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DEPARTMENT OF PHYSICS

ENGINEERING PHYSICS LABORATORY MANUAL

I/II SEMESTER (CBCS SCHEME)

SUBJECT: ENGG. PHYSICS LAB

SUBJECT CODE: 18PHYL 16/26

PREPARED BY:

Staff members, Department of Physics, BMSIT&M.

August- 2020

PERFORMANCE SHEET

NAME OF THE CANDIDATE:

SECTION: **SEMESTER: I/II**

ROLL NO/USN:

Max. Marks for each expt. 30

Sl. No.	Name of the Experiment	Marks	Initial of staff
1.	TORSIONAL PENDULUM		
2.	TRANSISTOR CHARACTERISTICS		
3.	FERMI ENERGY OF COPPER		
4.	SERIES AND PARALLEL LCR CIRCUITS		
5.	NEWTON'S RINGS		
6.	YOUNG'S MODULUS BY SINGLE CANTILEVER		
7.	DIELECTRIC CONSTANT		
8.	LASER DIFFRACTION GRATING		
9.	NUMERICAL APERTURE		
10.	DETERMINATION OF SPRING CONSTANT		
11.	PHOTO DIODE		
12.	MAGNETIC INTENSITY ALONG THE AXIS OF A COIL		

Signature of Batch in charge **Signature of Head of the Dept.**

DEPARTMENT OF PHYSICS

DOs

- Bring observation book, Lab manual & record book regularly.
- Write the write up of the experiment in advance in the observation book before coming to the practical class.
- Bring calculator to the practical class regularly.
- Handle the apparatus/equipment gently and carefully.
- Return the apparatus collected, to lab instructor before leaving the lab.

DON'Ts

- Dumping your bag on the work table.
- Giving your observation book and record books to others.
- Forgetting to check your belongings before leaving the lab.
- Spoiling of the apparatus/equipment as it is meant for your benefit only.
- Switch on electronic equipment before getting the approval by the teacher/instructor.
- Bringing mobile phones inside the Laboratory.

Instructions to students:

1. All calculations must be carried out using SI units.
2. All entries in the observation book should be done using pen only
3. Wherever graphs have to be plotted plotting has to be done using pencil only.

CONTENTS

1. TORSIONAL PENDULUM

AIM: To determine the moment of inertia of an irregular body and to calculate the rigidity modulus of the material by the principle of torsional pendulum.

FORMULA:

Moment of Inertia of an irregular body is given by

$$I_0 = \left(\frac{I}{T^2}\right)_{mean} \times T_0^2 \quad \text{kgm}^2 \qquad (1)$$

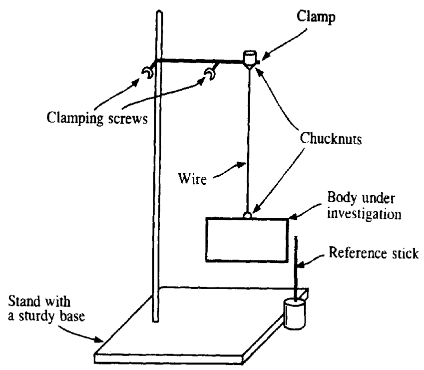
Where I_0 is the moment of Inertia of an irregular body in kg.m^2
I is the moment of inertia of regular body in kg.m^2
T is the period of torsional oscillation of regular body in s.
T_0 is the period of oscillation of an irregular body in s.

The rigidity modulus of the material of the wire is given by

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

Where l is the length of the wire in m.
r is the radius of the wire in m.

FIGURE:



TORSIONAL PENDULUM
Fig. 1

PRINCIPLE: The moment of inertia of a body about a given axis of rotation is defined as the product of mass of the body and the square of radius of gyration. The ratio of moment of inertia to the square of period of oscillation is constant for different axes of regular bodies will be constant for a given length of the wire. There is no direct formula to determine the moment of inertia of an irregular body about any axis. Hence, by the principle of torsional pendulum (I/T^2) of a regular body = (I_0/T_0^2) of irregular body. By knowing the mean (I/T^2) for regular bodies & the period of oscillation of an irregular body, the moment of inertia of irregular body can be calculated using the formula.

PROCEDURE:

- The mass (M_1) of the given circular disc and mass (M_2) of rectangular plate are indicated on the respective plates. The radius of the circular disc (R), length (L) and breadth (B) of the rectangular plate are also indicated on the respective plates. The moment of inertia values of the bodies about the respective axes are determined using the formulae indicated in the tabular column.

- The circular disc is suspended using the check nuts of the experimental wire such that the axis of suspension is perpendicular to the plane of the disc. A convenient reference mark is made on the edge of disc, using a piece of chalk and a reference pointer is placed just in front of the circular disc. The base of the chuck nut is twisted through a small angle **(small amplitude)** such that torsional oscillations are setup. A stop clock is started when the reference mark on the body crosses the reference stick in a particular direction. The time taken for the reference mark on the plate to cross the reference pointer in the same direction is taken as time for one oscillation. The time taken for 5, 10 and 15 such oscillations is noted using a stop clock. The period of oscillations is calculated by dividing the time taken for 10 oscillations by 10 and the mean period of oscillation is calculated.
- Again, suspend the circular disc in such a way that, the axis of the suspension passes through the diameter of the disc. The mean period of oscillation is calculated by repeating the above procedure.
- Then circular disc is removed from the wire and the rectangular plate is suspended, first about an axis perpendicular to the plane of the plate, next about an axis perpendicular to the length and lastly about an axis perpendicular to its breadth.
- The mean period of oscillation is calculated in each case separately. For each axis of suspension of circular & rectangular bodies, the ratio of moment of inertia to the square of period of oscillation i.e. (I/T^2) is calculated and hence, the mean value of (I/T^2) is calculated.

PART I: To determine moment of inertia of irregular body

- The given irregular body is suspended by the experimental wire, with an axis of suspension perpendicular to its plane or its length or its breadth of the irregular body. The body is set in to torsional oscillation and the period of oscillation (T_0) is calculated.
- The moment of inertia of the irregular body (I_0) about an axis is calculated by taking the mean value of (I/T^2) from the regular bodies using the formula.

$$I_0 = \left(\frac{I}{T^2}\right)_{mean} \times T_0^2 \quad \text{kgm}^2$$

PART II: To determine the rigidity modulus of the material of the experimental wire.

- The length (l) of the wire between the two chuck nuts is found by using a thread or scale. Using the radius of the wire which is given and by noting the mean value of (I/T^2) of regular bodies, the rigidity modulus of the material of the wire is calculated using the formula

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

OBSERVATIONS

Mass of the circular plate M_1 = --------- Kg

Radius of the circular plate R = --------- $\times 10^{-2}$ m

Mass of rectangular plate M_2 = --------- Kg

Length of the rectangular plate L = ------- x10^{-2} m

Breadth of the rectangular plate B = ------ x10^{-2} m

is the length of the wire l = ------- x10^{-2} m

r is the radius of the wire r = 0.45 x 10^{-3} m

TABULAR COLUMN

1. **Calculation of moment of inertia of regular bodies**

Body	Axis of suspension	Moment of Inertia (I) kgm^2	No. of oscillations	Time 't' (sec)	No. of oscillations	Time 't' (sec)	Time (t) taken For 10 oscillations	Avg. Time (t) taken for 10 oscillations	Period T =t/10 sec	T^2	(I / T^2) Kgm^2/S^2
Circular plate	Perpendicular to the plane	$I_1 = (M_1R^2) / 2$	**0** **5**		**10** **15**				**T_1**		**I_1/T_1^2=**
	Along the diameter	$I_2 = (M_1R^2) /4$	**0** **5**		**10** **15**				**T_2**		**I_2/T_2^2=**
Rectangular plate	Perpendicular to the plane	$I_3 = [M_2 (L^2+B^2)] / 12$	**0** **5**		**10** **15**				**T_3**		**I_3/T_3^2=**
	Perpendicular to the length	$I_4 = (M_2 L^2) / 12$	**0** **5**		**10** **15**				**T_4**		**I_4/T_4^2=**
	Perpendicular to the breadth	$I_5 = (M_2 B^2) / 12$	**0** **5**		**10** **15**				**T_5**		**I_5/T_5^2=**

Mean value of (I/T^2) = -------------- kgm^2/s^2

2. **Calculation of moment of inertia of an irregular body**

Axis of suspension	No. of oscillations	Time 't' sec	No. of oscillations	Time 't' sec	Time (t) taken For 10 oscillation	Avg. Time (t) taken for 10 oscillations	Period T_0 = t/10	T_0^2	Moment of inertia of irregular body $I_0 =(I/ T^2)_{mean} \times T_0^2$
Perpendicular to its plane	**0** **5**		**10** **15**						I_0 = -------

Length of the wire between the two chuck nuts l = - - - - - cm

= - - - - - x 10^{-2} m

Calculation of Rigidity modulus $$\eta = \left(\frac{8\pi l}{r^4}\right)\left(\frac{I}{T^2}\right)_{mean}$$

= -------------------- N/m^2

Calculations:

RESULT:

1. The moment of inertia of the given irregular body about an axis perpendicular to its plane is found to be I_0 = -------------- kgm^2

2. The rigidity modulus of the material of the wire is η = -------- N/m^2.

PRECAUTION:

While changing the axis of the plates care should be taken to see that the wire does not break. Therefore the chuck nut should be removed from the top.

2. TRANSISTOR CHARACTERISTICS

AIM: To study the input, output and transfer characteristics of an N-P-N transistor in the common emitter mode and also determining the input resistance (R_i) and the current gain factor (β) of the given transistor.

APPARATUS: Given transistor (NPN), variable DC power supplies (0-1V&0-10V) DC micro ammeter (0-200µA), DC milli ammeter (0-10 mA), DC voltmeter (0- 1V&0-l0V) and connecting wires.

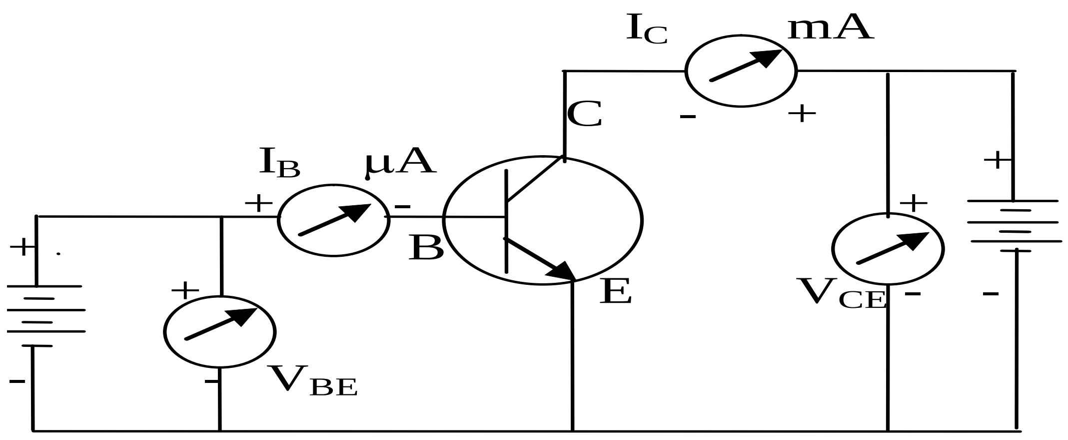
FORMULA:

1) Input resistance $$Ri = \frac{\Delta V_{BE}}{\Delta I_B} \quad (\Omega)$$

Where, ΔV_{BE} = Change in the base emitter voltage in volts
ΔI_B = Change in the base current in µA

2) Current gain $$\beta = \frac{\Delta I_C}{\Delta I_B}$$

CIRCUIT DIAGRAM:



PROCEDURE:

- The common emitter circuit for studying the transistor characteristics of a NPN transistor is shown in fig. First identify the terminals of different devices required for the experiment on the experimental box.
- Give the connections using connecting wires carefully according to the circuit diagram. Before switching on the circuit, verify once again the circuit connections. Now turn all power supply knobs to the minimum position & switch on the power supply. Check that circuit is working properly.

Input characteristics:

- To study the input characteristics of the transistor first turn all power supply knobs to minimum position. Now collector-Emitter voltage V_{CE} is set to 2 volt by varying Vcc. Keeping V_{CE} = 2 volt as constant vary the Base-Emitter voltage V_{BE} by turning V_{BB} till the base current reaches around 5 µA. After this increase V_{BE} insteps of 20 mV until the base current reaches around 150 µA.

- A graph of V_{BE} along X- axis & I_B along Y- axis is plotted. Slope of the curve is found in active region of transistor which is (i.e. linear portion of the curve) the reciprocal of the input resistance values.

Output characteristics:

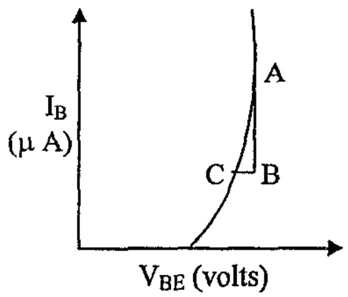
- To study the output characteristics of the transistor. Again turn all the power supply knobs to minimum position. Now the Base current I_B is set to 25 μA by turning V_{BB} knob. Keeping I_B =25 μA, apply V_{CE} values as 0.2, 0.4, 0.6, 0.8 volts till 1 volt and note down corresponding I_C values. Tabulate all the values in relevant tabular column for output characteristics. Care should be taken that while taking each reading of Ic, I_B should read the constant values i.e. I_B =25 μA.
- Now a graph of V_{CE} along X-axis and Ic along Y-axis is plotted. Slope of the curve is found in the active region of the transistor (i.e. linear portion of the curve). Reciprocal of slope is the ratio $\Delta V_{CE} / \Delta I_c$, and hence the output resistance value.

Transfer characteristics:

- To study the Transfer characteristics of the transistor. Turn all the power supply knobs to minimum position again. Now set the collector-Emitter voltage V_{CE} = 2 volt.
- Apply I_B values as 25 μA, 50 μA, 75 μA & 100 μA & note the Ic values in milli amperes each time. Tabulate the readings in relevant tabular column for transfer characteristics.
- A graph of I_B along X-axis & Ic along Y-axis is plotted. The graph obtained will be a straight line, calculate the slope and slope will be the ratio $\Delta I_C / \Delta I_B$, and hence the current gain β values.

OBSERVATIONS:

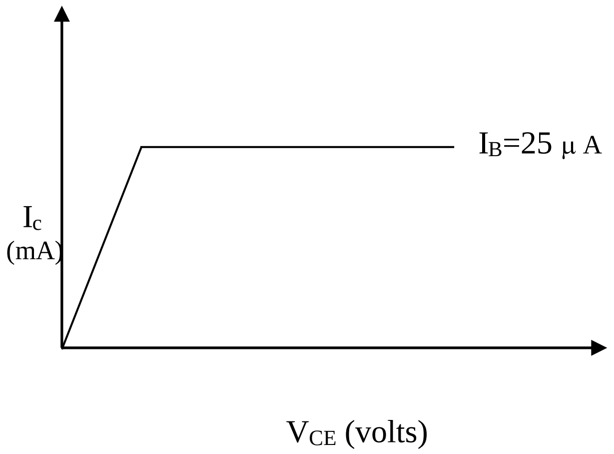
Input characteristics:



V_{CE} = 2V	
V_{BE}(mV)	I_B(μA)
0	0
	5

Output characteristics:

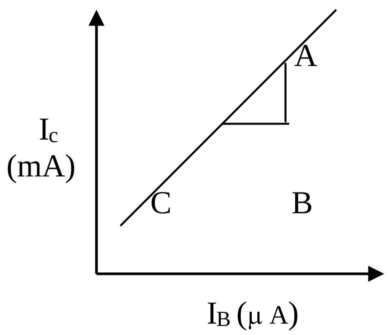
I_B = 25 μ A	
V_{CE}(V)	I_C (mA)
0	
0.2	
0.4	
0.6	
0.8	
1.0	



Note: For Input characteristic triangle form should be small & it should be taken in the linear portion of the curve

Transfer characteristics:

V_{CE} =2 volt	
I_B (μA)	I_C (mA)
10	
20	
30	
40	
50	
60	
70	
80	
90	
100	



RESULT:

1. The input resistance = R_i = ---------------- Ω
2. Current gain factor = β = -----------------

3. DETERMINATION OF FERMI ENERGY

AIM: Determination of Fermi energy of copper using a Wheatstone metre bridge.

APPARATUS: Copper coil, standard resistance box, Metre Bridge, hot water, thermometer.

PRINCIPLE: Fermi energy is the energy of the electron at the highest occupied energy level at absolute zero Kelvin

FORMULA:

$$E_F = \left[\frac{ne^2\pi Ar^2}{L\sqrt{(2m)}}\right]^2 x \left(\frac{\Delta R}{\Delta T}\right)^2 x \frac{1}{1.6x10^{-19}} \quad (eV) \quad \text{.......(1)}$$

Where

n is the free electron concentration in m^{-3},
e is the charge of electron in C,
A is the metal constant in mK,
r is radius of the coil in m,
L is the length of the copper wire in m,
m is the mass of electron in kg and
$\frac{\Delta R}{\Delta T}$ is the slope of the straight line obtained by plotting resistance of the copper coil against absolute temperature in Ω/K.
E_F is the Fermi energy in joule

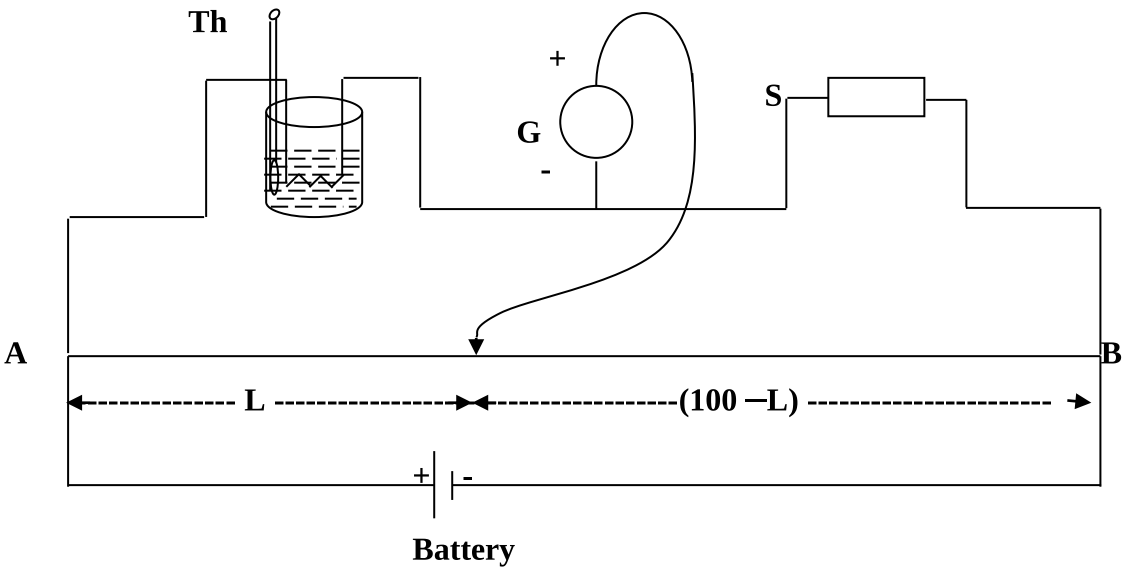
PROCEDURE:

1. A copper coil which is wound on a wooden bar is immersed in hot water taken in a beaker. A thermometer is also immersed in the beaker to note the temperature of water. The two ends of the coil are connected to the left gap of a metre bridge.
2. A shunt resistance of 1Ω is connected in the right gap. The circuit is completed as shown in the circuit diagram.
3. The water is allowed to cool and the balancing length is noted for every 5^0C decrease in temperature starting from 80 ^{o}C.
4. The readings are tabulated and the resistance of the coil at various temperatures is calculated.
5. A graph of resistance against absolute temperature is plotted which will be a straight line (as shown in figure) and the slope is determined.
6. The slope is substituted in equation (1), the Fermi energy is calculated and also it is expressed in eV.

OBSERVATIONS:

Length of the copper wire, L = 4m, Radius, r = $0.12x10^{-3}$m.
Metal Constant, A = λ_F T= $2.32x10^{-8}$ x 318 = $7.4x10^{-6}$mK.
Free electron concentration, n = $8.464x10^{28}/m^3$.
Mass of electron, m = $9.1x10^{-31}$kg.
Charge of an electron, e = $1.6x10^{-19}$C

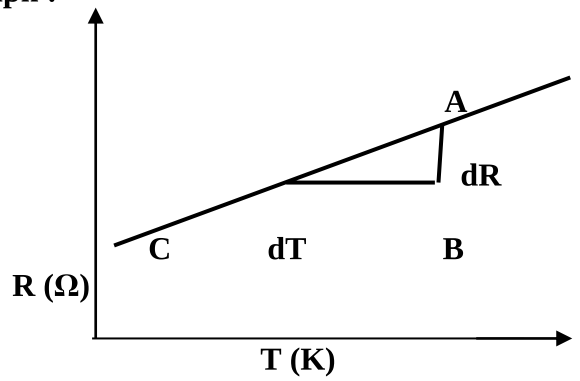
CIRCUIT DIAGRAM:



TABULAR COLUMN:

Trials	Temp. (°C)	Temp. (K)	Balancing length ' L'(cm)	Resistance $R = \frac{SxL}{(100-L)}$ (Ω)
1	80	353		
	75	348		
2	70	343		
	65	338		
3	60	333		
4	55	328		
5	50	323		

Graph :



RESULT: The Fermi energy of copper is found to be ____________ eV.

4. VERIFICATION OF SERIES AND PARALLEL RESONANCE USING L. C. R. CIRCUITS.

AIM: To study the frequency response of the given series and parallel resonance circuits, and hence to determine the inductance value of the unknown inductor, also to determine the bandwidth and quality factor of the circuit in series resonance.

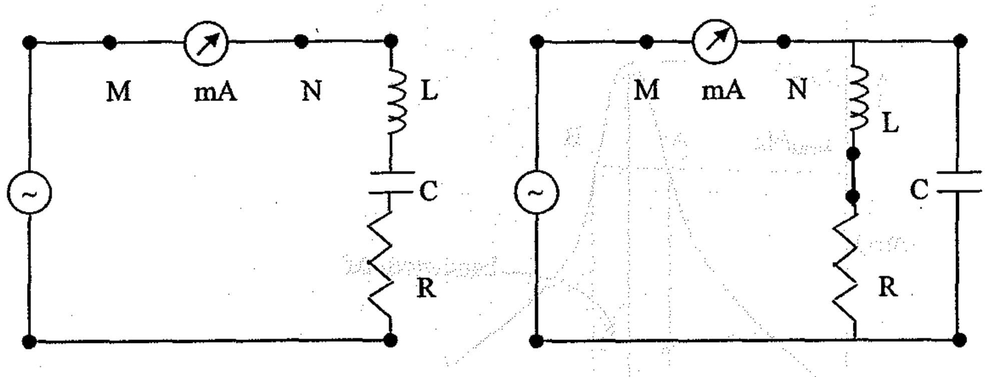
APPARATUS: Audio frequency oscillator, a c milliammeter, standard inductance coil, standard resistors and capacitors, patch cards, etc.

PRINCIPLE: This experiment is based on the principle of resonance in AC electrical circuits. An LCR circuit is essentially an oscillator; therefore it will have a definite natural frequency depending on the value of L & C when the natural frequency of the LCR matches with applied frequency supplied by the signal generator resonance takes place. In the case of series LCR the current at resonance will be maximum, and in the case of parallel LCR current at resonance will be minimum. A series LCR will be used as a tuning circuit and the parallel circuit will be used as a filter circuit

CIRCUIT DIAGRAM:

Choose $L = L_1$, R = 750Ω & C = 0.01μF

SERIES RESONANCE **PARALLEL RESONANCE**



(fig. a) **(fig. b)**

FORMULA: The unknown Inductance L is given by the formula

$$1.\quad L = \frac{1}{4\pi^2 f_r^2 C} \quad \text{(H)}$$

Where f_r = Resonant frequency (Hz)

C = Capacitor value of the given LCR circuit. (μF)

The Band width of the given series LCR circuit is given by 2. $\Delta f = f_2 - f_1$ (Hz)

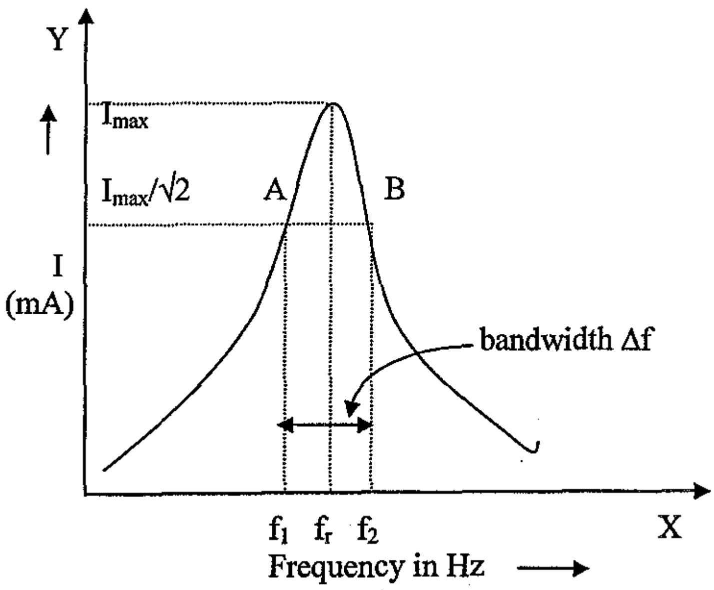
Where f_1 and f_2 are lower and upper cutoff frequencies

Quality factor Q is given by $$3.\quad Q = \frac{f_r}{\Delta f}$$

PROCEDURE: SERIES RESONANCE

- Connect the components, inductance $L = L_1$, Resistance R = 750Ω**,** Capacitance C = 0.01μF in series and the function generator as shown in the circuit diagram. Initially the circuit should be closed by switching on the power supply. The amplitude in the signal generator is adjusted for an optimum value and the signal generator should be adjusted for sinusoidal mode. The frequency in the signal generator is set to 1 KHz.

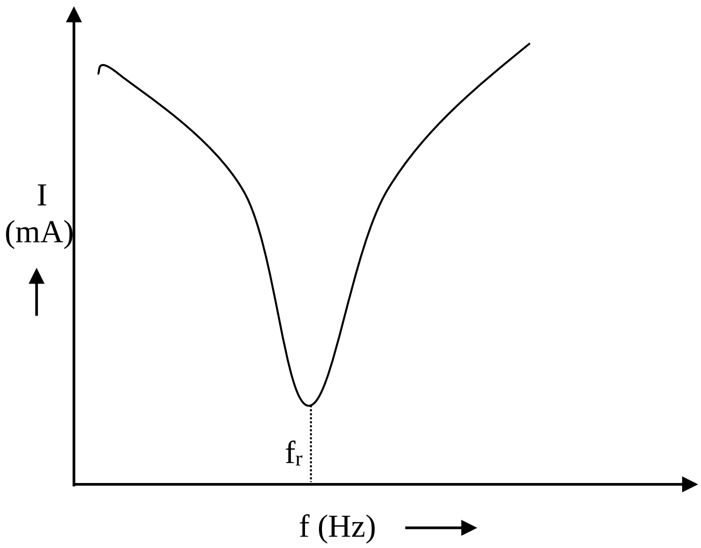
- The frequency is varied in steps of 500 Hz up to 4000 Hz, then insteps of 100 Hz from 4000 Hz to 5500 Hz, then in steps of 500 Hz till 8000 Hz and the corresponding current for each frequency is noted down. At a particular frequency we observe that, the current in circuit becomes maximum and this frequency is called resonant frequency (f_r).
- A graph is plotted between current and the frequency and the curve obtained is called the frequency response curve of the given series LCR circuit. The bandwidth of the LCR circuit gives us the measure of appropriate frequencies, which the given circuit can pick up when used as a tuning circuit. The band width can be calculated as follows: in the frequency response curve at a value of current equal to Imax/ √2 a straight line parallel to frequency axis is drawn which cuts the curve at points A & B, the frequencies corresponding to A&B are called f_1 & f_2 respectively. The difference in f_2 & f_l is called bandwidth. The quality factor Q gives us the sharpness of the resonance curve which is given by the ratio of resonant frequency (f_r) to band width (Δf)



(fig.c)

PARALLEL RESONANCE:

- The circuit is connected as shown in the circuit diagram. The amplitude adjusted for series resonance should be kept constant. The frequency is varied from1KHz to 8 KHz as before and the corresponding current is noted down in the milli ammeter. In this case we observe that the current in the circuit gradually decreases in the beginning and reaches a minimum value at resonance. The frequency corresponding to minimum current in the circuit is called resonant frequency of the given parallel LCR.
- Since we are using same value of Inductance (L) and Capacitance (C) for both series and parallel LCR circuit the value of resonant frequency in both cases should match. A plot between current and the frequency is drawn as follows.



TABULAR COLUMN: Choose L = L1, R = 750Ω & C = 0.01µF

Series LCR circuit		Parallel LCR circuit	
Frequency (Hz)	**Current (mA)**	**Frequency (Hz)**	**Current (mA)**
1000		1000	
1500		1500	
2000		2000	
2500		2500	
3000		3000	
3500		3500	
4000		4000	
4100		4100	
4200		4200	
4300		4300	
4400		4400	
4500		4500	
4600		4600	
4700		4700	
4800		4800	
4900		4900	
5000		5000	
5100		5100	
5200		5200	
5300		5300	
5400		5400	
5500		5500	
6000		6000	
6500		6500	
7000		7000	
7500		7500	
8000		8000	

Calculations:

RESULT: The frequency response curve is studied, the values of
Series Resonant frequency = …………………….Hz
Unknown Inductance = ………………………….H
Bandwidth= ……………………………………...Hz
Quality factor =…………………………………...
Parallel resonant frequency = ……………………Hz

Note: Experiment can be repeated for different values of inductance ‘L’ and capacitor ‘C’ accordingly the range of frequencies must be selected.

5. NEWTON'S RINGS

AIM: To determine the radius of curvature of a given Plano convex lens by Newton's rings method.

APPARATUS: Plano convex lens, Plane glass plate, Stand with a turn able glass plate, traveling microscope, sodium vapour lamp etc.

PRINCIPLE: This experiment is based on the principle of interference of light in thin films. In this experiment an air film is formed between a ground glass plate and a plano convex lens. When a monochromatic light is made to incident on the combination of a Plano convex lens and the remaining portion of light passes through Plano convex lens and gets reflected from the bottom ground glass plate, these two components of light undergo interference to form Newton's Rings.

FORMULA: The radius of curvature of the curved surface of the lens is given by

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

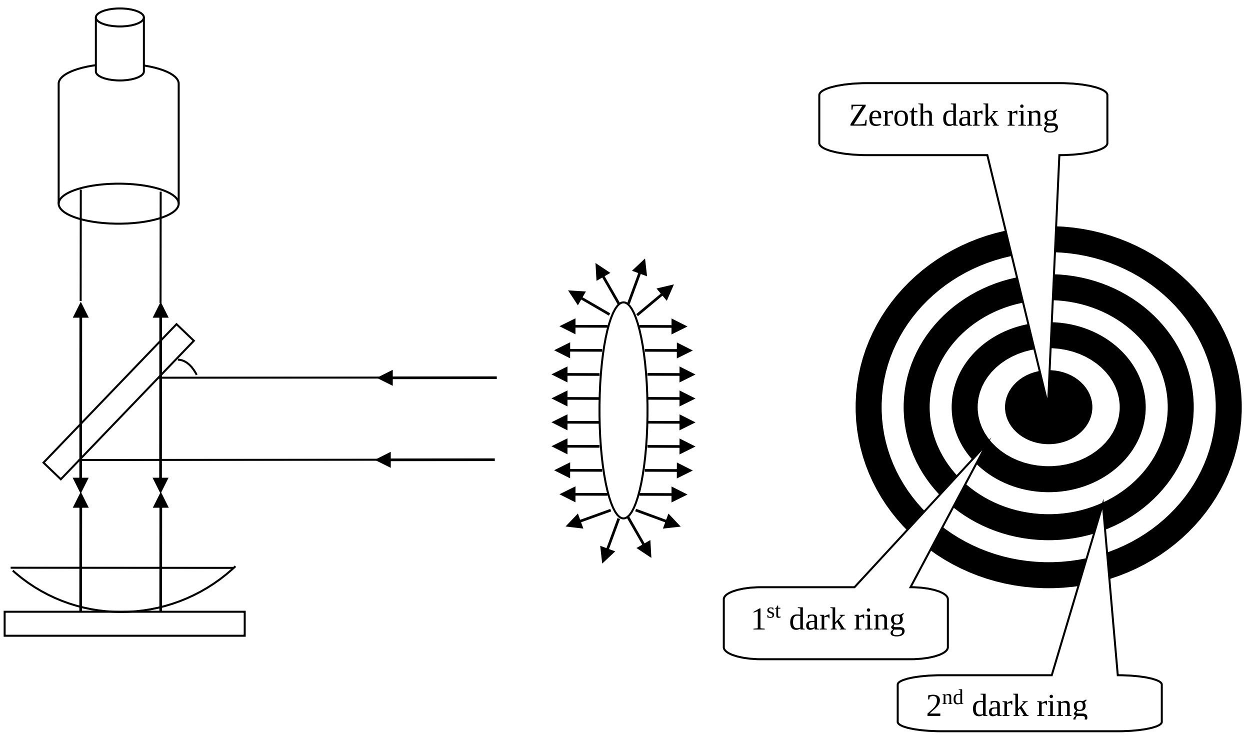
Where, R= radius of curvature of the Plano convex lens in m.

D_m= diameter of the m^{th} dark ring in m.

D_n= diameter of the n^{th} dark ring in m.

λ= Wavelength of sodium light i.e., 5893 x10^{-10} m.

FIGURE:



PROCEDURE:

- Initially the Plano convex lens is tested to find out the curved surface of and the plane surface which is done as follows. The Plano convex lens is placed on the ground glass plate and it is rotated gently, if the lens rotates freely then the curved surface is facing the ground glass otherwise due to friction the rotation will not be smooth in which case the plane surface of the lens is in contact of the ground glass plate. Now we should place the curved surface towards the ground glass plate, care should be taken to see that there are no dust particles on both the surface of the lens and the surfaces of the ground glass plate.

- Now the reflector plate is adjusted until the intensity of light in the eyepiece becomes maximum. When the intensity of the light is maximum the reflector plate will be at an angle of 45^0 to the horizontal, later the focusing screw of the traveling microscope is adjusted until the fringe patterns are seen. Initially the center of the fringe pattern may not appear, and then the traveling microscope is aligned such that the intersection of the cross wires coincide with the centre of the fringe pattern.
- In an ideal Newton's Ring set up there will be a central dark spot which corresponds to the zeroeth ring of the system, in case if the central dark spot is not present the inner most ring should be taken as ring no 1, initially the vertical cross wire of the traveling microscope should be taken tangentially to 12^{th} dark ring, therefore 12 rings should be counted carefully towards left of the centre and the vertical cross wire should be moved gradually tangential to the outer portion of the 12^{th} ring, this is the starting point of the experiment. The reading corresponding to the 12^{th} dark ring is noted down and tabulated in the given tabular column.
- Later the vertical cross wire should be moved towards the centre and it should be made coinciding with 10^{th} dark ring and the reading for the 10^{th} dark ring is noted. Similarly readings of 8^{th}, 6^{th}, 4^{th} and 2^{nd} dark ring of the left hand side are noted down by adjusting the vertical cross wire tangential to the respective rings. When the cross wire reaches 2^{nd} dark ring the counting of the rings can be verified. If the initial counting of rings is correct then the cross wire will be exactly at two rings away from the dark spot, otherwise either it will be ahead of the 2^{nd} dark ring or behind the 2^{nd} dark ring.
- Now the cross wire should be moved towards RHS (right side) of the ring pattern. On the right side readings should be taken in the ascending manner i.e. in the order 2, 4, ---10 & 12 in this manner every ring will have a LHS reading and RHS reading.
- The difference between the two will give us the diameter of the respective ring, thus diameter of 12^{th}, 10^{th} & 8^{th} are calculated and tabulated under the column D_m. Similarly diameters of 6^{th}, 4^{th}& 2^{nd} rings are calculated and tabulated under the column D_n.
- The values of D_m^2 and D_n^2 are separately determined and finally the value of $(D_m^2- D_n^2)$ is determined in each case. As per the theory of the Newton's ring the value of $(D_m^2- D_n^2)$ in each case should be a constant. Therefore mean value of $(D_m^2- D_n^2)$ is found out and radius of curvature (R) of the Plano convex lens can be determined by using the given formula.

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

OBSERVATIONS:

Least count of Screw gauge type traveling microscope:

$$\text{Pitch of screw gauge} = \frac{\text{Distance moved on pitch scale on n rotations}}{\text{No of rotations given to head scale (n)}}$$

Pitch = ………… mm

$$\text{L.C} = \frac{\text{Pitch}}{\text{No. of divisions on the head scale}}$$

L.C = ………….mm

TABULAR COLUMN:

Split readings:

Ring No.	PSR (mm)	HSR	TR= PSR+(HSRxLC) (mm)
LHS 12			
10			
8			
6			
4			
2			
RHS 2			
4			
6			
8			
10			
12			

To determine $D_m^2 - D_n^2$:

Ring No 'm'	TM reading (mm)		Diameter $D_m = L_m - R_m$ (mm)	D_m^2 (mm^2)	Ring No 'n'	TM reading (mm)		Diameter $D_n = L_n - R_n$ (mm)	D_n^2 (mm^2)	$D_m^2 - D_n^2$ (mm^2)
	Left L_m	Right R_m				Left L_n	Right R_n			
12.					6.					
10.					4.					
8.					2.					

Mean ($D_m^2 - D_n^2$) = …………….mm²

= …………… x 10^{-6} m²

Calculations:

RESULT: The radius of curvature of the given Plano-convex lens R = ………m.

PRECAUTIONS:

1. While adjusting for the ring pattern care should be taken to see that the centre portion of the Plano convex lens is right below the objective lens of traveling microscope.
2. While taking readings the cross wire should always be tangential to outer portion of the ring.

6. 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.

PRINCIPLE: The experiment is based on the theory of bending moment of beams. .

Bending moment of a beam depends on the following factors:

a) Young's modulus of the material of the beam

b) The cross section geometry of the beam

FORMULA:

$$Y = \frac{4Mgl^3}{bd^3\delta} \ \mathbf{N/m^2}$$

where, M – mass for which depression is found (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).

δ - mean elevation produced (in m).

DIAGRAM:

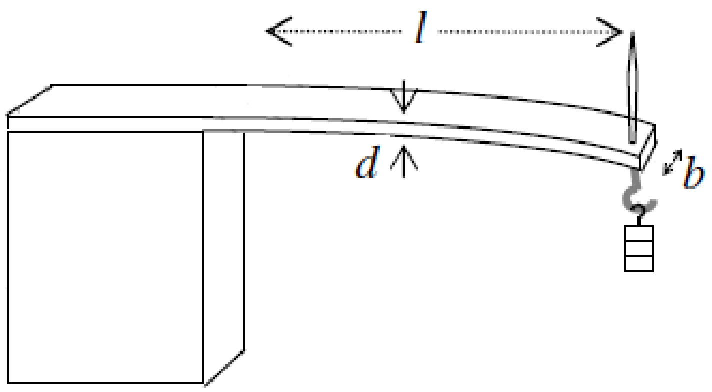


Fig.1 Single cantilever

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 dead load reading (ie. x g).

• Now add some weight to the hook (say 20 g). 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 100 g in steps of 20 g 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 20 g and the corresponding readings are taken and are tabulated.

• The depression or deflection of the cantilever beam 'δ', 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.

Precaution:

1. The pin has to be vertical before focusing

2. The beam must be parallel to horizontal scale of travelling microscope

Least count of travelling microscope:

LC = Value of 1MSD - Value of 1VSD (or) LC= Value of 1MSD/Number of VSD

TR= MSR+ (CVD x LC)

Tabular column to find elevation																
Load in hanger (g)	Load increasing			Load decreasing			Mean R1 (cm)	Load in hanger (g)	Load increasing			Load decreasing			Mean R2 (cm)	Depression δ= R1~R2 (cm)
	MSR (cm)	CVD	TR (cm)	MSR (cm)	CVD	TR (cm)			MSR (cm)	CVD	TR (cm)	MSR (cm)	CVD	TR (cm)		
X+0								X+60								
X+20								X+80								
X+40								X+100								

Mean depression, δ = -----------$\times 10^{-2}$m

CALCULATION:

$$Y = \frac{4Mgl^3}{bd^3\delta} \text{ N/m}^2$$

RESULT:-Young's modulus of the material of the beam is found to be Y= -------------N/m^2

7. DETERMINATION OF DIELECTRIC CONSTANT BY CHARGING AND DISCHARGING METHOD

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

APPARATUS: Capacitor, Resistor, Two way toggle switch, Voltmeter, stop watch.

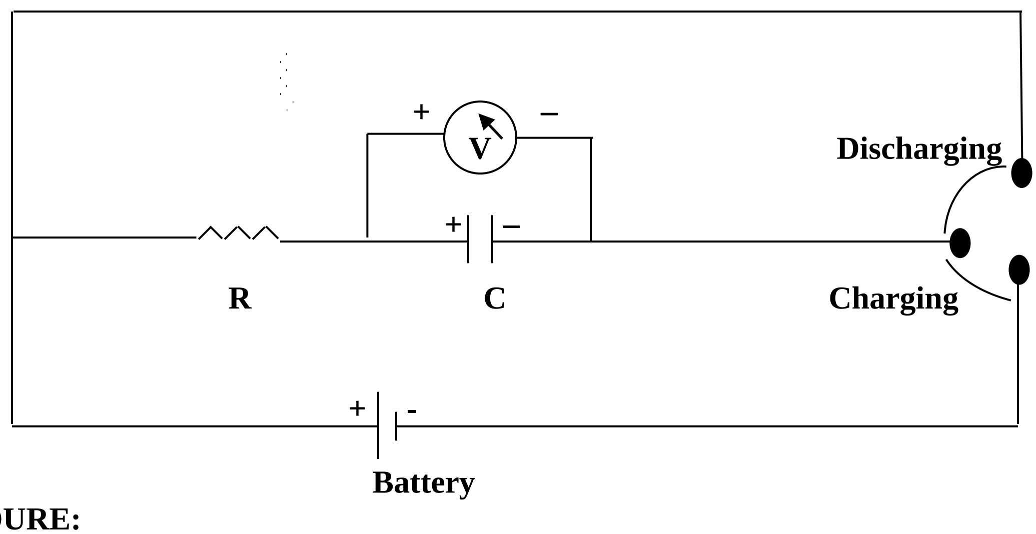
FORMUIA: Dielectric constant of a given material is given by

$$K = \frac{T_{1/2} \times d \times 10^{-6}}{0.693 \varepsilon_0 A R}$$

Where,
- K = Dielectric constant of the material
- $T_{1/2}$ = Time taken by the capacitor for half charging / discharging in S.
- d = Distance between the two plates = m.
- ϵ_0 = Permittivity of free space = 8.852×10^{-12} F/ m
- A = Area of the capacitor plate = m^2.
- R = Resistance = Ω.

[Constans for Kit-1: A = 47x5x10^{-6} m^2, C = 0.01μF, d = 0.075x10^{-3} m, R = 100 kΩ]
[Constants for kit-2: A = 120x6x10^{-6} m^2, C = 220μF, d = 0.1x10^{-3} m, R = 100 kΩ]

CIRCUIT DIAGRAM:



PROCEDURE:
- Make the connections as shown in the circuit diagram
- The capacitor is allowed to charge by switching the toggle switch to the position 1and simultaneously a stop watch is started.
- The voltage across the capacitor is noted down at an interval of 5 second using a stop watch and the readings are entered in the tabular column.

- Now the stop watch is reset, the capacitor is allowed to discharge by switching the toggle switch to the position 2 and simultaneously stopwatch is started, the voltage across the capacitor is noted down for the same interval of time.
- A graph of t along X-axis and V along Y-axis is plotted for both charging and discharging as shown in the sketch of the graph.
- The time ($T_{1/2}$) corresponding to the intersection of the two curves is noted.
- The dielectric constant of the material is calculated by substituting the value of $T_{1/2}$ in the given formula.
-

TABULAR COLUMN:

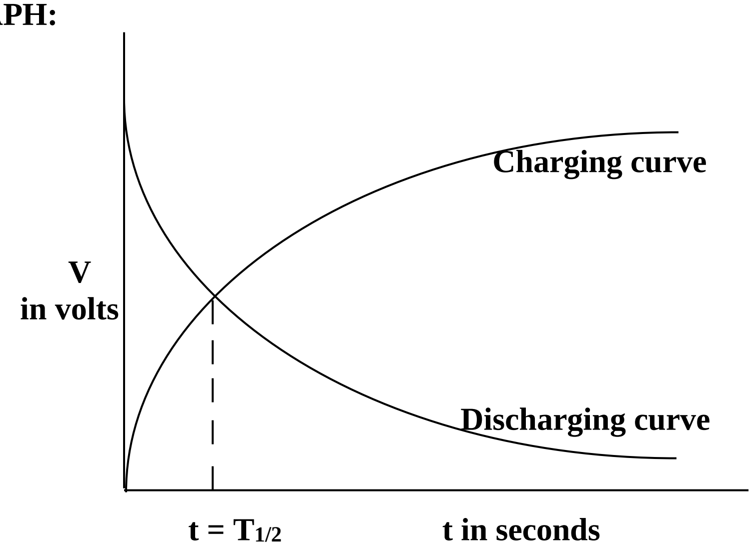
CHARGING

Time 't' in second	Voltage 'V' in volts
0	0
5	
10	
15	
20	
25	
30	
35	
40	
45	
50	
55	
60	

DISCHARGING

Time 't' in second	Voltage 'V' in volts
0	
5	
10	
15	
20	
25	
30	
35	
40	
45	
50	
55	
60	

GRAPH:



RESULT: Dielectric constant (K) of the given material is found to be ---------------------

8. WAVELENGTH OF LASER LIGHT USING A SEMICONDUCTOR LASER

AIM: To determine the wavelength of laser light by diffraction technique using a plane diffraction grating.

APPARATUS: Semiconductor diode laser source, grating with holder, scale, screen.

PRINCIPLE: Diffraction of light occurs when the width of the obstacle is comparable to the wavelength of the light source. The light from the laser source is allowed to fall normally on the grating, by measuring the distance between the diffracted spots, the wavelength of laser light is determined.

FORMULA:

$$\lambda = \frac{d \sin \theta_m}{m} \qquad \text{nm}$$

Where λ = Wavelength of laser light measured in m

d = Grating constant measured in m

Example:- For 100 number of lines per mm of a grating 'd' can be calculated as below

$$d = \frac{1}{\text{Number of lines / m}} = \qquad\qquad m$$

m = difference between the order of spots

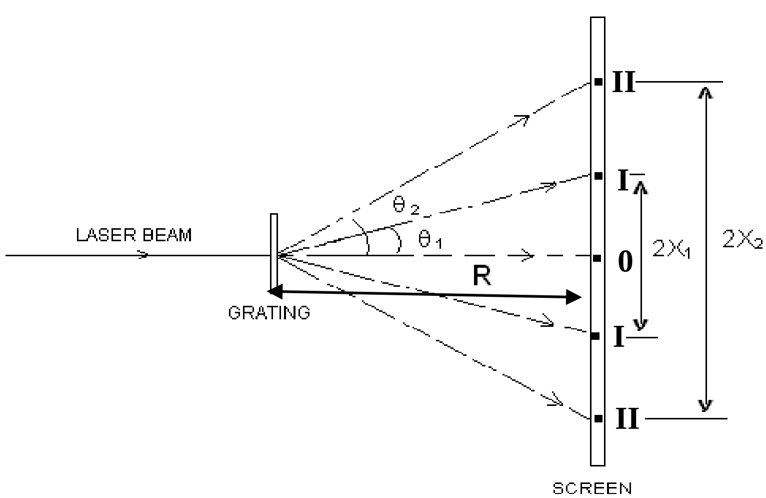
$$\theta_m = \tan^{-1}\left(\frac{x_m}{R}\right)$$

θ_m = angle of diffraction for mth order spot

X_m = distance between Zeroth order spot and mth order spot measured in m

R = distance between screen and grating measured in m

DIAGRAM:



Procedure:

1. Place the grating in its holder and the screen is placed at a distance of R cm as mentioned in the tabular column.
2. The grating is kept between the laser source and the screen.
3. Laser beam undergoes diffraction after passing through the grating. The diffraction spots are observed on the screen.
4. The distances $2x_m$ between the symmetrical spots on either side of central bright spot are measured and recorded.
5. The angle of diffraction θ_m is calculated using $\theta_m = \tan^{-1}\left(\frac{x_m}{R}\right)$.
6. λ is calculated using the formula $\lambda = \frac{d \sin\theta_m}{m}$.

TABULAR COLUMN.

Trial No.	R (In cm)	Order of the diffraction pattern (m)	$2x_m$ (in cm)	x_m (in cm)	$\theta_m = \tan^{-1}\left(\frac{x_m}{R}\right)$	$\lambda = \frac{d \sin\theta_m}{m}$ (in m)
1	*80*	*1*				
2		*2*				
3		*3*				
4		*4*				
5		*5*				
1	*90*	*1*				
2		*2*				
3		*3*				
4		*4*				
5		*5*				

λ_{av} = …………………. *m*

CALCULATIONS:

RESULT:- The wavelength of the given laser light source is: ………………..nm.

9. 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,**

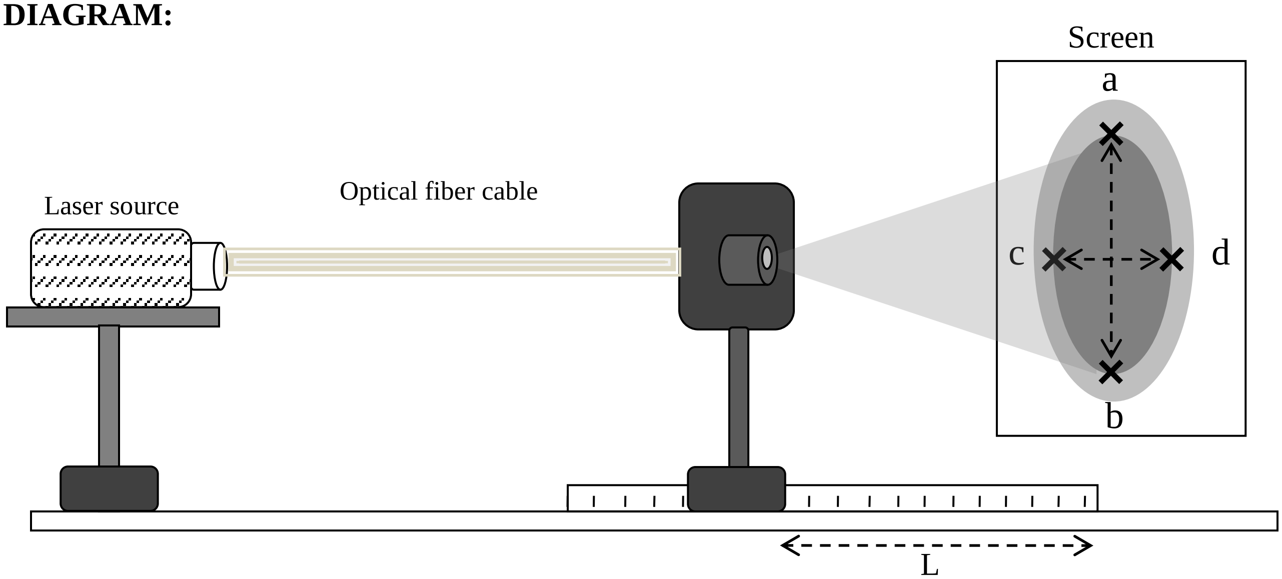
$$\theta_0 = \tan^{-1}\left(\frac{D}{2L}\right)$$

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

And the Numerical Aperture,

$$NA = \sin\theta_0$$

DIAGRAM:



PROCEDURE:

- Switch on the laser source and adjust the distance between output end of the optical fiber and the screen 'L' (say 2 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, 6cm, …).
- Find the Acceptance angle from the tabular column and hence the Numerical aperture.

Tabular column:

Trail No.	**L** (in cm)	**Horizontal diameter D1** (in cm)	**Vertical diameter D2** (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	2					
2	4					
3	6					
4	8					
5	10					

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

CALCULATIONS:

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

$\theta_0 =$

NA =

Note:

- The **source of error** in this experiment is, **marking of the dark circle**. The diameter markings should be **done only on the inner dark circle**, not for the outer circle. Refer the diagram given above for correct markings. Error in this part would be more as it depends on the eye sensitivity of the observer also.
- Avoid staring at the light spot for longer times, as it will strain the eye quickly.
- Do not view the laser light directly from source as it may damage eye permanently
- Do not bend the fiber with sharp bending curvatures as it may damage the fiber permanently. Do not touch the fiber end points with bare hands as it may contaminate the fiber open end surface and it may degrade the output quality.

10. DETERMINATION OF SPRING CONSTANT

AIM: a) To determine spring constant for the material of the given spring and b) To determine Spring constant in series and parallel combination.

APPARATUS: Given springs, slotted weights

PRINCIPLE: Elastic materials are those which retain their original dimensions after the removal of deforming forces. Application of a force on a spring causes elongation. When subjected to stress, strain is produced. Within the elastic limit, the ratio of stress to strain is a constant known as modulus of elasticity. The restoring force is always directed opposite to displacement.

Restoring force α – displacement

$$F = -K \Delta x \quad (N)$$

Here "k" is the proportionality constant known as spring constant. It is a relative measure of stiffness of the material.

Formula: (1) Spring constant $K = -F/\Delta x$ (N/m)

(2) Spring constant in series combination $k\ series = \frac{K1\ K2}{K1+K2}$ (N/m)

(3) Spring constant in parallel combination $\mathrm{k\ parallel} = \mathrm{k1} + \mathrm{k2}$ (N/m)

PROCEDURE:

1. Connect the given spring to a rigid support.
2. Attach the weight hanger (dead load) to the end of the spring and note down the initial displacement "a" produced on the scale.
3. Increase the weight in steps of 50 g and note down the displacement (b) produced in the spring. Find the elongation Δx= (b-a) . Using the formula (1) find spring constant K_1.
4. Repeat the above steps and find spring constant K_2 for the second spring.
5. Connect the two springs in series combination and repeat the above procedure to find k_{series}.
6. Connect the two springs in parallel combination and repeat the above procedure to find $k_{parallel}$.
7. Compare the experimental results obtained with the theoretical value.

Tabular column:

Determination of spring constant for spring 1

Displacement for the initial load (W+0) a = …..cm.

Tr. no	Mass m (g)	F = mg (N)	Displacement b (cm)	Elongation ΔX= (b-a) (cm)	Spring constant K_1 (N/m)
1	W+50				
2	W+100				
3	W+150				
4	W+200				

Average K_1= ………………….N/m

Determination of spring constant for spring 2

Displacement for dead load (W+0) a = …..cm.

Tr. no	Mass m (g)	F = mg (N)	Displacement b (cm)	Elongation ΔX=(b-a) (cm)	Spring constant K_2 (N/m)
1	W+50				
2	W+100				
3	W+150				
4	W+200				

Average K_2= ………………….N/m

Determination of spring constant in series combination

Displacement for dead load (W+0) a = …..cm

Tr. no	Mass m (g)	F = mg (N)	Displacement b (cm)	Elongation ΔX= (b-a) (cm)	Spring constant K_{series} (N/m)
1	W+50				
2	W+100				
3	W+150				
4	W+200				

Average K_{series}= ………………….N/m

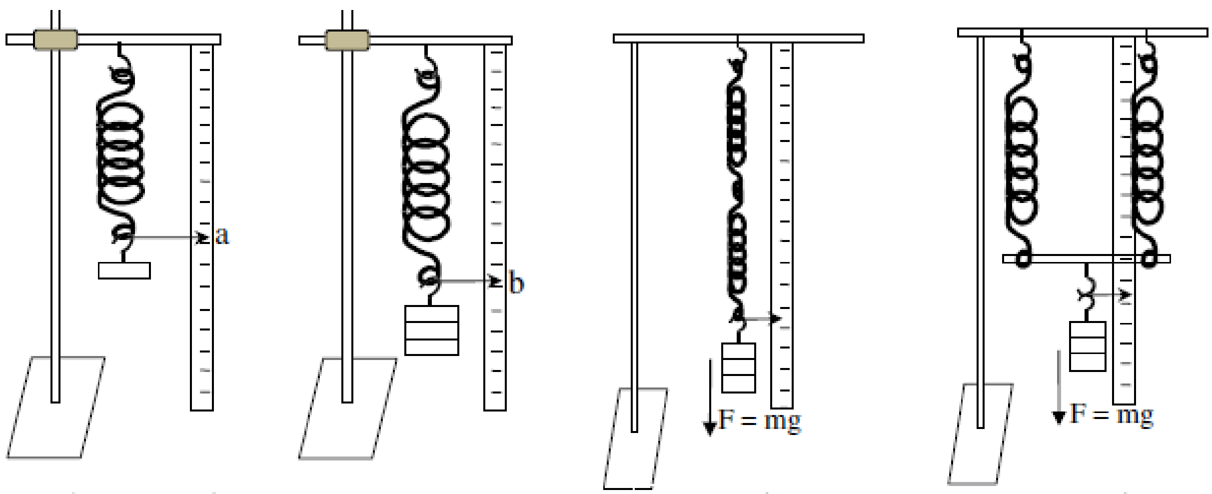
Determination of spring constant in parallel combination

Displacement for dead load (W+0) a = …..cm

Tr. no	Mass m (g)	F = mg (N)	Displacement b (cm)	Elongation ΔX= (b-a) (cm)	Spring constant $K_{parallel}$ (N/m)
1	W+50				
2	W+100				
3	W+150				
4	W+200				

Average $k_{parallel}$= ………………….N/m

Diagrams:



With initial load
With load
Series combination
Parallel combination

Result:

1. The spring constant of the given material of the springs are found to be

K_1=…………… N/m

K_2 ……………. N/m.

2. Spring constants in series and parallel combinations are found to be

Combination	Theoretical (N/m)	Experimental (N/m)
Series	K_{series} =	K_{series} =
Parallel	$k_{parallel}$ =	$k_{parallel}$ =

11. CHARACTERISTICS OF PHOTODIODE

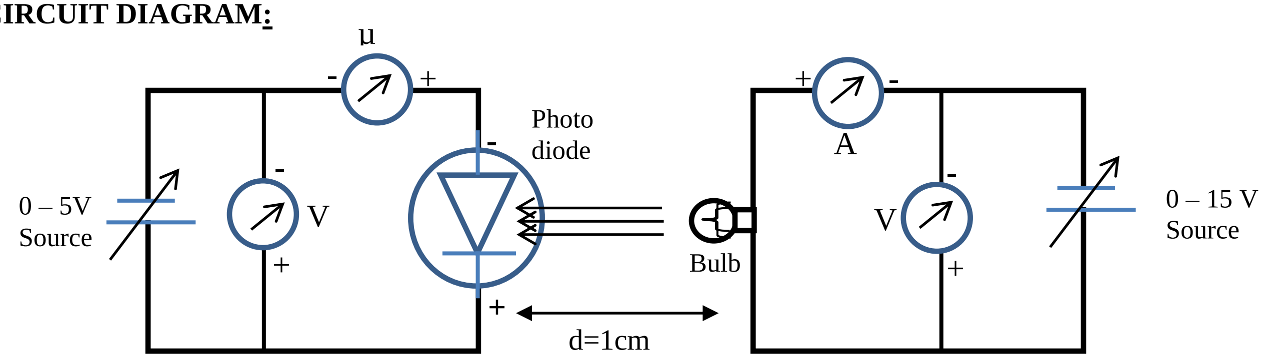
AIM: To study the reverse bias characteristics of the photodiode and hence to find the Responsivity.

APPARATUS: Photodiode, Bulb, power supplies and Ammeter, micro ammeter, Voltmeters.

PRINCIPLE: Photodiode is a two terminal junction diode in which the reverse saturation current changes when it's reverse biased junction is illuminated by suitable wavelength of light. This small amount of reverse saturation current is due to thermally generated electron-hole pairs. The number of these minority charge carriers depends on the intensity of light incident on the junction. When the diode is in a glass package, light can reach the junction and thus changes the reverse current.

Formula: Responsivity of the Photo diode, R = slope of the graph ampere /watt

CIRCUIT DIAGRAM:



PROCEDURE:-

To study the reverse bias characteristics of the photodiode.

1) The electrical connections are made as shown in the circuit diagram;
2) The photo diode is moved towards the bulb and the distance between them is adjusted to around 1cm.
3) The Power supplies are switched on and the voltage across the bulb is increased or the distance between the bulb and the diode is adjusted till the micro ammeter reads photocurrent of 3**μA**.
4) For this fixed intensity of the bulb the reverse bias voltage across the photodiode varied as 1, 2, 3 and 4 volts and the corresponding micro ammeter reading is recorded in the tabular column.
5) The experiment is repeated by varying the intensity of the bulb for 5**μA** and 10**μA** of photo currents.
6) The graph is plotted between current versus voltage for different intensity of the bulb in the third quadrant of the graph, because the current and voltages are for the reverse bias.

7) The characteristics of photodiode in reverse bias condition are obtained as shown in the specimen graph.

To find the Responsivity of the photo diode

1) With the same electrical connections the distance between the diode and the filament of the bulb is adjusted to 1cm.
2) The voltage across the bulb is adjusted to say 5V (> 5V to get linear response) and the corresponding current through the diode is noted in the second tabular column.
3) The voltage is increased in steps of 0.5V up to around 12V and the corresponding currents through the photo diode are tabulated.
4) A graph of photo current v/s power is plotted and the Responsivity is calculated from the slope of the curve.

Specimen graph:-

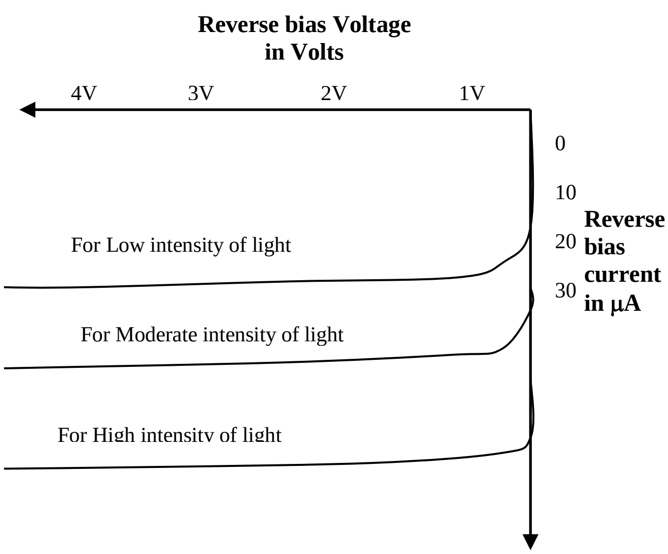


Photo diode reverse characteristics curves

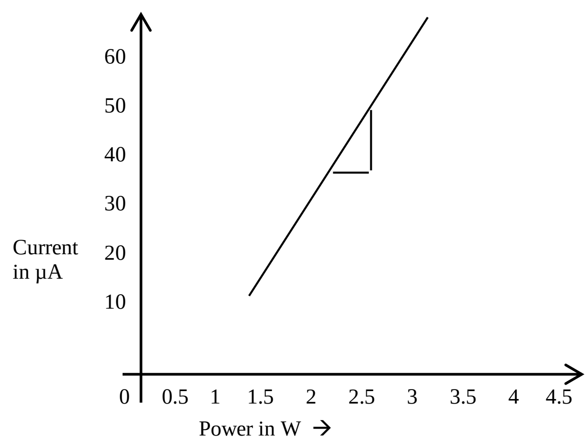


Photo diode Responsivity graph

OBSERVATIONS:

Reverse bias characteristics

Sl No.	For various Intensity of the Bulb					
	Low intensity		Moderate intensity		High intensity	
	Biasing voltage in volts	Current(I) in μA	Biasing voltage in volts	Current (I) in μA	Biasing voltage in volts	Current (I) in μA
1	0	3	0	5	0	7
2	1		1		1	
3	2		2		2	
4	3		3		3	
5	4		4		4	

<u>Power Responsivity</u>

Radius of the photodiode, r = 2mm,
Distance from filament of the bulb to the photodiode, d = ……………. Cm (say 1cm)

Sl No.	Across the bulb			Power falling on photodiode $P = \frac{P_o \times r^2}{4d^2}$	Photodiode Current in μA
	V in V	I in A	P_o in W		
1	5				
2	5.5				
3	6				
4	6.5				
5	7				
6	7.5				
7	8				
8	8.5				
9	9				

Result: - The I-V characteristics of the given photodiode for different intensity of light is as represented in the graph. From the graph it is clear that the reverse saturation current is independent of biasing voltage and depends only on light intensity.

The Power Responsivity of the given photodiode is found to be, R =

12. Magnetic Intensity 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:

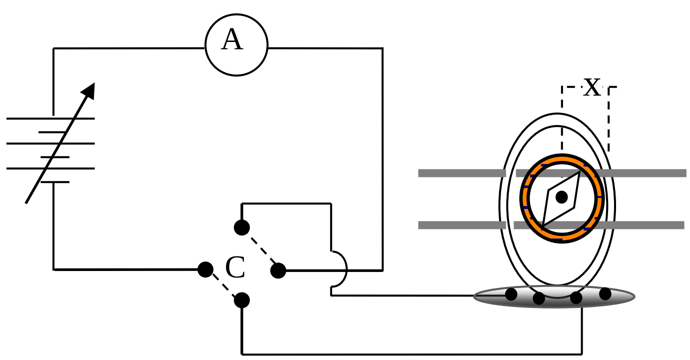
$$B = \frac{\mu_0 n I}{2} \frac{a^2}{\left(a^2 + x^2\right)^{3/2}} \quad \textbf{(T)}$$

Where B – the magnetic field intensity at the centre of a circular coil, (T)
n – Number of turns in the TG coil,
a – radius of the coil (cm)
x – Distance between the center of the coil and pointer in the compass box
μ_0 - Permeability of free space = $4\pi x 10^{-7}$ Hm^{-1}.
I – the current through the coil (I)

$$B_H = \frac{B}{\tan\theta} \quad \textbf{(T)}$$

Where B_H – horizontal component of earth's magnetic field and
θ – mean deflection in TG.

CIRCUIT DIAGRAM:



PROCEDURE:

1. The connections are made as shown in the circuit diagram.
2. Arrange the deflection of the magnetometer in the magnetic meridian of the earth
3. Now align the plane of the coil with respect to 90°-90° line of the magnetometer.
4. Keep the magnetometer exactly at the centre of the coil (for this case x = 0).
5. Pass a current I (say 0.3 A) to flow through the coil and the corresponding magnetometer deflections θ_1 and θ_2 are noted.
6. The direction of the current is reversed by using the commutator C and the corresponding magnetometer deflections θ_3 and θ_4 are noted.
7. Average deflection θ is calculated.

8. 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 .
9. Repeat the experiment for different values of x (say 5cm, 10cm, …) by sliding the magnetometer along the axis.
10. Find the average of both B and B_H.

TABULOR COLUMN:

Radius of the coil, a = 8.2 cm and for n = 50 turns

Sl. No.	**Current I in A**	**X in cm**	**Deflections in degrees**				**Average θ in degree**	**B in x10^{-5} T**	$B_H = \frac{B}{\tan\theta}$ **in x10^{-6} T**
			θ_1	θ_2	θ_3	θ_4			
1	0.3	0							
2		5							
3		10							
1	0.4	0							
2		5							
3		10							

Mean value of B_H = ……………….(T)

Calculations:

Result: 1. Magnetic field at the center of the circular coil carrying current is found to be

(i) For current I= 0.3 A, B=…………………… T

(ii) For current I= 0.4 A, B=…………………… T

2. Earth's horizontal magnetic field is found to be B_H ………………T.

VIVA QUESTIONS

1. TORSIONAL PENDULUM

1. What is torsional pendulum?
2. Define moment of inertia?
3. What are the factors which affects the moment of inertia?
4. Define rigidity modulus?
5. On what factors the rigidity modulus depends?
6. Explain the applications of torsional pendulum?

2. TRANSISTOR CHARACTERISTICS

1. What is a transistor?
2. What are input characteristics curves? What information we can get from input characteristics curves?
3. Explain the terms depletion region, barrier potential.
4. What are the different configurations in which a transistor can be used in a circuit?
5. Define current gain.
6. What do you mean by doping?
7. Explain the mechanism of amplification in an NPN transistor under CE mode.

3. DETERMINATION OF FERMI ENRGY OF A METAL

1. Define the terms Fermi energy, Fermi velocity and Fermi temperature of a metal.
2. What is Fermi factor?
3. What is the probability of occupation at Fermi level for a temperature $T \neq 0^0$ K?
4. What are the factors which will influence the Fermi energy of the metal?
5. What is the average value of Fermi energy for metals?

4. SERIES AND PARALLEL RESONANCE

1. What are inductor, capacitor and resistor?
2. What are active and passive circuit elements?
3. What is resonance?
4. Why current is maximum at resonance in series resonance circuit?
5. Why current is minimum at resonance in parallel resonance circuit?
6. What is meant by quality factor?
7. What do you mean by sharpness of resonance?

5. NEWTON'S RINGS

1. What are Newton's rings?
2. Why Newton's rings are circular in shape.

3. Why the rings are observed only for an inclination of 45^0 of the glass plate to the incident light.
4. Why the centre of the Newton's rings in a reflected system of light is always dark.
5. What will be the effect on the ring system if we introduce water between the lens and the glass?
6. What do you mean by radius of curvature?

6. YOUNG'S MODULUS

1. Define Young's modulus.
2. How many types of stresses are there?
3. What is elasticity? Give an example for an elastic body.
4. Explain the terms stress, strain.
5. State Hook's law.
6. What is a beam?
7. Give an example of elastic body and non-elastic body.

7. DIELECTRIC CONSTANT

1. What are dielectrics?
2. What is the role of dielectric in a capacitor?
3. What are the applications of dielectric materials?
4. What are the different types of dielectrics?
5. What is Static and Dynamic dielectric constant?
6. What is Polarization?

8. LASER DIFFRACTION

1. What kind of LASER light source is used in this experiment?
2. What is diffraction? State the condition to have proper diffraction.
3. State the principle of semiconductor diode laser?
4. Define stimulated emission, population inversion and metastable state?
5. List few applications of diode laser?

9. Numerical Aperture

1. What is the basic principle that can guide the signal through optical fiber?
2. Define Numerical aperture.
3. What is acceptance angle?
4. What are differences between Step Index and Graded index fibers?
5. What is V-number?
6. No. of guided modes through step index multimode fiber is ________

10. DETERMINATION OF SPRING CONSTANT

1. Define simple harmonic motion.
2. What are free vibrations?
3. Period of oscillation of a spring depends on what factors.
4. When two springs are connected in series what is the net spring constant?
5. When two springs are connected in parallel what is the net spring constant?
6. Define spring constant.
7. Mention the factors on which spring constant of a material depends.

11. PHOTO DIODE

1. What is a photo diode?
2. What is the difference between LED and photo diode?
3. What is the principle of operation of Photo diode?
4. What is responsivity?
5. What is dark current?

12. MAGNETIC FIELD ALONG THE AXIS OF A COIL

1. What is the principle involved in the experiment?
2. State Biot Savart's law
3. Mention the factors on which magnetic field due to a circular coil carrying current depends.
4. What is the magnetic flux associated with a current carrying a circular coil of radius with? current strength equal to I?
5. Define 1 weber.

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