Labotary Manual
B.Sc. 1st Year

Physics

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Experiment: 1

Aim:

To draw forward and reverse bias characteristics of a semiconductor diode.

Apparatus:

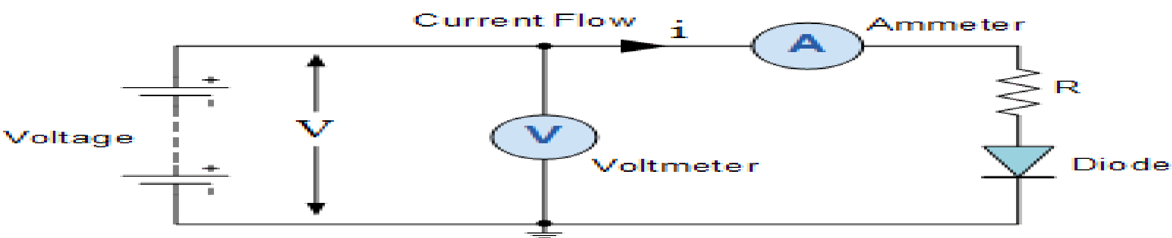
Diode, resistor, variable DC power supply, millimetre, voltmeter, Rheostat and wire.

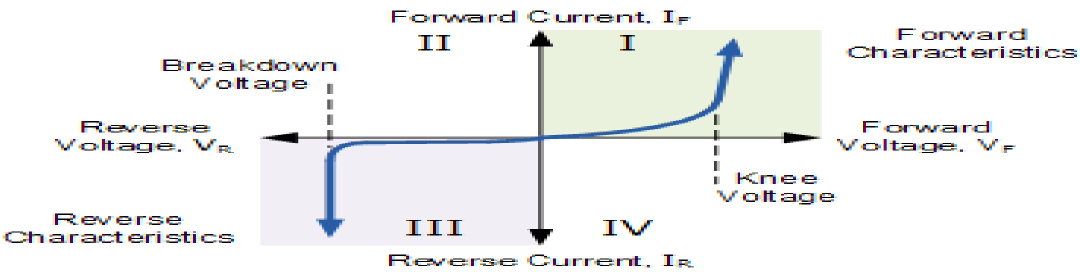
About experiment:

A diode, in electronics, is a two terminal electronic component with an asymmetric transfer characteristic, with low resistance to current flow in one direction and high resistance to current flow in the other direction. A semi-conductor diode is the most common type diode, which is a piece of semi-conductor material with a p-n junction connected to two terminals.

A diode allows electric current to pass in forward direction and block current in reverse direction. The behaviour of a diode in a circuit is given by its I-V characteristics. The shape of the curve is determined by the transport of charge carriers through the depletion layer that exist at the p-n junction. When a p-n junction is first created, diffusion of holes and electrons take place through the junction. As recombination proceeds, more ions are created at the junction and a built-in potential is developed at the depletion zone.

If a voltage of same polarity as that of built-in potential is applied across the junction, depletion zone acts as an insulator, preventing significant current flow through the junction. This is the reverse bias phenomenon.





Procedure:

(A) For forward bias characteristics:

1. Using millimeter and a voltmeter. Check your connections.
2. Adjust the position of the variable contact of the rheostat (or the potentiometer) so that the voltmeter reads zero. Now increase the voltage in small steps of about 0.1 volt each and note the reading of voltmeter and the corresponding reading of milli ammeter.
3. Plot a graph between forward voltage V_F and forward current IF by taking V_F along x-Axis and IF along y-axis.
4. Draw a tangent on V_F - IF curve and find its slope. Reciprocal of slope gives the Forward resistance of the diode.

(B) For reverse bias characteristics.

5. Complete the electric circuit as shown in fig (b).
   Using micro ammeter and 15 volt voltmeter.Check the connections.
6. Starting with zero voltage increase the reverse voltage in steps of 1 - 2 volts reach and note the reading of voltmeter as well as the corresponding readings of micro ammeter.
7. Plot a graph between reverse voltage V_R and IR taking V_R along x-axis and IR along y-axis.

Observations:

S. No. .	**For** forward **biasing**		**For reverse biasing**	
	Voltagevf (mA)	**Current I (mA)**	. Voltage **V_R**	**Current IR** (a)
1.				
2.				
3.				
4.				
5.				

Precautions:

1. Connections in forward and reverse bias arrangement should be thoroughly checked and voltmeters and milli micro ammeters of appropriate range should be used.
2. Voltages applied should not be so high and should be within safety limit of given diode.
3. The current drawn from semiconductor diode in forward bias should not exceed its current carrying capacity. A suitable resistance of about 100 ohm may be applied in series of the diode circuit.
4. For determining resistance, so use only the middle smooth portions of the characteristic curves.

Result:

The forward and reverse bias characteristics of given semi-conductor diode are

attached herewith.
The forward bias resistance of the given diode =………. ohm
The reverse bias resistance of the given diode =……….. ohm

EXPERIMENT-2

Aim:

To determine the moment of inertia of a flywheel.

Apparatus:

Fly wheel, weight hanger, slotted weights, stop watch, meter scale.

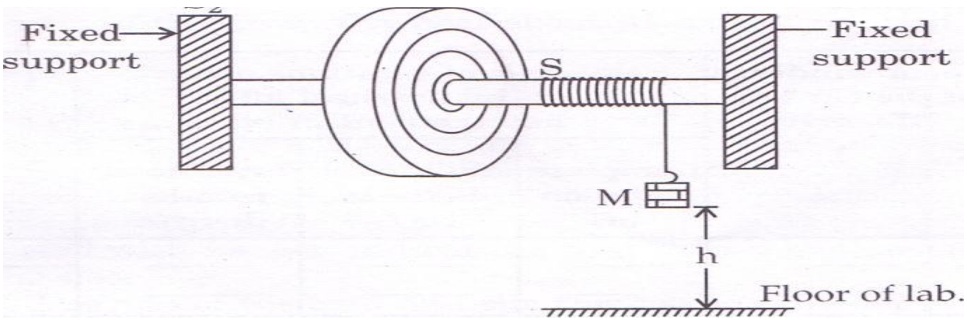
Formula used:

$$I = \frac{Nm}{N+n}\left(\frac{2gh}{\omega^2} - r^2\right) \qquad (4)$$

Where, I = Moment of inertia of the flywheel assembly
N = Number of rotations of the flywheel before it stopped
m = mass of the rings
n = Number of windings of the string on the axle
g = Acceleration due to gravity of the environment.
h = Height of the weight assembly from the ground.
r = Radius of the axle.

About experiment:

The flywheel consists of a heavy circular disc/massive wheel fitted with a strong axle projecting on either side. The axle is mounted on ball bearings on two fixed supports. There is a small peg on the axle. One end of a cord is loosely looped around the peg and its other end carries the weight-hanger.



Procedure:

1. The length of the cord is carefully adjusted, so that when the weight-hanger just touches the ground, the loop slips off the peg.
2. A suitable weight is placed in the weight hanger
3. A chalk mark is made on the rim so that it is against the pointer when the weight hanger just touches the ground.
4. The other end of the cord is loosely looped around the peg keeping the weight hanger just touching the ground.
5. The flywheel is given a suitable number (n) of rotation so that the cord is wound round the axle without overlapping.
6. The height (h) of the weight hanger from the ground is measured.
7. The flywheel is released.
8. The weight hanger descends and the flywheel rotates.
9. The cord slips off from the peg when the weight hanger just touches the ground. By this time the flywheel would have made n rotations.
10. A stop clock is started just when the weight hanger touches the ground.
11. The time taken by the flywheel to come to a stop is determined as t seconds.
12. The number of rotations (N) made by the flywheel during this interval is counted.
13. The experiment is repeated by changing the value of n and m.

Observations

Mass suspended (m) $\times 10^{-3}$ kg	Height above the ground (h) $\times 10^{-2}$ m	No. of revolutions		Time for N revolution (t) s	Mean ang:vel: $\omega = 4\pi N/t$	M.I of the Fly wheel (kgm^2)
		n	N			

Result

Moment of inertia of the fly wheel =.........kgm^2

EXPERIMENT-3

Aim:

Young's modulus by bending beam.

Apparatus:

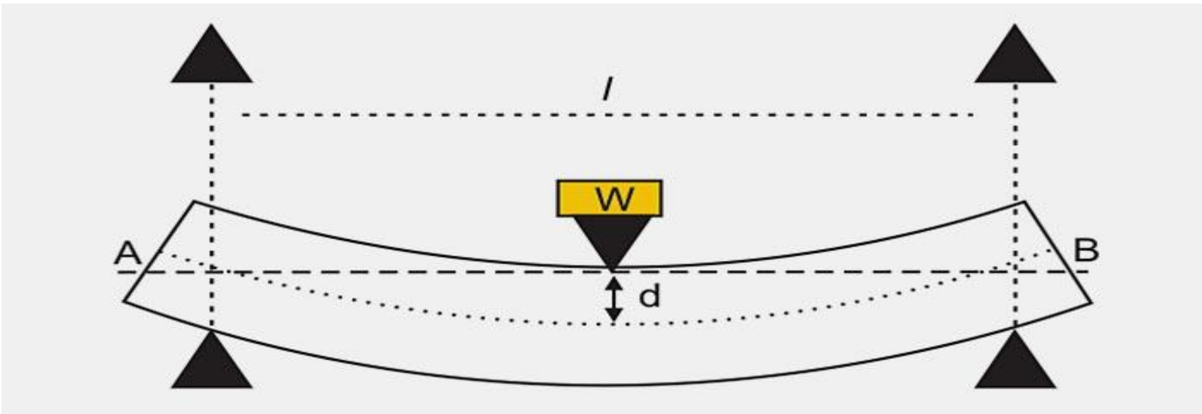
Pin and Microscope arrangement, Scale, Vernier callipers, Screw gauge, Weight hanger, Material bar or rod.

Formula used:

$$Young's\ modulus = \frac{Normal\ stress}{Longitudinal\ strain} = \frac{F/a}{l/L} \quad Y = \frac{3mgpl^2}{2bd^3e}$$

About experiment:

Young's modulus is named after Thomas Young, 19th century, British scientist. In solid mechanics, Young's modulus is defining as the ratio of the longitudinal stress over longitudinal strain, in the range of elasticity the Hook's law holds (stress is directly proportional to strain). It is a measure of stiffness of elastic material.



Procedure:

The bar is placed symmetrically on two knife edges. Two weight hangers are suspended at equal distance from the knife edges. The distance between knife edges and distance p of the weight hanger from knife edges are measured. A pin is fixed vertically at the midpoint of the bar with its pointed end upwards. The microscope is arranged in front of the pin and focused at the tip of the pin. The slotted weights are added one by one on both the weight hangers and removed one by one a number of times, so that the bar is brought into an elastic mood. With the some "dead load" W_0 on each weight hanger, the microscope is adjusted so that the image of the tip of the pin coincides with the point of intersection of cross wires.

The reading of the Vernier scale and Vernier of microscope are taken. Weights are added one by one and corresponding reading are taken. From these readings, the mean elevation (e) of the mid-point of the bar for a given mass is determined. The value of is calculated. The breadth of the bar (b) is measured by using Verniercallipers and thickness of the bar (d) is measured by using screw gauge. Hence calculate the Young's modulus of the material bar.

Observations

No	Distance of the knife edges, l (cm)	Distance between weight hanger and knife edges, p (cm)	Load M(kg)	Telescope reading			Elevation for load 4m, e (cm)	Mean e (cm)	$\frac{pl^2}{e}$ (cm^2)	Mean $\frac{pl^2}{e}$ (cm^2)
				Loading (cm)	unloading (cm)	mean (cm)				
1			Wo Wo+m Wo+2m Wo+3m Wo+4m Wo+5m Wo+6m Wo+7m			Xo X1 X2 X3 X4 X5 X6 X7	X4-X0 X5-X1 X6-X2 X7-X3			
2										
3										
4										

Thickness of the material bar "d" = ………………………….. mm

Breadth of the material bar "b" = ……………………………cm

Mean value of pl^2/e = ………………………….m

Load applied for elevation's" = ………………………… m

Young's modulus of the material bar ,

Calculations:

$$Y = \frac{3mgpl^2}{2bd^3e} = \text{…………………………} Nm^{-2}$$

Result

Young's modulus of the given material using uniform bending method= ……………………… Nm^{-2}.

EXPERIMENT-4

Aim:

Moment of Inertia of an irregular body using a torsion pendulum.

Apparatus:

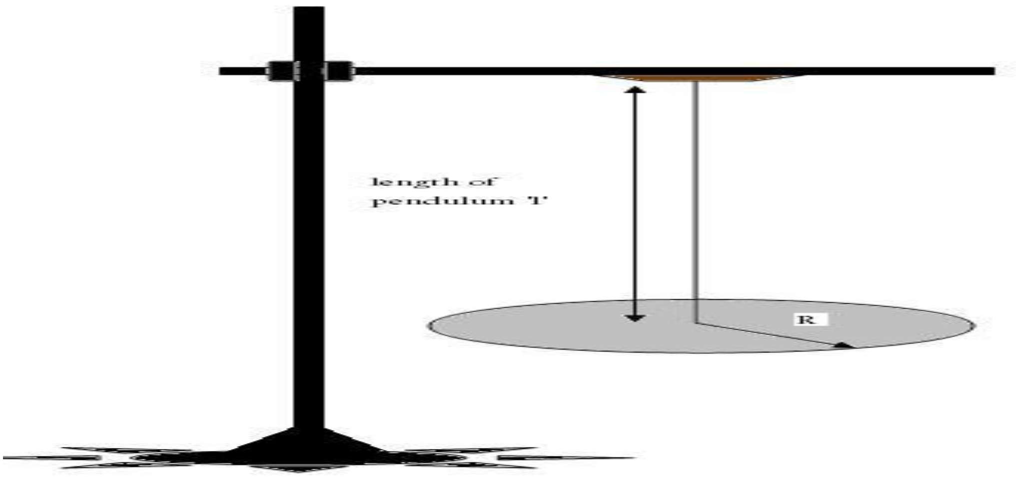
The given torsion pendulum, two identical cylindrical masses, stop watch, metre scale, etc.

Formula used:

$$I_0 = 2m\left(d_2{}^2 - d_1{}^2\right)\frac{T_0{}^2}{\left(T_2{}^2 - T_1{}^2\right)} = \ldots\ldots\ldots\ldots kgm^2$$

About experiment:

A body suspended by a thread or wire which twists first in one direction and then in the reverse direction, in the horizontal plane is called a torsional pendulum. The first torsion pendulum was developed by Robert Leslie in 1793.



Procedure:

1. The radius of the suspension wire is measured using a screw gauge.
2. The length of the suspension wire is adjusted to suitable values like 0.3m,0.4m,0.5m,.....0.9m,1m etc.
3. The disc is set in Oscillation. Find the time for 20 oscillations twice and determine the mean Period of oscillation ' T_0 '.
4. The two identical masses are placed symmetrically on either side of the suspension wire as Close as possible to the centre of the disc, and measure d_1 which is the distance between theCentres of the disc and one of the

identical masses.

5. Find the time for 20 oscillations twice and determine the mean period of oscillation ' T_1 '.
6. The two identical masses are placed symmetrically on either side of the suspension wire as Far as possible to the centre of the disc, and measure d_2 which is the distance between the Centres of the disc and one of the identical masses.
7. Find the time for 20 oscillations twice and determine the mean period of oscillation ' T_2 '.
8. Find the moment of inertia of the disc using the given formulae.

Observations:

Length of the suspension wire=................m

Radius of the suspension wire=.............m

Mass of each identical masses=............kg

d_1=...........m

d_2=...........m

Length of the suspension wire 'l'(m)	Time for 20 oscillations in seconds									Period of oscillation (s)			$T_0^2/(T_2^2-T_1^2)$	$l/(T_2^2-T_1^2)$ (ms^{-2})
	Without mass			With masses at d_1			With mass at d_2			T_0	T_1	T_2		
	1	2	Mean	1	2	Mean	1	2	Mean					

Calculations:

T_0 =........s

T_1 =. ....s

T_2 =.........s

Moment of inertia of the given disc,

$$I_0 = 2m\left(d_2{}^2 - d_1{}^2\right)\frac{T_0{}^2}{\left(T_2{}^2 - T_1{}^2\right)} = \ldots\ldots\ldots\ldots kgm^2$$

Result:

Experiment-5

Aim:

Zener Diode as voltage regulation characteristics.

Apparatus

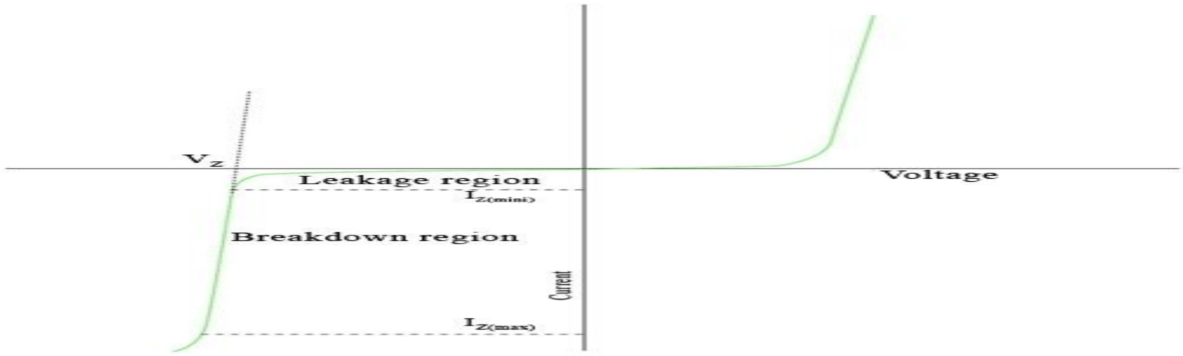
Zener diode, resistor, variable DC power supply, milliammeter, voltmeter, Rheostat and wire.

About experiment:

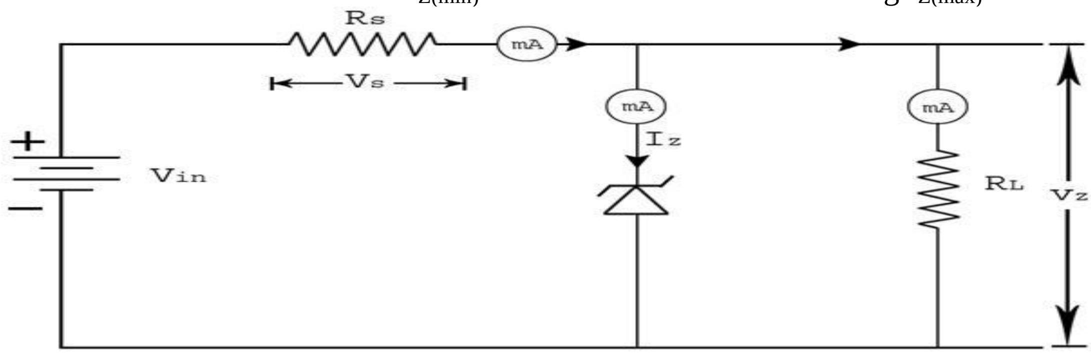
The Zener diode is like a general-purpose signal diode. When biased in the forward direction it behaves just like a normal signal diode, but when a reverse voltage is applied to it, the voltage remains constant for a wide range of currents.

Avalanche Breakdown: There is a limit for the reverse voltage. Reverse voltage can increase until the diode breakdown voltage reaches. This point is called *Avalanche Breakdown* region. At this stage maximum current will flow through the zener diode. This breakdown point is referred as “Zener voltage”.

The Zener Diode is used in its "reverse bias". From the I-V Characteristics curve we can study that the zener diode has a region in its reverse bias characteristics of almost a constant negative voltage regardless of the value of the current flowing through the diode and remains nearly constant even with large changes in current as long as the zener diodes current remains



between the breakdown current $I_{Z(min)}$ and the maximum current rating $I_{Z(max)}$.



Procedure:

1. Complete the connections as shown in the circuit diagram. Be sure that the zener diode is connected in reverse bias.
2. Introduce a fixed resistance (100 to 500 ohm) in series of diode and keep it constant throughout the experiment. Introduce a resistance of about 2000 ohm from the resistance box being used as the load resistance.
3. Change the input voltage in small steps from low voltage to well above the zener voltage of given diode. For each value of input voltage note the reading of output voltage across the load resistance.
4. Plot a curve between input voltage (along x axis) and output voltage (along y-axis). We see that after a certain value, output voltage does not increase with the increase in input voltage. The constant output voltage gives us the value of zener voltage of given diode.
5. Keep the input voltage more than the zener voltage. Starting from about 50 ohm, increase the load resistance in steps of 50 - 100 ohms and note the corresponding values of output voltage.
6. Plot a graph between load resistance (along x-axis) and the output voltage (along y-axis).

From this graph we see that initially the output voltage increases with increase in load resistance but after a certain value of load resistance the output voltage remains constant and does not change with further increase of load resistance.

Observations:

(A) Table to study variation in output voltage with input voltage:

Fixed series resistance Rs = ... ohm

Fixed load resistance RL = ...ohm

B) Table to study variation in output voltage with

Sr. No.	Input Voltage (Volts)	Output voltage (Volts)
1.		
2.		
3.		
4.		
5.		
6.		
7 .		

Load resistance:

Fixed series resistance Rs = ... ohm

Fixed input voltage = ... volt.

Sr.no	Loadresistance (ohm)	Output voltage
1.		
2.		
3.		
4.		
5.		
6.		
7.		

Calculations:

Plot graphs between (i) variation of output voltage V with input voltage, and (ii) variation of output voltage V with load resistance and observe their nature.

Precautions:

1. The zener diode must be connected only in reverse bias configuration.
2. A suitable resistance should be connected in series with the zener diode so

that current flowing through the diode does not exceed its safe limit.
3. While studying the variation of output voltage with variation of load, the input voltage should be kept constant throughout the observation set.

Result:

Experiment-6

Aim:

To determine ‘g’ by Bar Pendulum.

Apparatus used:

Bar pendulum, stop watch and meter scale.

Formula used:

Acceleration due to gravity,

$$g = 4\pi^2 \frac{L}{T^2}$$

Where L is the equivalent length of the bar pendulum corresponding to the period T.

About experiment:

Galileo was the first person to show that at any given place, all bodies – big or small – fall freely when Dropped, with the same (uniform) acceleration, if the resistance due to air is negligible. . Thegravitational attraction of a body towards the center of the earth results in the same acceleration for all

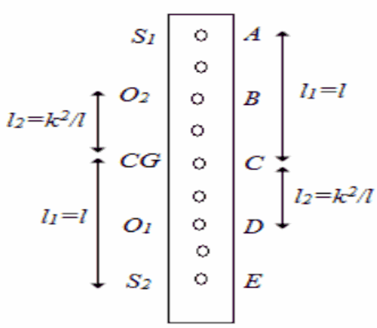


Fig.1

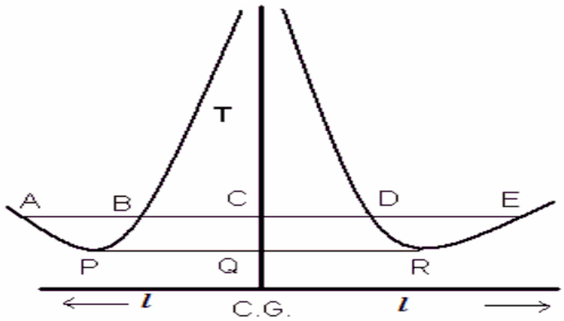


Fig. 2

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 (θ=3~40).

(4) Note the time taken for 20 oscillations and measure the distance of the hole

(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.from the C.G. 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

Table for l and T

S. No.	No. of hole	On side of centre of Gravity (Knife edge A)				On other side centre of gravity (Knife edge A)			
		Time for 20Vibrations in sec.			Time period in sec.	Time for 20Vibrations in sec.			Time period in sec.
		1	2	Mean		1	2	Mean	
1									
2									
3									
4									
5									
6									
7									
8									

Calculations:

L= (AD+EB)/2=…., T=…sec,

k=PR/2=… T min=…sec

l1= (AC+CE)/2=…., l2= (BC+CD)/2

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.

Results:

The acceleration due to gravity (g) = ……….m/s2

Radius of gyration (k) =………cm (from calculation)

=………cm (from graph)

Experiment-7

Aim:

To determine the modulus of rigidity using Maxwell Needle.

Apparatus used:

Maxwell needle, stop watch, screw gauge, meter scale.

Formula used:

$$n = \frac{2\pi l}{r^4}\frac{(m_{s-m}{}_{h})l^2}{(T_1{}^2 - T_2{}^2}$$

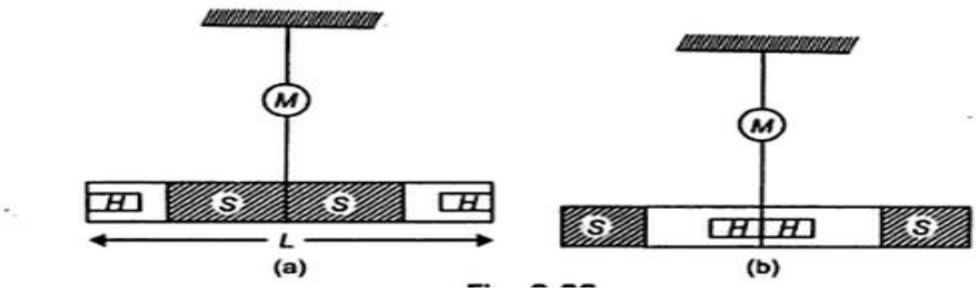
Where

l: length of wire, L: length of Maxwell needle, r: radius of wire
mS: mean mass of solid cylinders, mH; mean mass of hollow cylinders,
T1: time period of oscillation when solid masses are outside,
F oscillation when solid cylinders are inside

About experiment:

The Maxwell model can be represented by a purely viscous damper and a purely elastic spring Connected in series, the diagram. In this configuration, under an applied axial stress, the total stress.

The equation can be applied either to the shear stress or to the uniform tension in a material. In the former case, the viscosity corresponds to that for a Newtonian fluid. In the latter case, it has a slightly different meaning relating stress and rate of strain.



Procedure:

1. Measure the length of wire using meter scale through which the Maxwell needle is hanged.
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 mS.
4. Measure the mass of the both hollow cylinders and do its half, this will provide the value of mH.
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 outside 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 T1.
9. Now place solid cylinders at inside and hollow cylinders at outside 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 T2.
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 (mS) =……..gm
(4) Mean mass of hollow cylinders (mH) =……gm
(5) Least count of screw gauge=
Number of divisions on circular scale *Pitch* =……..cm
(6) Zero error in screw gauge=………..cm

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

5					
6					

Sr. No.	Number of oscillations	For outside solid cylinders			For inside solid cylinders		
		t_2 sec	$T_2=t_2/N$ sec.	MeanT2 (sec)	t_2 sec.	$T_2=t_2/N$ sec.	MeanT2 (sec)
1.	10						
2.	20						
3.	30						
4.	40						

Result:

Experiment-8

Aim:

To determine the value of elastic constant by Searle's method.

Apparatus used:

Searle's apparatus, Sprit level

Formulae used:

(i) Young's modulus=

$$Y = \frac{8\pi \ell I}{T_1^2 r^4}$$

(ii) Modulus of rigidity=

$$\eta = \frac{8\pi \ell I}{T_2^2 r^4}$$

(iii) Poisson's ratio:

$$\sigma = \frac{T_2^2}{2T_1^2} - 1$$

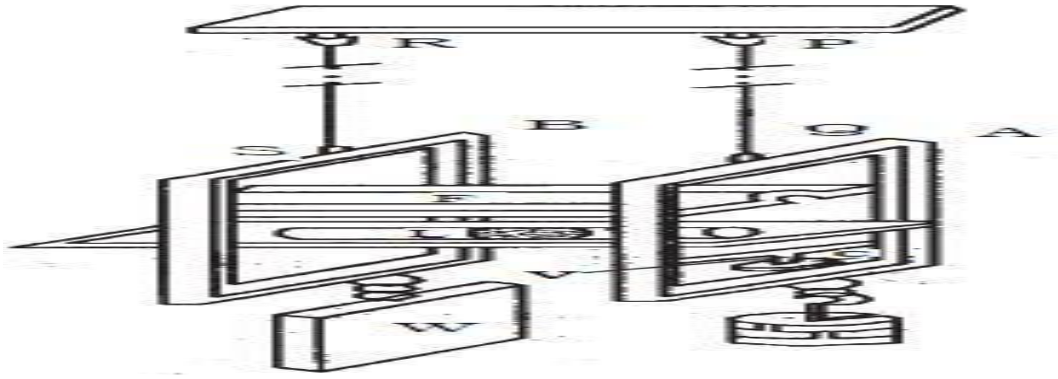
(iv) Bulk modulus,

$$K = \frac{Y}{3(1-2\sigma)}$$

Where *l* is the length of wire, r is the radius of wire; Tl is the time period of torsional vibrations when both the bars are suspended. T 2 is the time period of torsional vibrations when one bar is clamped and the other one is suspended and **I** is moment of inertia of one bar about the suspension axis.

About experiment:

The Searle's apparatus consists of two rectangular steel frames A and B. The two frames are hinged together by means of a frame F. A spirit level L is provided such that one of its ends is pivoted to one of the frame B whereas the other end rests on top of a screw working through a nut in the other frame. The bottom of the screw has a circular scale C which can move along a vertical scale V graduated in mm. This vertical scale and circular scale arrangement act as pitch scale and head scale respectively of a micrometer screw.



Procedure:

1. Fasten the two ends of the given experimental wire to the two identical bars AB and CD using the binding screws provided at the middle points of each of the bars. The two long torsion threads to the hooks provided in the bars. Suspend these bars by fastening the threads to the hooks provided in the bars. Suspend these bars by fastening the threads to the rigid support. So that the two bars are parallel to each other in a horizontal plane.
2. Mark a vertical reference line at the centre of the cross section at one end of a bar. Place a telescope at about two metre and set the eye piece so that cross wires are clearly visible. Now focus the telescope on the reference line marked on the bar so that the vertical cross-wire coincides with this reference line.
3. Tie the ends Band D of the given bar with a cotton thread which is slightly shorter in length than the length of the experimental wire so that the bars are inclined and the wire bent into a circular are. Allow the system to come to rest. Turn the loop (using candle) so that the ends B and D are released and the bars begin to oscillate in horizontal plane about their mean positions. Find the time for 20 vibrations using a stop watch.
4. Repeat the step no. 3 and measure time for 25 and 30 oscillations.
5. Remove the suspension threads and now clamp one of the bars (say AB) horizontally in the rigid support (Fig. *c*). In this case the excremental wire becomes vertical and the other bar CD suspends horizontally from the wire.
   Now focus the telescope on the reference line marked on bar CD.
6. Without disturbing the centre of the lower bar CD, give slight turn to its end in a horizontal plane so as to twist the wire. Then release the bar. It starts executing torsion vibrations. Using a stop watch measure the time for 20 vibrations.
7. Repeat the step 6 and measure time for 25 and 30 vibrations.
8. Find its least count and zero error of the screw gauge. Using screw gauge measure the diameter of given wire in two mutually perpendicular directions at several places along the whole length of wire. Find the mean corrected diameter and then the radius of wire.

9.Measure the length of the wire using a metre scale.

10. Find the vernier constant and zero error of verniercallipers using vernier measure the breadth or the diameter of the bar. Also measure the length of the same bar using a meter scale.
11. Also find the mass of the bar [whose length and breadth (or diameter) has been measured] using a balance.
12. Calculate the moment of inertia of the bar.
13. Using observations, calculate Y, 11, 0" and K.

Observations:

S.No.	Number of	Time for n vibaration			Time Period	Time for n vibaration			Time Period
		min.	Sec.	Total t_1 in sec		min.	sec. in sec	Total t2 in sec	
1.	20								
2.	25								
3.	30	.							

Measurements of time periods (T 1 and T 2) :

Least count of stop watch = ...sec.

Mean T_1=............... sec. Mean T_2= .... sec

Measurement of dimensions of the wire

Length of the wire between the binding screws, I =.............cm

Pitch of the screw gauge = ...cm

Least count of the screw gauge = ... cm

Zero error of the screw gauge = ...cm

S.No.	Observed diameter of wire cm)			Corrected diameter (in cm)
	in one direction $(a)_1$	Inperpendicular direction (b_l)	mean $\frac{a_{1+b_2}}{2}$	
1. 2. 3.				

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

Mean radius of wire, r =D/2..cm

M. of the inertia bar, M =........................ ... gm.

Length of the inertia bar, L = ...cm.

Vernier constant of verniercallipers= .... cm.

Zero error of verniercallipers=........... cm.

S.No.	Observed breadth (diameter) of bar in Cm			Corrected breadth (diameter) of bar in cm
	in one direction (b_1)	in perpendiculars direction (b2)	Mean $\frac{a_{1+b_2}}{2}$	
1. 2. 3.				

Result:

Experiment-9

Aim:

To determine the surface tension by Jaeger's method.

Apparatus:

Jaeger's apparatus, capillary tube, a travelling microscope, metre scale, thermometer, Adjustable stand and a stop watch.

Formula used:

$$T = \frac{rg}{2}[H\rho - \text{h}\sigma]$$

Where r is radius of orifice of the capillary
g is acceleration due to gravity (= 981 dyne cm-^{2})
H is the maximum difference of the liquid levels in two limbs of manometer.

h is depth of orifice below free surface of liquid in the beaker

ρ is density of liquid in manometer tube.

σ is density of experimental liquid (e.g. water) taken in beaker.

About experiment:

Surface tension is the elastic tendency of a fluid surface which makes it acquire the least surface area possible. Surface tension allows insects usually denser than water, to float and stride on a water surface. At liquid-air interfaces, surface tension results from the greater attraction of liquid molecules to each other than to the molecules in the air .The net effect is an inward force at its surface that causes the liquid to behave as if its surface were covered with a stretched elastic membrane. Thus, the surface becomes under tension from the imbalanced forces, which is probably where the term "surface tension" came from.[1] Because of the relatively high attraction of water molecules for each other through a web of hydrogen bonds, water has a higher surface tension (72.8 millinewtons per meter at 20 °C) compared to that of most other liquids.

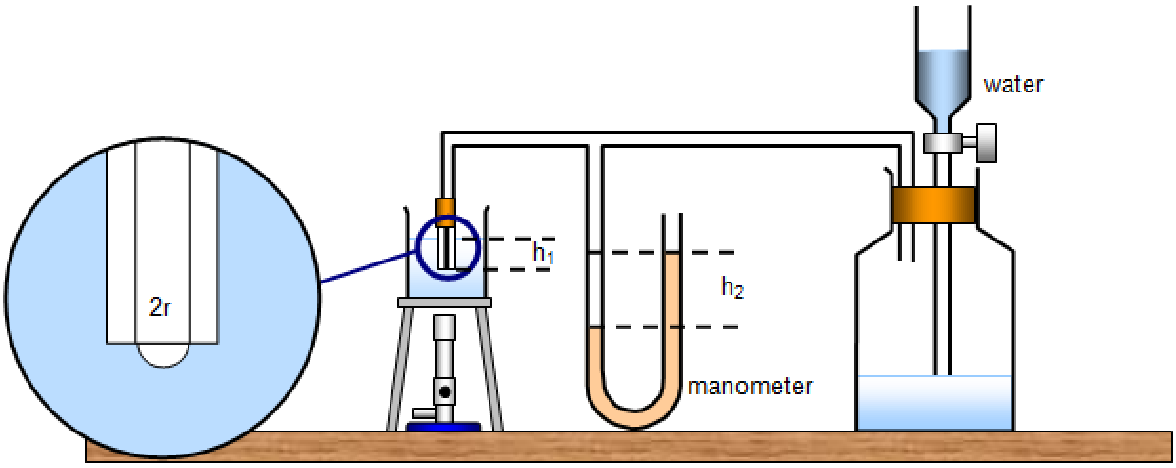


Figure 1

Procedure:

1. Take a capillary tube about 0.2 to 0.3 mm in diameter and graduated in mm along its length clean it thoroughly.
2. Clamp the capillary horizontally and examine its orifice under a travelling microscope. The orifice should be circular.
3. Move the microscope tube horizontally in one direction (say from left to right) by using slow motion screw so that vertical cross-wire is in position P. Note the position of microscope tube on horizontal scale. Shift the tube further towards right so that vertical cross-wire is in position Q. Again note the reading on the horizontal scale of the microscope. PQ gives the horizontal diameter of the orifice.
4. Measure the vertical diameter of the orifice by using horizontal cross-wire

and the vertical scale of the microscope. For this, we displace the microscope tube in downward or vertical upward direction. Find the mean diameter of the orifice.

5. Rotate the capillary slightly and measure the diameters PQ and RS again by repeating steps (3) and (4). Then find the mean diameter.
6. Clamp the capillary in vertical position in the apparatus so that its orifice is 1 to 2 cm below the free surface of liquid in the beaker. Note the exact depth h of the orifice below the free surface of liquid using the scale graduated on the capillary.

7. Open the pinch-cock P of the funnel so that water drops fall slowly in the bottle. Adjust the rate of flow of water *into* the bottle so that a bubble is formed at the orifice in about 10 seconds. When the bubble grows, the pressure indicated by manometer rise and becomes maximum when the bubble breaks. Note the lowest level of liquid in closed limb and highest level in open limb of the manometer at the. time when the bubble just breaks. Just after the bubble breaks levels in two limbs of manometer are same. After this, the levels in two limbs again start departing as the bubble at the orifice grows till the bubble breaks. Note the levels of liquid in the limbs of manometer when the bubble is just at the verge of breaking. Repeat this observation 3-4 times.
8. Increase the depth of the office below the free surface of liquid. Note this depth and repeat step 7 again.
9. Take observations with three or four different values of h.

Observations:

Diameter of orifice of capillary:

Vernier constant of travelling microscope = ... cm.

S. No.	Microscope reading in cms				Diameter D_1=PQ in cm	Diameter D_2=RS in cm	Mean Diameter D' $\frac{D_1 + D_2}{2}$ in cm
	along horizontal direction		along vertical direction				
	At end P	At end Q	at end R	At end S			
1.							
2.							
3.							

Mean diameter of the orifice, D = ... cm.

Temperature of the water =......... °C

Density of water at =……….. °C(room temperature),

The density of liquid in manometer, p = ...,gms cm-^{3}

S. No.	Depth of orifice (h) in cm	Manometer reading in cm				H'= (a - b) " In cm	'(Hp -hσ) (gm 'cm^2)
		highest level in open limb (a)	lowest level in closed limb (b)	Mean(a)	Mean		

1.	...	(i) ... (ii) ... (iii) ...	... ...	...	.. .	...	.. .
2.	...	(i) ..• (ii) ... (iii)...	... ...				
3.	...	(i)... (Ii)... (iii) ...	... ...	..	...	...	. ..

Mean value of (Hp - hσ) = ...g cm-^{2}

Calculations:

The surface tension of water is..............

Precautions:

1. The capillary tube should be thoroughly cleaned and there should be no traces of oil or grease etc. in or on it.
2. The experimental liquid should also be clean and free from dirt as well as oily impurities. Don't use distilled water as it contains traces of greasy material.
3. The orifice of the capillary tube should be circular and its radius should be small (",,0.5 mm).
4. The whole apparatus should be air tight.
5. The liquid used in the manometer should be of flow density.
6. The bubbles must be formed singly and slowly (One bubble should be formed in about 10 to 15 seconds). For this control the flow of water into the woeful's bottle allow achieve this the volume of air in the woulfe bottle should be kept small.
7. The diameter of the orifice of capillary tube should be measured several times by slightly rotating the tube about its own axis. Moreover, every time reading should be taken in horizontal as well as in vertical direction.

Result:

Experiment: 10

Aim:

To determine the viscosity of water by studying its flow through a capillary tube.

Apparatus:

A long capillary tube of narrow bore, viscosity apparatus, constant level water reservoir arrangement with stand, a graduated cylinder, stop watch, a travelling microscope, spirit level and a thermometer.

Formulaused:

$$\eta = \frac{\pi p r^4}{8Vl} = \frac{\pi h d g r^4}{8Vl}$$

Where
I is the length of capillary tube, r is the radius of capillary Tube,
h is the difference in water levels in two limbs of manometer,
d is the density of water at room temperature and
V is the volume of water flown per second.

About experiment:

The coefficient of viscosity of a fluid can be found from measurements of the volume rate of flow through small tubes. For simple analysis to be possible laminar or streamlined flow must prevail. Conditions of flow can be described by a dimensionless quantity, The flow of water, Q, is to be measured at several values of p and for two or three different capillary tubes (available at the Resource Centre). The pressure p depends on the head of water, i.e., the height of the water in the reservoir above the level of the tube. The length of the tube can be readily found. The radius is more difficult to find. It has been measured for you by introducing a thread of mercury into the tube, determining its length and then its mass (and hence volume). The resulting values of the radii of the tubes are provided.

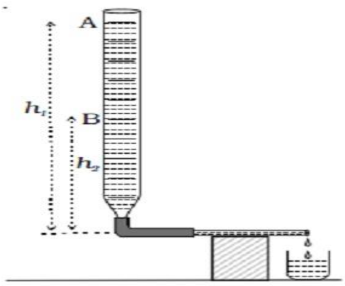


Fig. Determination of coefficient of viscosity by Poiseuille's flow

Procedure:

1. Tube having a length about 30 to 35 cm and uniform circular bore of about 0.5 mm. Clean in thoroughly. Fit this tube in the apparatus properly as shown in the fig. Now set leveling screws fitted at the base of viscosity apparatus so as to make it perfectly horizontal.
2. Allow the water to flow and adjust the height of the constant level tank till the water flows out of the capillary tube in drops. Use pinch cock for regulating the flow of water (if required). However, pinch cock should be used only when it is necessary.
3. Find their difference (h) i.e. a- b. Value of h should be of the order of 5 cm and in no case more than 10 cm. If h is more, then recheck your adjustment of height of tank and flow of water. Now measure the value of h.
4. Find the volume of water collected per unit time = V. Repeat the observations 2 - 3 times and find mean volume of V.
5. Measure the temperature of water.
6. Remove the capillary tube from the apparatus and hold it in a horizontal position.
7. Constant of horizontal as well as vertical scales of travelling microscope. Focus the microscope on one end of the capillary tube.
8. Again measure the diameter of the bore from the other end of capillary tube. The mean is the corrected diameter and half of it is the correct radius.
9. Measure the length of the capillary tube.
10. From density table, find the value of density of water at the room temperature of water.

Observations:

(a) Determination of V and h:

Least count of the graduated cylinder = ... " $cm3$

End of capillary	Reading along vertical direction in cm			Reading along horizontal direction in cm			Mean Diameter $D=D_1+D_2/2$ =IDem
	One end of section(p)	Other end of section{Q}	Diameter D_1= (P - Q)	One end of Section R	Other end of Section S	Diameter D_2=(R-S)	
1.(i)							
(ii)							
2. (i)							
(ii)							

Lest count of the stop watch = sec.

S.no.	Measurement of h in cm				Measurement of Volume (V)				
	Reading of one limb (a)	Reading of other limb (b)	h=a-b	Mean h	Time t(s)	volume of water collected Q (in sec)	V=q/t (cm^3/sec	Mean V (cm^3/sec	$\frac{V}{h}$ (cm^2/sec

1. (i) (ii) (iii)									
2. (i) (ii) (iii)									
3. (i) (ii) (iii)									

Mean value of v/h =……….cm^2/sec.

(b) Determination of r

Vernier constant of horizontal scale of microscope = ...cm

Vernier constant of vertical scale of microscope = ...cm.

Mean diameter of capillary tube, D =.................... Cm

Temperature of water, θ= ………………… ℃

Length of the capillary tube, l = ... Cm

Density of water at………………………… ℃

Calculations:

$$\eta = \frac{\pi h d g r^4}{8Vl} = \frac{\pi d g r^4}{8l(V/h)} = \ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots \text{ poise.}$$

Result:

The experimentally determined value of the coefficient of viscosity at..°C=…….poise.

Standard value at.. ℃=............. poise

Percentage error = %

Experiment: 11

Aim:

To determine the thermal conductivity (K) of good conductor by a Searle's method.

Apparatus:

Searle's conductivity apparatus, two thermometers each of 112°, two thermometers reading up to 0.2°, a steam generator, stand, heat source, a constant level tank arrangement, measuring cylinder, stop watch, beam compass, verniercallipers, half meter rod and pinch cock.

Formula used:

K=

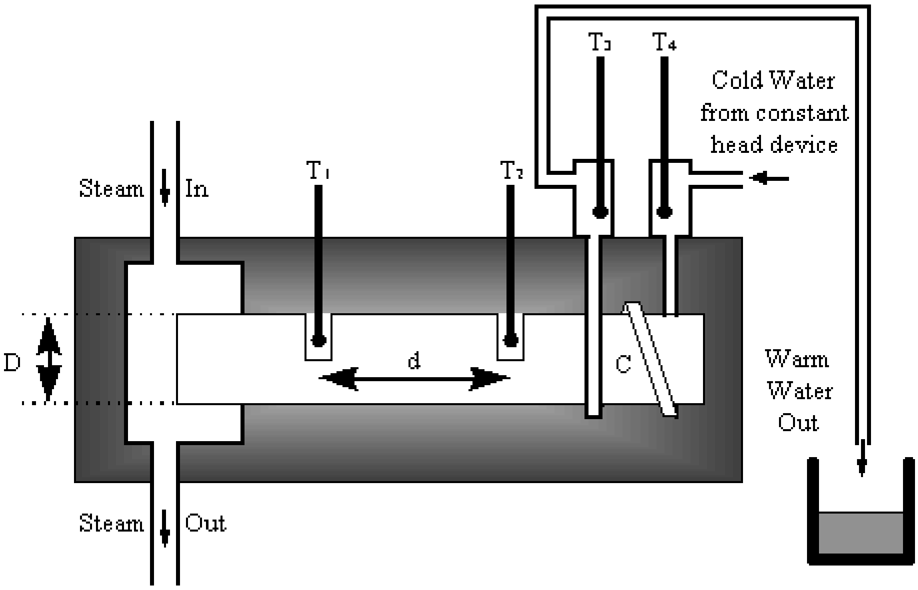
$$\frac{m(\theta_4-\theta_3)d}{A(\theta_1-\theta_2)t} = \frac{4m(\theta_4-\theta_3)d}{\pi D^2(\theta_1-\theta_2)t}$$

Whereθ_1, θ_2, θ_3, $\theta_4 8_4$ are the steady temperatures recorded y thermometers T_1 T_2,T_3 and T4 respectively,
D the diameter of metal bar and d is the distance between the two cavities made in metal rod and m is the mass of water collected in time *t*.

About experiment:

The Searle's apparatus to measure the thermal conductivity of a solid. The solid is taken in the form of a cylindrical rod. One end of the rod goes into a steam chamber. A copper tube is coiled around the other end of the rod. A steady flow of water is maintained in the copper tube. Water enters the tube at the end away from the steam chamber and it leaves at the end nearer to it. Thermometers T_3 and T_4 are provided to measure the temperatures of the outgoing and incoming water. Two holes are drilled in the rod and mercury is filled in these holes to measure the temperature of the rod at these places with the help of thermometers T_1 and T_2. The whole apparatus is covered properly with layers of an insulating material like wool or felt, so as to prevent any loss of heat from the sides.

Steam is passed into the steam chamber and a stream of water is maintained. The temperatures of all the four thermometers rise initially and ultimately become constant when the steady state is reached. The readings q_1, q_2, q_3, and q_4 are noted in steady state.



Procedure:

1. Fill the steam generator with water 2 up to about 3' rd height. Keep it on a tripod stand on which a wire gauze has been placed. Place a heat source below the wire gauze.
2. Put a little amount of mercury in each of the two cavities in the metal bar and place two half degree thermometers T1 and T2 in these cavities. Insert the two one fifth degree thermometers Ts and T4 at the entrance and exit points of water.
3. When stem is being formed in the steam generator, connect it using a delivery tube to the inlet I of the steam chamber. Place a metallic beaker below the outlet O of the stem chamber to collect the condensed water.
4. By adjusting the height of constant level tank or by the use of a pinch cock adjust the rate of flow of water through copper coil C so that water comes out as a trickle through the outlet end 0' of coil C. Place a bucket or trough below 0' for collecting the water.
5. The readings of all the four thermometers remain constant for nearly 10 minutes, note the thermometer readings. Now place a clean and dry measuring cylinder below the outlet O' of the copper coil C and collect the water flown for a definite time interval.

Observations:

For measurement of temperature:

Initial reading of thermometer T 1 =.................. °C

Initial reading of thermometer T 2 = ...°C
Correction to be applied in T 2 as compared to T 1 = ...°C
Initial reading of Thermometer T 3 = ...°C
Initial reading of Thermometer T4 = ...°C
Correction to be applied in T 4 as compared to T 3 = ...°C
Hence, final corrected steady temperature from the above table:
To mass of water collected:

S. No.	Time in minutes	Thermometer readings in °C			
		Q_1	Q_2	Q_3	Q_4
1. 2.	30 35				
S. No.	Time in minutes	Thermometer readings in °C			
		Q_1	Q_2	Q_3	Q_4
1. 2. 3. 4.	30 35 40 45				

S. No	Time t(s)	Volume of water collected V (cm)3	Mass of water m = V. do (gm)	m/t (g/s)in sec.
1. 2. 3.				

(C) For measurement of D:
Vernier constant of the calipers =...cm

Zero error of the calipers =

S. No.	Observed diameter in cm			Corrected diameter D (in cm)
	In one direction (a)	In Perpendicular direction (b)	mean $\frac{a+b}{2}$ \	
1. 2. 3. 4.		.		

Mean diameter = ... cm

Temperature of water, e = ... °C.
Length of the capillary tube, l = ... cm

End of capillar	Reading along vertical direction in cm			Reading along horizontal direction in cm			Mean Diameter
	One end of section(P)	Other end of section(Q)	Diameter D_1= (P-Q)	One end of Section R	Other end of Section S	Diameter D_2=(R,.S)	
l.(i)							
(ii)							
2. (i)							
(ii)							

Density of water at ...."C (from density table), d = ... gram cm-3.

Calculations:

$$J = \frac{(V'I' - VI)t}{(m' - m)(\theta_2 - \theta_1)} \text{ J cal}^{-1} = \text{....... J cal}^{-1}$$

Precautions:

1. The capillary tube should be of a narrow and uniform bore. The tube should be cleaned thoroughly.
2. The flow of water should be drop by drop.
3. The pressure difference between the ends of capillary tube should be small. To achieve this value of h should be kept small.
4. Water should be collected for a fairly long time so that large volume is collected which can be
Measured accurately.
5. Before collecting water in a measuring cylinder, check that no water drops are present in it.
6. After each setting of the constant level tank, wait for some time before collecting the water.
7. Since the viscosity changes rapidly with temperature, the temperature of water should bEmeasured during the flow.

Result:

Experiment: 12

Aim:

To determine the mechanical equivalent of heat by Calendar and Barnes's method.

Apparatus:

Continuous flow calorimeter, two 0.2 degree thermometers, battery, rheostat, key, an ammeter, voltmeter, constant level tank arrangement, stop watch, measuring cylinders, connecting wire and pinch cock.

Formula used:

$$J = \frac{(V'I' - VI)t}{(m' - m)(\theta_2 - \theta_1)} \text{ J/calorie}$$

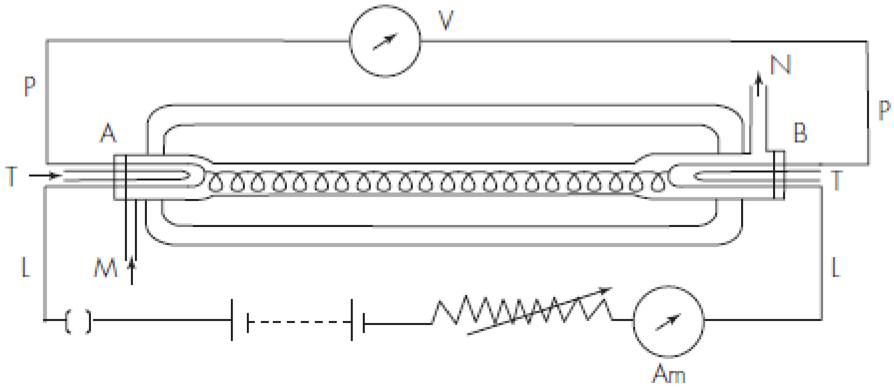
Q_1 and Q_2 are the temperatures of inflowing and out flowing water, m is the mass of water collected in gram in time t in steady state when current and voltage are I and V and m' is the mass of water collected in gram in time t in steady state when current and voltage are I' and V' respectively.

r_1 and r_2 are the temperatures of inflowing and out flowing water, m is the mass of water collected in gram in time t in steady state when current and voltage are I and V and m' is the mass of water collected in gram in time t in steady state when current and voltage are I' and V' respectively.

About experiment:

The apparatus consists of a horizontal corning glass tube open at both ends. The heating element is a coil about 40cm long of Ni-chrome wire and is wound spirally inside the axis of the glass tube. The element is easily detachable and is encased in a wooden case lined with felt and provided with a hinged cover. Terminals are brought at each end of the tube for the electrical supply. The horizontal tube is connected either by rubber tube or rubber cork to the inlet and the outlet system, each having a short vertical extension to accommodate a thermometer.

The complete apparatus is mounted on a polished wooden base board. Supplied with constant level tank fitted on stand but without thermometer & Transformer.



Procedure:

1. Draw the circuit diagram as shown in the diagram and make the electrical connections according to this diagram then check the connections.
2. Fix the constant level tank in a stand and adjust it at a suitable height. Join the inlet tube I of tank to water tap outlet tube O to continuous flow calorimeter and the overflow tube T to sink. Now open the water tap so that water flows steadily and the water level in the tank remains above the upper end of the overflow tube T. Adjust the rate of flow of water either by adjusting the height of constant level tank or by regulating the pinch cock K, so that water is flowing at
   a slow but continuous rate. .
3. Note the initial readings of two thermometers Tl and T2 and find out the correction to be applied in the reading of one thermometer is compared to the other thermometer.
4. From density table find the density of water at the temperature of water.
5. Now apply the plug in key K so as to complete the electric circuit and current begins to flow through the heater coil. Using rheostat adjust the value of current (at least 1 ampere or more).
6. Wait for some time and then note the readings of the thermometers after every two minutes.
   When the readings of both thermometers become constant (but not equal) and do not change for at least five minutes, note the readings. If the difference in temperature (8_2 - 8_1) is 5°C or more then it is all right otherwise increase the current in the circuit till you find that in the steady state the rise of temperature of flowinK- water is at least 5°C. When in the steady state, note reading of V and I and the temperatures recorded by two thermometers.
7. Place a clean and dry measuring cylinder below the jet of calorimeter and collect the water flown for a definite time interval t so that volume of water collected is large enough and we may read its volume accurately.
8. Increase the current flowing in the circuit slightly by the use of rheostat. Also increase the rate of flow of water and adjust it so thatthe steady state remains unaffected. When the steady state is again reached and the thermometers readings are exactly same

asbefore, again collect the volume of water collected in time t. Thistime should be exactly the same as in the first case.current AndVoltage.

Observations:

Initial temperature indicated by thermometer T 1 = ...°C
Initial temperature indicated by thermometer T 2 = ...°C
Correction to be applied in T 2 assuming T 1 correct = ... °C
Density of water at room temperature ....°C, d = ...gram/cm

S. No.	In first case			In second case		
	Time (minute)	Reading of Thermo meter T, (θ_1) °C	Reading of Thermo meter Tj (θ_2) °C	Time (minutes	Reading of Thermo meter T1 (θ_1) °C	Reading Thermo meterT_2 (θ_2) °C
1.	15					
2.	20					
3.	22					
4.	24					
5.	. ..					

Sr. No.	Current (I) In A		Potential (V) in volts		Temperature (in DC)		(θ_2- θ_1). in ·C	Time t in sec	Volume water collected (in cm^3)	Mass In gm
	Obser-ved	Corre ted	Obser ved	Correct ted	Observ temp. thermo meter $T_1(\theta_1)$	Correct temp. Thermo meter $T_2(\theta_2)$				
1.										
2.										

Calculations:

$$J = \frac{(V'I' - VI)t}{(m' - m)(\theta_2 - \theta_1)} \text{ J cal}^{-1} = \text{........ J cal}^{-1}$$

Precautions:

1. The heating coil should have a resistance of about 10 ohm and it should be

in the form of a helix D.

2. Positive terminals of ammeter and voltmeter should be joined towards the higher potential points.
3. If A.C. is being used then only A.C. ammeter and voltmeter should be used and initially output voltage of step down transformer should be kept small.
4. A constant level water tank arrangement should be used for controlling the rate of flow of water through the calorimeter.
5. The rate of flow of water should be steady and continuous.
6. To measure the rise of temperature accurately 0.2 degree thermometers should be used.

   Appropriate correction should be applied for the initial difference in temperatures recorded by thermometers T 1 and T 2'

Result:

The experimentally determined value of mechanical equivalent of heat, J = ...J
Standard value of J = ...- J

Experiment: 13

Aim:

To determine the value of a given low resistance by Carey Foster`s Bridge with calibration.

Apparatus:

Carey-Foster's bridge, two equal low resistances (value 2 - 5 ohm), a fractional resistance box (range 0.1 -1 ohm), a cell, a sensitive galvanometer, jockey, thick copper strip, one-way key, thick connecting wires and given low resistance of unknown value.

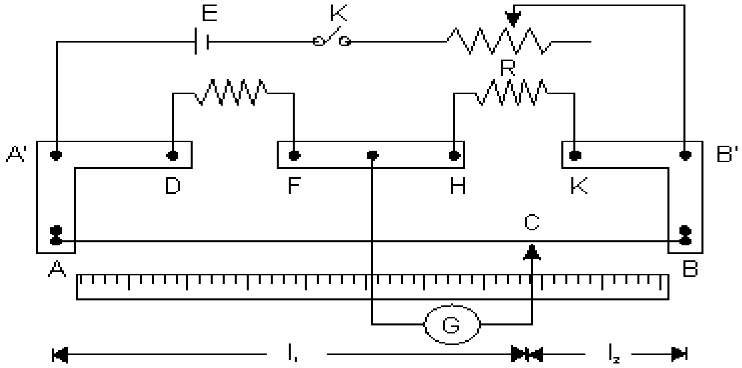
Formula used:

$$\sigma = \frac{r}{(l_2' - l_1')}$$

Where r =resistance drawn from resistance box

About experiment:

Two resistances to be compared, X and Y, are connected in series with the bridge wire. Thus, considered as a Wheatstone bridge, the two resistances are X plus a length of bridge wire, and Y plus the remaining bridge wire. The two remaining arms are the nearly equal resistances P and Q, connected in the inner gaps of the bridge.



The Meter Bridge
Fig. 14.4

Procedure:

1. Draw a circuit diagram as shown in fig (a) clean the ends of the connecting wires and thick copper strip using a sand paper.
2. Complete the electric connections as shown in fig. (a). Join the fractional resistance box in extreme left gap (marked as X) and the thick copper strip in extreme right gap (marked as Y in fig. (a). Use thick copper wires of shortest possible lengths to connect the fractional resistance box as well as the resistances P and Q. Check the connections once again.
3. To test the connections, make all the plugs of the fractional resistance box tight and insert plug in key K. Gently touch the jockey on the bridge wire at one end (say M) and note the direction of deflection in galvanometer. Now touch the jockey at the other end marked as N of bridge wire and again note the direction of galvanometer deflection. If the direction of deflection is now opposite then the electrical connections are correct else recheck your connections. Now slide the jockey on the bridge wire and obtain the position of null point. If the null point is obtained at the middle of wire i.e. at 50 cm length, it is alright otherwise tighten all the terminals as well as all the plugs of resistance box so that the null point is obtained at almost 50 cm mark.
4. Now take out 0.1 ohm plug from the fractional resistance box joined in extreme left gap (i.e. r = 0.1 ohm) and slide the jockey on bridge wire so as to obtain the null point position. Note the distance *tl'* of the null point from zero end of wire.
5. Take out the plug from key K. Interchange fractional resistance box and thick copper strip (i.e. join resistance box in extreme right gap and copper. strip in left gap). Put the plug in key K. Slide the jockey on bridge wire and obtain the length 1_2' for new position of null point. Calculate the value of resistance per unit length a. Find the mean value of $a$from these observations.
6. Repeat the step no. 4 and 5 (above) by taking 0.2, 0.3 ohm etc. resistance from fractional resistance box and find a.

Observations:

Sr. No.	Resistance inserted from resistance box (r) in ohm	Position of balance point with resistance box joined in (in cm)		(r_{1-r_2}) in cm	$\sigma = \frac{r}{l_2 - l_1}$ In ohmcm^{-1}
		left gap l_1	right gap l_2		
1.	0.1				
2.	0.2				
3.	0.3				
4.	0.4 .				
5.	0.5				

For resistance per unit length '0' of the bridge wire:

B) For low resistance Y:

S. No. I"	Resistance inserted from resistance (R) in ohm	Position of balance point with resistance box joined in (in cm)		(l_{1-l_2}) In cm	y= R - $(l_{1-l_2})\sigma$ ohm
		left gapl_1	right gap l_2		
1.	0.1				
2.	0.2				
3.	0.3				
4.	0.4				
5.	0.5				

Precautions:

1. The ends of the connecting wires, thick copper strip and the copper leads should be properly cleaned using sand paper.
2. The fractional resistance box and the unknown low resistance should be connected to the bridge by thick copper leads of shortest possible length.
3. All the plugs of the resistance box should be tight.

4. The jockey should be touched with wire gently and should just touch the wire while being moved along.
5. The difference between X and Y should not be more than the resistance of bridge wire otherwise it will not be possible to obtain the balance point.
6. In order that the bridge may have high sensitiveness, the resistances of the four arms should be of the same order.
7. The bridge wire must be of uniform cross section area.
8. The cell circuit should be closed only when the readings are to be taken.
9. While checking for null point, the cell circuit must be completed before pressing the jockey attached in galvanometer circuit on the wire.

Result:

Experimentally determined value of given low resistance = ...ohm

Experiment: 14

Aim:

To determine the given high resistance by substitution method.

Apparatus:

Sensitive galvanometer, a high resistance of the order of 0.5 - 1.0 mega ohm, a mega ohm box, a resistance box, one way key, battery, connecting wires etc

Formula used:

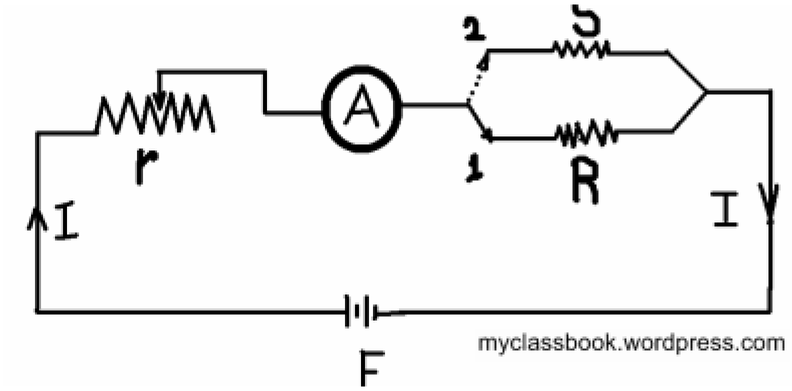
(i) For galvanometer resistance'

$$G = \frac{RS}{R-S}$$

Where R is the resistance inserted from mega ohm resistance box joined in main circuit and S is the shunt resistance.

About experiment:

R is the unknown resistance to be measured, S is the standard variable resistance, ‘r’ is the regulating resistance and ‘A’ is an ammeter. There is a switch for putting S and R in a circuit.



Firstly switch is at position 1 and R is connected in a circuit. The regulating resistance ‘r’ is adjusted till ammeter pointer is at chosen scale. Now switch is thrown to position ‘2’ and now ‘S’ is in a circuit. The value of standard variable resistance ‘S’ is varied till the same deflection as was obtained with R in the circuit is obtained. When the same deflection obtained it means same current flow for both the resistances. It means resistances must be equal. Thus we can measure the value of unknown resistance ‘R’ by substituting another standard variable resistance ‘S’. Therefore this method is called Substitution method

Procedure:

1. accordingly and complete the electrical circuit using connecting wires of appropriate lengths but before joining the key in the circuit, plugs should be removed from the keys. Compare the circuit connections with the circuit diagram and see that the connections made are correct and tight.

   Setting of galvanometer.

2. Release the clamp provided at the back of galvanometer so that the coil is free to vibrate.

   Adjust the levelling screws provided at the base of galvanometer till the coil can move freely.

3. Adjust the scale provided so that its extremities are equally distant from the mirror of galvanometer. Now place the eye in front of the slit provided on the scale to observe the image of the scale in the mirror fixed to the suspension strip in the galvanometer. Adjust height of the scale such that image of the scale is clearly visible in the mirror.
4. Turn \the torsion head of the galvanometer very slowly till zero mark on the image coincides with the image of central reference mark observed in the fixed mirror attached on the front panel of galvanometer. Fix the torsion head in this position. Now the galvanometer is ready for use.

   Determination of galvanometer resistance.

5. Put a suitable resistance R from mega ohm box and put in the plug between the terminals marked 1 and 3 in two way key K. Note the deflection of the galvanometer. The deflection should be large enough but within the scale.
6. Also insert the plug in key K, and adjust the resistance S taken from the shunt resistance box till the deflection of the galvanometer is exactly half

i.e. %. Apply the formula and find the value of G.

7. Repeat the step no. 5 and 6 three times find and then mean value of galvanometer resistance G.

Observations:

A) For galvanometer resistance (G) :

S. No.	Resistance R {in ohm}	Initial deflection, θ	Half deflection, $\frac{\theta}{2}$	Shunt S (in ohm)	RS G= $\frac{RS}{R-S}$ (in ohm)
1. 2. 3.					

Mean value of galvanometer resistance, G = … .ohm

(B) For unknown high resistance (X):

S. No.	Deflection with X (in cm)	R (in ohm)	S (in ohm)	Deflection (in cm)	X=$\frac{S+G}{S}$ (in ohm)
1. 2. 3.					

Mean value of given high resistance, X = … ohm

Precautions:

1. A sensitive suspended type moving coil galvanometer should only be used.
2. The resistance of galvanometer should be high (a few hundred ohms). **If** galvanometer resistance is too low then Join a resistance of appropriate value in series with the galvanometer. In such case G is the total resistance of galvanometer and the resistance added in its series.
3. The galvanometer should be set carefully. Always clamp the suspended end when the galvanometer is not in use.
4. The unknown high resistance, the galvanometer and the connecting wires should be carefully insulated so as to avoid any leakage of current.

Result:

Observed value of given high resistance, X = ...ohm

Experiment: 15

Aim:

To determine the electro - chemical equivalent of hydrogen using voltammeter.

Apparatus:

A voltameter, a graduated glass tube of capacity 50 cm", battery, ammeter, rheostat, key, connecting wires, Fortin's barometer, thermometer, beaker, clamp stand, plumb line, half meter scale and stop watch.

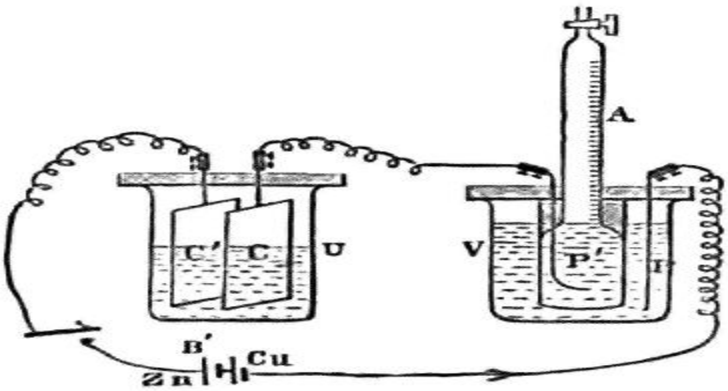
Formula used:

$$Z = \frac{m}{I \cdot t} = \frac{V_0 \cdot d}{I \cdot t}$$

Where **I** is the current flown for time t
m is the mass of hydrogen evolved at cathode Vo is the volume of hydrogen gas evolved at cathode under N.T.P condition and d is the density of hydrogen gas at N.T.P

About experiment:

Generally said, electrolytes are substances, which are built of atoms and their groups with charges of counter signs called ions. Coulomb forces are acting among them. Electrolytes are salts dissolved in water, bases and acids characterized by a big value of electric permeability. If we dissolve or melt such a substance, coulomb forces diminish and slight energy can break ionic bonds – this process is called dissociation. While in metals conduction was connected with the movement of small unitary mass electrons, in case of electrolytes charge bearers are hard ions. Conduction of electrolytes must be connected with transport of mass. The dissociation process aims at a complete dissolution of a substance in solvent. Nevertheless because of the processes of recombination of ions, by set temperature, given type of the substance and concrete solvent a permanent state of balance between the process of dissociation and the process of recombination is established – at the same time the same amounts of particles dissociate and recombinate.



Procedure:

1. Draw a circuit diagram as shown in fig. and assemble the apparatus accordingly using insulated copper wires of appropriate lengths but do not insert the plug in key K.

2. Clean the graduated glass tube and fill it with the acidulated water taken in the trough.
3. Close the open end of tube using your thumb and invert it over the cathode. Remove your thumb only when open end of the tube is immersed into water taken in the through. Clamp the tube vertically using a clamp stand.
4. Adjust the height of the graduated tube so that its open end is just below the top of cathode so as to prevent escape of hydrogen evolved. Open end of the tube should not touch the base or side of the Greinger's electrode.
6. Insert the plug in the key K so that a current begins to flow through the acidulated water. Soon hydrogen gas in the form of small gas bubbles is seen moving upward in the graduated tube.
7. Adjust the current in the circuit with the help of rheostat so that nearly 2 cm" hydrogen gas is collected in the tube in one minute. If the rate of evolution of hydrogen gas does not increase appreciably then bring the Greinger's electrodes closer to one another or add a few more drops of sulphuric acid in trough or use a battery of higher voltage till desired current and desired rate of evolution of hydrogen gas is obtained.

Finally test your setting by collecting the hydrogen gas for a few minutes. Remove the plug from key K.

8. Remove the graduated tube and again fill it completely with acidulated water and keep it in inverted position above the cathode. Insert the plug in key K so that current begins to flow. Simultaneously start the stop watch. Note the current flowing in the circuit after every two minutes and be sure current should remain constant throughout. If the current changes then using rheostat adjust the current to its original value. Mer 20 minutes (when about 40 cm" of hydrogen gasis collected in the tube) remove the plug from key K and simultaneously stop the stop watch. Also note the total time recorded by stop watch.

9. Wait for few minutes so that water in the voltameter attains the room temperature again.
Gently tap the glass tube so that hydrogen bubbles stuck with electrode or sides of tube, if any, move upward and are collected in the tube above the water level. Now read the volume of the gas collected in the tube. Also note the height 'h' of water column inside the graduated tube as compared to the water level in the trough using a plumb line and scale.

10. Note the least count of Fortin's barometer and note the atmospheric pressure.

11. Note the room temperature. Find the saturated vapour pressure of water corresponding to this temperature from S.V.P. table. .

Observations:

Least count of ammeter = ...A

Zero error of ammeter = ... A

S. No.	Time in minute	Observed current in ampere	S. No.	Time in minute	Observed current in ampere
1	0		1	0	
2	2		2	2	
3	4		3	4	
4	6		4	6	
5	8		5	8	

Total time for which current is passed = ...minute =..........second

Mean value of corrected current flowing I = ...A

Height of the water column in the tube, h = ...cm

Least count of Fortin's barometer = ...cm

Atmospheric pressure as read by barometer, P = ...cm of Hg

Room temperature T1 = ... "C = ... K

Calculations:

Pressure of water column in the graduated tube in terms of height of

mercury h Column, $P_{1} = h/13.6 =$ …………………..cm of hg

S.V.P. of water corresponding to temperature T l' P 2 = …………   cm of Hg

Precautions:

1. Graduated tube should be set vertically.
2. The tube should be set carefully so that the gas does not escape from the sides.
3. Tube should neither touch the bottom nor the sides of the Greinger's electrode.
4. The rate of evolution of hydrogen should be nearly 2 cm" of hydrogen per minute.

Result:

Experimentally found value of E.C.E. of hydrogen = ... gm C1

Standard Value of E.C.E. of hydrogen = ... 1.05×10^{-5} C-I

Experiment: 16

Aim:

To plot the calibration curve of give copper constanton thermocouple (copper-constanton) using a potentiometer arrangement.

Apparatus:

A 5 -10 wire potentiometer, copper constanton thermocouple, heating arrangement, a 360^0 thermometer, a 50^0 thermometer, resistance box, one way key, metre bridge, sliding jockey, connecting wires, a cell (or battery) of constant e.m.f., a voltmeter, a galvanometer, beaker containing cold water, wooden screen clamp, stands, sand paper etc.

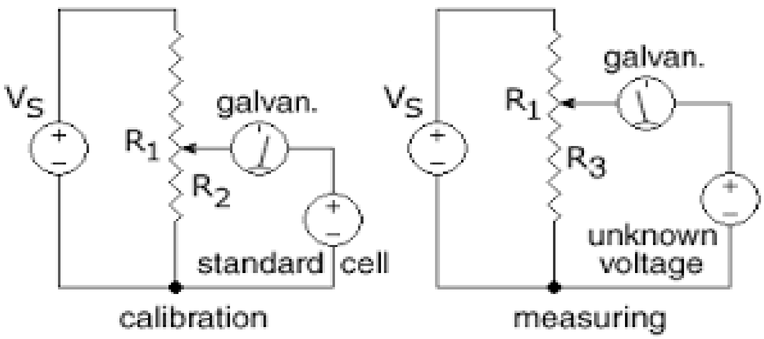
Formula used:

$$\text{Thermo electric e.m.f., } E' = \frac{Er}{(R+r)} \cdot \frac{l}{L}$$

Where E is the e.m.f. of given battery,
L is the total length of potentiometer wire,
r is the total resistance of potentiometer wire,
R is the resistance inserted from a resistance box, and *I* is the length for balance point.

About experiment:

A thermocouple is a device used extensively for measuring temperature. Learn how the device works here.A thermocouple is comprised of at least two metals joined together to form two junctions. One is connected to the body whose temperature is to be measured; this is the hot or measuring junction. The other junction is connected to a body of known temperature; this is the cold or reference junction. Therefore the thermocouple measures unknown temperature of the body with reference to the known temperature of the other body.



Procedure:

Preparation of tberrno-couple.

1. Take a thick constanton wire and solder two long copper wires at its two ends. Take a borosil glass tube having diameter 2- 3 cm and length 6- 8 cm. Take liquid paraffin in the tube up to about half of its height. Drill two fine holes in the rubber cork, to be fitted in the tube and pass copper and constant on wires through these holes as shown in fig *(a).*

2. Tightly fit the rubber cork in the mouth of test tube so that the soldered junction is fully immersed into liquid paraffin. Drill another fine hole in the rubber cork and insert a mercury thermometer of range 360°C in it. Immerse the other soldered junction into cold water taken in a beaker and insert a thermometer of range 50°C in it. Place the corning glass tube on a heat source on an iron tray containing large quantity of sand. Place the tray on the heat source and fix the tube in it using a clamp stand.

Measurement of potentiometer resistance.

3. Measure the total resistance of potentiometer wires by using a meter bridge arrangement. For this complete the circuit arrangement as shown in (b) and connect the two ends of potentiometer in the right

hand side gap of the meter bridge. Insert a suitable resistance R from resistance box R.B. connected in left side gap of meter bridge arrangement and slide the jockey gently **I** over the bridge wire so as to obtain the balance point position.

4. Repeat the observation 2 -3 times as mentioned in step 2 by changing the resistance inserted
From the resistance box and determine the mean value of potentiometer resistance.

Measurement of thermo e.m.f. at different temperatures.

5. Determine the e.m.f. of given accumulator using a voltmeter.
6. Assemble the apparatus according to circuit diagram shown in fig. *(c).* Clean the ends of connecting wires and complete the circuit arrangement. The thermo couple is connected to the potentiometer in such a way that direction of the thermo electric current in the potentiometer wire is the same as that due to battery B. For a copper-constanton couple, the hot junction should be joined to the zero end of potentiometer where +ve terminal of the battery has been joined. However, for a copper-iron couple the cold junction should be joined to the zero end.
7. Using the heat source start heating of sand so that temperature of hot junction begins to rise and after some time attains a high steady value. Take out a resistance of approximately 200 ohm from the resistance box and put the plug into key K. Press the sliding jockey at one end of potentiometer wire and note the direction of deflection. Then press the jockey at the other end of potentiometer. If now the deflection is in reverse direction, the electrical connections are correct otherwise not. Now slide the jockey and obtain the position of balance point. The balance point preferably should lie on the last wire of the potentiometer. **If** not, adjust the value of resistance form resistance box.
8. Remove the heat source. Temperature of hot junction falls. Carefully note the positions of balance points after every 10^0fall in temperature and go on taking the readings till the temperature of hot junction becomes same as room temperature.
9. Find the e.m.f. of the accumulator battery. Be sure that its e.m.f. has
10. remained constant throughout.
11. Calculate the thermo-electric e.m.f. corresponding to different temperatures of hot junction and plot a graph between temperature of hot junction (along x-axis) and the thermo e.m.f (along y-axis).

Observations:

S. No.	Resistance (R) from R.B. in ohm	Position of balance point *(l)* in cm	$R(1$ $\frac{R(100-R)}{l}$ in ohm

1. 2. 3.			

Mean value of potentiometer resistance, r =………. ....Ohm

E.M.F. of battery E = ...volt

Total length of potentiometer wire L = ...cm

Resistance inserted from resistance box in battery circuit R = ……..ohm

Table for the determination of thermo e.m.f :

S.r .No.	Temperature of hot, junction (°C)	Length of potentiometer wire corresponding to thermo e.m.f. In cm			Thermo e.m.f. E' = x.l (volt)
		no. of complete wires	balancing length In cm	Total length In cm	
1. 2. 3. 4. 5. 6. 7. 8 .	.				

Precautions:

1. The ends of the connecting wires should be thoroughly cleaned and the connections should be tight. As the magnitude of thermo e.m.f. is small, even one loose contact may lead to problem. .
2. The battery used should be fully charged and its e.m.f. should remain constant throughout the course of your experiment.
3. The thermo couple should be carefully examined. The soldering at the junctions should be checked and there should be no oxide layer over the wires.
4. The resistance of potentiometer should be determined accurately using a meter bridge or post office box arrangement.
5. The thermo-couple should be so connected that the current due to thermo couple in potentiometer wire flows in same direction as due to battery.
6. Temperature of cold junction should remain constant throughout the experiment.
7. The value of resistance R inserted from the resistance be adjusted such that the balance point at the highest temperature of hot junction is obtained on the last wire of potentiometer.

Result:

The calibration curve of given copper-constanton thermocouple is as show in the graph:

Experiment: 17

Aim:

To determine the frequency of A.C. mains using sonometer and an electromagnet.

Apparatus:

Sonometer,steel wire, hanger and slotted weights, step-down transformer, electromagnet, meter rod, weight box and a physical balance.

Formula used:

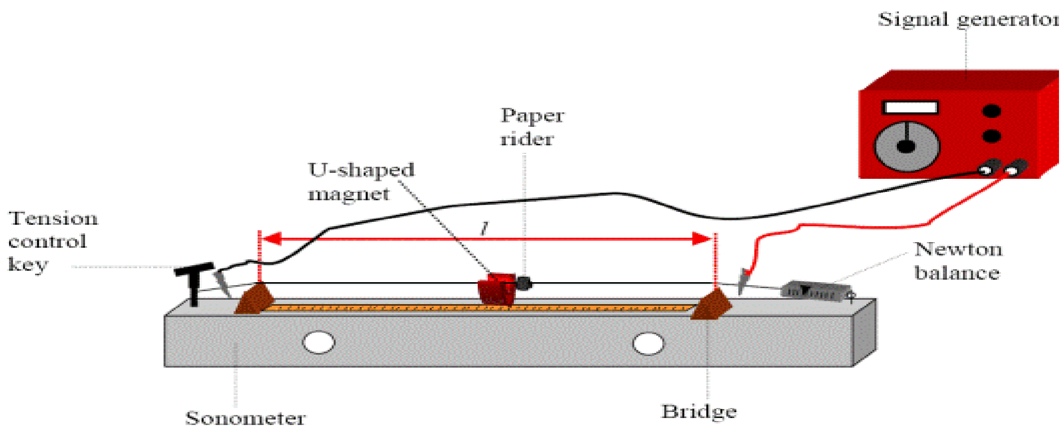
Frequency of A.C. mains, f =

$$f = \frac{l}{4l}\sqrt{\frac{T}{m}} \qquad f = \frac{l}{4l}\sqrt{\frac{T}{m}}$$

Where *l* is the length of sonometer wire between the bridges in resonance condition, T is the tension and m is the mass per unit length of string.

About experiment:

A sonometer is a hollow wodden box used in lab to study the transverse vibrations of string. It is also called the monochord because it often has only one string. On the wooden rectangular box are two fixed bridges, near the ends, and at one end is a pulley. A string, often a steel wire is fastened at one end run over the bridges and the pulley, and attached to a weight holder hanging below the pulley. Weights can be added to the holder to produce tension in the wire, and a third movable bridge can be placed under it to change the length of the vibrating section of the string.



Procedure:

1. Stretch a steel wire over a sonometer. Check that the pulley is frictionless and is free to move.
   Oil it if necessary. Now pass the steel wire over the pulley and with its free end suspend the hanger with suitable weights.
2. Set the electromagnet arrangement as shown in fig. The electromagnet should be supported with a clamp stand about 2-3 mm about the steel wire. Switch on A.C. mains and test the magnetisation of electromagnet with the help of an iron needle or pin.
3. Bring the wooden bridges near one another and place a small paper rider over the steel wire in between the bridges. Now gradually increase the distance between the two bridges till wire starts vibrating with a large amplitude. Now adjust the bridges minutely till resonance occurs and the rider falls away. In this position amplitude of the vibrations is maximum. Note the distance between the two bridges' with the help of a metre scale.
4. Move the bridges apart so as to increase the length of wire between them by about 5 cm. Now gradually bring the bridges closer till resonant vibrations again take place and rider flies off. Again measure the length of the wire between the two bridges. Mean of these two lengths is the true resonant length.
5. Take at least three sets of observations by changing load suspended in hanger in steps of 2' kg.
6. Switch off the A.C. mains and remove the electromagnet. Remove the hanger and load from the sonometer wire. Cut a piece of length about 50 - 60 cm of sonometer wire and measure its length using a meter scale.
7. Cut the given wire and find its mass accurately using a sensitive physical balance.

Observations:

Mass of steel wire M……………………… gm

Mass per unit length of wire m =………………………………….Gram/cm

Table for frequency of A.C. mains:

S. No.	Stretching load W in kg	Tension T= W x 1000 x 980 (dyne)	Resonant length of wire in cm			$F = \frac{1}{4l}\sqrt{\frac{T}{M}}$ (HZ)
			Increasing l_1	Decreasing l_2	Mean $l = \frac{l_1 + l_2}{2}$	
1. 2. 3.						

Mean frequency of A.C. mains = ... Hz

Precautions

1. The wire should be of uniform area of cross section and free from kinks.
2. Only a steel wire is to be used, which may experience magnetic force due to the electromagnet.
3. Pulley should be frictionless otherwise tension in the string may not be equal to suspended weights.
4. Start with minimum possible length, otherwise, it is possible that resonance may be obtained at double the length.
5. Bridges should be of sufficient height so as to support the wire.
6. The resonance should be obtained by first increasing and then by decreasing the distance between two bridges.
7. The electromagnet should be kept a few millimeter above the sonometer wire.
8. Initially magnetisation of electromagnet should be checked with the help of an iron needle or pin.
9. The pole of the electromagnet should always be adjusted to be in the middle of the bridges.

Result:

Experimental value of frequency of A.C. mains = ...: . Hz
Standard value of frequency of A.C. mains = ... 50 Hz

Experiment: 18

Aim:

To determine the frequency of A.C. mains using an electrical vibrator in (i) transverse and (ii) in longitudinal arrangement.

Apparatus:

An electric vibrator, uniform cord, pan, weight box, frictionless pulley, meter rod, physical balance etc.

Formula used:

transverse arrangement:

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

(ii) In longitudinal arrangement :

$$f = \frac{1}{l}\sqrt{\frac{T}{m}} = \frac{1}{l}\sqrt{\frac{Mg}{m}}$$

Where *l* is the length of cord between two consecutive nodes
m is the mass per unit length of the cord and
T is the tension applied to the cord and M is the total mass suspended in the pan including the mass of pan and f is the frequency of A.C.

About experiment:

A.C. (Alternating Current): An alternating current (AC) is an electrical current whose magnitude and direction vary cyclically, as opposed to direct current, whose direction remains constant. The usual waveform of an AC power circuit is a sine wave, as this results in the most efficient transmission of energy. Most students of electricity begin their study with what is known as direct current (DC), which is electricity flowing in a constant direction, and/or possessing a voltage with constant polarity. DC is the kind of electricity made by a battery (with definite positive and negative terminals), or the kind of charge generated by rubbing certain types of materials against each other. As useful and as easy to understand as DC is, it is not the only "kind" of electricity in use. Certain sources of electricity (most notably, rotary electro-mechanical generators) naturally produce voltages alternating in polarity, reversing positive and negative over time. Either as a voltage switching polarity or as a current switching direction back and forth, this "kind" of electricity is known as Alternating Current (AC):

Procedure:

1. Take a uniform fishing cord of about 2 meter length. Tie its one end to the free end of steel rod in electrical vibrator. To the other end of cord, attach a light aluminum pan and suspend it freely after passing it over a frictionless pulley fixed at the edge of the table.
2. Check that pulley is frictionless. If required oil it. Also see' that the height of pulley is such that the cord remains horizontal.
3. Complete the electrical Circuit of the electrical vibrator and set the adjustable clamping screws provided on it such that the steel rod of vibrator starts vibrating with sufficiently large amplitude.
4. Set the vibrating rod of electrical vibrator in line with the cord (figure (ai), such that about 1.5 meter length of cord lies between the vibrator and the pulley. Now apparatus is set for transverse arrangement.
5. Place some weights in the pan. If the electrical circuit of vibrator is complete, the cord also vibrates. Usually the amplitude of vibrations of the cord is very small. Add more weights to the pan slowly in small steps and adjust the length of cord between the vibrator and pulley by moving the vibrator till the vibrations of maximum amplitudes are obtained. In this situation cord vibrates in a finite number of loops and sharp nodes and anti-nodes are formed.
6. Gently mark the position of the extreme nodes leaving out the two extreme loops and count the number of loops formed between these marks. Switch off the AC. mains and carefully measure the distance between the marks using a meter scale. Divide the distance by the counted number of loops and find the value of *l*. Also note the mass placed in the pan.
7. Repeat the steps 5 and 6 for different loops. Different number ofloops may be formed either by
   Changing the mass put in the pan or by altering the length of the cord.
8. Turn the electrical vibrator by 90° fig. (b) . Now the apparatus is set in longitudinal arrangement.
9. Repeat steps 5, 6 and 7 in this arrangement.
10. Find the mass of the pan using a sensitive balance.
11. Find the mass of about 2 m of the cord and then find m, i.e., the mass per unit length of the cord.

Observations and Calculations:

Mass of the pan M, =...................................... gm
Mass of cord M' =... gm
Length of cord L' =...

S.No.	Mass placed in pan In gms	Total tension in terms of weight $=M_1+M_2$	No. of loops'	Corres - ponding length of cord,L	Length for one loop $=\frac{L}{p}$	Frequency, $f=\frac{1}{2l}\sqrt{\frac{Mg}{m}}$ (Hz)

		(in gm)		Incm	in cm	
1. 2. 3.						

Mean frequency of AC. mains (in transverse arrangement), f = ... Hz

For cm (A) For transverse arrangement:

S. No.	Mass placed in pan M2 in gms	Total Tension in	No. of loops, p	Correspondi Cord Lin cm	Length for one loop $L = = \frac{L}{p}$ cm	Frequency, $f = \frac{1}{2l}\sqrt{\frac{Mg}{m}}$ (Hz)
1. 2. 3.						

Precautions

1. The cord used should be flexible, in extensible and of uniform thickness.
2. The pulley should be frictionless and the cord between vibrator and pulley should be perfectly horizontal.
3. The steel rod should be so adjusted before attaching the cord to it, that it vibrates with a large amplitude with the frequency of A.C. mains.
4. Sharply defined nodes and antinodes should be obtained in the cord. Moreover, the loops formed in the cord should appear stationary.
5. Not too much load should be placed in the pan.

Result:

Experimentally determined value of frequency of AC. mains (in transverse arrangement) f= ……….. Hz

Experimentally determined value of frequency of AC. mains (in longitudinal arrangement) f=…………………… Hz

Standard value of frequency of AC. mains = ... Hz

Experiment: 19

Aim:

To determine the impedance of an a.c. circuit and verify the relation.

APPARATUS:

Inductance (L), capacitor (C) and resistance (R), digital millimeter variable step-downtransformer, a.c. voltmeter and a.c. millimeter of suitable range, one-way key and flexible wires.

Formula used:

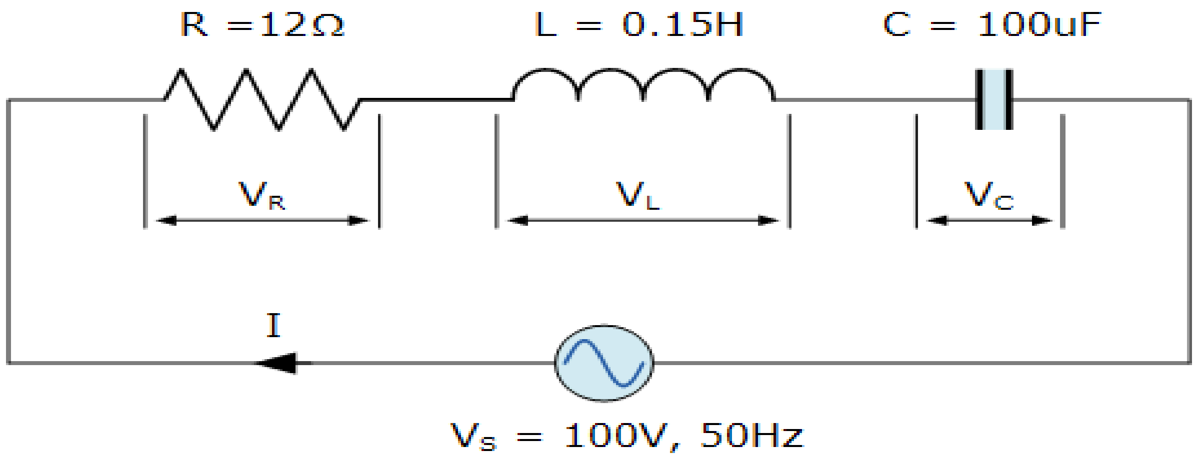
The impedance of a.c. circuit is given b

$$Z = \frac{V_{rms}}{I_{rms}} = \sqrt{R^2 + (X_L - X_C)^2}$$

Where Vrms = effective or rms voltage across the source or series LCR combination effective or rms current in LCR series circuit
R Total ohmic resistance (including resistance of the inductor).
XL = Inductive reactance (XL = WL)
Capacitive reactance (Xc=*l/wC)*

About experiment:

we have seen that the three basic passive components: resistance (R), inductance (L), and capacitance (C) have very different phase relationships to each other when connected to a sinusoidal AC supply. In a pure ohmic resistor the voltage waveforms are “in-phase” with the current. In a pure inductance the voltage waveform “leads” the current by 90^o, giving us the expression of: ELI. In a pure capacitance the voltage waveform “lags” This **Phase Difference, Φ** depends upon the reactive value of the components being used and hopefully by now we know that reactance, (X) is zero if the circuit element is resistive.



PROCEDURE:

1. Using multimeter, measure the d.c. resistance of the inductor.
2. Make the electrical connections as shown in Fig. 14.1 using flexible connecting wires.
3. Keeping the variable transformer at its lowest voltage, switch on the a.c. mains.
4. Increase the voltage from the transformer so that milliammeter shows some suitable readings.
   Note the value of current. Also measure potential difference across LCR series combinations inductor (L), capacitor (C) and resistance (R). Let their values be represented by Eeff> E_L, Ecand E_R.

Make the necessary calculations to obtain the values of XL', XL>Xc' Rl' R and ultimately Z and Z'.

OBSERVATIONS:

Resistance (d.c.) of inductor, r = Q (using digital multimeter)

Least count of a.c. millimeters = ... mA

Zero' error of a.c. millimeters = ... mA

Least count of a.c. voltmeter = ... V

S.No.	Corrected	Corrected value of P.D. across				$z = \frac{E_{eff}}{I_{eff}}$ l	' XL $=\frac{E_L}{I_{eff}}$	Xc$=\frac{E_C}{I_{eff}}$	R$=\frac{E_R}{I_{eff}}$
	Value of Current (I_{eff}) mA	LCR (E_{eff})	(L + R) (EL)	C (Ec)	R (E_R)				
1. 2. 3.	..... 10^{-3}A	.. .v	.. .v	.. .v	.. .	... n	... n	... n	... n

Zero error of a.c. voltmeter = ... V

Precaution:

1. All the connections should be made using flexible wires.
2. A.C. voltmeter and a.c milliammeter of proper range should be used so as to avoid damage to these instruments.
3. Inductor (L), capacitor (C) and resistance (R) of proper rating must be used to avoid their overheating or burning.
4. Naked part of wires or terminals must not be touched with hand to avoid electrical shock.

RESULT:

1. The impedance of the given LCR series circuit is ...... n
2. Z' = Z is verified within limits of experimental errors.

Experiment: 20

Aim:

To verify the inverse square law with the help of a photovoltaic cell.

Apparatus:

Photovoltaic cell, optical bench with two uprights, an electric bulb with a bulb housing, sensitive low resistance galvanometer or a sensitive microammeter.

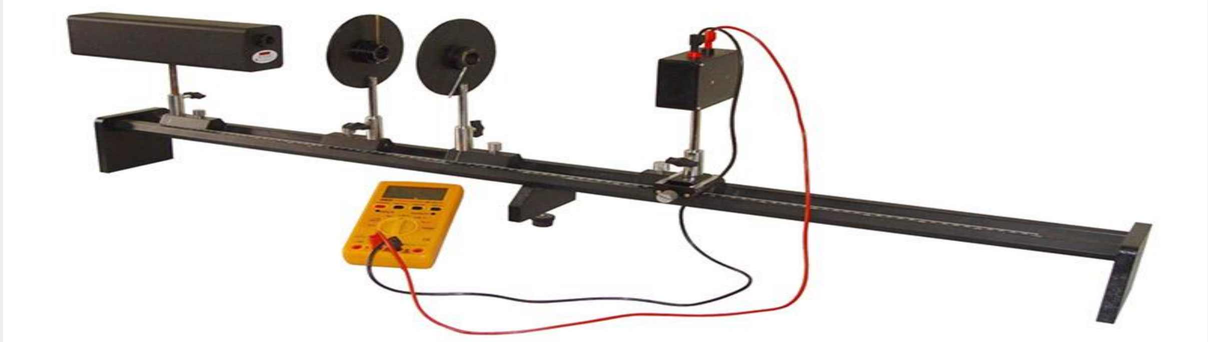
Formula used:

For a source of light having constant luminous intensity and for normal incidence, the intensity of illumination E at a surface is inversely proportional to the square of the distance between light source and the With a very low external resistance the output current of a photovoltaic cell is proportional to the intensity of illumination, hence,

$$\theta \propto \frac{1}{r^2}$$

About Experiment:

This is because you are confusing the intensity of the source with the intensity of a reciever. A photocell works by allowing light into it. The light then gives energy to the electrons in the material. It does this to free the electrons from there bound state, so they can become "conduction electrons" and pass on a current. By "knocking off" the electrons, it reduces the resistance and allows a current to pass. The relationship between the current flowing through the LDR (photocell) is dependant on the reduction in resistance which is independant of the intensity coming in, as it is a discrete process of either giving energy to conduction electrons, or simply not.



Procedure:

1. Inside a dark room place two uprights on an optical bench. One upright should carry an electric bulb and the bulb housing so that a fine collimated light beam comes out of it. The other upright facing it should carry a proper mounting containing a photovoltaic cell.
2. Join a sensitive low resistance galvanometer (or a micro ammeter) to the two terminals of the photovoltaic cell.
3. Adjust the height of lamp housing and the photo cell so that they lie in the same horizontal plane.
4. Adjust the distance of the lamp from the photocell in such a way that when light is allowed to fall on the sensitive portion of photocell, we get maximum possible deflection in galvanometer. Note the position of photo cell as well as lamp and determine the distance r between them. Note the galvanometer deflection e.
5. Move the lamp upright away so that the distance between the photocell and lamp is increased by 5 cm. Again note the deflection in the galvanometer.
6. Increase the distance in steps of 5 cm and note the corresponding galvanometer deflections when light is allowed to fall on photo cell. Take at least six readings.

B. Preferably repeat the experiment by using a bulb of different wattage.

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Observations:

Zero error in galvanometer = ...

S.No.	Position on optical bench (in cm)			$\frac{1}{r^2}cm^{-2}$	Deflection θ	
	Upright carrying Photocell (a)	Lamp (b)	Distance r=a-b		Observed	Corrected
1.						
2.						
3.						
4.						
5.						
6.						

Calculations:

Graph between $1/r2$ and. This graph is a straight line.

Precautions:

1. Use a low resistance and voltage sensitive galvanometer.
2. The photocell should not be exposed to light continuously.
3. The light from the source should be incident normally on the photosensitive surface.

Result:

The graph between $r^2$and $r$is a straight line .It shows that deflection (and hence the intensity of Illumation) is inversely proportional to the square of the distance between source and surface. Thus, inverse square law of photometry is verified.

Experiment: 21

Aim:

To determine the angle of dip in your laboratory using an earth inductor and ballistic galvanometer.

Apparatus:

An earth inductor, ballistic galvanometer, lamp' and scale arrangement, resistance box, magnetic compass needle, tapping key, one way key and connecting wires.

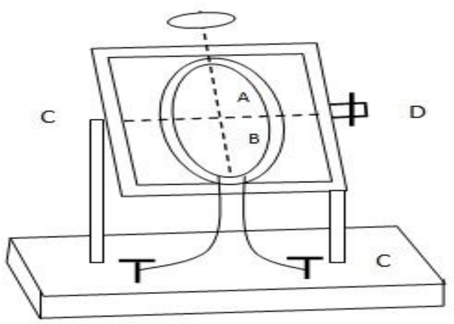
Formula used:

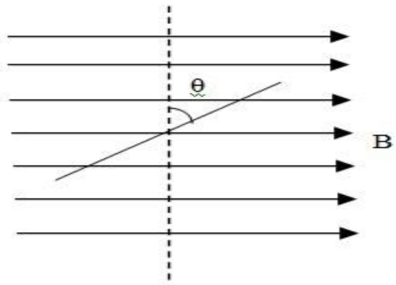
$$\tan\delta = \frac{\theta_2}{\theta_1} = \frac{x_2}{x_1}$$

Where θ= angle of dip,$\theta_1$and θ_2 are the first throws of galvanometer coil when earth inductor is set normal to H and V respectively and Xl and x_2 are the corresponding linear throws of light spot on the scale.

About experiment:

Earth inductor is an instrument used for the measurement of magnetic elements of earths. The purpose of an earth inductor is to generate an induced emf by virtue of the rotation of coil in earth's magnetic field. Earth inductor is simply a circular coil consisting of a large number of turns of insulated Cu-wire wound over a wooden or ebonite frame. The coil is fitted in wooden frame. The coil can be rotated quickly through 180 about an axis passing through 180 about an axis passing through the centre of the coil and lying in its plane (i.e., about diameter AB). The frame itself can be rotated about an axis CD | to AB. Thus the axis of the rotation of the coil can be adjusted vertical or horizontal as desired. The ends of the coil are connected by means of flexible wired to two binding screws on the frame.





Procedure:

1. Place the ballistic galvanometer on a rigid and uniform platform and set the galvanometer as well as the lamp and scale arrangement.
2. With the help of magnetic compass draw the magnetic meridian on the table using a piece of chalk. Also draw a line perpendicular to the magnetic meridian i.e. along magnetic east-west.
3. Draw the circuit diagram. Assemble the apparatus and make the electrical connections. The resistance box R.B. should be a high resistance box.
4. Place the earth inductor vertically along magnetic east-west direction i.e. the earth inductor should be set such that its axis of rotation is vertical and its plane is perpendicular to the magnetic meridian Now bring the coil of ballistic galvanometer to rest by pressing the tapping key K. Note the initial resting point of the light spot on the scale and than release the coil of earth inductor by pressing the push button provided for this purpose. The earth inductor rotates through 180°. Note the maximum position on the scale up to which the light spot moves.
5. Place the earth inductor with its coil lying in the horizontal plane and its axis of rotation in the magnetic meridian i.e. in magnetic north-south.
6. resistance box same as in step 4, allow the coil of earth inductor to quickly rotate through 180° and note the maximum value of first throw 8_2 produced due to cutting of flux lines due to V. Repeat steps 4 and 5 by changing the resistance introduced from the resistance box.

Observations:

S.No.	First throw in the galvanometer due to H (in			First throw in the galvanometer due to V (in			$\frac{x2}{Xl}$
	Initial readin	Final reading	Throw Xl	Initial reading	Final reading	ThrowX_2	

	of spot	of spot		of spot	of spot		
1.							
2.							
3.							
4.				I			

Precautions:

1. The coil of the ballistic galvanometer should be free to oscillate.
2. The earth inductor should be placed at a large distance from the ballistic galvanometer so that the flux due to the magnet of the galvanometer may not affect the earth inductor.

Result

The experimentally observed value of angle of dip in the laboratory is =

Standard value of angle of dip at = .

Percentage error =