KAMMAVARI SANGHAM (R) 1952

K. S. INSTITUTE OF TECHNOLOGY

Affiliated to VTU, Belagavi & Approved by AICTE, New Delhi, Accredited by NAAC & IEI

No.14, Raghuvanahalli, Kanakapura Main Road, Bengaluru - 560109

ENGINEERING PHYSICS

LABORATORY MANUAL

18-PHYL16 / 26

I / II SEMESTER

DEPARTMENT OF PHYSICS

NAME: ______________________

U S N No.: ______________________

SEMESTER: __________ BATCH: __________

BRANCH: ______________________

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Vision

"To impart quality technical education with ethical values, employable skills and research to achieve excellence"

Mission

- To attract and retain highly qualified, experienced and committed faculty.
- To create relevant infrastructure.
- Network with industry and premier institutions to encourage emergence of new ideas by providing research and development facilities to strive for academic excellence.
- To inculcate the professional and ethical values among young students with employable skills and knowledge acquired to transform the society.

DEPARTMENT OF SCIENCE AND HUMANITIES

VISION

"To create a conducive environment to impart sound fundamentals and problem solving skills among the students and prepare them for higher learning"

Mission

- To continuously improve the teaching-learning process and maintain effective pedagogy.
- To inculcate ethical and professional values among students.
- To create institute –industry interaction to promote research.

DEPARTMENT OF PHYSICS

Sunil kumar N,
Assistant Professor.

Dr Renuka C
Assistant Professor.

ENGINEERING PHYSICS LABORATORY

18-PHYL16 / 26

INSTRUCTIONS TO STUDENTS

Students must

1. Adhere to the **discipline** laid down by the college.
2. Attend the lab classes with **uniform.**
3. Conduct the experiments with interest and attitude of learning.
4. Come to the laboratory **in time** and carry **Record book, lab manual, observation book and graph book**.
5. Should use only **black ball point pen** or black fountain pen for all purposes in lab – for writing in observation book, lab manual, record book, drawing and plotting the graphs (**Do not use pencil** in the lab)
6. Handle the apparatus gently and carefully.
7. Take **responsibility** of the materials issued to you, **remove circuit connections** after the completion of experiment and return borrowed materials in the same condition.
8. Don't Not write/mark anything on the working table or apparatus.
9. Submit **observation book, lab manual** and **laboratory record** completed in time.
10. Attend the lab **with prior preparation** for the experiments.
11. Take signature from staff in charge for the **first reading** of the experiments.
12. Write laboratory records as explained. In the laboratory record, **Aim, Apparatus, Principle, Procedure and Result should be written in the ruled page in the same order.** Circuit diagram/Block diagram, Nature of graphs, Observations [includes Formula with explanation of the terms with proper SI units, Least count formula (if necessary), Data given, Tabular column and Calculations] should be written in the blank page in the same order.
13. **Graph** plotted should be **pasted** similar to the record pages.
15. **No additional** lab test will be given for the student who is absent for the lab internals and Uniform is compulsory for lab internals and repetitions.

<u>**Note**</u>: Continuous Internal Evaluation (CIE) marks [Max. Marks: 40] is awarded based on:

1.	Performance in laboratory (Observation book, viva voice and lab record)	- 30 M
2.	Performance in Internal Test	- 10 M
	Total:	**40 M**

Minimum CIE marks to be scored: 20 marks

Course Objectives and Course Outcomes

Course: Engg. Physics Lab **Course Code:** 18PHYL16/26

Course Objectives:

To make students gain practical knowledge to correlate with theoretical studies and achieve perfectness in experimental skills in general physics, electronics, mechanical & magnetism.

Course Outcomes:

After the completion of Engineering Physics Lab course, students will be able to

Analysis, examine the chateristics of photo diode, transistor, elasticity for various rigid bodies and understand Fermi energy in metals.
Design and discover the ability to use various passive electrical components, determine Dielectric constant and electrical resonance. Study the concepts of diffraction and interference of light

Note:

i) Distribution of Marks in Observation Book

1. Write-up	07 M
2. Experimental set up / Circuit connection	03 M
3. Conduction and Reading	06 M
4. Graph, Calculation & Accuracy	04 M
5. Viva-Voce	10 M
Total:	**30 M**

ii) Distribution of Marks in Lab Record

1. Presentation:	08 M
2. In time Submission:	02 M
Total:	**10 M**

INDEX

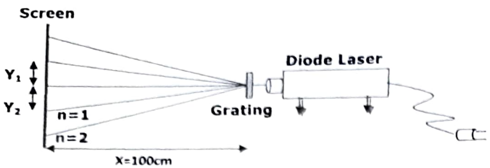
SL.No.	EXPERIMENT	DATE OF CONDUCTION	DATE OF SUBMISSION	MARKS			SIGNATURE
				RECORD	OBSERVATION	viva	
			I WEEK				
1	DIFFRACTION GRATING						
2	TORSIONAL PENDULUM						
			II WEEK				
3	CHARGING AND DISCHARGING						
4	I-V CHARACTERISTICS OF PHOTO DIODE						
			III WEEK				
5	FERMI ENERGY						
6	NEWTONS RINGS						
			IV WEEK				
7	TRANSISTOR CHARACTERISTS						
8	SINGLE CANTILEVER						
			V WEEK				
9	SERIES PARALLEL						
10	MAGNETIC FIELD INTENSITY						
			VI WEEK				
11	SPRING CONSTANT						
12	OPTICAL FIBER						

EXPERIMENTS PRINCIPLE AND VIVA SAMPLE QUESTIONS

Rubrics for Evaluation of Engg. Physics Lab (18PHYL16/26) Observation Book

Sl.No	Attributes	Sub-attributes	Descriptor (score)	Max. Score
1	Write-up (07)	Formulae (03)	• Formulae with explanation of terms with units (03) • Formulae with explanation of terms without units(02) • Formulae without explanation of terms & units (01)	07
		Tabular column (02)	• Tabular column with required terms & units (02) • Tabular column with required terms & no unit (01) • Tabular column without required terms & unit (01)	
		Circuit diagram / Ray diagram / Block diagram (02)	• Diagram with labeling of parts / components / polarity including model graphs (02) • Diagram with labeling of parts / components / polarity without model graphs (01) • Diagram without labeling of parts / components /polarity & model graphs (01)	
2	Experimental set up / Circuit connection (03)	-	• Makes complete experimental set up / circuit connections (03) • Makes experimental set up / circuit connections with one or two inputs from faculty (03) • Makes experimental set up / circuit connections with three to four inputs from faculty (02)	03
3	Conduction and Readings (06)	Conduction (04)	• Conducts experiment with variation of parameters in specified steps (4) • Conducts experiment with variation of parameters not in specified steps (03) • Conducts experiment without the knowledge of variation of parameters in specified steps (02)	06
		Readings (02)	• 100 % of the readings are followed to exact result (2) • More than 50% of readings are following the proper trend (1) • More than 25% of readings are following the proper trend (0)	
4	Graph , Calculations , Results and accuracy (04)	-	• Plotting proper Graph with scale, Proper Calculations, mention of result and accuracy (04) • Plotting proper Graph, Proper Calculations, without mention of result (03) • Plotting proper Graph, wrong Calculations (02) **Note: For experiments without graph, add 2 marks to calculation part.**	04
5	Viva – voce (one question of definition type (4M) + 4 questions of explanatory type (2M) + 2 and applications (1M) + 2 = 10)	-	• Answers all the questions (10) • Answers all explanatory questions only (04) • Answers two explanatory questions and one question of definition type only (05) • Answers two explanatory questions only (04) • Answers one explanatory question and one question of definition type only (03) • Answers one explanatory question only (02) • Answers one question of definition type (01)	10
			Total Max. Marks = Observation marks 20/2=**10**, viva voice=**10**	**20**

OBSERVATION:



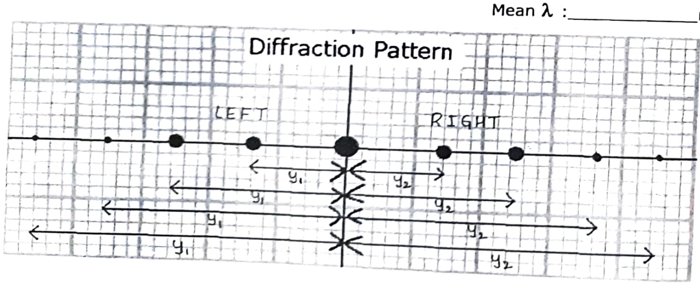
Formula: $\lambda = \frac{\sin\theta}{nN} m$

No. of lines per meter on the grating **N**= 2.2×10^4 lines/m.

Distance between the grating and the screen **X**=100cm.

Order of diffraction n	Distance between central maximum of the n^{th} order maximum		Average $Y = \frac{Y_1+Y_2}{2}$ (cm)	Deviation $\theta = \tan^{-1}\left(\frac{Y}{X}\right)$	$\lambda = \frac{\sin\theta}{nN}$ (m)
	Left Y_1 (cm)	Right Y_2 (cm)			
1					
2					
3					
4					

Mean λ :______________m



DIFFRACTION GRATING

AIM: To determine the wavelength of LASER beam using diffraction grating.

APPARATUS: Diffraction grating, grating holder, diode laser (semiconductor laser), screen fixed with graph sheet and meter scale.

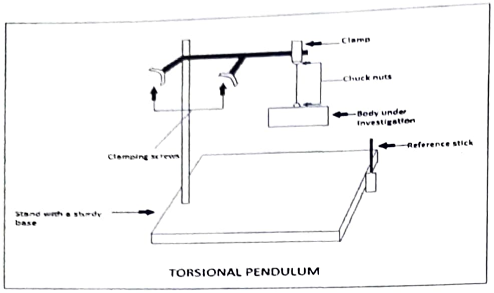
PROCEDURE: The experimental arrangement is made as shown in the figure. Distance between the grating and the screen is adjusted to 1 meter (X). The laser beam is incident normally on the grating. Diffraction pattern is obtained on the screen. The screen is adjusted such that the central bright maximum coincides with the '0' of the scale fixed on the screen. The separation between central bright maximum and first order maximum to the left of diffraction pattern (say Y_1) is measured. Same is repeated to first order maximum to the right of the screen (say Y_2). Procedure is repeated by taking readings for up to fourth order and readings are tabulated. Angle of deviations (θ) for each order is calculated. Wavelength of Laser beam is determined using the formula

$$\lambda = \frac{\sin\theta}{nN} m$$

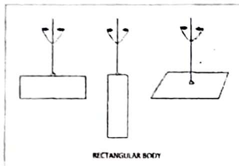
where n is order of diffraction pattern, $N=2.2\times10^4$ lines/m. The average wavelength is determined from the table.

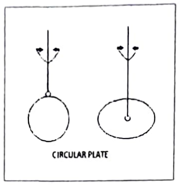
Result: The wavelength of LASER beam is given by λ = __________________m.

Observations:



TORSIONAL PENDULUM





Formula:

The Rigidity modulus of the Material of the wire:

$$\eta = \frac{8\pi l}{r^4}\left(\frac{I}{T^2}\right)_{mean} \quad N/m^2$$

Measurement of Dimensions

a) Mass of the rectangular plate M_1 =______________

b) Length of the rectangular plate L =______________

c) Breadth of the rectangular plate B=______________

d) Mass of the circular plate M_2=______________

e) Radius of the circular plate R = ______________

EVALUATION OF THE RIGHIDTY MODULUS OF THE MATERIAL OF THE SUSPENSION WIRE:

Diameter of the wire **d**=0.062cm

Measurement of radius of the suspension wire **r**

Radius **r**= d/2 =____________m

Length of the wire **l**=____________

TORSIONAL PENDULUM

Aim: To determine the rigidity modulus of the material of the given suspension wire, by setting up a torsional pendulum.

Apparatus Required: Rectangular plate, circular plate, and stand with clamp. Steel wire fixed between check nuts, reference stick, thread, meter scale, stop clock.

Procedure: The masses M1 and M2 of the rectangular and circular plates respectively, are found by weighing then each in a rough balance upto accuracy of ± gm. The length L, the Breadth B, of the rectangular plate, and also the circumference C of the circular plate (with the help of a thread), are found by using a meter scale, to an accuracy of ± 1 mm. The moment of inertia values of the two bodies about the respective axes are evaluated by using the corresponding equations listed in tab- column I.

The experimental wire whose both ends are tightly fastened to two check nuts is taken. One of the check nuts is firmly clamped to the stand. The rectangular plate is screwed on to the other check nut (Fig 1), without permitting the wire to undergo any twisting while the body is fixed to it.

A convenient reference mark at the edge of the body is identified [for Examples in fig 1, it is one of its edges]. The reference stick is placed just next to it. The body is given a gentle rotation, so that it oscillates in small amplitude with the wire as its axis, without any wobbling motion. At the moment when the body reference mark crosses the reference stick, a stop clock is started. The oscillation is counted as one, when the body reference mark crosses the references stick again in the same direction. Time taken't' for completing 10 oscillations is found under two trials. The body is then gently removed from the check nut.

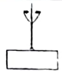
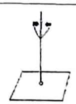
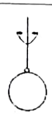
The same procedure is repeated for all the axes of oscillations of the rectangular and circular plates, listed in tab column I. Mean value of 't' is found from which the period T and hence T^2 are determined. The value of (I/T^2) is found out in each case. Mean value of (I/T^2) is found out.

The radius 'r' of the wire is found length "L" of the wire exposed between check nut to check nut is found out. The rigidity modulus '**η**' is evaluated by using the formula.

$$\eta = \frac{8\pi l}{r^4}\left(\frac{I}{T^2}\right)_{mean} \quad N/m^2$$

TABULAR COLUMN – I

MEASURTMENT OF (I/ T²) USING REGULAR BODIES —

	Axis through CG	Symbolic Representation	Moment of inertia I		Time for 10 oscillations(sec)		Mean (t) (Sec)	Period T= t/10	T^2 (SEC)	I/ Kgm²
			Concerned Equation	Value (kgm²)	Tiral-1	Tiral-2				
Rectangular Body	Perpendicular to the Length		$\frac{M_1L^2}{12}$							
	Perpendicular to the breadth		$\frac{M_1B^2}{12}$							
	Perpendicular to the plane		$\frac{M_1(L^2+B^2)}{12}$							
Circular Body	The Diameter		$\frac{M_2R^2}{4}$							

$$\left(\frac{I}{T^2}\right)_{mean} =$$

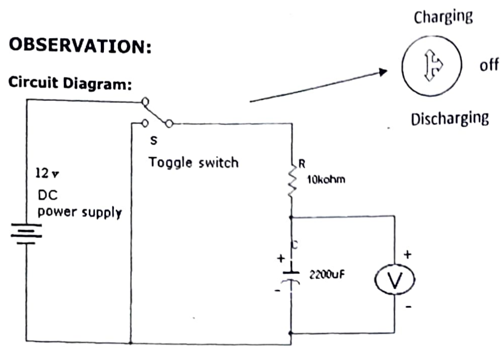
Calculations: $\eta = \frac{8\pi l}{r^4}\left(\frac{I}{T^2}\right)_{mean} N/m^2$

RESULTS:

The value of rigidity modulus of the material of the given suspension wire is found to be **η** =

OBSERVATION:

Circuit Diagram:



V = Voltmeter

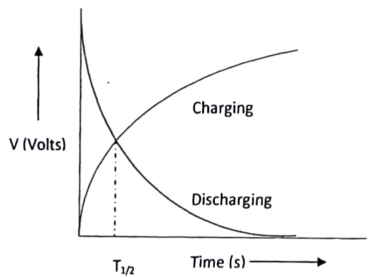
C = Electrolytic Capacitor

R = Resistor

S=Toggle switch

Formula: Dielectric Constant, $\varepsilon_r = \frac{1.44\times10^{-9} T_{1/2}\, d}{\varepsilon_0 R A}$

Time t (s)	Voltage (V)	
	Charging	Discharging
0		
10		
20		
30		
40		
50		
60		
70		
80		
90		
100		
110		
120		



Calculations:

From Graph $T_{1/2}$ = Sec

Area of the Capacitor plates = **A**= 35.15mm^2

Distance between the plates = **d**= 8.85mm

Resistance **R** = 100K Ω

Permittivity of free space ϵ_0=8.854× $10^{-12}\, f/m$

ε_r= ____________

DIELECTRIC CONSTANT

AIM: To determine the dielectric constant of the dielectric material of the capacitor by the method of charging and discharging.

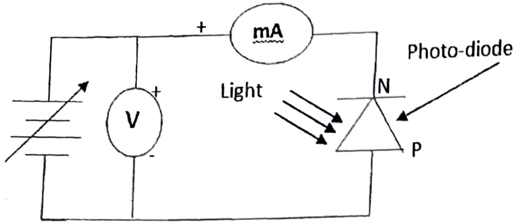
APPARATUS: 12V DC Adaptor, Toggle switch(S), Electrolytic capacitor(C), Resistor(R), connecting wires.

PROCEDURE: The circuit connections are made as shown in the circuit diagram. The terminals of the capacitor are shorted before connecting it in the circuit to remove the residual charge. It is ensured that the toggle switch is at the center. The Toggle switch is turned-on for charging and simultaneously a stop clock is started. The potential difference across the capacitor is noted for every 10 seconds until the saturation is reached (i.e. the voltage across the capacitor remains constant). The readings are tabulated in the tabular column. After the saturation is achieved the toggle switch is turned off (Center). The stop clock is reset to zero. Then the Toggle switch is turned on for discharging and the stop clock is started. The voltage across the capacitor is noted for every 10 seconds until the capacitor discharges completely. The readings are tabulated in the tabular column. A graph of voltage Vs time is plotted on a single graph sheet for both charging and discharging. Time $T_{1/2}$ corresponding to the intersection of two curves is noted from the graph. The dielectric constant of the material of the capacitor is determined using the formula

$\varepsilon_r = \frac{1.44\times10^{-9} T_{1/2}\, d}{\varepsilon_0 R A}$, Where ε_0 is permittivity of free space, R is the resistance, A is area of the plates of the capacitor and d is the thickness of the dielectric material between the plates of the capacitor.

RESULT: The dielectric constant of electrolytic parallel plate capacitor is found to be ε_r = ____________

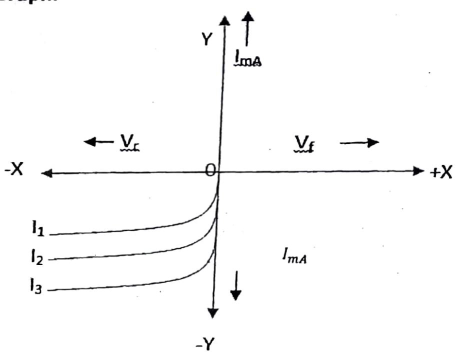
OBSEVATION:



Variation of PD voltage with current

V_{PD}(V)	I_{PD}(mA)		
	INENSITY 1	INENSITY 2	INENSITY 3
0			
-0.2			
-0.4			
-0.6			
-0.8			
-1.0			
-2.0			
-3.0			
-4.0			
-5.0			

Graph:



I V CHARATERSTICS OF PHOTO DIODE

AIM: To study the I V characteristics of photodiode

APPARATUS:

Photo-diode (PN junction), Voltmeter, micro-ammeter, Variable DC Source and light source (Electric bulb)

PROCEDURE:

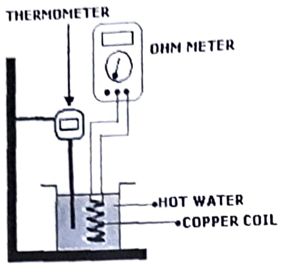
The circuit connection as made as shown in the diagram. The P-N junction photo diode is reverse biased.

1. Set the voltage to 5 V, adjust the light falling on the photodiode to maximum intensity and adjust the distance between light source and photodiode such that micro-ammeter reads maximum current and bring back the voltage to zero.
2. Now vary the voltage in steps as shown in the tabular column and note down the corresponding reverse bias current readings.
3. Repeat the experiment by decreasing the intensity range as before and tabulate the values in the tabular column
4. Plot a graph of reverse bias voltage along the −ve X-axis and the corresponding currents along the −ve Y-axis. We get the V-I characteristic curve of photo-diode as shown in the graph

RESULT:

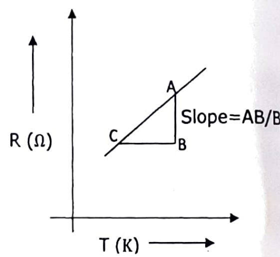
From the graph it is clear that the current through the photo-diode increases due to the decrease of the resistance of diode junction with the increase of intensity of light.

OBSERVATION:



Formula: Fermi Energy $E_F = 1.37 \times 10^{-15}\sqrt{\frac{DAS}{L}}$ J

Sl.No.	Temperature		Resistance R (Ω)
	T(°C)	T (K)	
1			
2			
3			
4			
5			
6			
7			



Calculation:
The Length of the Copper wire **L**=11 m
The Diameter of the Copper wire **d**=0.25mm
Density of copper **D**= 8.96×10^3 kg/m^3

Area of Cross-section of the copper wire = $A = \frac{\pi d^2}{4}$ =__________ m^2

Slope= **S**=

E_F=____________________J

E_F=____________________eV

FERMI ENERGY OF COPPER

AIM: To determine the Fermi energy of copper by studying the variation of resistance with temperature.

APPARATUS: Copper coil, Thermometer, Ohmmeter, Beaker and hot water.

PROCEDURE: The circuit connections are made as shown in the circuit diagram. The copper coil is immersed in the beaker filled with hot water. A thermometer is introduced into hot water. Starting with the temperature of 85°C, the resistance (R) of the copper coil is measured using ohmmeter and the temperature of the water is measured using the digital thermometer. The resistance of the copper coil is measured for every 5°C fall in temperature (T) of water up to 60°C. A graph of Resistance (R) Vs Temperature (T) is plotted. The slope (S) is determined. Given the Length (L) and the diameter (d) of the copper wire, the Fermi energy of copper is calculated using the formula

$$E_F = 1.37 \times 10^{-15}\sqrt{\frac{DAS}{L}} \text{ J}$$

(Where D is Density of copper = 8.96×10^3 kg/m^3, L is the Length of the copper wire, 'A' is the area of cross-section of the wire and 'S' is the slope).

The value of Fermi Energy obtained in units of joule is divided by 'e', the charge of an electron ($e = 1.6 \times 10^{-19} C$) to obtain the value of Fermi energy in units of electron volt (eV).

Result: - The Fermi energy of Copper is found to be **E_F**= ______________ eV

OBSERVATION:

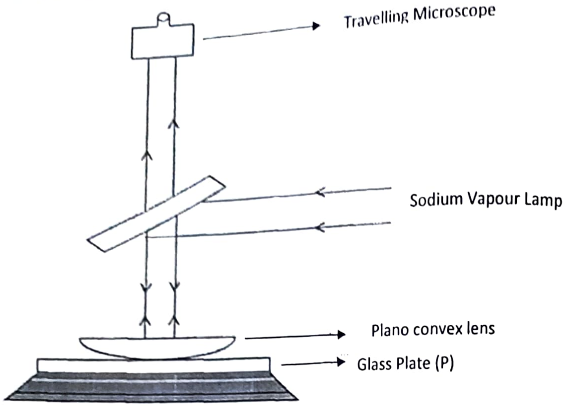


Figure: Newtons Ring Set up

Least count of travelling microscope, LC = $\frac{\text{Value of one PSD}}{\text{Total number of HSD}} = \frac{1\text{mm}}{100} = 0.001$ cm

HSD= Head scale divisions

PSD= Pitch scale division

Table 1:

Ring No.	LEFT			RIGHT		
	PSR(cm)	HSR	TR = PSR + (HSR × LC) (cm)	PSR(cm)	HSR	TR = PSR + (HSR × LC) (cm)
12						
10						
08						
06						
04						
02						

Table 2:

Ring No. m	Left (TR)	Right (TR)	D_m(cm)	D_m^2(cm²)	Ring No. n	Left (TR)	Right (TR)	D_n(cm)	D_n^2 (cm²)	$D_m^2 - D_n^2$ (cm²)
12					06					
10					04					
08					02					

Mean $D_m^2 - D_n^2$ =________cm²

R = Radius of curvature of the surface of the lens in contact with the glass plate (P)

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

NEWTON'S RINGS EXPERIMENT

Aim: To determine the radius of curvature of the surface of the lens, by forming Newton's rings.

Apparatus: Newton's ring set, Sodium vapor lamp & Plane mirror.

Procedure:

The apparatus consists of a light source (Sodium vapour lamp). The parallel rays are incident on a plane glass plate through the magnifying glass inclined at 45° to the path of incident rays. Alternate bright & dark rings are observed through a traveling microscope.

The point of intersection of cross wires in the microscope is brought to the center of ring system; the cross wires is perpendicular to the line of travel of the microscope. The wire may be set tangential to any one ring and starting from the center of the ring system, the microscope is moved on to one side, say left, across the field of view counting the number of rings. After passing beyond 12th ring, the direction of motion of the microscope is reversed and the cross wire is set at the 12th dark ring, tangential to it. The pitch scale and the head scale reading on the microscope scale are noted. Similarly, the readings with the cross-wires set on 10th, 8th, 6th, 4th and 2nd dark rings are noted. The microscope is moved in the same direction and the readings corresponding to the 2nd, 4th, 6th, 8th, 10th and 12th dark ring on the right side are noted. Readings are to be taken with the microscope moving in one & the same direction to avoid errors due to backlash.

The observations are recorded in table 1 and the total reading is entered into table 2. The difference between the left and right total readings gives the diameter of the rings. The diameters of 12th, 10th and 8th rings are denoted by D_m. The diameters of 6th, 4th and 2nd dark rings are denoted by D_n. Where the difference between m and n is 6. The wavelength(λ) of the source used is 5890Å. Substituting these values in the formula below we can determine the radius of curvature, R of the lens

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

Where, D_m and D_n are the diameters of the m^{th} and n^{th} dark rings

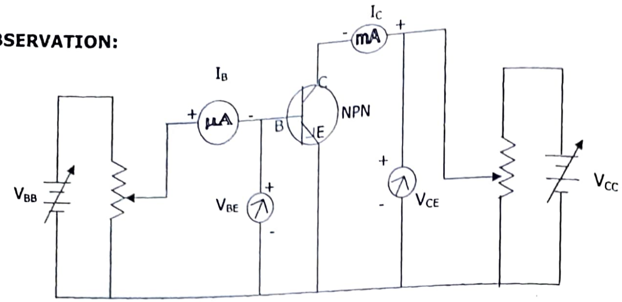
λ is the wavelength of the source(5890Å).

The values of D_m and D_n are very small and occur to the second power in equation. Hence they are to be measured carefully with the traveling microscope. Care is to be taken in moving the microscope to travel in a direction without moving back and forth while taking readings. This is very essential since the variation in the diameter of the rings is in the second decimal place and any back and forth movement of the microscope will result in wrong readings.

Result: The experiment on Newton's ring was conducted and the radius of curvature of the lens is found to be ______________m

DATE:

OBSERVATION:



To Study **INPUT** Characteristics

V_{CE}=2Volt	V_{BE} (Volt)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
	I_B(μA)								

Fig 1

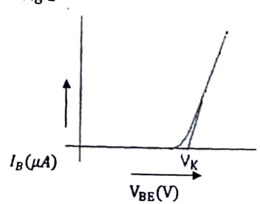
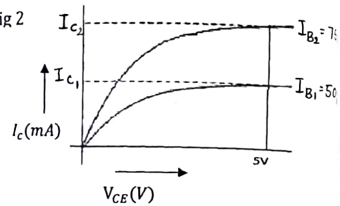


Fig 2



To Study **Output** Characteristics

	V_{CE}(Volt)	0	0.5	1	2	3	4	5	6	7	8
I_{B1} =50μA	I_{C1} (mA)										
I_{B2} =75μA	I_{C2}(mA)										

To find current amplification factorβ of the Transistor:

β of the transistor is given by $\beta = \frac{I_{C2} - I_{C1}}{I_{B2} - I_{B1}}$ = ...=....................

α of the transistor is given by $\alpha = \frac{\beta}{\beta+1}$ =..............

DATE:

TRANSISITOR CHARACTERISTS

AIM: To study input and output characteristic of the given NPN Transistor in CE mode and to findα and β of the transistor and also the knee voltage for silicon.

APPARATUS: Transistor, DC Regulated power supplies, DC Micro ammeter, DC Milliammeter, DC Voltmeter, Circuit board and patch cords.

PROCEDURE: The electrical connections are made as shown in the circuit diagram. The voltmeter is connected across collector-emitter junction and V_{CE} is adjusted for 2 volts. The voltmeter is now connected across emitter-base junction and V_{BE} is increased in terms of 0.1 volts up to 0.8 volts and corresponding value of base current I_B are recorded. A graph of base current I_B against base emitter voltage V_{BE} for constant V_{CE} is plotted. The graph obtained is as shown in the fig1. The straight-line portion of the curve is extrapolated so as to intersect the x-axis. The value of V_{BE} corresponding to pointof intersection is the **Knee Voltage.**.

The voltmeter is connected across collector-emitter junction. The base current I_B is adjusted for 50μA. The collector-emitter voltage V_{CE}isvaried in steps of 1volt till8volts and corresponding values of collector current I_C is recorded. The experiment is repeated by adjusting I_B for 75μA. The graph of I_C against V_{CE} is plotted for both the values of I_B. The graph obtained is as shown in the fig2.Horizontal lines are drawn to meet Y-axis at I_{C1} and I_{C2} from the point where the vertical line intercepts the curve. The value of current amplification factor βis determined using the formula.

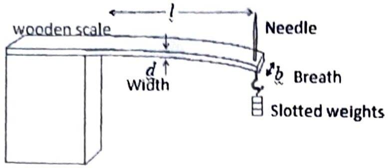
$$\beta = \frac{I_{C2} - I_{C1}}{I_{B2} - I_{B1}} \qquad \alpha = \frac{\beta}{\beta+1}$$

I_c is Collector Current, I_B is Base Current, β is Current Amplification Factor.

RESULT: The knee voltage of the transistor is found to be =____________V
The β of the transistor is found to be β = ________________
The α of the transistor is found to be **α**=________________

DATE:

OBSERVATION:
DIAGRAM:



FORMULA:

$$q = \frac{4mgl^3}{bd^3y} \; Nm^{-2}$$

M- mass producing the Elevation (in kg). g- Acceleration due to gravity= 9.8 ms^{-2}. l - Distance between the needle and fixed end is 20 cm (in m). b & d -2.845cm and 0.605cm breadth and thickness of the wooden scale (in m). y - Mean elevation produced (in m).

Travelling microscope:

$$LC = \frac{Value\, of\, 1\, MSD}{Total\, no.\, of\, VSD} = \text{..............}$$

TR= MSR+ (CVD x LC)

Tabular column to find elevation

Load in hanger (g)	Load increasing			Load decreasing			Mean R_1 (cm)	Load in hanger (g)	Load increasing			Load decreasing			Mean R_2 (cm)	Elev… y=R (cm
	MSR (cm)	CVD	Total (cm)	MSR (cm)	CVD	Total reading (cm)			MSR (cm)	CVD	Total reading (cm)	MSR (cm)	CVD	Total reading (cm)		
0								150								
50								200								
100								250								

Mean elevation, y = ------------ m

CALCULATION:

$$q = \frac{4M\,g\,l^3}{b\,d^3\,y}$$

DATE:

YOUNG'S MODULUS BY SINGLE CANTILEVER

AIM: - To determine the young's modulus of the material of the given beam by the method of single cantilever.

APPARATUS: - Single cantilever setup, slotted weights, travelling microscope, reading lens and lamp.

FORMULA:

$$q = \frac{4mgl^3}{bd^3y} \; Nm^{-2}$$

Where, M- mass producing the Elevation (in kg).

g- acceleration due to gravity (= 9.8 ms-2).

l- distance between the needle and fixed end (in m).

b&d -breadth and thickness of the wooden scale (in m).

y- mean elevation produced (in m).

PROCEDURE:-

The tip of the needle (inverted image) on the single cantilever is made to coincide with the intersection of the cross wire of the travelling microscope (with no load in the hook). Note down the readings of the travelling microscope in the tabular column as the no load reading.

Now add some weight to the hook (say 50gm). Again coincide the tip of the needle to the intersection of the cross wire and corresponding readings are noted in the tabular column. This is repeated up to 250gm in steps of 50 gm every time and corresponding readings are noted in the tabular column.

The experiment is repeated by decreasing the load in the weight hanger in steps of 20g and the corresponding readings are taken and are tabulated. The elevation or deflection of the cantilever beam 'y', for load 'M' in kg is found out from the tabular column. By using the breadth (b) and thickness (d) of the bar, the young's modulus of the material of the beam is calculated.

RESULT:- Young's modulus of the material of the beam is found to be

q= ---------------- Nm^{-2}

OBSERVATION:

Series and Parallel LCR Circuits :

Frequency 'f' in KHz	Series Current 'I' in mA	Parallel Current 'I' in mA
1.0		
1.5		
1.6		
1.7		
1.8		
1.9		
2.0		
2.1		
2.2		
2.3		
2.4		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		

Series Resonance Circuit

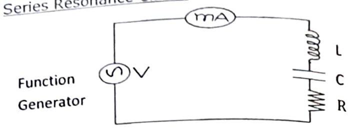


Fig 1

Parallel Resonance Circuit

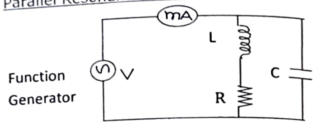


Fig 3

Series Resonance Circuit

Resonant frequency = $\mathbf{f_0}$=________________ Hz

Band Width=**BW**= (f_2-f_1) = ________________

Capacitance = **C**=0.047μF

Inductance = $\mathbf{L}=\frac{1}{4\pi^2 f_0^2 C}$ = ________ mH

Quality factor=**Q**=$f_0/(f_2-f_1)$ =

Series

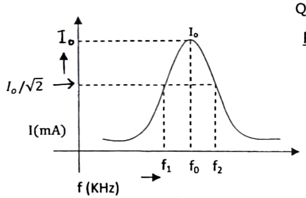


Fig 2

Parallel

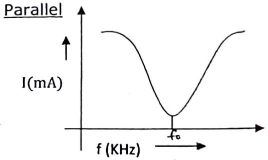


Fig 4

Parallel Resonance Circuit: Resonant frequency $\mathbf{f_0}$=________________ Hz.

Calculation:

SERIES PARALLEL RESONANCE

AIM: To study the frequency response of series LCR and parallel LCR circuit and to determine the following.

Series: Resonant frequency $\mathbf{f_0}$, Bandwidth **BW**, Quality factor **Q** and Inductance L.

Parallel: Resonant frequency $\mathbf{f_0}$.

APPARATUS: Resistor, Inductor, Capacitor, Function generator, AC milli ammeter, and patch cords.

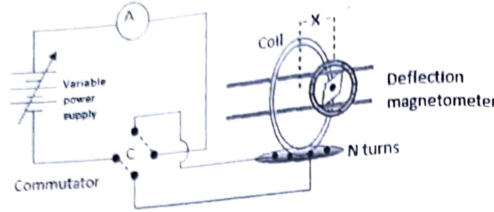
PROCEDURE: The resistor, capacitor and inductor are connected in series with milli ammeter and function generator as shown in the fig. 1. The frequency is increased in steps of 500Hz starting from 1000Hz till 5000Hz and corresponding values of current are recorded until current increases, becomes maximum and decreases. Between 1500Hz to 2500Hz increase the frequency in steps of 100Hz. A graph of current against frequency is plotted. The curve obtained is as shown in fig.2. The Resonant frequency, Bandwidth and Quality factor are determined with the help of graph. The inductance of the given Inductor is determined using the formula.

The capacitor is connected in parallel with resistor and inductor. This combination is then connected in series with milliammeter and function generator as shown in fig3. The experiment is repeated as it was done for series resonant circuit. Here current decreases, becomes minimum and again increases as frequency is increased. A graph of current against frequency is plotted. The curve obtained is as shown in the fig4. From the graph, resonant frequency is determined.

RESULT:

	Series	Parallel
Resonant frequency f_0	Hz	Hz
Band width BW	Hz	
Quality factor Q		
The Inductance L	mH	

OBSERVATION:
CIRCUIT DIAGRAM:



Formula: $B = \frac{\mu_0 nI}{2} \frac{a^2}{(a^2 + x^2)^{3/2}}$

$B_H = \frac{B}{\tan\theta}$

Tabulor column:

Sl. No.	Current I in A	x in m	Deflections in degrees				Average θ in degree	B inT	$B_H = \frac{B}{\tan\theta}$ In T
			θ_1	θ_2	θ_3	θ_4			
1	0.4	0							
2		0.05							
3		0.1							
4		0.15							
5	0.8	0							
6		0.05							
7		0.1							
8		0.15							

Number of turns n = 50 turns

Radious of the coil a = 8.6cm

The Earth's horizontal magnetic field intensity is found to be B_H =...............T

MAGNETIC FIELD ALONG THE AXIS OF A COIL

AIM: To determine the magnetic field intensity along the axis of a circular coil carrying current and earth's horizontal magnetic field by deflection method.

APPARATUS: Deflection magnetometer, sprit level, commutator, ammeter, variable power supply and connecting wires.

FORMULA:

$$B = \frac{\mu_0 nI}{2} \frac{a^2}{(a^2 + x^2)^{3/2}}$$

Where B - the magnetic field intensity at the centre of a circular coil, n - number of turns in the T_G coil, a - radius of the coil x - distance between the centre of the coil and pointer in the compass box , μ_0 - permeability of free space = $4\pi x10^{-7}$ Hm^{-1}, I - the current through the coil.

$B_H = \frac{B}{\tan\theta}$ Where B_H - horizontal component of earth's magnetic field and θ - mean deflection in TG.

PROCEDURE:

The connections are made as shown in the circuit diagram. Arrange the deflection of the magnetometer in the magnetic meridian of the earth Now align the plane of the coil with respect to 90°-90° line of the magnetometer. Keep the magnetometer exactly at the centre of the coil (for this case x = 0). Pass a current I (say 0.4 A) to flow through the coil and the corresponding magnetometer deflections θ_1 and θ_2 are noted. The direction of the current is reversed by using the commutator C and the corresponding magnetometer deflections θ_3 and θ_4 are noted. Average deflection θ is calculated.

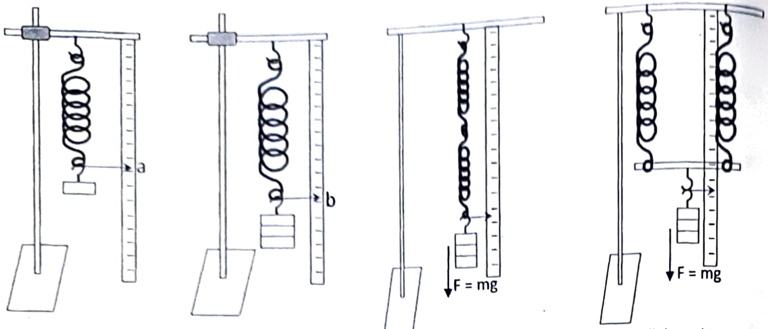
Calculate the magnetic field at the centre of the coil by using the given formula $B = \frac{\mu_0 nI}{2} \frac{a^2}{(a^2 + x^2)^{3/2}}$ and also B_H. Repeat the experiment for different values of x (say 5cm, 10cm,) by sliding the magnetometer along the axis. Find the average of both B and B_H.

RESULT: The magnetic field intensity along the axis of the given circular coil is calculated and is as shown in the tabular column.

The Earth's horizontal magnetic field intensity is found to be B_H =...............T

DATE:

DIAGRAM:-



With initial load   With load   Series combination   Parallel combination

FORMULA:- 1) Spring constant, $k = \frac{F}{x}$ $in\ Nm^{-1}$

2) Spring constant for Series combination of springs,

$$k_{Series} = \frac{k_1 k_2}{k_1 + k_2} \quad in\ Nm^{-1}$$

3) Spring constant for Parallel combination of springs

$$k_{Parallel} = k_1 + k_2 \quad in\ Nm^{-1}$$

Where, F – Force applied (= mg) in N.   x – Displacement produced in the spring in m.

TABULAR COLUMN:-

To find k_1

Pointer reading with initial load(w), a = ... cm

Trial No.	Load in gm	Pointer reading 'b' in cm	Spring stretch (x = b - a) in cm	Force, F (F = mg) in N	Spring constant k_1 = F/x in N/m
1	W + 50				
2	W + 100				
3	W + 150				

Average k_1 = ... N/m

DATE:

SPRING CONSTANT

AIM: - To determine the spring constants in Series and Parallel combination.

APPARATUS: Springs, Scale, Rigid stand, Slotted weights, etc.

FORMULA: - 1) Spring constant,

$$k = \frac{F}{x} \quad in\ Nm^{-1}$$

Where, F – Force applied (= mg) in N.

x – Displacement produced in the spring in m.

2) Spring constant for Series combination of springs,

$$k_{Series} = \frac{k_1 k_2}{k_1 + k_2} \quad in\ Nm^{-1}$$

3) Spring constant for Parallel combination of springs,

$$k_{Parallel} = k_1 + k_2 \quad in\ Nm^{-1}$$

PROCEDURE:-

Hang the spring1 to the given rigid stand with dead load and note down the position 'a' of the pointer on the scale with initial load. Add some more load into the weight hanger (say 50gm) and note down the position 'b' of the pointer on the scale with final load. Repeat the same for some more loads in steps of 50gm and tabulate the readings in the tabular column. Find out the average spring constant 'k_1'.Repeat the above steps for the spring 2 and find out 'k_2'

DATE:

To find k_2

Pointer reading with initial load(w), a = ... cm

Trial No.	Load in gm	Pointer reading 'b' in cm	Spring stretch (x = b - a) in cm	Force, F (F = mg) in N	Spring constant $k_2 = F/x$ in N/m
1	W + 50				
2	W + 100				
3	W + 150				

Average k_2 = ... N/m

To verify series combination of springs

Pointer reading with initial load(w), a = ... cm

Trial No.	Load in gm	Pointer reading 'b' in cm	Spring stretch (x = b - a) in cm	Force, F (F = mg) in N	Spring constant $K_{series} = F/x$ in N/m
1	W + 50				
2	W + 100				
3	W + 150				

Average K_{series} = ... N/m

Theoretical calculation, $k_{Series} = \frac{k_1 k_2}{k_1 + k_2}$ in Nm^{-1}

To verify parallel combination of springs

Pointer reading with initial load (w), a = ... cm

Trial No.	Load 'm' in gm	Pointer reading 'b' in cm	Spring stretch (x = b - a) in cm	Force, F (F = mg) in N	Spring constant $K_{parallel} = F/x$ in N/m
1	W + 50				
2	W + 100				
3	W + 150				

Average $K_{parallel}$ = ... N/m

Theoretical calculation, $k_{Parallel} = k_1 + k_2$ in Nm^{-1}

DATE:

To verify Series combination law of springs:

Hang the springs in series combination as shown in the diagram. With the initial load, note down the position 'a' of the pointer on the scale. Add some more load into the weight hanger (say 50gm) and note down the position 'b' of the pointer on the scale with final load. Repeat the same for some more loads in steps of 50gm and tabulate the readings in the tabular column. Find out the average spring constant 'K_{series}'.

To verify Parallel combination law of springs:

Hang the springs in parallel combination as shown in the diagram. With the initial load, note down the position 'a' of the pointer on the scale. Add some more load into the weight hanger (say 50gm) and note down the position 'b' of the pointer on the scale with final load. Repeat the same for some more loads in steps of 50gm and tabulate the readings in the tabular column. Find out the average spring constant '$K_{parallel}$'.

Calculate the theoretical values of K_{series} and $K_{parallel}$ and compare the values with experimental values.

RESULT:-

The spring constants for the springs are found to be, k_1 = ... N/m

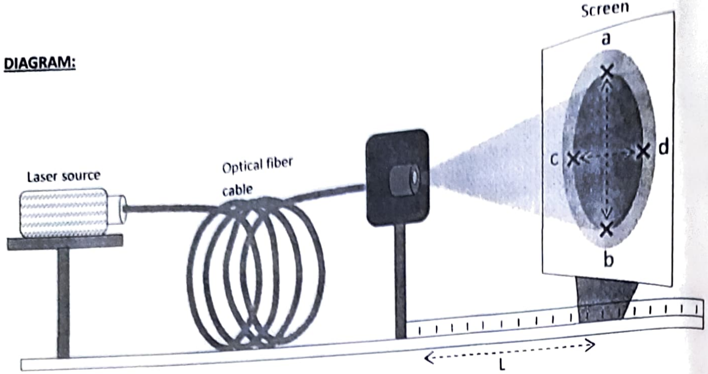
k_2 = ... N/m

The spring constants for the combination of springs are found to be,

Combination	Theoretical	Experimental
Series	K_{series} =	K_{series} =
Parallel	$K_{parallel}$ =	$K_{parallel}$ =

DATE:

DIAGRAM:



FORMULA: The Acceptance angle,

$$\theta_0 = \tan^{-1}\left(\frac{D}{2L}\right)$$

Numerical Aperture,

$$NA = \sin\theta_0$$

Where D – the diameter of the bright circle formed on screen,

L – the distance between the optical fiber end and screen.

Tabular column:

Trail No.	L (in cm)	Horizontal diameter D_1 (in cm)	Vertical diameter D_2 (in cm)	Mean Diameter D (in cm)	Acceptance angle $\theta_0 = \tan^{-1}\left(\frac{D}{2L}\right)$	Numerical aperture NA $NA = \sin\theta_0$
1	3					
2	6					
3	9					
4	12					

$(\theta_0)_{mean}$ = __________ $(NA)_{mean}$ = __________

DATE:

ACCEPTANCE ANGLE AND NUMERICAL APERTURE

AIM: To determine the Acceptance angle and Numerical aperture of the given optical fiber.

APPARATUS: Laser source, Optical fiber, Screen, Scale.

PRINCIPLE: The Sine of the acceptance angle of an optical fiber is known as the numerical aperture of the fiber. The acceptance angle can also be measured as the angle spread by the light signal at the emerging end of the optical fiber. Therefore, by measuring the diameter of the light spot on a screen and by knowing the distance from the fiber end to the screen, we can measure the acceptance angle and there by the numerical aperture of the fiber.

FORMULA: The **Acceptance angle,** $\theta_0 = \tan^{-1}\left(\frac{D}{2L}\right)$

Where D – the diameter of the bright circle formed on screen,
L – the distance between the optical fiber end and screen.

Numerical Aperture,

$$NA = \sin\theta_0$$

PROCEDURE:

Switch on the laser source and adjust the distance between output end of the optical fiber and the screen 'L' (say 5 cm). Place a graph sheet on the screen and observe the circle formed on the graph sheet. Mark the points 'a','b','c' & 'd' on the inner bright circle as shown in the diagram. Note down the horizontal diameter D_1 and vertical diameter D_2 of the inner bright circle in the tabular column. Repeat the above steps for different values of L (for 4cm, 3cm, ...). Find the Acceptance angle from the tabular column and hence the Numerical aperture.

RESULT: The Angle of acceptance and Numerical aperture of the given optical fiber are found to be

θ_0 = ... NA = ...

APPLICATIONS

DIFFRACTION GRATING

Medicine: Bloodless surgery, laser healing, surgical treatment, kidney stone treatment, eye treatment, dentistry.

Industry: Cutting, welding, material heat treatment, marking parts, non-contact measurement of parts.

Military: Marking targets, guiding munitions, missile defense, electro-optical countermeasures (EOCM), alternative to radar, blinding troops.

Law enforcement: used for latent fingerprint detection in the forensic identification field.

Research: Spectroscopy, laser ablation, laser annealing, laser scattering, laser interferometry, LIDAR, laser capture microdissection, fluorescence microscopy.

Semiconductor lasers find important use in optical communications, also used as reading devices for CD players.

CHARGING AND DISCHARGING

A capacitor can store electric energy when disconnected from its

Charging circuit, so it can be used like a temporary battery. Capacitors are commonly used in electronic devices to maintain power supply while batteries are being changed. In car audio systems, large capacitors to store energy for the amplifier are on demand. Capacitors are widely used in electronic circuits to perform variety of tasks, such as smoothing, filtering, bypassing etc....

TRANSISITOR CHARACTERISTICS

The design of a transistor allows it to function as an amplifier or a switch.From mobile phones to televisions, vast numbers of products include amplifiers for sound reproduction, radio transmission, and signal processing.

Fermi Energy of Copper

It is used, for example, to describe metals, insulators, and semiconductors. It is a very important quantity in the physics of superconductors.
The concept of Fermi energy is crucially important concept for the understanding of the electrical and thermal properties of solids.

SERIES PARALLEL RESONANCE

They are used in many different types of oscillator circuits. Another important application is for tuning, such as in radio receivers or television sets, where they are used to select a narrow range of frequencies from the ambient radio waves.
One use for resonance is to establish a condition of stable frequency in circuits designed to produce AC signals.

NEWTONS RINGS

An important application of interference in thin films is the formation of Newton's rings. The interference technique of Newton's Rings is widely used for the quality control of optical surfaces because the precision obtained with this method proves to be very satisfactory. The dimensions of the rings permits calculation of the radii of curvature of the analysed surfaces and deformation of the interference pattern can be utilised to calculate other parameters, such as astigmatism

Torsional pendulum

The working of "Torsion pendulum clocks" is based on torsional oscillations. The freely decaying oscillation of Torsion pendulum in medium(like polymers) helps to determine their characteristic properties.

PHOTODIODE CHARACTERISTICS

Photodiodes have wide range of applications. Photodiodes are used in camera for auto-focus and photographic flash control, in medical field as blood particle analyzers, in safety equipments as smoke detectors and flame monitors, in automotive industry as sunlight detectors, in optical fiber communication systems and in industries like bar code scanners, position sensors, light pens etc

Young's modulus

The Young's modulus calculates the change in the dimension of a bar. For instance, it predicts how much a wire extends under tension or buckle under compression. Some calculations also require the use of other material properties, such as the shear modulus, density, or Poisson's ratio.

They find applications in Earthquake zones/ buildings/ civil engineering to compare the stretch ability of diagonal cables to the stability required by the concrete existing structures to prevent cracking during earthquake tremors. They also find applications in medical engineering and aeronautical engineering.

PRINCIPAL & VIVA SAMPLE QUESTIONS

Diffraction Grating

When laser light is passed through a prism there won't be diffraction but then the light gets deviated due to change in the refractive index when light travels from air to glass and then from glass to air. So we can't use prism to find the wavelength of laser as there is no diffraction. Laser being monochromatic will not get dispersed by prism, instead will form a spot on the screen deviated from the direction of incidence. Among visible light red gets least deviated and maximum deviation is observed for violet. If the prism is kept in such a way that the deviation of light from the initial direction is minimum then this position of prism is called minimum deviation position.

A photographic slide with a fine pattern of black lines forms a simple grating. For practical applications, gratings generally have grooves or rulings on their surface rather than dark lines. Such gratings can be either transparent or reflective. The space between two lines on the grating acts as a slit for the light to pass through. When the wavelength of light is comparable to the distance between the lines (grating constant) diffraction takes place. Thus we call grating as diffraction grating. Grating constant is the distance between two lines on the grating it is given by $\frac{1}{N}$ m, where N is the number of lines per meter.

Now what is diffraction? One of the properties of light is rectilinear propagation. When a light encounters an obstacle whose size is comparable to the wavelength then light bends over it into the regions where shadow should have been there if light had travelled straight (region of geometrical shadow). Now since light gets into these regions we may rightly define diffraction as encroachment of light into regions of geometrical shadow after it passes through an obstacle whose size is comparable to the wavelength of light. Diffraction can be classified mainly two types Fraunhofer and Fresnel diffraction. In Fraunhofer diffraction the distance between screen and the slit is much larger compared to the width of the slit. In Fraunhofer diffraction we consider the light reaching the screen to be plane waves due to the large distance between the screen and slit. In Fresnel diffraction the distance between screen and the slit is much lesser so we can't consider light reaching the screen as plane waves. In this experiment the width of the slit is much lesser than the distance between the grating and the screen so this is Fraunhofer diffraction. More the number of slits in the grating more resolved will be the spots on the screen. In this experiment we are using diffraction grating and the diffraction is due to multiple slits.

The expression for constructive interference for light passing through a slit is given by $d\sin\theta = n\lambda$, where n is the order of diffraction,d is the grating constant and θ is the deviation angle. The intensity is maximum when θ gives integral multiple of wavelength. We get spots where there is constructive interference. Thus, the wavelength of light depends on the angle of deviation and the grating constant. The intensity of spot decreases as the order of diffraction increases.

The diffraction grating which we use is called plane transmission grating because it consists of a large number of narrow transparent and opaque slits alternating side by side in regular order and with uniform separation, through which a beam of light is transmitted as a series of spectra in various orders of interference.

LASER is acronym for Light Amplification by Stimulated Emission of Radiation. For the basic principle of lasers please refer to notes LASER chapter. The laser used in this experiment is a semiconductor laser. The energy gap in the material (GaAsP) is comparable to the energy of a red photon so it emits red coherent light by stimulated emission. Two waves are said to be coherent if they have well defined frequency and phase. Laser is monochromatic (mono-single, chroma-colour). The wavelength which we obtain depends on the type of material used.

Sample Questions

1. **What do you mean by diffraction of light?**
   Bending of light around the edges of an obstacle whose dimension is same as the wavelength of the light and encroachment into the geometrical shadow.
2. **What are the types of diffraction?**
   Fresnel diffraction andFraunhoffer diffraction.
3. **Distinguish between Fresnel and Fraunhofer classes of diffraction.**
   In Fresnel class of diffraction source and screen are at finite distances from obstacle or aperture. The wave front involved in producing Fresnel diffraction effect is either spherical or cylindrical wave fronts. Fraunhoffer diffraction effect observed only when a plane wave front is involved the source and screen is at infinite distance from the obstacle or aperture.
4. **Distinguish between Interference and Diffraction.**
   Interference is due to the resultant effect of overlapping of light waves, originating from two coherent sources. Diffraction is due to the resultant effect of overlapping of light waves originating from every point on the exposed part of the same wave front. The fringe width in Interference could be either constant or varying .In diffraction the fringe width always varies.
5. **What is grating? Define grating constant.**
   Grating is an optically plane glass plate on which a very large number of equally spaced parallel straight rulings are made with a diamond point. Since diffraction effects are observed by way of transmission of light it is called as plane transmission diffraction grating. The distance between two consecutive rulings is called the grating constant C. (width of the slit).

6. **Expand LASER?**
   Light amplification by stimulated emission of radiation.
7. **What is stimulated emission?**
   A system (atom) comes from a higher energy state to lower energy state with the help of an external agency (like photon of right energy).
8. **What is diffraction grating?**
   It is an arrangement of large number of fine, equidistant & parallel lines with a diamond point on a glass plate.
9. **What are the characteristic features of laser?**
   It has intensity, directionality, coherence and mono-chromaticity.
10. **What are the different types of laser?**
    Ruby laser, HE-Ne laser, Semi-conductor laser, CO_2 laser, Quantum well laser etc

Torsional Pendulum

1. **What is meant by Torsion?**
   When a body is fixed at one end and is twisted about its axis by means of external torque (or couple) at the other end of the body then it is said to beunder "Torsion ".
2. **What is meant by Torsional pendulum?**
   Consider a rigid body (disc, rod, etc.,) attached to the lower end of the wire, whose top end is fixed to the rigid support and make to oscillate about its axis, then the arrangement is called Torsional pendulum and oscillations are called Torsional oscillations.
3. **Define moment of inertia?**
   When rigid body rotates about an axis, it has tendency to oppose the change in its state of rest or of uniform rotation about its axis. This tendency is called moment of inertia of a body about the axis of rotation
4. **What is the physical significance of moment of inertia?**
   In translational motion, force: $F = Ma$: a = linear acceleration. In rotational motion, force: $C = I\alpha$: α = angular acceleration. The mass is a measure of resistance a body offers to have its translational motion changed by a given force. Similarly moment of inertia (I) is a measure of resistance a body offers to have its rotational motion changed by a given torque.
5. **What are the factors on which moment of inertia of a body depends?**
   Moment of inertia depends on a) mass of the body b) axis of rotation c) The distribution of mass about the axis of rotation.
6. **Define rigidity modulus?**
   Within the elastic limit, the ratio of shear stress and shear strain is constant for a given material and is known as rigidity modulus.

7. Define shear stress or Tangential stress?
It is defined as restoring force per unit area parallel to the surface of the body.

8. Define shear strain or Tangential strain?
If an external force is applied tangentially to a free portion of the body (another part is fixed) then its layers slide one over other and the body experiences a turning effect; as a result the shape of the body changes. This is called shearing and the angle through which the turning takes place is called shearing angle (θ).This angle θ is measured in radians is called shearing strain.

9. On what factors (I/T^2) of torsion pendulum depends?
I/T^2 of torsion pendulum depends on a) Length of the wire in the torsion pendulum b) Diameter of the wire in the torsion pendulum c) The nature of the material of the wire in the torsion pendulum.

10. Why is (I/T^2) is constant for a given wire?

For a torsion pendulum, the period of torsion oscillation is

$T = 2\Pi \, \mathrm{Sqrt}(I/C)$. Where I = the moment of inertia of about its axis.

C = couple per unit twist of the suspended wire. Rearranging $(I/T^2) = (C)/(4\Pi^2)$

Since "C" is constant for a given wire; I/T^2 = constant. Because of this fact (I/T^2) remains constant for all regular bodies executing torsion oscillations about the axis of suspension.

Charging and Discharging of a Capacitor

A capacitor is a passive device which can store charges. There are many types of capacitor. The most common type is ceramic and electrolytic capacitors. The electrolytic capacitors have polarity (positive and negative) so care should be taken while connecting. The capacity of the capacitor to store charges is called capacitance. Its unit is Farad. A capacitor has two plates separated by a dielectric material. In theory, the dielectric can be any non-conductive substance. However, for practical applications, specific materials are used that best suit the capacitor's function. Mica, ceramic, cellulose, porcelain and even air are some of the non-conductive materials used. The dielectric dictates what kind of capacitor it is and for what it is best suited. Depending on the size and type of dielectric, some capacitors are better for high frequency uses, while some are better for high voltage applications. Capacitors can be manufactured to serve any purpose, from the smallest plastic capacitor in your calculator, to an ultra capacitor that can power a commuter bus. The dielectric material will increase the capacitance of the capacitor. In the present experiment we are using electrolytic capacitor. When the capacitor is

connected to a dc power supply the electrons are pulled from one plate and pumped into another plate till the potential difference across the capacitor become equal to that of the dc power supply. If we connect a bulb in series with the capacitor then during charging the bulb will glow brightly initially and then with time it becomes dimmer and dimmer till it goes off. This observation tells us that the current in the circuit becomes maximum when the capacitor just begins to charge then it slowly decreases and becomes zero after the capacitor has been charged. During discharging of capacitor the current in the circuit is maximum in the beginning then it decreases to zero as it discharges. Thus by studying charging and discharging of a capacitor we can understand its behavior. The resistance opposes the flow of current and hence increases the time taken to charge/discharge the capacitor. Time constant $\tau = RC$ is the time required to charge the capacitor, through the resistor, to 63.2 (≈ 63) percent of full charge; or to discharge it to 36.8 (≈ 37) percent of its initial voltage. In the experiment for charging and discharging a capacitor by using a high resistance in series with capacitor we can reduce the rate of charging and discharging so that we can easily note down the voltage reading across the capacitor at different instants of time. The toggle switch is used to switch over from charging to discharging without taking the trouble of modifying the circuit. $T_{1/2}$ is the time taken for the voltage to decrease from its maximum value to half of its maximum value during discharging or the time taken for the voltage to increase from zero to half of its maximum value during charging. This is given by intersection of the charging and discharging curves. Dielectric constant is the relative permittivityε_r of the dielectric material used between the plates of the capacitor. Permittivity is the materials ability to permit electric field lines. By determining the dielectric constant we can identify the type of dielectric material used. We can also use combination of capacitors (series/parallel) but then if we don't use the same type of capacitor we cannot identify the dielectric material though we can compute the net dielectric constant. So now how do we obtain the dielectric constant by charging or discharging the capacitor? To determine the dielectric constant lets compare with the radioactive decay where at $t = 0s$ we have N_o atoms and in time t number of atoms becomes N and λ is the decay constant. Thus, $N = N_o e^{-\lambda t}$, Similarly during discharging the voltage decreases from maximum value V_o to V and $\tau = RC$ is the time constant. Hence, $V = V_o e^{-(t/RC)}$. At $t = T_{1/2}$,$V = \frac{V_o}{2}$. Therefore,$\frac{V_o}{2} = V_o e^{-(T_{1/2}/RC)}$ this implies$\frac{1}{2} = e^{-(T_{1/2}/RC)}$. Taking reciprocal on both sides we get $2 = e^{T_{1/2}/RC}$. Now take ln on both sides then $\ln 2 = \frac{T_{1/2}}{RC} \Rightarrow C = \frac{T_{1/2}}{R\ln 2}$ and the capacitance $C = \frac{\varepsilon_0 \varepsilon_r A}{d}$ where A is the area of the plates and d is the distance between the plates. Substituting for C we get $\frac{\varepsilon_0\varepsilon_r A}{d} = \frac{T_{1/2}}{R\ln 2} \Rightarrow \varepsilon_r = \frac{dT_{1/2}}{A\varepsilon_0 R\ln 2}$ and $\ln 2 = 0.693$

so we have $\varepsilon_r = \frac{dT_{1/2}}{A\varepsilon_0 R(0.693)}$ which is the dielectric constant of the given capacitor.

Sample Questions

1. **What is dielectric constant?**
   It is the ratio of capacitance in presence of dielectric to the capacitance in presence of vacuum. Or it is the ratio of voltage measured in presence of vacuum to the voltage measured in medium
   $\epsilon_{MEDIUM} = V_{VACCUM}/V_{MEDIUM}$ or $\epsilon_{MEDIUM} = E_{VACCUM}/E_{MEDIUM}$ $\epsilon_{MEDIUM} = \epsilon_0 \times \epsilon_{MEDIUM}$
   where ϵ_0 =absolute dielectric constant/absolute permeability & $\epsilon_0 = 8.854 \times 10^{-12}$ F/m
2. **What is capacitance of the capacitor?**
   Ratio b/w charge and voltage between the plates, ability to store charge.
3. **Define one farad?**
   It is the amount of charge required to raise the potential by one volt.
4. **What is dielectric?**
   Dielectric is an insulator which is used to increase the capacitance of the capacitor.
5. **When does the body get charged?**
   When a body rubbed with another body it gets charged due to loss or gain of electron.
6. **What are the examples for dielectrics?**
   Glass, Mica, Ceramics, Asbestos, Resins, Rubber, Transformer Oil etc
7. **What is $T_{1/2}$ (half time)?**
   It is the time taken for the Capacitor to get charged/discharged to 50% of max^m charging. Graphically it given by the intersection of charging and discharging curves
8. **What are the types of dielectrics?**
   Polar and non – polar dielectrics
9. **What are Polar and non – polar dielectrics?**
   In case of polar dielectrics effective center of positive and negative charges does not coincide. ex: HCL, nitro benzene. In case of non polar, effective center of positive and negative charges coincide ex: paraffin.
10. **What is Capacitor?**
    A Capacitor is a passive component used to store energy in the form of an electrostatic field.
11. **What are passive elements?**
    The circuit element which cannot deliver any electrical power and does not performs the operations like amplification, rectification etc., are called passive elements.
12. **What are active elements?**
    Circuit elements which can deliver electrical power to the system and can perform the operations like amplification, rectification, etc., are called active elements.

13. **What is meant by capacitance of a capacitor?**
    It is defined as the ratio of charge on either conductor to the potential difference between the conductors forming the capacitor.
14. **How Capacitance of the capacitor can be increased?**
    Capacitance of a capacitor can be increased by introducing a dielectric material between the two parallel plates of the capacitor
15. **Is the time constant for charging and discharging of the capacitor is the same in the experiment?**
    No. The time constant for discharging the capacitor is larger than that for its Charging.
16. **What are the factors that Dielectric constant depends?**
    Dielectric constant mainly depends on the nature of the material and does not depends on the size or shape of a capacitor or dielectric material
17. **What is polarization of dielectrics?**
    The process of acquiring charges by a dielectric when placed in a dielectric medium is called polarization
18. **What is the unit of Dielectric constant?**
    Dielectric constant is a dimension less constant hence it has no unit.
19. **Give applications of Dielectrics?**
    Dielectrics can be used as a dielectric medium in capacitors, as an insulator inpower transmission, as a heating material in microwave oven (cooking rice in microwave oven)

Photo-diode

1. **What is LED?**
   LED stands for light emitting diode and it is a p-n- junction semiconductor diode that gives off light when it is forward biased.
2. **What is a photovoltaic cell?**
   The cell which converts optical energy into electrical energy is known as photovoltaic cell.
3. **What is a solar cell?**
   A solar cell is a p-n junction semiconductor device. It is used to convert solar energy directly into electrical energy.
4. **What are photo diodes?**
   These are semiconductor devices responsive to high energy particles and photons.
5. **What are photons?**
   Photons are quantized packets of light.

6. What is responsivity of a photodiode?
It is the measure of its sensitivity to light and is defined as the ratio of the photocurrent to the incident light power at a given wavelength.

7. How does the photo diode works?
It is made up of radiation sensitive material whose resistivity changes when illuminated.

8. What are the applications of a photodiode?
P-N photodiodes are used in photoconductors, charge-coupled devices, and photomultiplier tubes. Photodiodes are used in compact disc players, smoke detectors.

9. What is photo diode?
A photo diode is a light sensitive electronic device capable of converting light into a voltage or current signal. It works on the principle of photoelectric effect.

Photo diode has two terminals anode and cathode with the arrows indicating that the light rays falling on photo diode reflecting its significance as a photo detector.

10. What are the types of photo diodes?
There are mainly three types of photo diodes

- PN junction photo diode
- Avalanche photo diode
- PIN photo diode

Normal PN junction photo diode is used in low frequency and low sensitive applications. When high frequency of operation and high sensitivity is needed avalanche photo diode or PIN photo diodes are used.

11. Mention the physical structure of photo diode
A normal PN junction photo diode is made by sandwiching a P type semiconductor into N type semiconductor. All the sides of PN junction diode is enclosed in metallic case or painted black except for one side on which radiation is allowed to fall.

12. Modes of operation of Photo diode
A photo sensitive diode can be operated mainly in two modes
Photo conductive mode
Photo voltaic mode
The photo diodes used as photo detectors are optimized (in the physical construction of the device itself) to have fast response times whereas the photo diodes used in electrical energy generation are optimized to have high efficiency of energy conversion. The photo detectors are operated in photo conductive mode. Solar cells are operated in Photo voltaic mode.

Experiment Principle and Viva Questions

13. What is luminance?
The intensity of light emitted from a surface per unit area in a given direction.

14. V-I characteristics of photo diode
A photo diode is always operated in reverse bias mode. From the photo diode characteristics, it is seen clearly that the photo current is almost independent of applied reverse bias voltage. For zero luminance, the photo current is almost zero except for small dark current. It is of the order of nano amperes.
As optical power increases the photo current also increases linearly. The maximum photo current is limited by the power dissipation of the photo diode.

15. Applications of photo diodes

1. Photo diodes are used as photo detectors
2. Photo diodes are used in providing electric isolation using a special circuitry called as Optocouplers. Optocoupler is an electronic component which is used in coupling optically the two isolated circuits by using light. The two circuits are optically coupled but electrically isolated. It is a combination of light emitting diode and photo diode (or) avalanche diode (or) photo transistor.
3. Optocouplers are faster than the conventional devices.
4. They are used in consumer electronics
5. They are used in cameras as photo sensors, Slotted optical switch, in scintillators etc.

16. Why photo-diode works in the reverse bias?
The current in the forward bias is primarily due to major carriers but in reverse bias it is due to the minor carriers. As the fractional change in the reverse current due to the photo effects is more easily measurable than in the forward bias current. So photodiodes are operated in the reverse bias.

Fermi Energy

Fermi energy is the maximum energy that an electron can have at $T = 0K$. When a metal is heated the lattice ions vibrate and the area of scattering cross section increases. So when the electrons pass through the metal the frequency of scattering increases with temperature and the mean free path decreases. Thus the resistance of metals is directly proportional to the temperature given by $\rho = \rho_o(1 + \alpha T)$ where ρ is the resistivity at temperature T, ρ_o is the resistivity of the metal at 0K and α is the temperature coefficient of resistance.
To measure the Fermi energy we have to find the rate of change of resistance with temperature. The resistance of the copper coil is determined using multimeter. We can use copper plate instead of copper wire to do the same experiment. The only problem which we encounter will be that the resistance of copper plate would be much less compared to copper wire due to more area and small length of copper

Department of Physics, K. S. I. T, Bangalore-109.

plate and the multimeter should have more sensitivity to measure the resistance of the copper plate, therefore to get more accurate reading copper wire is used instead of copper plate.

The resistance of copper is found out at different temperatures by immersing it in hot water and taking down the resistance reading for every five degree decrease in temperature. Here water is the heating medium, we can use other medium like oil to heat it but then the specific heat capacity of oil is 1.8 $KJkg^{-1}K^{-1}$ compared to specific heat capacity of water 4.19 $KJkg^{-1}K^{-1}$ hence the rate of increase/decrease of temperature of oil the is faster than that water which makes it difficult for us to take down the reading. We may also heat the beaker and take down the resistance reading as the temperature increases provided the heat source has a constant high temperature. A graph of resistance versus temperature is plotted and the slope of the graph gives us the rate of change in resistance with respect to temperature which is the temperature coefficient of copper coil's resistance. Once we obtain the temperature coefficient of copper coil's resistance we can find the Fermi energy of copper.

Sample Questions

1. **What is Fermi energy?**
   The energy of the electron in Fermi level at absolute 0k or It is the energy of the highest occupied level at zero absolute.
2. **What is Fermi level?**
   The top most occupied energy level, below which all are occupied and above which all levels are empty at absolute zero.
3. **What is Fermi velocity?**
   The velocity of electron in the Fermi level
4. **On what factors the Fermi energy depends on?**
   It depends on the electron concentration and temperature.
5. **What type of material for which we are determining Fermi energy?**
   Metals- copper
6. **What is Fermi factor?**
   Gives probability of occupancy of a given energy level (E) at a temp(T)
7. **State pauli's exclusion principle?**
   It states that no 2electrons having same quantum number can occupy the same energy level at the same time.
8. **What are fermions?**
   Electrons in metals &semiconductors are called fermions.
9. **What is meant by Fermi gas?**
   It is a collection of non-reacting Fermi ions.

10. **What is the importance of Fermi energy?**
    It helps to understand electrical and thermal properties of solids. it gives the information about the velocity of electrons which participate in ordinary electrical conduction.
11. **What are conductors?**
    Conductors are a class of materials that allow the current to pass through them very easily and the resistivity or the conductors is of the order of micro ohm meter.
12. **What happens to the electrical conductivity of a conductor with increase in temperature why?**
    With increase in temperature of a conductor resistivity of a conductor increases due to increase in lattice vibrations hence electrical conductivity decreases.
13. **Define Fermi energy at room temperature?**
    At room temperature Fermi energy is the average energy of conduction electrons taking part in electrical conductivity.

Newton Rings

We can determine the radius of curvature (the radius of the imaginary sphere of which the lens is a part) of plano-convex lens (plane on one side and bulged on other) by placing the bulged side on a reflecting mirror. The light is obtained from the sodium vapor lamp by applying voltage to the filament placed inside the tube containing sodium vapor. The current flowing through the filament heats up the filament and the energy is transferred to sodium atoms there by exciting them to higher energy level. When the atoms come back to the ground state they emit D1 and D2 lines having wavelengths 5890Å and 5896Å which lies in the yellow region of the electromagnetic spectrum. Thus, the light appears to be yellow in color. Sodium vapor lamp is not monochromatic since it emits two different wavelengths. The light from the sodium vapor lamp is made to fall on convex lens to focus the beam of light onto semitransparent glass plate kept at an angle of 45° which reflects some part of the light at 90° onto the plano-convex lens kept on a reflecting mirror. Due to the change in the air gap at the bulged side of the plano-convex lens, the light travels different optical distance through different parts of lens. The thickness of the air film varies along the lens and the waves superpose to form constructive and destructive interference. If the path difference is $\delta = n\lambda$ then constructive interference takes place. If the path difference is $\delta = \frac{(2n+1)\lambda}{2}$ then destructive interference takes place. Since the thickness of the lens decreases in the radial direction from the centre of the lens, the path difference also varies radially from the center of lens forming dark and bright rings. The dark rings are due to destructive interference and bright rings are due to constructive interference. The diameter of the rings depends on the radius of curvature of the lens. Lesser the radius of curvature more bulged is the lens and the path difference also increases making constructive and destructive interference to take place closer to the center of the lens, thus the rings will have lesser diameter. Similarly, more the radius of curvature more will be the diameter of the rings formed. Thus, by measuring the diameters of the rings and knowing the wavelength we can determine the radius of curvature of the lens. Same principle is used in Air wedge experiment where we find the thickness of a paper. In that case we place a small piece of paper at one end between two plane glass plates forming a thin film of air similar to the thin film of air formed at the gap between the bulged side and reflecting plate in case of Newtons ring experiment. The interference takes place due to the air gap.

Sample Questions

1. **What are newton's rings?**
   Newton's rings are alternate dark and bright rings observed due to interference of light.
2. **How newton's rings are formed?**
   They are formed by the interference b/w the wavefronts reflected from the lower spherical surface of the lens and the upper surface of the plane glass plate.
3. **How the rings are alternate dark and bright?**
   The light rings are caused by constructive interference b/w the light rays reflected from both surfaces,while the dark rings are caused by destructive interference.
4. **What is interference?**
   It is the superposition of two or more waves resulting in a new wave pattern.
5. **Are the rings equi-spaced?**
   No, with the increase of the diameters, the rings get closer and closer.
6. **Why do you hold the glass plate at 45^0 to the vertical?**
   So that the rays may be incident normally on the glass plate-lens system or to make the light to fall normally on the Newton's rings apparatus. When the rays fall normally, the angle of incidence and angle of reflection are equal to zero.
7. **What will happen if a white light source is used,instead of a sodium lamp?**
   Few coloured fringes with a dark centre will be observed.
8. **Name the phenomena on which this experiment is based.**
   Interference of Light.
9. **Define radius of curvature?**
   The radius of the sphere to which the lens becomes a part is called radius of curvature.

10. **How air film is formed in this experiment?**
    When a convex surface of the plano convex lens is placed on the plane glass plate, a thin film of air is enclosed between the lower surface of the lens and upper surface of the glass plate
11. **What happens to the fringe pattern if the lens of large radius of curvature is used?**
    We can observe wider and clear fringes.
12. **If the optically plane glass plate is replaced by a plane mirror, will you get the ring system?**
    No, because the intensity of light reflected from the plane mirror will be so large that the different interference fringes will not be visible and we will get general illumination
13. **What are the applications of the Newton's rings experiment?**
    a. It is used to determine the wavelength of the monochromatic source
    b. it is used to determine radius of curvature of lens
    c. it is used to find out the refractive index of the transparent liquids
    d. it is used to determine the Young's modulus of the transparent materials.
14. **On what factors the diameter of the ring depends?**
    The diameter of the particular ring depends on,
    - the radius of curvature of lens
    - Wavelength of the light used.

1. **How are Newton's rings formed?**
   When a monochromatic light is made to fall normally on the lens system consisting of a Plano- convex lens with its convex surface on a plane glass plate then large number of alternate bright and dark concentric interference fringes formed between lens and the glass plate due to interference of light in thin air film between the lens and glass plate. They are known as Newton's rings.

16. **What are the uses of newton's rings?**
    a. to determine wavelength of monochromatic light.
    b. to determine the refractive index of a liquid.
    c. to measure the radius of a spherical surface.
    d. to measure the expansion-coefficients of crystals.

Transistor Characteristics

A transistor is made by using three regions where a P-region is sandwiched between two N-regions called as NPN transistor or N-region sandwiched between two P-regions called as PNP transistor. Thus a transistor has three sections known as emitter, base and collector. The emitter is most heavily doped, base is lightly doped and collector is moderately doped. The emitter as the name suggests pumps the electrons into the base which is thin and lightly doped. The electrons spend very less

time in base because it's thin and the base current is very small (μA) due to light doping where as most of the electrons are collected by collector so the length of collector is kept greatest.
Diodes have two types of biasing forward and reverse but a transistor has two junctions so while biasing the transistor we need two voltage source and one of the sections is kept common to both the batteries leading to three configurations- common emitter, common base and common collector (where emitter, base and collector respectively is connected to both the batteries).
The configuration which is used most often is common emitter in which the emitter is common to both the input side and output side. In the input side of common emitter configuration we have base-emitter junction and at the output side we have collector-emitter junction. These are the two junctions which we will be biasing.
We can have four types of biasing, if base-emitter junction is forward biased and collector-emitter is forward biased then the transistor is in saturation mode, if base-emitter is reverse biased and collector-emitter is forward biased then the emitter is connected to positive of the battery and will not work as desired, base-emitter is reverse biased and collector-emitter is reverse biased then transistor works in cutoff mode. The best type of biasing is to make base-emitter junction forward bias and collector-emitter junction reverse bias so that the transistor will work in the active mode. In active mode transistor works as an amplifier.
To study the characteristics of transistor lets bias it so that it's in the active mode. In the input side we have base-emitter junction which is forward biased. Thus the input characteristics is the V-I characteristics of input side which is a graph of base-emitter voltage versus base current keeping the voltage in the output side collector-emitter voltage V_{CE} = constant(say 2V). The output characteristics is the V-I characteristics of the output side which is a graph of collector-emitter voltage versus collector current keeping the current in the input side base current I_b = constant(say 50μA, 100μA). In saturation transistor works as a closed switch and in cutoff mode the transistor works as an open switch hence transistor plays important role in digital electronic circuits. In the output characteristics of the transistor when the transistor is cutoff it's open and the voltage V_{CE} is maximum and the collector current is zero, when the transistor is in saturation its like a closed switch and the voltage across it is zero but current is maximum. The line obtained by joining this maximum collector current on y-axis and maximum voltage on x-axis is called dc load line. In transfer characteristics is the graph of input current I_b versus output current I_c. The point on the dc load line in the active mode where transistor is operated is called operating point.

Sample Questions

1. **What is semiconductor?**
   A material whose electrical property lies b/w a conductor and an insulator.

2. **What is a transistor? Why is it so called?**
   Transistor is three terminals, two p-n junction semiconducting device. It issued to amplify electrical impulses applied at its input terminals. It transforms the input signal from low resistance region to a high resistance region. Due to this transfer of signal across a resistance, it is called as transistor.

3. **What does an arrow in a transistor symbol indicate?**
   It indicates the direction of current.
4. **What is the difference b/w NPN and PNP transistor?**
   In a PNP transistor current enters through the emitter lead and in a NPN transistor current leaves through the emitter lead. In pnp majority charge carriers are +vely charged holes & minority charge carriers are –vely charged electrons. In npn majority charge carriers are –vely charged electrons &minority charge carriers are +vely charged holes.

5. **What are the functions of emitter, base and collector of transistor?**
   Emitter – emit the majority charge carrier, Collector- collects the charge carrier. Base- recombination of some charge carrier takes place.., there by controlling the current.
6. **What do you mean by Doping?**
   The process of changing the conductive properties of semiconductor by adding trace amounts of impurities (other elements)
7. **Mention the three modes in which a transistor can operate?**
   CE(common emitter),CB(common Base) &CC(common collector)
8. **What is an input, output and transfer characteristics of a transistor?**
   Input: variation of input current with input voltage when output voltage\current in constant.

   Output: Variation of output current with output voltage when input current is constant.

   Transfer: variation of output current with output voltage when input voltage is constant.
9. **Define Current gain of a transistor?**
   Ratio of output current to input current. It is also called as current amplification Factor. The symbols which are used to represent current gains in CB mode, CE mode & CC mode are α, β and γ.
10. **Mention some uses of transistor?**
    Used in amplifiers, oscillators, switch.
11. **Can we interchange the emitter and collector region in a transistor?**
    No. the doping concentration is different. It's maximum in emitter, least in base and moderate in collector.
12. **Give the Biasing condition for the transistor to work.**
    Emitter base junction forward biased and collector base junction reverse biased.

13 .Define α and β ?
αis the current gain in common base configuration. It is the ratio of collector current to emitter current. Its value ranges from 0.95 to 0.99.βis the current gain in common emitter configuration? It is the ratio of collector current to base current. Its value ranges from 40 to 200.

14.What is an amplifier?
An amplifier increases the strength or magnitude of the weak signal.

15.Why is a transistor called as a current controlled device?
A transistor is called a current controlled device because the output current is controlled by the input current.

Young's Modulus

1. **Name the principle of the experiment?**
   Elasticity
2. **What is elasticity?**
   The property of the substance to regain its original form once the deforming force is removed.
3. **State modulus of elasticity.**
   The ratio between stress and strain with in elastic limit.
4. **Define stress.**
   Deforming force per unit area.
5. **Define strain.**
   Change in dimension by original dimension.
6. **Define young's modulus.**
   Ratio b/w longitudinal stress to longitudinal strain.
7. **What are elastic and plastic bodies?**
   Bodies which regain their shape or size or both completely as soon as deforming forcesare removed are called perfectly elastic, if not then it is plastic body.
8. **What is Hooke's law?**
   This law states that within elastic limits, the stress is proportional to strain, i.e., stress/strain = a constant, called modulus of elasticity.
9. **What is the practical use of the knowledge of the elastic moduli?**
   This enables to calculate the stress and strain that a body of given size can bear. This helps in defining the body.
10. **What is the effect of temperature on elastic moduli?**
    In general, the elastic limit decreases with rise in temperature.
11. **What do you mean by a beam?**
    A bar of uniform cross-section whose length is much greater as compared to thickness is called a beam or a rod or bar of uniform cross section whose length is Large compared to its other dimensions.
12. **Does the modulus of elasticity change with increase in temperature?**

As the temperature increases the inter atomic distance increases causing the inter atomic force to decrease, Hence the expansion is more than that before heating, hence the modulus of elasticity decreases as temperature increases.

13. **Which is more elastic steel or rubber & why?**
    Steel is more elastic than rubber because when same force is applied on both materials, rubber elongates more when compared to steel that shows that greater force is required to produce small deformation in steel.

Series and Parallel Resonance

In both series and parallel resonant circuit we use three passive devices Resistor, Capacitor and Inductor. Lets now understand how each of these passive devices work. Resistor opposes the flow of current and the ability of resistor to oppose current is called resistance. Its unit is ohm (Ω). Capacitor stores charges and Capacitance is a measure of the amount of electric charge stored (or separated) for a given electric potential. Its unit is farad (F). In inductor a change in the electric current through that circuit induces an electromotive force (EMF) that opposes the change in current. This property is called Inductance. Its unit is henry (H). In case of resistors the opposition to the flow of current is independent of frequency (i.e. the opposition is same for all frequencies). In case of inductor and capacitor the opposition depends on the frequency of the input signal. Inductor and capacitor reacts to the input frequency, thus we have inductive reactance and capacitive reactance. Inductive reactance is given by $X_L = 2\pi fL$ whereL is the inductance andf is the frequency of the signal. Since the inductive reactance is directly proportional to frequency, the inductor offers more reactance to the flow of current with the increase of frequency. The unit of inductive reactance is ohm (Ω).

Inductors work based on the two laws of electromagnetic induction which are the Faraday's law of induction which states that "The induced electromotive force or EMF in any closed circuit is equal to the time rate of change of the magnetic flux through the circuit" and Lenz's law which states that "An induced current is always in such a direction as to oppose the motion or change causing it". In an inductor if the current is passed using dc source and if the current is continuously decreased then the inductor will oppose the decrease in current. When the current is decreased continuously, the magnetic field around the coil keeps current flowing in the coil until the field collapses. In other words, an inductor can store energy in its magnetic field, and an inductor tends to resist any change in the amount of current flowing through it. Similarly when the current is increased the inductor opposes the increase in current.

Capacitive reactance is given by $X_C = \frac{1}{2\pi fc}$. Since the capacitive reactance is inversely proportional to the frequency, the capacitive reactance decreases with the increase in frequency. The unit of capacitive reactance is ohm (Ω).Impedance is the resultant opposition to the flow of current offered by the resistor, inductor and capacitor. It's given by $Z = \sqrt{R^2 + (X_L - X_C)^2}$. Its unit is ohm (Ω). A series resonant circuit is designed to accept (allow with minimum impedance) a particular frequency called the resonant frequency hence it's known as acceptor circuit. But, a parallel resonant circuit is designed to reject (oppose with maximum impedance) the resonant frequency, hence it's known as rejecter circuit.

Electrical resonance occurs in an electric circuit at a particular resonance frequency when the impedance of the circuit is at a minimum for series resonant circuit and maximum for parallel resonant circuit.

In a series resonant circuit when the inductive reactance and the capacitive reactance's are equal then the net reactance becomes zero due to phase difference in the current and voltage. To understand why the current leads voltage in capacitor we have to know how the capacitor works. When the capacitor is connected to the voltage supply the charges move to the plates. The rate of flow of charges is current, so the moment the capacitor is connected to the supply there is current in the circuit. These charges pile up in the plates of the capacitor while charging. The plate where electrons are accumulated becomes negative plate and the other plate becomes positive plate thus creating potential difference between the plates. So only after current flows a potential difference is created and hence we can understand that the current leads voltage in a capacitor.

In case of inductors when there is change in magnetic flux a back emf is generated which then induces current. Thus voltage leads current or current lags behind voltage in an inductor.

The natural frequency of series resonance circuit is obtained by equating the capacitive reactance with inductive reactance

$$X_L = X_C \Rightarrow 2\pi f L = \frac{1}{2\pi f C}, \text{ rearranging we get } f^2 = \frac{1}{4\pi^2 LC} \Rightarrow f = \frac{1}{2\pi\sqrt{LC}}$$

This is the frequency at which the capacitive and inductive reactance cancels with each other so that there is minimum impedance. This frequency when applied matches with the natural frequency of the circuit and is called resonant frequency.

To understand the frequency response we should know how the capacitor and inductor respond to frequency. Capacitor will offer high reactance to low frequency and inductor offers high reactance to high frequency. Thus circuit offers minimum impedance at resonance when the reactance X_L and X_C cancels each other. So the current increases as the frequency is increased the current reaches maximum value at resonant frequency. If we still keep increasing the frequency then the current starts decreasing because now the inductive reactance increases.

In parallel resonant circuit the inductor is connected in parallel to the capacitor. At low frequency all current passes through the inductor and inductor acts like a short

across the capacitor thus, there is no reactance. At high frequencies the capacitor acts as a short across inductor and the current becomes large so the reactance becomes zero. At resonance path offers equal reactance and the net reactance is half of capacitance or inductive reactance. The total reactance and hence the impedance becomes maximum at resonance.

While determining the bandwidth we take maximum current I_o divided by $\sqrt{2}$ because $\frac{I_o}{\sqrt{2}}$ gives the current at which the power is half that of at the maximum. At $\frac{I_o}{\sqrt{2}}$ on Y-axis (current) we draw a horizontal line parallel to X-axis (frequency) which cuts the curve at two parts known as half power points. Let's check it, $P_{1/2}$ = half power of P_o, where P_o is the peak power of series resonant circuit. Therefore we have $P_{1/2} = \frac{P_o}{2} \Rightarrow I_{1/2}^2 R = \frac{I_0^2 R}{2} \Rightarrow I_{1/2}^2 = \frac{I_0^2}{2}$. Thus we get $I_{1/2} = \frac{I_o}{\sqrt{2}}$. This is the reason why we divide the peak current by $\sqrt{2}$.

So taking band width bisects the response were such that the power is within the lower the and higher cut off frequencies of band width measurement.

Quality factor tells about the selectivity of the circuit. A series resonant circuit is supposed to accept only a narrow band of frequency and a parallel resonant circuit is supposed to reject only the narrow band of frequency the one which we don't need. Thus the quality factor is inversely proportional to band width and is given by $= \frac{f_2 - f_1}{BW} = \frac{f_o}{BW}$, where f_2 and f_1 are higher and lower cut off frequencies and f_o is the resonant frequency. If the quality factor is large then the circuit has a good selectivity and it selects only that narrow band of frequency which we need.

Connecting a resistor only limits the flow of current independent of frequency. There won't be any change in the resonant frequency if L and C are interchanged in the circuit. At higher resistance the maximum current I_o decreases since I_o is inversely proportional to resistance. If high resistance is connected then the current in the circuit decreases and we won't get steep curve. A device which converts AC to DC is called oscillator. Sine wave is the simplest form of wave and it varies continuously so the function generator is set to sine wave. We can also do the experiment with other types of waves like square and triangular which are combinations of sine waves.

When the current flowing through the inductor changes then back emf is generated which in turn opposes the change in current. This emf generated by the coil itself is proportional to the change in magnetic flux and the proportionality constant is self inductance. If the change in magnetic field linked with another nearby coil induces current in the coil then the proportionality constant of back emf is called mutual inductance.

Capacitive reactance is given by $X_C = \frac{1}{2\pi fC}$. The frequency of dc is 0. Therefore the capacitive reactance is infinity for dc. This is because once the capacitor is fully charged no more current flows through the circuit.

There is change in current in case of pulsating dc. When the current increases the capacitor charges and when the current decreases the capacitor discharges and thus the pulsating dc is allowed but the ripple factor decreases depending on time constant *RC* which is why we use capacitor as filters in rectifier circuits.

Since in dc the current doesn't change there is no back emf and inductor allows dc since the inductive reactance $X_L = 2\pi fL = 0$ as the frequency of dc = 0.

An inductor blocks the changing current of pulsating dc so we can connect the inductor in series or suitable combination of inductor and capacitor can act as an effective filter.

Sample Questions

2. **What is meant by Resonance?**
   The condition at which applied frequency of the oscillator and natural frequency of LCR Combination becomes equal is called Resonance.

3. **What is meant by resonant frequency?**
   The frequency at which both reactance X_L and X_C becomes equal then the circuit is said to be at Resonance. The corresponding frequency is called resonant frequency.

4. **Why series resonance circuit is called as Acceptor circuit and parallel resonance circuit called as rejecter circuit?**
   In the case of series resonance circuit the current is maximum at resonance this is because, the impedance is minimum. In the case of parallel resonance circuit the current is minimum at resonance this is because, the impedance is maximum.

5. **Define Impedance.**
   Resistance offered by the circuit elements to the flow of A.C. Or The opposition offered to the flow of AC by an element in a circuit is Called Impedance. At resonance $X_L = X_C$.

6. **Define Resistor, Capacitor and Inductor.**
   A Resistor is a component that offers opposition to the flow of electric current. A Capacitor is a passive component used to store energy in the form of a Electrostatic field. An Inductor is a passive component used to store energy in the form of a Magnetic field.

7. **What is Resistance?**
   The opposition offered to the flow of DC by an element in a circuit is called Resistance.

8. **Define Q-factor and Band width.**

   Q-factor:

   It is defined as the ratio of resonant frequency to the bandwidth of the circuit. Quality factor measures the sharpness of resonance.

   Band width:

   It is the difference between upper and lower cut - off frequencies. Bandwidth is the range of frequencies within which rms value of current flow and the LCR circuit is efficient.

9. **Give the uses of LCR circuit.**
   Used in Transmission and receiving of signals in radio stations. i.e., in Radio/Television for tuning & also in amplification & oscillation circuits

10. **Define Wave amplitude, Period, Frequency.**
    Wave amplitude-amplitude of a wave is the maximum value of current or voltage. Period- it is the time taken by the current or voltage to complete one cycle. Cycle –one complete cycle of positive and negative values of an AC Frequency – number of cycles per second.

11. **What is Inductive reactance?**
    The opposition offered by the inductor to the flow of AC in an AC circuit is $X_L = \omega L$ is called inductive reactance.

12. **What is capacitive reactance?**
    The opposition offered by the Capacitor to the flow of AC in an AC circuit is $X_C = 1/\omega C$ is called Capacitive reactance.

13. **How do you identify the resonance in the LCR circuits?**
    Observing the current in the circuit identifies the resonance in the circuit. In series LCR circuit, at resonance current will be maximum and impedance will be minimum. In parallel resonance circuit at resonance the current will be minimum and impedance will be maximum.

Acceptance angle and Numerical Aperture

1. What is Angle of Acceptance?

It is the maximum angle which can be sent into the optical fiber such that it suffers Total Internal reflection and reaches other end of the fiber.

2. **What is Numerical Aperture?**

It is light gathering capacity of an optical fiber and it is given by

$$N.A = \sin\theta_0$$

3. **What is Optical fiber?**

Optical fibers are essentially light guides used in optical communication as wave guides. They are transparent dielectrics and able to guide visible and IR rays over long distances.

4. **What is attenuation and mention the types.**

"Attenuation is the loss of power suffered by the optical signal as it propagates through the fiber". It is also called fiber loss.

There are three types of attenuation

Absorption loss
Scattering loss
Radiation loss

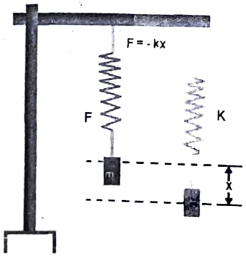
5. **What are the advantages if Optical fiber.**

1. It carries very large amount of information in either digital or analog form due to its large bandwidth.
2. Since it is made by using dielectrics, it doesn't produce or receive any electromagnetic interference.
3. It is easily compatible with electronic system
4. Can operate in high temperature range
5. Not affected by corrosion and moisture

Spring constant

1. Explain the formula of spring constant.

According to Hooke's law, the force required to compress or extend a spring is directly proportional to the distance it is stretched. It can be represented in an equation as F = kx, where F is the force applied, k is the spring constant and x is the extension of the object usually in meters.



The Spring Constant Formula is given as,

$$K = -\frac{F}{X}$$

Where,

F = Force applied,

x = displacement by the spring

It is expressed in Newton per meter (N/m).

2. Write a note on Hookes law.

Hooke's Law

According to Hooke's law for a small deformation, the stress in a body is proportional to the corresponding strain." i.e.,

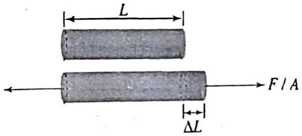
$$Stress \propto Strain$$

$$Stress = E\ Strain$$

There are three types of modulus,

1. Young's Modulus of Elasticity (Y)

When a wire is acted upon by two equal and opposite forces in the direction of its length, the length of the body is changed. The change in length per unit length (Δl/l) is called the longitudinal strain and the restoring force (which is equal to the applied force in equilibrium) per unit area of cross-section of wire is called the longitudinal stress.



For small change in the length of the wire, the ratio of the longitudinal stress to the corresponding strain is called the Young's modulus of elasticity (Y) of the wire. Thus,

$$Y = \frac{F/A}{\delta l/l} = \frac{Fl}{A\delta l}$$

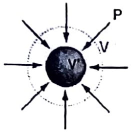
Let there be a wire of length 'l' and radius 'r'. Its one end is clamped to a rigid support and a mass M is attached at the other end. Then

$F = Mg$ and $A = \pi r^2$

Substituting in above equation, we have

$$Y = \frac{Mgl}{(\pi r^2)\,\delta l}$$

2. Bulk Modulus of Elasticity (B)

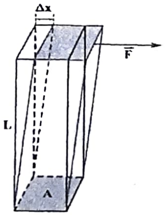


When a uniform pressure (normal force) is applied all over the surface of a body, the volume of the body changes. The change in volume per unit volume of the body is called the 'volume strain' and the normal force acting per unit area of the surface (pressure) is called the normal stress or volume stress. For small strains, the ratio of the volume stress to the volume strain is called the 'Bulk modulus' of the material of the body. It is denoted by B. Then

$$B = \frac{-P}{\Delta V/V}$$

Here, the negative sign in formula implies that when the pressure increases volume decreases and vice-versa.

3. Modulus of Rigidity (η)



When a body is acted upon by an external force tangential to a surface of the body, the opposite surfaces being kept fixed, it suffers a change in shape of the body, its volume remains unchanged. Then the body is said to be sheared.

Experiment Principle and Viva Questions

The ratio of the displacement of a layer in the direction of the tangential force and the distance of the layer from the fixed surface is called the shearing strain and the tangential force acting per unit area of the surface is called the 'shearing stress'.

For small strain in the ratio of the shearing stress to the shearing strain is called the 'modulus of rigidity' of the material of the body. It is denoted by 'η'.

$$\eta = \frac{F/A}{\varphi} = \frac{F}{A\varphi}$$

11. YOUNG'S MODULUS BY SINGLE CANTILEVER

1. **What is stress? Give its unit.**
   The force applied on a body per unit area is known as stress. its unit is N/m^2

2. **What is strain? Give its unit.**
   The ratio of change in dimension to original dimension is called strain. It is a ratio of same quantities; hence it has no unit.

3. **What is elasticity?**
   The property of the body to regain its original shape and size, after the removal of the applied stress.

4. **What are the factors affecting the elasticity of a material?**
   Effect of stress Effect of change in temperature Effect of Impurities Effect of hammering, rolling and annealing Effect of crystalline nature.

5. **What are the elastic bodies?**
   The bodies which regain its original shape or size after removal of the deforming force are called elastic bodies.

6. **Define the term Young's modulus.**
   Young's modulus is defined as the ratio of longitudinal stress to the longitudinal strain.

7. **State Hooke's law?**
   It states that within the elastic limit, the stress generated within the body is proportional to the strains. Stress/strain = constant.

8. **What is modulus of elasticity?**
   The ratio of stress to strain is a constant and is known as modulus of elasticity.

9. **What is Young's modulus?**
   Young's modulus is defined as the ratio of the longitudinal stress to the longitudinal stress.

Department of Physics, K. S. I. T, Bangalore-109.

10. What is a beam?
When the length of the rod of uniform cross-section is very large compared to its breadth such that the shearing stress over any section of the rod can be neglected, the rod is called a beam.

11. How the longitudinal strain and stress is produces?
Due to depression, the upper or concave side of the beam becomes smaller than the lower or convex side of the beam, As a result longitudinal strain is produced. The change in length will be more to the force acting along the length of the beams. These forces will give rises to longitudinal stress.

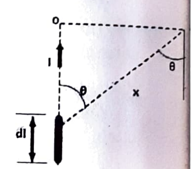
12. How do you ensure that in your experimental your elastic limit is not exceeded?
The consistency in the readings of depression both for increasing and decreasing the loads indicates that in the elastic limit is not exceeded.

13. What is Single cantilever?
A **cantilever** is a rigid structural element, such as a beam or a plate, anchored at one end to a (usually vertical) support from which it protrudes; this connection could also be perpendicular to a flat, vertical surface such as a wall. **Cantilevers** can also be constructed with trusses or slabs.

12. Magnetic Field Intensity

1. State Biot-Savart's law

BiotSavart Law states that, the magnetic intensity dH at a point A due to current I flowing through a small element dl is



1. Directly proportional to current (I)
2. Directly proportional to the length of the element (dl)
3. Directly proportional to the sine of angle θ between the direction of current and the line joining the element dl from point A.
4. Inversely proportional to the square of the distance (x) of point A from the element dl.

where k is constant and depends on the magnetic properties of the medium.

$$dH = \frac{\mu_0 \mu_r}{4\pi} x \, Idl \, Sin\theta / x^2$$

$$K = \mu_0 \mu_r / 4\pi \qquad dH = k \, x \, Idl \, Sin\theta / x^2$$

$$dH \propto Idl \, Sin\theta / x^2$$

μ_0 = absolute permeability of air or vacuum and its value is 4 x 10^{-7} Wb/A-m
μ_r= relative permeability of the medium.

2. What is magnetization?

Magnetization is the polarization is the vector field that expresses the density of permanent or induced magnetic dipole moments in a magnetic material.
The magnetization field or M-field can be defined according to the following equation

$$M = \frac{dM}{dV}$$

dM is the Elementray Magnetic moment and dV is the Volume element.

3. Mention the classes of Magnetic materials

The magnetic behavior of materials can be classified into the following five major groups:

1. Diamagnetism
2. Paramagnetism
3. Ferromagnetism
4. Ferrimagnetism
5. Antiferromagnetism

4. What is Diamagnetism?
Diamagnetic substances are composed of atoms which have no net magnetic moments (ie., all the orbital shells are filled and there are no unpaired electrons). However, when exposed to a field, a negative magnetization is produced and thus the susceptibility is negative

5. What is paramagnetism?
This class of materials, some of the atoms or ions in the material have a net magnetic moment due to unpaired electrons in partially filled orbitals. One of the most important atoms with unpaired electrons is iron. However, the individual magnetic moments do not interact magnetically, and like diamagnetism, the magnetization is zero when the field is removed. In the presence of a field, there is now a partial alignment of the atomic magnetic moments in the direction of the field, resulting in a net positive magnetization and positive susceptibility.

6. What is Ferromagnetism?
The atomic moments in these materials exhibit very strong interactions. These interactions are produced by electronic exchange forces and result in a parallel or antiparallel alignment of atomic moments. Exchange forces are very large, equivalent to a field on the order of 1000 Tesla, or approximately a 100 million times the strength of the earth's field. These materials shows Spontaneous magnetization.

7. What is Ferrimagnetism?
Ferrimagnetic material is one that has populations of atoms with opposing magnetic moments.

8. What is Antiferromagnetism?
The spins of electrons, align in a regular pattern with neighboring spins pointing in opposite directions.

PLOT EXERCISE

1) Plot the graph of Frequency (s^{-1}) Vs Energy (J) and find the slope:

Energy of the photon, E (J)	Frequency, ν (s^{-1})
2.19×10^{-19}	4.6×10^{14}
2.44×10^{-19}	4.8×10^{14}
2.54×10^{-19}	5×10^{14}
2.70×10^{-19}	5.2×10^{14}
3.62×10^{-19}	6.8×10^{14}

2) (i) Plot the graph of Voltage (V) Vs Current (mA), forward and reverse bias:
(ii) Find Knee Voltage and Breakdown Voltage:

Forward Bias:

$V_f(V)$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.75	0.78	0.8
$I_f(mA)$	0	0	0	0	0	0	0.5	2.1	4.1	10.5

Reverse Bias:

$V_r(V)$	1	2	3	4	5	6	7	8	8.5	8.7	8.8	8.9	9
$I_r(mA)$	0	0	0	0	0	0	0	0	1.4	8.6	14.7	17.1	21.8

3) (i) Plot the graph of Frequency (Hz) Vs Current (mA), in series resonance circuit:
(ii) Plot the graph of Frequency (Hz) Vs Current (mA), in parallel resonance circuit:
(iii) Find f_0 resonance frequency and Bandwidth of both the graphs:

Frequency, f (Hz)	Series Current, I (mA)	Parallel Current, I (mA)
1000	3.85	9.82
1500	8.04	5.00
2000	15.78	1.31
2200	16.84	0.72
2500	14.33	1.84
3000	9.29	4.39
4000	5.21	8.24
5000	4.06	10.83
6000	3.10	12.97
7000	2.57	14.89

4) Plot the graph of Temperature (K) Vs Resistance (Ω) and find the slope:

Temperature, T (K)	Resistance, R (Ω)
~~299.5~~	~~6.25~~
~~355~~	~~7.72~~
353	7.49
351	7.36
349	7.33
347	7.30
345	7.27
343	7.24
341	7.20
339	7.14