BOOKLET

FOR

ENGINEERING PHYSICS LAB.

PHY – 119

B.TECH 1st & 2nd SEMESTER

DEPARTMENT OF PHYSICS

LOVELY PROFESSIONAL UNIVERSITY PHAGWARA

(PUNJAB)

Safety Precautions for Physics Lab

1) Handle the each equipment carefully.

2) Do not operate any equipment in the absence of lab in-charge.

3) After making the connection ask the in-charge to check the connections then perform the experiment.

4) Thermometer must be handled carefully.

5) Diffraction grating and prism must be handled carefully.

6) Clean the lenses of the spectrometer before use.

7) After the completion of experiments switch off the instruments.

8) Don’t touch the main power lead with bare hand avoid body earth.

9) In case of overheating/excessive current flow in any circuit, switch off the power supply immediately.

10) Don’t allow any instrument to overshoot its scale.

Experiment No.1

AIM:- To find the refractive index of a prism using spectrometer.

Equipment required: Sodium light, Spectrometer, Prism, Spirit level, Magnifying Lens and Torch

Leaning Objective:

1. Students will know about the setting of spectrometer
2. Students will be able to find out angle of prism and angle of minimum deviation.
3. Students will learn to calculate the refractive index.

Theory and formula used:

When a ray of light passes through a prism it suffers refraction as shown in Fig. 1.1. If EF is the incident ray, FG the refracted ray and GH the emergent ray, then the angle IDH is the angle of deviation. It is the angle between the direction of the incident ray and the emergent ray. The angle of deviation depends upon the angle of incident. For a certain value of the angle of incidence the angle of deviation is minimum. If D_m denotes the angle of minimum deviation for the prism of angle A, then the refractive index is given by, $\mu = \sin(A+D_m)/\sin(A/2)$.

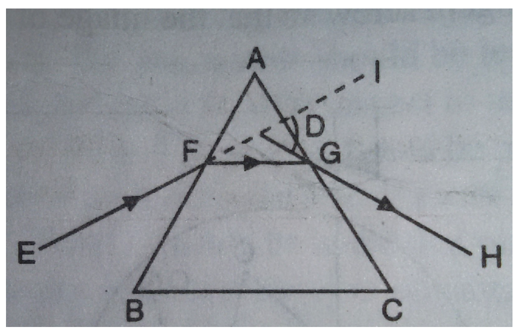
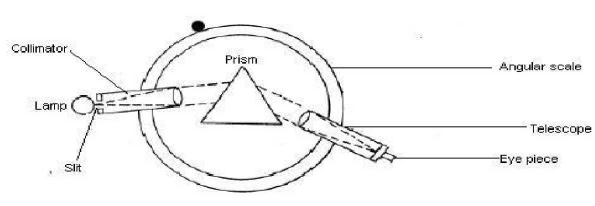


Fig. 1.1: Minimum angle of deviation

Procedure: (1) First the telescope has to be focused distant objects i.e. infinity and this has to be maintained until the experiment is over, so as not to refocus again. Then, the cross-wires should be focused by moving the eye-piece of the telescope.

(2) Adjust the collimator such that the image seen in the telescope is sharp of the slit without the prism.



Prism Spectrometer

Fig 1.2: Experimental setup

(3) **Measuring the Angle of Prism A:** Place the prism on the Prism Table and lock the prism table in the position so the incident beam falls on one of the edges of the prism. Now, move the telescope and locate the images of the slit and note down the angles. The difference between both the angles is 2A. Hence, half of the difference will give us A.

(4) Place the prism with the centre coinciding with the centre of the prism table and set it approximately in the position of minimum deviation, so that light falls on the face AB and emerges out from the face AC as shown in Fig. 1.3.

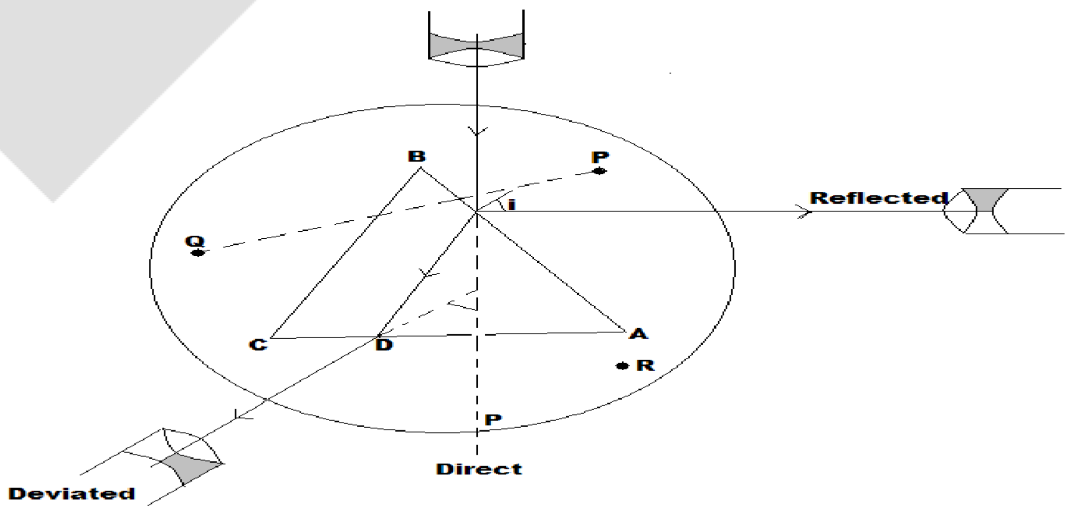


Fig 1.3: Set up for minimum deviation

(5) Turn the telescope to receive the emergent light and adjust its position so that the image of the slit is formed on the cross-wire. Clamp the telescope and note its reading on both verniers V1 and V2

(6) Now turn the telescope to receive the reflected light from the face AB as shown in fig. 1.3. Adjust the position of telescope till the image of the slit falls on the vertical cross-wire. Clamp it and note the reading on both the verniers.

(7) Bring the telescope back to receive the deviated ray. Turn the prism table without disturbing the circular scale in the clockwise direction so that the deviated ray is displaced by about one degree. Adjust the telescope so that the image is formed on vertical cross-wire again. Note the reading on both the vernier scales.

(8) Turn the telescope again to receive the reflected light from the face AB. Make the necessary adjustments and note the reading on both the vernier scales.

(9) Turn the table in clockwise direction again and take three or four observations as explained.

(10) Rotate the prism table back to its starting position so that the prism is again in the minimum deviation position approximately.

(11) Remove the prism and turn the telescope so that the direct light is received and the image of slit falls on the vertical cross wire. Note the reading of both the verniers.

Plots and parameters:

D_m: Angle of minimum deviation

μ: Refractive index

A=Angle of prism

Precautions:

- It must be ensured that the light rays coming out of collimator are parallel.
  Hence, the collimator must be focused properly before the experiment.
- The plane on which the prism rests must be horizontal
- The slit must be as thin as possible in order to avoid diffraction.

Book suggested

1. B.Sc. Practical Physics by C.L. Arora S. Chand Publication, 20th edition (2015).

2. B.Sc. Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011).

Worksheet of the student

AIM: To find the refractive index of a prism using spectrometer.

Observation:

Vernier constant:

Observation table for Angle of prism

Vernier1					Veriner2			
S.No.	Telescope Reading		Difference(Θ)	A=Θ/2	Telescope Reading		Difference(Θ)	A=Θ/2

Mean A=

Angle of minimum deviation

Vernier1				Veriner2		
S.No.	Telescope Reading		Difference(D_m)	Telescope Reading		Difference(D_m)
	Min. Dev.	Direct		Min. Dev.	Direct	

Mean D_m=

Calculation:

Refractive index $\mu = \sin[(A+D_m)/2]/\sin(A/2)$

Error Analysis:

Result and discussion

Learning Outcomes (what I have learnt):

To be filled by the faculty:

S. No.	Parameters	Marks obtained	Max. Marks
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion of experiment, discipline and cleanliness		10

	Signature of Faculty	Total marks obtained	

Experiment No.2

Aim: To find the wavelength of sodium light by measuring the diameter of Newton Rings

Equipment to be used: A travelling microscope, a sodium lamp, Newton's rings apparatus consisting of an optically plane glass plate and a convex lens placed in a box having an optically plane glass plate inclined at an optically plane glass plate inclined at an angle of 45°, a spherometer, a convex lens of short focal length etc.

Learning Objectives:

1. Students will learn about circular interference fringes.
2. Students will develop the understanding of phase change at reflection.
3. Students will understand the concept of thin films.
4. Students will understand the principles of reading microscope structure

Theory and formula used: Circular interference fringes produces by enclosing a thin film of varying thickness between the surface of a convex lens of large radius of curvature and a plane glass plate. These circular fringes are known as Newton's rings.

The wavelength of the monochromatic light which produces these rings is given by

$$\lambda = D^2_m - D^2_n / 4(n-m)R$$

Diagram:

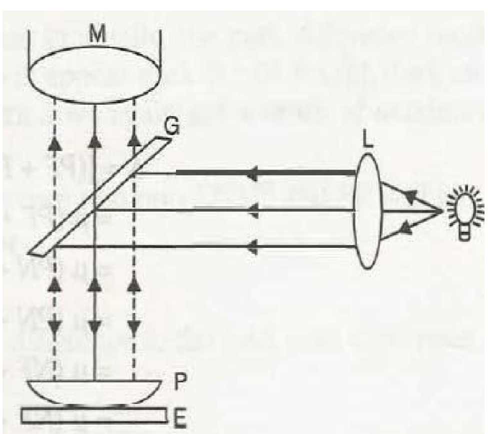


Fig. 2.1: Newton ring set up

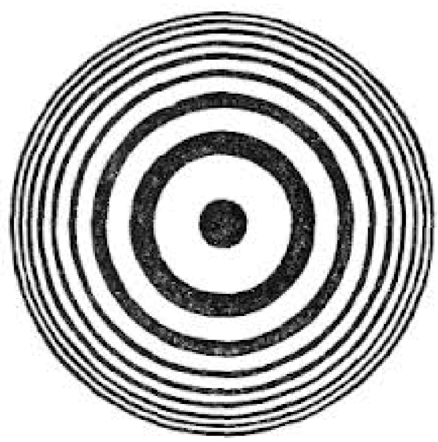


Fig. 2.2: Interference pattern (Newton Ring)

Procedure:

1. Level the microscope table and set the microscope tube in a vertical position. Find the vernier constant of the horizontal scale.

2. Clean the surface of the glass plate P, the lens N and the glass plate G. Place them in position as shown in Fig.2.1. Place the arrangement in front of a sodium lamp so that the height of the centre of the glass plate G is the same as that of the centre of the sodium lamp. Place the convex lens in between and adjust its position so that a parallel beam of light is made to fall on the glass plate G inclined at an angle of 45°.

3. Adjust the position of the microscope so that it lies vertically above the centre of the lens N. Focus the microscope, so that alternate dark and bright rings are clearly visible (see Fig. 2.2)

4. Adjust the position of the microscope till the point of inter-section of the cross- wires coincides with the centre of the ring system and one of the cross-wires is perpendicular to the horizontal scale.

5. To measure the diameter of the ring move the microscope to the left side so that cross wire coincides with ring and note the reading of microscope. Now move the microscope to the right side and note the reading of microscope for the same ring.

6. Remove the lens and find the radius of curvature of the surface of the lens in contact with the glass plate P accurately.

Calculation:

Vernier constant = ………. Radius of Curvature =………

Formula used

Wavelength of sodium light is given by

$$\lambda = D^2_m - D^2_n / 4(n-m)R$$

Precautions:

1. The lens and the glass plate should be cleaned.
2. A lens of large radius of curvature (preferably plano-convex) should be used.
3. The point of intersection of the cross-wires should coincide with the centre of the interference ring.
4. The radius of curvature of the surface of the lens in contact with the glass plate should be measured accurately.
5. The amount of light from the source should be adjusted for maximum visibility. Too much light increases the general illumination and decreases the contrast between bright and dark fringes.

Book suggested

1. B.Sc. Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).

2. B.Sc. Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011).

Worksheet of the student

AIM: To find the wavelength of sodium light by measuring the diameter of Newton Rings

Observations:

Least count of Travelling Microscope:

Ring No.	**Microscope Reading**		**Diameter**	**Microscope Reading**		**Diameter**	**Mean Diameter**
	Left	**Right**		**Up**	**Down**		

Calculation:

$$\lambda = D^2_m - D^2_n / 4(n-m)R$$

Result and discussion:

Error Analysis:

Learning Outcomes (what I have learnt):

To be filled by the faculty:

S. No.	**Parameters**	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20

3	Completion of experiment, discipline and cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.3

Aim: To investigate the intensity of light coming through two crossed polaroids and to verify the Malus' law.

Equipment to be used: Semiconductor laser, polarizer, analyzer, detector, ammeter, optical bench.

Theory and formula used: Malus cosine-squared law states that the intensity of a beam of plane-polarized light after passing through a rotatable polarizer varies as the square of the cosine of the angle through which the polarizer is rotated from the position that gives maximum intensity. Malus' law, $I = I_0 \cos^2\theta$.

Learning Objectives:

1. Students will understand the concept of polarization of light.
2. Students will learn about the position of the axis of the analyzer (θ) with respect to the axis of polarizer and the polarization intensity (I).
3. Students will verify the Malus' law, $I = I_0 \cos^2\theta$.

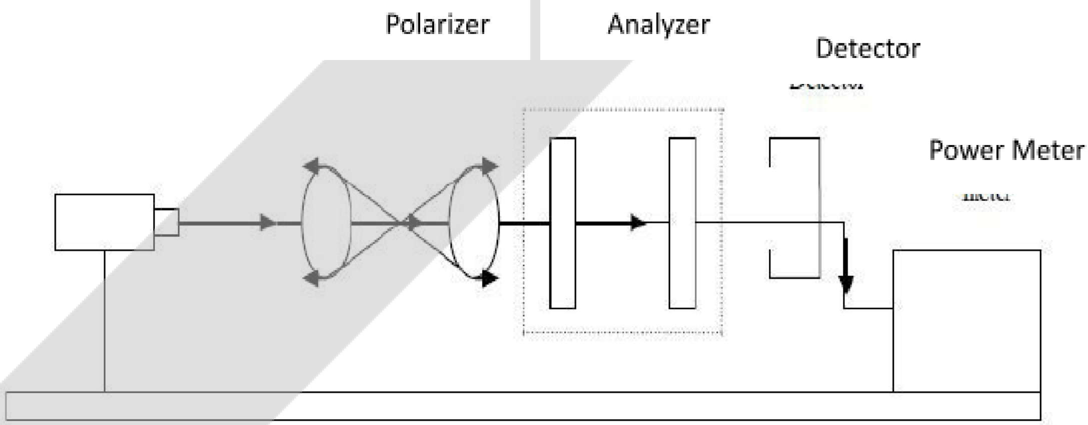


Fig 3.1 Analysis of polarized light

Procedure:

1. Place polarizer, analyzer and laser source on optical bench and verify the alignment of detector with laser beam.
2. Adjust polarizer and analyzer to get maximum value of current on ammeter. Rotate analyzer at an angle of 10^0 and note down the corresponding value of current in the ammeter.
3. Note the value of current from 0^0 to 360^0 by rotating analyzer and calculate theoretical value of intensity.

Observations: Intensity of laser light is proportional to current in ammeter i.e., maximum intensity I_0 =

Table 3.1: Variation of Intensity with Analyzer angle

Sr. No.	Analyzer Rotation, θ (degree)	Ammeter Reading (I_p)	Experimental relative intensity I_p/I_0	Theoretical relative intensity I_{th}/I_0

CALCULATIONS:

Plots & Parameters:

The validity of Malus law can be verified by plotting a graph between θ vs I_p/I_0 and θ vs I_{th}/I_0. For comparison, both the curves must be on the same graph paper.

Precautions:

1. Laser beam should be incident along the axis of polaroid.
2. Good quality laser beam should be used.
3. Power supply should be continuous.
4. There should be dark room for this experiment.
5. No obstacle should lie in the path of beam

Book suggested

1. B.Sc. Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.Sc. Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

Worksheet of the student

Aim: To investigate the intensity of light coming through two crossed polaroid's and to verify the Malus law.

Observations:

Sr.No.	Analyzer Rotation, θ (degree)	Ammeter Reading (I_p)	Experimental relative intensity I_p/I_0	Theoretical relative intensity I_{th}/I_0

Calculation:

Error Analysis:

Learning Outcomes (what I have learnt):

To be filled by the faculty:

Sr.No.	Parameters	Marks obtained	Max. Marks
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion of experiment, discipline and cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.4

Aim: To verify the expression for the resolving power of a telescope (circular aperture)

Equipment to be used: A telescope, sodium light, double slit, variable rectangular slit, Travelling microscope and measuring tape

Learning objectives:

1. Students will learn about the resolving power
2. Students become familiar with the various parameters affecting the resolving power

Theory and Formula Used:

The theoretical and practical resolving powers are given by

Practical resolving power = D/d and

Theoretical resolving power = a /λ

Where λ = mean wavelength of light employed,

a = width of the rectangular slit for just resolution of two objects,

d = separation between two object and

D = distance of the objects from the objective of the telescope.

Hence a /λ = D/d

Rayleigh's criterion of resolution: According to Rayleigh's criterion, two equally bright sources can be just resolved by any optical system when the distance between them is such that in the diffraction pattern, the maximum due to one bright source falls on the minimum due to the other source.

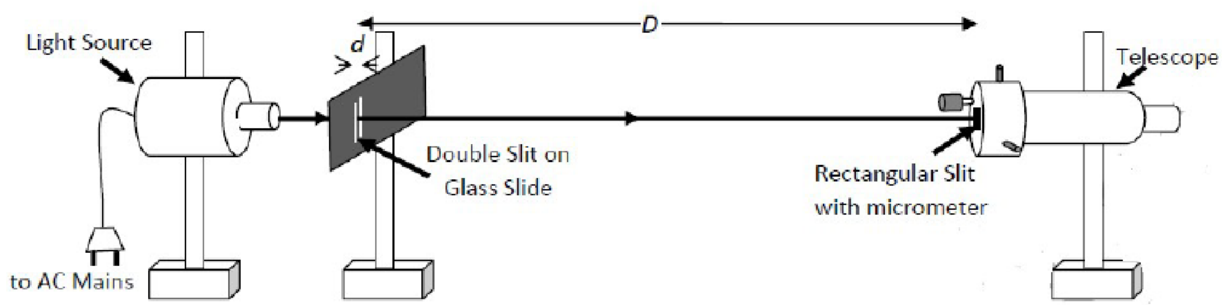


Fig 4.1 Resolving power of a telescope apparatus

Procedure:

1. Focus the telescope for clear image far from the telescope.
2. Keep the sodium lamp in the front of slit pattern.
3. Mount the telescope on a stand such that its axis lies horizontal and the rectangular lines in first row marked on pattern board on stand which are vertical. Place the two stands at a suitable distance (say about 2 meters)

4. Illuminate the object with source of light. Now open the slit with the help of micrometer screw and move the telescope in the horizontal direction such that the images of two vertical sources are in the field of view of the eyepiece.

5. Gradually reduce the width of the slit till the two images just cease to appear as two. Note down the reading of the micro meter. Again close the slit completely and note down the micrometer reading. The difference of the two readings gives the width of the slit (a) just sufficient to resolve the two images.

6. Width (d) of white or black rectangular strips in the first row marked on pattern board is one mm.

7. Measure the distance between the object and the slit with the help of inch tape, which gives D.

8. The experiment is repeated for different values of D.

General Calculation:

The theoretical and practical resolving powers are given by

Theoretical resolving power = a/λ

Practical resolving power = D/d

Where $\lambda = 5890 \times 10^{-10}$ m (for Sodium light)

a = width of the rectangular slit for just resolution of two objects,

d = separation between two object and

D = distance of the objects from the objective of the telescope.

Result: $a/\lambda = D/d$

Precautions and Sources of Error:

1. The axis of telescope should be horizontal.
2. The rectangular object drawn on the pattern board should be vertical.
3. Backlash error in the micrometer screw should be avoided.

<u>Book suggested</u>

1. B.Sc. Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.Sc. Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011).

Worksheet of the student

Aim: To verify the expression for the resolving power of a telescope (circular aperture)

Observations:

Calculation:

Error Analysis:

Result and discussion:

Learning Outcomes (what I have learnt):

To be filled by the faculty:

Sr. No.	Parameters	Marks obtained	Max. Marks
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion of experiment, discipline and cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.5

Aim: To measure the logarithmic decrement, coefficient of damping, relaxation time and quality factor of damped simple pendulum.

Apparatus: A brass bob, thread, meter scale and stop watch.

Theory and formula used: An ideal simple pendulum consists of a heavy point mass suspended from a rigid support by a weightless, inextensible and perfectly elastic string. A practical simple pendulum consists of a heavy metallic bob suspended by a long silk thread from a rigid support as shown in the Fig. 5.1. A graduated scale is fixed slightly above the bob and the bob oscillates parallel to this scale. When the bob oscillates, its amplitude goes on gradually decreasing due to viscous drag of the air and finally the pendulum stops after oscillating through a number of vibration.

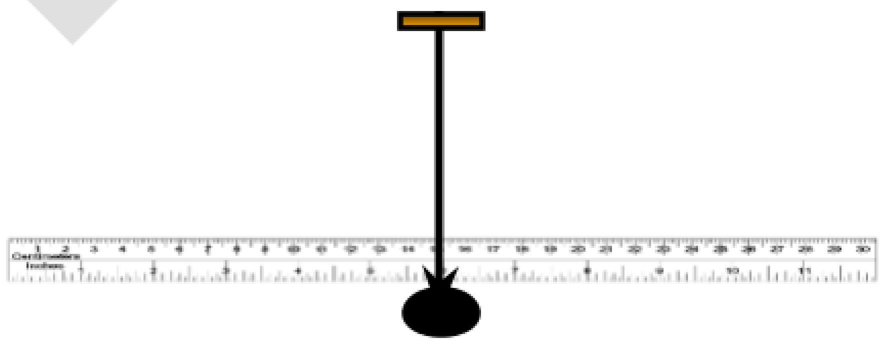


Fig. 5.1: Simple pendulum

Procedure:

1. Take a thread of length 150 cm and attach a brass bob to the lower end of this thread and finally set up the pendulum with a scale as shown in Figure 5.1.

2. Give the displacement of about 75 cm to the bob on one side and let it oscillate freely. The thread and the bob should not touch the scale behind it.

3. When the amplitude of the bob decreases to about 50 cm, note it. Let it be A_o.

4. Now go on noting the amplitude after every five oscillations i.e. after 5, 10, 15, 20, oscillations and so on till the amplitude becomes about 10 cm.

5. Now as the amplitude of the bob is small hence start the stop watch and note down the time taken for 20 oscillations. Repeat this step at least three times and note down the corresponding times taken for each 20 oscillations. Furthermore, while noting down the time for the 20 oscillations, in between keep on measuring the amplitude of oscillation after each five oscillations.

6. Repeat the above experimental procedure with aluminum bob and then with iron bob.

Observations and records:

S.No.	No. of oscillations	Amplitude A_n		$Log_{10} A_n$ for	
		Brass bob	Aluminum bob	Brass bob	Aluminum bob
1	20				
2	40				
3	60				
4	80				

Table 1: For the calculation of the amplitude

Table 2: For the calculation of the time period

Type of bob	Time for 20 oscillations (t)	Time period $T = t/20$	Mean time period
Brass	**i)** **ii)** **iii)**		$T_1 =$
Aluminum	**i)** **ii)** **iii)**		$T_2 =$

Graph: Draw the graph between number of oscillations n taking along the x-axis and $Log_{10}A_n$ along y-axis.

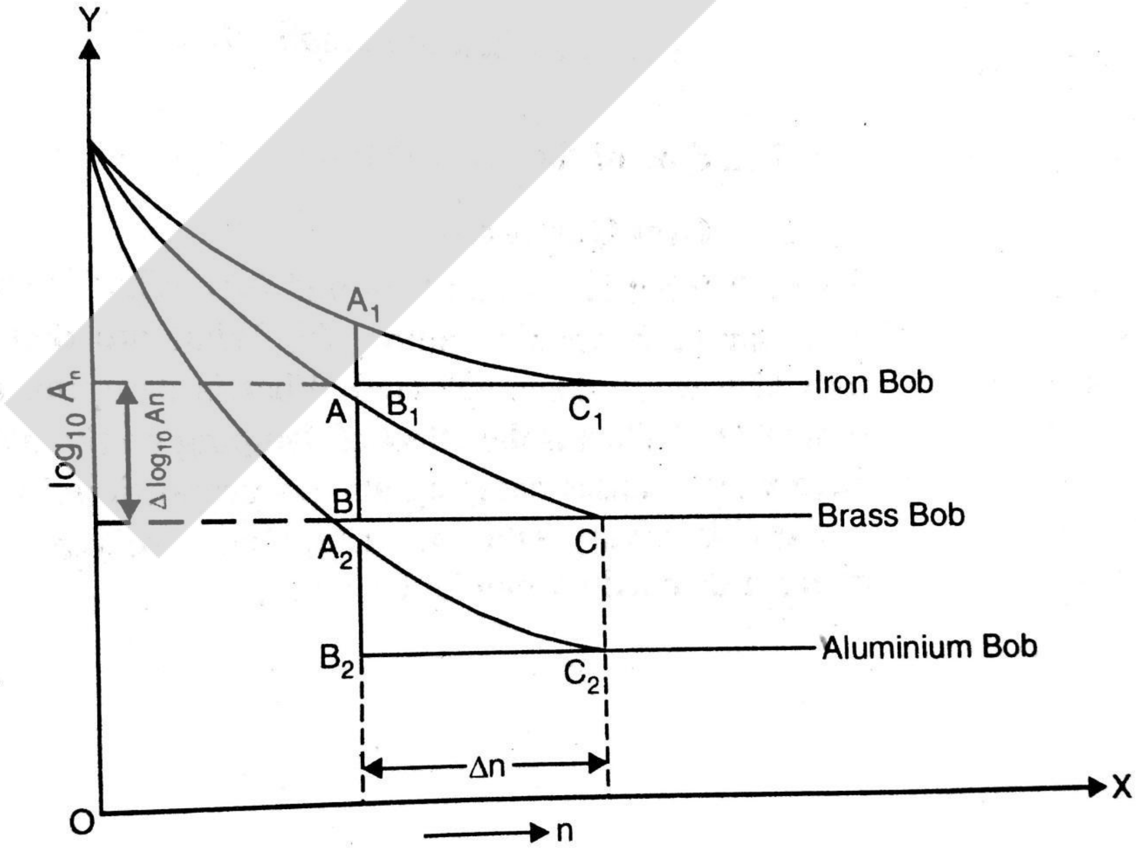


Fig. 5.2: Graph between number of oscillations, n and Log_{10} A_n

Calculations:

Slope of the curve= $Log_{10}A_n/\Delta n$ = AB/BC

Where Δn is the number of oscillations between B and C.

$$\frac{\Delta Log_{10}A_n}{\Delta n} = \frac{\Delta Log_{10}A_n}{\Delta n\, T_1} = \frac{AB}{BC}\frac{1}{T_1}$$

Where T_1 is the time period of the pendulum with brass bob.

$$\frac{2.3026}{T_1}\frac{AB}{BC}$$

And co-efficient of damping for Brass = K_{brass} =$-2.303/T_1 \times AB/BC$ -

s^{-1}

= + s^{-1}

Relaxation time, $\tau_{brass} = 1/K_{brass}$

Quality factor $Q_{Brass} = 2\pi/T_1 \times \tau_{brass}$

$$\lambda_{Brass} = \frac{T_1}{\tau_{Brass}}$$

Logarithmic decrement, $\lambda_{brass} = T_1/\tau_{brass}$ =

Similarly calculate the values for the pendulum with aluminum bob.

λ_{Al}

K_{Al} =……….. ; T_{Al} =………………. ; Q_{Al} =…………; λ_{Al} =…………;

Precautions:

1. The bob or the thread of the pendulum should not touch the scale behind it.
2. Amplitude of initial displacement of the bob should not be less than 70-80 cm.
3. Time of 20 oscillations should be counted when the amplitude becomes small i.e., about 10 cm.
4. Bobs of different materials should be of the same diameter or same mass.

<u>Book suggested</u>

1. B.Sc. Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.Sc. Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011).

Worksheet of the student

Aim: To measure the logarithmic decrement, coefficient of damping, relaxation time and quality factor of a damped simple pendulum.

Observation table:

Calculation:

Error analysis:

Learning Outcomes (What I have learnt?): To be written by the students in 50-70 words.

To be filled by the faculty:

S. No.	Parameters	Marks obtained	Max. Marks
1	Understanding of the student about the procedure/apparatus.		20

2	Observations and analysis including learning outcomes		20
3	Completion of experiment, discipline and cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.6

Aim: To determine the wavelength of sodium light by diffraction grating spectrometer

Apparatus required: A diffraction grating, spectrometer, sodium lamp and magnifying lens.

Theory and formula used: When a parallel beam of monochromatic light is incident normally on a grating, the transmitted light gives rise to primary maxima in certain directions given by the relation,

$(a+b)\sin\theta = n\lambda$

Here $(a+b)$ = grating element, θ = angle of diffraction, n = order of spectrum, λ = wavelength of any spectral lines

Procedure:

Adjustments: Before using the spectrometer, the following adjustments are made:

(i) **The axis of the telescope and that of the collimator must intersect the principal vertical axis of rotation of telescope.**

This adjustment is done by the manufacturer and can only be tested in laboratory. For this purpose a pin is mounted vertically in the center of prism table and observing its image in the telescope tube without eyepiece and for a wide slit in the collimator. If the image appears in the middle, then the adjustment is perfect otherwise the image is made in the center by using the screws supporting the telescope and collimator.

(ii) **Prism table should be leveled.**

(a) The prism table is leveled with the help of three screws supporting the prism table. A spirit level is placed along a line joining the screws and the two screws are moved till the air bubble appears in the middle. Now place the spirit level along a line perpendicular to the previous line and adjust the third screw such that again the air bubble appears in the middle. Here one thing should be remembered that the first two screws should not be touched this time. The prism table is now leveled.

(b) The second method which is generally used in optical leveling of the prism table In this method the prism is placed on the prism table with its refracting edge at the center of the prism table and one of its polished surface perpendicular to the line joining the two leveling screws P and Q as shown in Fig 6.1.

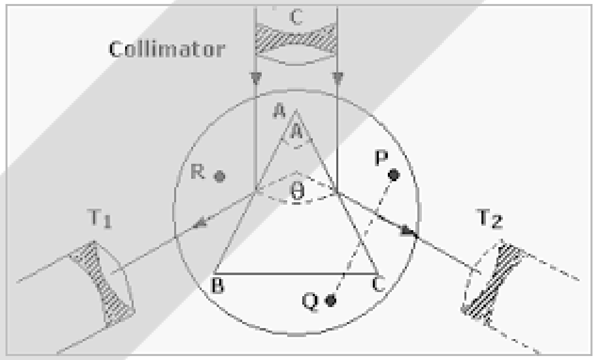


Fig.6.1: Alignment of spectrometer by prism

Now rotate the prism table in such a way that refracting edges AB and AC face towards the collimator and light falling on the prism is usually reflected on both sides as shown in Fig 6.1. The telescope is moved to one side to receive the light reflected from the face AC and the remaining third screw R is adjusted till the image in the center of the field of view.

Again the telescope is moved to the other side to receive the light reflected from the face AC and the remaining third screw R is adjusted till the image becomes in the central field of view of the telescope. The procedure is repeated till the two images from both the reflecting faces are seen in the central field of view of the telescope. The prism table is now leveled.

(iii) **Telescope and collimator are adjusted for parallel light by Schuster's method.**

First of all the prism table is placed on the prism and then adjusted approximately for minimum deviation position. The spectrum is now seen through the telescope. The prism table is rotated slightly away from this position towards collimator and the telescope is brought in view. The collimator is well focused on the spectrum. Again rotate the prism table on the other side of minimum deviation position i.e. towards telescope and focus the telescope for the best image of the spectrum. The process of focusing the collimator and telescope is continued till the slight rotation of the prim table does not make the image to go out of focus. This means that both collimator and telescope are now individually set for parallel rays.

1) **Setting of the grating normal to the incident light**

Place the telescope in line with the collimator so that the vertical cross-wire falls exactly in the center of the image of the slit. Note the scale reading. Add 90º to the reading and place the telescope at this reading to set it perpendicular to the axis of the collimator. Clamp it in this position.

Rotate the grating table till the plane face of the grating is facing both the collimator and the telescope. Look through the telescope and turn the table very slowly till the center of the slit falls exactly on the vertical cross-wire as shown in Fig. 6.2.

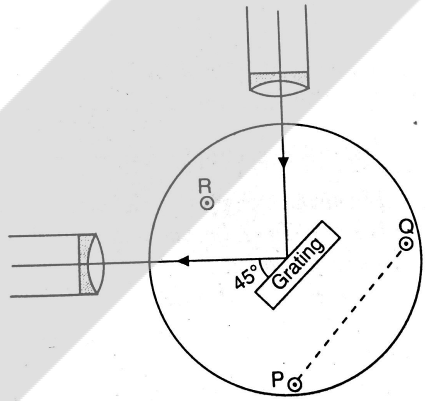


Fig. 6.2: Shows grating mounted on spectrometer stage

In this position the plane of grating is inclined at an angle of 45^0 to the incident light. Note the reading. Turn the table through 45^0 from this position so that the plane of the grating is normal to the incident light with its plane face towards the collimator. The grating is now set normal to the incident light with its ruled surface away from the collimator. Clamp the table in this position.

2) Place the eye in front of the collimator and move it gradually towards the telescope till the first order diffracted image is visible. Bring the telescope in this position and observe the image through it. Clamp the telescope in this position. If the resolving power of the grating is sufficiently high, two distinct narrow lines corresponding to the wavelength 5890Å and 5896Å will lie side by side in the field of view. Ordinarily the two lines will appear as in the first order spectrum. Turn the tangent screw of the telescope till the vertical cross wire coincides with the center of the image of the slit. Note the reading of both the vernier scales. Similarly, observe the first order spectrum on the other side of the direct image and note the reading on both the vernier scales.
3) Similarly note the reading of the vernier scales by setting the telescope on the second order diffracted image on either side of direct light.
4) Repeat he above observation three times.
5) Note the number of lines per inch as marked on the grating and replace it carefully in the box with ruled surface upwards.

Observation:

Vernier Constant =

Number of lines per inch on the grating, N =

Grating element (a+b) = 2.54/N =   cm

Direct reading of telescope =

Table: For the angle of diffraction

S.No.	**Order of Spectrum**	**Vernier**	**Telescope reading**			**Angle of diffraction**		
			Left	**Direct**	**Right**	**Left**	**Right**	**Mean**
1		**V_1**						
		V_2						
2	**First Order**	**V_1**						
		V_2						
3		**V_1**						
		V_2						
1		**V_1**						
		V_2						
2	**Second Order**	**V_1**						
		V_2						
3		**V_1**						
		V_2						

Calculation:

Wavelength of the light is calculated from

First Order, $\lambda = (a+b)\sin\theta_1 =$ cm

Second order, $\lambda = (a+b)\sin\theta_2/2 =$ ….cm

Mean wavelength = cm = m

Precautions:

1. The grating should be held from the edges and the ruled surface should not be touched.
2. The telescope should be focused on the brightest image of the slit while seeing the reflected image.
3. The ruled surface should face away from the collimator.
4. The light should fall on the whole of the grating surface

<u>Book suggested</u>

1. B.Sc. Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.Sc. Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011).

Worksheet of the student

Aim: To determine the wavelength of sodium light by diffraction grating spectrometer.

Observation table:

Calculation:

Error analysis:

Learning Outcomes:

To be filled by the faculty:

S. No.	Parameters	Marks obtained	Max. Marks
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion of experiment, discipline and cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.7

AIM: To compare the frequency of oscillations produced by two audio oscillators using Lissajous Figures.

Apparatus Required: A standard 1000 Hz audio oscillator, a variable frequency audio-oscillator and CRO, trace paper.

Learning Objectives:

1. The wave shapes analysis of Lissajous figures.

Theory:

When a particle is acted upon simultaneously by two simple harmonic motions at right angle to each other the resultant path traced out by the particle is called a Lissajous figure.

Two sinusoidal inputs are applied to the oscilloscope in X-Y mode and the relationship between the signals is obtained as a Lissajous figure. To generate a Lissajous pattern two different signals are applied to the vertical and horizontal inputs of the CRO. Earlier this technique used to measure frequencies before the frequency meter were discover.

A signal generally sine wave of unknown frequency was applied to horizontal input and a frequency whose value is known applied to the vertical input of CRO. The pattern observed was depend on the ratio of the two frequencies applied to the vertical and horizontal inputs. When the signals generally sine wave are of equal frequency and are in phase with each other, Lissajous figure obtain will diagonal line which is display on the screen. When the signals generally sine wave are of equal frequency and 180° out of phase with each other Lissajous figure obtained will a diagonal line which is more towards left which is display on the screen. When the signals generally sine wave are of equal frequency and 90° out of phase with each other a Lissajous figure obtained will a circle.

Procedure:

1. Connect the standard frequency oscillator (1000 Hz) to the "vertical input" terminals of an oscilloscope. Connect the audio-oscillator whose frequencies are to be compared with the standard oscillator to the 'horizontal input' terminals. Connect together the ground terminals of both the oscillators.
2. Set the C.R.O, to get the sharp, bright spot is at the centre of the screen. Turn the sweep control to off position by setting it to ext. input position. Set the audio-oscillator frequency to the marked value of 1000 cycles/-sec.
3. Switch on both the oscillators and adjust the gain controls of the two oscillators as well as the horizontal and vertical gains of the oscilloscope so that a good size ellipse (a 1: 1 Lissajous figure) appears on the screen. Adjust the necessary controls to stop the ellipse. The actual oscillator frequency is now 1000 Hz. Record the dial reading. (It will, in general, have a slightly different value, say 990 Hz).
4. By switching off the audio oscillator allow the ellipse to change phase and note various shapes that appear on the screen. By phase change and amplitude try to obtain a circular trace.
5. Set the oscillator frequency to the mark value of 500 and adjust slowly so that a 1 : 2 Lissajous figure as shown in Figure 1 is obtained. If possible, adjust the controls to lock the figure. Read the dial reading.
6. Similarly obtain (1: 3, 3: 1), (2: 3, 3:2) Lissajous figures and so on upto (1 : 4, 4 : 1)

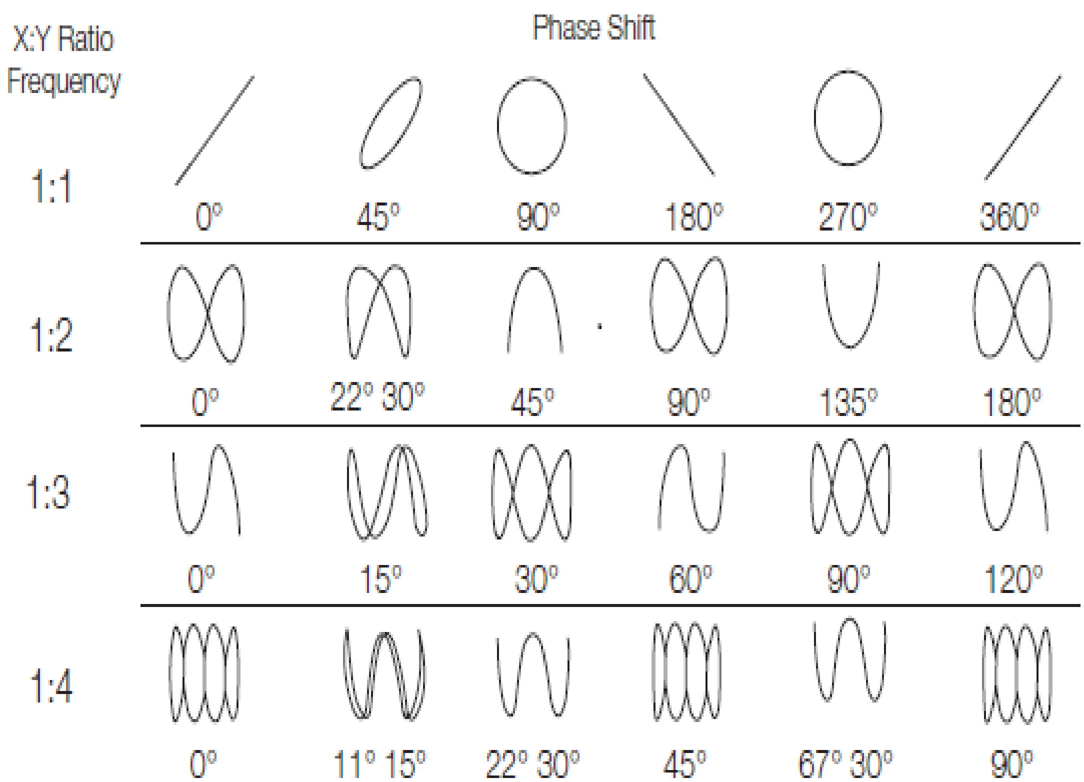


Fig: 7.1Lissajous figures

Book suggested

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

Worksheet of the student

AIM: To compare the frequency of oscillations produced by two audio oscillators using Lissajous Figures.

Observations: Trace figures on given paper.

Calculation:

Error Analysis:

Result and discussion:

Learning Outcomes (what I have learnt):

To be filled by the faculty:

S.No.	Parameter (Scale from 1-10, 1 for very poor and 10 excellent)	Marks obtained	Max. Marks
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion* of experiment, Discipline and Cleanliness		10
	Signature of Faculty	Total marks obtained	

Experiment No.8

AIM: To find the value of Planck's constant and work function of the material by using photoelectric effect.

Apparatus: A photocell, Power supply, digital ammeter and voltmeter, Filters of different colors

Learning Objectives:

1. Students will be able to learn about dependence of photoelectric current on frequency
2. To make them understand working of photo-electric cell
3. To provide hand on experience on handling photo-electric cell and measuring photoelectric current.
4. To study variation of stopping potential with frequency of light.

Theory

If a light strikes the surface of the metal and the wavelength of the light is longer than a specified amount, there would be no electron emitted from the surface of the metal to induce the photo current whatever the strength of the light is. This is the phenomenon that the classical wave model can't explain. Einstein announced the theory of photoelectric effect in 19th century, that is, explained the photoelectric effect in terms of the quantum model of light. Let the energy of the photon is $h\nu$, the work function is φ, the stopping potential is eV, and the charge of the electron is e. Therefore, the variables have the following relationship:

$$eV = h\nu - \varphi$$

In the experiment, through measuring the relationship between the stopping potential and the frequency of the light, we can derive the work function of the metal slab and explain the photoelectric effect.

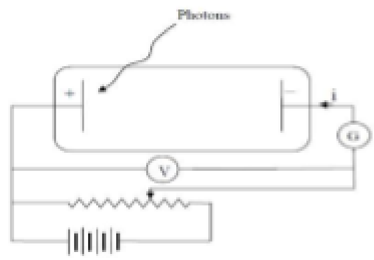


Fig.8: Circuit diagram of Planks constant

Procedure:

1. Make the connections as shown above.
2. Adjust the set zero knob so that the voltmeter reading and ammeter reading is zero when there is no light falling on the photo cell
3. Switch ON the mercury lamp and place the blue filter in front of the photocell.
4. Go on increasing the negative potential applied to the anode of the photocell slowly so that the ammeter reading just becomes zero. The voltmeter reading is recorded.
5. Repeat the experiment by placing different filters i.e. blue, green, and yellow colors and find the corresponding stopping potentials.

Observations:

S.No	**Filter colour**	**Wavelength**	**Frequency** $\nu = \frac{c}{\lambda}$	**Stopping potential V (volts)**

Calculations: h=e × slope= …… Jsec

Work function = $h\upsilon_o$ (in eV) where υ_o is the threshold frequency (intercept on X-axis)

Precautions:

1. While adjusting the ammeter reading at zero mark and voltmeter reading at 0 volt, no light should fall on photo cell.
2. The distance between the mercury and the photo cell should be kept constant during the experiment.

Book suggested

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

Worksheet of the student

AIM: To find the value of Planck's constant and work function of the material by using photoelectric effect.

Observations:

S.No	Filter colour	Wavelength	Frequency $\nu = \frac{c}{\lambda}$	Stopping potential V (volts)

Calculation:

Error Analysis:

Result and discussion:

Learning Outcomes (what I have learnt):

To be filled by the faculty:

S.No.	**Parameter** (Scale from 1-10, 1 for very poor and 10 excellent)	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion* of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.9

AIM: To draw the V-I characteristics of forward and reverse bias diode using ICs and Breadboard

Apparatus: PN Junction Diode, Resistance, Regulated power supply, -Ammeter, Voltmeter, Bread board and connecting wires

Learning Objectives:

1. Students will learn how to calculate the V-I characteristics of junction diodes both in forward and reverse bias conditions.
2. Students will learn to make the circuit of junction diodes on breadboard using appropriate ICs.
3. Students will learn how to use the junction diodes in various electronic applications.
4. Student will learn difference between forward and reverse bias diode.

Theory:

Donor impurities (pentavalent) are introduced into one-side and acceptor impurities into the other side of a single crystal of an intrinsic semiconductor to form a p-n diode with a junction called depletion region (this region is depleted off the charge carriers). This region gives rise to a potential barrier called Cut- in Voltage. This is the voltage across the diode at which it starts conducting. The P-N junction can conduct beyond this Potential.

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to anode (P-side) and –ve terminal of the input supply is connected to cathode (N- side), then diode is said to be forward biased. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from p-side and electrons from n-side cross the junction simultaneously and constitute a forward current (injected minority current – due to holes crossing the junction and entering N-side of the diode, due to electrons crossing the junction and entering P-side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short-circuited switch. If –ve terminal of the input supply is connected to anode (p-side) and +ve terminal of the input supply is connected to cathode (n-side) then the diode is said to be reverse biased. In this condition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction. Both the holes on p-side and electrons on n-side tend to move away from the junction thereby increasing the depleted region. However the process cannot continue indefinitely, thus a small current called reverse saturation current continues to flow in the diode. This small current is due to thermally generated carriers. Assuming current flowing through the diode to be negligible, the diode can be approximated as an open circuited switch.

The volt-ampere characteristics of a diode explained by following equation:

$$I = Io\,(Exp\,(V/\,\eta V_T\,)-1)$$

I=current flowing in the diode

Io=reverse saturation current

V=voltage applied to the diode

V_T = volt-equivalent of temperature= kT/q=T/11,600=26mV (at room temp).

η=1 (for Ge) and 2 (for Si)

Experiment procedure:

Forward Biased Condition:

1. Connect the PN Junction diode in forward bias i.e. Anode is connected to positive of the power supply and cathode is connected to negative of the power supply.
2. Use a Regulated power supply of range (0-30) V and a series resistance of 1kΏ.
3. For various values of forward voltage (V_f) note down the corresponding values of forward current(If) .

Reverse biased condition:

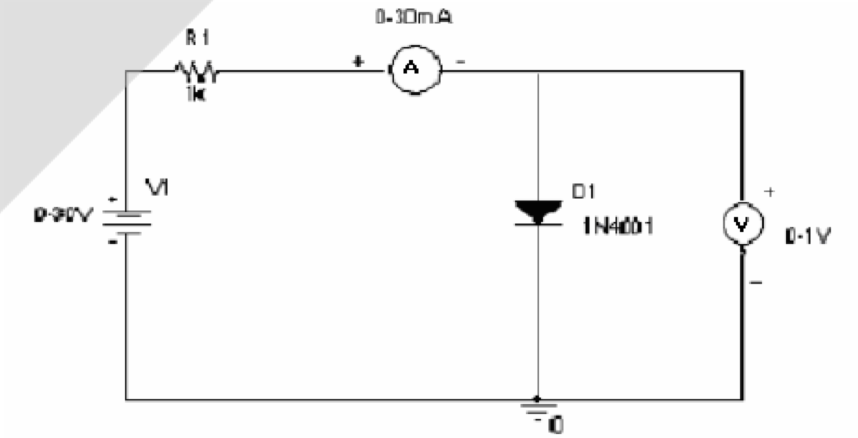
1. Connect the PN Junction diode in Reverse bias i.e.; anode is connected to negative of the power supply and cathode is connected to positive of the power supply.

2. For various values of reverse voltage (V_r) note down the corresponding values of reverse current (Ir).

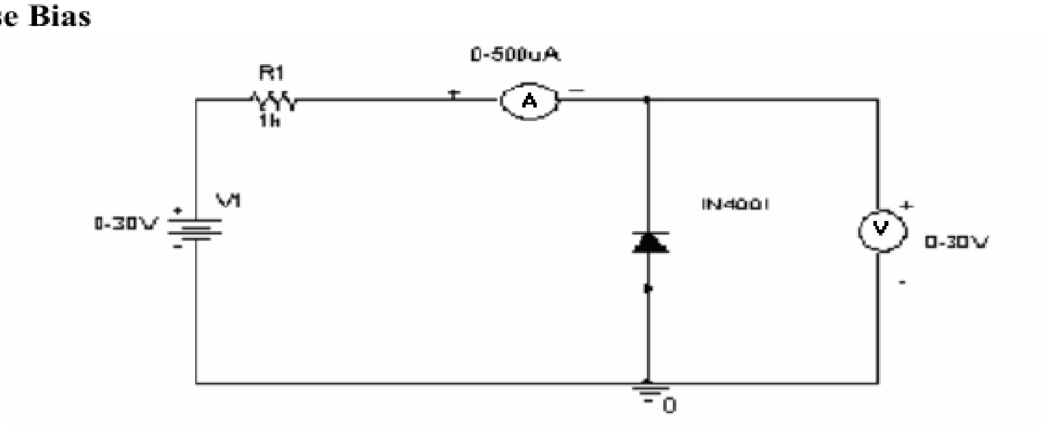
Observations:

Circuit diagram:

Forward Bias



Reverse Bias



Forward biasing:

Sr. No.	Forward Voltage	Forward current

Reverse biasing:

Sl. No	Reverse Voltage	Reverse current

Graph (instructions):

1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Mark the readings tabulated for diode forward biased condition in first Quadrant and diode reverses biased condition in third Quadrant.

Precautions:

1. While doing the experiment do not exceed the ratings of the diode. This may lead to damage of the diode.
2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

<u>Book suggested</u>

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

Worksheet of the student

AIM: To draw the V-I characteristics of forward and reverse bias diode using ICs and Breadboard

Observations:

Forward biasing:

Sr. No.	Forward Voltage	Forward current

Reverse biasing:

Sl. No	Reverse Voltage	Reverse current

Graph:

Error Analysis:

Result and discussion:

Learning Outcomes (what I have learnt):

To be filled by the faculty:

S. No.	**Parameter** (Scale from 1-10, 1 for very poor and 10 excellent)	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion* of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

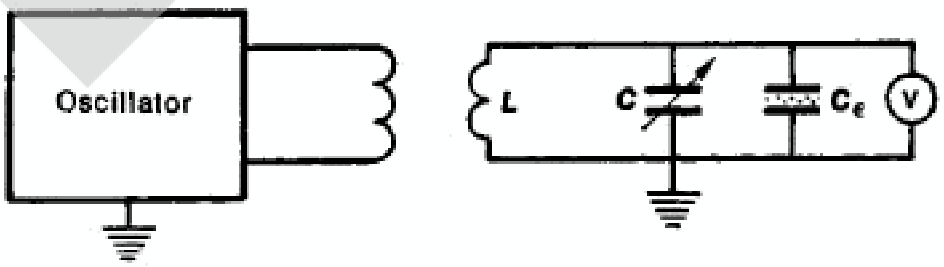
Experiment No.10

AIM: To determine the dielectric constant of solid by resonance method

Equipment to be used: A variable radio-frequency calibrated oscillator with variable output power, a calibrated variable capacitor with capacitance from 50 to 1000 pF, a circular parallel plate capacitor whose dielectric can be removed or inserted without changing the distance between the plates, an A.C. milliammeter.

Learning Objectives:

1. The students will understand the concept of atomic dipole moment.
2. The students will have the idea of resonance.



Dielectric constant definition

The dielectric constant definition or the relative static permittivity, ε_r, can be measured for static electric fields as follows: first the capacitance of a test capacitor, C_0, is measured with vacuum between its plates. Then, using the same capacitor and distance between its plates, the capacitance C_x with a dielectric between the plates is measured.

The relative dielectric constant can be then calculated as $$\varepsilon_r = \frac{C_x}{C_0}.$$

Procedure:

1. Switch on the R.F. oscillator. Set it at the lowest frequency. Vary the value of the graduated variable capacitor C, and not the resonance. Now, set the oscillator on the highest frequency, again vary C and note the resonance. This shows that resonance will take place for the whole range of the oscillator from the lowest to highest value.
2. Disconnect the capacitor C'.Set the oscillator at a convenient frequency say f=ω/2π. Vary C and note the value of C for which the gives the maximum current i.e. , if we increase the C beyond this value, the voltage

begins to decrease. This is the value at resonance. Note the value of C. Let it be C1, then ω=1/2π√LC1………… (a)

3. Now include the unknown capacitance C' (with dielectric disc in it) and having a capacitance say CD. Repeat the experiment by varying C to again obtain maximum voltage or resonance. Let the reading of the variable capacitor now be C2, then ω=1/2π√L (CD+C2)…….. (b)

4. Now carefully remove the dielectric disc from the capacitor C without changing the distance between the plates. Repeat the experiment again by varying C to obtain maximum voltage or resonance. Let the reading of the variable capacitor now be C3, then ω=1/2π√L (CA+C3)…(c)

Where CA is the capacitance of the capacitor C with air as dielectric. From (a) and (b), we have 1/2π√LC1=1/2π√L (CD+C2) or CD+C2=C1 or CD=C1-C2 From (a) and (c), we have 1/2π√LC1=1/2π√L (CA+C3) or CA+C3=C1 or CA=C1- C3 Therefore, Dielectric Constant k =CD/ CA=C1- C2/C1-C3.

5. Repeat the experiment by setting the variable R.F. Oscillator at two more different frequencies.
6. Repeat the same for different dielectric materials.

Observations and Record

Frequency of oscillator	Value of Variable capacitor at resonance when		
	Alone C1	With Dielectric Capacitor C2	With Air capacitor C3

Dielectric Constant

$$K = \frac{C_1 - C_2}{C_1 - C_3}$$

Precautions

1. Resonance should be checked for whole frequency range by noting the resonance for the lowest as well as the highest frequency of the R.F. oscillator.
2. Resonance must be sharp
3. The dielectric disc must fit tightly into the capacitor and should be removed carefully without disturbing the capacitor.

<u>Book suggested</u>

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

Worksheet of the student

AIM: To determine the dielectric constant of solid by resonance method

Observations:

Frequency of oscillator	**Value of variable capacitor**			**Dielectric constant** $K = \frac{C_1 - C_2}{C_1 - C_3}$
	Alone C_1	**With dielectric C_2**	**With air C_3**	

Calculation:

Error Analysis:

Result and discussion:

Learning Outcomes (what I have learnt):

To be filled by the faculty

S. No.	**Parameter** (Scale from 1-10, 1 for very poor and 10 excellent)	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20

3	Completion* of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.11

AIM: To study the induced emf as a function of velocity of a magnet

Apparatus required: Apparatus for the study of electromagnetic induction, a small strong permanent magnet mounted at the middle of a semi-circular arc, a coil consisting of number of turns, two weights, a stopwatch, circuit arrangement for measuring the peak value of induced e.m.f. etc.

Learning Objectives:

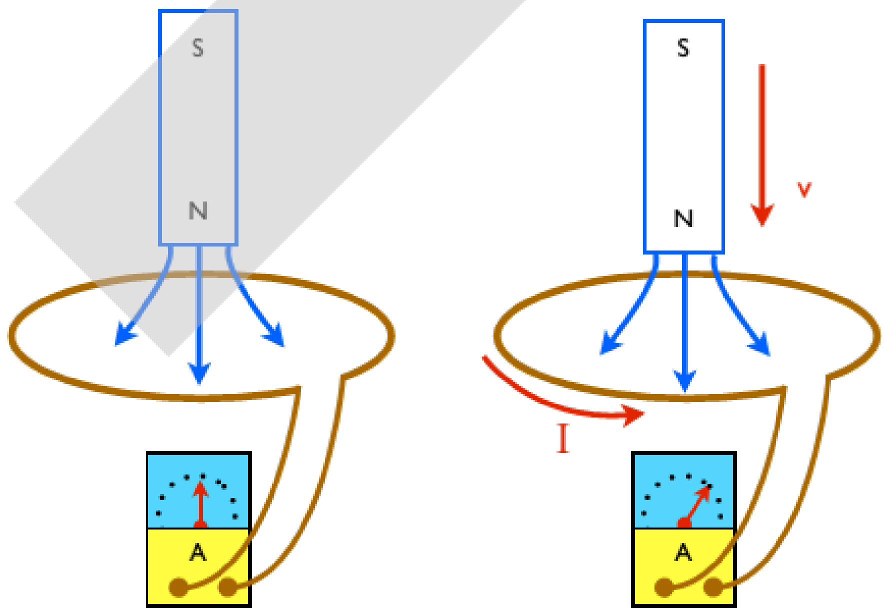
1. To know about Electromagnetic induction
2. To learn how to measure induced e.m.f
3. To know the dependence of the magnitude of induced e.m.f on the velocity of the magnet.

Theory

Faraday's law of induction is a basic law of electromagnetism predicting how a magnetic field will interact with an electric circuit to produce an electromotive force (EMF) — a phenomenon called electromagnetic induction. This law explains the working principle of most of the electrical motors, generators, electrical transformers and inductors.

In 1831, Faraday demonstrate that a changing magnetic field can induce an emf in a circuit. Consider a conducting wire loop (a closed circuit) connected to an ammeter (A) with a bar magnet(initially at rest) placed above the center axis of the wire loop, as shown in Figure (a). When the magnet is held stationary, there is no current in the loop, even if the magnet is inside the loop. However, when the magnet is brought near (or pulled away from) the loop, the ammeter needle deflects indicating an *induced* current in the loop produced by an induced emf (Figure b). From these observations, Faraday concluded that there exists a relationship between the induced current/emf and the changing magnetic field. The results of his experiments are now referred to as Faraday's Law of Induction. In general, Faraday's Law states that an induced emf (E) along any closed path in a magnetic field is equal to the rate at which the magnetic flux sweeps across the path. The closed path can be thought of as the surface within the path that the magnetic field intercepts. Quantitatively,

$$\epsilon = -\frac{d\varnothing_B}{dt}$$

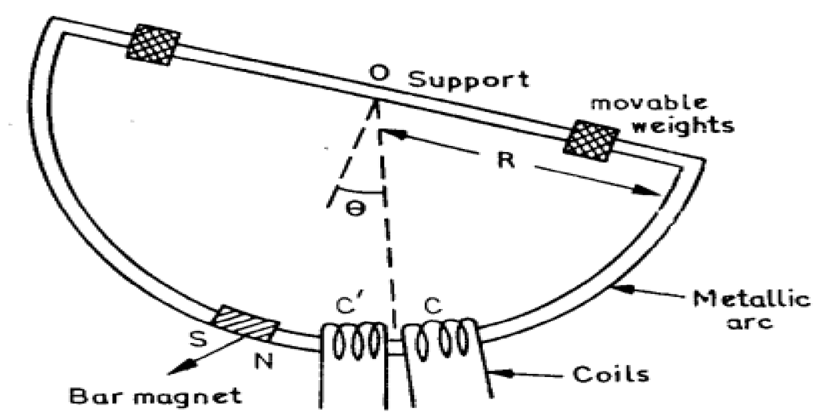


(a) (b)

The negative sign in Faraday's law indicates that the induced emf and the change in flux have opposite signs (Lenz' Law).

Basic Methodology:-

1. A bar magnet is made to pass through a coil .The resulting emf produced by Faraday' s effect charges a capacitor .The voltage of the capacitor is a measure of the induced emf .



Figure(c)

2. In this experiment we will measure εo by charging a capacitor by the induced emf .The capacitor is connected in series with the coil along with a diode and a resistance R.(figure c) The resistance R_{int} is the internal resistance of the coil and forward resistance of diode and is about 500Ω. The diode allows current to flow only in one direction and hence the capacitor charges only during one swing of the complete oscillation .If the time constant RC is small compared to the pulse width, then the capacitor gets fully charged to the maximum voltage εo in the swing. However if RC >relaxation time, then the capacitor gets fully charged only after several swings.

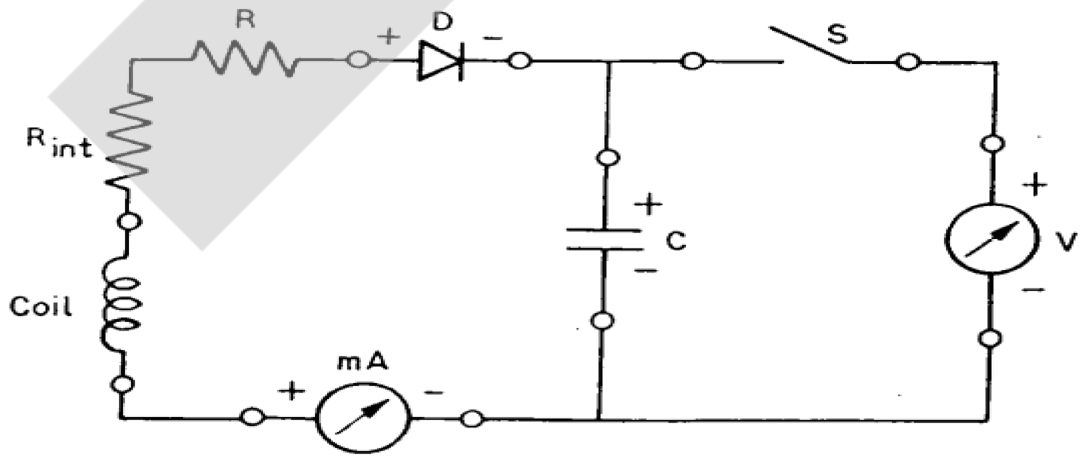


Figure (d)

Setup and Procedure:

1. Make sure that the equilibrium position of the metal arc and magnet is at 0^0.if not then adjust the position of the weights to ensure this.
2. Check that the oscillation of the arc through the coils are free and that the arcs does not touch the sides of the coils when oscillating
3. Connect the terminals of the coil to the diode circuit (fig 3) to note the peak voltage generated.
4. Displace the metal arc to one side so that amplitude of vibration is about 20 cm and then release it .note the time for 20 oscillations.
5. Repeat thrice keeping the amplitude same and find the time period.
6. Repeat the experiment after changing the amplitude and take at least 8 readings.
7. Now change the time period by adjusting the position of the weights on the diameter of arms. Now take 8 readings by changing the time period but keeping the amplitude same for all set of observations.

Observations:

(A) Time period constant, amplitude variable.

Mean position of the Centre of the magnet =

Radius of a semi circular metallic arc R =   cm

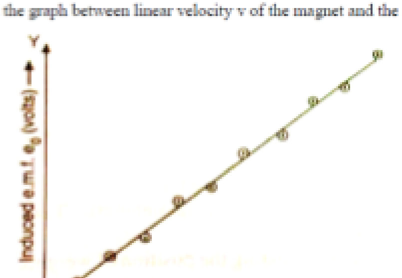
S.No	Amplitude a = Rθ	Time for 20 oscillations	Time Period (T)	ε_0	$\frac{\varepsilon_0}{a} = \frac{\varepsilon_0}{R\theta}$	Linear velocity $v = \frac{2\pi}{T} R\,\theta$
1						
2 . . . 8						

(B) Amplitude constant, time period variable

S.No	Amplitude a = Rθ	Time for 20 oscillations	Time Period (T)	ε_0	$\frac{\varepsilon_0}{a} = \frac{\varepsilon_0}{R\theta}$	Linear velocity $v = \frac{2\pi}{T} R\,\theta$
1						
2 . . . 8						

Plot a graph between linear velocity (x-axis) of the magnet and maximum induced EMF ε_o (y-axis).

Model Plot: Plot the graph between linear velocity v of the magnet and the maximum induced e.m.f.



Precautions

1. The semi circular frame should oscillate freely.
2. The magnet should pass freely through the coils c_1 and c_2..
3. The EMF developed in the coil should be measured with the help of electronic circuit.

Book suggested

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

WORKSHEET OF THE STUDENT

AIM: To study the induced emf as a function of velocity of a magnet.

OBSERVATIONS:

S.No	Amplitude a = Rθ	Time for 20 oscillations	Time Period (T)	ε_0	$\frac{\varepsilon_0}{a} = \frac{\varepsilon_0}{R\theta}$	Linear velocity $v = \frac{2\pi}{T} R\,\theta$
1						
2						
3						
4						
5						

(B) Amplitude constant, time period variable

S.No	Amplitude $a = R\theta$	Time for 20 oscillations	Time Period (T)	ε_0	$\frac{\varepsilon_0}{a} = \frac{\varepsilon_0}{R\theta}$	Linear velocity $v = \frac{2\pi}{T} R\,\theta$
1						
2						
3						
4						
5						

Calculation:

Error Analysis:

Result and discussion:

Learning Outcomes (what I have learnt):

To be filled by the faculty

S. No.	**Parameter** (Scale from 1-10, 1 for very poor and 10 excellent)	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion* of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.12

AIM: To find the capacitance of an unknown capacitor using Flashing and quenching of a neon lamp.

Equipment Required: A condenser of unknown capacity, 3 condensers of known Capacity (say 1μF, 2μF, and 3μF), resistance of the order of few mega-ohm, a Neon flashing bulb, stabilized DC power supply of 250V; one way keys.

Learning Objectives:

1. To learn about capacitance of a capacitor
2. To learn how capacitances behave in parallel combination
3. To learn a method to find unknown capacitance of a capacitor.

Theory: When the electrodes connected to a D.C source stray, electrons in the gas are attracted towards the positive electrode. As voltage is increased, the speed of electrons also increases and at particular voltage speed becomes high to ionize the gas so lamp begins to conduct and glows. This voltage is known as flashing potential. When we place a capacitor in parallel with lamp, due to conduction of lamp capacitor begins to discharge through it. It continues to do this until quenching potential reached. When neon lamp ceases to conduct, the capacitor then begins to charge again and whole process goes on repeatedly. The flashing and quenching time can be determined by noting time taken by lamp for 'n' consecutive flashes and quenches. If t1 is time taken by capacitor voltage to fall from V1 to V2 and t2 is time for voltage to rise from V2 to V1, then

$$V_2 = V_1 e^{-t_1/CR}$$

$$t_1 = -CR \log_e \frac{V_2}{V_1}$$

$$V_2 = V_1 (1 - e^{-t_2/CR})$$

$$t_2 = -CR \log_e \left(1 - \frac{V_2}{V_1}\right)$$

$$t = t_1 + t_2 = C\left[-R \log_e \frac{V_2}{V_1} - R \log_e \left(1 - \frac{V_2}{V_1}\right)\right]$$

As R, V1 and V2 have constant fixed values, so we get T= k C where k is constant.

Circuit diagram:

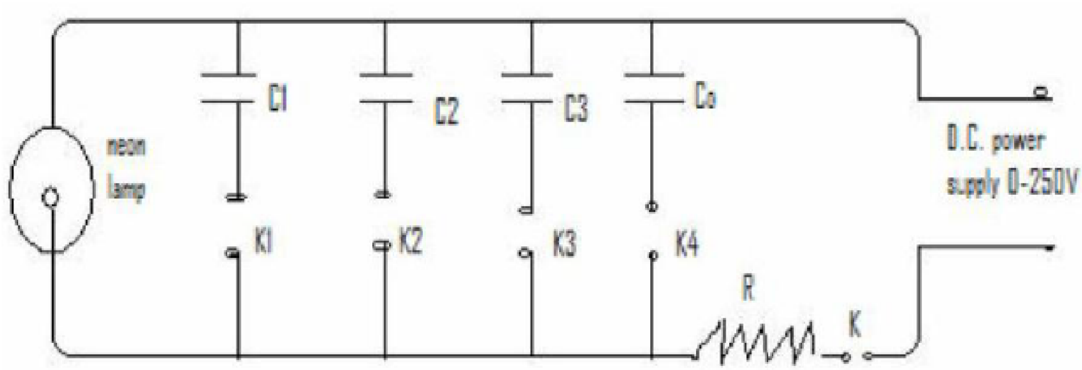


Fig 12.1

Outline of the Procedure: (i) Draw the diagram and make the connections as in the fig. Connect the condenser C_1 in the circuit by inserting K_1. Also insert the key K to connect power supply and increase the voltage till neon lamp just begins to flash. As already explained, the bulb starts flashing and quenching as it is connected in parallel with the condenser. Note the flashing and quenching time for 20 flashes. Take out the key K so that the power supply is disconnected.

(ii) Put in the key K_4 for the circuit of unknown capacity C_0.Since C_1 and $C_0$are in parallel their capacities get added up and total capacity in parallel with the lamp is $(C_1 + C_0)$. Again

insert the key K and adjust the power supply voltage to previous value. Note the time for 20 flashes. Remove the key K_1 and K_4.

(iii) Now repeat the experiment with the capacity C_2, C_3 and with all the three known capacitor connected together in parallel with C_0. Scope of result expected: By Connecting the condensers of known capacity in parallel with lamp and with unknown condenser, time t for 20 flashes with and without unknown capacitance can be obtained.

Observations and Calculations:

Quenching and Flashing Time without unknown capacitor: t_0

Quenching and Flashing Time with unknown capacitor: t_1

Plot two graphs between values of capacitance along x-axis and flashing and quenching time t (without and with unknown capacitance) y-axis For three different values of flashing and quenching time draw three straight lines parallel to x-axis cutting the two graphs at A and B, C and D, E and F respectively.

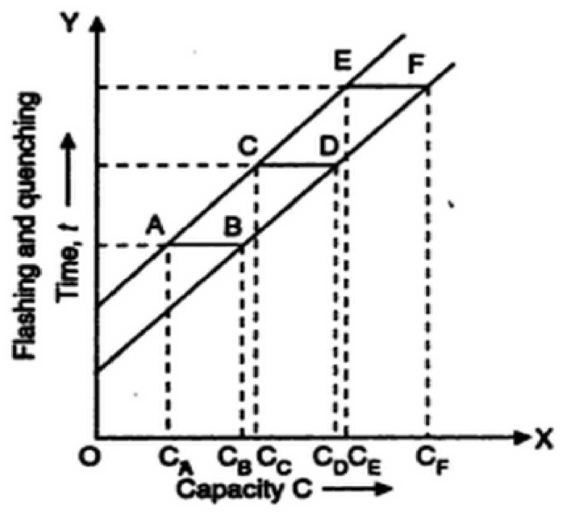


Fig-12.2

Precautions:

1. Count the number of flashes very carefully.
2. Connections should be tight.
3. Capacitors should always be connected parallel to the lamp.

4. The voltage from D.C. power supply should remain constant

Book suggested

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

WORKSHEET OF THE STUDENT

AIM: To find the capacitance of an unknown capacitor using Flashing and quenching of a neon lamp.

Observation

Sr. No	**Capacitance**	**Time for 20 flashes without unknown capacitor (t_0)**	**Time for 20 flashes with unknown capacitor (t_1)**	

Calculation

Error analysis

Learning outcomes

To be filled by the faculty

S. No.	**Parameter** (Scale from 1-10, 1 for very poor and 10 excellent)	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion* of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

EXPERIMENT 13

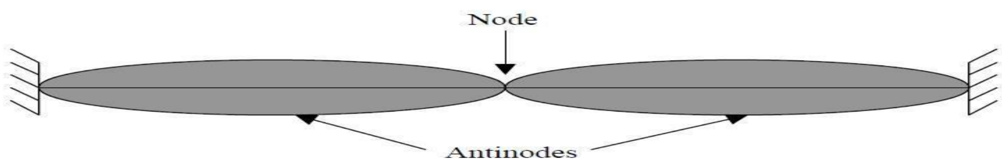
AIM: To find the frequency of a.c. supply using an electric vibrator.

Apparatus: Electric vibrator frictionless pulley, a string of uniform thickness, a light weight pan, a weight box, a balance and a meter rod

Learning objective

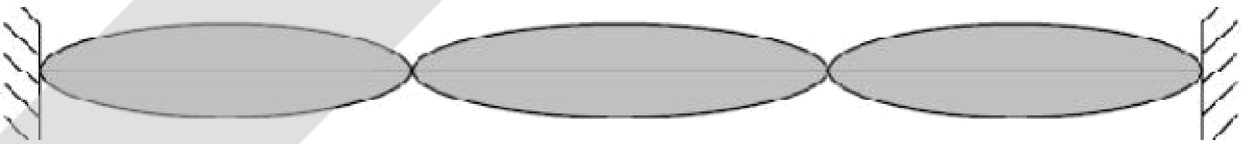
- The students will learn about formation of standing waves and their dependence on various parameters
- The students will learn about the magnetic field produced by solenoid in response to alternating current
- Students will get information about nodes and antinodes

Theory: When a string is tied between two fixed supports, pulled tightly and sharply plucked at one end, a pulse will travel from one end of the string to the other. When you pluck the string you put energy into an elastic medium, and this energy travels through the medium as a transverse pulse. Transverse means that the amplitude is at right angles to the direction of propagation. The speed of the pulse through the medium, in this case the string, is a function of the properties of the string. Specifically, it is a function of the linear density of and the tension in the string. Making the string tighter and lighter increases the pulse speed, and making the string looser and heavier slows the pulse speed down. Standing waves on a string are a result of traveling waves interfering both destructively and constructively. The nodes (places of zero amplitude) are due to destructive interference, and the antinodes (places of maximum amplitude) are due to constructive interference. When a standing wave appears, the nodes and antinodes are fixed in place. When the conditions of the tension in the string, the linear density and the frequency of oscillations are just right, standing waves appear. As the standing waves on the string are sinusoidal, the allowed number of waves on the string will be an integral number of half wavelengths, or $n\lambda/2 = L$



$L=\lambda$

L=3λ/2



If l is the length of one loop of the string, T is the tension and the mass per unit length of string, then the frequency of the vibrator is

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}} \quad f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

Procedure

1. Switch on the current and adjust the length of the steel rod till the free end attains the maximum amplitude.

2. Switch off the current and tie one end of a string about 2m long to the free end of the steel rod .Pass over a frictionless pulley fixed on the table and attach a light weight pan to the other end .Add some weights in the pan to make the string taut.

3. Switch the current, the string will be found to vibrate in a number of loops .Adjust the load if necessary .Change the length of the vibrating string by shifting the vibrator forward or backward so that the loops are sharply defined and nodes are clearly marked.

4. Mark the positions of the extreme nodes leaving out the first and last loop as their position cannot be clearly defined. Measure the distance between the two marks and divide t by the number of loops contained in the length of string. Repeat the experiment by changing the load in the pan.

Observations and Calculations:

Mass of the pan m = …………..gm

Mass per unit length of string **μ=** …………gm/cm

Transverse arrangement

S. No.	Mass placed in pan M (in grams)	Total Tension in the string T=(m+M) g	No. of loops (n)	Length between extreme nodes L (cm)	Length for one loop l=L/n (cm)	Frequency $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ (Hz)
1.						
2.						
3.						
4.						

Mean frequency ν = …..

Mean frequency =…………

Percentage Error in frequency =…………

Precautions

1. The string should be of uniform thickness so that it has a fairly uniform mass per unit length.
2. Nodes and antinodes must be clearly defined.
3. There should not be friction in the pulley

Book suggested

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

Worksheet of the student

AIM: To find the frequency of a.c.supply using an electric vibrator.

Observations

Mass of the pan m = …………..gm

Mass per unit length of string **μ=** …………gm/cm

S. No.	*Mass placed in pan M (in grams)*	*Total Tension in the string T=(m+M) g*	*No. of loops (n)*	*Length between extreme nodes L (cm)*	*Length for one loop l=L/n (cm)*	*Frequency* $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ *(Hz)*

1. 2. 3. 4.						

Calculation

Mean frequency ν = …..

Error analysis

Learning outcomes

To be filled in by Faculty

S. No.	**Parameter** (Scale from 1-10, 1 for very poor and 10 excellent)	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion* of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment 14

AIM: To find the wavelength of laser light by using Michelson interferometer.

Equipment Required: A Michelson interferometer, He-Ne Laser, collimating lens, Screen, magnifying lens.

Learning objectives:

1. To determine the wavelength of monochromatic light (He-Ne Laser).
2. To study the phenomena of interference of light.

Theory:

The interferometer is adjusted to obtain circular fringes in the field of view of the telescope. the mirror Ml and M2 are equidistant from the glass plate Gl , the field of view will be perfectly dark. The position of the mirror Ml is adjusted till a particular bright fringe appears in the field of view of the telescope with its centre coincides with the cross-wire. When the mirror Ml is moved backward or forward, each fringe in the focal plane of the telescope is displaced parallel to half. When the mirror Ml is moved through a distance $\lambda/2$, the path difference changes by λ and the position of a particular bright fringe is taken by the next bright fringe. If n is the number of fringes that more across the field of view when the mirror is displaced through a distance L then .. $n(\lambda/2) = L$ wavelength $\lambda = (2L/n)$

Diagram:

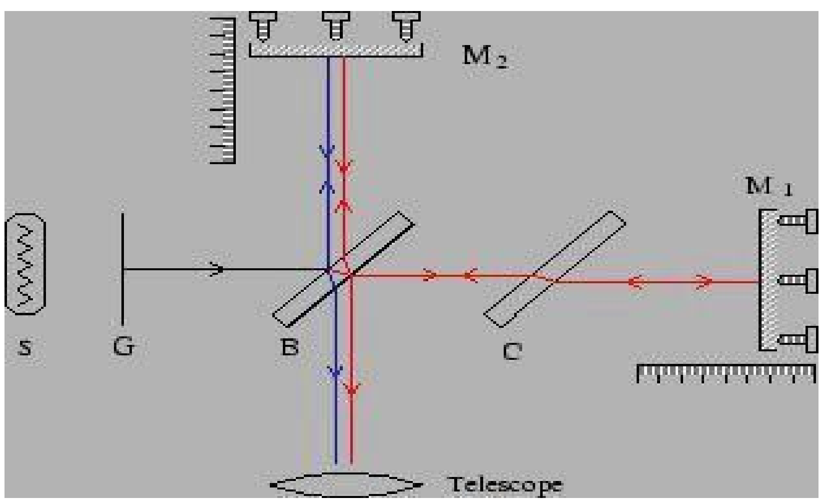


Fig .1- Interference pattern by Michelson Interferometer

Outline of the procedure:

l. First put the interferometer on a rigid table and level the instrument with three leveling screws provided at the base.

4. Put the Helium-Neon laser, about 50 to 60 cm away from the instrument such that its beam passes through the pin hole fitted in front of the instrument. Make sure that the laser beam falls at the middle of the Mirrors Ml and M2 after getting split from beam splitter plate Gl.

5. The beam after the reflections will make four spots on the wall or on a screen. One pair is formed due to partial reflections at the unsilvered surface of Gl and reflections at Ml and M2 respectively. While the other pair is formed due to partial reflections at Ml and M2 respectively. Out of these one pair is brighter than the other.

6. Now mirrors Ml and M2 are tilted carefully such that the two brighter images coincide.

7. Now the instrument is aligned and the fringes are formed on the wall or screen.

8. The mirror M2 is kept fixed and the mirror Ml is moved with the help of the fine movement screw and the number of fringes that cross the field of view is counted.

Scope of the results: The student will be able to find the wavelength of He-Ne laser with the help of interference phenomena and will come to know about the role of path difference in interference of light.

Observations:

Least reading on the main (Linear Scale) = ………………… mm = ……………………… cm

Least count of rough micrometer screw (R.M.S.) = ………...mm = ……………………… cm

Least count of fine micrometer screw (F.M.S.) = ……… ....mm=………...……….…… cm

S.No.	No of fringes shifted	Position of Mirror M_1	Difference for 100 fringes

		Main scale reading (cm)	R.M.S. reading (cm)	F.M.S. reading (cm)	Total cm	

Mean difference for 100 fringes L= …………………………cm

Wavelength of light λ = (2l/n) = …………………cm = ………………………… Ao

Parameter and Plots:

Take any value of n>20 and note down the value of distance (d) through which the mirror is moved and apply theory of interference of light to find wavelength of light. [Report data in tabular or systematic manner.

Caution:

1. Do not use the telescope.
2. Do not see directly into the laser beam.
3. Make sure that the distances of mirror M1 and M2 are almost equal from beam splitter G1.
4. Make sure that centre of the circular fringes are properly adjusted.

Book suggested

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

Worksheet of the student

AIM: To find the wavelength of laser light by using Michelson interferometer.

Observations:

Least reading on the main (linear scale) = ………………… mm= ………… cm

Least count of rough micrometer screw (R.M.S.) = …...........mm=…....…… cm

Least count of fine micrometer screw (F.M.S.) = ………..mm=…………… cm

S.No.	No of fringes shifted	Position of Mirror M_1				Difference for 100 fringes
		Main scale reading (cm)	R.M.S. reading (cm)	F.M.S. reading (cm)	Total cm	
1. . . 9	25 . . 225					

Mean difference for 100 fringes =……………. L=……………cm

Calculation:

Wavelength λ= (2l/n)……………………cm=……………………….Å

Error analysis

Learning Outcomes:

To be filled by the faculty:

S. No.	**Parameter** (Scale from 1-10, 1 for very poor and 10 excellent)	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion* of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.15

AIM: To determine the Hall voltage and Hall coefficient using Hall effect

Equipment Requirement: -Hall probe, Gauss probe, Gauss meter, electromagnet, constant current power supply, digital voltmeter.

Material used: Germanium (Ge) crystal

Learning objectives:

1. To study Hall Effect in semiconductor and calculate the parameter related to it.
2. To study the variation of Hall voltage with magnetic field keeping current through specimen fixed
3. To study the variation of Hall voltage with current through specimen keeping fixed magnetic field

Theory: - When a magnetic field is applied perpendicular to a current carrying conductor, a voltage is developed in a specimen in a direct ion perpendicular to both the current and the magnetic field. This phenomenon is called the Hall Effect. The voltage is so produced is called hall voltage. When the charges flow, a magnetic field directed perpendicular to the direction of flow produces a mutually perpendicular force on the charges. Consequently the electrons and holes get separated by opposite forces and produce an electric field, there by setting up a potential difference between the ends of specimen. This is called Hall potential.

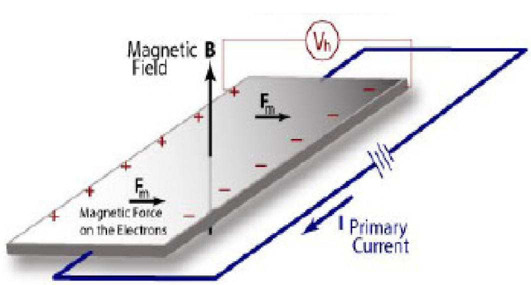


Fig. 15.1 Block diagram of Hall set up

Procedure:-

1. Place the specimen at the centre between the pole pieces and exactly perpendicular to the magnetic field.

2. Place the hall probe at the centre between the pole pieces, parallel to the semiconductor sample and note the magnetic flux density from the guess meter keeping the current constant through the electro magnet.

3. Before taking the reading from the gauss meter ensure that gauss meter is showing zero value. For this put the probe away the electromagnet and switch on the gauss meter and adjust zero.

4. Vary the current in small increment. Note the current and the hall voltage.

5. For the 2nd observation keep the current constant through the specimen and vary the current through electromagnet and note the hall voltage.

6. The graph between the V_H vs I Keeping B fixed and V_H vs B keeping I (current through specimen) fixed. Then calculate the Hall coefficient from the slope of graphs

The Hall coefficient is given $\mathbf{R_H = V_H\, b / IB}$, Where, **b** = thickness of the specimen, $\mathbf{V_H}$ = Hall Voltage, **I** = Current through the specimen, **B** = Magnetic Field

GENERAL CALCULATIONS:

Observations:

Fixed Current through the electromagnet =

Fixed Magnetic field (as measured by the Gauss meter), B=

Hall coefficient from the graph between V_H and I keeping B Fixed

R_H = Slope × (b / B) =

Hall coefficient from the graph between VH and B keeping I Fixed

R_H = Slope × (b / I) =

Mean Hall coefficient =…………

Plots & Parameters:

The graph between the V_H vs I Keeping B fixed and V_H vs B keeping I (current through specimen) fixed. Then calculate the Hall coefficient from the slope of graphs.

Precaution:-

1. The Hall probe should be placed at the centre of the electromagnet.
2. The specimen should be placed at the centre of the electromagnet.
3. Zero should be ensured in the gauss meter before placing the hall probe between the centre of the electromagnet

<u>Book suggested</u>

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20^{th} edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1^{st} edition (2011)

Worksheet of the student

AIM: To determine the Hall voltage and Hall coefficient using Hall Effect.

Observations:

Calculation

Error analysis

Learning outcomes

To be filled by the faculty

S. No.	**Parameter**	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20

2	Observations and analysis including learning outcomes		20
3	Completion of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.16

AIM: To find out the energy band gap of a semiconductor by four probe method

Equipment Required: Probes arrangement, sample crystal (Germanium), oven, four probes setup with digital voltmeter (range 0 to 200mV and 0 to 2V) and constant current generator (range is 0 to 20mA)

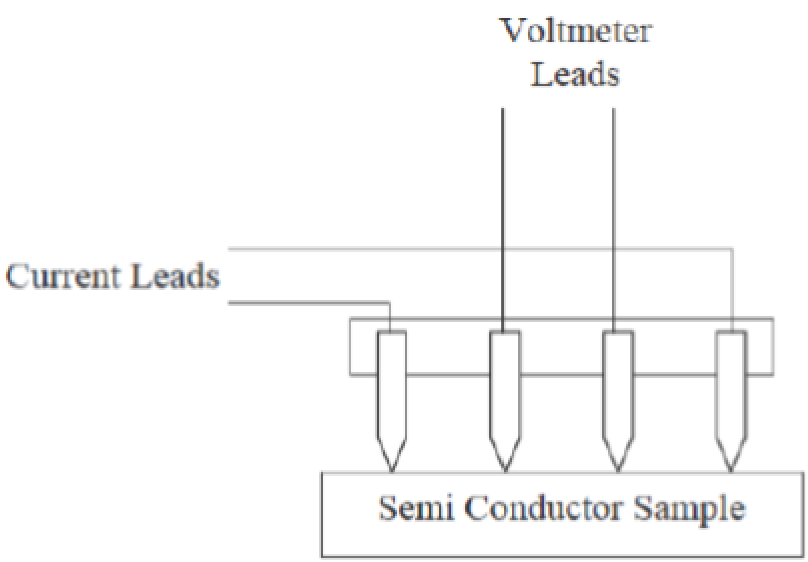
Learning objectives:

1. To find the band gap of semiconductor.
2. To study the variation of resistivity of semiconductor with temperature.

Theory

The energy band gap, E_g, of semiconductor is given by $E_g = 2k.\ 2.3026 \log_{10} \rho\ /\ 1/T$ (in K) in eV, where k is Boltzmann constant equal to 8.6×10^{-5} eV/deg., and 'ρ'is the resistivity of the semiconductor crystal, given by

$\rho = \rho_o\ /\ f\ (W/S)$ Where $\rho_o = V/I \times 2\pi S$. For function f (W/S) refer to the data table given in the calculations. S is the distance between the probes and W is the thickness of semi conducting crystal. V and I are the voltages and current across and through the crystal chip.



ng the four probes and let
and tighten the pipe in this

Four Probe Set Up

2. Place the four probe arrangement in the oven and fixed the thermometer in the oven through the hole provided.

3. Switch on the AC main of four probe set up put the digital meter in the current measuring mode through the selector switch. In this LED facing mA would glow. Adjust the current to a desire value (say 5 mA).

4. Note down the readings of milli voltmeter with the rise in temperature and corresponding value of temperature.

5. Plot the graph between 1000/T along x-axis and $\log_{10} \rho$ along y-axis. (T is absolute temperature)

GENERAL CALCULATIONS:

Sr.No	***Temp. T (K)***	***Voltage across inner probes V***	***10^3 /T where T is in K***	***ρ_o =(V/I) 2πs***	***$Log_{10}\rho$***

For a given sample, W/S =…….

Correction factor F (W/S) = ……

$\rho = \rho_o$ / f (W/S) =……….

Energy Band Gap = $2.303\times10^3 \times2\times8.617\times10^{-5}\times$Slope =…….eV

Plots: Plot the graph between 1000/T and $Log_{10}\ \rho$

Precaution:

1. The Ge crystal is very brittle. Therefore apply minimum pressure for proper electrical contacts.

2. Connect the outer pair of probes leads to the constant current power supply and the inner pair of probes to the voltage terminals.

3. The resistivity of the material is uniform in the area of measurement.

4. Measurement should be made on surface which has high recombination, such as mechanical lapped surfaces.

5. The surface on which the probe rest is flat with no surface leakage.

6. The four probes used for resistivity measurement contact the surface at points that lie in a straight line.

7. The boundary between the current carrying electrodes and the bulk material is hemispherical and small in diameter.

WORKSHEET OF THE STUDENT

AIM: To find out the energy band gap of a semiconductor by four probe method

Observation

Calculation

Learning Outcomes (what I have learnt)

To be filled by the faculty:

S. No.	**Parameter**	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.17

AIM: Determination of the velocity of Ultrasonic waves using Ultrasonic interferometer. Hence find the compressibility of the given liquid

Equipment to be used

Ultrasonic interferometer (High frequency generator and measuring cell with micrometer and quartz Crystal), Experimental liquid

Learning objectives:

1. Students will be able to learn about standing waves in liquid column
2. To provide had on experience of handling ultrasonic interferometer
3. To enhance their knowledge of production of ultrasonic waves.
4. To understand the dependence of velocity in different medium.

Theory:

Ultrasonic sound refers to sound wave with a frequency greater than the human available range (20 Hz to 20 KHz). When an ultrasonic wave propagates through a medium, the molecules in that medium vibrate over short distance in a direction parallel to the longitudinal wave. During this vibration, momentum is transferred among molecule. This causes the wave to pass through the medium. An Ultrasonic Interferometer is a simple and direct device to determine the ultrasonic velocity in liquid with a high degree of accuracy. In an ultrasonic interferometer, the ultrasonic waves are produced by the piezoelectric methods. At a fixed frequency variable path interferometer, the wavelength of the sound in an experimental liquid medium is measured, and from this one can calculate its velocity through that medium. The ultrasonic cell consists of a double walled brass cell with chromium plated surfaces having a capacity of 10 ml. The double wall allows water circulation around the experimental liquid to maintain it at a known constant temperature. The micrometer scale is marked in units of 0.01 mm and has an overall length of 25 mm. Ultrasonic waves of known frequency are produced by a quartz crystal which is fixed at the bottom of the cell. There is a movable metallic plate parallel to the quartz plate, which reflects the waves. The waves interfere with their reflections, and if the separation between the plates is exactly an integer multiple of half wave length of sound, standing waves are produced in the liquid medium. Under these circumstances, acoustic resonance occurs. The resonant waves are a maximum in amplitude, causing a corresponding maximum in the anode current of the piezoelectric generator. The ultrasonic interferometer consists of the following mainly two parts:

The high frequency generator

The high frequency generator is designed to excite the quartz crystal fixed at the bottom of the measuring cell at its resonant frequency to generate ultrasonic waves in the experimental liquid filled in the "measuring cell".

The measuring cell:

The measuring cell is specially designed for maintaining the temperature of the liquid constant during the experiment. A fine digital micrometer screw (LC 0.001 mm) has been provided at the top, which can lower or raise the reflector plate in the liquid within the cell through a known distance. It has a quartz crystal fixed at its bottom.

Working principle: The principle used in the measurement of velocity (U) is based on the accurate determination of the wavelength λ in the medium. Ultrasonic waves of known frequency (f) are produced by quartz crystal fixed at the bottom of the cell.

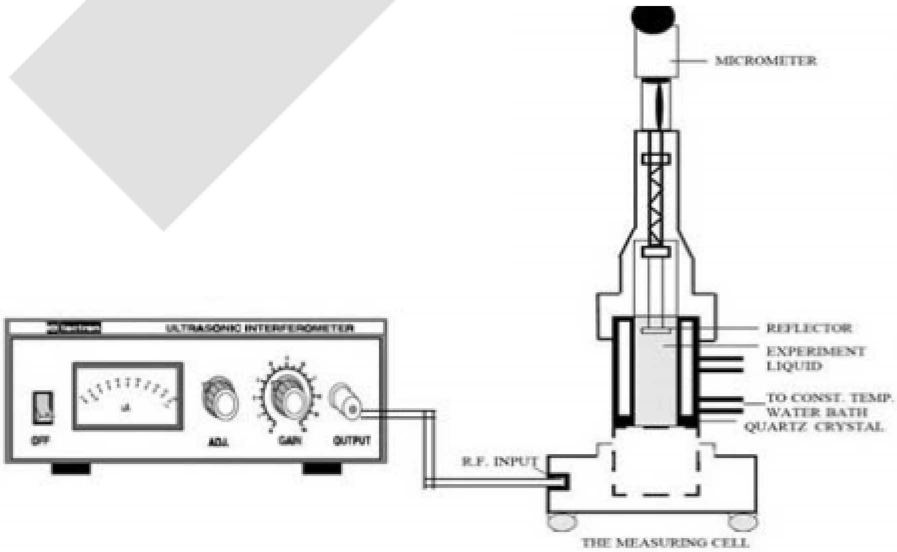


Figure 17.1: Schematic diagram of ultrasonic interferometer

A movable metallic plate kept parallel to the quartz crystal reflects these waves. If the separation between these two plates is exactly a whole multiple of the sound wavelength, standing waves are formed in the medium. This acoustic resonance gives rise to an electrical reaction on the generator driving the quartz crystal and anode current of the generator become a maximum. If the distance is now increased or decreased and the variation is exactly one half wavelengths (λ/2) or multiple of it, anode current become maximum from the knowledge of wavelength the velocity.

Figure 17.2: Experimental set-up of ultrasonic interferometer

It can be obtained by the relation: Velocity = Wavelength × Frequency

$$U = \lambda \times f$$

Adjustment of ultrasonic interferometer For initial adjustment two knobs are provided on high frequency generator, one is marked with “ADJ” to adjust the position of the needle on the ammeter and the knob marked “GAIN” is used to increase the sensitivity of the instrument for greater deflection, if desired. The ammeter is used to notice the number of maximum deflection while micrometer is moved up or down in liquid.

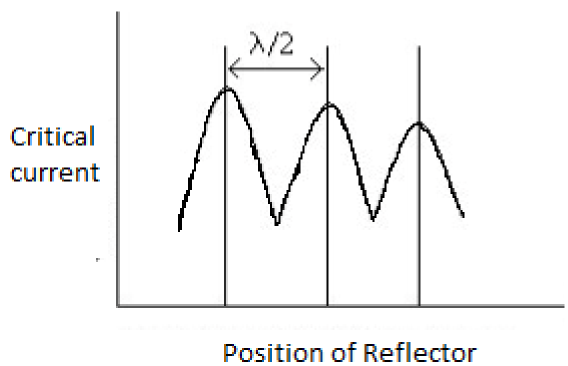


Figure17.3: Distance between antinodes

Procedure:

1. Unscrew the knurled cap of the cell and lift it away from double walled construction of the cell.
2. In the middle portion of it pour experimental liquid and screw the knurled cap. Wipe out excess liquid overflowing from the cell.
3. Insert the cell in the socket and clamp it with the help of a screw provided on its side. High frequency generator is connected to the cell using co-axial cables.
4. Move the micrometer slowly in either clockwise or anticlockwise direction till the anode current on the ammeter on the high frequency generator shows a maximum or a minimum. Note the readings of micrometer.
5. Take readings of a few consecutive maximum or minimum. The difference between two consecutive readings will give $\lambda/2$. Once the wavelength (λ) is known the velocity of ultrasonic wave in the liquid can be calculated.

Observations and Calculation:

Order of Maxima (n)	Micrometer reading for maximum			$\lambda/2 = (X_{n+1} - X_n)$	λ (mm)
	MSR (mm)	CSD	MSR + (CSD x LC) mm		
1 . 6					

Mean λ=

CALCULATIONS:

Frequency of the ultrasonic wave (f) = Wavelength
of the ultrasonic wave (λ) =
Velocity of the ultrasonic waves in the given liquid (v) = $\lambda \times f$
Compressibility $=1/\rho v^2$

Precautions:

1. Move the micrometer slowly in either clockwise or anticlockwise direction till the anode current on the ammeter on the high frequency generator shows a maximum or minimum.
2. Partially fill the liquid in the cell.

<u>Book suggested</u>

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

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WORKSHEET OF THE STUDENT

AIM: Determination of the velocity of Ultrasonic waves using Ultrasonic interferometer also find the compressibility of the given liquid

Order of Maxima (n)	**Micrometer reading for maximum**			**$\lambda/2 = (X_{n+1} - X_n)$**	**λ (mm)**
	MSR (mm)	CSD	MSR + (CSD x LC) mm		
1					
2					
3					
4					
5					
6					

Mean λ=

CALCULATIONS:

Frequency of the ultrasonic wave (f) =

Wavelength of the ultrasonic wave (λ) =

Velocity of the ultrasonic waves in the given liquid (v) = $\lambda \times f$

Compressibility $=1/\rho v^2$

Error analysis:

Learning Outcomes:

To be filled by the faculty:

S.No.	**Parameter**	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20

3	Completion of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.18

AIM: To find the numerical aperture of an optical fibre using He-Ne laser

Apparatus: He-Ne laser source, A microscope, two fiber optic chucks, optical fibre, screen, graph paper, millimeter scale, measuring tape.

Theory:

An optical fibre consists of a core that is surrounded by a cladding. The core and cladding are normally made of silica glass, although polymer materials are also in use. The function of the core is to transmit an optical signal while the purpose of the cladding is to guide the light within the core, in effect to confine the light within the core. A fibre is sometimes called an optical waveguide because light is guided through the fibre. The basic construction of a fibre is shown in figure 18.1. In order to confine the optical signal to the core of the fibre the core and cladding materials are deliberately given different refractive indices, so that the refractive index of the core (n_1) is higher than that of the cladding (n_2). The refractive index of a material decides whether the material transmits or reflects a light ray that intersects the surface of the material. The simplest type of fibre is called a step index fibre, since in such a fibre there is a step in the value of the refractive index at the boundary between the core and the cladding. This is shown in figure 18.2 which displays the so called refractive index profile of a step index fibre. The refractive index profile of a fibre is a graph which shows how the refractive index varies with distance from the centre of the fibre. In a step index fibre the refractive index is constant at n_1 until the core cladding boundary is reached, where the refractive index falls to n_2. The core diameter of step index multimode fibre is typically 200nm, with a cladding diameter of 300nm. A light ray that enters the fibre does not merely travel straight down through the centre of the core. Instead light rays within the core are continually reflected at the core/cladding boundary so that the rays remain within the core. This process is called total internal reflection and is the means by which an optical signal is confined to the core of a fibre. Figure 18.3 illustrates the process for a step index fibre.

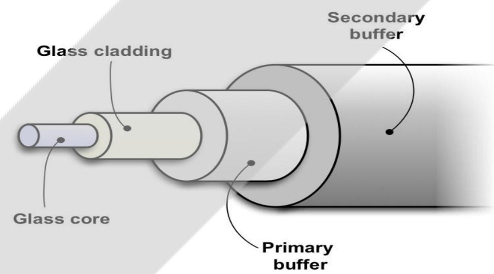


Fig.18.1 The basic construction of a fibre

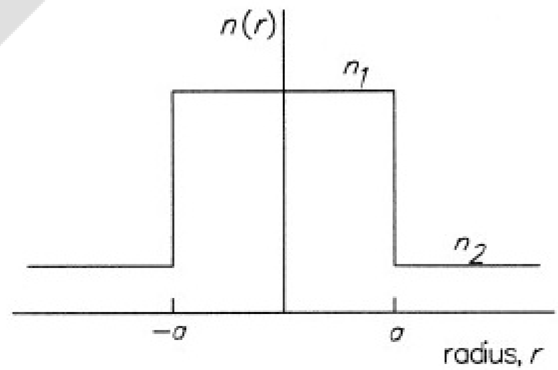


Fig.18.2: Refractive index profile of a step index fibre

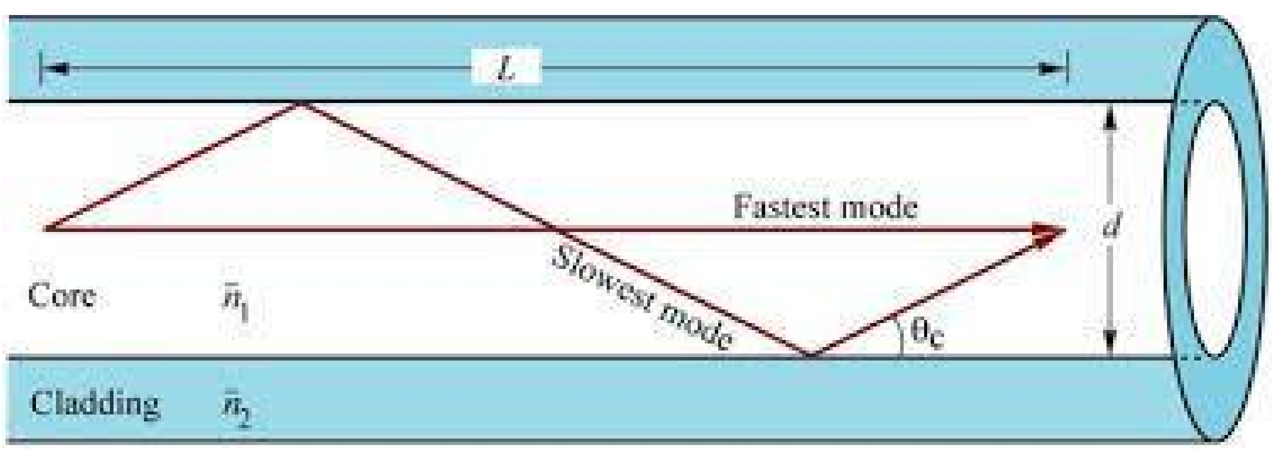


Fig.18.3: Fibre Optic Cable

In order to understand the process in more detail consider in Figure18.3 a light ray (i) entering the core and then travelling through the core until it reaches the core cladding boundary . As long as the light ray intersects the core/cladding boundary at a small enough angle the ray will be reflected back into the core to travel where the process of reflection is repeated. If a ray enters the fibre at a steep angle, for example light ray (ii), then when this ray intersects the core/cladding boundary the angle of intersection is too large and reflection back in to the core does not take place and the light ray is lost in the cladding. This means that to be guided through a fibre a light ray must enter the core with an angle that is less than the so called acceptance angle for the fibre. A ray which enters the fibre with an angle greater than the acceptance angle will be lost in the cladding. By convention the acceptance angle for a fibre can also be described by the term "numerical aperture". The fibre acceptance angle can be calculated from the refractive indices of the core and cladding using the formula:

$$\theta_1 = Sin^{-1}[\sqrt{n_1^2 - n_2^2}]$$

The numerical aperture of a fibre is simply equal to the mathematical sine of the fibre acceptance angle hence the numerical aperture (NA) is given by:

$$\mathrm{NA} = [\sqrt{n_1^2 - n_2^2}]$$

Procedure:

1. Mount both ends of optical fibre on fibre optic chucks.
2. Couple the light from He-Ne laser source to one end of the optical fibre through a 20 X microscope objective. This is the *'input end'*.
3. Place a white screen on which a m.m. graph paper has been pasted at some distance from the end other than the one which has been coupled to the light source. This end is known as *'output end'*.
4. Adjust the position of the screen such that it is perpendicular to the axis of the fibre. Move the screen towards or away from the output end of the optical fibre such that a circular spot is formed on the screen. Measure the distance between the output end of the optical fibre and the screen. Let it be L.
5. Measure the diameter of the circular spot in two directions at right angles either by counting the number of m.m. squares on the graph paper or by using am.m. scale. Let the diameter be D. then numerical aperture is given by:

$$A = \mathrm{Sin}\theta_a = D/2\sqrt{L^2 + (D/2)^2} = D/\sqrt{4L^2 + D^2}$$

6. Repeat the procedure for different values of L and corresponding values of D.

Observations:

S. No.	**Diameter of the spot**			**Distance (L)**	**Numerical aperture, A= Sinθ_a**
	Vertical	**Horizontal**	**Mean(D)**		

Mean A=

Therefore, mean numerical aperture, A =

Acceptance angle, $\theta_a = \text{Sin}^{-1}A =$

Precautions:

I. Do not see He-Ne laser source directly with naked eye .

II. The optical fibre must be connected through optic fibre chucks to avoid any leakage.

III. The light from the He-Ne source must be coupled to the optical fibre through a 20 X microscopic objective.

<u>Book suggested</u>

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

WORKSHEET OF THE STUDENT

AIM: To find the numerical aperture of an optical fibre using He-Ne laser.

Observation

Calculation

Error analysis

Learning outcomes

To be filled by the faculty

S. No.	Parameter	Marks obtained	Max. Marks

1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.19

AIM: To measure the attenuation and propagation loss in optical fibre using He-Ne Laser

Material required: He-Ne Laser, 20 X microscope objectives, fibre chucks, optical fibre, photo detector, digital multimeter etc.

Learning Objective:

1. To study the losses associated with optical fibre.
2. To study variation of attenuation loss with distance of an optical fibre.

Theory:

The detector circuit consists of a photo-transistor which converts the incoming light signal to a small current which flows through a series resistor. This gives rise to a voltage, the amplitude of which is controlled by the light intensity received by the phototransistor. This voltage is amplified and rectified (if necessary) within the detector circuit. We can, therefore, get a d.c. or an a.c. voltage at the output terminal of the photo-detector. The voltage is finally measured by a multi meter or a calibrated cathode ray oscilloscope.

Attenuation means loss of power. When light propagates along a fibre there is a loss of energy due to various mechanisms, thereby reducing its amplitude. For a single guided mode the attenuation of power can be represented as

$$P_{(Z)} = P_0\, e^{-\alpha Z}$$

Where $P_{(0)}$ is the power at the input end of the fibre, $P_{(Z)}$ the power after traversing a distance Z in the fibre and α the absorption coefficient. Thus loss in decibel per kilometer is given by

$$\text{Loss (dB/km)} = (10/Z) \log (P_0/P_Z)$$

The losses in optical fibre are due to absorption, scattering, bending and micro bending. When the light pulse is converted into an electrical signal of voltage V, then P is proportional to V^2. If the voltage reading at the input end of the optical fibre is V_1, then

$$P_0 \;\alpha\; V_1^2$$

Again, if V_2 is the voltage reading at the output end of the fibre of length Z, then

$$P_Z \alpha V_2^2$$

$$(P_0/P_Z) = (V_1^2/V_2^2)$$

Hence, $$\text{Loss (dB/km)} = (10/Z) \log (P_0/P_Z) = (10/Z) \log (V_1^2/V_2^2)$$

$$= (20/Z) \log (V_1/V_2)$$

Where Z is in Km.

Procedure:

1. Measure the length of the optical fibre. Let it be Z. Mount both ends of the optical fibre on fibre chucks.
2. Couple a 20X microscope objective to the He-Ne Laser source. Place the photo detector in such a manner that light from the microscope objective is completely falling on it.

   Set the multi meter in **d.c.** voltage mode and connect it to the output terminal of the photo detector. Note the reading of the voltage in the multi meter. Let it be V_1.
3. Couple one of the fibre ends to the 20X microscope objective attached to the He-Ne Laser source. This is the input end. Now place the photo detector just at the output end of the fibre so that light coming out of this end falls completely on the detector. Let the reading of the multimeter connected to the output terminal of the photo detector now be V_2.
4. Take 3 readings with one length of the fibre and repeat with one more length.

Precautions:

1. Observe all precautions for use of a He-Ne Laser source.
2. The optical fibre must be connected through optic fibre chucks to avoid any leakage.
3. The light from the He-Ne source must be coupled to the optical fibre through a 20X Microscope objective.

Required Results: Measurement and corresponding error analysis.

Parameters: NA

Relationship to be determined: NA

Graph: NA

<u>Book suggested</u>

1. B.Sc Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.sc Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

WORKSHEET OF THE STUDENT

***AIM**: To measure the attenuation and propagation loss in optical fibre using He-Ne Laser*

Observation

Calculation

Error analysis

Learning outcomes

To be filled by the faculty

S. No.	Parameter	Marks obtained	Max. Marks

1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No.20

AIM: To study the characteristics of a Zener diode using ICs

Equipment required: R.P.S. (range 0-30V), Ammeter (0-100) μA, voltmeter (0-1V), diode (IN4001) and resistor (1K-Ohm)

Material Required: Bread board, connecting wires etc

Theory:

Diodes which are designed with adequate power dissipation capabilities to operate in the breakdown region are known as avalanche, breakdown, or zener diodes. Zener diodes are heavily doped diodes. It behaves as ordinary diode in the forward bias mode. When the applied reverse bias voltage across the diode is increased, the electric field across the depletion layer becomes very intense and electrons get pulled out from covalent bonds, generating electron hole pairs. Thus heavy reverse current flow, so this phenomenon is known as zener breakdown.

Formula:

Percentage load regulation = $(V_{NL}-V_{FL})/V_{NL}$

Where, V_{NL} is No load voltage, V_{FL} is full load voltage

Specifications

1N5V6

Nominal zener voltage, Vz = 5.6V

Zener test current, I_{ZT} = 45mA

Maximum zener impedence, Z_{ZT} = 5ohms, Z_{ZK} = 600 ohms

Zener knee current, I = 1mA

Procedure:

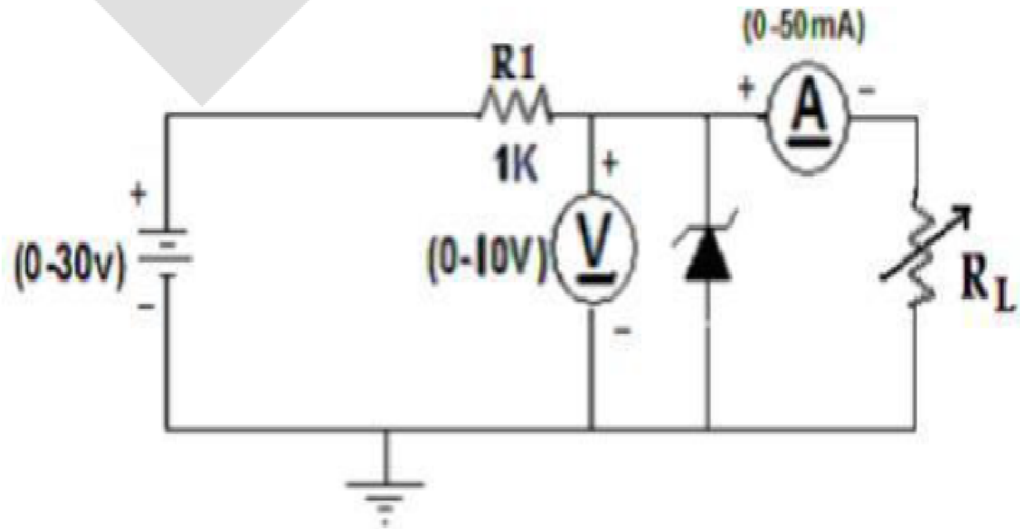
1. Set up the circuit as per the circuit diagram with correct polarity provisions.

2. Keep potentiometer at constant maximum value for various input voltages, measure output voltage.

3. Plot the graph between input and output voltages, and is called line regulation.

4. Keep the input voltage as constant for various loads, measure IL and output voltage Vo.

5. Plot the graph between load current and output voltage and is called load regulation



Model Graph:

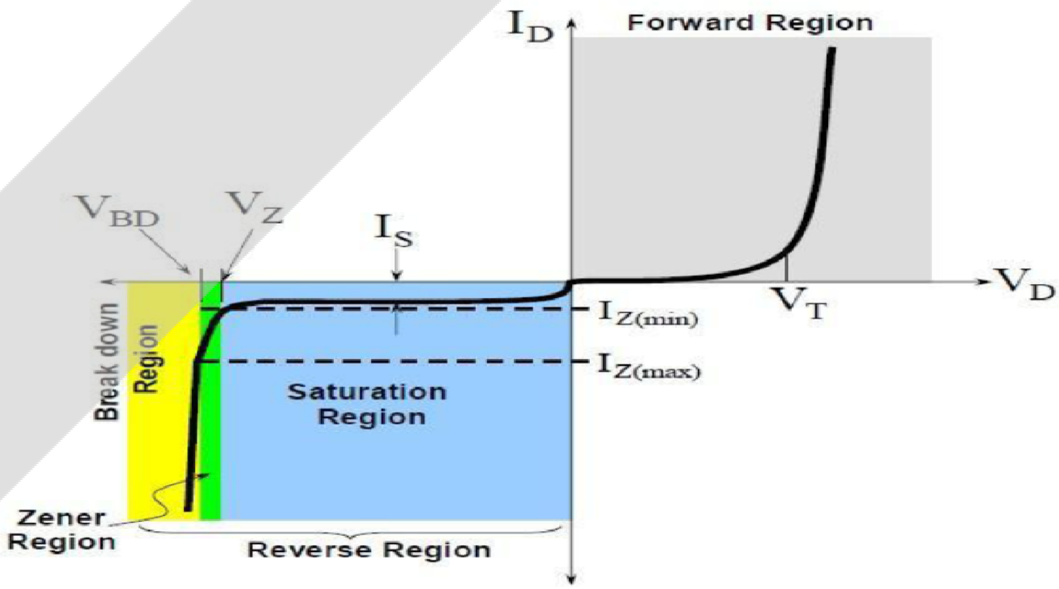


Figure No. 20.1

Figure no 20.2

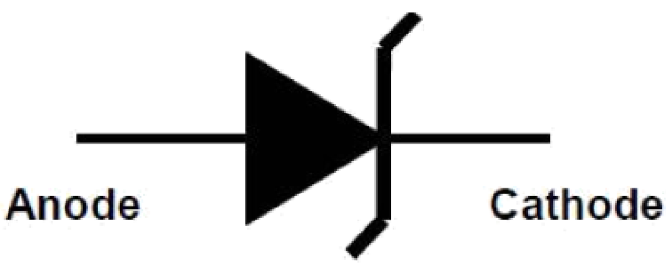


Fig. 3 Zener diode schematic symbol

Figure no 20.3

Result:

Precautions:

1. Connect circuit very carefully with all connections tight and clear.
2. Do not short circuit positive and negative terminals of supply at any point in circuit.

<u>Book suggested</u>

1. B.Sc. Practical Physics by C.L. Arora S.Chand Publication, 20th edition (2015).
2. B.Sc. Practical Physics by Harman Singh and Dr. P.S. Hemne, S.Chand Publication, 1st edition (2011)

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WORKSHEET OF THE STUDENT

AIM: To study the characteristics of a Zener diode using ICs

Observation

Calculation

Error analysis

Learning outcomes

To be filled by the faculty

S. No.	**Parameter**	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		20
2	Observations and analysis including learning outcomes		20
3	Completion of experiment, Discipline and Cleanliness		10
	Signature of Faculty	**Total marks obtained**	

Experiment No. 21

Aim: To plot a graph between current and frequency in LCR series and parallel circuit and find resonant frequency, quality factor and band width.

Equipment Required: An audio-frequency oscillator (range 10 Hz to 10 kHz), an electronic or vacuum tube voltmeter or a cathode ray oscilloscope (C.R.O.), a millimeter. Connecting wires, an inductance coil, a capacitor, a non-inductive resistance box etc.

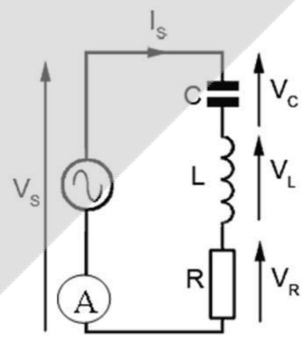
Learning Objectives:

Study the response of LCR circuit by varying the resistance in the circuit

Student will learn about the variation of current with frequency in LCR series and parallel circuit.

Outline of the Procedure: Series LCR circuit

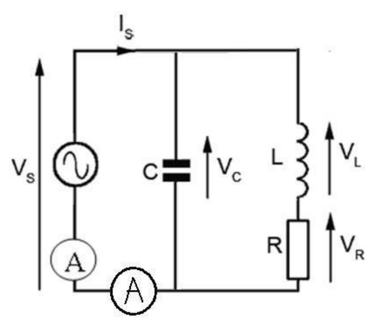
Connect the LCR (series/parallel) circuit as per circuit diagram. Join other components in the circuit.



With output voltage of the oscillator kept constant throughout the experiment vary the value of A.F. in steps of 100 Hz and measure the corresponding value of current in milliameter for each observation. Repeat the experiment for two more different values of R. Plot a graph between current and frequency. Make analysis from the graph.

Parallel LCR circuit

Connect the L, R and C in parallel as shown in the figure below:



From the given values of L and C, calculate the natural frequency of the circuit and adjust the oscillator to the frequency N for Parallel resonance. Adjust the output voltage of the oscillator and the resistance R to get minimum current within the range of mA. The value of output voltage of the oscillator and R must be kept constant throughout the experiment. Now decrease the frequency of the A.F. oscillator in steps of 100 Hz and measure the corresponding value of current in milli-ammeter for each observation. Similarly increase the frequency above the resonance frequency in steps of 100 Hz and measure the value of current in each case. Repeat the experiment for different values of R.

Scope of the results expected:

Graph between current and frequency will be Gaussian.

Resonant frequency, quality factor and band width can be calculated from the graph. And the results calculated from the given values should be compared with the results from the graphs.

Parameters:

Resistance R =

Inductance L=

Capacitance C=

Current at different values of frequency at a specific value of resistance (Also compare the result with values from graph) to find resonant frequency, current at resonance, quality factor, band width for series and parallel combination. [Report data in tabular or systematic manner.

Observations (SERIES):

S.No.	Frequency (Hz)	Current in the circuit in mA for		
		1	R_2	R_3

(PARALLEL):

S. No.	Frequency (Hz)	Current in the circuit in mA for		
		1	R_2	R_3

Example: Quality Factor (For R1) Maximum value of current at resonance I = mA Corresponding frequency N = Hz 0.707 I = mA

Corresponding value of frequency Below N = N_1 = Hz

Above N = N_1 = Hz Band width $\beta = N_2 - N_1$= Hz

So, Quality factor $Q= 2\pi N/ (N_2-N_1)$

Calculated value of Q from inductance L= $L\omega/R = 2\pi NL/R$

Calculated value of Q from Capacitance C= $1/\omega CR=1/2\pi NCR$

Plots:

Plot a graph between current and frequency at different values of resistance (Series).

Plot a graph between current and frequency at different values of resistance (Parallel).

Precautions:

The value of inductance L and capacitance C should be properly selected so that the natural frequency of the circuit lies between 1000 and 2000 Hz.

Adjust the frequency of AF oscillator when the milliammeter in the LCR gives maximum current.

The value of output voltage of oscillator and resistance R must be kept constant throughout the experiment.

Resonance position must be obtained first by decreasing frequency and then by increasing the frequency.

The VTVM or the CRO must be used with its proper range.

Suggested readings for students:

Books:

1. ELECTRICITY MAGNETISM & ELECTROMAGNETIC THEORY, by Shobhit Mahajan and S Rai Choudhury, Tata McGraw-Hill Education, 2012

2. Introduction to Electrodynamics (3rd Edition) by David J. Griffiths, Prentice Hall, 1999

Weblinks:

1. http://hyperphysics.phy-astr.gsu.edu/hbase/electric/rlcpar.html
2. http://hyperphysics.phy-astr.gsu.edu/hbase/electric/rlcser.html

Worksheet of the student

Date of Performance Registration Number

Experiment: To plot a graph between current and frequency in LCR series and parallel circuit and find resonant frequency, quality factor and band width.

Parameters:

Resistance R =

Inductance L=

Capacitance C=

Observations (SERIES):

(PARALLEL):

S.No.	Frequency (Hz)	Current in the circuit in mA for		
		1	R_2	R_3

(PARALLEL):

S.No.	Frequency (Hz)	Current in the circuit in mA for		
		1	R_2	R_3

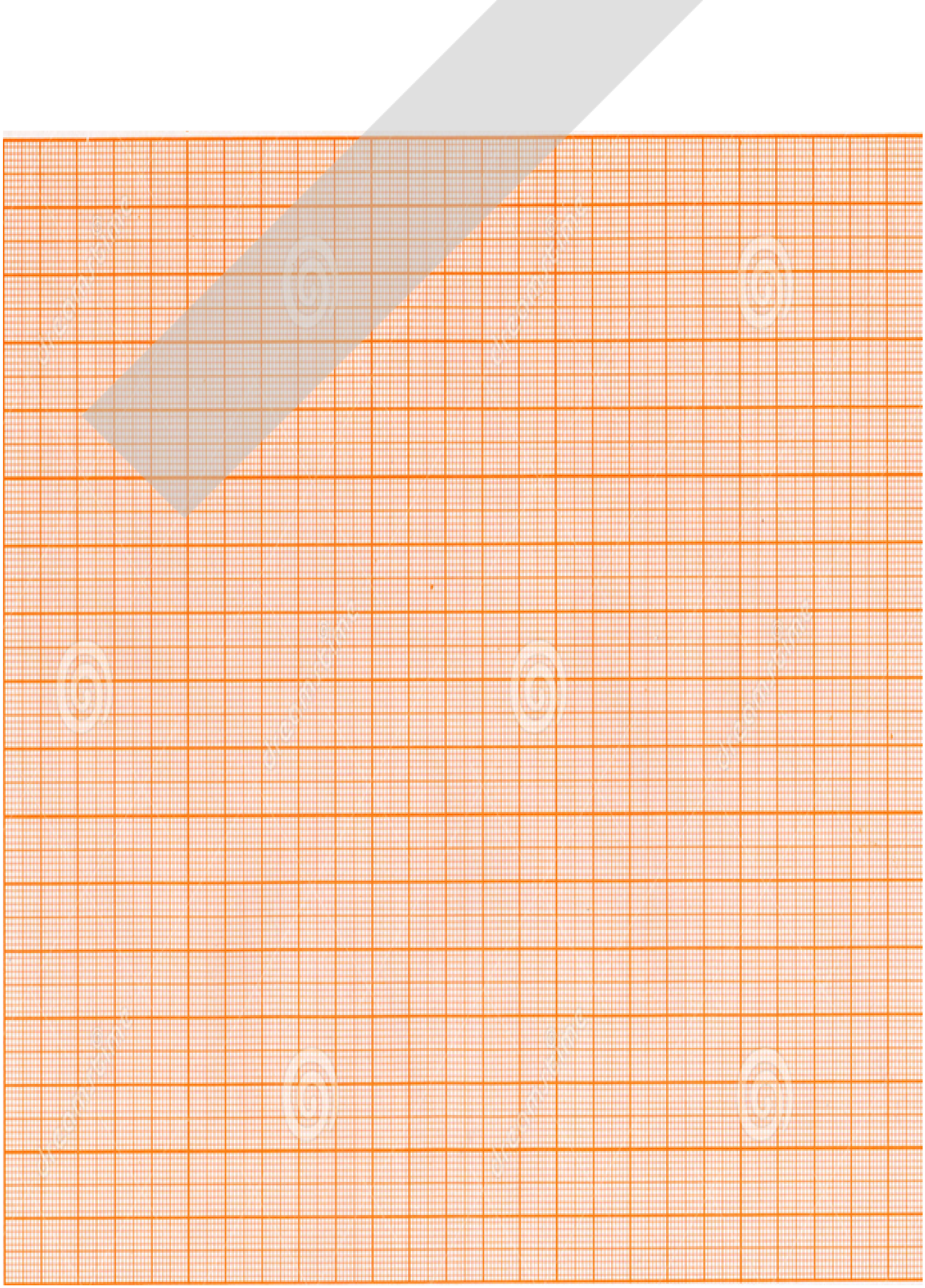
Calculations:

Learning Outcomes (what I have learnt):

To be filled in by Faculty:

S.No.	**Parameter**	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the		**20**

	procedure/apparatus.		
2	Observations and analysis including learning		**20**
3	Completion of experiment, Discipline and		**10**
	Signature of Faculty	**Total marks**	



Experiment No. 22

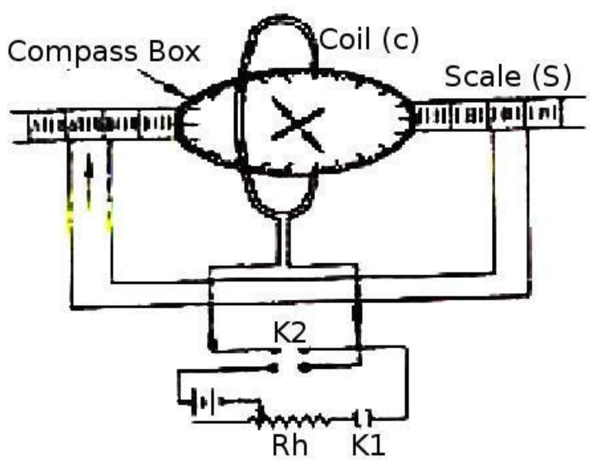
Aim : To study the variation of magnetic field with distance along the axis of a circular coil carrying current by plotting a graph

Equipments required: Stewart and Gee's type tangent galvanometer, a battery, a rheostat, an ammeter, a one-way key, a reversing key, connecting wires.

Learning Objectives:

1. To understand the working of Tangent Galvanometer using Tangent Law.
2. To study the direction and magnitude of the magnetic field around the coil.

Circuit Diagram



Procedure:

1. Place the instrument in such a way that the arms of the magnetometer lie roughly east and west and the magnetic needle lies at the centre of the vertical coil. Place the eye a little above the coil and rotate the instrument in the horizontal plane till the coil, the

needle and its image in the mirror provided at the base of the compass box, all lie in same vertical plane. The coil is thus set roughly in the magnetic meridian. Rotate the compass box so that the pointer lies on the 0-0 line.

2. Connect the galvanometer to a battery, rheostat, one way key and an ammeter through a reversing key.
3. Adjust the value of the current so that the magnetometer gives a deflection of the order of 60-70 degrees. Reverse the current and note the deflection again.
4. Now slide the magnetometer along the axis and find the position where the maximum deflection is obtained. Note the position of arm against the reference mark and also the value of current. Read both ends of the pointer in the magnetometer, reverse the current and again read both ends. Now shift the magnetometer by 2 cm and note the reading again. Record a number of observations. Similarly repeat the observation by shifting the magnetometer in the opposite direction and keeping the current constant at the same value.

Observations:

Least count of magnetometer=

Current I =

r. o.	**e from the tre, x (in cm)**	**Left Side**		**Mean θ**	**tan θ**	**Right Side**		**Mean θ**	**ta θ**
		Direct	**Reversed**			**Direct**	**Reversed**		

5. **Plots & Parameters**: Plot a graph between tan θ and x, where θ is the deflection produced in a deflection magnetometer and ‘x’ is the distance from the centre of the coil. The intensity of magnetic field varies with distance from the centre of coil, the graph can be plotted and variation can be known. The intensity of magnetic field is maximum at the centre and goes on decreasing as we move away from the centre of the coil towards right or left.
6. The value of magnetic field at the centre of coil and radius of coil can also be determined from this experiment. A graph showing the relation between B and the distance ‘x’ is plotted. The curve is first concave towards O and then afterwards becomes convex. Then the points where the curve changes its nature are called the point of inflection. The distance between the two points of inflexion is equal to the radius of the circular coil.

Plot in *x and tanθ*: *The plot of **tanθ** vs x will be found as shown in Fig 3.*

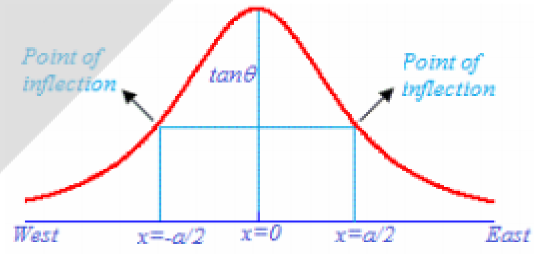


Fig. 3

Result: With help of the graph between tan θ and x, following points can be concluded.

1. The intensity of magnetic field is maximum at the centre and goes on decreasing as we move away from the centre of the coil towards right or left.

2. The point on the both side of graph where curve becomes convex to concave (i.e. the curve changes its nature) are called the point of inflection. The distance between the two points of inflexion is equal to the radius of the circular coil.

3. The radius of coil= distance between points of inflection=………..cm

Precautions:

1.There should be no magnet, magnetic substances and current carrying conductor near the apparatus.

2.The plane of the coil should be set in the magnetic medium.

3.The current should remain constant and should be reversed for each observation.

Suggested readings for students:

Books:

1. ELECTRICITY MAGNETISM & ELECTROMAGNETIC THEORY, by Shobhit Mahajan and S Rai Choudhury, Tata McGraw-Hill Education, 2012

2. Introduction to Electrodynamics (3rd Edition) by David J. Griffiths, Prentice Hall, 1999

Worksheet of the student

Date of Performance　　　　　　　　　　　　　　　Registration Number

Experiment: To study the variation of magnetic field with distance along the axis of a circular coil carrying current by plotting a graph.

Observations:

Least count of magnetometer=

Current I =

r. o.	e from the tre, x (in cm)	Left Side		Mean θ	tan θ	Right Side		Mean θ	ta θ
		Direct	Reversed			Direct	Reversed		

Calculation : Plot the graph between the tanΘ along Y axis and ‘x ‘along x axis and calculate the radius of coil from graph.

Learning Outcomes (what I have learnt):

To be filled in by Faculty:

.No .	**Parameter**	**Marks obtained**	**Max. Marks**
1	Understanding of the student about the procedure/apparatus.		**20**
2	Observations and analysis including learning		**20**
3	Completion of experiment, Discipline and		**10**
	Signature of Faculty	**Total marks**	