Name of the student____________________ Branch & Roll No

LIST OF EXPERIMENTS

INDEX

COMPOUND PENDULUM

AIM : To determine acceleration due to gravity (g)at a place using compound pendulum.

APPARATUS: Compound pendulum, knife edges, telescope, stop watch, meter scale.

DEFINATION OF 'g': When a body is left to free fall, then it acquires a constant acceleration andmove towards earth, due to earth's gravitation. Now the constant acceleration acquired by that freely falling body is called acceleration due to gravity.

FORMULA: Time period of oscillation of a physical pendulum or compound pendulum is given by

$$T = 2\pi\sqrt{\frac{K^2 + D^2}{gD}}\ Sec$$

Compare the above formula with time period of oscillation of a simple pendulum. i.e.

$$T = 2\pi\sqrt{\frac{L}{g}}\ sec$$

Here $\mathbf{L} = \frac{K^2+D^2}{D}$ is called length of equivalent simple pendulum. K is radius of gyration; 'D' is distance of the point of suspension from center of gravity. The value of " L " is estimated from a graph drawn between distance of point of suspension (l) verses time period of oscillation (T)

From the above formula acceleration due to gravity is given by $\mathbf{g} = 4\,\pi^2\left(\frac{L}{T^2}\right)$ cm/s²

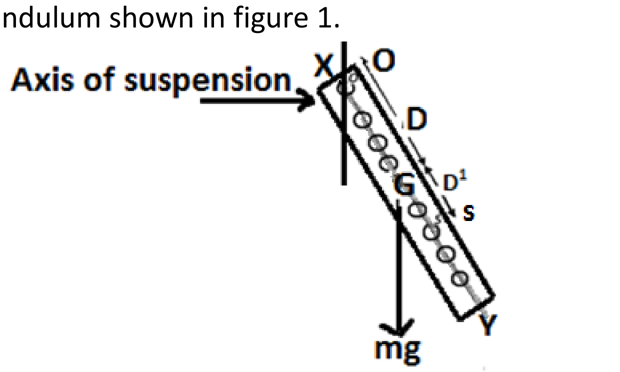
THEORY:

In lower classes you might be familiar with simple pendulum experiment for the determination of acceleration due to gravity, hence before to do this experiment one has to know the difference between simple pendulum, and compound pendulum experiment, both of them were meant for determination of 'g' value. They are

1. Simple pendulum is an ideal case, because it require a point mass object
2. It requires torsion less string.

The above mentioned two conditions are not practically possible, hence it is only a mathematical ideal case, and whereas compound pendulum is a physical pendulum.

A rigid body of any shape which is free to oscillate without any friction on a vertical plane is called compound pendulum. It swings harmonically back and forth about a verticalz-axis (Passing through point"O" as shown in Fig),when compound pendulum is displaced from its equilibrium position by an angle $\boldsymbol{\theta}$. In the equilibrium position, the center of gravity of the body is vertically below at a distance of OG. Let the mass of the body is m, In this experiment you are going to measure theacceleration due to gravity, g by observing the motion of a compound pendulum. Let us consider acompound pendulum shown in figure 1.



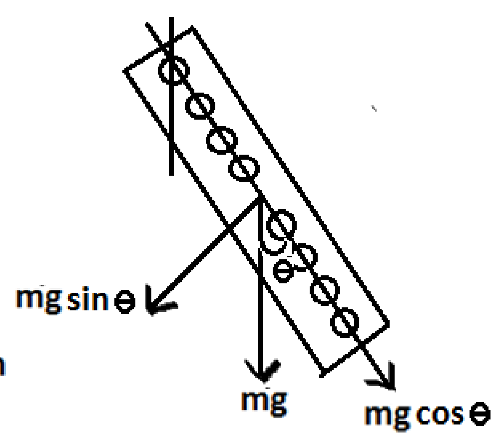


Fig 1. oscillation of a compound pendulum

Pull the compound pendulum through an angle $\boldsymbol{\theta}$ and release it, then it makes angular oscillations due totorque acting on it, given by

$$\vec{\tau} = \vec{r}\ X\ \vec{F}$$

$$\vec{\tau} = \overrightarrow{OG}X\,\overrightarrow{mg}\ sin\theta$$

$$\vec{\tau} = -mgDsin\theta - - - -(1)$$

Here –ve sign is because of force and displacement is opposite to each other.

For small amplitudes $Sin\theta \approx \theta$

Now expression (1) becomes $\vec{\tau} = -mgD\theta$

We know that torque $\vec{\tau} = (\boldsymbol{Moment\ of\ inertia\ (I)})[\boldsymbol{Angular\ accelaration\ (\alpha)}]$

$$\tau = I\frac{d^2\theta}{dt^2}$$

$$=> I\frac{d^2\theta}{dt^2} = -mgD\theta$$

$$\frac{d^2\theta}{dt^2} + \left(\frac{mgD}{I}\right)\theta = 0 - - - -(2)$$

Here I is the moment of inertia of pendulum, about an axis passing through point "O".

Equation (2) represents simple harmonic equation of the form, i.e.

$$\frac{d^2\theta}{dt^2} + \omega^2\theta = 0$$

Here $\omega$is angular frequency of simple pendulum. From comparison with Eq (2), we can write

$$\omega = \sqrt{\frac{mgD}{I}}$$

$$=>\omega = \frac{2\pi}{T} = \sqrt{\frac{mgD}{I}}$$

$$=>T = 2\pi\sqrt{\frac{I}{mgD}} - - - -(3)$$

According to parallel axes theorem, the rotational moment of inertia, about any axis parallel to the one passing the center of gravity is given by

$$I = I_G + mD^2 - - - (4)$$

We know that moment of inertia about an axis passing through center of gravity "G", given by

$$I_G = mk^2$$

Here "K" is radius of gyration of the body about an axis passing through "G".

Thus $T = 2\pi\sqrt{\frac{mk^2+mD^2}{mgD}} = 2\pi\sqrt{\frac{D+\frac{k^2}{D}}{g}} - - - - - (5)$

Comparing expression (5) with expression for time period of simple pendulum i.e.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

This suggests that $L = D + \frac{k^2}{D} = D + D^1 - - - -(6)(\ let\ D^1 = \frac{k^2}{D})$

The term **"L"** is called length of ***"equivalent simple pendulum".***

This is because simple pendulum of length "L" is having a time period, same as that of time period of compound pendulum. Also it seems that all the mass of the body were concentrated at point **"S",** along "OG" produced such that $OS = D + \frac{k^2}{D} = D + D^1$

The point "S" is called center of oscillation. In analogy with simple pendulum we may suppose that, the entire mass is concentrated at that point.

From expression (6), the extra distance $D^1 = \frac{k^2}{D}$is below the center of gravity "G", at a point "S", and is shown in Figure (1).

From expression (6) we can write

$$D^2 - LD + K^2 = 0$$

The above equation is a quadratic equation in "D" and it's two roots are given by

$$D_1 = \frac{L + \sqrt{L^2 - 4K^2}}{2}\ and\ D_2 = \frac{L - \sqrt{L^2 - 4K^2}}{2}$$

That is for each half of pendulum, there are two different points of oscillation ***(do not get confusion with center of oscillation)*** i.e. which are at $D_1 and\ D_2$ distance away from center of gravity **"G"**, for which the value of **"L"** is same. Since **"L"** is same for $D_1 and\ D_2$**,** then, the time period is also same. When we perform this experiment on both sides of center of gravity "G" we have a total of 4 points (2 points on one side) having same time period "T", as shown in Figure 2. The points $D\ and\ D^1$ are clearly shown in Graph.

It is sometimes convenient to specify, the location of axis of suspension or point of oscillation "O", by the distance from end of the bar, instead of distance "D" from center of gravity. By varying the position of axis of suspension, measure the corresponding time period, and tabulate all the observation in the following

TABULAR FORM FOR THE DETERMINATION OF TIME PERIOD

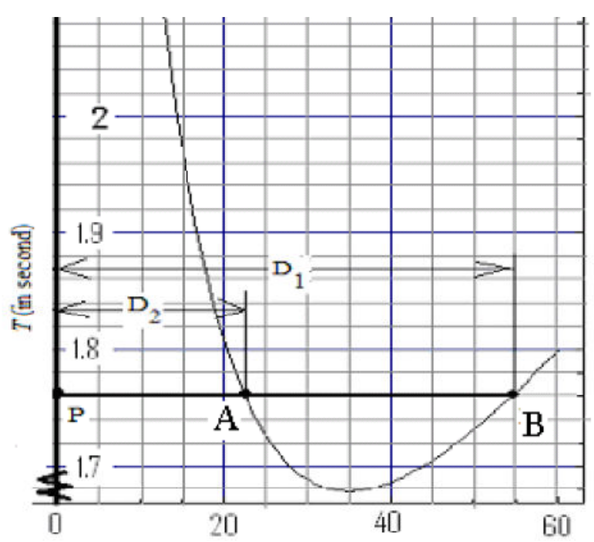
S.No	Distance of knife edge from one end of the bar. "D"	Time taken for 20 oscillations			Time period T=t/20 Sec
		Trail 1	Trail 2	Mean time (t) sec	
1					
2					

TABULAR FORM FOR THE DETERMINATION OF EQUIVALENT LENGTH OF SIMPLE PENDULUM

S.No	Time period "T"	T^2	AC	BD	$L = \frac{AC + BD}{2}$	$\frac{L}{T^2} = Constant$
1						
2						

Graph:

1. Draw a graph between "D" values on x-axis and corresponding "T" values on Y- axis, then we get the following nature of graph.(Fig 1). Draw a straight line, at one particular "T" value, then it intersect the graph at four points and mark them as A,B,C,& D



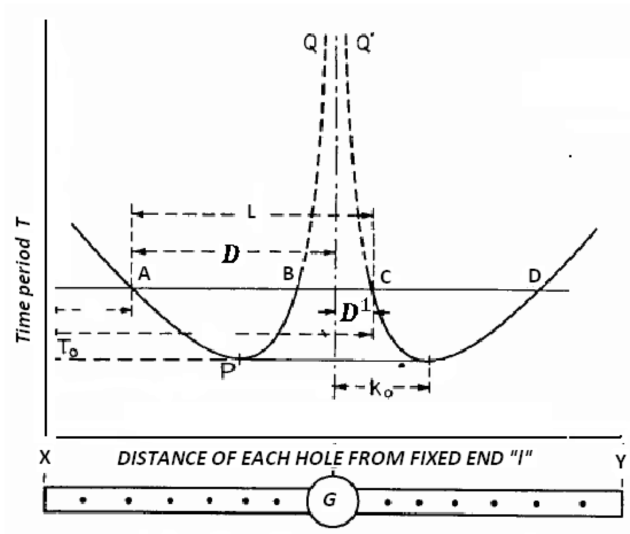


Fig. T verses D graph on both sides of center of gravity

Fig. "T" verses "D" graph for each half of the compound pendulum

GRAPH 2.

A graph is drawn between "L" values on X-axis and corresponding "T^2" values from table 2, on Y-axis, and then the nature of graph is as shown in Fig4

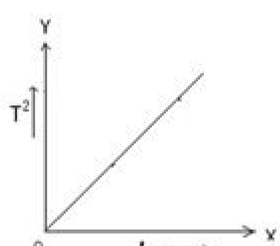


FIGURE 4. L Verses T^2 graph

NOTE: We can also find "L" value from Fig 2 as sum of $D_1 and\ D_2$. We can show it as sum of expression for $D_1\&D_2$.

i.e. **L=D_1 + D_2 = PA + PB (According to Fig1)**

$$D_1 + D_2 = \frac{L + \sqrt{L^2 - 4K^2} + L - \sqrt{L^2 - 4K^2}}{2} = \frac{2L}{2} = L$$

PRECAUTIONS: 1.Angular displacement of the pendulum should be confined to below 10^o
2. Pendulum should oscillate only in vertical plane, without wobbling.
3. Knife edge should rest on horizontal surface only.

RESULT: Acceleration due to gravity using compound pendulum was found to be ______.

TORSIONAL PENDULUM-- RIGIDITY MODULUS

AIM: To determine the rigidity modulus of the material of the wire by the method of oscillations.
APPARATUS: Circular disc with chuck, given wire (suspension wire), stop clock, two equal cylindrical masses, screw gauge, vernier calipers and meter scale.

FORMULA: Rigidity modulus of given wire using torsional pendulum is given by

$$\eta = \frac{16\pi ml}{a^4}\left(\frac{d_2^2 - d_1^2}{T_2^2 - T_1^2}\right) dynes/cm^2$$

Here m=mass of each cylinders
l = length of the wire
a = radius of the wire
$d_1 \& d_2$ *are distance of the cyllender center from chuck nut center*
$T_1 \& T_2$ *are time period of oscillation corresponding to distance* $d_1 \& d_2$

THEORY:
Torsion pendulum consists of a metal wire clamped to a rigid support at one end and carries a heavy circular disc at the other end. When the suspension wire of the disc is slightly twisted, the disc at the bottom of the wire executes torsional oscillations such thatthe angular acceleration of the disc is directly proportional to its angular displacementand the oscillations are simple harmonic.

PROCEDURE:
One end of a long, uniform wire whose rigidity modulus is to be determined is clamped by a vertical chuck. To the lower end, a heavy uniform circular disc is attached by another chuck. The length of the suspension $\boldsymbol{l}$ (from top portion of chuck to the clamp) is fixed to a particular value (say 60 cm or 70 cm). Keep the two cylindrical masses are at equal distance from chuck nut, and note down this distance. At this position, the suspended disc is slightly twisted so that it executes torsional oscillations. The first few oscillations are omitted. By using the pointer, (a mark made in the disc) the time taken for l0 complete oscillations are noted. Two trials are taken. Then the mean time period T (time for one oscillation) is found. The above procedure is repeated, by keeping the cylinders at various equal distances from chuck nut. The diameter of the wire is accurately measured at various places along its length with screw gauge. From this, the radius of the wire is calculated. Tabulate all the observations in the various table forms, shown below.

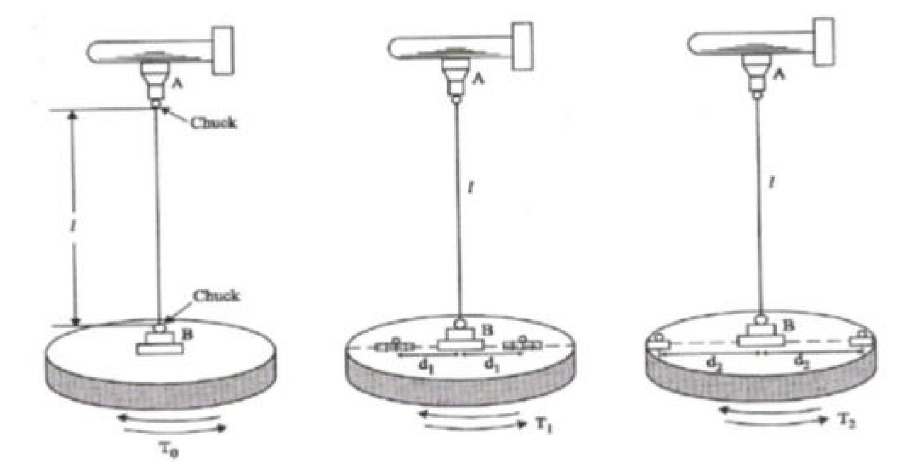


TABLE -1 FOR THE DETERMINATION OF RADIUS OF CYLINDER USING VERNIER CALIPERS.

S.No	M.S.R "a" cm	VC	VCxLC "b" cm	Radius=$\frac{a+b}{2}$ cm

TABLE-2 FOR THE DETERMINATION OF RADIUS OF CHUCK NUT USING VERNIER CALIPERS

S.No	M.S.R "a" cm	VC	VCxLC "b" cm	Radius=$\frac{a+b}{2}$ cm

TABLE-3 FORTHE DETERMINATION OF RADIUS OF WIRE USING SCREW GAUGE

Screw gauge error: ___+ve/___-Ve Correction ___-ve/___+ve LC=0.001cm

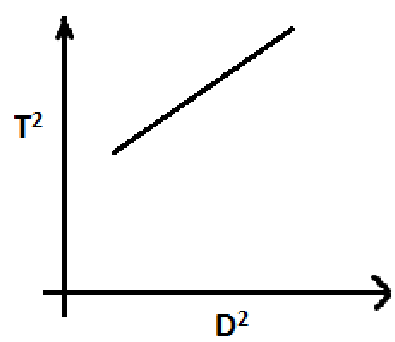
S.No	P.S.R "a" cm	H.S.R		b=nxLC cm	Diameter "a+b" Cm	Radius=$\frac{a+b}{2}$ Cm
		Observed	Corrected "n"			

TABLE -4 FOR THE DETERMINATION OF TIME PERIOD OF OSCILLATION

Length of the wire $l = ----cm$

S.No	Distance of the cylinder center from chuck nut center (d) cm	Time taken for 10 oscillations			Time period(T)= t/10 sec	d^2	T^2
		Trail-1	Trail-2	Mean(t)			

GRAPH: A graph is drawn between d^2values on X-axis and T^2values on Y-axis, then the nature of the graph is as shown in Figure.



PRECAUTIONS:

I. The suspension wire should be well clamped, thin long and free from kinks.

2. The period of oscillations should be measured accurately since they occur in second power in the formula.

3. Radius of the wire should be measured very carefully since it occurs in fourth power.

Applications:

1. This method is used to find the moment of inertia of any irregular materials and the elastic limit of the given wire.

2. By knowing the moment of inertia, the time period of oscillations can be found.

RESULT: Rigidity modulus of the wire is given by __________dynes/cm^2

NEWTON RINGS

AIM : To determine the radius of curvature of given plano - convex lens by formingNewton rings.

APPARATUS : Plano – convex lens, optically plane glass plate, Plane glass plate inclined at 45^0,sodium vapour lamp, travelling microscope, reading lens, black sheet.

PRINCIPLE: This experiment is based on the principle of interference.

NATURE OF INTERFERENCE PATTERN: In this experiment all the fringes are circular inshape, with central dark fringe(in reflected system only). The fringes are circular due tolocus all the points which are having, constant air film thickness is lie along the circumference of a circle.

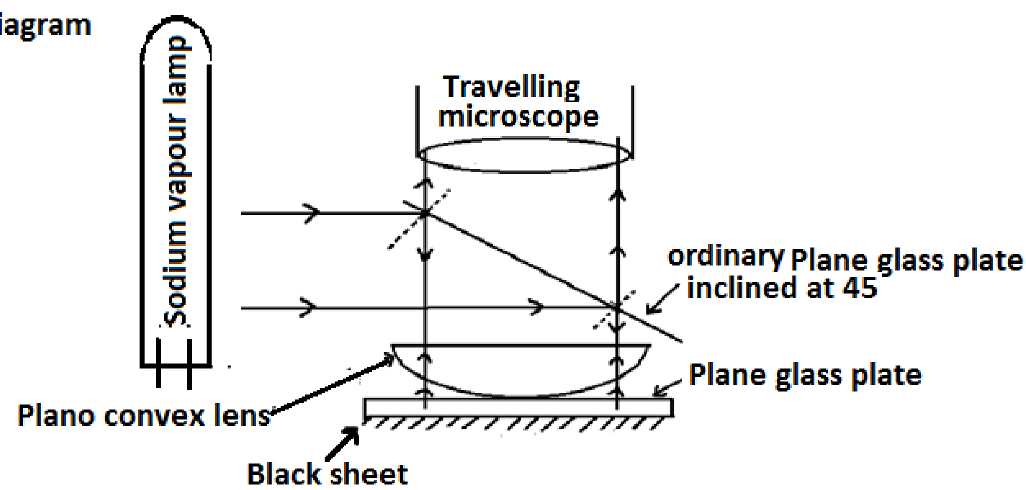
FORMULA: The expression for radius of curvature of a given plano-convex lens, in Newton rings is given by

$$R = \frac{D_m^2 - D_n^2}{4\lambda(m-n)} cm$$

Here D_m&D_n are the diameters of m^{th}& n^{th} ring respectively.

λ= Wavelength of light source used.

Ray diagram



THEORY :

When light from sodium vapour lamp is allowed to fall directly on to an ordinary plane glass plate inclined at 45^0 , it is reflected at 45^0 (according to laws reflection and refraction) and fall normally (i.e angle of incidence ' i ' = 0^0) onto the system of plane glass plate and plano-convex lens . When convex surface of plano- convex lens is placed on plane glass plate, it rest at one point, as shown infig. The airfilm thickness between convex surface and plane glass plate is gradually increasing fromthe point ofcontact(where thickness of the film is zero), called wedge shaped film. The light rayswhich fall normallyonto the system under go first reflection at plano - convex lens surface, andsecond reflection from plane glass plate. Since both these light rays are derived from same source, they possess same wavelength and has a constant phase difference equal to thickness of the air filmat that place. These light rays interfere in the field of view of travelling microscope,producing interference fringes as concentric circles of alternate bright and dark. This is because, locus of all the points, which are reflecting at same air film thickness lie along the circumference of a circle.

PROCEDURE:-

1) Glass plate and lenses are thoroughly cleaned.

2) First one has to detect the plane glass plate and plano-convex lens. This can be done by shaking the lens while viewing anyobject through it.

(i) If the object is seen through the lens is shaking, when the lens is shaking, then that lens is a plano convex lens.

(ii) If the object seen through the lensis not shaking, when the lens is shaking, then that one is a plane glass plate.

Now keep the plano-convex lens on plane glass plate and gently rotate. If it stops rotating immediately, then it means that the plane side of plano-convex lens is rest on the plane glass plate. If it rotates for some time, then it means the convex side of plano-convex lens is rest on plane glass plate.

3) The glass plate in the Newton's rings apparatus is set such that it makes an angle of 45^0 with the direction of incident light coming from the source. It is the necessary condition for the well illumination of combination and to allow light rays to fall normally on to that system.

4) The microscope is moved in the vertical direction till the rings are seen distinctly.

5) The center of the fringes is brought symmetrically below the cross wires by adjusting the position of the lens and the microscope.

6) The microscope is moved in horizontal direction to one side of the fringes such that one of the cross wires becomes tangential to the 18th ring. Note down the main and vernier scale readings.

7) Move the microscope and make the cross wire tangential to the 16th, 14th up to 8th ring and on the other side up to 18th ring. Note down the readings.

8) The radius of curvature of the curved surface of the plano-convex lens is determined using spherometer. Place the lens with its curved surface upwards on the glass plate. Take the spherometer reading when it just touches the surface. Remove the lens. Take the reading on the plane surface.

9) Place the spherometer on the note book and gently press to obtain the impression of the three legs of the spherometer. Join the three points and determine the mean distance between the legs.

Radius of curvature " R" of plano-convex surface is given by

$$R = \frac{l^2}{6h} + \frac{h}{2} cm$$

where$l$= distance between two legs of the spherometer, h = thickness of the lens at the centre

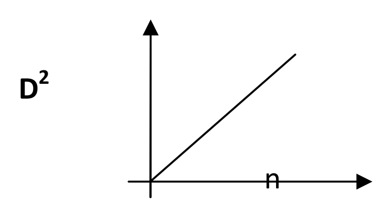
TABLULAR FORM FOR THE DETERMINATION OF DIAMETER OF A RING

S.No	Ring number " n "	Readings of travelling microscope						Diameter of the ring D = $R_L \sim R_R$ cm	D^2
		Left			Right				
		M.S.R " a "	VC x LC " b"	Total reading R_L= a+b	M.S.R " a "	VC x LC " b"	Total reading R_R= a+b		

GRAPH:

Plot a graph by taking ring number on X- axis and corresponding square of the diameter of the ring on Y-axis, we get a graph as a straight line passing through origin as shown in Fig. below.

" R " value can also be found from the graph, by taking the slope of the straight line



PRECAUTIONS:-

1) Glass plates and lens should be cleaned thoroughly.
2) In order to avoid any error due to back-lash of the screw in the travelling microscope, the micrometer screw should be moved only in one direction for the measurement of diameter of rings
3) Crosswire should be focused on a bright ring tangentially.
4) Do the calculation in cgs units only.

RESULT: The radius of curvature of given plano - convex lens was found to be _______ cm

DIFFRACTION GRATING

AIM: -To determine the wavelength of spectral lines of mercury spectrum using diffractiongrating by normal incidence method.

APPARATUS:-Plane transmission grating, mercury vapor lamp, spectrometer, grating stand,spirit level, table lamp and magnifying lens.

PRINCIPLE:- Diffraction phenomenon is the principle of this experiment.

FORMULA:- The wavelength of spectral line is given by

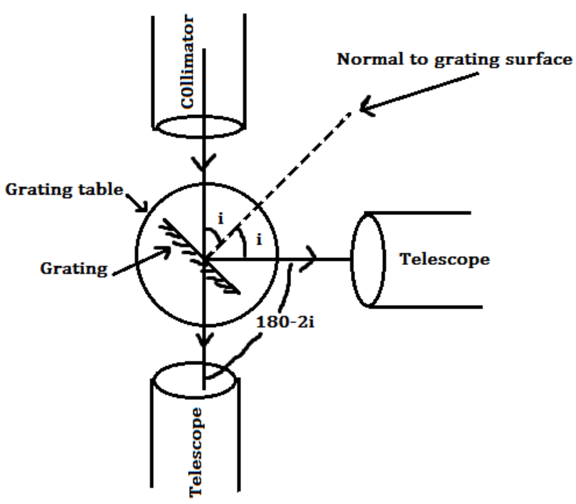
$$\lambda = \frac{Sin\theta}{Nn} A^o$$

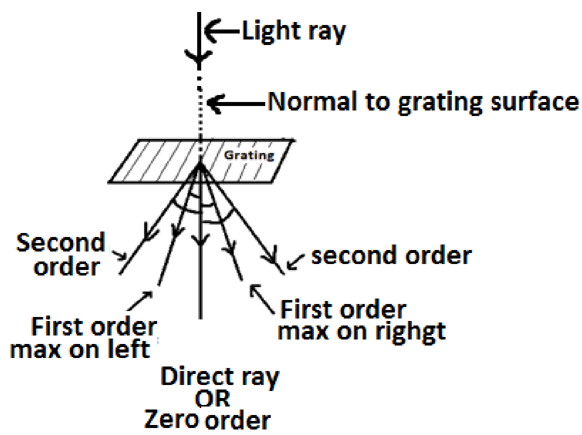
Here "θ" is the angle of diffraction

"N" is number of ruled lines per centimeter on grating surface.

"n" is order of diffraction spectrum.

DIAGRAM:





WORKING:-

Grating refers to an arrangement of set of parallel lines with equal spacing. The opticalplane Diffraction grating that we are using consists of a set of parallel lines (15000 lines per inch) drawn on an optical surface. These ruled lines are opaque to light or acts as obstacle to light propagation, while the spacesbetween them are transparent. When a monochromatic light of wavelength 'λ' is incident normally, thediffracted beams at each ruled line interfere with one another producing diffraction pattern in thefield of view of telescope. Since we are using mercury vapor lamp (polychromatic) in this experiment, the diffraction consists of beautiful VIBGYOR on their either sides of the central maxima. By measuringangle of diffraction, the wavelength of each color can be determined usingthe above expression.

NORMAL INCIDENCE PROCEDURE:-

Normal incidence means the angle of incidence is zero degrees i.e. we have to set both the light ray and normal to the surface are parallel to each other, and this can be done as follows by using spectrometer.

1. Release the locks provided at vernier table and telescope

2. Focus the telescope to a distant object and rotate the Rack& Pinion screw till the image of the distinct object appears clearly.(***NOTE: DO NOT CHANGE THE POSITION OF THE SCREW,TILL THE EXPERIMENT IS OVER.)***

3.Bring the telescope in line with collimator and observe the slit through telescope .If the image of theslit is blurred, then rotate Rack & Pinion of the collimator till slit appears veryclear.***(NOTE: DO NOT CHANGE THE POSITION OF THE SCREW,TILL THE EXPERIMENT ISOVER.)***

4. Coincide the cross wire with slit image and lock the telescope.

5. Set the position of the vernier table at 0° -0° or 0°-180° and lock the vernier table.

6. Release the telescope and rotate it (either left side or right side) through 90° and lockthe telescope.

7. Place the diffraction grating into grating stand and rotate the grating table towards telescope till the reflected image coincides with the vertical cross-wire. (i.e., angle of incidence is 45°.)

8. Release the vernier table and rotate it through 45° towards collimator and lock it.

9. Release the telescope and observe the diffraction pattern on either side of the central maxima.

MEASUREMENT OF WAVELENGTH:

After adjusting for normal incidence the telescope is then rotated towards either left or right side of the central maxima so as to catch first order spectrum. Let us first move the telescope towards left side of the central maxima. Now set the position of the telescope such that the intersection of cross wires coincides with red spectral line and note down the reading in any one of the vernier. (It should be noted that all the readings should be noted from only one vernier i.e., either from vernier-1 or vernier-2. After noting down the reading, the telescope is move towards next spectral line, and note down the reading of that spectral line. Repeat the same process for each spectral line on left side of the central maxima.Now the telescope is moved in the same direction i.e., towards right side of the central maxima such that the cross-wires coincide with violet to red spectral line. (If you begin your experiment by moving telescope to the right side first, then the procedure is repeated by noting the spectral line position from right to left side). The difference between the readings of spectral line on left and right is equal to twice the angle of diffraction (2θ) and wavelength of spectral line is determined after substituting θ in the above mentioned formula.

TABLULAR FORM FOR DETERMINATION OF ANGLE OF DIFFRACTION AND WAVELENGTH:

S.No	Colour of the spectral line	Readings of the telescope								$\theta = \frac{R_L \sim R_R}{2}$	$\lambda = \frac{Sin\theta}{Nn} A^o$
		Left (Degree)				Right (Degree)					
		M.S.R'a'	V.C	VCXLC 'b'	Total reading R_L=a+b	M.S.R 'a'	V.C	VCXLC 'b'	Total reading R_R=a+b		
	Red										
	Orange										
	Yellow										
	Green										
	Blue										
	Violet										

PRECAUTIONS:

1. Always the grating should be held by the edges. The ruled surface should not be touched.
2. Light from the collimator should be uniformly incident on entire surface of the grating.

RESULT:

The wavelength of all spectral lines of mercury spectrum are calculated and compared with standard wavelength and found that they are nearly equal.

DETERMINATION OF LASER WAVELENGTH BY DIFFRACTION GRATING

AIM: To determine wavelength of LASER source by using plane transmission grating.

APPARATUS: Diode LASER, power supply,, plane transmission diffraction grating, scale, screen, graph paper.

FORMULA: The condition for nth order diffraction principle maxima is given by

$$(e + d)sin\theta = n\lambda - - - - - (1)$$

Here (e+d) is width of each slit or grating element, "n" is order of diffraction.

From Fig 1 $\quad Sin\theta_n = \frac{x_n}{\sqrt{x_n^2+D^2}} - - - (2),$

wherex_n *is the distance of* n^{th} *order from zeroth order*

The expression for wavelength of LASER source from the above expression is given by

$$\lambda = \left(\frac{e+d}{n}\right)\left[\frac{x_n}{\sqrt{x_n^2+D^2}}\right] Å$$

"D" is distance between grating and screen

THEORY:

We know that grating refers to a set of parallel lines with equal spacing. When such arrangement was made on a plane glass plate, then it is called optical grating. Each line on the slit is acting as an obstacle to the light propagation and light undergoes diffraction. The plane transmission diffraction grating used in the laboratory is consists of 15,000 lines per inch. Width of each opaque part is'd' and width of each transparent part is 'e'. 'e+d' is called grating element or width of each slit. When LASER light falls on grating surface it is diffracted and diffraction spots were observed on either side of central maxima as shown in Fig. The distance of each order spot from central bright spot must be equal. At one particular distance between grating and screen distance of each 'D' , note down the distance of each spot, on both sides of central maxima. Repeat the same for other distances also.

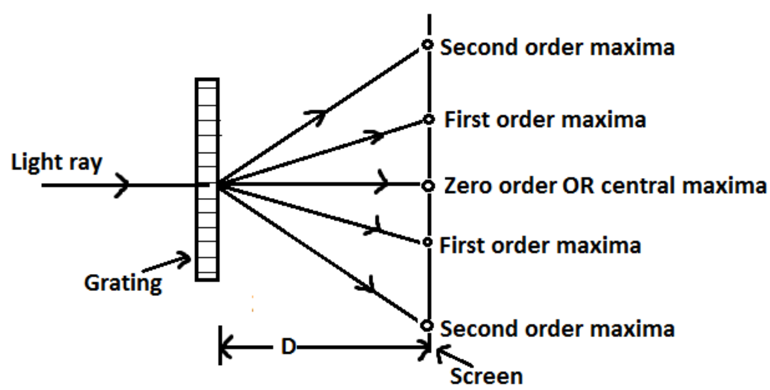


FIGURE 1

TABLE FORM

S.No	Distance between screen & grating (D)	Distance of n^{th} order from central maxima			$\lambda = \left(\frac{e+d}{n}\right)\left[\frac{x_n}{\sqrt{x_n^2+D^2}}\right] Å$
		Left	Right	Mean(X_n)	

PRECAUTIONS

1. Clean the grating surface with soft cloth and do not touch thesurface with fingers till the experiment is over.

2. Mark spots of various orders on graph paper with pencil at the center of that spot.

3. Do not see the LASER light with naked eye, because it cause loss of sensation of vision

RESULT: The wavelength of laser light using plane diffraction grating was found to be____

SOLAR CELL

AIM: To study the characteristics of a photo voltaic cell (Solar cell) and to find Fill factor.

APPARATUS: Solar cell, d.cmilli volt meter, d.c micro ammeter, variable resistance box, 100W Lamp, connecting wires.

PRINCIPLE: This experiment is based on the principle of photo voltaic effect. i.e. When light energy falls on to a open circuited P-N junction, electron- hole pairs are created, and they were separated by junction electric field. These separated charges accumulated on P and N regions and leading to create potential difference across the ends, called Photo – voltaic effect.

FORMULA: Fill factor of a solar cell is given by

$$\text{Fill Factor} = \frac{P_{Max}}{I_{sc}\, X\, V_{oc}} = \frac{V_m\ X\ I_m}{I_{sc}\, X\, V_{oc}}$$

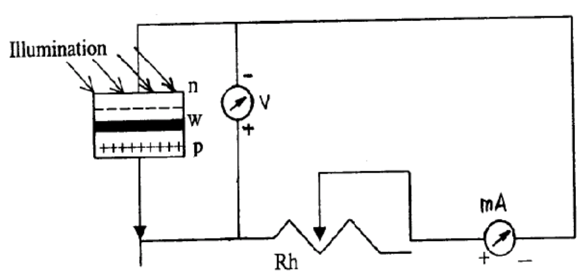
Where I_{sc} = short circuited current (when resistance in the circuit is zero i.e. R=0)

V_{oc} = open circuited voltage (when resistance in the circuit is infinity i.e. R= ∞)

$I_{sc}\, X\, V_{oc}$= is the ideal power or dummy power output, and $V_m\ X\ I_m$ is actual maximum obtainable power

The fill factor is defined as the ratio of the actual maximum obtainable power, to the product of the open circuit voltage and short circuit current. This is a key parameter in evaluating the performance of solar cells. Typical commercial solar cells have a fill factor > 0.70. Grade B cells have a fill factor usually between 0.4 to 0.7. The fill factor is, besides efficiency, one of the most significant parameters for the energy yield of a photovoltaic Cells with a high fill factor have a low equivalent series resistance and a high equivalent shunt resistance, so less of the current produced by light is dissipated in internal losses.

CIRCUIT DIAMGRAM:



THEORY:A solar cell (also called photovoltaic cell or photoelectric cell) is a solid state electrical device that converts the energy of light directly into electricity by the photovoltaic effect. Assemblies of solar cells are used to make solar modules which are used to capture energy from sunlight. When multiple modules are assembled together, the resulting integrated group of modules all oriented in one plane is referred to in the solar industry as a solar panel. The electrical energy generated from solar modules, referred to as solar power, is an example of solar energy. A solar cell is basically a P-N Junction semiconductor diode, usually made from silicon. The thickness of P- region and N-region are kept very small so that electrons and holes generated near the surface can diffuse across the junction before recombination takes place. A heavy doping of p– and n- regions is recommended to obtain a large photo voltage. When light falls on a pn- junction diode, photons collide with valence electrons,

and impart them sufficient energy enabling them to leave their parent atom. Thus electron-hole pairs are generated in both the p- and n- sides of the junction. These electrons and holes reach the depletion region by diffusion and are then separated by the strong barrier field existing there. However, the minority carrier electrons in the p-side slide down the potential barrier to reach the n-side, and holes in the n-side move to the p-side. Their flow continues the minority current, which is directly proportional to the illumination, and also depends on the surface area being exposed to light. The accumulation of electrons and holes on the two sides of the junction give rise to an open circuited voltage V_{oc} , which is a function of illumination. The open circuit voltage for a silicon solar cell is typically 0.6 volt and short circuit current is about 40ma/cm^2.

EXPERIMENTAL PROCEDURE

1.Keep the solar cell in the sun light for 15 to 20 minutes.

2. Adjust the rheostat position for resistance so that the volt meter reads zero. This is the short circuit connection. Note down the value of the current as short circuited current, Isc. Disconnect the rheostat from circuit, then voltmeter shows maximum reading, note down the value of voltage as open circuit voltage (V_{oc})

3. Increase the resistance by varying the rheostat slowly and note down the readings of current and voltage till a maximum voltage is read. Ensure to take at least 15–20 readings in this region.

4. Repeat the experiment for another intensity of the illumination source.

5. Tabulate all readings in Table 1. Calculate the power using the relation, P = V xI.

6. Plot I vs. V with Isc on the current axis at the zero volt position and Voc on the voltage axis at the zero current (see Figure 5.)

7. Identify the maximum power point Pm on each plot. Calculate the series resistance of the solar cell using the formula as follows : RS = [DV/DI].

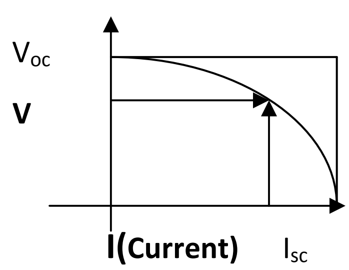
8. To see the performance of the cell calculate fill factor (FT) of the cell, which can be expressed by the formula, FF = [P_{Max}/I_{sc} x V_{oc}].

TABLE FORM FOR MEASUREMENT OF POWER

S.No	**Resistance in ohms (R)**	***Reading of volt meter & ammeter***		**Power =IxV watt**
		Volt meter V (Volt)	**Ammeter I (ma)**	

GRAPH:

Draw a graph by taking current values on X-axis and corresponding voltage values on Y-axis, we get the following nature, as shown in Fig. Also draw two straight lines at V_{oc} and I_{sc}. The area spanned by I_{sc} x $V_{oc}$is the dummy power or ideal power produced from the circuit.



PRECAUTIONS:

1. Expose the solar cell to sun light for few minutes, for attaining stable values of current and voltage
2. A resistance in the cell circuit should be introduced so that the current does not exceed the safe operating limit.

RESULT: The characteristic curve for solar cell was drawn and fill factor was found to be______

FIELD ALONG THE AXIS OF A CUURRENT CARRYING CIRCULAR COIL

AIM : To determine the magnetic field along the axis of a current circular coil, using Stewart-Gees apparatus.

APPARATUS: Stewart-Gees apparatus, D.C. Power supply, magnetometer, commutator, rheostat, ammeter.

Working formula: The magnitude of the field B along with the axis of a coil is given by

$$\boldsymbol{B = \frac{\mu_0 ni\, a^2}{2(x^2 + a^2)^{3/2}}\ Tesla}$$

Where n = number of turns in the coil.

a = radius of the coil

i = current in ampere flowing in the coil

x = distance of the point from the centre of the coil.

μ_0 = permeability of free space

In this experiment, the coil is oriented such that, the plane of the coil is along the magnetic meridian. This can achieved by arranging the plane of the coil parallel to magnetic needle in the magnetometer. When there was no current through the coil, needle in the magnetometer is rest along geographic north and south direction (neglecting angle of declination), due earth's magnetic field. When current is passing through the circular coil, magnetic field is produced along the axis of coil i.e along geographic east and west directions. Now the needle in the magnetometer is under the influence of two magnetic fields,(one is earth's magnetic field acting along north to south & the other is magnetic field produced along east-west direction due to current carrying coil.) acting perpendicular to one another. Due to the influence of above said two fields, needle in the magnetometer is deflected to an angle $\theta$with respect to earth's magnetic field as shown in Fig shown below. According to tangent law, magnetic field along the axis of circular coil is given by $B = B_E Tan\theta$.UsuallyB_E horizontal component of earth's magnetic field (when neglecting angle of declination).

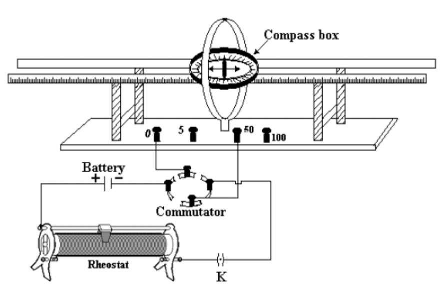
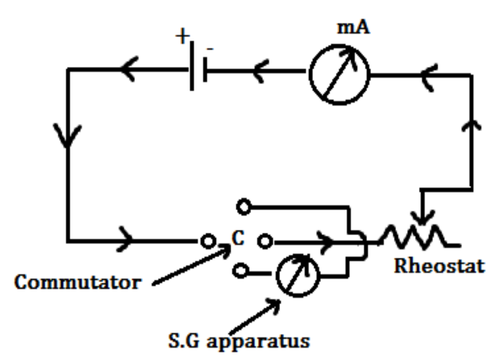


Fig. 1



CIRCUIT DIAGRAM

DESCRIPTION:

The apparatus consists of a circular coil mounted perpendicular to the base as shown in fig. A sliding compass box is mounted on aluminum rails graded with a scale on the rails, so that the compass is always slides on the axis of the coil, and distance from the center of the coil can be measured.

PROCEDURE: -

1. Place the magnetometer compass box on the sliding bench so that its magnetic needle is at the centre of the coil. By rotating the whole apparatus in the horizontal plane, set the coil in the magnetic meridian roughly. In this case the coil, needle and its image all lie in the same vertical plane. Rotate the compass box till the pointer ends read 0 – 0 on the circular scale.

2. To set the coil exactly in the magnetic meridian set up the electrical connections as shown in Fig. Send the current in one direction with the help of commutator and note down thedeflection of the needle. Now reverse the direction of the current and again note down thedeflection. If the deflections are equal then the coil is in magnetic meridian. Otherwise turnthe apparatus a little, adjust pointer ends to read 0 – 0 till these deflections become equal.

3. Using rheostat Rh adjust the current such that the deflection is between $50^0 - 60^0$ degrees is produced in the compass needle placed at the centre of the coil. Read both the ends of the pointer. Reverse the direction of the current and again read both the ends of the mean deflection at x =0.

4. Now shift the compass needle through 5 cm each time along the axis of the coil and for eachposition note down the mean deflection. Continue the process till the compass box reaches the end of the bench.

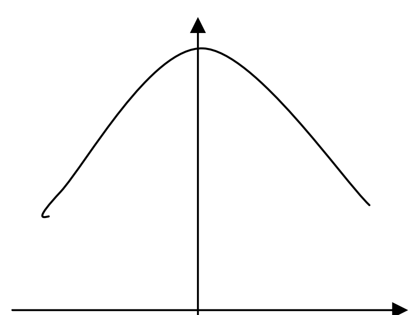
5. Repeat the measurements exactly in the same manner on the otherside of the coil.

6* Keep it mind that same current should flow at all observations. If there is any variation in current due to fluctuation, adjust the rheostat position to get that same value of current.

TABLE FORM FOR THE DETERMINATION OF 'B' VALUES.

S.No	Distance of each point from center of the circular coil (cm) "x"	Deflections in magnetometer										θ=(Average of θ_E to θ_W) (deg)	Tan θ	B = B_H Tan θ Tesla	$B = \frac{\mu_0 n\, i\, a^2}{2(x^2+a^2)^{3/2}}$ Tesla
		East side of the coil (degrees)					West side of the coil (degrees)								
		Direct		Reverse		θ_E=Average of θ_1 to θ_4	Direct		Reverse		θ_W=Average of θ_5 to θ_8				
		θ_1	θ_2	θ_3	θ_4		θ_5	θ_6	θ_7	θ_8					

GRAPH: Plot graph taking "x" along X-axis, and tanθ along Y- axis, and then we get a bell shaped graph as shown in Fig. below. The nature of the graph is symmetrical about Y- axis.



PRECAUTIONS: -

1) The coil should be carefully adjusted in the magnetic meridian.

2) All the magnetic materials and current carrying conductors should be at a considerable distance from the apparatus.

3) The current passed in the coil should be of such a value as to produce a deflection of nearly 50^o -60^o

5) Parallax should be removed while reading the position of the pointer. Both ends of the pointer should be read.

6) The curve should be drawn smooth.

7) The pointer ends should be at zero each time before sending the current through the coil. If they are not at zero, the top of the glass cover should be gently tapped to bring them to zero.

RESULT:

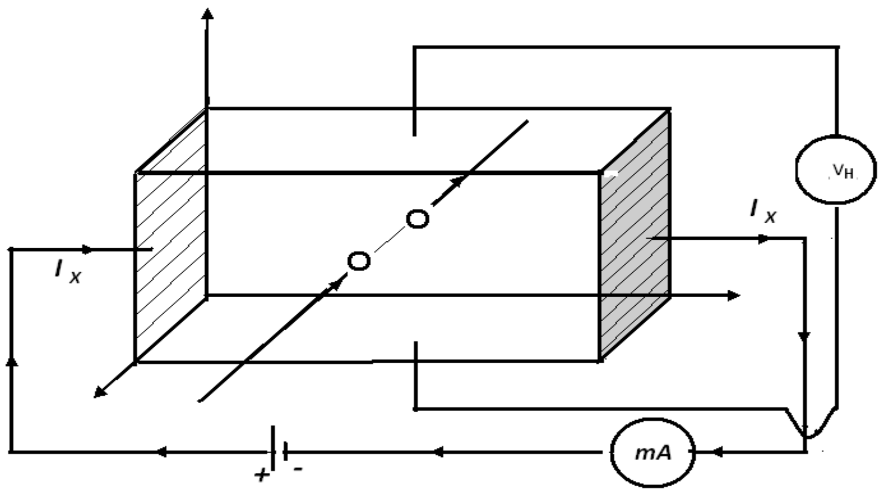
It was observed that magnetic field along the axis of a circular was found to be decreasing with increase of distance from center of circular coil. Also the value of magnetic field from above two formula was found be nearly equal.

HALL EFFECT

Aim: To determine the hall coefficient (k_H), mobility of charge carriers(μ) and concentration of charge carriers(n) in a given material

Apparatus: Hall probe, Hall effect setup for measurement of current and voltage, electro-magnet, constant dc power supply to electro-magnet and Gauss meter.

Hall Effect: When magnetic field is applied perpendicular to a current carrying conductor, then a voltage is developed in a direction both perpendicular to charge flow and applied magnetic field direction ; is known as Hall effect. The developed voltage is known as Hall voltage(v_H).



CIRCUIT DIAGRAM

FORMULA:

$$\textit{Concentration of charged carriers}\ (\text{n}) = \frac{1}{K_H e}\ Per\ m^3$$

Where "e" is the charge of electron, K_H ***is Hall coefficient, and it is given by***

$$K_H = \frac{V_H t}{B_Z I_x}\Omega - \frac{m^3}{Web}\ \&\ it\ can\ be\ measured\ from\ graph\ as$$

$$K_H = \frac{(slope\ of\ V_H Verses\ I_x\ graph)t}{B_Z}$$

Here $t = thickness\ of\ the\ sample = 0.5mm = 0.5x10^{-3}$

$B_Z = applied\ magnetic\ field\ in\ the\ z\ direction$

$V_H = Hall\ voltage$

Mobility of charge carriers (μ)= $K_H\sigma$

where σ = conductivity of sample = 1/ρ

ρ= resistivity of sample, given by

$$\rho = \frac{RA}{l} = \frac{R(bt)}{l} = \text{Rt}\Omega - \text{m}\ (since\ in\ our\ sample\ "l" = "b" = 5mm)$$

$$Resistance\ of\ the\ sample\ "R" = \frac{V_x}{I_x}$$

THEORY:

Let us consider a rectangular plate of a conductor or semiconductor placed with its thickness along z-direction, the length along the x-direction and width along y-direction as shown in the above Figure1. Let a voltage be applied along x-direction such that it produce a current I_x, given by $I_x = J_x A(where\ J_x is\ current\ density \& A\ is\ area\ of\ cross\ section)$.Now let a magnetic field B_Z is applied along Z-direction. The applied magnetic field deflects the charge carriers towards positive Y-direction, and direction of deflection force can be known from Fleming's left hand rule. If the given sample contain both +ve and –ve charges, then both of them will be deflected towards same side, leading to creation of potential difference between top and bottom face of the sample(i.e. along Y-direction), called hall voltage. After creation of potential difference charged particles moving along x- direction do not under go any deviation from magnetic field, and move in straight path. This is because the deflection

force from magnetic field is balanced by force exerted by Hall electric field (i.e., force of repulsion exerted by already settled charges on the top surface of the sample).
At equilibrium the above two mentioned forces are equal.

$$i.e \qquad F_H = F_B$$

$$=> E_H\, e = Bev_d$$

$$E_H = B_Z \left(\frac{J}{ne}\right) (since\, J = nev_d)$$

$$E_H = B_Z \left(\frac{1}{ne}\right) J$$

The term $\frac{1}{ne}$ is is called Hall coefficient denoted by R_H. It is numerically equal to the developed Hall electric field when unit strength current is passing through the sample, in the presence of unit strength of externally applied magnetic field.
We know that the relation between E, V and 'd' is E = V/d

$$=> \frac{1}{ne} = \frac{V_H}{bB_Z J_x}$$

$$=> \frac{1}{ne} = \frac{V_H A}{bB_Z I_x} \left[since\ J = \frac{I}{A}\right]$$

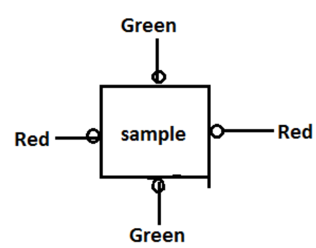
$$=> K_H = \frac{1}{ne} = \frac{V_H bt}{bB_Z I_x} [since\ area\ of\ the\ sample\ A = bt]$$

From the above expression we can calculate density of charged carriers.
We know that conductivity of the sample σ = neμ
Where μ is mobility of charged carrier. It is defined as the drift velocity acquired by charged carrier under the application of unit electric field.

$$=> \mu = \frac{1}{ne} \sigma$$

$$=> \mu = K_H \sigma$$

PRACTICAL:
In the experiment Hall probe consists of a semiconductor sample in square shape having four pressure contacts as shown in fig. The two opposite ends are connected by a same color wire.



1.For the measurement of resistivity of sample connect one red and one green wire to current terminals, and other two wires connected to voltage terminals of Hall effect setup. Measure the voltage (V_x) for each current value and tabulate them.
2.Connect one set of same colour wires to current terminals and other set of colour wires to voltage terminals of Hall effect setup. Measure the error voltage (i.e., voltage in the absence of magnetic field) at different values of current passing through the sample. Measure the transverse voltage or Hall voltage in the presence of magnetic field for the same values of current passing through the sample, for the measurement of error voltage. The difference in the two voltages is the correct Hall voltage.

Table – I:FOR THE MEASUREMENT OF RESISTIVITY

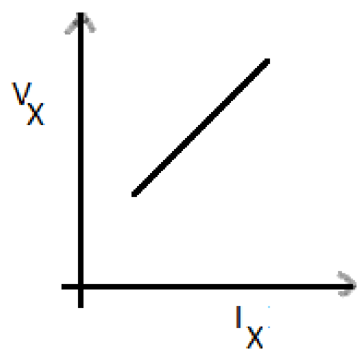
S.No.	Current I_x (mA)	Voltage V_x (mV)

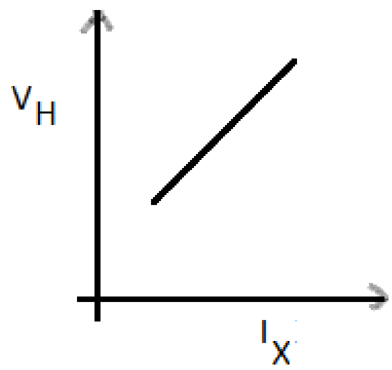
Table – II: FOR THE MEASUREMENT OF HALL VOLTAGE.

S.No.	Current I_x	Transverse voltage(OR)HALL VOLTAGE		True Transversevoltage (OR) True Hall voltage V_y= b-a (mv)
		With out magnetic field 'a'	With magnetic field 'b'	

Model graph:

(1) Plot the graph between I_x on x-axis, V_x on y-axis, we get a straight line.
(2) Plot the graph between I_x on x-axis, V_H on y-axis we get a straight line.





CALCULATION PART:

(1). Find the slope of straight line in the graph (i.e., I_x V_s V_x) and it is equal to resistance

(R) of the sample.

(2). We know that Resistivity $\boldsymbol{\rho} = \frac{RA}{l} = \frac{Rbt}{l} = Rt[since\ l = b]\ \Omega - m$

(3). Conductivity $\boldsymbol{\sigma} = \frac{1}{\rho}\ \Omega - m^{-1}$

(4). Find the slope of $I_x VsV_x$graph, put this value in K_H expression.

(5).$K_{H=}\frac{V_H t}{I_x B_z} = (slope\ of\ I_x V_s V_H)\frac{t}{B_z}$**Ω-m³/Web**

$$(6).\ Concentration\ of\ charged\ carriers(n) = \frac{1}{K_H e}/m^3\ (\text{Since } k_H = \frac{1}{ne})$$

(7). $Mobility\ of\ charged\ carrier(\mu) = K_H\sigma\quad m^2/volt - sec$

Sample dimensions are l =   mm, b = 5mm = 5X10⁻³m, t =0.5mm = 0.5X10⁻³m

PRECAUTIONS:

1 Increase slowly the current through electromagnet from power supply (max up to 2A).

2 Before to switch off power supply, reduce current to zero and the switch off.

3 Keep the probe in the Gauss meter at the center of pole pieces and rotate at till it shows maximum reading for the measurement of magnetic field.

RESULT:

1.$Hall - coefficient\ K_{H=} - - - - - - - \Omega - m^3/Web$

2.$Conductivity\ of\ the\ sample\ \sigma = \frac{1}{\rho} - - - - - - - \Omega - m^{-1}$

3.$Concentration\ of\ charged\ carriers\ 'n' - - - - - - - - - Per\ m^3$

4.$Mobility\ of\ charged\ carrier(\mu) = K_H\sigma = - - - - - -\quad m^2/volt - sec$

RESONANCE IN LCR CIRCUIT

AIM: To study resonance effect in series LCR circuit and quality factor.

APPARATUS: A signal generator, inductor, capacitor, ammeter, resistors, AC milli voltmeter.

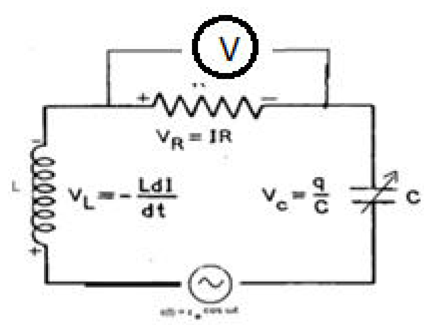
BASIC METHODOLOGY:

In the series LCR circuit, an inductor (L), capacitor (C) and resistance(R) are connected in series with a variable frequency sinusoidal emf source and the voltage across the resistance is measured. As the frequency is varied, the current in the circuit (and hence the voltage across R) becomes maximum at the resonance frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$. In the parallel LCR circuit there is a minimum of the current at the resonance frequency.

THEORY:-

Circuits containing an inductor L, a capacitor C, and a resistor R, have special characteristics useful in many applications. Their frequency characteristics (impedance, voltage, or current vs. frequency) have a sharp maximum or minimum at certain frequencies. These circuits can hence be used for selecting or rejecting specific frequencies and are also called tuning circuits. These circuits are therefore very important in the operation of television receivers, radio receivers, and transmitters. In this section, we will present two types of LCR circuits, viz., series and parallel, and also discuss the formulae applicable for typical resonant circuits. A series LCR circuit includes a series combination of an inductor, resistor and capacitor whereas; a parallel LCR circuit contains a parallel combination of inductor and capacitor with the resistance placed in series with the inductor. Both series and parallel resonant circuits may be found in radio receivers and transmitters.

SERIES RESONANCE CIRCUIT:-



When an alternating e.m.f$E = E_0 sin\omega t0$ was applied to circuit having an inductance L,capacitance C and resistance R in series as shown in fig. The current in the circuit atany instant of time t isgiven by the following equation

$$I = I_0 Sin(\omega t - \varphi)$$

Where it can also be proved that the maximum current I_0 is

$$\boldsymbol{I_0} = \frac{\mathbf{E_0}}{\sqrt{\mathbf{R}^2 + \left(\boldsymbol{\omega}\mathbf{L} - \frac{\mathbf{1}}{\boldsymbol{\omega}\mathbf{C}}\right)}} - - - - - (\mathbf{1})$$

From the above expression(1)the impedance of circuit is given by is

$$Z = \sqrt{\mathbf{R}^2 + \left(\boldsymbol{\omega}\mathbf{L} - \frac{\mathbf{1}}{\boldsymbol{\omega}\mathbf{C}}\right)}$$

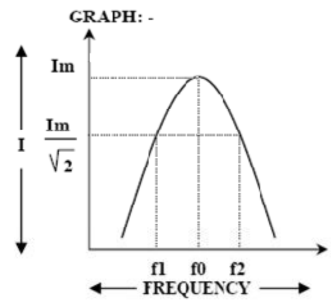
The L - C - R series circuit has a very large capacitive reactance $(\frac{\mathbf{1}}{\boldsymbol{\omega}\mathbf{C}})$ at low frequencies and a very large inductance reactance $(\boldsymbol{\omega}\mathbf{L})$ at high frequencies. So at a particular frequency, the total reactance in the circuit is zero $(\boldsymbol{\omega}\mathbf{L} = \frac{\mathbf{1}}{\boldsymbol{\omega}\mathbf{C}})$. Under this situation, the resultant impedance of the circuit is minimum. The particular frequency of A.C at which impedance of a series L - C - R circuit becomes minimum is called the resonant frequency and the circuit is called as series resonant circuit.

At resonance frequency $\boldsymbol{\omega}\mathbf{L} = \frac{\mathbf{1}}{\boldsymbol{\omega}\mathbf{c}}$

$$=> \omega = \frac{1}{\sqrt{LC}}$$

$$=> f_0 = \frac{1}{2\pi\sqrt{LC}} \quad (since\ \omega = 2\pi f)$$

The above equation shows that the resonant frequency depends on the product of L and C and does not depend on R. The variation of the peak value of current with the frequency of the applied e.m.f is shown in Fig.



Let f_1 and f_2 be these limiting values of frequency. Then the width of the band is

$$BW = f_2 - f_1$$

The quality factor is defined as $\boldsymbol{Q} = \frac{\textbf{Resonant frequency}}{\textbf{Band width}} = \frac{f_0}{f_2 - f_1}$

Q-factor is also defined in terms of reactance and resistance of the circuit at resonance,

$$\boldsymbol{Q} = \frac{\boldsymbol{\omega L}}{\boldsymbol{R}}$$

PROCEDURE:

1. The series and parallel LCR circuits are to be connected as shown in fig 1 & fig 2.
2. Set the inductance of the variable inductance value and the capacitances the variable capacitor to low values (L ~ 0.01H , C ~ 0.1 μ F) so that the resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$ is of order of a few kHz .
3. Choose the scale of the AC milli voltmeter so that the expected resonance occurs at approximately the middle of the scale.
4. Vary the frequency of the oscillator and record the voltage across the resistor.
5. Repeat (for both series and parallel LCR circuits) fir three values of the resistor (say R = 100, 200 &300 Ω).

TABLE FORM

L = ____________________________ mH C = ____________________________ μF.

S.No	Applied frequency f Hz	Voltage across resistor (R)		
		R=	R=	R=

RESULT :

Estimated value of Q for series resonance from graph :

Resonance frequency for series LCR circuit =______________kHz

FORBIDDEN ENRGY GAP OF MATERIAL OF A PN-JUNCTION SEMICONDUCTOR DIODE

AIM: To determine the energy gap of material of PN junction diode by connecting in reverse bias

Apparatus : Electric heater Transformer oil Ge/Si diode DC Power supply, micro ammeter, voltmeter, thermometer & retard stand.

FORMULA: When PN-Junction diode is reverse biased using a voltage source, the relation between the diode current and (I) and the voltage is given by

$$\boldsymbol{I = I_s\left[e^{qV/kT} - 1\right]} \quad \text{----------------------------(1)}$$

Where I_S is called reverse current or reverse saturation current

q is electronic charge e =$1.6\text{x}10^{-19}$ Coulomb

k is Boltzman constant = 1.38x10-23J/K

T is temperature in degree Kelvin.

The saturation current(I_S) is a function of diffusion length, electron diffusion co-efficient as well as concentration of electrons and holes present is given by

$$\boldsymbol{I_s = A\left(e^{-E_G/2kT}\right)} \quad \text{--------------------------(2)}$$

Where "A" is constant and $\boldsymbol{E_G}$ **is** energy gap of the semiconductor material used for preparation of PN –Junction diode.

Apply ting logarithm on both sides of the above equation, we get,

$$log_e I_s = log_e A - \left[\frac{E_G}{2K}\right]\frac{1}{T}$$

$$log_{10} I_s = \left[\frac{-E_G}{(4.606)K}\right]\frac{1}{T} + log_{10}A \quad \left[\begin{matrix} since\ log_e I_s = 2.303\ log_{10} I_s\ and \\ log_e A = 2.303 log_{10} A \end{matrix}\right]$$

When a graph is drawn between $log_{10} I_s$ on y-axis and $\frac{1}{T}$x10^3 on x-axis we get a straight line having a negative slope as show in Fig. The slope of the graph is given by

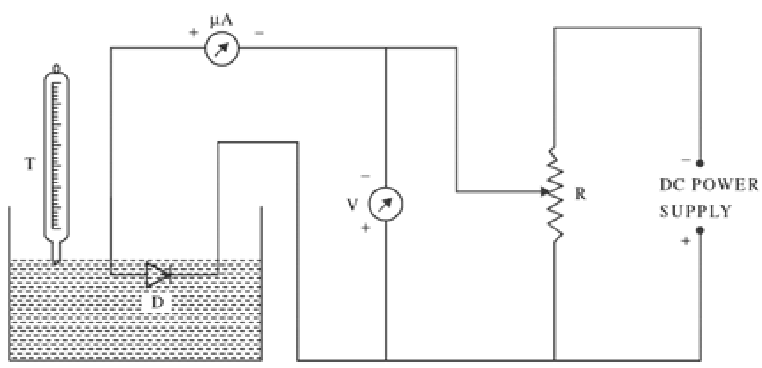
$$\text{m} = \frac{E_G}{(4.606)K}$$

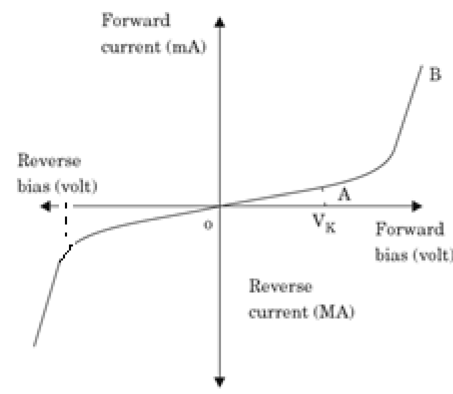
Energy gap of the semiconductor material can be determined by substituting the Boltzmann constant "k"=$8.62\text{x}10^{-5}$ eV/K in the above expression for slope, we get

$$E_G = slope\ x\ (4.606)k \quad eV$$

Introduction:

We come across the word saturation in physics in lower classes while dealing with solutions A "solvent" forms "solution" for example sugar dissolved in water forms sugar solution This solution is said to be saturated when no more amount of solute can be dissolved in the available solvent. similarly if a parameter say current reaches a steady (constant) value such that any furthers increase in voltage, does not alter the magnitude of current, then such current is called saturation current. If it is so, then why do we add another word reverse and coin the term Reverse saturation current?. To get the answer for this question we have to recollect the V-I characteristics of a PN-junction diode. The V-I characteristics of a pn-junction diode is shown in Fig. below. The curves in the first and third quadrants represent the forward and reverse bias characteristics of a PN-Junction diode. Restricting ourselves to the third quadrant, it can be observed that, with the increase in reverse bias voltage(V_R), there is a sharp rise in current(I_R),initially. Then with the further increase in the voltage, current gradually approaches a steady value. This current is what we have earlier defined as saturation current. As we observe this saturation current in the reverse characteristics of the PN-Junction diode, we call it reverse saturation current. In reverse biased PN-Junction diode, the width of depletion region increases, such that the majority charge carriers are not are not allowed to pass through the junction. Hence in an ideal diode, current is zero in the case of reverse bias. But when we consider practical diode, there is always some amount of current even in the case of reverse bias, called leakage current. This leakage current exist due to minority carriers. The rate of generation of minority carriers depends upon temperature. If the temperature is fixed, the rate of generation of minority carriers remains constant. Therefore the current due to the flow of minority carriers remains the same, whether the battery voltage is low or high. In fact as soon as minority carrier is generated, it is swept or drifted across the junction because of barrier potential. Beyond the voltage V_R , the abnormal rise in reverse current is due to breaking of large number of covalent bonds, leads to very large change in current for a small change in voltage, called avalanche breakdown.





Procedure: 1. Wire the connections as per the circuit diagram.

2. Insert the thermometer into the opening of Bekelite cap.

3. Now switch on the oven and allow the oven temperature to rise upto 75° C. As the temperature reaches to this value switch off the oven. The temperature will further rise up to 85C to 90C.

4. Now vary basing voltage insteps of 0.1 volt and note the corresponding current. The constant current is the saturation current(I_S). at that temperature.

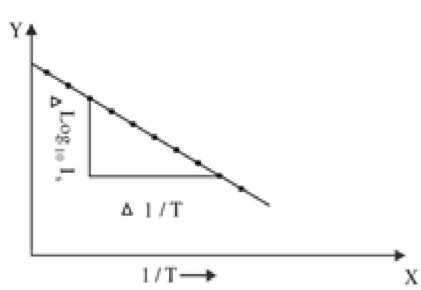
5. After some time the temperature will begin to fall. Now fix the voltage at 5volts.

6 . Take current in μA and temperature reading in Kelvin in steps of 5μA fall in current.

TABLE FOR OBSERVATIONS

S.NO.	CURRENT I_s IN μA	TEMPERATURE IN C	TEMPERATURE IN K	$log_{10} I_s$

MODEL GRAPH: A graph is drawn between $log_{10} I_s$ on y-axis and $\frac{1}{T}$ x10^3 on x-axis we get a straight line as show in Fig. and measure the slope of the graph.



Result: Energy gap of the semiconductor diode is determined both during heating and during cooling is given by

$$E_G = \qquad eV$$

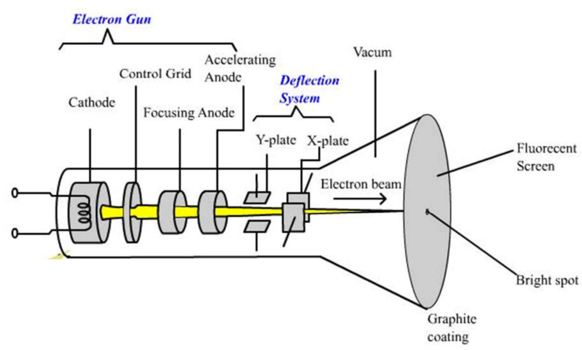
CATHODE RAY OSCILLOSCOPE

AIM:- To study the different waveforms, to measure peak and rms voltages and thefrequency of A.C.

APPARATUS:- A C.R.O and a signal generator.

BLOCK DIAGRAM OF CRO: The various main parts of CRO are shown in Fig. below

Cathode Ray Oscilloscope



THEORY :-

Cathode ray oscilloscope is one of the most useful electronic equipment, which gives a visual representation of electrical quantities, such as voltage and current waveforms in an electrical circuit. It utilizes the properties of cathode rays of being deflected by an electric and magnetic fields and of producing scintillations on a fluorescent screen. Since the inertia of cathode rays is very small, they are able to follow the alterations of very high frequency fields and thus electron beam serves as a practically inertia less pointer. When a varying potential difference is established across two plates between which the beam is passing, it is deflected and moves in accordance with the variation of potential difference. When this electron beam impinges upon a fluorescent screen, a bright luminous spot is produced there which shows and follows faithfully the variation of potential difference. When an AC voltage is applied to Y-plates, the spot of light moves on the screen vertically up and down in straight line. This line does not reveal the nature of applied voltage waveform. Thus to obtain the actual waveform, a time-base circuit is necessary. A time-base circuit is a circuit which generates a saw-tooth waveform. It causes the spot to move in the horizontal and vertical direction linearly with time. When the vertical motion of the spot produced by the Y-plates due to alternating voltage, is superimposed over the horizontal sweep produced by X-plates, the actual waveform is traced on the screen.

PROCEDURE:-

STUDY OF WAVEFORMS:

To study the waveforms of an A.C voltage, it is ledto the y – plates and the time base voltage is given to the X-plates. The size of the figure displayed on the screen, can be adjusted suitably by adjusting the gain controls. The time base frequency can be changed, so as to accommodate one, two or more cycles of the signal. There is a provision in C.R.O to obtain a sine wave or a square wave or a triangular wave.

MEASUREMENT OF D.C.VOLTAGE : -

Deflection on a CRO screen is directly proportional to the voltage applied to the deflecting plates. Therefore, if the screen is first calibrated in terms of known voltage.i.e. the deflection sensitivity is determined , the direct voltage can be measured by applying it between a pair of deflecting plates. The amount of deflection so produced multiplied by the deflection sensitivity, gives the value of direct voltage.

MEASUREMENT OF A.C VOLTAGE : -

To measure the alternating voltage of sinusoidal waveform, The A.C. signal, from the signal generator, is applied across the y – plates. The voltage(deflection) sensitivity band switch (Y-plates) and time base band switch (X-plates) are adjusted such that a steady picture of the waveform is obtained on the screen. The vertical height (l) i.e. peak-to-peak height is measured. When this peak-to-peak height (l) is multiplied by the voltage(deflection) sensitivity (n) i.e. volt/div, we get the peak-to-peak voltage (2Vo). From this we get the peak voltage (Vo). The rms voltage V_{rms} is equal to Vo/ 2 . This rms voltage Vrms is verified with rms voltage value, measured by the multi-meter.

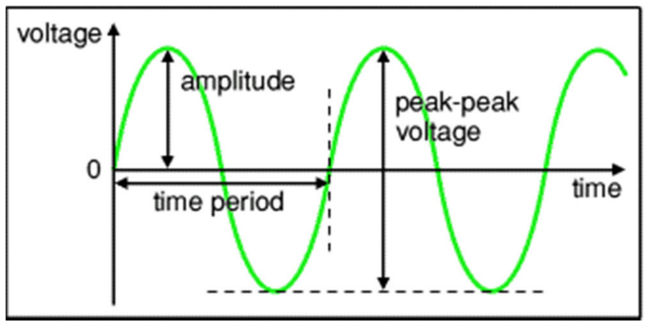


TABLE-1 FOR VOLTAGE COMPARISION

S.No	Applied voltage 'A' Volts	Height of the signal (or) Number of divisions 'x'	Volt/Div (y)	Observed voltage B = xy Volts	difference in volts A~B Volt

MEASUREMENT OF FREQUENCY : -

An unknown frequency source (signal generator) is connected to y- plates of C.R.O . Time base signal is connected to x – plates (internally connected) . We get a sinusoidal wave on the screen, after the adjustment of voltage sensitivity band switch (Y-plates) and time base band switch (X-plates). The horizontal length(l) between two successive peaks is noted. When this horizontal length (l) is multiplied by the time base(m) i.e. sec/div , we get the time-period(T).The reciprocal of the time-period(1/T) gives the frequency(f). This can be verified with the frequency, measured by the multi-meter.

TABLE -2 FOR FREQUENCY COMPARISION:

S.No	Applied frequency A Hz	Width of the signal 'x'	Time/Div 'y'	Time period T = xy sec.	Observed frequency B = 1/T	Difference in frequency A~B Hz

PRECAUTIONS :-

1) The continuity of the connecting wires should be tested first.

2) The frequency of the signal generator should be varied such that steady wave form isformed.

3. An oscilloscope should be handled gently to protect its fragile (and expensive) vacuum tube.

4. Oscilloscopes use high voltages to create the electron beam and these remain for some time after switch-off. For your own safety do not attempt to examine the inside of an oscilloscope.

RESULTS : - The voltage, and frequency of given ac signal were measured & compared, and they were found nearly equal.