ATRIA INSTITUTE OF TECHNOLOGY

Anandanagar, Bengaluru – 560 024

ENGINEERING PHYSICS LABORATORY MANUAL 18PHYL16 / 26

2020-21

Department of Basic Science Engineering & Humanities (Physics)

ATRIA
INSTITUTE OF TECHNOLOGY

LABORATORY MANUAL

I / II SEMESTER

ENGINEERING PHYSICS LAB (18PHYL16/26)

Faculty In-charge : **Department of Physics**

Name of the Student : ______________________________

BRANCH : ______________________________

USN. : ______________________________

SEMESTER & SECTION : ______________________________

GROUP : ______________________________

DO'S

1. Attend Lab regularly and punctually.
2. Prepare for the practical classes before coming to Lab sessions.
3. Bring manual and record to the lab regularly and follow instructions to carry out experiments.
4. Wear the college ID card at all times.
5. Always bring scientific calculator, graph sheets and other essential stationeries.
6. Get your completed record and observation books signed before leaving the lab for the day.
7. Mobile phones are strictly prohibited.
8. Get the teacher to verify the circuit connection before switching power supply 'ON'.
9. Maintain discipline and silence.

CONTENTS

SCHEME OF EVALUATION - VTU PRACTICAL EXAMINATION

Sl no.	Description	Max marks	Part-A Max marks for first experiment	Part-B Max marks for second experiment
1	Write up: Formula with units, circuit diagram and tabular column.	16	4+2+2=8	4+2+2=8
2	Experimental Setup / Circuit connection	10	05	05
3	Conduction and Reading	40	20	20
4	Calculation, Graph, Result and Accuracy	20	2+4+2+2=10	2+4+2+2=10
5	Viva –voce	14	07	07
	Total	**100**	**50**	**50**

1. 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

$$k = \frac{F}{x}$$

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

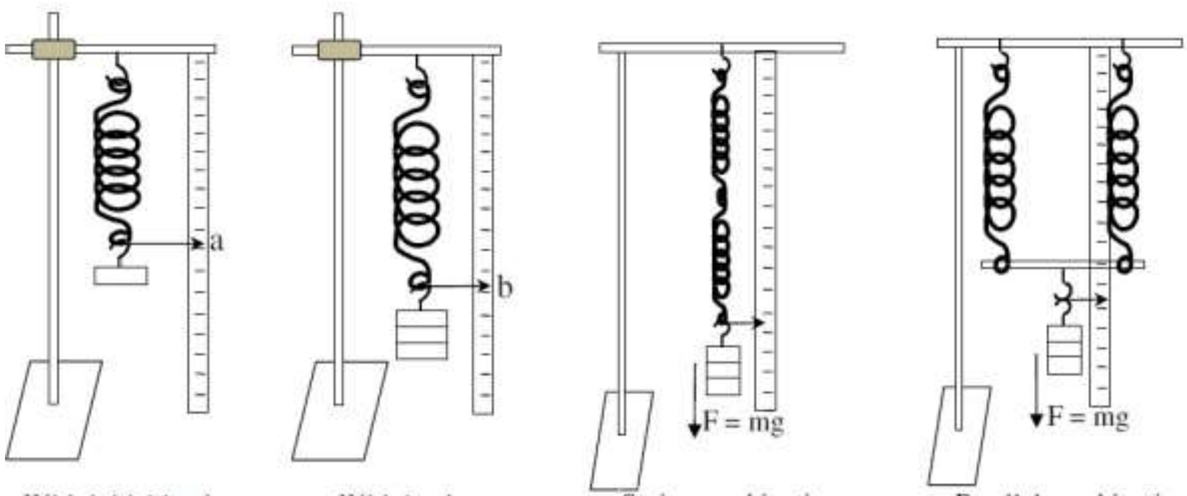
2) Spring constant for Series combination of springs

$$k_{series} = \frac{k_1 k_2}{k_1 + k_2}$$

3) Spring constant for Parallel combination of springs

$$k_{parallel} = k_1 + k_2$$

DIAGRAM:



With initial load — With load — Series combination — Parallel combination

PROCEDURE:-

1. 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.
2. 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.
3. Repeat the same for some more loads in steps of 50gm and tabulate the readings in the tabular column.
4. Find out the average spring constant ‘k_1’.
5. Repeat the above steps for the spring 2 and find out ‘k_2’.

To verify Series combination law of springs:

1. 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.
2. 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.
3. Repeat the same for some more loads in steps of 50gm and tabulate the readings in the tabular column.
4. Find out the average spring constant ‘k_{series}’.

To verify Parallel combination law of springs:

1. Hang the springs in parallel combination shown in the diagram. With the initial load, note down the position ‘a’ of the pointer on the scale.
2. 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.
3. Repeat the same for some more loads in steps of 50gm and tabulate the readings in the tabular column.
4. 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.

TABULAR COLUMN:

To find k_1
Pointer reading with initial load (w), a = ...cm

Trail No.	Load in gm	Pointer reading 'b' in cm	Spring Stretch x = (b-a) in cm	Force F = mg in N	Spring constant $k_1 = \frac{F}{x}$ in N/m
1	w+50				
2	w+100				
3	w+150				

Average k_1 = ... N/m

To find k_2

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

Trail No.	**Load in gm**	**Pointer reading 'b' in cm**	**Spring Stretch x = (b-a) in cm**	**Force F = mg in N**	**Spring constant $k_2 = \frac{F}{x}$ 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

Trail No.	**Load in gm**	**Pointer reading 'b' in cm**	**Spring Stretch x = (b-a) in cm**	**Force F = mg in N**	**Spring constant $k_{series} = \frac{F}{x}$ 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 N/m

<u>To verify parallel combination of springs</u>

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

Trail No.	**Load in gm**	**Pointer reading 'b' in cm**	**Spring Stretch x = (b-a) in cm**	**Force F = mg in N**	**Spring constant** $k_{parallel} = \frac{F}{x}$ **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 N/m

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	$k_{parallel}$ =	$k_{parallel}$ =

2. TORSIONAL PENDULUM

Aim: To determine the moment of inertia of a circular disc about its axis of suspension and modulus of rigidity of a given wire by the method of Torsional oscillations.

Apparatus: Circular disc with chuck, suspension wire, stop clock, thread and meter scale.

Principle:

Torsion pendulum is an illustration of angular harmonic oscillation. Moment ~~of a~~ body is the reluctance to change its state of rest or uniform circular motion. The moment of inertia (MI) of a regular body about any axis is calculated by knowing its mass and dimensions. A body whose moments of inertia about different axes are known, is made to oscillate about the same axes, corresponding periods are noted. If the moment of inertia is I and the time period is T then for all axes chosen for all the bodies the ratio I/T^2 is a constant as long as the dimensions of the suspension wire remains the same.

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

Formula:

Moment of inertia of the disc is given by

I=___

Modulus of rigidity of the material of the wire is given by

___ _( )mean

___ ( )

Where Mass of the circular plate, (M)in kg
Radius of the circular plate, (R) in meter.
Length of the wire between the two chuck nuts (l) in meter
Length of the suspension wire (L) in meter.
Radius of the suspension wire (r) in millimetre.
Time period oscillations of the torsional pendulum (T) in seconds.

Procedure:

One end of a long, uniform wire whose rigidity modulus is to be determined is clamped by a vertical chucknut. To the lower end, a heavy uniform circular disc is attached by another chuck.
The diameter of the wire is accurately measured at various places along its length with screw gauge. From this, the radius of the wire is calculated. The circumference of the disc

is measured by using a thread wounding round on the circular disc. The radius of the disc is calculated.

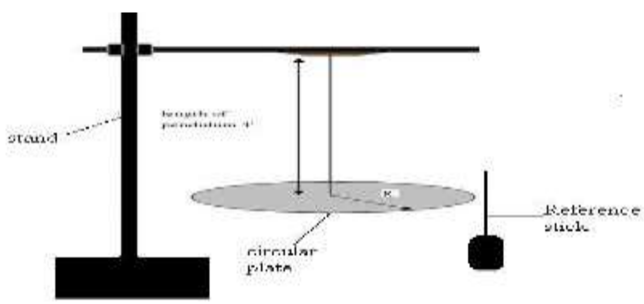
The length (L) of the suspension wire (from the top portion of chucknut to the clamp) is fixed to a particular value (say 45 cm). The suspended disc is slightly twisted so that it executes torsional oscillations. The first few oscillations are omitted. By using the pointer made on the disc the time taken for 10 complete oscillations (to and fro oscillations) are noted. Three trials are taken. The mean time period 'T' i.e. time for one oscillation is found. The above procedure is repeated for the three different lengths of the pendulum wire. From the above values of 'L' and 'T' .Calculate ( )for each trial.

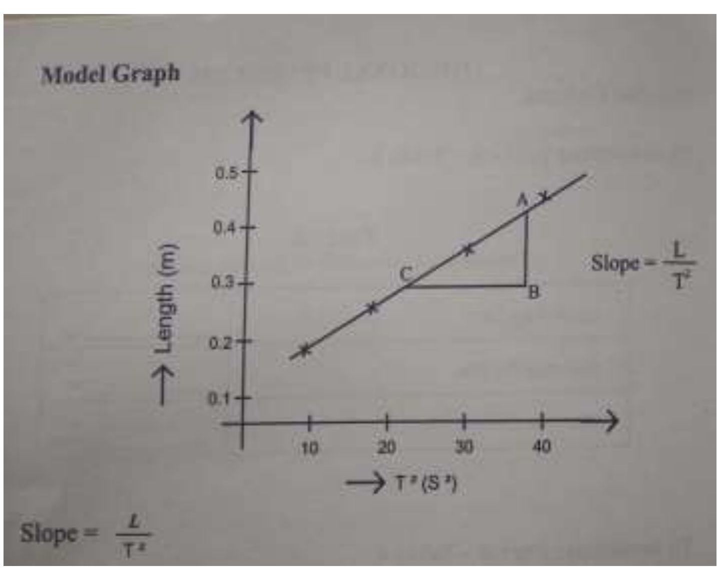
The moment of inertia of the disc and the rigidity of modulus of the wire are calculated using the given formulae.

Precautions to be taken:

The suspension wire should be well clamped, thin long and free from kinks.
The period of oscillations should be measured accurately since they occur in second power in the formula.

Diagram:





Mass of the circular plate, (M)................................... in kg.
Radius of the circular plate, (R)… .... in meter.
Length of the wire between the two chuck nuts (l) in….......... meter
Length of the suspension wire (L) in… ....meter.
Radius of the suspension wire (r) in… ....millimetre.

Tabular column:

Determination of Time period of oscillation:

Trial No.	**Length of the pendulum $(L)\times10^{-2}$ m**	**Time for 10 oscillations (second)**			**Time Period** in seconds	— in ms^{-2}	
		in seconds	in seconds	Mean (t)= in seconds			
1.							
2.							
3.							
4.							
5							
6							

() mean = ……………….

Result:

1. Moment of Inertia of a circular disc about the axis passing through its centre
   I = ...
2. Modulus of rigidity of the material of the wire = ...

3. SINGLE CANTILEVER

Aim: To determine Young's modulus of a given iron bar.

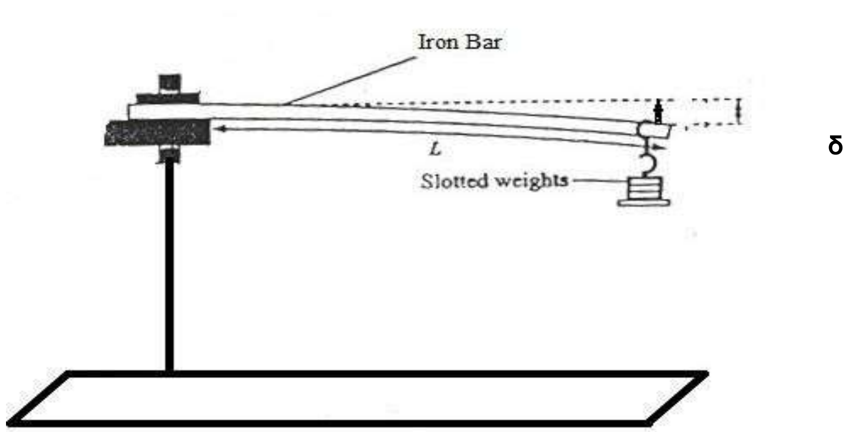
Apparatus: Travelling microscope, magnifying lens, slotted weights, etc.,

Formula:

$$q = \frac{}{} \quad N/m^2$$

Where,
M = Load for which elevation is found (150×10^{-3} Kg)
g = Acceleration due to gravity ($9.8\ m/s^2$)
L = Length of the Iron bar from clamp to tip in m
b = Breadth of the given iron bar in m
d = Thickness of the Iron bar in m
δ = Mean value of elevation (for $150\ 10^{-3}$ Kg) in m

Diagram:



Procedure:

Apparatus consist of an Iron bar supported on only one end.

1. The apparatus is set up as shown in figure.

1. A 50 g of slotted mass is hung. The travelling microscope is adjusted to the pin with the point of intersection of cross wire
2. The travelling microscope reading is noted and the length of the deflection is observed.
3. The reading obtained is tabulated in a table.
4. The experiment is repeated by increasing the load in each slotted weight in steps of 100,150,200,250,300gm and the corresponding readings are noted.
5. The Young's modulus, q of the Iron bar is calculated.

Tabular column:

Load in hanger (g)	TM reading (mm)		Mean R_1 (mm)	Load in hanger (g)	TM reading (mm)		Mean R_2 (mm)	Elevation $y = R_1 \sim R_2$ (mm)
	Load increasing	Load decreasing			Load increasing	Load decreasing		

Mean **(δ)** =__________m

CALCULATIONS:

$M = 150\times10^{-3}$kg,

$L = \times10^{-2}$ m,

$B = \times10^{-2}$m

$d = \times10^{-2}$m

q = N/m^2 =

Result: The Young's modulus of a given Iron bar is (q) =_______________N/m^2

4. 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:
$$B = \frac{\mu_0 n I}{2}\frac{a^2}{\left(a^2 + x^2\right)^{3/2}} = \frac{X}{\left(a^2 + x^2\right)^{3/2}}$$

Where $$X = \frac{\mu_0 n I a^2}{2}$$

B – The magnetic field intensity at the centre of a circular coil,

n – Number of turns in the TG 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 = $4\pi x 10^{-7}$ Hm^{-1}.

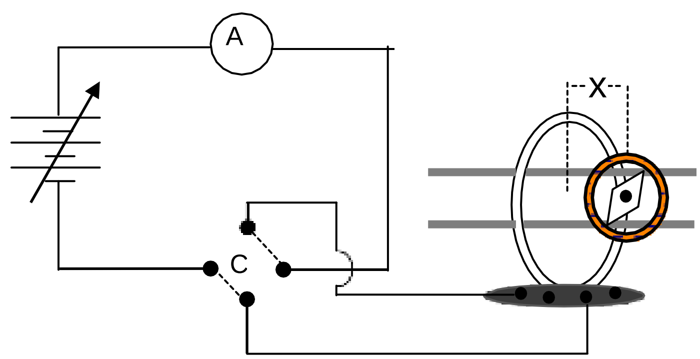
I – the current through the coil

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

Where B_H – horizontal component of earth's magnetic field and

– 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 0.5A) 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 $B = \frac{\mu_0 nI}{2}\frac{a^2}{\left(a^2 + x^2\right)^{3/2}}$ 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 = 0.082 m and for **n = 50 turns**

I in A	**X in m**	**Deflections in degrees**				**Average θ in degree**	**B in T (…..×10^{-5})**	$B_H = \frac{B}{\tan\theta}$ **in × 10^{-5} T**
		θ_1	θ_2	θ_3	θ_4			
0.25	0							
	0.05							
	0.10							
	0.15							

RESULT:

1. The magnetic field at the centre of the coil (B) = x 10^{-5} Tesla.

2. Horizontal component of earth's magnetic field (B_H) = x 10^{-5} Tesla

5. NEWTON’S RINGS

Aim: To determine the radius of curvature of the given Plano convex lens.

Apparatus: Plano-convex lens, optically plane glass plate, traveling microscope (TM), stand with a turntable glass plate, sodium vapour lamp.

Principle: Newton’s ring experiment is based on interference of light. When two coherent superpose modification in the intensity of light results in the formation of alternate bright and dark fringes. This pattern is known as interference pattern and the phenomenon is known as interference.
When waves of light are reflected at the surface of a denser medium a phase changes of **λ/2** or **π** is produced. The regions of crossover with the path difference **2n (λ/2)** forms the bright ring and **(2n+1) λ/2** forms dark ring. And the radius of curvature of lens can be found by measuring the diameter of the rings.

Formula:
The radius of curvature of the given Plano convex lens is given by

$$\frac{(\qquad)}{(\ )} \text{ in meter}$$

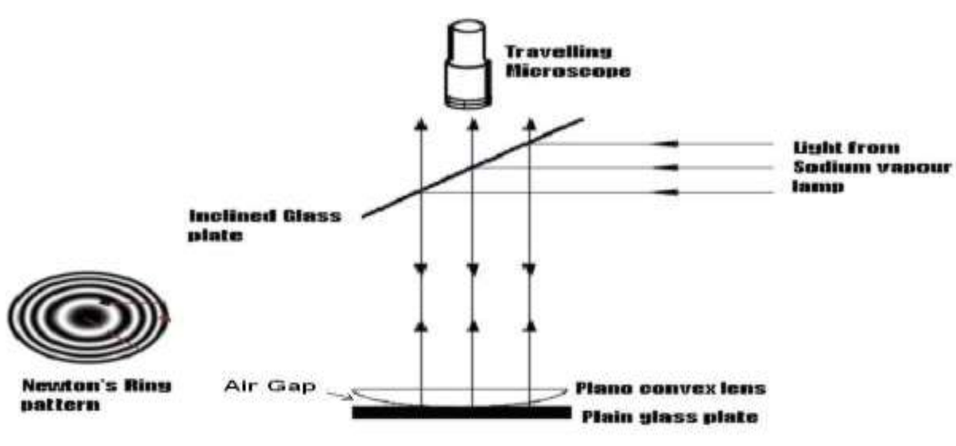
Where, R is the radius of curvature of the given lens (meter)

m & n are the ring ordinal number

D_m & D_n are the diameters of m^{th} & n^{th} rings

λ is the wavelength of sodium light = 5893×10^{-10} m

Diagram:



Newton rings Experimental Set-up

Procedure:

1. The arrangement of the Plano convex lens on the plane glass plate resting with its curved surface is placed below the turntable glass plate.
2. This setup is then placed below the objectives of the microscope of the T.M such that the axis of the microscope is through the centre of the lens when viewed from the top.

3. The sodium vapour lamp is switched on. The T.M unit is positioned properly to receive the light straight to the turntable glass plate.
4. The orientation of the turntable glass plate is changed slowly so that its upper part makes an angle of 45^0 with respect to the direction of the incident light, at which time the field of view suddenly becomes bright yellow in the microscope.
5. Maximum brightness is obtained by fine adjustments.
6. Operate the rack and Pinion screw till the bright patch of light modifies itself into a series of alternate bright and dark rings.
7. The intersection of the cross-wire is made to coincide with the centre of the ring system which is a dark spot.
8. The eyepiece is rotated to make one of the cross-wires align in a direction parallel to the scale of the TM.
9. By rotating the head scale drum, the microscope is moved to the left side and the vertical cross wire is set to the left edge of 12^{th} dark ring and the corresponding microscope reading is recorded.
10. Similarly, the readings are recorded for left edges of alternate even numbers of dark fringes in sequence till the 2^{nd} ring and the readings are noted in the L.H.S. column of the tabular column.
11. Now, continuing further after crossing the central dark spot, the readings of the T.M are noted in the same way to the right edges of 2^{nd} to 12^{th} dark ring in sequence.
12. The readings are entered in R.H.S column from 2^{nd} ring to 12^{th} ring in back track order in the tabular column. The ring diameters Dm and Dn are obtained for various rings and tabulated.
13. For three pairs of ordinal numbers which satisfy m-n = 6, the value of (Dm2 – Dn^2) is evaluated and their mean is found.
14. The radius of curvature of the Plano convex lens is calculated using the formula.

Observations:

$$\text{Pitch of the head scale drum} = \frac{\text{Distance moved on the main scale}}{\text{Number of rotations given to the head scale drum.}}$$

Pitch = 1mm /1 = 1mm

Total No. of division on the head scale drum, N = 100 divisions.
Least count of the traveling microscope is = Pitch/ N

L.C = = 1mm/100= **0.01mm**

Tabular column 1: Travelling microscope readings
Left side:

Ring number (m)	MSR in cm	CVD	Total Reading (TR)=MSR+(CVD x LC)
12			
10			
8			
6			
4			
2			

Right side:

Ring number (m)	MSR in cm	CVD	Total Reading (TR)=MSR+(CVD x LC)
12			
10			
8			
6			
4			
2			

Tabular column 2:

Ring No. m	TM Reading in cm		Diameter in cm D_m=L-R	( ) in mm^2	Ring No. m	TM Reading in cm		Diameter in cm D_m=L-R	( ) in mm^2	)
	Left L	Right R				Left L	Right R			
12					6					
10					4					
8					2					

( )

Result:

The **r**adius of curvature of the given Plano convex lens R = -------------------- m

6. SERIES AND PARALLEL RESONANCECIRCUIT

Aim: To study the frequency response characteristics of a series and parallel resonance circuits and hence to determine the resonance frequency, bandwidth, quality factor of the circuits and the unknown inductance of an inductor.

Apparatus: Audio frequency generator, Decade inductance box, Decade capacitance box, resistance box, milli ammeter, connecting wires.

Principle: In a series resonance circuit, the current depends on the frequency of the input voltage. With the increase in frequency, the inductive reactance (X_L) increases and capacitive reactance (X_C) decreases. At resonance ($X_L = X_C$) the output voltage and current are in phase and have maximum value. Knowing the capacitance and resonant frequency, inductance, band width and the Quality factor value are calculated. But in a parallel resonant circuit, at resonance with resistance in the inductance arm, the current in the increase arm is equal to the current in the capacitance arm ($I_L = I_C$) the impedance is maximum and hence the current is minimum. The output voltage and current are out of phase. By measuring the resonant frequency, the inductance of the given coil can be calculated.

Formula:

1. The unknown inductance of an inductor in the circuit is given by

Henry$X_L = X_C$)

Where L = Unknown value of inductance, Henry
C = value of capacitance, Farad.
f_r = Resonance frequency, Hz

2. The bandwidth is given by ,

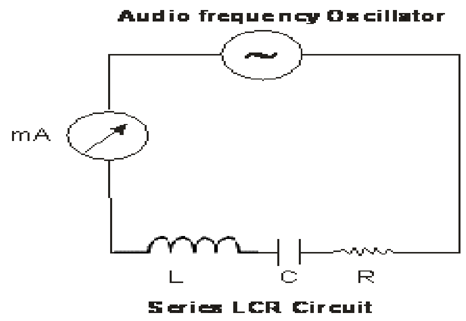
$$\text{Bandwidth} = (f_2 - f_1) \text{ Hertz}$$

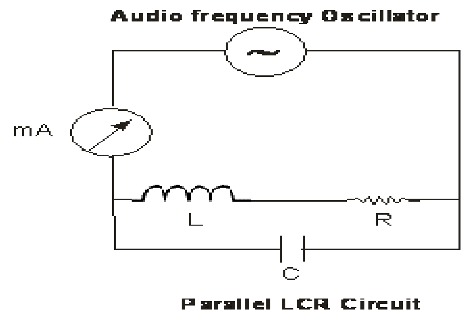
Where f_2 = Upper cut-off frequency in Hertz
f_1 = Lower cut-off frequency in Hertz.

3. The quality factor of the circuit is given by

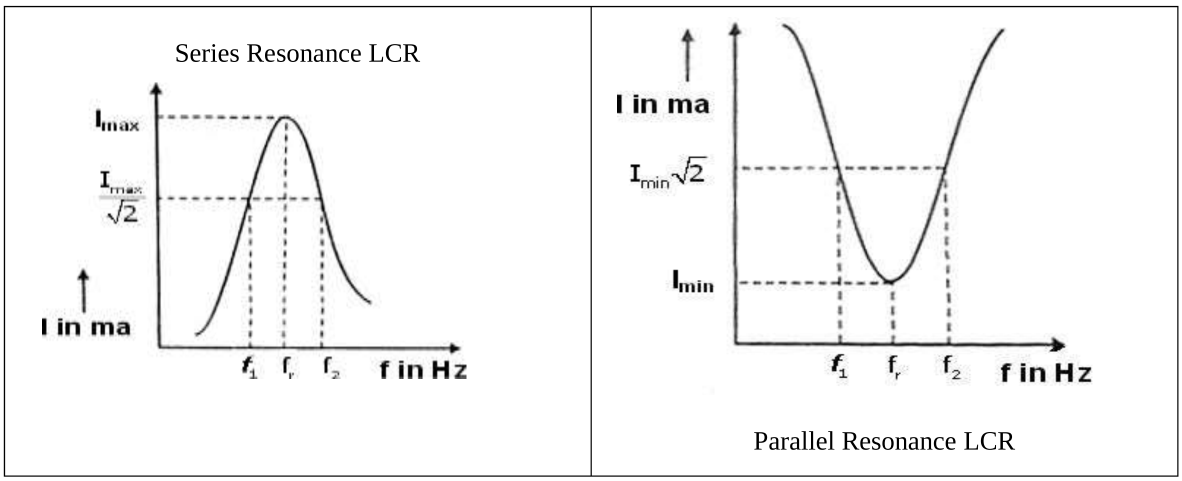
( )

Circuit diagram





Nature of the graph



Procedure:

1. The electrical connections are made as shown in the circuit diagram.
2. Switch on the power supply and set the amplitude to maximum.
3. The frequency generator is switched on and Increase the frequency from 100 Hz to 2000 Hz (in suitable steps) and note down the corresponding readings of the current in the milli ammeter.

For series resonance circuit:

1. A graph is plotted by taking frequency along the X-axis and current along the Y-axis.
2. The frequency corresponding to the maximum value of current (I_{max}) which is called resonance frequency (f_r) is noted from the graph.
3. The maximum value of current (I_{max}) of a resonance curve for a particular value of C is noted.
4. A straight line parallel to X - axis corresponding to the value of (I_{max} / $\sqrt{2}$) is drawn on the curve such that the line cuts the curve at two points on either side of the resonance frequency.
5. Thefrequencies$f_1$and$f_2$correspondingtothesepointsarenotedfromthegraphandtheband width ($f_2 \sim f_1$) is calculated for series LCR circuit.
6. The quality factor of the circuit and the inductance of an inductor are determined by using the above relations.

For parallel Resonance Circuit:

1. A graph is plotted by taking frequency along the x- axis and current along the Y-axis.
2. In this case the resonance occurs when the current in the circuit is minimum.
3. HencethefrequencycorrespondingtoI_{min}givestheresonancefrequency$f_r$of the circuit.
4. A straight line parallel to X- axis corresponding to the value of (I_{min} x □2) is drawn on the curve such that the line cuts the curve at two points on both side of resonance frequency.
5. The quality factor of the circuit and the inductance of an inductor are determined by using the above relations.

Tabular column:

Series resonance circuit

C = 0.1 µF, R = 750Ω

Frequency in hertz	Current reading I in mA

Parallel resonance circuit

C = 0.1 µF, R = 750Ω

Frequency in hertz	Current reading I in mA

Result:

Series Resonance circuit:

The series resonance frequency f_r =..................................Hz
Bandwidth=… ....Hz
Quality factor = ………………..
Inductance of an inductor=................................ Henry.

Parallel Resonance Circuit:

The parallel resonance frequency f_r= ....Hz
Bandwidth=… ....Hz
Quality factor = ………………….
Inductance of an inductor =................................ Henry

7. NUMERICAL APERTURE AND ANGLE OF ACCEPTANCE

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

Apparatus: Laser source, Optical fibre, Screen, Scale.

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

Formula:

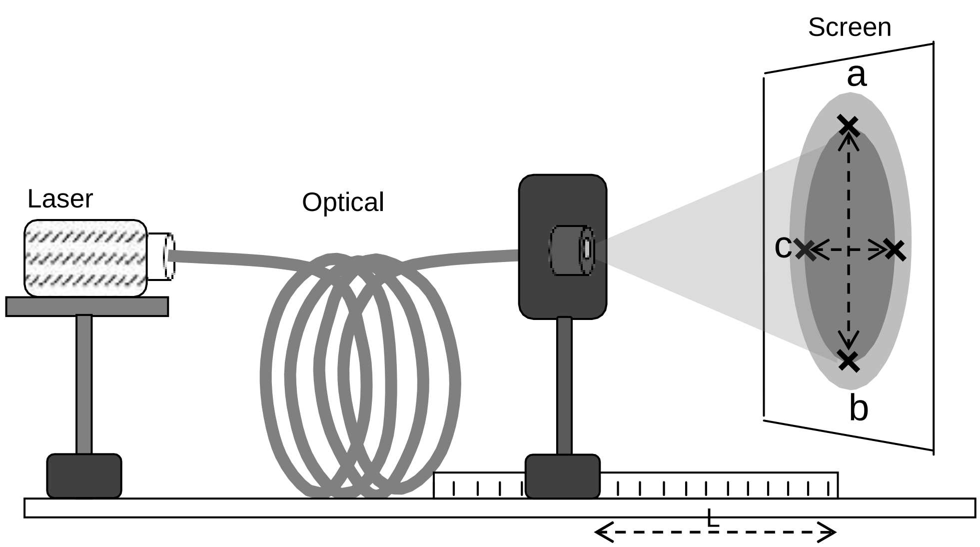
The Acceptance angle, $\theta_0 = \tan^{-1}\left(\frac{D}{2L}\right)$

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

The Numerical Aperture (NA),

$$NA = \sin(\theta_0)$$

DIAGRAM:



PROCEDURE:

1. Switch on the laser source and adjust the distance between output end of the optical fibre and the screen ‘L’ (say 2 cm).
2. Place a graph sheet on the screen and observe the circle formed on the graph sheet.
3. 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.
4. Repeat the above steps for different values of L (for 4cm, 6cm…….).

5. Find the Acceptance angle from the tabular column and hence the Numerical aperture.

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	2					
2	4					
3	6					
4	8					
5	10					

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

RESULT:

The Angle of acceptance and Numerical aperture of the given optical fibre are found to be

$\theta_0 =$

NA =

8. DIFFRACTION GRATING

Aim: To determine the wavelength of the Laser light using diffraction grating.

Apparatus: Diffraction grating (500 LPI), diode LASER source, image screen, meter scale.

Principle: Laser is a monochromatic, coherent and intense beam of light. When laser falls on a grating, it undergoes diffraction and produces alternative bright spots on the screen. The spots become well observable if the grating constant is comparable with the wavelength of the laser. If θm is the angle through which light is diffracted to give the m^{th} order diffraction then the condition to be satisfied is

$$\boxed{d \sin \theta m = m\lambda}$$

In the experiment, grating of known value of grating constant is used. When laser is incident on it, the spots produced due to diffraction are recorded on the screen. If **'f'** is the distance between the grating and the screen, $\mathbf{X_m}$ is the distance of the m^{th} spot from the central maximum, then the angle $\boldsymbol{\theta m}$ can be measured using

$$\theta m = \tan^{-1}(X_m/f)$$

If N is the number of lines per unit length of the grating, then the grating constant is determined by using the formula

$$\boxed{d = 1/ N \text{ meter}}$$

Formula:

1. The grating constant is determined by using the formula ,**d = 1/N** meter Where **N** is the number of lines on the grating

2. Wavelength of laser source λ is given by $\lambda = d \sin \theta_m / m$

   Where**, m** is the order of the spots

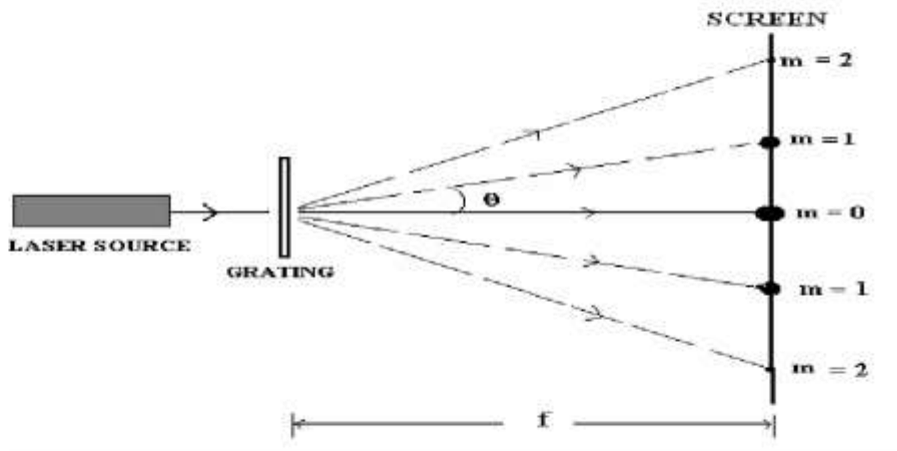
   λ is the wavelength of the laser light nm
   d is the grating constant in m
   θm is the angle of diffraction

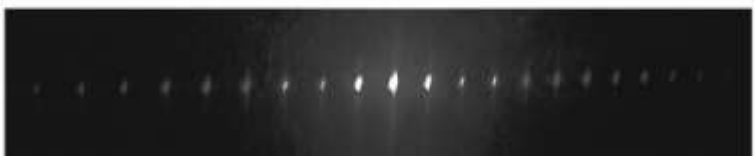
Observations:

1. Distance between the grating and screen, f = ------------- m.

2. Grating constant or the distance between two consecutive rulings on grating
   For **500 LPI**, d = ------------m

Ray Diagram:





Procedure:

1. The laser is placed on a study table and switched on. At about a meter away on the path of the laser a white laminated wooden screen is placed. The levelling screws of the laser are adjusted such that the laser beam exactly falls on the centre of the screen. The exact distance between the grating stand and image screen are noted, **f** = 1 meter = 100 cm.

2. The 500 LPI grating is now placed on the grating stand close to the laser source and the diffraction pattern is observed as shown in the figure. (The equally spaced diffracted laser spots are observed on either side of central maxima. The central maximum is very bright and as the order of diffraction increases the brightness decreases).

3. The centre of the spots of the diffraction pattern are marked placing a paper or graph sheet on the screen using pencil and after marking the diffraction pattern, the image screen is removed and the distances between consecutive order of diffraction is measured using a scale.

4. The distance between the two first order diffraction spots is measured as $2x_1$ cm**.**

5. Similarly the distance between second order diffraction spots is measured and recorded as $2x_2$ cm. This is continued up to 8^{th} order, $2x_8$ cm and the readings are tabulated.

6. Using equation, θm = $\mathbf{tan^{-1}(Xm/f)}$ diffraction angles are calculated for various orders of diffraction and are noted in Table.

7. Using equation, $\boldsymbol{\lambda = d \sin \theta_m / m}$ wavelength of given laser source is calculated for various orders of diffraction and the average wavelength is obtained.

Tabular Column:

500 LPI grating, f =100 cm				
Diffraction Order M	**Distance $2x_m$ (cm)**	**Diffraction Angle** $\theta_m = \tan^{-1}\frac{X_m}{F}$	**$\sin\theta_m$**	**Wavelength** $\lambda = d \sin\theta_m / m$ **(nm)**
1				
2				
3				
4				
5				
6				
7				
8				

Average λ =… .... nm

Result:

The wavelength of given laser light by diffraction method using grating is… .... nm.

9. FERMI ENERGY

Aim: Determination of Fermi energy of given specimen (copper wire).

Apparatus: Copper coil, DC regulated power supply, digital milIi ammeter (mA), Digital milli voltmeter (mV), Heating arrangements, Thermometer 0-100^{o}C and copper wire, patch cards, etc.

Principle:
Metals have positive temperature coefficient of resistance. When the temperature of a metal increases its resistance also increases. By noting the change in resistance with temperature for copper metal and knowing the density of copper, its Fermi energy can be calculated using the formula.

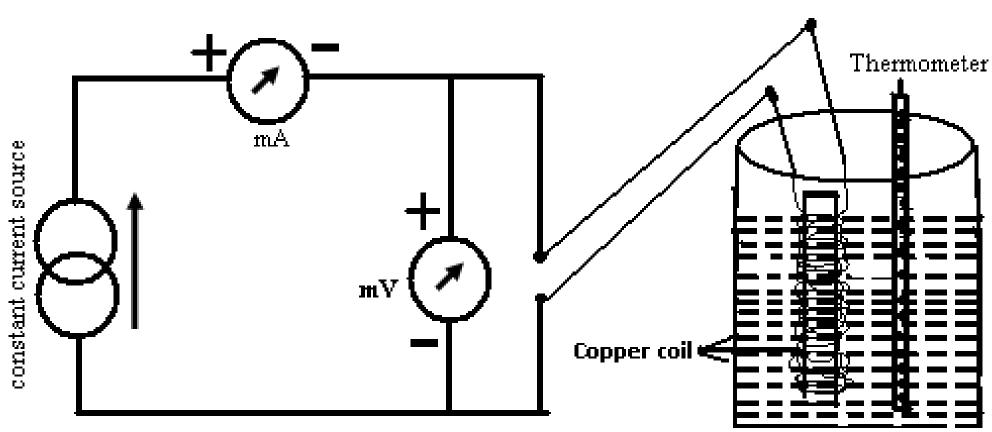
Formula:

Fermi energy $E_F = [\frac{\quad}{\sqrt{\quad}}]^2 \text{ x} [\ ]^2$

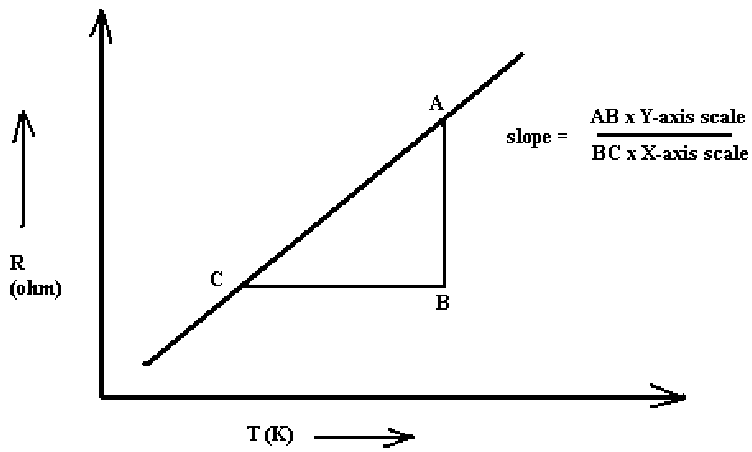
Fermi temperature $T_F = [\ ]$

Where
n is the electron density of copper (8.464x10^{28}/m3)
A is the area of cross section of copper wire (m^2) = $^{\mathbf{2}}$
r is the radius of copper wire (0.26 mm)
L is the length of the copper wire (3.6 m)
m is the electron mass (9.1x10^{-31} Kg)
e is the charge of an electron (1.602x10^{-19}C)
k is the Boltzmann constant (1.38x10^{-23} J/K)

Circuit Diagram:



Nature of Graph:



Procedure:

1. The wire is wound over an insulating material to form a coil.
2. The coil is immersed in pre-heated water as shown in the figure.
3. A thermometer is immersed in the beaker containing water and coil.
4. Temperature of the copper coil is placed in water beaker around 80^{o}C then for every 5^{o}C decrease in temperature note the corresponding milli-ammeter and milli-voltmeter readings are noted down in the tabular column.
5. Plot the graph of Resistance (□) versus Temperature (K) and calculate the slope **m = ( )** from the graph.

Tabular column:

Sl. no.	**Temperature**		**Voltage in mV**	**Current in mA**	**Resistance (R) =_ in Ω**
	in ^{0}C	**in K (T+273)**			
1					
2					
3					
4					
5					
6					
7					
8					

Observations:

Length of the copper wire L=   m
Radius of the copper wire r=m
Cross sectional area of copper wire (A) =πr^2 m^2
Density of copper wire **ρ**=   8960 kg/m^3
Slope (**m**) =--------------

Calculation:

$$E_F = [\ ]^2 \times [\ ]^2 \quad \sqrt{}$$

Result: Fermi energy of the given metal copper is found to be E_F =.................. eV

10. TRANSISTOR CHARACTERISTICS

Aim: To study the input and output characteristics of the given NPN transistor in the common emitter mode and calculation current gain, amplification factor& knee voltage..

Apparatus: Given Transistor (NPN), variable DC power supply, DC micro ammeter, DC milli ammeter, DC voltmeter, patch cords. (All these devices are internally connected in the kit).

Principle: Transistor is a three terminal semi-conducting device basically used for amplification. It is operated in three different modes viz., CE mode, CB mode and CC mode. In any transistor emitter-base junction is always forward biased and collector-base junction is reversed biased.

In CE mode, the following characteristics are studied.

Input characteristics: The study of variation in input current (base current) with input voltage (base−emitter voltage) at constant output voltage (collector−emitter voltage). **Output characteristics:** The study of variation in output current (collector current) with output voltage (collector−emitter voltage) at constant input current (base current).

Formula:

1. $\beta = \frac{\Delta I_C}{\Delta I_B}$ $\beta_1 = \frac{I_{C_2} - I_{C_1}}{I_{B_2} - I_{B_1}}$, and calculate β_2, β_3

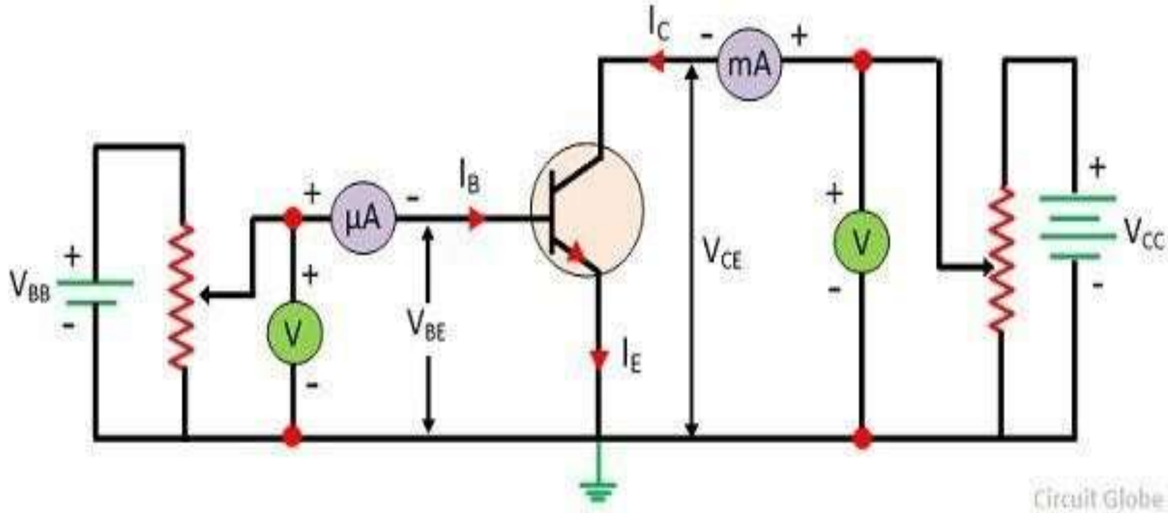
$(\beta_1 + \beta_2 + \beta_3)/3$

Where, β is the current amplification factor,
$\Delta I_B = I_{B_2} - I_{B_1}$ is the change in the base current,
$\Delta I_C = I_{C_2} - I_{C_1}$ is the corresponding change in collector current.

2. $\alpha = \underline{\qquad}$

Where, α is the current gain in common-base mode.

Circuit Diagram:



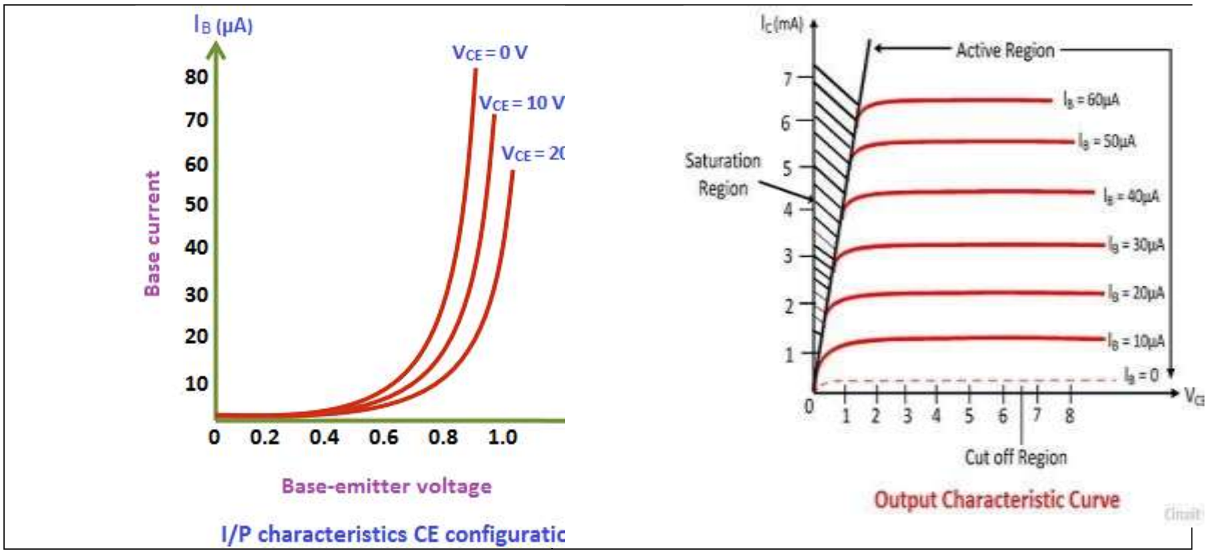
Procedure:

1. The common emitter circuit for studying the transistor characteristics of a NPN transistor is as shown in the figure.
2. Identify the base, the collector and the emitter leads of the given NPN transistor and then insert it into the transistor socket in the circuit.
3. Before switching on the circuit, turn all power supply knobs to the minimum position.

<u>Input characteristics:</u>

1. The DC voltmeter is connected across collector-emitter junction.
2. The collector emitter voltage V_{CE} is set to 1 volt by varying V_{CC}.
3. The voltmeter is disconnected and then connected across base-emitter junction.
4. Keeping V_{CE} = 2 volt ,as constant , the base-emitter voltage V_{BE} (input voltage) is increased from zero volt in steps of 0.1 V up to 0.8 V, by varying the knob V_{BB} and the corresponding values of base current I_B are noted from the micro ammeter.
5. A graph of V_{BE} along X-axis and I_B along Y-axis is plotted.

GRAPH:



Tabular column:

Input Characteristics			**Output characteristics**			
V_{BE} (V)	**I_B (μA)**		**V_{CE} (V)**	**I_C (mA)**		
	V_{CE} = 2V	**V_{CE} = 4V**		**I_{B1} = 25 μA**	**I_{B2} = 50 μA**	**I_{B3} =100 μA**

Result:

For the given NPN transistor,

1. The knee voltage, V_K =_______________V
2. The value of β = ________________
3. The value of α =________________________

11. PHOTODIODE CHARACTERISTICS

Aim: To draw photodiode characteristics in reverse bias and to study variation of photodiode current with reverse voltage.

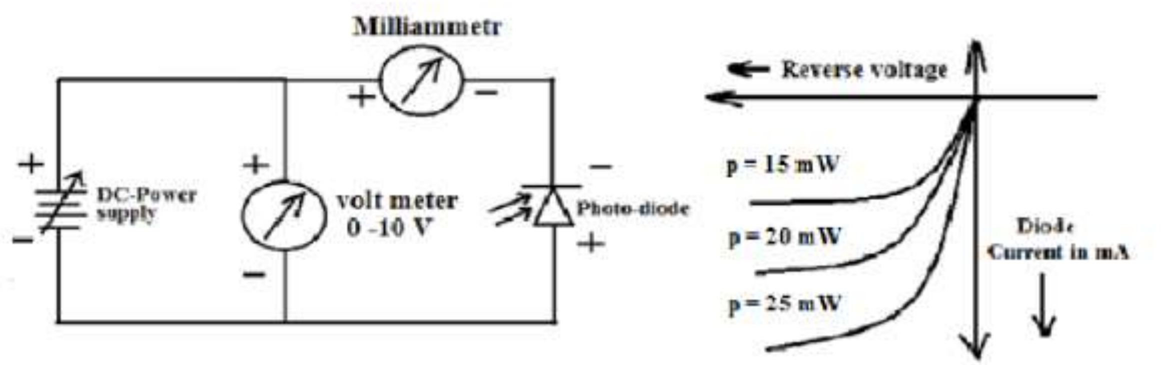
Apparatus: A photodiode, DC milliammeter, DC voltmeter, Power supply, Power supply with light source, Patch cards etc.

Formula: Slope=I/V
Output resistance= 1/slope Ω

Principle: Photodiodes are semiconductor devices responsive to high-energy particles and photons. Radiation- sensitive junction is formed in a semiconductor material whose resistivity change when illuminated or by the photon. Photodiodes operate by absorption of photons or charged particles and generate a flow of current in an external circuit, proportional to the incident power.

OBSERVATIONS:

Circuit diagram:



Procedure:

1. The circuit connections are made as shown in figure. The n-side of photodiode is connected to + ve terminal and p-side is connected to – ve terminal of the DC power supply.

2. Set the reverse bias voltage to 10 Volt. Now increase the light intensity to set the photodiode current of (power (p) = 10mWatt). Turn down the voltage to 0 Volt. Vary the voltage from 0 to 1.0 Volt and note down the corresponding photodiode current as given in the Table.

3. The above procedure is repeated for different constant photodiode current (p= 21 mW) and 2. (p=30mW) by varying light intensity.

4. Plot a graph of reverse voltage versus photodiode current.

5. From the graph we can noticed that each curve as the voltage increases with photodiode current gradually and reaches saturation.

Tabular column :

Reverse Voltage V_{PD} in volts	**P_{lED}= 10mW**	**P_{lED}= 21mW**	**P_{lED}= 30mW**
	I_{PD} in μA	**I_{PD}** in μA	**I_{PD}** in μA

Result:

The photodiode characteristics in reverse bias are drawn and variation of photodiode current with intensity is studied.

12. DIELECTRIC CONSTANT

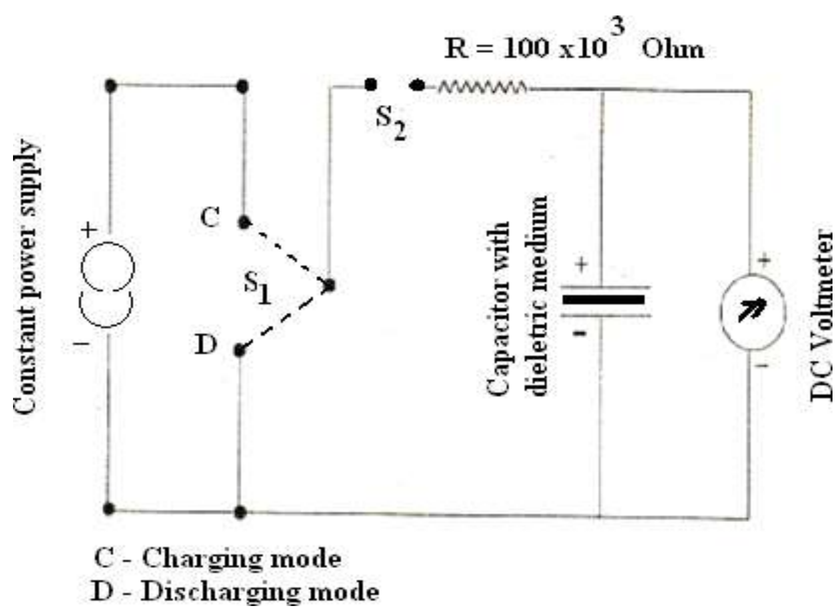
Aim: To determine dielectric constant of a material within a parallel plate capacitor by using a DC charging and discharging circuit.

Apparatus: Constant 5V DC power supply, digital voltmeter, timer, resistor of known values and capacitor with known values of dimensions, circuit unit and patch cords etc..

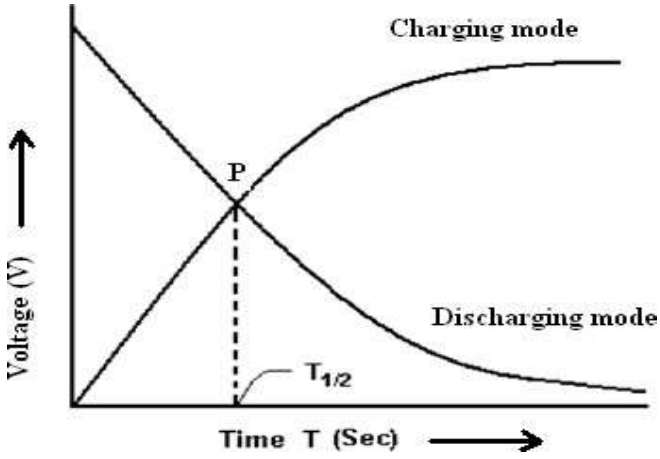
FORMULA: K = ________

Where
K is the dielectric constant of the material within the capacitor
d is the thickness in m
A is the area of the dielectric material in m^2
$T_{1/2}$ is the time in seconds required to get charged / discharged to 50% of the capacitance value Ris the resistance in the circuit (□)
$\epsilon_0 = 8.85\times10^{-12}$ F/m is the permittivity of free space.
Area (A)= l × b in m^2
(l& b are length and breadth of the dielectric material in m.)

Ciruit diagram:



Model graph:



Procedure:

1. The circuit diagram is shown in Figure.
2. The supply points are switched on.
3. The 5v constant DC power supply connected to the charging (C) and discharging (D) modes.
4. The given resistor ($R=100\times10^3$□) is connected between the timer and the capacitor.
5. The given capacitor (C_1) is connected between the constant DC power supply.
6. The voltmeter is connected parallel to the capacitor.
7. To begin with, the toggle in the switch S_2 is set to halt position. The timer is set to zero by pressing the reset button. The digital voltmeter in the circuit reading is zero.

Charge mode studies:

1. To start with, the toggle of the switch S_1 is set to charging mode (C).
2. Thetoggle in switch S_2 is set to start position, at which instant the capacitor begins to get charged to higher voltage and the timer starts counting simultaneously.
3. Immediately start noting down the voltage readings 'V' in the tabular column at every 10 second interval form 0 to 70 s, until V become practically constant (i.e reaching saturation voltage). Under charging mode the initial readings must be V= 0for T= 0.

Discharging mode studies:

1. The toggle of the switch S_2 is changed to halt position,
2. The timer is reset to read zero,
3. The toggle in switch S_1 is changed to discharge mode and simultaneously,
4. The toggle in switch S_2 isset to start position.
5. Immediately start noting down the reading for V at every 10 seconds interval from 0 to 70 s until V become practically constant(minimum saturation value) i.e. constant over two consecutive observations. the readings for V are tabulated under discharge mode. Under discharging mode the initial readings must be V= maximum for T= 0.

EVALUTION OF UNKNOWN:

1. From the tabular column readings, a graph is plotted with time T in seconds taken along X-axis and the voltage V in volts along Y-axis the charge mode curve and the discharge mode curve intersect at a point P.
2. By referring the position of Pin X-axis, the value of $T_{1/2}$ in sec is found out. The value of the dielectric constant K is given above.

Tabular column:

Dependence of capacitor's Voltage on time:

Time in seconds T	**R = 100kΩ, voltage across C in volts V**	
	Charge mode	**Discharge mode**
00		
5		
10		
15		
20		
25		
30		
35		
40		
45		
50		
55		
60		

CALCULATION:

R=Ω

$T_{1/2}$= S

ϵ_0=8.85×10^{-12} F/m

Length (**l**)= m

Breadth (**b**)= m

Thickness (**d**) =m

Area of the dielectric material**(A)**=**l** × **b**=m^2

Formula :

K =$\underline{\quad - \quad}$ =

RESULT:

The dielectric constant of the material in the capacitor is found as **K =**

ATRIA INSTITUTE OF TECHNOLOGY
Anandanagar, Bengaluru – 560024

Department of Basic Science Engineering & Humanities

Vision Mission Department

VISION

To Mold Engineers into better professionals through effective Mathematical thinking, multifaceted application of Applied Sciences to solve societal Issues, fostering liberal arts in realistic situations and to inculcate interdisciplinary research.

MISSION

Department of Basic Science Engineering & Humanities is committed to :

M1. *Enriching Mathematical logic through a multi-disciplinary approach among students.*

M2. *Augmenting the use of cutting edge technology and theoretical scientific concepts in the area of Applied Sciences.*

M3. *Developing effective and ethical communication based on awareness of diverse perspectives, contexts and social identities.*

M4. *Creating a culture that promotes critical consciousness and empathy at various personal, professional and civic contexts.*

M5. *Nurturing the ability to perform interdisciplinary research.*