ENGINEERING PHYSICS PRACTICAL OBSERVATION AND DATA ENTRY BOOK

Academic year: 2021 – 2022 onwards

Name of the student	
Section, Batch	
Branch	
Roll No./USN	
Faculty in-charge	

Department of Physics
B.M.S. College of Engineering
Bull Temple Road, Bengaluru-560019

http://www.bmsce.ac.in/home/Physics-Department-About

Syllabus from the year 2021-2022 onwards

Engineering Physics Laboratory			
Course Code	21PY1BSPHL / 21PY2BSPHL	CIE Marks	50
Teaching Hours/Week (L:T:P:S)	0:0:2:0	SEE Marks	50
Credits	01	Exam Hours	3 Hours

Course objectives:

1. To give hands-on experience on various experiments
2. To demonstrate competency and understanding of the basic concepts in experimental Physics

List of Experiments:

Ten Experiments to be performed

No.	Name of the experiment	Mapping with Units	Skill
1	Wavelength of transparent LEDs	Unit-1	Determine
2	Wavelength of semiconductor LASER source using diffraction grating	Unit-2	Determine
3	Numerical aperture and attenuation coefficient of an optical fiber	Unit-2	Analyse
4	Divergence angle of semiconductor LASER beam	Unit-2	Determine
5	Fermi energy of copper	Unit-3	Determine
6	Thermal conductivity of a poor conductor by Lee Charlton's method	Unit-3	Determine
7	Thermal conductivity of a metal by Forbe's method	Unit-3	Determine
8	Dielectric constant of a material by charging and discharging of a capacitor	Unit-4	Determine
9	Energy gap of a semiconductor using four probe method	Unit-4	Determine
10	Series and parallel resonance in LCR circuits	Unit-5	Analyse
11	Spring constant of a given spring	Unit-5	Determine
12	X-ray film analysis	General	Analyse

Course outcomes:

	On completion of the course, the student will have the ability to:	POs Mapped	Strength of mapping
CO1	**Conduct** experiments to obtain the desired physical parameter of the given system	PO4	3

Assessment Details:

Scheme of Continuous Internal Evaluation (CIE):

Criteria	Conduction of experiment and reporting	Record writing	Viva-voce	Lab Test	Total Marks
Marks	10	10	5	25	50

Lab Test: One experiment will be allotted for each student

Details of marks for each experiment

1. Write-up : 05
2. Conduction of experiment : 10
3. Result : 05
4. Viva : 05

Total : 25

Eligibility for Semester End Examination

Submission and certification of lab manual and record is compulsory to attend SEE

Minimum marks required in CIE to attend semester end practical examination: 20 marks

Viva-voce will be conducted individually

Semester End Examination:

All 10 experiments are included for the practical examination.

<table>
<tr><td colspan="4">Scheme of Semester End Examination (SEE):</td></tr>
<tr><td>1.</td><td colspan="3">Exam will be conducted for 50 marks in 3 hours duration

Two experiments will be allotted for each student</td></tr>
<tr><td>2</td><td colspan="3">Minimum marks required in SEE to pass: 20 out of 50 marks</td></tr>
<tr><td>3</td><td>Write-up</td><td>10 marks</td><td rowspan="4">50 marks</td></tr>
<tr><td>4</td><td>Conduction of experiments</td><td>20 marks</td></tr>
<tr><td>5</td><td>Calculations, result with unit, accuracy</td><td>10 marks</td></tr>
<tr><td>6</td><td>Viva- voce</td><td>10 marks</td></tr>
</table>

Suggested Learning Resources:

https://bmsce.ac.in/home/contentView/Physics-Department/PHY/47

https://vlab.amrita.edu/?sub=1&brch=282&sim=1512&cnt=1

https://bop-iitk.vlabs.ac.in/basics-of-physics/List%20of%20experiments.html

https://virtuallabs.merlot.org/vl_physics.html

https://phet.colorado.edu

https://www.myphysicslab.com

DATA OF REQUIRED PARAMETERS

1	Fermi energy of copper	$n = 8.45 \times 10^{28}/m^3$
		Debye temp. (θ) = 343 K
		$A = 1.193 \times 10^{-5}$ mK
		L = 10 m
2	Thermal conductivity of a poor conductor by Lee & Charlton's method	m = 0.93 kg
		s = 520 J/kg K
3	Thermal conductivity of a good conductor by Forbe's method	s = 452 J/kg K, $\rho = 7850$ kg/m^3 (for iron)
		s = 401.93 J/kg K, $\rho = 8520$ kg/m^3 (for brass)
4	Dielectric constant	$d = 70 \times 10^{-6}$ m
		$A = 57.4 \times 10^{-4}$ m^2
		$R = 10^4$ Ω
5	Four probes method	$\ell = 2 \times 10^{-3}$ m
		$A = 3.75 \times 10^{-6}$ m^2

PHYSICAL CONSTANTS		
Name of the constant	**Symbol**	**Value with unit**
Planck constant	h	6.63×10^{-34} Js
Speed of light	**c**	3×10^{8} m/s
Boltzmann constant	k_B	1.38×10^{-23} J/K
Elementary charge	e	1.602×10^{-19} C
Mass of electron	m_e	9.1×10^{-31} kg
Mass of proton	m_p	1.67×10^{-27} kg
Mass of neutron	m_n	1.67×10^{-27} kg
Permittivity of free space	ε_0	8.85×10^{-12} F/m

CONTENTS

The true sign of Intelligence is not knowledge but Imagination - ***Albert Einstein***

You cannot teach a man anything; you can only help him discover it in himself – ***Galileo Galilei***

TEACHING STAFF:

S.No	Name of the Faculty	BMSCE Mail Ids
1	Dr. Murugendrappa M V Associate Professor & HoD	hod.phy@bmsce.ac.in, murugendrappamv.phy@bmsce.ac.in
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10	Dr. Manjunatha S O Assistant Professor	

NON-TEACHING STAFF:

Sl.no	Name	Lab In-charge
1	Sri. V Venkatesh Helper	Engineering Physics Lab 1
2	Sri. G Manjunath Mechanic	Engineering Physics Lab 1, 2 and 3
3	Sri. Boriah Peon	Engineering Physics Lab 3
4	Sri. Anand T A S.D.A	Physics Office
5	Sri. Dhanush	Engineering Physics Lab 2

Teachers inspire the smallest hearts to grow big enough to change the world !

General instruction to students:

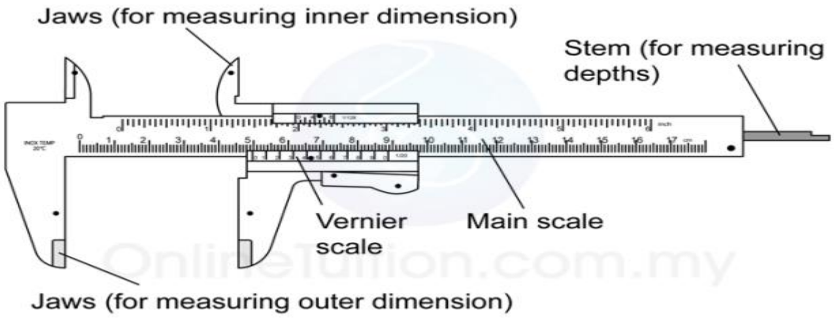
1. Submission of manual and record in every class for evaluation is mandatory.
2. Entries of observations should be made in manual only in **Blue pen.**
3. Calculations and substitutions should be shown explicitly.
4. After completion of the experiment, student should switch off the instruments and disconnect the circuit.
5. The record book should be written following the format given in the manual.
6. Transfer the readings to the record book only after the evaluation by faculty in-charge in the manual.
7. An additional graph should be drawn and attached to the record.
8. Mobile phones and smart watches are not allowed to the lab.
9. The student should bring his/her own calculator (except programmable calculator), pen, pencil, eraser, etc., borrowing the same from others is not permitted.

Safety precautions about LASER:

Students are advised:

- Not to look at the LASER beam directly as it is hazardous to eyes
- To conduct the experiment only in the presence of faculty
- To switch OFF LASER source immediately after the completion of experiment
- Not to play with the LASER beam

Vernier Calipers



Least count of the Vernier calipers =

Trial No.	MSR cm	CVD	TR=MSR+(CVD×LC) cm
1			
2			
3			

Mean thickness of the metallic disc =………......cm =……..m

Traveling Microscope

Least count of the travelling microscope =

Trial.	MSR cm	CVD	TR=MSR+(CVD×LC) cm (For a particular position)
Using X scale			
Using Y scale			

MEASUREMENTS

To conduct various experiments in the Physics Laboratory, we need to learn measurement of dimensions and other physical quantities using a few instruments. Measurement of various dimensions of object using (1) Vernier Calipers, (2) Traveling Microscope, (3) Screw gauge and (4) Multimeter are discussed here.

1. <u>Vernier Calipers</u>: It is used to measure the length and breadth of some small objects accurately. The main scale is graduated in cm and each division is 0.1 cm. The Vernier scale consists of ten divisions. When an object is held between the jaws of the calipers, the MSR (main scale reading) is taken as the value on the main scale which Vernier zero has crossed. The CVD (coinciding Vernier division) is that number of division which exactly lies in line with some main scale division. **Total reading TR= MSR+ (CVD×LC) cm**

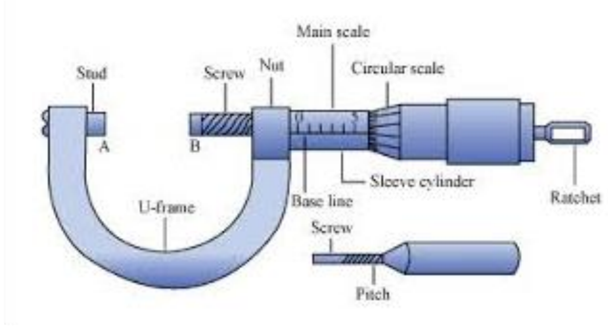
$$Least\,count = \frac{Value\,of\ 1MSD}{Total\ No.of\ \mathrm{VSD}}$$

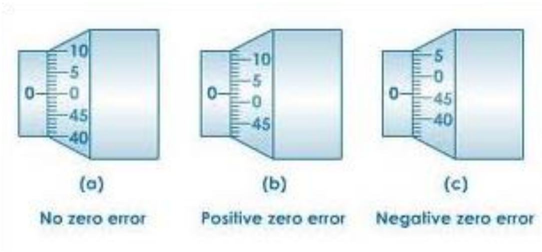
Using the formula given above, calculate the least count of the Vernier Calipers. Perform the measurement of main scale reading and Vernier coincidence at three different places to find the thickness of metallic disc by holding it between the calipers.

2. <u>Traveling Microscope</u>: It is used for more precise measurements than Vernier calipers. Calculate the least count and note down the readings of MSR and CVD for few positions by moving the microscope. The main scale is graduated in cm and each division is 0.05 cm. The Vernier scale consists of 50 divisions. When an object is focused through the TM and aligned with the cross hairs, the MSR (main scale reading) is taken as the value on the main scale which Vernier zero has crossed. The CVD (coinciding Vernier division) is that number of division which exactly lies in line with some main scale division. Total reading **TR= MSR+ (CVD×LC) cm**

$$Least\,count = \frac{Value\,of\ 1MSD}{Total\ No.of\ \mathrm{VSD}}$$

Screw gauge





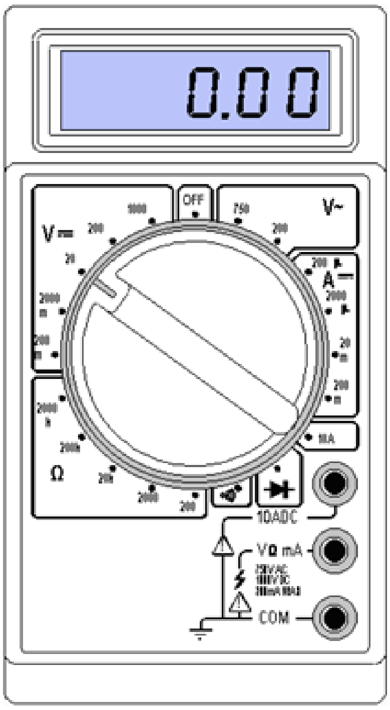
Diameter of the wire using screw gauge

Zero Error (ZE) = Zero Correction (ZC) =

Trial No.	PSR mm	HSR	TR=PSR+{(HSR±ZC)×LC} mm
1			
2			
3			

Mean Diameter of the wire=……………mm =………………….m

<u>Multimeter</u>:



3. <u>Screw gauge</u>: Unlike the above instruments, screw gauge has a pitch scale graduated in mm and a rotating head scale.

Pitch is the distance moved on the pitch scale for one rotation of the head. It is calculated by giving an even number of rotations to the head and measuring the distance traveled on the pitch scale.

Pitch = [Distance moved on the pitch scale / No. of rotations given to the head scale]

The least count for this type of instruments is given by

$$\text{Least Count} = \frac{\text{Pitch}}{\text{No. of head scale divisions}}$$

=_________________ mm = _______________ m

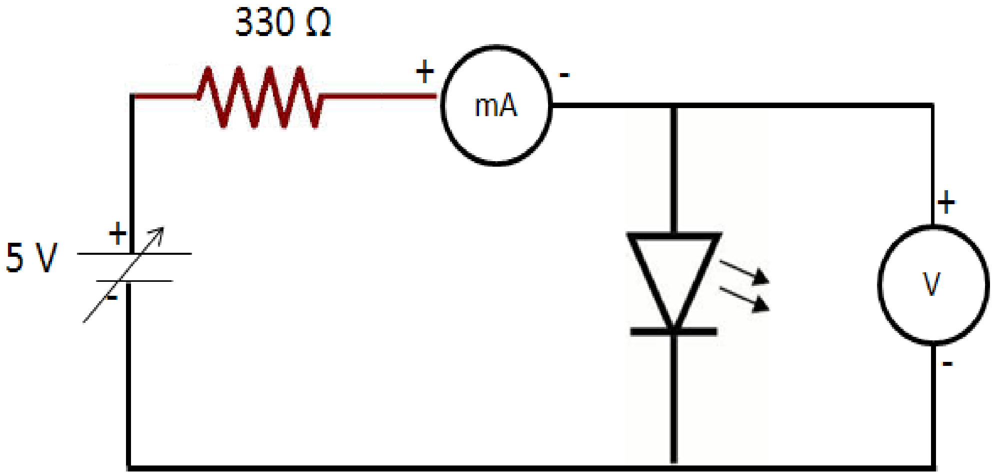
These instruments have an error called zero error which results due to the zero of the head scale not coinciding with the zero of the pitch scale. This error can be both positive and negative. Zero of the head scale below the pitch line corresponds to positive zero error. Conversely, the zero of the head scale above the pitch line corresponds to negative zero error (see figures). The zero correction is opposite to the zero error.

The total reading is calculated using the formula: **TR=PSR+ {(HSR±ZC) ×LC}** mm

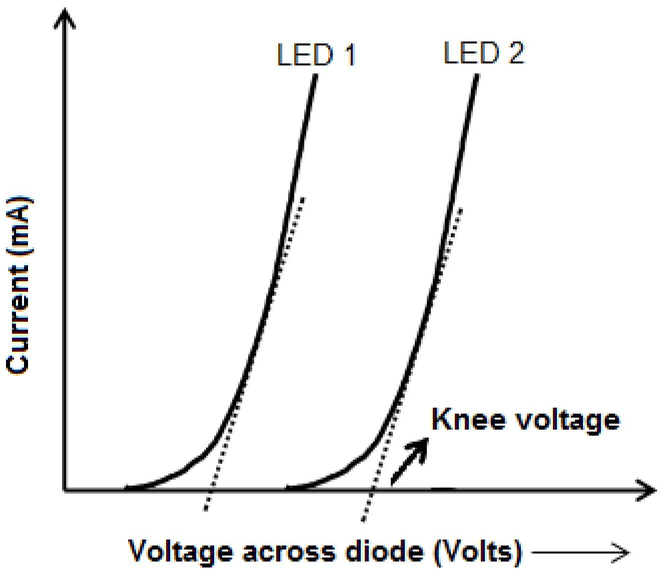
Calculate the L.C of the screw gauge. Measure the diameter of the given wire and the thickness of the cantilever beam and tabulate the readings as below.

4. <u>Multimeter</u>: A multimeter is a measuring instrument of electrical quantities in a circuit like current, voltage and resistance. It can function as ammeter, voltmeter (both AC and DC) and ohmmeter. It has various ranges built into it. By conveniently switching the rotatable knob of the multimeter, we can choose the electrical meter required for a particular measurement. In our lab, we need to use the multimeter for a few experiments.

Circuit diagram:



Expected Graph:



Experiment No: Date:

WAVELENGTH OF TRANSPARENT LIGHT EMITTING DIODES

Aim: To determine the wavelengths of the given light emitting diodes (LED s).

Apparatus: 0-5 V Power supply, LED s, 330 Ω resistor, 0-5 V Voltmeter, DC milliammeter.

Principle: Energy quantization

Formula: The wavelength of LED is calculated using the relation,

$$\lambda = \frac{hc}{eV}$$

Where, **h** is Planck's constant = 6.63×10^{-34} Js

c is speed of light = 3×10^{8} m s^{-1}

e is electron charge = 1.602×10^{-19} C

V is the knee voltage in volts of the LED, (to be measured from graph).

Procedure:

1. Connect the circuit as shown in the figure, with a 5 volts supply, 330 Ω resistor, milliammeter and an LED connected in series and a voltmeter connected in parallel to LED.
2. Increase the voltage of the source in steps of 0.2 V using fine adjustment knob. Note down the voltage across the LED and the current through the LED.
3. Repeat the above steps for another LED.
4. Plot the V-I characteristics on a graph sheet.
5. Mark the voltage at which non-zero current is registered. Draw a tangent to the curve at that point. Project it to voltage axis. Read the voltage at the intersection which is the knee voltage.
6. Calculate the wavelength of given LEDs using the above formula.

Observations:

Applied Voltage in volts	LED 1		LED 2	
	Colour:		Colour:	
	Voltage across LED (V)	Current I (mA)	Voltage across LED (V)	Current I (mA)
0.2				
0.4				
0.6				
0.8				
1.0				
1.2				
1.4				
1.6				
1.8				
2.0				
2.2				
2.4				
2.6				
2.8				
3.0				
3.2				
3.4				
3.6				

Substitution & Calculation:

Knee voltage for LED 1 = ___________ V (From graph)

Knee voltage for LED 2 = ___________ V (From graph)

$$\lambda = \frac{hc}{eV}$$

Error Analysis:

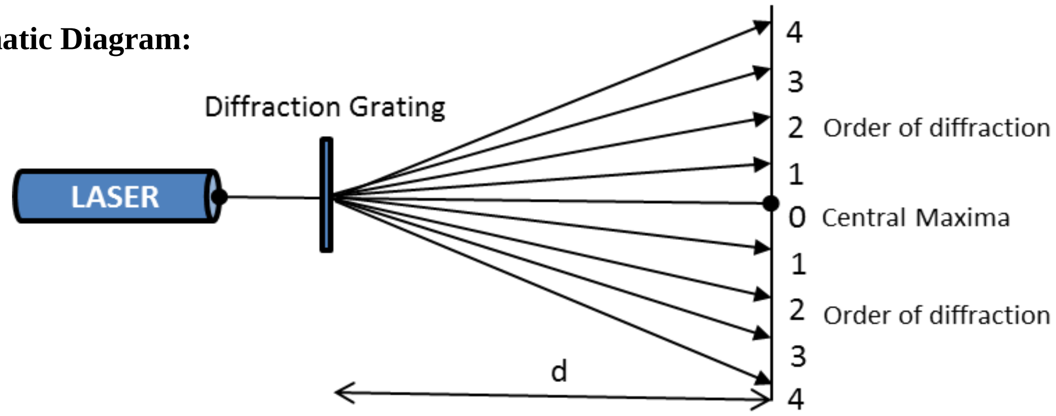
During the calculation of certain parameters from the experimental results that are aiming for known values, the percent error formula is a useful tool for determining the precision of your calculations. The formula is given by:

$$\%\ Error = \left| \frac{Experimental\ value - Expected\ value}{Expected\ value} \right| x\, 100$$

Result:

1. The wavelength of given LED 1, λ_1 = _______________ m
2. The wavelength of given LED 2, λ_2 = _______________ m

Schematic Diagram:



Observations:

Distance between grating and the screen, d =

The number of rulings per inch on the grating, N =

For Grating-1 & LASER-1

Order of diffraction **n**	Distance of the spot from the centre in m			$\theta = \tan^{-1}\left(\frac{x}{d}\right)$	sin θ	λ nm
	Left	Right	Mean (x)			
1						
2						
3						
4						
					Mean, λ_1 =	

For Grating-2 & LASER-2

Order of diffraction **n**	Distance of the spot from the centre in m			$\theta = \tan^{-1}\left(\frac{x}{d}\right)$	sin θ	λ nm
	Left	Right	Mean (x)			
1						
2						
3						
4						
					Mean, λ_2 =	

Experiment No. Date:

WAVELENGTH OF SEMICONDUCTOR LASER SOURCE USING DIFFRACTION GRATING

Aim: To determine the wavelength of the given laser source.

Apparatus: Diode laser source, optical bench, moveable stand and screen and metre scale.

Formula: The wavelength, λ of the laser beam is given by

$$\lambda = \left[\frac{\sin\theta}{n}\right]\left[\frac{2.56\times10^{-2}}{N}\right]\ m$$

where, θ is the angle of diffraction

n is the order of diffraction

N is the number of rulings on the grating per inch

The angle of diffraction θ is given by

$$\theta = \tan^{-1}\left(\frac{x}{d}\right)$$

where, x is the distance between the central spot and the spot of n^{th} order

d is the distance of the screen from the grating.

Procedure:

1. Note down the distance d between the grating and the screen. Mount the laser source at one end of the optical bench.
2. Mount the directional pointer on another stand of the optical bench.
3. Arrange the laser beam to touch the pointer for horizontal alignment of the optical bench.
4. Remove the pointer and mount the grating on that stand to get the diffraction pattern on the screen.
5. Attach a graph sheet on the screen and mark the central maxima and at least four orders of the diffraction pattern on either side of the central maxima on it.

Error Analysis:

The formula for error analysis is given by:

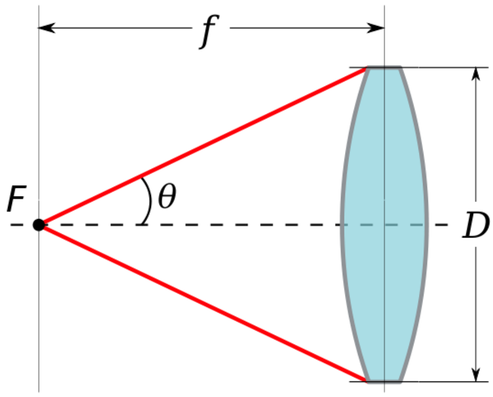
$$\% \, Error = \left| \frac{Experimental \ value - Expected \ value}{Expected \ value} \right| x \, 100$$

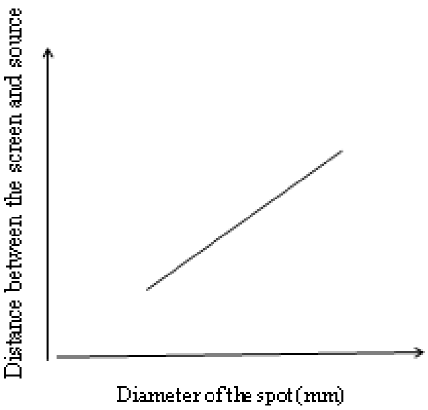
Substitution & calculation:

Result:

The wavelength of the given laser source is found to be λ_1 = ...nm & λ_2 = ...nm.

Schematic Diagram:





Observations:

Cable	Spot diameter D (mm)	Distance f (mm)	$\tan\theta = \frac{D}{2f}$	θ	Sin(θ Average)	Intensity (mA)
Cable 1						
			Average θ			
Cable 2						
			Average θ			

Substitution & calculation:

$$NA = \sin\theta$$

$$\alpha = \frac{20}{(l_x \sim l_y)} \log_{10}\left[\frac{I_x}{I_y}\right] dB/km$$

Error Analysis:

The formula for error analysis is given by:

$$\% \, Error = \left|\frac{Experimental\ value - Expected\ value}{Expected\ value}\right| x\,100$$

Experiment No. Date:

NUMERICAL APERTURE AND ATTENUATION COEFFICIENT OF AN OPTICAL FIBER

Aim: To determine the numerical apertures of the given two optical fibers and measure their attenuation coefficient.

Apparatus: Laser source, optical fiber cables, screen, transverse motion bench and relative intensity meter.

Formula: (i) The numerical aperture (NA) of an optical fiber is given by

$$\boxed{NA = \sin\theta}$$

where, θ is acceptance angle of the fiber.
(ii) The attenuation coefficient of the given cables

$$\boxed{\alpha = \frac{20}{(l_x \sim l_y)} \log_{10}\left[\frac{I_x}{I_y}\right] \, dB/km}$$

where,
I_x= Intensity of LASER at the end of shorter cable ; I_y= Intensity of LASER at the end of longer cable
l_x=Length of the shorter cable ; l_y= Length of the longer cable

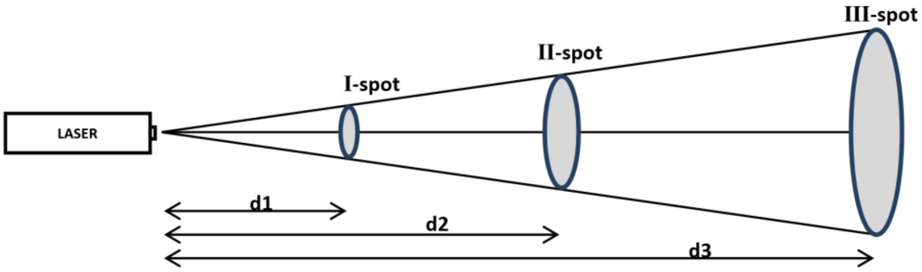
Procedure:

1. Connect one end of the optical fiber cable (OFC) to the LASER source and the other end to the connector which slides on the transverse motion bench.
2. Slide the connector close to the graduated screen (every line is 2 mm apart), fixed at the end of the transverse motion bench and note down the spot diameter and the distance between the OFC connector and the screen.
3. Move the connector to four more different distances from the screen and note down the spot diameter each time.
4. Disconnect the cable from slide motion bench and connect it to the relative intensity meter and note down the reading.
5. Repeat the experiment for the second cable.
6. Plot the graph of distance between the source (OFC connector) and the spot diameter.

Result: 1. The numerical apertures of the given two optical fiber cables are:
-------------for cable 1 and ---------------for cable 2.

2. Attenuation coefficient α = ------------------------------

Schematic Diagram:



Tabular Column:

For LASER - 1					
Spot No	Distance 'd' in m	Horizontal Diameter (w_h) in m	Vertical Diameter (w_v) in m	Mean diameter (m) $w = \left[\frac{w_h + w_v}{2}\right]$	$\theta = \tan^{-1}\left(\frac{w}{2d}\right)$
I					
II					
III					
				Average θ_1 =	

For LASER - 2					
Spot No	Distance 'd' in m	Horizontal Diameter (w_h) in m	Vertical Diameter (w_v) in m	Mean diameter (m) $w = \left[\frac{w_h + w_v}{2}\right]$	$\theta = \tan^{-1}\left(\frac{w}{2d}\right)$
I					
II					
III					
				Average θ_2 =	

Error Analysis:

The formula for error analysis is given by: $$\%\ Error = \left|\frac{Experimental\ value - Expected\ value}{Expected\ value}\right| x\,100$$

Substitution & calculation:

Experiment No. Date:

DIVERGENCE ANGLE OF SEMICONDUCTOR LASER BEAM

Aim: To determine the half angle of divergence of the given laser beam.

Definition: Divergence of a laser beam is defined as its spread with distance. It is measured in terms of angle subtended by the laser spot at the point of origin of the laser beam.

Apparatus: Diode laser source, optical bench, moveable stand and screen and metre scale.

Formula: The half angle of divergence θ of the laser beam is given by

$$\theta = \tan^{-1}\left(\frac{w}{2d}\right)$$

where, **w** is the mean diameter of the laser spot

d is the distance of the screen from the source.

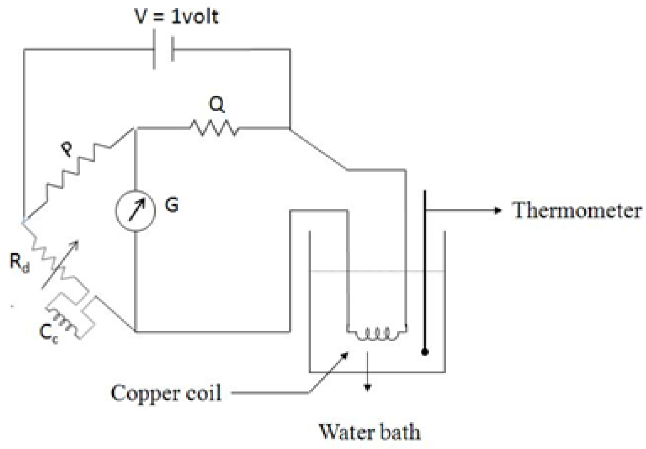
Procedure:

1. Mount the laser source at the one end of the optical bench.
2. Mount the directional pointer on the other end of the optical bench.
3. Arrange the laser beam to touch the pointer for horizontal alignment of the optical bench and then remove the pointer.
4. Now place the moveable stand and screen at distance d_1 and note down the horizontal and vertical diameters of the spot.
5. Repeat the above step for two more distances.

Result: The half angle of divergence of given LASER beam is found to be

θ_1 = ...deg. & θ_2 = ...deg.

Circuit Diagram:



Observations:

Free electron concentration of copper,	$n = 8.45 \times 10^{28}/m^3$
Debye temperature of copper,	$\theta = 343$ K
The atomic weight of copper,	M = 63.45
The area of cross section,	$A = 0.0769 \times 10^{-6}\ m^2$
The length of the copper wire,	ℓ = 10 m
The resistance per unit length of the bridge wire,	ρ = _______ Ω/cm
The dial resistance,	R_d = ___ Ω

Experiment No: Date:

FERMI ENERGY OF COPPER

Aim: To determine the Fermi energy of copper.

Apparatus: Copper coil, oil/water bath, thermometer, Callender - Griffith's bridge, galvanometer, power supply

Formula: The Fermi energy of copper is given by

$$E_F = 1.764 \times 10^{-31} \left[\sqrt{\frac{n\theta^2 MA \frac{R}{T}}{L}} \right] \quad J$$

where,

- **n** is the free electron concentration of copper in $/m^3$
- **θ** is Debye temperature of copper in K
- **M** is the atomic weight of copper in kg
- **A** is the area of cross section in m^2
- ***L*** is the length of the copper wire in m
- **R/T** is the mean experimental constant in Ω/K

Procedure:

1. A copper wire of given length is wound on a fiber sheet in the form of a coil.
2. This coil is immersed in water bath and is connected to one arm of a Callender-Griffith's bridge (the S arm). A compensating wire is connected to the opposite arm (the R arm).
3. Now adjust the standard resistance dial to 1 ohm. Set the voltage output of the power supply to 1 V. Slide the key along the bridge and obtain null deflection. Note down balancing length 'x' in cm.
4. Obtain the balancing lengths at various temperatures. Tabulate the results.

Sl. No.	Temp ^{0}C	Temp K	'x' in cm	R= R_d + x ρ in Ω	[R/T] in Ω/K
1	Room Temp =				
2	80	353			
3	75	348			
4	70	343			
5	65	338			
6	60	333			
				Mean [R/T] =	

Substitution & Calculation:

$$E_F = 1.764 \times 10^{-31} \left[\sqrt{\frac{n\theta^2 MA\frac{R}{T}}{L}} \right] \quad J$$

Error Analysis:

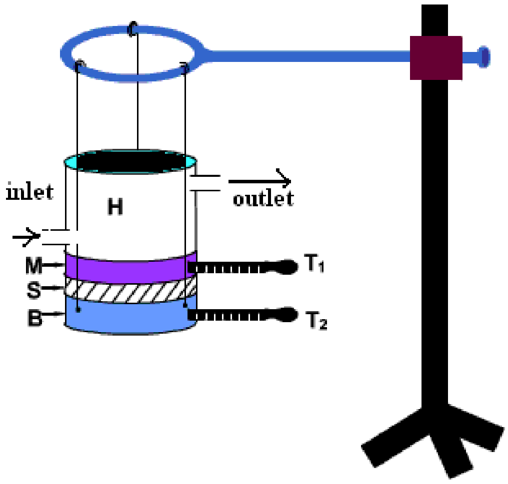
The formula for error analysis is given by:

$$\% \, Error = \left| \frac{Experiment\,al\ value - Expected\ \ value}{Expected\ \ value} \right| x\,100$$

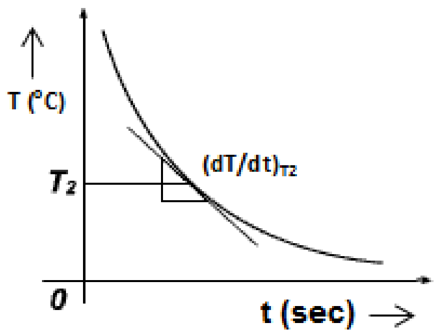
Result:

The Fermi energy $\mathbf{E_F}$ of copper = ________________J = __________eV.

Experimental Setup:



Expected Graph:



Observations:

Thickness of a poor conductor using screw gauge:

Zero error (ZE) = Zero Correction (ZC) =

Least count (LC) = __________________mm

Trial No.	PSR mm	HSR	TR=PSR+{(HSR-ZE)×LC} mm
1			
2			
3			

Thickness of a poor conductor =…………..mm =…………………m

Experiment No: Date:

THERMAL CONDUCTIVITY OF A POOR CONDUCTOR BY LEE AND CHARLTON'S METHOD

Aim: To determine the thermal conductivity of given poor conductor by Lee and Charlton's method.

Apparatus: Lee and Charlton's apparatus, poor conductor in the form of a disc, stop clock, Vernier callipers, screw gauge, two thermometers, steam generator and balance.

Experimental set up:

The experimental set up is shown in the figure. The steel disc B is hung from the stand with the help of three strings. On the steel disc, the poor conductor sample disc 'S' is placed and over that a metallic disc M is placed. On the metallic disc, a heating chamber H, with facility for steam-in and steam-out is placed.

Formula: The thermal conductivity of a poor conductor is calculated using the relation,

$$K = \frac{msd}{\pi r^2\,(T_1 - T_2)}\left(\frac{dT}{dt}\right)_{T_2}\frac{r+2h}{2r+2h}\;W/mK$$

where,

m	is mass of the metallic disc B in kg
s	is specific heat of the material of B in J/kg.K
d	is thickness of the poor conductor S in m
r	is radius of the poor conductor S in m
T_1	is steady temperature of disc M in ^{0}C
T_2	is steady temperature of disc B in ^{0}C
h	is height of the metallic disc B in m
dT/dt	is rate of cooling as calculated from the graph

Procedure:

1. Measure the diameter and hence the radius, **r** of the poor conducting specimen S, using a scale.

2. Measure the thickness, **d** of the sample using a screw gauge.

3. Arrange the steel disc, poor conductor and steam chamber as shown in the schematic diagram. Insert the thermometers into the grooves of steam chamber and steel disc, which measure the temperatures T_1 and T_2, respectively.

Observations:

Mass of the metallic disc B, m = 0.93 kg

Specific heat of the material of B, s = 520 J/kg.K

Thickness of the poor conductor, d = m

Radius of the poor conductor S, r = m

Steady temperature of disc M, T_1 = ^oC

Steady temperature of disc B, T_2 = ^oC

Height of the metallic disc B, h = 0.01 m

Rate of cooling of brass disc:

Sl. No.	Time (min)	Time in s	Temperature of steel disc T ^oC
1	0	0	
2	1	60	
3	2	120	
4	3	180	
5	4	240	
6	5	300	
7	6	360	
8	7	420	
9	8	480	
10	9	540	
11	10	600	

4. Turn on the heater and monitor the temperatures T_1 and T_2 at a regular interval till they reach the steady state. Note the steady state temperatures T_1 and T_2.

5. To determine the rate of cooling of brass disc, lift the heating chamber and remove the sample disc S, then place the heating chamber directly on the brass disc, B.

6. Allow the brass disc B to heat at least about 10^0C above the steady state temperature T_2 measured in the first part of the experiment. Remove the heating chamber.

7. Switch on the stop clock and measure the temperature of brass disc at an interval of 60 s as it cools down.

8. Plot a graph of temperature T of brass disc as a function of time. Draw tangential line to the curve, corresponding to the temperature T_2 and determine its slope. The slope is equivalent to $\left[\frac{dT}{dt}\right]_{T_2}$

9. Calculate the thermal conductivity, K by the given formula.

Substitution & Calculation:

Rate of cooling from the calculated graph [dT/dt] =

$$K = \frac{msd}{\pi r^2\ (T_1 - T_2)}\left(\frac{dT}{dt}\right)_{T_2}\frac{r+2h}{2r+2h}\ \ W/mK$$

Error Analysis:

The formula for error analysis is given by:

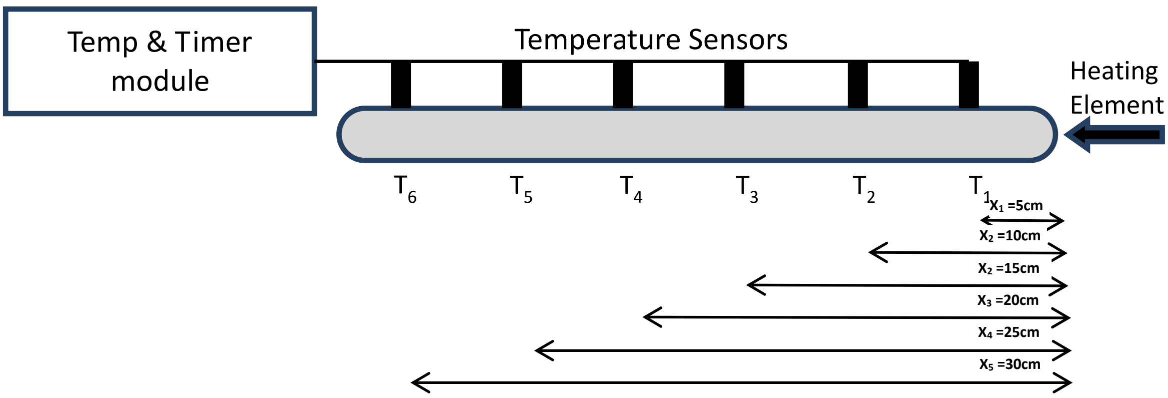
$$\%\ Error = \left|\frac{Experiment\,al\ value - Expected\ \ value}{Expected\ \ value}\right| x\,100$$

=

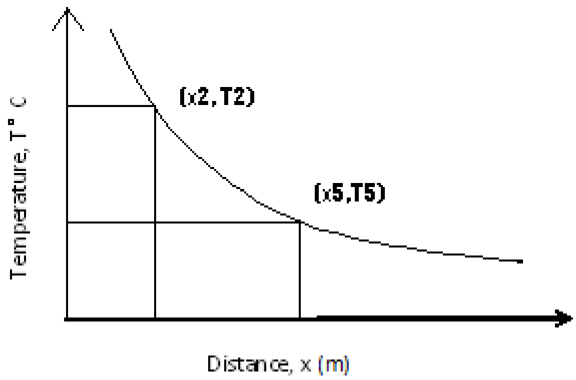
Result: Thermal conductivity of the given poor conductor specimen is found to be

………………………………W/mK

Experimental setup:



Expected Graph:



Observations:

Table 1:

Distance (m)	x_1 5 x10^{-2} m	x_2 10 x10^{-2} m	x_3 15 x10^{-2} m	x_4 20 x10^{-2} m	x_5 25 x10^{-2} m	x_6 30 x10^{-2} m
Steady temperature T in °C						

Experiment No: Date:

THERMAL CONDUCTIVITY OF A METAL BY FORBE'S METHOD

Aim: To measure the thermal conductivity of a good conductor by Forbe's method.

Apparatus: A long uniform hollow metal rod with holes drilled at appropriate places with semiconductor thermometers (six), temperature and time reading unit.

Formula: The coefficient of thermal conductivity of the metal rod is given by

$$K = \frac{\rho \, s \sum_{0}^{L} \frac{\Delta T}{\Delta t} \Delta x}{\left(\frac{dT}{dx} \right)_{x_2, x_5}} \, W/mK$$

where,

ρ	is the density of the metal rod in kg/m^3
s	is its specific heat J/kg.K
[ΔT/Δt]	is rate of change of temperature
[dT/dx]	is temperature gradient $[(T_2-T_5)/(x_5-x_2)]$

Procedure:

1. Insert the heating element into open end of the hollow metal rod. Heat the rod for about half an hour so as to attain steady state.
2. Connect the output of the thermometers to the temperature and timer module.
3. Note down the temperature at different distances x as in Table 1. Plot a graph *T vs X.*
4. Find the ratio $[(T_2-T_5)/(x_5-x_2)]$ from the graph.
5. Now turn off the heating. Reset the timer. Note down the temperature of all six thermometers at an interval of two minutes, up to ten minutes as in Table 2.
6. Calculate $\Delta T = [T_{@\,0s} \sim T_{@\,600s}]$ and consider $\Delta t = 600$ s. Compute the sum $\sum_{0}^{L} \frac{\Delta T}{\Delta t} \Delta x$ as indicated in Table 2 and Table 3.

Table 2:

Time t (sec)	Temperature °C					
	T_1 (at x_1)	T_2 (at x_2)	T_3 (at x_3)	T_4 (at x_4)	T_5 (at x_5)	T_6 (at x_6)
0						
120						
240						
360						
480						
600						
[ΔT/Δt] =						

Table 3:

x, cm	Δx, m	$\left[\frac{\Delta T}{\Delta t}\right]$	$\left[\frac{\Delta T}{\Delta t}\right]\Delta x$
5	0.05		
10	0.05		
15	0.05		
20	0.05		
25	0.05		
30	0.05		
	$\sum_0^L \frac{\Delta T}{\Delta t}\Delta x$	Total	

Observations:

Density of the material (brass or iron) of the rod, ρ= (8520 or7850) kg/m^3

Specific heat of the material (brass or iron) of the rod s = (401.93 or 452) J/kg.K

Substitution & Calculation:

$\sum_{0}^{L} \frac{\Delta T}{\Delta t} \Delta x$ From the table=

dT/dx, the temperature gradient [$(T_2-T_5)/(x_5-x_2)$] from the graph =

$$K = \frac{\rho \, s \sum_{0}^{L} \frac{\Delta T}{\Delta t} \Delta x}{\left(\frac{dT}{dx}\right)_{x_2, x_5}} W/mK$$

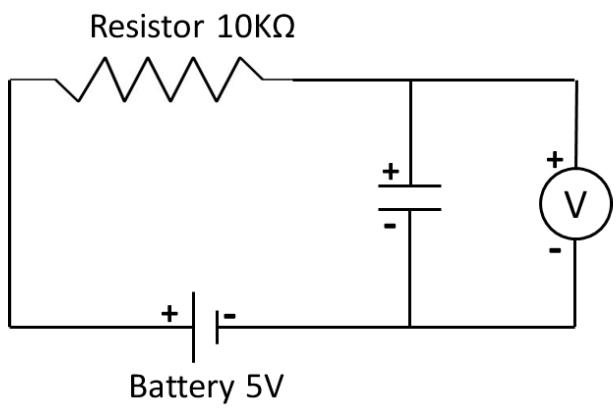
Error Analysis:

The formula for error analysis is given by:

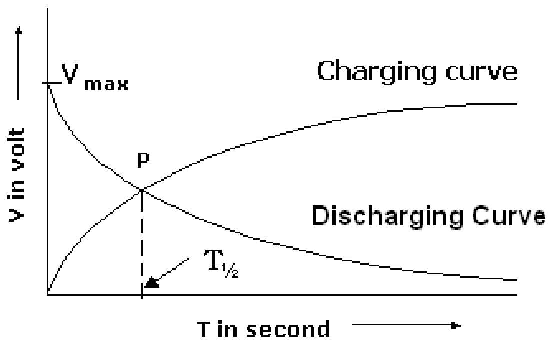
$$\%\,Error = \left| \frac{Experimental\ value - Expected\ value}{Expected\ value} \right| x\,100$$

Result: The thermal conductivity of the given good conductor is = ………………..W/mK

Circuit Diagram:



Expected graph:



Observations:

Thickness of the dielectric material,	d =	70×10^{-6} m
Area of cross section of the dielectric material	A =	57.4×10^{-4} m^2
Time taken for charging /discharging to 1/e of the voltage value	$T_{½}$ =	________ s
Resistance connected in the circuit	R =	1×10^4 Ω
Permittivity of free space	ε_o =	8.85×10^{-12} F/m

Experiment No. Date:

DIELECTRIC CONSTANT OF A MATERIAL BY CHARGING AND DISCHARGING OF A CAPACITOR

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

Apparatus: Capacitor with known dimensions, 5 V DC power supply, voltmeter, resistor, stop clock.

Formula: The dielectric constant **k** of the material inside the capacitor is

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

where,

- **d** is the thickness of the dielectric material in m
- **A** is the area of cross section of the dielectric material in m^2
- $\mathbf{T_{1/2}}$ is the time taken for charging /discharging to rise/fall to 1/e times of the initial value of voltage in seconds
- **R** is the resistance connected in the circuit in Ω
- $\boldsymbol{\varepsilon_0}$ is permittivity of free space= 8.85×10^{-12} F/m

Procedure:

1. Connect the circuit as shown and discharge the capacitance fully so that the voltmeter reads zero volts.
2. Switch on the power supply and stop clock simultaneously.
3. Note down the voltage across the capacitor at 10 s intervals up to 150 s.
4. Reset the stop clock. Now switch off the power supply and start the stop clock simultaneously.
5. Again note down the voltage across the capacitor at 10 s intervals.
6. Plot a graph of voltage across the capacitor and time both while charging and discharging. Find $T_{1/2}$.

Observation:

Time in seconds	Voltage across capacitor in V	
	Charging Mode	Discharging Mode
0	0	
10		
20		
30		
40		
50		
60		
70		
80		
90		
100		
110		
120		
130		
140		
150		

Substitution & Calculation:

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

Error Analysis:

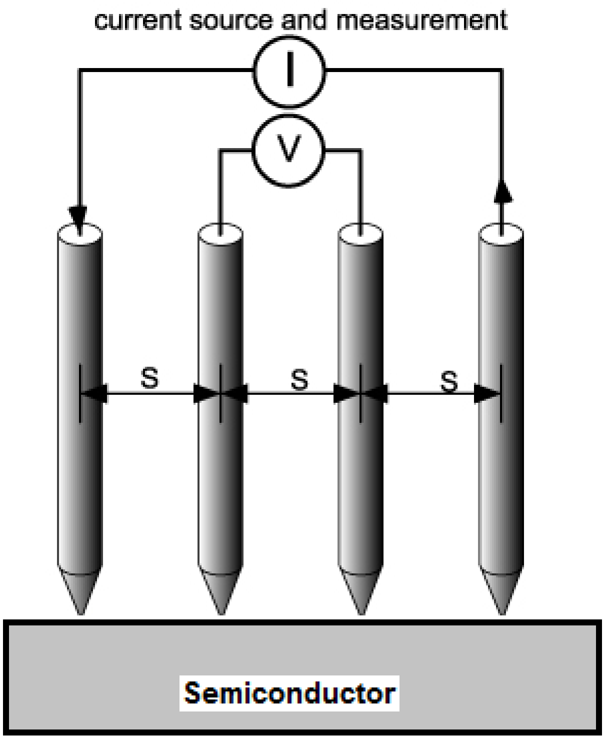
The formula for error analysis is given by:

$$\%\,Error = \left| \frac{Experimental\ value - Expected\ value}{Expected\ value} \right| x\, 100$$

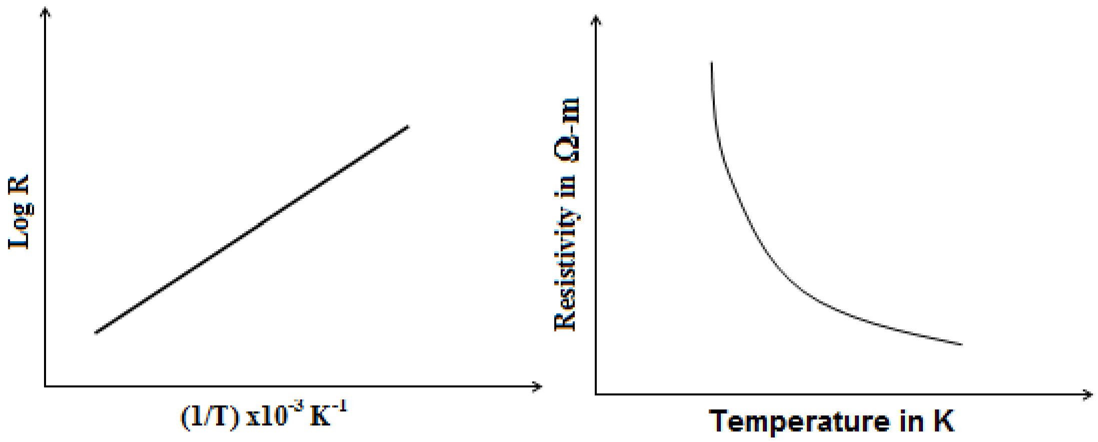
Result: The dielectric constant of the material present between the plates of the capacitor is,

k = ____________

Schematic diagram:



Expected graph:



Experiment No. Date:

ENERGY BAND GAP OF A SEMICONDUCTOR BY FOUR PROBE METHOD

Aim: To study the temperature dependence of resistivity and to determine the energy gap of a semiconductor.

Apparatus: Semiconductor in the form of a crystal, thermometer, four probes apparatus

Formula: The resistivity of the material of the crystal is given by

$$\boxed{\rho = R\frac{A}{l} \ \ \Omega m}$$

where, R is the resistance of the crystal in ohm,

A is area of the crystal in m^2

l is the length of the crystal in m.

Energy gap of the semiconductor is given by

$$E_g = \left[\frac{2.303 \times 2 \times k \times Slope}{1.602 \times 10^{-19}}\right] \text{eV}$$

where, k is Boltzmann constant =1.38×10^{-23} J/K

Slope is calculated from the graph of ***$\log_{10}$ R vs (1/T)***

Procedure:

1. Connect the circuit as in diagram.
2. Immerse the thermistor in the port in the crystal holder of the four probes apparatus.
3. Adjust the current at 2.00 mA. This value of current should be kept constant.
4. Switch on the oven and heat the sample up to 200 ^{o}C.
5. Switch off the oven and allow the crystal to cool.
6. Note down the value of voltage for every 10 ^{o}C fall in temperature starting from 200 ^{o}C.
7. Plot a graph of *ρ versus T*.
8. Plot another graph of *$\log_{10}$ R versus (1/T)* and calculate its slope.

Observations:

Sl. No.	Temp ° C	Temp T, K	Voltage in mV	Resistance $R = \frac{V}{I}$ Ω	Resistivity $\rho = R\frac{A}{l}$ Ω-m	[(1/T) x 10^{-3}] K^{-1}	$\log_{10} R$
1.	160	433				2.309	
2.	150	423				2.364	
3.	140	413				2.421	
4.	130	403				2.481	
5.	120	393				2.544	
6.	110	383				2.610	
7.	100	373				2.680	
8.	90	363				2.755	
9.	80	353				2.833	
10.	70	343				2.915	

Current, I = 2.00 mA

Area of the crystal, A = 3.75×10^{-6} m^2

Length of the crystal, $l = 2 \times 10^{-3}$ m

Substitution & calculation:

$$E_g = \left[\frac{2.303 \times 2 \times k \times Slope}{1.602 \times 10^{-19}}\right] \text{eV}$$

Error Analysis:

The formula for error analysis is given by:

$$\%\,Error = \left|\frac{Experiment\,al\ value - Expected\ \ value}{Expected\ \ value}\right| x\,100$$

Result:

The temperature dependence of the resistivity of the given semiconductor is studied.

The energy gap of the given semiconducting material is E_g = ___________ eV

Circuit Diagram:

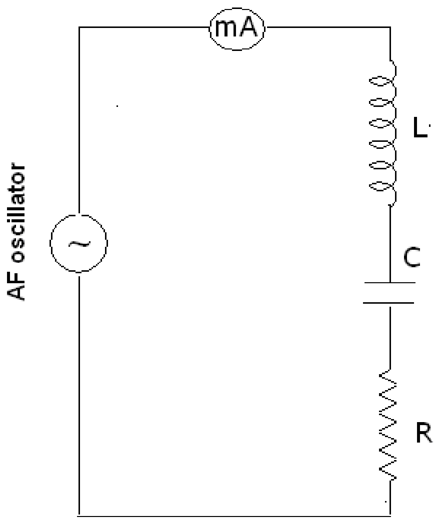


Fig.1. Series resonance circuit

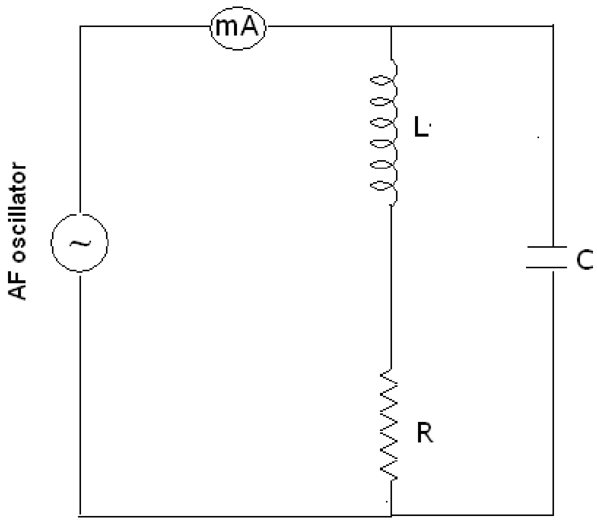


Fig.2. Parallel resonance circuit

Frequency response curve:

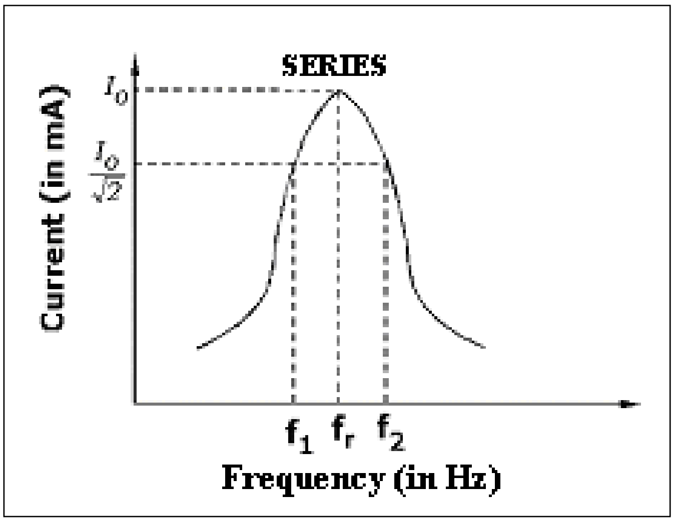


Fig.3. Series resonance curve

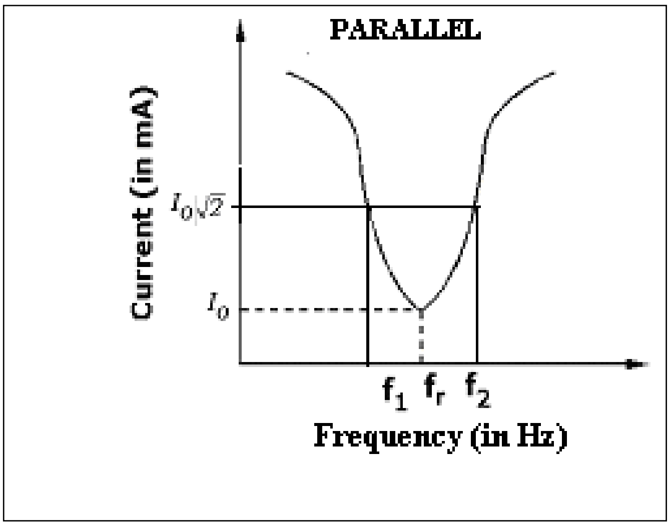


Fig.4. Parallel resonance curve

Experiment No. Date:

SERIES AND PARALLEL RESONANCE IN LCR CIRCUITS

Aim: 1. To study the frequency response of the series and parallel resonance circuits.

2. To determine the unknown value of the given inductor, bandwidth and quality factor for the series resonance circuits.

Apparatus: Audio frequency generator, resistor, inductor, capacitor and milliammeter.

Formula: (i) The value of inductance is given by

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

where f_r is resonant frequency in Hz
and C is the capacitance in F

(ii) Band width = ($f_1 \sim f_2$) in Hz

(iii) Quality factor of the series circuit is given by

$$Q = \frac{f_r}{f_2 - f_1}$$

f_1 and f_2 are lower and upper cut-off frequencies respectively in Hz

Procedure:

1. Connect a signal generator, a resistor, an a.c. milliammeter, an inductor and a capacitor in series.
2. Switch on the signal generator and adjust its amplitude knob to get the milliammeter readings within the scale for all frequencies between 200 to 1200 Hz.
3. Increase the frequency in steps of 50 Hz up to 1200 Hz starting from 200 Hz and note down the milliammeter readings.
4. Connect the parallel LCR circuit and conduct the experiment as in case of series LCR circuit.
5. Perform the calculations for the observations of series LCR circuit.

Observations:

Series Circuit		Parallel Circuit	
Frequency Hz	Current mA C = _______ μF	Frequency Hz	Current mA C = ______ μF
200		200	
250		250	
300		300	
350		350	
400		400	
450		450	
500		500	
550		550	
600		600	
650		650	
700		700	
750		750	
800		800	
850		850	
900		900	
950		950	
1000		1000	
1050		1050	
1100		1100	
1150		1150	
1200		1200	

Substitution & calculation:

$$Q = \frac{f_r}{f_2 - f_1}$$

$$L = \frac{1}{4\pi^2 f_r^2 C}$$

Error Analysis:

The formula for error analysis is given by:

$$\% \, Error = \left| \frac{Experimental\ value - Expected\ value}{Expected\ value} \right| x\,100$$

<u>Results</u>:

The resonant frequency of series LCR circuit = ____________________ Hz

The bandwidth of the series LCR circuit = ____________________ Hz

The quality factor of the series LCR circuit = ____________________

The value of the inductance of the coil L = ____________________ H

The resonant frequency of parallel LCR circuit = ____________________ Hz

MODEL VIVA QUESTIONS AND ANSWERS

EXPERIMENT 1 : WAVELENGTH OF TRANSPARENT LEDs

1 **What is a diode?**
Diode is a p-n junction semiconductor device which allows current to flow in one direction

2 **How LED gives light?**
Light Emitting Diode gives light as a result of recombination of charge carriers

3 **What is recombination radiation?**
When forward biased a p-n junction develops a depletion region. With further increase in forward bias voltage the holes and electrons recombine to gives out recombination radiation

4 **What is the wavelength range for UV, Visible and IR radiation in nanometre?**
Ultra Violet wavelength lies less than 400 nm, Visible lies between 400 nm – 700 nm, IR lies in the range greater than 700 nm

5 **Why different LED have different colour?**
Different colour or wavelength of LED is because of different energy band gap of semiconducting materials

6 **What is the amount of energy consumed by LED to emit any wavelength?**
E = e V where is e is charge of electron and V is the knee voltage of the LED

7 **How does the product λV remain constant?**
$E = eV$ also $E = hc / \lambda$ Therefore, $eV = hc/\lambda$ or $\lambda V = hc/e$ = constant.

8 **Mention some applications of LED. Which type of LED is used to send signal from the remote to the TV?**
LED's are used in sensors, bulbs, lasers etc. LED's which gives out IR radiation are used in TV remote control

9 **What is knee voltage?**
The voltage at which conduction due to recombination of electrons and holes just starts is known as knee voltage

10 **Does all the diodes gives out radiation? Justify**
Every LED gives light due to recombination. If the radiation lies in visible range of wavelength, then we can visualize

11 **What do you mean by depletion layer?**
The junction region obtained due to fusing p & n semiconducting materials is known as depletion layer

12 Mention some semiconducting materials used in the manufacturing of diode.

Gallium Arsenide (GaAs) – infra-red
Gallium Arsenide Phosphide (GaAsP) – red to infra-red, orange
Aluminium Gallium Arsenide Phosphide (AlGaAsP) – high-brightness red, orange-red, orange, and yellow
Gallium Phosphide (GaP) – red, yellow and green
Aluminium Gallium Phosphide (AlGaP) – green
Gallium Nitride (GaN) – green, emerald green
Gallium Indium Nitride (GaInN) – near ultraviolet, bluish-green and blue
Silicon Carbide (SiC) – blue as a substrate
Zinc Selenide (ZnSe) – blue
Aluminium Gallium Nitride (AlGaN) – ultraviolet

13 What is Planck's constant? Mention its significance.

In the formula E = hv ; h = Planck's constant = 6.634 E - 34 J-s. The same formula can be written as h = E/v with this h = E for v = 1. Hence Planck's constant is nothing but energy itself for radiation of unit frequency.

EXPERIMENT 2 : WAVELENGTH OF A LASER BEAM

1 **What is diffraction?**

Bending of light and its enter into the region of geometrical shadow of an object is called diffraction.

2 **What is the required condition for diffraction?**

Diffraction takes place if the size of the obstacle is comparable to the wave length of incident light.

3 **What is a diffraction grating?**

It is a plane glass plate, on which numbers of opaque lines are drawn at equidistant parallel lines are drawn with the help of diamond point. The distance between two successive opaque lines act as a slit whose width will be comparable with wavelength of incident light. Thus, when light falls on a grating it undergoes diffraction.

4 **What is the significance of grating**

Distance between two consecutive lines of grating is comparable to wavelength of light; so that light is obstructed by the edges of the rulings and hence diffraction takes place.

5 **Define grating constant and what is its significance?**

The spacing between two consecutive lines is called grating constant. As the distance between two consecutive lines is of the order of size of the obstacle and hence diffraction takes place when light incident on the grating.

6 **What is order of diffraction?**

They are the repeated diffraction patterns obtained on either side of the central maxima.

7 **What is zeroth order?**

The central maxima formed when light incident normally on grating ($\theta = 0$) is called zeroth order spectrum.

8 **What kind of laser is used in the experiment?**

Semiconductor diode laser is used in the experiment.

9 **What happens to the fringe pattern if monochromatic light is replaced by composite source?**

Colored fringes are obtained with white fringe at the centre of the pattern.

10 Why ordinary glass plates do not produce diffraction bands when exposed to light?

Because size of the object is very large compared to wavelength of light.

11 How many lines are there in the grating you have used

It is 250 Lines Per Inch (check before confirming)

12 What is stimulated emission?

Stimulated emission is the emission of a photon by a system, under the influence of a passing photon of just the suitable energy, due to which the system transits from a higher energy state to a lower energy state. The photon thus emitted is called the stimulated photon and will have same phase, energy and direction of movement as that of the passing photon called the stimulating photon.

13 How the gratings are prepared?

Gratings are prepared by ruling parallel and equidistant lines on a well-polished glass plate using sharp diamond edge. Now a days Holographic method is used to create gratings.

14 What is the type of diffraction involved in the diffraction grating experiment?

Fraunhoffer diffraction is involved in this experiment, because the source and screen are effectively at infinite distance (collimator gives parallel rays of light).

15 What are the conditions required for LASER action

Population inversion and Metastable state.

16 What is Population inversion?

It is a stage at which number of atoms in the excited state exceeds the number of atoms in the ground state ($N_2 > N_1$)

EXPERIMENT 3 : NUMERICAL APERTURE OF AN OPTICAL FIBER

1 Define Numerical aperture of an OFC

It is defined as the light gathering capacity of an OFC. If A is the angle of incidence then Sin A is known as Numerical Aperture.

2 If n_1 is the RI of core and n_2 is the RI of cladding, then what is the dependence between the them?

$n_1 > n_2$

3 Define acceptance angle

The angle made by the signal at the core point in order to propagate within the fiber is known as acceptance angle.

4 If A is the apex angel of the acceptance cone and B is any angle other than acceptance angle, then write the relation between A & B.

Initially $B \leq A$ or $\sin B \leq \sin A$ or $\sin B \leq NA$

5 How many types of optical fiber cables are there?

There are three types, 1 Single mode step-index, 2. Multi mode step-index & 3. Graded index fiber

6 What is attenuation in OFC?

The Sum total loss in the signal strength while traversing through the fiber is known as attenuation

7 What are macro bend and micro bend losses?

Macrobend losses occurs when radius of curvature is large as compared to fiber diameter. Whereas, microbend losses are small scale fluctuations in radius of curvature of the fiber axis.

8 State the losses responsible for attenuation in optical fibers.

1. Absorption 2. scattering 3. Bending

9 Write the formula for attenuation of OFC with unit

$\alpha = -10/L \log(P_o/P_i)$ dB/km

10 A single mode fibre has low intermodal dispersion than multimode. Explain

In both single and multimode fibres the refractive indices will be in step by step. Since a single mode has less dispersion than multimode, the single mode step index fibre also has low intermodal dispersion compared to multimode step index fibre.

11 How does the refractive index vary in Graded Index fibre?

The refractive index of the core is maximum along the fibre axis and it gradually decreases. Here the refractive index varies radially from the axis of the fibre. Hence it is called graded index fibre.

12 Explain why multi mode fiber has more distortion?

When rays travel through longer distances there will be some difference in reflected angles. Hence high angle rays arrive later than low angle rays. Therefore the signal pulses are broadened thereby results in a distorted output.

13 Why graded index fiber has less distortion?

The light travels with different speeds in different paths because of the variation in their refractive indices. At the outer edge it travels faster than near the centre But almost all the rays reach the exit end at the same time due to the helical path. Thus, there is no dispersion in the pulses and hence the output is not a distorted output.

14 What causes microscopic bend?

Micro-bends losses are caused due to non-uniformities inside the fibre. This micro-bends in fibre appears due to non-uniform pressures created during the cabling of fibre.

15 What is normalized frequency or V-number? How many modes are allowed to pass through the fiber at maximum?

It is given by $V = \pi d/\lambda$ (NA) ; Maximum no of modes = $V^2/2$

EXPERIMENT 4 : DIVERGENCE OF A LASER BEAM

1 **Define divergence of laser beam**

Spread of the beam with distance is known as divergence

2 **Which property of laser is responsible for low value of divergence**

Highly directional property

3 **Give one application of highly directional or low value of divergence for laser light**

Measuring the distance between distant objects. For example, distance between earth and moon using the formula **Distance = velocity x time**

4 **What is the formula used to find half angle of divergence?**

$\theta = \tan^{-1}(w/2d)$

5 **What will happen when laser light is focussed on a particular area for a long time.**

Laser beam has very high intensity, directional properties and coherence. When it is focussed on a particular area, for a long time then, the area alone will be heated and the other area will remain as such . This is called thermal effect

6 **Which laser system you have used?**

Semiconductor laser

7 **How recombination radiation gets converted into laser light in semiconductor laser?**

After fulfilling the conditions and requirements of laser, the recombination radiation gets converted to laser light

8 **What do you understand my metastable state?**

The energy state in which an atom remains in the excited state for a relatively longer time duration

9 **What is the time duration of an atom in metastable state?**

It is greater than 10^{-8} sec

EXPERIMENT 5 : FERMI ENERGY OF COPPER

1 **Define Fermi energy.**

Energy of the maximum occupied level at absolute zero.

2 **Is Fermi energy the same for all the metals?**
No. It is constant for a given metal. For different metals it varies from 1eV to 10 eV.

3 **What is Fermi level?**

The highest occupied level is known as Fermi level

4 **Define Fermi energy at a temperature greater than absolute zero.**

Energy of the level at which the Fermi factor f (E) = 1/2 at T > 0 K.

5 **What is the significance of the concept of Fermi energy ?**

Conduction becomes possible only when some free electrons get energies greater than the Fermi energy. Larger value of EF indicates better conduction property

6 **What is the significance of the concept of Fermi level?**

Conduction is possible only when the electrons cross this level

7 **What is Fermi factor?**

Probability of occupancy $f(E) = 1/1+\exp(E-E_F)/kT$ of electrons in a given energy level E at a given temperature T.

8 **What is the probability occupancy below Fermi level at 0K?**

f (E) = 1. All the levels are occupied.

9 **What is the probability occupancy above Fermi level at 0K?**

f (E) = 0. All the levels are vacant.

10 **What is the probability occupancy at Fermi level at T > 0K?**

f (E) = 0.5

11 **Define Fermi Temperature**

It is defined as the ratio of E_F to Boltzmann constant, $T_F = E_F/k_B$

12 **Define Fermi Velocity**
The velocity of electrons at Fermi level is known as Fermi velocity given by
$V_F = (2E_F / m)^{1/2}$

13 **What is the difference between Fermi energy of a metal and semiconductor?**

Fermi energy of a metal is constant however that of semiconductor depends on temperature

14 What are Fermions?

Fermions are the particles having half integer spin which obey Fermi - Dirac statistics

15 How many electrons are there in each energy level?

According to Pauli's exclusion principle, there are 2 electrons are there in each energy one with spin up and other with spin down

16 What is the effect of atomic number Z on E_F & T_F?

As Z value decreases E_F & T_F increase.

EXPERIMENT 6 : K OF A POOR CONDUCTOR (LEE & CHARLTON'S METHOD)

1 **Define Thermal conductivity with unit**

It is defined as the ratio of amount of heat conducted to its temperature gradient. Its unit is ***watts/meter.kelvin***

2 **What do you mean by temperature gradient?**

The rate of change of temperature with respect to distance is known as temperature gradient

3 **How you define steady state temperature?**

If A & B are two points where in heat energy is flowing, then steady state is the point at which temperatures at points A & B becomes equal

4 **Name the poor conductor you have used in the experiment**

Cardboard sheet made of Cellulose

5 **What are the sources of errors in this experiment?**

1. Improper fixing of poor conductor between brass disk & metal drum & 2. Heating & Cooling environment should be same

6 **How to minimize the errors and improve the accuracy of the result**

1. Care should be taken to fix the cardboard sheet exactly in between the drums in such a way that the edges should not peed outside & 2. In order to maintain similar heating & cooling environment, fans should be kept off till the completion of the expt.

7 **What correction factor has been added for this experiment?**

(r + 2h)/(2r + 2h) is added in the formula to balance between heating & cooling environments

8 **Define specific heat capacity of a material with unit**

The amount of heat energy required to raise the temperature of the substance by one kelvin is specific heat capacity having unit J/Kg.K

9 **Does the value of thermal conductivity depend on the dimension of the specimen?**

No. For a given material the thermal conductivity is constant

10 **Can this method be used for good conductors?**

This method cannot be used for good conductors as T_1 & T_2 becomes almost equal

11 **Is there any reason to take the specimen in the form of a disc?**

For a disc the thickness is small whereas the cross-sectional area is large. Hence the amount of heat that is conducted is large.

EXPERIMENT 7 : K OF A GOOD CONDUCTOR (FORBE'S METHOD)

1 Define Thermal conductivity with unit

It is defined as the ratio of amount of heat conducted to its temperature gradient. Its is unit is watts/meter/kelvin

2 What do you mean by temperature gradient?

The rate of change of temperature with respect to distance is known as temperature gradient

3 How you define steady state temperature?

If A & B are two points where in heat energy is flowing, then steady state is the point at which temperatures at points A & B becomes equal

4 Name the good conductor you have used in this experiment

We have two sets of instruments which uses Alloy of brass and Alloy of iron

5 How to minimize the errors and improve the accuracy of the result

1. After heating good conductor one should not remove the soldering gun from the good conductor, instead heating should be just switched off & 2. Fans should be kept off till the completion of experiment to maintain uniform heating and cooling environment.

6 Mention some applications of this experiment

In selecting the material for heating coils, In identifying various heat sources & sinks

7 Define molar specific heat capacity of a material.

The amount of heat energy required to raise the temperature of one mole of the substance by one kelvin is known as molar specific heat capacity

8 Can this method be used for poor conductors?

No, it cannot be used for poor conductors as the setup is digital and uses temperature sensors

9 Can we say material with good thermal conductivity also has good electrical conductivity? Explain

Yes. This is according to Weidemann-Franz law

EXPERIMENT 8 : DIELECTRIC CONSTANT OF A CAPACITOR

1 **What is a dielectric material?**

It is an insulator. It has no free electrons for conduction. It can undergo polarization and an electric field can exist inside. Eg. Glass, wood, mica, water, paper, bakelite, teflon, etc.,

2 **How many types of dielectric materials are there? Explain with an example**

Polar dielectric : Here the positive and negative charge centers are separated with a distance, ex: H_2O, NH_3. Non polar dielectric : Here the positive and negative charge centers coicides with eachother, ex: Methane, Benzene

3 **Define dielectric constant or Relative permittivity**

It is defined as the ration of C/Co or the ability of the material to get polarised

4 **What is time constant?**

It is the time required for increasing the voltage of the capacitor to half of its maximum value during charging.OR It is the time required for decreasing the voltage of the capacitor to half of its maximum value during discharging and it is represented by $T_{1/2}$.

5 **Define dipolar polarization**

It can be defined as the dipole moment per unit volume having unit C/m^2

6 **Why the capacitance of the capacitor increases when a dielectric material is placed between parallel plate capacitor**

When dielectric is introduced between parallel plate, net field decreases (E = QV). This inturn decreases the net voltage. Hence capacitance increases according to the equation C = Q/V

7 **In what form is the energy stored in a capacitor?**

As electrostatic potential energy or electric potential energy of the charges.

8 **Is there any capacitor (conductor) which can take unlimited charge?**

Yes. The earth.

9 **What is an electric dipole?**

A pair of equal opposite charges separated by a small distance.

10 **What is dipole moment? Mention its unit**

Product of magnitude of either charge and the distance between the charges is dipole moment ($\mu = q\,l$). Its unit is C-m

11 What is the product RC called?

RC = t is called the time constant of the circuit. It decides the charging rate (fast / slow).

12 Why does a capacitor block DC and allow AC?

When a capacitor is connected across a DC source, electrons are pulled out from the positive plate and are transferred to the negative plate by the source. The pd between the plates starts increasing. During this stage there is a flow of current. As the pd across the plates becomes sufficient, the electrons on the negative plate start to repel the incoming electrons. When the pd across the plates becomes equal and opposite to that of source, there is no further flow of charges and hence capacitor blocks the direct current. But when an AC source is used, the capacitor is charged and discharged periodically. Thus a periodically varying current is maintained in the circuit.

13 Can we use an AC source to charge a capacitor?

No. Because, the direction of AC current alternates periodically. During one half cycle, the capacitor is charged to some level (The plates acquire +ve and –ve charges). In the next half cycle, the capacitor is discharged and recharged to the same level but oppositely (the same charges are pulled out from plates and opposite charges are added). Hence there no continuous accumulation of charges.

14 What is the role of the dielectric in the capacitor

When a capacitor with air between the plates is connected to a battery, it gets charged to the source voltage. Now, if a dielectric is introduced between its plates, it reduces the existing field. Hence pd between the plates drops. Then some more charges can be added to the plates to maintain the original pd. In other words, it takes some more charges at the same source voltage. Thus, its capacity increases.

15 To study charging or discharging, why do you plot voltage versus time instead of charge versus time?

The charge cannot be measured directly whereas the voltage can be measured. Since $V \alpha Q$, that is voltage is a measure of charge, we can conveniently plot V versus t.

EXPERIMENT 9 : ENERGY BAND GAP OF A SEMICONDUCTOR BY FOUR PROBES METHOD

1 **Why is Four-Probe method preferred over other conventional methods for measuring resistivity?**

In Four Probe Method, the voltage across the inner two probes at different temperatures is recorded. This voltage is an indication of resistance or resistivity only if V is proportional to R or I is constant. This is why a constant current source is necessary.

2 **How do the conductivities of metals and semiconductor depend on temperature?**

The conductivity of a semiconductor increases with increasing temperature while that of a metal decreases with increasing temperature.

3 **What is the equation giving the variation of conductivity/resistivity of a semiconductor with temperature?**

Resistivity: $\rho = \rho_0 \exp\{E_g/2kT\}$; $\sigma = \sigma_0 \exp\{E_g/2kT\}$

4 **Why we use a four point probe in comparison with two point probe?**

Four-point probe is preferred than two-point probe as the contact and spreading resistances in two point probe are large and the true resistivity cannot be actually separated from measured resistivity. In the four probe method, contact and spreading resistances are very low with voltage probes and hence accuracy in measurement is usually very high. To measure very low resistance values, four probe method is used. The resistance of probe will be not be added to that of sample being tested. It uses two wires to inject current in the resistance and another two wires to measure the drop against the resistance. Two Probe technique is suitable for measuring resistivity of high resistivity samples, e.g., polymer films/sheets.

5 **Define resistance and resistivity of a material.**

Resistance is the property of substance due to which it opposes the flow of electrons. However Resistivity is defined as the resistance of material having specific dimensions ($\rho = RA/L$)

6 **Define energy band gap**

It is defined as the energy required for an electron to jump from valence band to conduction band

7 Name some semiconductors with energy band gap values

Material	Energy gap (eV) 0K
Si	1.17
Ge	0.74
InSb	0.23
InAs	0.43
InP	1.42
GaP	2.32
GaAs	1.52
GaSb	0.81
CdSe	1.84
CdTe	1.61
ZnO	3.44
ZnS	3.91

8 What is a semiconductor ?

It is a substance with conduction properties between metals and insulators.

9 What is meant by intrinsic semiconductor ?

A pure semiconductor completely free from impurities is called intrinsic semiconductor.

10 What do you mean by an extrinsic semiconductor ?

It is a semiconductor to which an impurity from group 13 or group 15 has been added.

11 What are the charge carriers in a pure semiconductor.

A pure semiconductor has electrons and holes as charge carriers. Their number densities are equal.

12 What is the effect of temperature on conductivity of a semiconductor ?

It increases with rise in temperature.

13 Why conductivity of metals decreases with increase in temperature?

However, when we increase the temperature the vibrational motion of electrons increases and thus cause unwanted collisions which results in the increase of resistance in metals. Therefore, **the mobility of electrons decreases** and causes decrease in conductivity.

14 Why conductivity of a semiconductor increases with increase in temperature

When temperature is increased in case of a semiconductor the **free electron gets more energy to cross the energy gap to the conduction band from the valence band**.so now more electrons can go easily to the conduction band so resistance decreases with temperature.

15 Where does the Fermi level exist for intrinsic semiconductor

In intrinsic or pure semiconductor, the number of holes in valence band is equal to the number of electrons in the conduction band. Hence, the probability of occupation of energy levels in conduction band and valence band are equal. Therefore, the Fermi level for the intrinsic semiconductor lies in the middle of forbidden band.

16 For a semiconductor what kind of trend a graph of log R vs (1/T) will be

Straight line trend with positive slope

EXPERIMENT 10 : SERIES AND PARALLEL RESONANCE IN LCR CIRCUITS

1 **What is an inductor?**
An inductor is a passive circuit component which stores energy in its magnetic field.

2 **What is impedance?**
The opposition offered to the flow of AC by an element or a circuit.

3 **What is capacitive reactance?**
The opposition offered by a capacitor to AC. $X_C = 1/2\pi f C$

4 **What is a series resonance circuit?**
A circuit containing an inductor, a capacitor and a resistor in series with an AC source.

5 **When does the resonance occur in LCR circuit?**
When the inductive reactance matches with the capacitive reactance.

6 **What is resonant frequency?**
The frequency at which inductive reactance matches with the capacitive reactance.

7 **What is quality factor?**
Ratio of resonance frequency to the band width

8 **What are the uses of an LCR circuit?**
In radio and TV receivers to select a particular station (frequency)
In communication devices like RADARs, etc.

9 **Why is the LCR resonance series circuit called acceptor circuit?**
When a number of signals of different frequencies are fed to an LCR series circuit, it accepts only that signal whose frequency matches with resonance frequency of the circuit.

10 **What is the importance of series resonance circuits?**
For high frequency A.C in radio communications, a series resonance circuit is used. LCR circuits are used in frequency filter circuits like high pass filter, low pass filter and band pass filter.

11 **Why is the LCR resonance parallel circuit called rejecter circuit?**
When a number of signals of different frequencies are fed to an LCR parallel circuit, it rejects only that signal whose frequency matches with resonance frequency of the circuit.

12 What is bandwidth?

It is the difference between the lower half power frequency and the upper half power frequency. That is BW = $f_1 - f_2$.

13 What is inductive reactance in an AC circuit?

The opposition offered to flow of AC by an inductor is called the inductive reactance, $X_L = 2\pi fL$. Where f is the frequency of AC supply in hertz and L is the inductance.

14 What is capacitive reactance in an AC circuit?

The opposition offered to flow of AC by a capacitor is called the capacitive reactance, $X_C = 1/2\pi fC$, where C is capacitance in farad and f is the frequency.

15 If the frequency of the AC source in a series LCR circuit is increased, how does the current in the circuit change?

With the increase in frequency, the current in a series LCR circuit undergoes a series of changes, that is the current first increases, attain a maximum value ($f = f_r$) and then decreases.

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