difference between one main scale division and one Vernier division is called Vernier constant or least count of the Vernier calipers.*

Vernier constant=least count of Vernier calipers= 1 M.S.D- 1V.D

Example: *Let the value of one division on main scale is equal to 1mm and the 9 main scale divisions is equivalent to 10 Vernier scale divisions.*

1 V.D = 9/10 M.S.D

Least count of Vernier calipers= 1 M.S.D- 1V.D = 1/10 M.S.D = 0.1 M.S.D = 0.1 mm=0.01cm

Second method:

1. *Find out the value of one division of main scale.*
2. *Find out the total number of divisions on Vernier scale.*
3. *The ratio of value of one division of main scale and total number of divisions on Vernier scale is called as Vernier constant or least count of the Vernier calipers.*

Vernier constants=least count of Vernier calipers= $\frac{\text{value of one division of main scale}}{\text{number of divisions on Vernier scale}}$

Example 1: *Let the 1cm of main scale is divided in to 10 divisions and total number of Vernier scale divisions are 10.*
Value of one division of main scale =1/10=0.1cm
Total number of divisions on Vernier scale=10
Least count of Vernier calipers=0.1/10 =0.01cm

Example 2: *Let the 1cm of main scale is divided in to 20 divisions and total number of Vernier scale divisions are 50*
Value of one division of main scale =1/20=0.05cm
Total number of divisions on Vernier scale=50
least count of Vernier calipers= 0.05/50=0.001cm

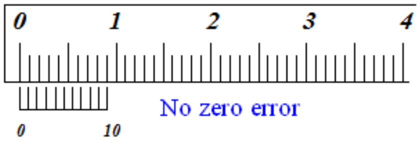
B. Checking of Zero error: Coincide the two jaws of Vernier calipers. If the zero of the Vernier scale coincides with the zero of the main scale then zero error in the Vernier calipers is zero. If it is not so then the instrument has a zero error. If zero of Vernier scale stays on right hand side of main scale zero then there is positive zero error. And if zero of Vernier scale goes to left hand side of main scale zero then there is negative zero error. Positive error is subtracted with measured length/diameter to find the correct length/diameter while negative error is added to measured length/diameter to find the correct length/diameter (see fig.2a, 2b and 2c).

C. Measurement: In order to find the diameter of a cylinder,

1. Hold it diameter wise between the jaws of the Vernier calipers tightly.
2. Now see the position of the zero of the Vernier against the main scale.
3. Note the reading on main scale and
4. Note which division of Vernier scale coincides with main scale division.
5. Use the following expression to find diameter.

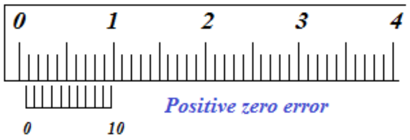
Diameter= M.S. + V.S. X L.C.

6. Repeat the procedure 1 to 5 at least four/five times by changing the position of the jaws.
7. Find the mean value.
8. Apply zero error to find the corrected diameter.



Zero error =0

Fig.2a

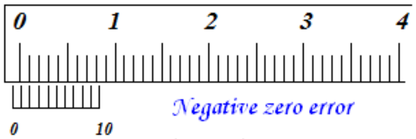


Zero error = + VS X LC

= + 8 X 0.01

= + 0.08 cm

Fig.2b



Zero error = - (10-VS) x LC

= - (10-2) x 0.01

= - 8 x 0.01

= -0.08 cm

Fig.2c

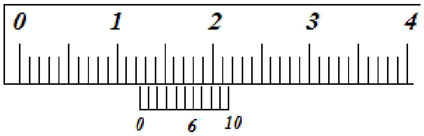


Fig.3

Example: Let least count of Vernier calipers is 0.01cm. Assume that the zero of Vernier lies between 1.2 cm and 1.3 cm on the main scale (Fig.3). This means that the diameter of the cylinder is more than 1.2 cm and less than 1.3 cm. Now main scale reading will be 1.2cm. If 6th division of Vernier coincides with any main scale division then Vernier scale reading will be 6.

Now total diameter will be, D= M.S. + V.S. x L.C. = 1.2 + 6 x 0.01=1.26 cm

Observations-

1. Value of one division of main scale =…..cm
2. Total number of divisions on Vernier scale=……..
3. Least count of Vernier calipers = ……..cm
4. Zero error =……….cm
5. **Table for diameter (D) of cylinder**

Sr. no.	M.S. (cm)	V.S. (div)	un-corrected diameter (d= MS + VS x LC) (cm)	Mean un-corrected diameter (d: cm)	corrected diameter (D=d± zero error) (cm)
1.					
2.					
3.					
4.					
5.					

Calculation: D= ……cm, r=D/2=…..cm

Result: The radius of cylinder = ……cm

Precautions-

1. Calculate the least count carefully.
2. Note the zero correction carefully.
3. Take the readings carefully.

Screw Gauge

OBJECT: *To determine the radius of a wire using screw gauge.*
Apparatus used: *wire, screw gauge.*
Formula: *Radius =diameter/2* *or* r=D/2

Theory - **Screw Gauge**- *It is an instrument designed to have a least count .01 mm or even smaller. It is used to measure the thickness of very thin objects such a thin sheet, a wire or a hair etc. It is based upon the principle of a screw. It consists of a* U*- shaped frame, which has a fixed end at A. A fine and an accurate cut screw of uniform pitch passes through the other end of the frame. A cap fits on to the screw and carries on its inner edge 100 or 50 equal division marks. This is called the circular/head scale (CS/HS). There is another linear scale graduated on the parallel to the axis of the screw. This is called main/pitch scale (S). When the screw is rotated, the number of complete rotations can be read on the pitch scale, while the fraction of rotation can be read from the circular scale. In some screw gauges, the screw head is provided with a ratchet arrangement R (See Fig.1). When the studs A and B are in contact with each other or with some other object placed in between, the ratchet slips over the screw without moving the screw forward. This helps in avoiding undue pressure between the studs or on the object for accurate measurements.*

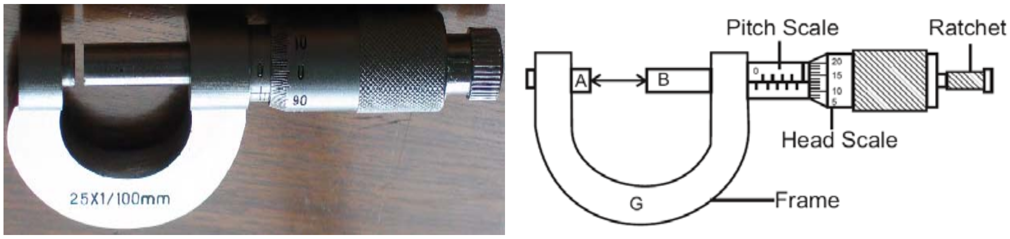


Fig.1

Procedure:

A. Least count of screw gauge: *Least Count of a screw gauge is defined as the distance through which the screw moves on the pitch scale when the cap of the screw is rotated through one division on the circular/head scale.*

$$\textbf{Least count of screw gauge=}\ \frac{\text{Pitch}}{\text{number of divisions on circular scale}}$$

Pitch: *The distance between two consecutive threads taken parallel to its axis is called the pitch of the screw. It is a distance through which the screw moves forward or backward when one full rotation is given to the screw cap.*

1. Find out distance moved on main scale for known number of rotation of circular scale. Find out distance traveled on main/pitch scale for one rotation of circular/head scale. This will provide you the pitch.

2. Find out the total number of divisions on circular scale.

3. Determine the ratio of pitch and total number of divisions on circular scale. This ratio is called as least count of the screw gauge.

Example: *if distance traveled on main scale is 1mm for one rotation of circular scale and there are 100 divisions on circular scale then,*
Pitch=1mm=0.1cm
Total number of divisions on circular scale=100
Least count of screw gauge=0.1/100=0.001cm

B. Checking of Zero error: *The Screw gauge is checked to find whether there is any initial (zero) error in the instrument or not. If there is any initial error, suitable correction is to be made. Bring the studs A and B to touch each other with help of ratchet.*

1. If the zero of the head scale lies on the pitch/main scale index line (I.L), the instrument has no error.

2. If the zero of the head scale is above the index line, it has negative error. So the zero correction is positive.

3. If the zero of the head scale is below the index line, it has positive error. So the zero correction is negative.

The type of error (ZE) and the suitable zero correction (ZC) for the given micrometer is determined with the help of fig.2.

C. Measurement:

1. Place the given wire gently in between the two studs A and B and rotate the ratchet till the wire is firmly but gently gripped.

2. Note the number of completed divisions in mm or cm on the main/pitch scale. This will give you main scale reading.

3. Note the reading on the circular/head scale against the index/reference line on the main/pitch scale. This will give you circular scale reading.

4. Multiply circular scale reading with the least count and add it to main scale reading. This will provide you un-corrected diameter of wire.

5. Repeat steps 1-4 minimum three times by griping the wire at different places.

6. Now turn the wire through 90^0 and again follow the steps 1-5.

7. Find the mean value of different readings.

8. Obtain the correct value of the diameter by applying correction.

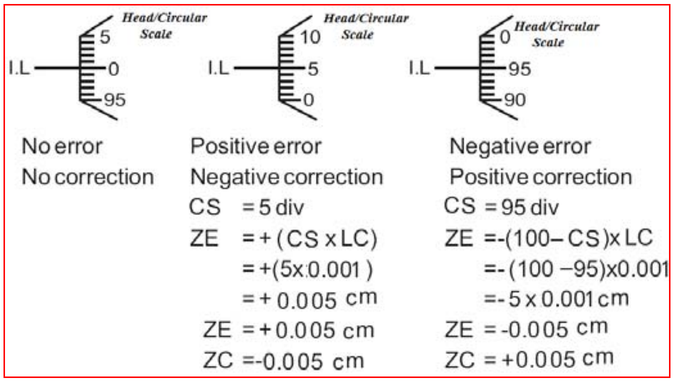


Fig.2

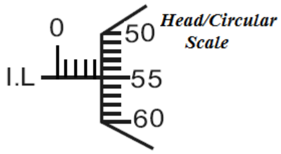


Fig.3

Example: *Suppose, pitch of screw gauge is 0.1cm and least count is 0.001cm. Assume 55th division of circular/head scale coincides with the index/reference line of pitch scale while the number of completed division on main/pitch scale is 4 (Fig.3). This means that the diameter of the wire is more than 0.4 cm and less than 0.5 cm. Now main scale reading will be 0.4cm and circular scale reading will be 55. Now un-corrected diameter will be,* *d*= M.S. + C.S. x L.C. = 0.4 + 55 x 0.001=0.455 cm

If there is 0.004cm of positive error in screw gauge then correct diameter will be: D=d+ZC=d-ZE=0.455-0.004=0.451cm

Observations-

1. Pitch =…..cm

2. Total number of divisions on circular scale=……..

*3. Least count of screw gauge (*LC*)= ……..cm*

*4. Zero error (*ZE*)=……….cm*

5. Table for diameter **(D)** *of wire*

Sr. no.	M.S. (cm)	C.S. (div)	un-corrected diameter (d= MS + CS x LC) (cm)	Mean un-corrected diameter (d: cm)	corrected diameter (D=d± zero error) (cm)
1.					
2.					
3.					
4.					
5.					
6.					

Calculation: D= ……*cm,* *r*=D/2=…..*cm*

Result: *The radius of wire = ……cm*

Precautions:

1. The circular scale should be rotated in the same direction to avoid backlash error.

2. There should be no undue pressure on the wire. Rotate the circular scale and stop when one click is heard on the ratchet arrangement.

3. Measure diameter in two perpendicular directions by turning the wire by 90^0.