DEPARTMENT OF PHYSICS

RV COLLEGE OF ENGINEERING®

(AUTONOMOUS INSTITUTION AFFILIATED TO VTU, BELAGAVI)

ENGINEERING PHYSICS

PRACTICAL FILE

COURSE CODE: 21PH12/22

2021-22

For the First / Second Semester B.E

Name of the student	
Section, Batch	
Program	
Roll No. / USN	
Faculty In-charge	**1.**
	2.

DEPARTMENT OF PHYSICS

VISION

TO ENABLE ENGINEERING GRADUATES TO UNDERSTAND, LEVERAGE AND APPRECIATE THE ROLE OF PHYSICS FOR THE DEVELOPMENT OF SUSTAINABLE AND INCLUSIVE TECHNOLOGY.

MISSION

- EDUCATES THE STUDENTS WITH A PROGRAM CHARACTERIZED BY ART OF TEACHING WITH EXPERIMENTING SKILLS, PROJECT WORK/SEMINAR, SELF STUDY, EFFECTIVE COUNSELING AND AN ACTIVE INVOLVEMENT OF STUDENTS IN THEIR EXPERIENTIAL LEARNING.
- IMBIBE INQUISITIVENESS IN STUDENTS TO USE PHYSICS FOR ENGINEERING INNOVATION.
- EMPOWER THE FACULTY AND STUDENTS TO INVOLVE IN RESEARCH AND TO DEVELOP THE DEPARTMENT AS A KEY FACILITATOR FOR R&D TO ALL ENGINEERING PROGRAMS.

RV COLLEGE OF ENGINEERING®

(An Autonomous Institution, Affiliated to V.T.U, Belagavi)

Mysuru Road, Bengaluru – 560059

DEPARTMENT OF PHYSICS

CERTIFICATE

This is to certify that Mr./Ms.……………………………………………….... has satisfactorily completed the course of experiments in **Engineering Physics practical** prescribed by the department of Physics for the I/II semester of BE graduate programme during the year 2021 - 2022.

Signature of Head of the Department
Date

Signature of the
faculty in-charge

50

Name of the Candidate……………………………

Roll / U.S.N No……………………………………

PHYSICS FACULTY

Sl. No.	Name	Designation	Initials
01	Dr. Sudha Kamath M K	Associate Prof. & Head	SKMK
02	Dr. Bhuvaneswara Babu T	Professor	TBB
03	Dr. Avadhani D N	Associate Professor	DNA
04	Dr. Shireesha G	Associate Professor	GHS
05	Dr. Shubha S	Assistant Professor	SHBS
06	Dr. Tribikram Gupta	Assistant Professor	TG
07	Dr. Rajesh B M	Assistant Professor	BMR
08	Dr. Ramya P	Assistant Professor	RAP
09	Dr. Karthik Shastry	Assistant Professor	KAS

STAFF

Sl. No.	Name	Designation	Initials
01	Eswarachari C	Assistant Instructor	EC
02	Satheesha KS	Attender	SKS
03	Shobha B	Peon	SB

INDEX

Course Outcomes: After completing the course, the students will be bale to	
CO1	Understand the basic principles of oscillator, elastic properties of materials, quantum mechanics, electrical properties of metals & semiconductors, dielectric properties of materials and behavior of charged particles in electric and magnetic field.
CO2	Apply the Physics principles to solve Engineering problems in elasticity, oscillation, applied optics, and semiconductors.
CO3	Analyze and solve complex problems using critical thinking.
CO4	Design and development of models by simulation using open-source tools and validate with real time experimentation.

CO mapping for Engineering Physics (21PH12/22) lab experiments

S.No	Experiments	CO1	CO2	CO3
1.	Single Cantilever	✓	✓	✓
2.	Torsional Pendulum	✓	✓	✓
3.	Energy band gap of a Thermistor	✓	✓	✓
4.	Spring Constant	✓	✓	✓
5.	Dielectric constant	✓	✓	✓
6.	Hall Effect	✓	✓	✓
7.	Numerical Aperture and Loss in Optical Fiber	✓	✓	✓
8.	Laser Diffraction	✓	✓	✓
9.	Fermi Energy of Copper	✓	✓	✓
10.	Verification of Stefan's law	✓	✓	✓

SCHEME OF EVALUATION:

Particulars	Course Outcomes	Marks
Data sheet + Experimental Set up	CO1	4+6
Conduction of Experiment	CO2	10
Substitution, Calculation & Accuracy	CO3	05
Lab Internal	CO1- CO3	05
Experiential Learning (15+05)	CO4	20
Total Marks		50

MARKS SHEET

Name :   Sec/Batch :   USN/Roll No :

SI.NO	SET NO.	LIST OF EXPERIMENTS	PAGE NO	DATE (EXPT SUBMITTED)	MARKS OBTAINED
1.	I	Single Cantilever			
2.		Energy band gap of a Thermistor			
3.	II	Torsional Pendulum			
4.		Laser Diffraction			
5.	III	Spring Constant			
6.		Hall Effect			
7.	IV	Numerical Aperture and Loss in Optical Fiber			
8.		Dielectric constant			
9.	V	Fermi Energy of Copper			
10.		Verification of Stefan's law			
11.		Average Marks			/25
12.	VI	Experiential Learning			/15
		Internal Marks			/5+5
		Total Marks			/50
		Signature of the faculty			

GENERAL INSTRUCTIONS TO STUDENTS

1. Scan the QR code in each experiment to watch the video tutorial and come prepare to the class.
2. Lab batches will be allotted at the beginning of the semester. Students will have to perform two experiments in one lab.

3. Every student has to perform the one/two experiments whichever is allotted to him /her, no change of experiments will be entertained.

4. While attending every laboratory session the student must bring the data sheets pertaining to the experiments.

5. **The data sheet must contain entries like *aim of the experiment, apparatus required, circuit diagram or the diagram of the experimental setup, tabular columns*, the necessary formulae of the experiments as given in the left hand side pages in the practical file.**

6. Separate data sheets should be prepared for each experiment. *The procedure and principle of the experiment must be read by the student before coming to the laboratory and it should not be written on the data sheets.*

7. All calculations pertaining to the two experiments should be completed in the laboratory. *The results must be shown to the batch teacher and must obtain the exit signature from batch teacher before he or she leaves the laboratory.*

8. Entries of observations should be made in data sheets only with pen.

9. Substitutions and calculations should be shown explicitly in the data sheet and the practical file.

10. Submission of practical file along with necessary data sheets (to be pasted to the particular experiment once readings are transferred to practical file) in every lab session for evaluation.

11. In the event the student is unable to complete the calculations in the regular lab session, with the permission of the lab in-charge, the student should complete calculations, transfer the readings to practical file and submit for the evaluation in the next lab session.(In case of any difficulty in calculation the student can consult the batch teacher within two working days).

12. Mobile phones are not allowed to the lab. The student should wear lab coat and also bring his/her own calculator, pen, pencil, eraser, etc.

13. The experiments are to be performed by the students in the given cyclic order. This will be made clear to the student in the instructions class. If for some reason a student is absent for a practical lab session then the student must move on to the next set in the subsequent lab session. The experiment, that he or she has missed, will have to be performed by him or her in the repetition lab.

14. ***Please remember that practical file is evaluated during regular lab session. Therefore it is imperative that each student takes care to see that the experiments are well conducted, recorded and submitted for valuation regularly.***

15. There will be a continuous internal evaluation (CIE) in the laboratory. An internal test will be conducted at the end of the semester. The internal assessment marks are for a maximum of 50 marks.

16. The semester end examination (SEE) of the lab will be conducted for 50 marks.

Note: Stamp of rubrics for evaluation on the first page of data sheet is mandatory for each Experiment.

RUBRICS FOR EVALUATION

Particulars	**Course Outcomes**	**Maximum Marks**	**Excellent**	**Very Good**	**Good**	**Satisfactory**
Data sheet + Experimental Set up	CO1	10	10	8	6	4
Conduction of Experiment	CO2	10	10	8	6	4
Substitution, Calculation & Accuracy	CO3	5	5	4	3	2
Experiential Learning	CO4	15	15	12	10	8

All students are strictly adhere to the Do's and Don'ts in the laboratory:

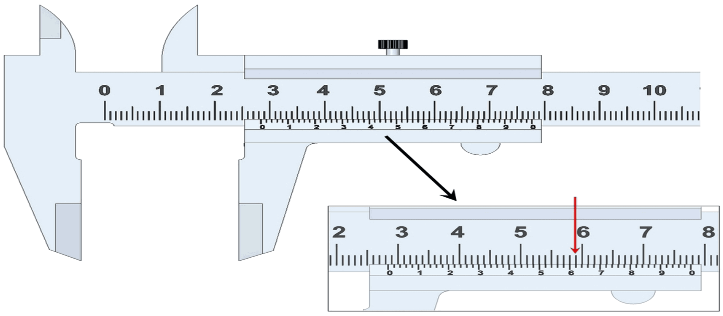
✓ **Do's**	× **Don'ts**
✓ Come prepared to the lab. ✓ Wear lab coat in the lab. ✓ Maintain discipline in the lab. ✓ Handle the apparatus with care. ✓ Confine to your table while doing the experiment. ✓ Return the apparatus after completing the experiment. ✓ Switch off the power supply after completing the experiment ✓ Switch off the electrical circuit breaker if there is burning of insulation. ✓ Utilize the First Aid box in emergency situation. ✓ Keep the lab clean and neat.	× Come late to the lab and leave the lab early. × Carry mobile phones to the lab × Touch un-insulated electrical wires. × Use switch if broken. × Overload the electrical meters. × Talk with other students in the lab. × Make the circuit connection when the power supply is on.

MEASUREMENTS

To conduct various experiments in the Physics Laboratory, we need to learn measurement of dimensions and other physical quantities using instruments. Measurements of various dimensions of object using Vernier Calipers, Screw gauge, Multi metre etc are discussed here.

Vernier Callipers

Vernier Callipers is used to measure dimensions like length, breadth, diameter of solid and hollow etc accurately.



Least count of vernier calipers

The vernier caliper has two scales – main scale and vernier scale. The main scale is graduated in cm while the vernier scale has no units. The vernier scale is not marked with numerals, what is shown above is for the clarity only.

Least count (LC) of the vernier calipers is the ratio of the value of 1 main scale division (MSD) to the total number of vernier scale divisions (VSD).

Example:

Value of 10 main scale divisions (MSDs) = 1cm
Value of 1 MSD = 0.1cm
Total number of VSD = 10 Therefore LC = 0.1cm/10 =0.01cm

To take readings using the calipers

(1) First see if the 0 of the vernier scale coincides with a main scale reading. If it coincides then the reading at the zero of the vernier is the main scale reading (MSR).
(2) **If the 0 of the vernier scale does not coincide with any main scale division then the division just behind the zero of the vernier is the main scale reading (MSR).**
(3) Then see which **vernier division** coincides with **a main scale division**. This division of the **vernier scale** is noted as the coinciding vernier scale division (CVD).
(4) The total reading is given by TR = MSR + VSR, TR = MSR + (CVD x LC)

Example:

If MSR = 1cm, CVD = 6, then TR = MSR + (CVD x LC) = 1cm + (6 x 0.01) cm = 1.06cm

Screw gauge:

Screw gauge is used to find the dimensions of small objects and it has a pitch scale and a head scale. The pitch scale is graduated in mm while the head scale has no units.

The least count for this type of instruments is given by

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

The pitch of the screw gauge is the distance moved on the pitch scale for one complete rotation of the head. To find pitch give some known number of rotations to the pitch scale and note the distance moved by the head scale.

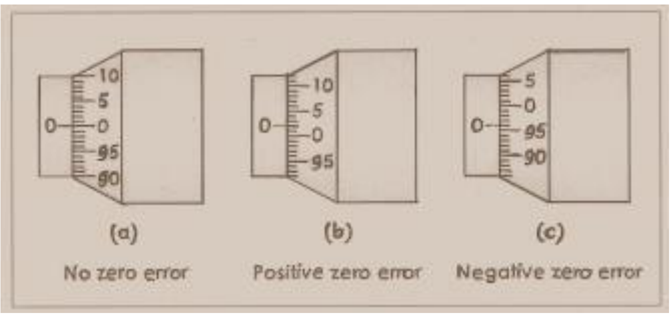
Pitch = distance moved on the pitch scale /No. of rotations given to head scale

Usually the pitch is 1mm, the head scale is divided into 100 divisions.

LC = pitch /No. of head scale divisions = 1/100 mm =0.01mm

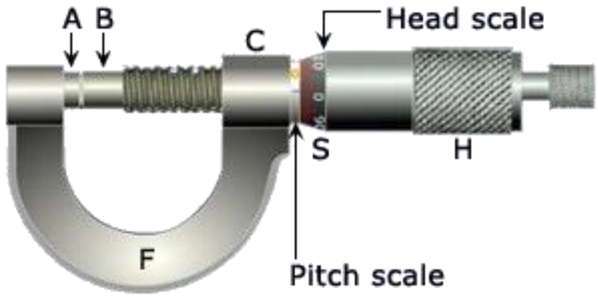
In the screw gauge the head is rotated until the plane faces of metal plug A and screw head B touch each other. If the pitch scale reading is zero and the zero of the head scale coincides with the pitch line then there is no zero error, otherwise there is a zero error(ZE). Determination of zero error is shown in the following figure.

If the pitch line is in the positive side of the HS then ZE is +ve
If the pitch line is in the negative side of the HS then ZE is –ve



(a) No zero error (b) Positive zero error (c) Negative zero error

ZE = 0 ZE = +2 ZE = -4



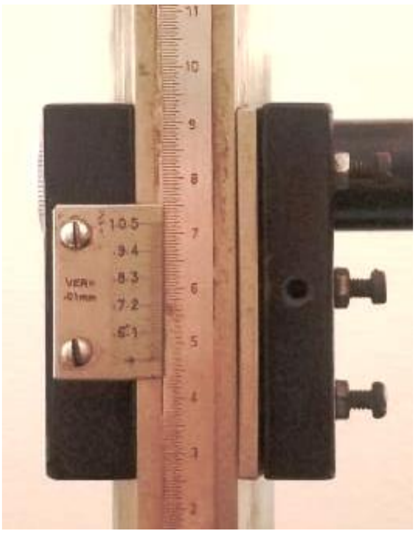
Pitch scale reading PSR : The reading on the pitch scale, at the edge of the head scale or behind the edge of the head scale.

Head scale reading HSR : The reading on the head scale that coinciding with the pitch line i.e horizontal line on the pitch scale or below the pitch line

The total reading is calculated using the formula: **TR=PSR+{(HSD - ZE)×LC} mm**

Travelling Microscope

Least count of the traveling microscope (T.M)
The scales on the travelling microscope are similar to those in vernier callipers. The difference being that the value of 1 main scale reading is 0.05cm and the number of divisions on the vernier is 50.



Value of 1msd = 1cm/20 = 0.05cm

Number of VSDs = 50.

The least count (LC) of the instrument = 1MSD / Total number of vernier scale divisions

L.C = 0.05cm/50 = 0.001cm.

The procedure for taking readings is the same as for vernier callipers.

(1) First see if the 0 of the vernier scale coincides with a main scale reading. If it coincides then take it as the main scale reading (MSR).
(2) **If the 0 of the vernier scale does not coincide with any main scale division then the division just behind the zero of the vernier is the main scale reading (MSR).**
(3) Then see which **vernier division** coincides with **a main scale reading**. This division of the **vernier scale** is noted as the coinciding vernier scale division (CVD).
(4) The total reading is given by TR = MSR + VSR, TR = MSR + (CVD x LC)

Example:
If MSR = 1.05cm, CVD = 19, then TR = MSR + (CVD x LC) = 1.05 + (19 x 0.001) = 1.069cm

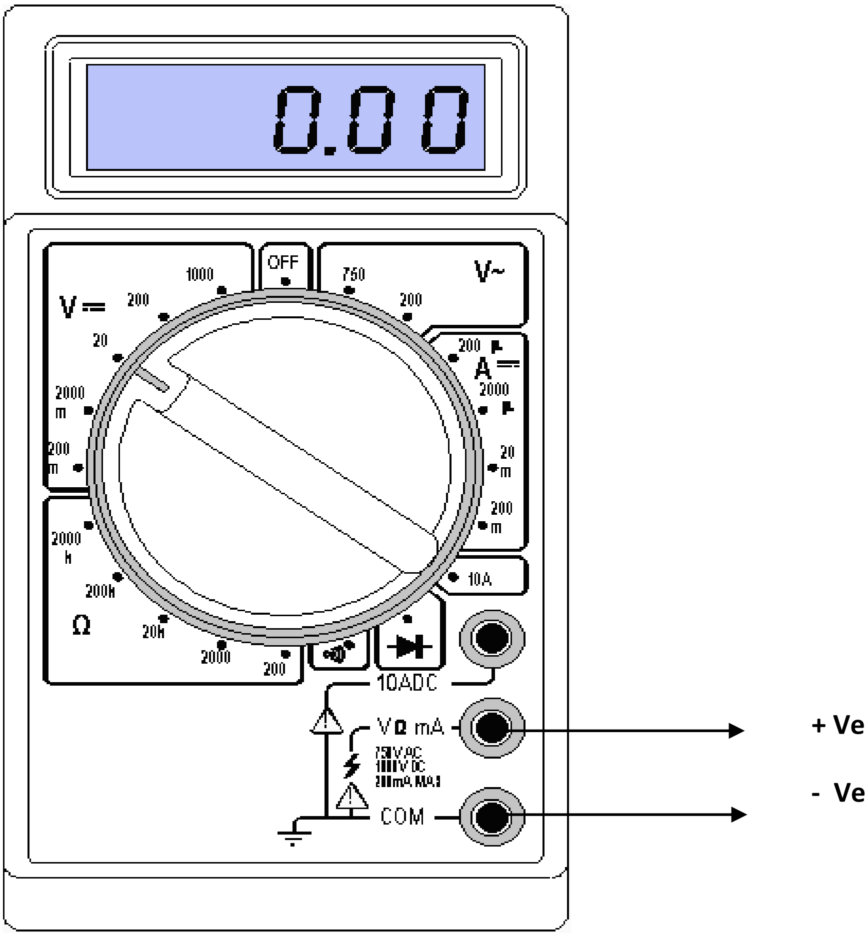
NOTE. Ignore the numbering on the vernier scale and read the divisions from 0 to 50

Multi meter:

A multi meter is an instrument with many meters like ammeters, voltmeters (both AC and DC), ohmmeters etc., of various ranges built into it. By conveniently switching the rotatable knob of the multi meter, we can choose the electrical meter required for a particular measurement.

Note;

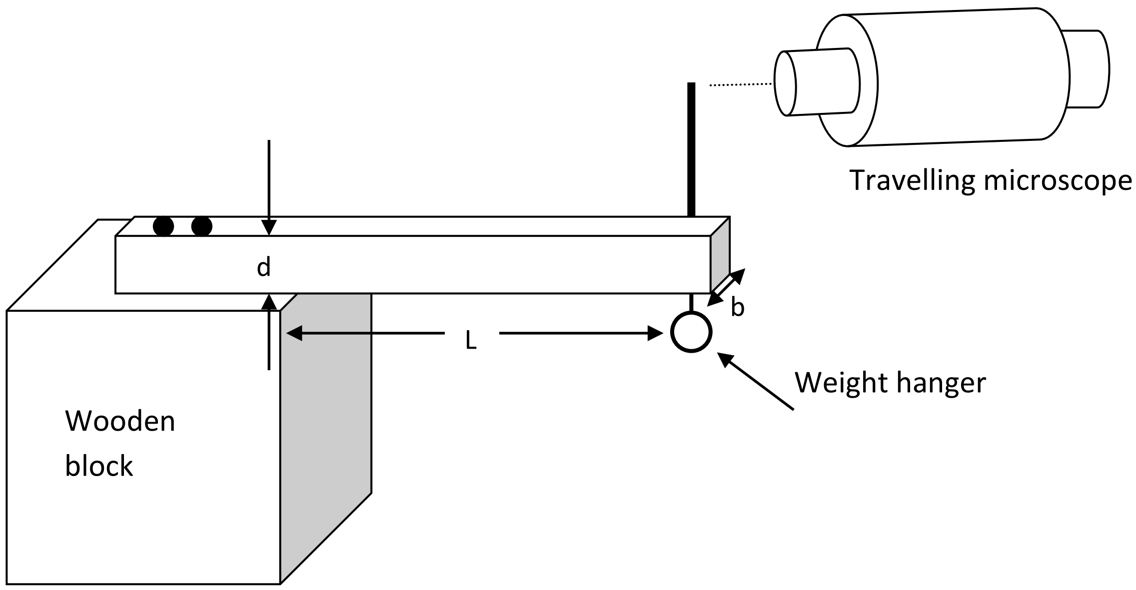
1. On the display if there is a numeral 1 at the extreme left the measured quantity is more than the maximum of the meter, move rotate the knob to the higher range .
2. If the display shows BAT the battery is low in power, ask for a different multi meter.



SINGLE CANTILEVER

OBSERVATIONS:

Experimental Setup:



Formula:

The Young's modulus of the material of the cantilever is calculated using the formula;

$$q = \frac{4mgL^3}{bd^3\delta_{mean}} \quad Nm^{-2}$$

Where, m = mass for which depression produced is 0.04 kg (40 gm),

L is the length of the cantilever in metre

b is the breadth of the cantilever in metre

d is the thickness of the cantilevering metre

δ is the mean depression for 40g in metre

g is the acceleration due to gravity = 9.8 m/s

Least count of the travelling microscope

$$L.C = \frac{\text{Value of 1 main scale division}}{\text{Total number of vertical scale divisions}} = \_\_\_ = \_\_\_\_\_ \text{c m}$$

Paste the data sheets here

SINGLE CANTILEVER

Experiment No: Date:

Aim: To determine the Young’s modulus of the material of the given metal strip.

Apparatus: Thick rectangular metallic strip (cantilever), slotted weights with hanger, travelling microscope, screw gauge, Vernier callipers and metre scale etc.

Principle: Young's modulus, which is one of the elastic constants, is defined as the ratio of longitudinal stress to the longitudinal strain within elastic limit. For a given strip, the depression produced at the loaded end of the cantilever depends on the load and on the distance from the fixed end. This is measured to calculate the Young's modulus (q) of the material.

Formula:

The Young’s modulus of the material of the cantilever is calculated using the formula;

$$q = \frac{4mgL^3}{bd^3\delta_{mean}} \quad Nm^{-2}$$

Where, m = mass for which depression produced is 0.04 kg (40 gm),

L is the length of the cantilever in metre

b is the breadth of the cantilever in metre

d is the thickness of the cantilevering metre

δ is the mean depression for 40g in metre

g is the acceleration due to gravity = 9.8 m/s

Procedure:

- Suspend the weight hanger with mass W, at the bottom of the free end of the metallic strip (into a metal loop fixed below the pin).
- Adjust the vertical traverse of travelling microscope to focus the tip of the pin with the horizontal cross wire or the point of the intersection of cross wires.
- Note down the reading of the travelling microscope on the vertical scale when the load is W in table 1.
- Now add a mass of 10 g to the weight hanger and adjust the travelling microscope using the fine motion screw (vertical motion) to focus the tip of the pin with the point of intersection of cross wires. Note down the travelling microscope reading (for a load of W+10).

Paste the data sheets here

Table 1: Travelling microscope readings for the load increasing.

Load (g)	MSR(cm)	CVD	TR= MSR + (CVD x LC) (cm)
W			
W + 10			
W + 20			
W + 30			
W + 40			
W + 50			
W + 60			
W + 70			

Table 2: Travelling microscope readings for the load decreasing.

Load (g)	MSR(cm)	CVD	TR= MSR + (CVD x LC) (cm)
W + 70			
W + 60			
W + 50			
W + 40			
W + 30			
W + 20			
W + 10			
W			

Table 3: Mean depression and depression for a load of 40g (difference column)

Load (g)	TM reading (cm)		Mean TMR $R_L = (R_1 + R_2)/2$	Load (g)	TM readings (cm)		Mean TMR $R_R = (R_3 + R_4)/2$	Depression δ for 40g ($\delta = R_L \sim R_R$) cm
	Load increasing R_1	Load Decreasing R_2			Load Increasing R_3	Load decreasing R_4		
W				W + 40				
W + 10				W + 50				
W + 20				W + 60				
W + 30				W + 70				

Mean depression for a load of 40 g = δ = ___________ cm.

- Repeat the procedure by increasing the load in the weight hanger in steps of 10g up to a maximum load of W+70.

- Repeat the same by decreasing the load in steps of 10g and note down the readings for W+70, W+60 up to W and enter the readings in table 2.

- Tabulate the readings of increasing and decreasing loads in table 3. Compute the mean value of the reading corresponding to each load and find the depression 'δ' for a load of 40 g (m) by a difference column method.

- Measure the length 'L' of the cantilever from the edge of the wooden block to the position of the pin using a metre scale.

- Determine the breadth 'b' of the cantilever using vernier callipers at four different places on the metal strip and calculate the mean breadth.

- Determine the thickness 'd' of the cantilever using screw gauge at four different places on the metal strip and find the mean thickness.

- Compute the Young's modulus of the material of the cantilever by substituting the values of m, L, b, d and δ in the given formula.

Note:

1. Level the travelling microscope using a spirit level.
2. Once you start the experiment do not shake or lean on the table, as this will disturb the focusing and affect the reading.
3. Add/ remove the weights gently on to/from the weight hanger
4. While performing the experiment care is to be taken to rotate the fine motion screw in only one direction so as to avoid backlash error.

Paste the data sheets here

Length of the cantilever, L = ____________ cm.

Table 4: Breadth of the cantilever using vernier callipers

$$L.C = \frac{\text{Value of 1 main scale division}}{\text{Total number of vernier scale divisions}} = \frac{\_\_\_}{\_\_\_} = \_\_\_\_\_ \text{cm}$$

Trial No.	MSR(cm)	CVD	TR = MSR + (CVD x LC) (cm)
1			
2			
3			
4			

Mean Breadth b =__________cm

Table 5: Thickness (d) of the cantilever using screw gauge.

Least Count of Screw Gauge:

$$\text{Pitch} = \frac{\text{Distance moved on the pitch scale}}{\text{Total number of rotations given to screwhead}} = \frac{\_\_\_}{\_\_\_} = \_\_\_\_\_ \text{mm}$$

$$L.C = \frac{\text{Pitch of the screw gauge}}{\text{Total number of head scale divisions}} = \frac{\_\_\_}{\_\_\_} = \_\_\_\_ \text{mm}$$

Zero error (ZE) =

Trial No.	PSR(mm)	HSD	TR= PSR + (HSD- ZE)LC (mm)
1			
2			
3			
4			

Mean thickness, d = __________mm

Result: Young's modulus of the given material is found to be ____________ N m^{-2}

CALCULATIONS:

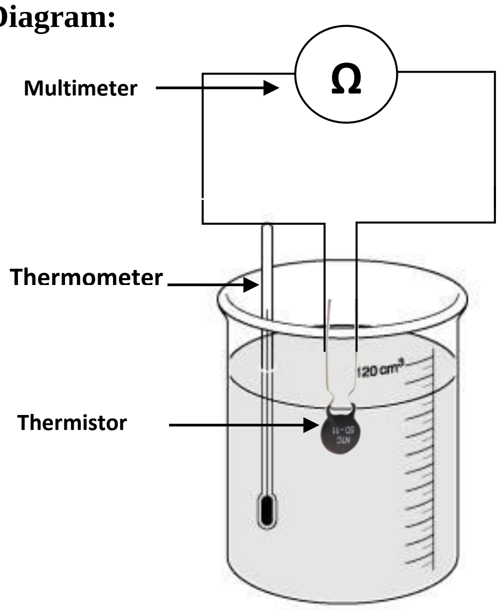
Result: Young’s modulus of the given material is found to be ____________ N m^{-2}

Paste the data sheets here

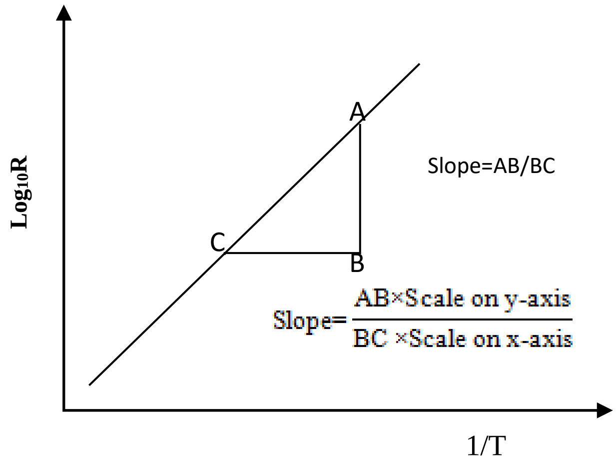
BANDGAP OF A THERMISTOR

OBSERVATIONS:

Diagram:



Model Graph:



Formula: $E_g = \frac{4.606 \times k \times m}{1.6 \times 10^{-19}}$ eV

Where E_g = Energy gap of a given thermistor in eV

k = Boltzmann constant = 1.381×10^{-23} J/K

m = Slope of the graph

Table:

Sl. No	**Temp t°C**	**Temp T(K)**	**R (Ω)**	**Log R**	**1/T**
1.	Room Temp				
2.					
3.					
4.					
5.					
6.					
7.					
.					
.					
.					

CALCULATIONS:

Result: The energy gap (band gap) of the given thermistor is __________eV.

BANDGAP OF A THERMISTOR

Experiment No: Date:

Aim: To determine the energy gap (E_g) of a Thermistor.

Apparatus and other materials required: Glass beaker, Thermistor, Multi meter, Thermometer.

Principle: A thermistor is a thermally sensitive resistor. Thermistor's are made of semiconducting materials such as oxides of Nickel, Cobalt, Manganese and Zinc. They are available in the form of beads, rods and discs.

The variation of resistance of thermistor is given by $R = a e^{\frac{b}{T}}$ where 'a' and 'b' are constants for a given thermistor. The resistance of thermistor decreases exponentially with rise in temperature. At absolute zero all the electrons in the thermistor are in valence band and conduction band is empty. As the temperature increases electrons jump to conduction band and the conductivity increases and hence resistance decreases. By measuring the resistance of thermistor at different temperatures the energy gap is determined.

Formula: $E_g = \frac{4.606 \times k \times m}{1.6 \times 10^{-19}} eV$

Where E_g = Energy gap of a given thermistor in eV.

k = Boltzmann constant = 1.381×10^{-23} J/K .

m = Slope of the graph.

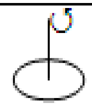
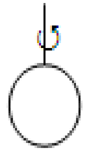
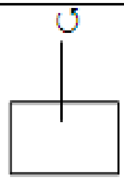
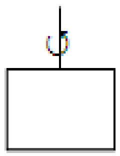
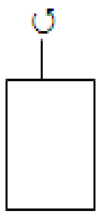
Procedure:

- Make the circuit connection as shown in the figure.
- Keep the multi meter in resistance mode (200 Ω range).
- Insert the thermometer in a beaker containing thermistor and note down the resistance at room temperature.
- Immerse the thermistor in hot water at about 90°C.
- Note down the resistance of the thermistor for every decrement of 2°Cupto60°C.
- Plot the graph of log R versus 1/T and calculate the slope 'm'.
- Calculate the energy gap of a given thermistor using relevant formula.

Result: The energy gap (band gap) of the given thermistor is __________eV.

Paste the data sheets here

TORSION PENDULUM – OBSERVATIONS

Body	M (Kg)	Dimension (m)	Axis	Moment of Inertia I (Kgm^2)	Time for 10 osc. (s)	Mean time 't' for 10 oscillation. (s)	Period T=t/10 (s)	$\frac{I}{T^2}$ (Kgm^2s^{-2})
Circular plate		Radius =		$I_1 = \frac{MR^2}{2}$ =	1. 2. 3.		T_1 =	$\frac{I_1}{T_1^2}$ =
				$I_2 = \frac{MR^2}{4}$ =	1. 2. 3.		T_2 =	$\frac{I_2}{T_2^2}$ =
Rectangular plate		Length, L =		$I_3 = \frac{M(L^2+B^2)}{12}$ =	1. 2. 3.		T_3 =	$\frac{I_3}{T_3^2}$ =
				$I_4 = \frac{ML^2}{12}$ =	1. 2. 3.		T_4 =	$\frac{I_4}{T_4^2}$
		Breadth, B =		$I_5 = \frac{MB^2}{12}$ =	1. 2. 3.		T_5 =	$\frac{I_5}{T_5^2}$

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

TORSION PENDULUM

Experiment No: Date:

Aim: To determine the moment of inertia of the given irregular body and Rigidity modulus of the material of the give wire.

Apparatus and other materials required: Rectangular, circular and irregularly shaped plates, steel or brass wire, chuck nuts, stop clock, pointer, metre scale, Screw gauge weight box.

Principle:

Torsion pendulum is an angular harmonic oscillation. Moment of Inertia of a body is the reluctance to change its state of rest or uniform circular motion. A body whose moment of inertia I about an axis is known, is made to oscillate about the same axis, corresponding period T is noted. The ratio $\frac{I}{T^2}$ is a constant for different bodies and different axes **as long as the dimension of the suspension wire remains the same.** For a torsion pendulum $T=2\pi\sqrt{\frac{I}{C}}$ where C is the couple per unit twist of the wire and it is a constant. Hence, $I/T^2=C/4\pi^2$ is a constant and $C= 8\pi nr^4/2L$

Formula:

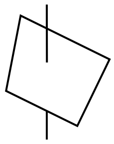
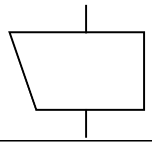
(a) Moment of inertia of irregular body about the axis through the CG and perpendicular to its plane, I'

$$I_\alpha = \left(\frac{I}{T^2}\right)_{mean} \times T_\alpha^2 = \_\_\_\_\_\_\_\_\_\_ \text{ Kgm}^2$$

(b) Moment of inertia of the irregular body about the axis through the CG and parallel to its plane

$$I_\beta = \left(\frac{I}{T^2}\right)_{mean} \times T_\beta^2 = \_\_\_\_\_\_\_\_\_\_ \text{ Kgm}^2$$

(c) Rigidity modulus $n=\left(\frac{8\pi L}{r^4}\right)\left(\frac{I}{T^2}\right)$ where r is the radius and L is the length of the wire.

Axis through CG	Time for 10 sec. (s)	Mean time(t) for 10 oscillations in s	Period T=t/10 s
	1. 2. 3.		T_α =
	1. 2. 3.		T_β =

Determination of Moment of Inertia of Irregular body

Formulae:

(a) Moment of inertia of irregular body about the axis through the CG and perpendicular to its plane, I'

$$I_\alpha = \left(\frac{I}{T^2}\right)_{mean} \times T_\alpha^2 \quad Kgm^2$$

(b) Moment of inertia of the irregular body about the axis through the CG and parallel to its plane

$$I_\beta = \left(\frac{I}{T^2}\right)_{mean} \times T_\beta^2 \quad Kgm^2$$

Determination of rigidity modulus of the material of the wire

Radius of the wire (r) using screw gauge.

$$\text{Pitch} = \frac{\text{Distance moved on the pitch scale}}{\text{Total number of rotations given to screwhead}} = \frac{\quad}{\quad} = \_\_\_\_\_ \text{mm}$$

$$\text{L.C} = \frac{\text{Pitch of the screw gauge}}{\text{Total number of head scale divisions}} = \frac{\quad}{\quad} = \_\_\_\_ \text{mm}$$

Zero error (ZE) = ______.

Paste the data sheets here

Procedure:

- Measure the dimensions of the given circular and rectangular discs.
- Clamp one end of the wire through the chuck nut to a regular disc and other end to the top end of the retard stand.
- Twist the wire through a small angle and then let free so that the body executes torsional oscillations **(The oscillations should be in a horizontal plane. Arrest the side ward movement or wobbling if any)**.
- For each configuration of the pendulum, note down the time taken for 10 oscillations and repeat the process thrice. Tabulate this in table 1.
- Calculate mean time (t) for 10 oscillations and hence the time period T then find $\frac{I}{T^2}$ for each axis.
- Follow the same procedure for two different axes of the irregular body, determine the average period of oscillation for two different axes and tabulate values in table 2.
- Find out the moment of inertia of irregular body using given formulae.
- Measure the diameter of the wire using screw gauge and enter the readings in the tabular column.
- Calculate the average diameter and radius of the wire.
- Measure the length L of the wire between the check nuts.
- Calculate the rigidity modulus of the material of the wire using the given formula.

Trial No.	PSR(mm)	HSD	TR= PSR + (HSD- ZE)LC (mm)
1			
2			
3			
4			

Mean diameter of the wire, d = ________mm ____________ m

Mean Radius of the wire, r =__________m

Length of the wire, L = __________m

Rigidity modulus $n=\left(\frac{8\pi L}{r^4}\right)\left(\frac{I}{T^2}\right)$

Result:

1. The moment of inertia of irregular body about an axis perpendicular to the plane I_α =______Kgm^2.

2. The moment of inertia of irregular body about an axis parallel to the plane

   I_β =______Kgm^2.

3. Rigidity modulus of the material of the wire 'n' =_________N/m^2

Paste the data sheets here

CALCULATIONS:

Result:

1. The moment of inertia of irregular body about an axis perpendicular to the plane
   I_α =______Kgm^2.

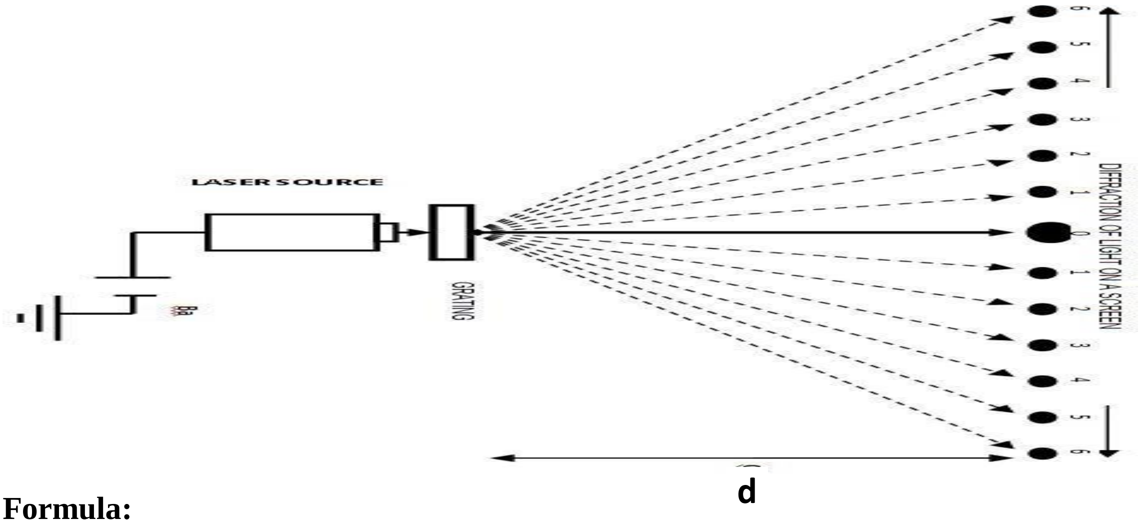
2. The moment of inertia of irregular body about an axis parallel to the plane
   I_β =______Kgm^2.

3. Rigidity modulus of the material of the wire ‘n’ =_________N/m^2

LASER DIFFRACTION

OBSERVATIONS:

Diagram:



Formula:

Wavelength of Laser source $\lambda = \dfrac{\mathbf{C \sin\theta_n}}{\mathbf{n}}$ ……. m

Where C is the grating constant, n is the order of the maximum, θ is the angle of diffraction

Grating Constant: $C = \dfrac{1\,\text{inch}}{\text{No. of lines (N) per inch}} = \dfrac{2.54\times10^{-2}\,m}{500} = 5.08\times10^{-5}\,\text{m}$

Distance between the grating and the screen, d = ________m

Table:

Diffraction order (n)	Distance $2X_n$(cm)	Distance X_n(cm)	Diffraction angle (θ_n) $\theta_n = \tan^{-1}\left(\frac{X_n}{d}\right)$	Wavelength λ (nm) $\lambda = \frac{C \sin\theta_n}{n}$
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

CALCULATIONS:

Result: The wavelength of laser light is found to be…………………………….nm

Paste the data sheets here

LASER DIFFRACTION

Experiment No: Date:

Aim: To determine the wavelength of a given laser beam

Apparatus and other required materials:
Laser source, Grating, Optical bench with accessories and metre scale etc.,

Principle: laser is a device, which gives a strong beam of coherent photons by stimulated emissions. The laser beam is highly monochromatic, coherent, directional and intense. The directionality of a laser beam is expressed in terms of full angle beam divergence. Divergence of a laser beam is defined as its spread with distance.

Formula:

Wavelength of Laser source, $\lambda = \frac{C \sin\theta_n}{n}$ ……. m

Where C is the grating constant: Distance between successive lines on the grating, n is the order of the maximum, θ is the angle of diffraction,

Procedure:

- Mount the laser on an upright and fix the upright at one end of the optical bench. Mount a screen on another upright and fix it at the other end of the optical bench.
- Mark four quadrants on a graph with 'O' as the origin and fix the graph sheet on the screen using pins. Place a laser source in front of the grating and adjust the position of the graph sheet, so that the centre of the laser spot coincides with the origin.
- Mount the grating on the grating stand such that the length of the grating is on the grating stand and move the stand closer to the laser source. Adjust the grating plane such that the diffraction pattern is along the horizontal on the screen with the central maximum is at the origin. Note down the distance'd' between grating and the screen.
- Mark the centres of the central maximum and secondary maxima on the graph sheet using pencil and remove the graph sheet from the stand. Measure the distance between the first order maxima on either side of the central maximum as $2X_1$, for the 2^{nd} order maxima measure the distance as $2X_2$, continue this up to 4^{th} order maxima.
- By using the grating constant C and the angle of diffraction θ_n, calculate the wavelength of laser light for all the orders. Finally find the average value of wavelength.

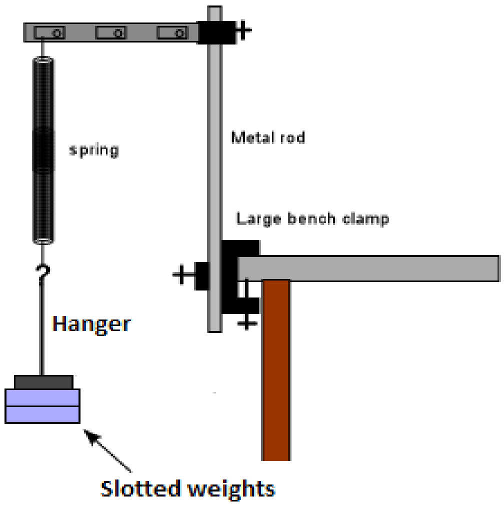
Result: The wavelength of laser light is found to be…………………………….nm

Paste the data sheets here

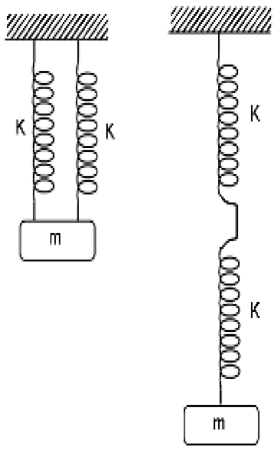
SPRING CONSTANT

OBESERVATIONS:

Experimental Setup:



Springs in parallel and series combination



Part A: Determination of spring constants for the given springs

Mass of the hanger + Mass of the slotted weights in the first spring = $\mathbf{m_1}$ = ________Kg

Table 1: Spring constant K_1 of the first spring.

Trial No	No. of Oscillations(n)	Time t(s)	Time for one osc T_1 (s)	T_1^2	Spring constant $K_1=4\pi^2\frac{m_1}{T_1^2}$(N/m)
1	10				
2	20				
3	30				

Mean K_1= $(K_1)_m$ = --------N/m

Mass of the hanger + Mass of the slotted weights in the second spring = $\mathbf{m_2}$ = ________Kg

Table2: Spring constant K_2 of the second spring.

Trial No	No. of Oscillations(n)	Time t(s)	Time for one osc T_2 (s)	T_2^2	Spring constant $K_2=\frac{4\pi^2 m_2}{T_2^2}$ (N/m)
1	10				
2	20				
3	30				

Mean K_2= $(K_2)_m$ = --------N/m

SPRING CONSTANT

Experiment No: Date:

Aim: a) Determine spring constant for the given springs.
b) Determine spring constant in series combination.
c) Determine spring constant in parallel combination.

Apparatus: springs, weight hanger, slotted weights, stop watch.

Principle: Spring constant (or force constant) of a spring is given by

$$K = \frac{\text{Restoring Force}}{\text{Extension}} \text{ N/m}$$

Spring constant is the restoring force per unit extension in the spring. Its value is determined by the elastic properties of the spring. Elastic materials are those which regain their original state from the deformed state after the removal of deforming forces. When material is subjected to strain, stress is produced. The restoring force is always directed opposite to the displacement. When the mass is displaced through a small distance and then released, it undergoes simple harmonic motion.

The time period **T** of oscillations of a spring is given by the relation,

$$T = 2\pi \sqrt{\frac{m}{K}} \text{ s}$$

By finding the time period (T) spring constant K can be determined.

Formula: Spring constant is given by

$$K = 4\pi^2 \frac{m}{T^2} \text{ N/m}$$

Where, *m* is the mass of the load in g.
T is the time period of oscillation in s and K is the spring constant in N/m.

Procedure:

- Suspend one of the given springs from a rigid support with the slotted weights at the free end.
- Note down the mass of added slotted weights and weight hanger (m_1).
- Pull the load slightly downwards and then release it gently so that it is sets into oscillations in a vertical plane about its mean position.
- Start the stop-watch the mass crosses the mean position and find the time (t)for a known number (n)of oscillations (say10). Calculate the period of the oscillation (T=t/n). Repeat the trial three times.
- Repeat this activity twice for 20 and 30 oscillations
- Enter the readings in Table1 and calculate the spring constant K_1

Part B: Springs in series combination

Mass of the hanger + Mass of the slotted weights = $\mathbf{m_s}$ = _______________Kg

Table 3: Spring constant K_S in series combination for the given material

Trial No	No. of Oscillations (n)	Time t(s)	Time for one osc. (T_S =t/10)s	T_S^2	Spring constant $K_S = 4\pi^2 \frac{m_s}{T_s^2}$ (N/m)	$K_{eff} = \frac{K_1 K_2}{K_1+K_2}$ (N/m)	Error = $K_{eff} \sim (\mathbf{K_s})_m$ (N/m)
1	10						
2	20						
3	30						

Mean K_s= $(K_s)_m$ = --------N/m

Part B: Springs in parallel combination

Mass of the Scale + Mass of the hanger + Mass of the slotted weights = $\mathbf{m_p}$ = ______Kg

Table 4: Spring constant K_P in parallel combination for the given material

Trial No	No. of Oscillations (n)	Time t(s)	Time for one osc T_P (s)	T_P^2	Spring constant $K_p = \frac{4\pi^2 m_p}{T_p^2}$ (N/m)	$K_p=K_1+K_2$ (N/m)	Error= $K_{eff} \sim (\mathbf{K_p})_m$ (N/m)
1	10						
2	20						
3	30						

Mean K_p= $(K_p)_m$ = --------N/m

Results:

a)	The spring constant for the given springs are	K_1= ____________N/m K_2=_____________N/m
b)	The spring constant in series combination is	Ks= ____________N/m
c)	The spring constant in parallel combination is	Kp=____________N/m

- Repeat the same procedure with load (m_2).for the second spring, enter the readings in table-2 and compute the value of spring constants K_2.
- Connect two springs in series combination and repeat the above activity, enter the readings in table-3. Calculate K_S. and K_{eff} .
- If K_{eff} ~ $(\mathbf{K_s})_m$ is small the law of combination of springs in series is verified.
- Connect two springs in parallel combination and repeat the above activity, enter the readings in table-. Calculate Kp and K_{eff} .
- If K_{eff} ~ $(\mathbf{K_p})_m$ is small the law of combination of springs in parallel is verified.

CALCULATIONS:

Results:

a)	The spring constant for the given springs are	K_1= ___________N/m K_2=____________N/m
b)	The spring constant in series combination is	Ks= ___________N/m
c)	The spring constant in parallel combination is	Kp=___________N/m

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HALL EFFECT

OBSERVATIONS:

Block Diagram of Experimental Setup:

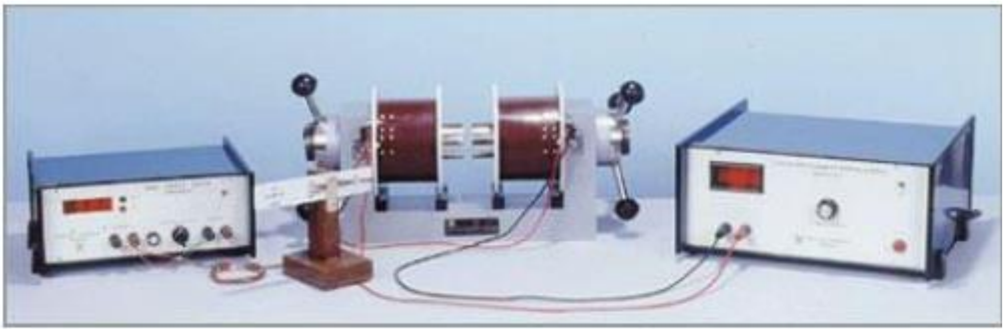
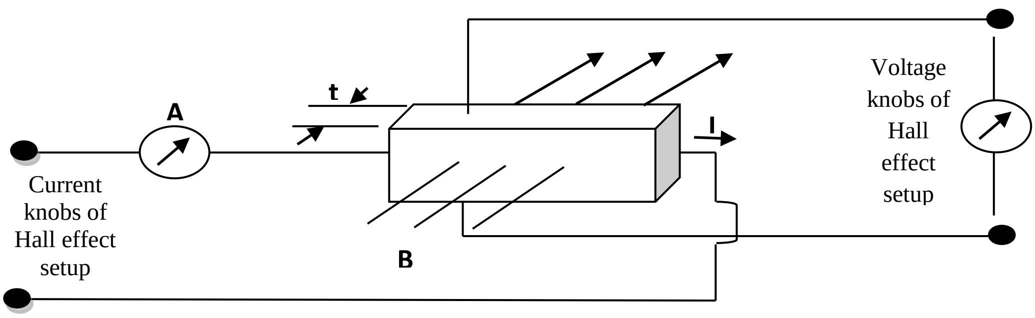
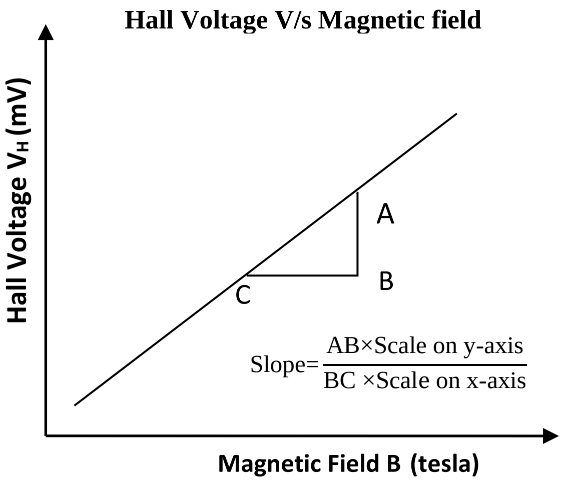


Figure 1.

Block diagram



Model Graph:



Hall Coefficient: $R_H = \left(\frac{V_H}{B}\right)\frac{t}{I_C} = \frac{m\,t}{I_C} =$ Ωm/Tesla

Where V_H = Hall Voltage in V
I_C = Current through the crystal in mA
t = thickness of specimen in meters (t = 0.5 X 10^{-3}m)
B = Magnetic flux density in Tesla.
m = Slop of the graph showing the variation of V_H with B

HALL EFFECT

Experiment No: Date:

Aim:
To study the Hall Effect in semiconductors / metals, to calculate the Hall Coefficient and to determine the concentration of charge carriers

Apparatus and other materials required:
Hall Effect setup, Hall Probe (Ge Crystal n or p type / Metal), Electromagnet, Constant Current Source, Digital Gauss meter etc.,

Principle:
When a metal or a semiconductor carrying current is placed in a transverse magnetic field B, a potential difference V_H is produced in a direction normal to both the magnetic field and current direction. This phenomenon is known as Hall Effect.

The Hall Effect helps to determine

1. The nature of charge carries. (electrons or holes)
2. The majority charge carrier concentration
3. The mobility of majority charge carriers
4. Metallic or semiconducting nature of materials

Formula:

i. Hall Coefficient: $R_H = \left(\frac{V_H}{B}\right)\frac{t}{I_C} = \frac{m\,t}{I_C}$ = …………….. Ωm/Tesla

Where V_H = Hall Voltage in V

I_C = Current through the crystal in mA

t = thickness of specimen in meters ($t = 0.5 \times 10^{-3}$m)

B = Magnetic flux density in Tesla.

m = Slop of the graph showing the variation of V_H with B

ii. Carrier Concentration: $n = \frac{1}{qR_H} = -----m^{-3}$

Where q = Charge of electrons/holes in C, R_H= Hall Coefficient in Ωm/T

Experimental Setup:
The experimental setup for the measurement of Hall voltage and determination of Hall coefficient is shown in the figure 1. A thin rectangular germanium wafer is mounted on an insulating strip and two pairs of electrical contacts are provided on opposite sides of the wafers. One pair of contacts is connected to a constant current source and other pair is connected to a sensitive voltmeter. This arrangement is mounted between two pole pieces of an electromagnet, such that the magnetic field acts perpendicular to the lateral faces of the semiconductor wafer.

Procedure:

Part A: Measurement of magnetic field as a function of current in the coils of the electromagnet.

- Connect the gauss meter to the mains and place the sensor of the digital gauss meter between the pole pieces of the electro magnet. Adjust the gap between the pole pieces of the electromagnet such that the sensor is not in contact with them. **Maintain the same gap throughout the experiment.**

Paste the data sheets here

Sl.No	Current I (A)	Magnetic field from gauss meter (B)		Current through the crystal, IC = -----mA
		B(Gauss)	B(Tesla)	Hall Voltage V_H (mV)
1.	**0**	**0**	**0**	**0**
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				

1 gauss = 10^{-4} Tesla

CALCULATIONS:

Result:

- Hall Coefficient (R_H) of the material = …………… Ω-m/tes
- Carrier Concentration (n) of the material = …………… /m^3

- Switch on the digital gauss meter and constant current supply, slowly increase the current to about 0.25 A. Now gently rotate the sensor of the gauss meter till the reading is maximum. At this stage area of the sensor plate is normal to the magnetic field and flux linked with it is maximum. Thus, the sensitivity of the gauss meter is maximum. (What if the digital gauss meter reading negative?)
- Without changing the orientation of the gauss sensor, make the current through the electro magnet zero and turn the adjustment knob in the Digital Gauss meter for zero reading.
- Slowly increase the current from zero ampere to the maximum of 4 ampere in convenient steps (say 0.2A or 0.25A) and note down the corresponding magnetic field from the gauss meter and enter the readings in the table 1.
- Remove the gauss probe and switch off the digital gauss meter.
- Reduce the current in the constant current supply to zero.

Measurement of Hall voltage

- Insert the **Hall Probe** between the pole pieces in the electromagnet such that the crystal in the Hall Probe is facing the north pole of the electromagnet.
- The wires connected to the length of the crystal (Black and Red) are connected to the current source so that current passes along the length of the crystal, the wires connected to the breadth of the crystal (Green and Yellow) are connected to the voltage source in the **Hall Effect setup** to measure hall voltage developed.
- In the Hall Effect setup turn the selector knob (Toggle switch) to the current and set the crystal current (I_C) to a small value (say 1 mA) by varying the current knob. Note down the crystal current I_C. **Maintain the same current (I_C) throughout the experiment.**
- Turn the selector knob to the voltage to measure Hall voltage V_H and set the voltage to zero using offset knob.
- Vary the current in the electromagnet (**for the same values** taken in the previous part) from zero ampere to four ampere, with the help of constant current source. Note down the Hall voltage (V_H) for the corresponding current (I in A) in the constant current source and enter the values in the table 1.
- Plot a graph of magnetic field (B) in tesla and a Hall voltage (V_H) in volt, find the slope (m) of the resulting graph.
- Calculate the Hall co efficient and carrier concentration using relevant formulae.

Result:

Hall Coefficient (R_H) of the material = …………… Ω-m/tesla

Carrier Concentration (n) of the material = …………… /m^3

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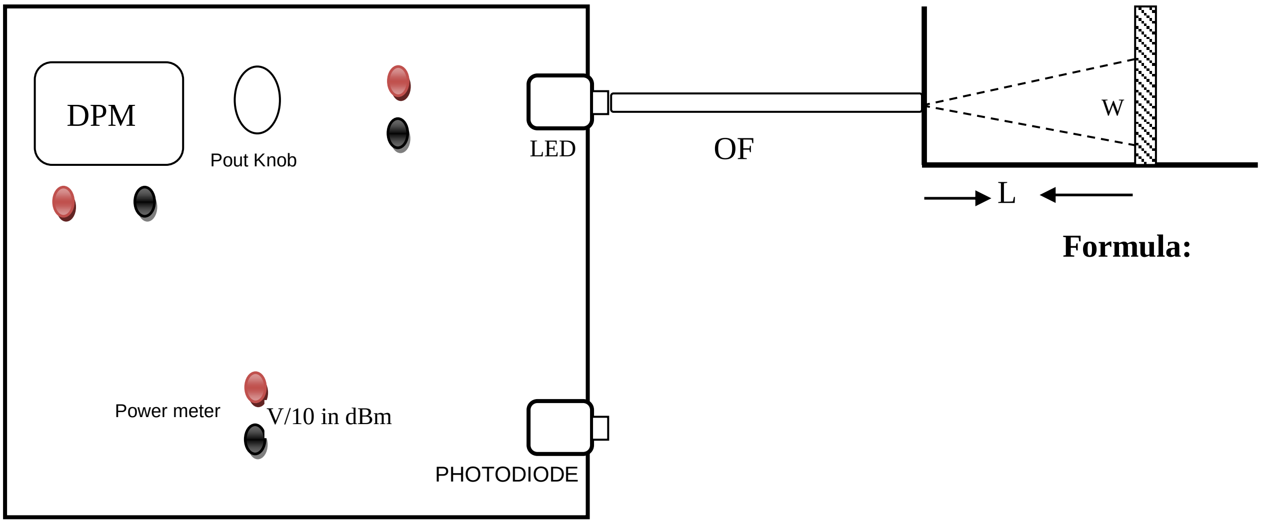
OBESERVATIONS:

Diagram: Experimental Setup:
Part A: Numerical aperture measurement

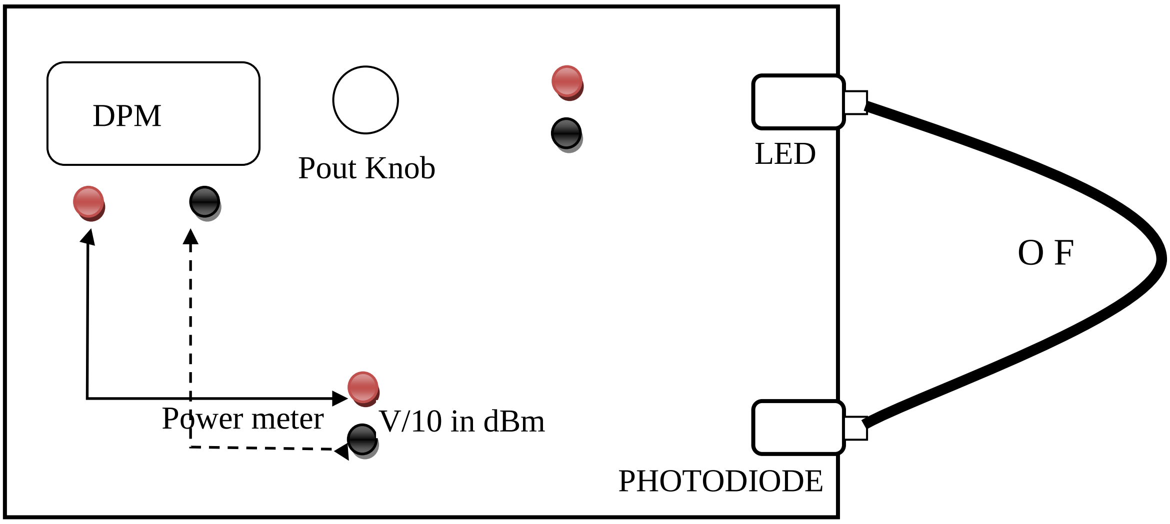


Formula:

Numerical Aperture, $N.A. = \sin\theta_0 = \frac{W}{\sqrt{(4L^2+W^2)}}$,

Where, W→ diameter of the beam spot, L→ distance from the Optical Fiber to the screen

Part B: Measurement of Transmission loss



NUMERICAL APERTURE AND ESTIMATION OF LOSS IN OPTICAL FIBER

Experiment No: Date:

Aim: Part A: To determine the Numerical aperture of the given Optical Fibre

Part B: To measure the transmission loss in the given Optical Fibre

Apparatus: Optical Fibre Kit, Optical fibre cables, In-line adapter, Numerical Aperture Jig.

Part A: To determine the Numerical aperture of Optical Fibre

Principle:

Optical fibres are wave guides that transmit light from one point to another. The principle behind the propagation of light in the optical fibre is Total Internal Reflection (TIR) at the core-cladding interface.

Acceptance angle (θ_0) is the maximum angle from the axis of the optical fibre at which the light ray may enter the fibre so that it may propagate via Total Internal Reflection in the core.

Numerical Aperture (NA): It is the light gathering ability of the optical fibre. Sine of acceptance angle gives the numerical aperture.

$$\mathrm{Sin}\theta_0 = \frac{n_1}{n_0}\sqrt{1-\frac{n_2^2}{n_1^2}} = \frac{\sqrt{n_1^2-n_2^2}}{n_0}$$

Where, n_1 and n_2 are the refractive indices of the core and cladding of the optical fibre respectively, n_0 is the refractive indices of the surrounding medium (n_0=1)

Formula: $$NA = \sin\theta_0 = \frac{W}{\sqrt{\left(4L^2+W^2\right)}},$$

Where, W→ diameter of the beam spot, L→ distance from the Optical Fibre to the screen

Procedure:

- Connect one end of the optical fibre cable (1-metre or 5 metre) to LED and the other end to the numerical aperture jig as shown in the figure.
- Plug the kit to the AC mains and switch on the circuit board. Light should appear at the end of the fibre on the numerical aperture jig.
- Turn the P_{out} knob clockwise to set to maximum P_{out} for the maximum intensity of the laser spot.
- Hold the white screen in front of the optical fibre such that the light coming out of the fibre falls on the screen and the centre of the spot coincides with the centre of the scale on the screen.
- Avoid bends in the optical fibre.

Paste the data sheets here

Table A:

Sl. No	W_1 (mm)	W_2 (mm)	W= $(W_1+W_2)/2$	L(mm)	Numerical aperture(NA)	Acceptance angle, $\theta = \sin^{-1}$(NA) in degree
1.						
2.						
3.						
4.						

Table B:

Length (m)	(A) Attenuation in dB	Length (m)	(B) Attenuation in dB	(B-A) Attenuation for 4m length in dB
1		5		

Attenuation coefficient: Attenuation per unit length (**α**)

$$\alpha = \frac{\text{Attenuation loss}}{Length} = \_\_\_\_\_ = \_\_\_\_\_\_ \text{dB/m} = \_\_\_ \text{ dB/km}$$

CALCULATIONS:

Result:

1.	The numerical aperture of the given optical fibre is	__________
2.	The acceptance angle θ is	__________°
3.	The attenuation coefficient of the fibre α	___________ dB/m

- Note down the diameter of the laser beam spot W_1 on the horizontal axis W_2 on the vertical axis of the scale and find the average width W of the laser spot.
- Repeat the experiment for different distances (L) and enter the readings in the table-A.
- Compute the numerical aperture and acceptance angle using the given formulae.

Note: ***<u>The cone of the laser beam coming out of the fiber is symmetric with the cone of laser beam entering in the beam. Hence the half cone angle of the output beam is also equal to the half cone angle of the input beam and hence equal to the acceptance angle of the fiber.</u>***

Part B: Measurement of Transmission loss in the given Optical Fiber

Principle: Attenuation is defined as the loss in the energy of the signal propagating in the fibre. The major factors contributing to the attenuation in optical fibre are i) Absorption loss, ii) Scattering loss, iii) Bending loss, iv) Intermodal dispersion loss and v) Coupling loss. These losses are a consequence of material, composition, structural design of the fibre and can be minimized by taking proper care in selection of materials, design and the operating wavelengths.

Attenuation in fibre is measured in terms of attenuation coefficient, (α). It is denoted by symbol α. mathematically attenuation of the fibre is given by,

$$\alpha = -\frac{10 \times \log(P_{out} / P_{in})}{L} \text{ dB/km}$$

Where Pout and Pin are the output power and input power of the signal respectively, and L is the length of the fibre.

Procedure:

- Connect one end of optical fibre cable (1 meter) to the LED and the other end to the photo diode.
- Connect the Digital Panel Meter (DPM) to the power meter as shown in the figure B
- Plug in AC mains, fix the output power (P_o) knob to some known value in the DPM. This is attenuation in the fibre of one metre length.
- Repeat the above procedure for a different cable length as given in table (say 5m) and note the attenuation of the fibre in the DPM.
- The difference in the DPM readings gives the transmission loss for a known length of the fibre (say 4m).
- Calculate the attenuation coefficient α (transmission loss / length)

Result:

1.	The numerical aperture of the given optical fibre is	__________
2.	The acceptance angle θ is	__________°
3.	The attenuation coefficient of the fibre α	___________ dB/m

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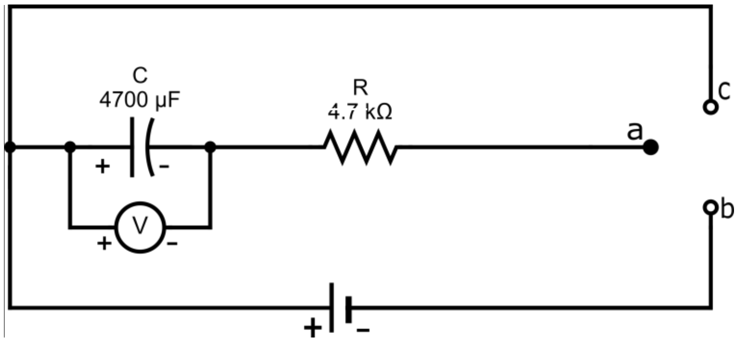
DIELECTRIC CONSTANT

OBSERVATIONS

CIRCUIT DIAGRAM:



R = 47 KΩ **Battery voltage=___________Volt**

Time in seconds (s)	Voltage during charging (V)	Voltage during discharging (V)
0		
30		
60		
90		
120		
.		
.		
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.		

DIELECTRIC CONSTANT

Experiment No: Date:

AIM: To determine the capacity of a parallel plate capacitor and hence to calculate the dielectric constant of the dielectric medium in it.

APPARATUS: Battery of ten volts, electrolytic capacitor, digital multi meter, two way key and stop clock.

PRINCIPLE: When a capacitor and a resistor are in series with a dc source, the capacitor gets charged and at any instant the voltage of the capacitor is $V = V_0(1-e^{-t/RC})$ where V_0 is the maximum voltage. Where RC = τ is called the time constant of the circuit, it is the time taken for the voltage to reach 63% of V_0.Similarly while discharging the voltage across the capacitor is given by $V = V_0(e^{-t/RC})$. The time constant is the time taken for voltage to decrease to 37% of the maximum value ie V_0

FORMULA:
The capacitance and dielectric constant of the given capacitor are calculated by using the formulae given below:

1. $C = \tau /R$ (F)

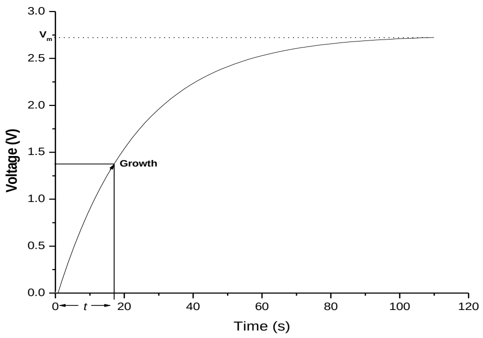
2. $\varepsilon_r = \dfrac{Cd}{\varepsilon_o A}$

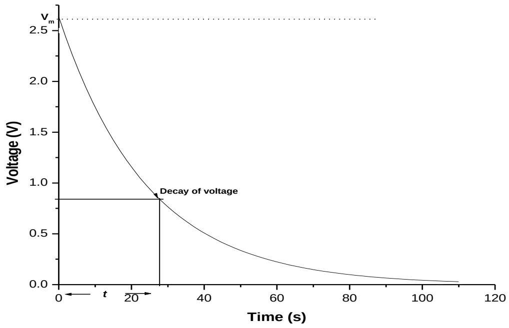
where τ : time constant.
ε_r : relative permittivity or the dielectric constant of the dielectric.
ε_o : Absolute permittivity of free space = 8.854×10^{-12} F/m.
C : capacitance of the capacitor (F).
R: resistance (Ω)
A: area of each plate (m^2).
d: thickness of the dielectric (m).

Data:

C = 3300 μF	C = 4700 μF
R = 47 kΩ	R = 47 kΩ
L = 47 cm	L = 55 cm
B = 1.5 cm	B = 2.5 cm
d = 80 μm	d = 80 μm

(I) CHARGING CURVE **(II) DISCHARGING CURVE**:





Charging time constant $\tau_1 =$ ______ s Discharging time constant $\tau_2 =$ ______ s

Average time constant $\tau = \frac{\tau_1 + \tau_2}{2} =$ ______ s

Capacitance of the capacitor $C = \frac{\tau}{R} =$ ______F

Where R is the resistance and C is the capacitance of the capacitor in the circuit.

Dielectric constant is determined by using the formula, $\varepsilon_r = \frac{Cd}{\varepsilon_o A}$

where τ : time constant, ε_r : dielectric constant of the dielectric.

ε_o : Absolute permittivity of free space = 8.854×10^{-12} F/m.

C: capacitance of the capacitor (F).

Calculation:

Thickness of dielectric medium, d (m)	
Area of each plate A (m^2)	

RESULT:

1. Capacity of parallel plate capacitor C = __________________F
2. Dielectric constant of the given dielectric material ε_r = ______

PROCEDURE:

(I) CHARGING:

The circuit connections are made as shown in the figure. To start with, the key K is closed along **a b**, the voltage across the capacitor increases slowly. For every thirty seconds, the reading of the voltmeter across the capacitor is recorded in tabular column till it reaches maximum (say 2 V). A graph of voltage versus time is drawn as shown in the figure. It is clear from the graph that the voltage increases exponentially with time and attains maximum value V_m after a finite time. The time taken by the voltage to become 63.2% of its maximum value V_m is noted. It is called time constant ($\tau = R \times C$) of the circuit

(II) DISCHARGING

When the voltage across the capacitor is maximum, the two way key K is opened along **a and b** and closed immediately along **a and c.** Then voltage decreases with time, for every thirty seconds the voltage across the capacitor as indicated by the voltmeter is recorded in the tabular column. A graph of voltage versus time is plotted as shown in the figure. The time taken for the voltage to become 36.8% of its maximum value is noted from the graph. This is again time constant (τ).

Note:

Don't connect a wire between *b* and *c*

Multiply the result by 10^{-6}. This correction is needed because the dielectric in the given electrolytic capacitor is not a homogenous medium and it is a paper with alumina deposition by electrolysis

RESULT:
1. Capacity of parallel plate capacitor C = __________________F

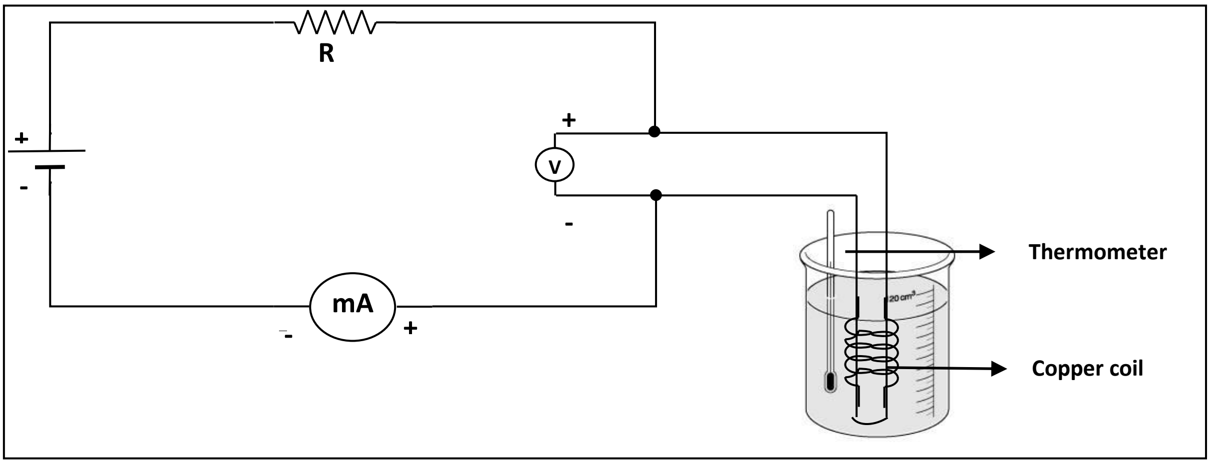
2. Dielectric constant of the given dielectric material ε_r = _____

Paste the data sheets here

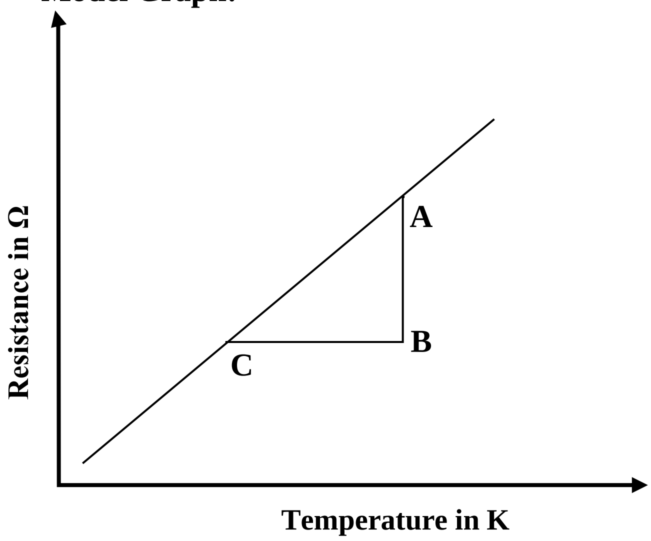
FERMI ENERGY OF COPPER

OBSERVATIONS:

Diagram:



Model Graph:



Formula:

$$E_F = 1.36\times10^{-15}\sqrt{\frac{\rho\, A\, m}{l}}\ \text{J}$$

$$E_F = \frac{1.36\times10^{-15}\sqrt{\frac{\rho\, A\, m}{l}}\ \text{J}}{1.6\times10^{-19}\,C} = \text{...........}\,eV$$

Where

E_F is the Fermi energy (eV)

T is the temperature of the coil in K

A (πr^2) is area of cross section of the given copper wire (m^2)

l is the length of the copper wire (m)

Charge of the electron, e = 1.602×10^{-19} C.

m is the slope of the straight line.

ρ is the density of copper = 8960 Kg/m^3

Slope, m= (**AB x Scale on y-axis**) / (BC x Scale on x axis)

FERMI ENERGY OF COPPER

Experiment No: Date:

Aim: To determine the Fermi energy of copper

Apparatus and other materials required: RPS**,** Multi meter, Milli ammeter, Beaker, Thermometer and copper wire.

Theory: In a conductor, the electrons fill the available energy states starting from the lowest energy level. Therefore at 0K, all the levels with an energy E less than a certain value $E_{F(0)}$ will be filled with electrons, whereas the levels with E greater than E_{F0} will remain vacant. The energy E_{F0} is known as Fermi energy at absolute zero and corresponding energy level is known as Fermi level. For temperature greater than zero Kelvin, Fermi energy is the average energy of the electrons participating in electrical conductivity. By measuring the resistance of the copper wire at different temperature, Fermi energy is calculated.

$$E_F = 1.36\times10^{-15}\sqrt{\frac{\rho\, A\, m}{l}}\ \text{J}$$

Where, E_F is the Fermi energy

T is the reference temperature (K),

A is area of cross section of the given copper wire (m^2)

l is the length of the copper wire (m)

Charge of the electron,e = 1.602×10^{-19} C.

ρ is the density of copper =8960 Kg/m^3

m is the slope of the straight line obtained by plotting resistance of the metal against absolute temperature of the metal.

Procedure:

- Make the circuit connections as shown in the diagram. The connections are made in the board, only the devices and meters are to be connected at the specified places.
- Set the multi meter to 200 mV DC mode.
- Immerse the copper coil in a beaker containing cold water, set the current to about 6 to 8 mA by varying the power supply voltage and note down the resistance of the coil at the ambient temperature. Note down the voltage in multi meter and current in milli ammeter and enter the readings in the tabular column
- Immerse the copper coil in a beaker containing hot water at about 90°C.
- Note down the voltage in multi meter and current in milli ammeter for every decrement of 2°Cto about 60°C and enter the readings in the tabular column.
- Calculate the resistance R (V/I) of the material of coil at various temperatures.
- Plot a graph of resistance along y-axis and temperature along x-axis and calculate the value of slope m of the resulting graph(m = AB/BC)
- Calculate the Fermi energy of the material by using the relevant formula.

Table:

Sl. No.	Temp ^0C	Temp K	V (mV)	I (mA)	R=V/I (Ω)
1.	Room Temp				
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

Paste the data sheets here

Result: The Fermi energy of copper is E_F = ____________________ J, _____________eV

CALCULATIONS:

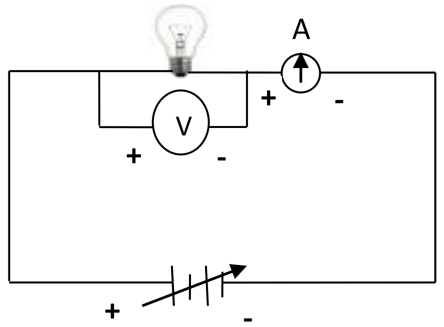
Result: The Fermi energy of copper is E_F = ___________________ J, _____________eV

STEFAN'S LAW

OBSERVATIONS:

Diagram **Model Graph:**

Bulb



RPS

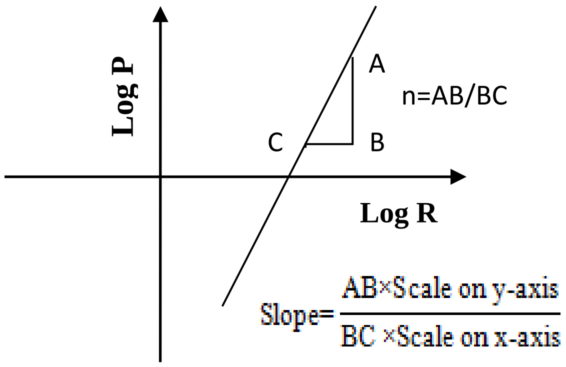


Table:

Trial No.	**Voltage, V (Volt)**	**Current, I (A)**	**R = V/I (Ω)**	**P = VI (W)**	log_{10}^{P}	log_{10}^{R}
1						
2						
3						
4						
5						
6						
7						
8						
9						

Note: Take readings only up to 12V.

Electrical power given to bulb = energy radiated by bulb per second

- P = VI = $e\sigma AT^4$ where A is the surface area of the filament, σ is Stefan's constant, T is the absolute temperature of the filament and e is the emissivity of the filament.
- Emissivity of the black body is 1
- Let P = e σ A T^n where it is to be proved that n = 4
  Log P = Log (σ) + Log (A) + n Log (T)+loge
  But T α R (R is the resistance of the filament)
  Log P = Log (σ) + Log (e A) + n Log (R)
  Log P= n log(R) + Log (σ e A)
  Log P= n log(R) + K , Hère log(σ e A) = K (a constant)
- This equation is of the form y = mx + c where y = Log P, the slope m = n and c = K
  Therefore, a plot of Log P versus Log R is a straight line with the slope = n
  If n= 4 Stefan's law is verified

RESULT: Slope = _______ Hence Stefan's law is verified.

STEFAN'S LAW

Experiment No.: Date:

Aim: Verification of Stefan's law of radiation.

Apparatus and other required materials: Regulated power supply (RPS), electric bulb (12 V, 10 W) and DC Ammeter, Voltmeter.

Principle: Stefan's law states that the energy dissipated per unit area per unit time by a perfect black body is proportional to the fourth power of its absolute temperature.

Stefan's law $E \alpha T^4$ or $E = \sigma T^4$

The filament is not a perfect black body, hence the Stefan's law for the filament is $E = \sigma e T^4$

Where, E is the energy dissipated per second per unit area of a black body

e is the emissivity of the filament material

σ is the Stefan's constant ($5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$)

T the temperature of the black body in Kelvin

Procedure:

- Make the electrical connections as shown in the diagram.
- Keep the display in the regulated power supply (RPS) in volts mode.
- Keep the current knob for the maximum position, keep the course volts and fine volts knobs at the minimum position before switching ON the RPS.
- Switch ON the RPS and vary the voltage knobs slowly till a faint glow is seen in the filament.
- Vary the voltage in convenient steps and note down the current I in the ammeter and the voltage V in multi meter set in voltage mode (0 – 20 V DC).
- Calculate the power (P) dissipated in the filament and resistance (R) of the filament material.
- Plot a graph of log_{10}^{P} versus $log_{10}^{R}$and calculate the slope 'n' of the graph.
- If the slope 'n' is 4, the Stefan's law is verified

Result: Slope n = _______. Hence Stefan's law is verified.

VIVA VOCE

SINGLE CANTILEVER

1. State Hooke's law if elasticity.
   Stress is proportional to strain within elastic limits.

2. Supposing the breadth, length and the thickness of the cantilever are altered, is there a variation in the Young's modulus?
   No, because it is a constant for a given material.

3. In the plot of stress versus strain, at a particular value of the applied force the material passes from an elastic state to the plastic state. What is this point called?
   Yield point.

4. What is stress?
   Restoring force per unit area

5. Does the modulus of elasticity change with increase in temperature?
   Yes

6. What is the dimension of strain?
   It is a dimensionless quantity

7. What is a cantilever?
   It is a homogenous beam whose length is more compared to its transverse dimensions.

BAND GAP OF THERMISTOR

1. What is a band gap?
   This is the energy gap between the conduction and valence bands of a semiconductor (or insulator).

2. How do you differentiate between a conductor, an insulator and a semiconductor in relation to energy gap?
   In conductors, the valence and conduction bands overlap each other. In insulators, there is large energy gap between valence and conduction bands, while in semiconductors this energy gap is not too large so that at room temperature the thermal energy gained by some of the electrons in the valence band is sufficient to make them jump to conduction band, crossing this energy gap.

3. What is intrinsic and extrinsic semiconductors?
   A pure or natural semiconductor free of impurities is called an intrinsic semiconductor e.g. silicon and germanium. But it has low electrical conductivity. When some pentavalent (like arsenic) or trivalent (like boron) impurity is added to it, then it is called an extrinsic semiconductor.

4. Why a semiconductor behaves as an insulator at zero degree Kelvin?

At 0K, electrons in valence band do not have sufficient energy to cross the energy band gap so as to reach to conduction band and to make them available for conduction. Thus semiconductor behaves as an insulator.

5. What do you mean by doping and what is the effect of doping on depletion region?
   Doping is a process of introducing a small amount of impurity into the intrinsic semiconductor. As the doping concentration increases width of the depletion region decreases.

6. Explain the effect of doping in a germanium crystal.
   The conductivity of germanium crystal is enhanced by adding the impurities from V or III group of periodic table e.g., arsenic or antimony from V group or indium from III group. When antimony or arsenic having five electrons in their outermost shell are introduced into the germanium crystal, the fifth electron of the impurity atom does not find a place in the symmetrical covalent bond structure and is free to move through the crystal. These free electrons are then available as current carriers. When a III group elements like indium is added each atom leaves behind a hole.

7. On what factors does the conductivity of an extrinsic semiconductor depend?
   The conductivity of an extrinsic semiconductor depends upon the type and amount of impurity added.

8. What do you mean by a hole?
   Hole indicates the deficiency or absence of an electron. It effectively behaves like a positively charged particle when an electric field is applied across the crystal.

9. What are values of energy gap of silicon & germanium?
   Silicon & Germanium energy gap values are 1.1eV & 0.7eV respectively at 20°C.

10. What is the effect of temperature on the energy gap of a semiconductor?
    As temperature increases energy gap decreases.

11. What are the factors on which energy gap of semiconductor depend?
    It depends on the material & temperature.

TORSION PENDULUM

1. What is meant by Torsion Pendulum?
   A pendulum in which the oscillations are due to the torsion in the suspension wire.

2. Describe Torsion pendulum?
   It consists of a rigid body (disc, rod, etc.,) attached to the lower end of the wire, whose top end is fixed to the rigid support and it is subjected to rotational oscillations.

3. Define moment of inertia?
   It is the opposition for the rotational motion. When rigid body rotates about an axis, it has tendency to oppose the change in its state of rest or of uniform rotation about its axis. This tendency is called moment of inertia of a body about the axis of rotation. Quantitatively it is the product of the mass and radius of gyration.

4. Define inertia of a body. What is the measure of the inertia of a body?
   The property of a body by virtue of which every body tries to stay in its state of rest or uniform motion along a straight line unless compelled by an external force. Mass is the measure of the inertia of a body.

5. What are the factors on which moment of inertia of a body depend?
   Moment of inertia depends on a) mass of the body b) The distribution of mass about the axis of rotation.

6. Why (I/T^2) is a constant for a given wire?
   For a torsion pendulum, the period of torsion oscillation is $T = 2\pi\sqrt{\frac{I}{C}}$ Where I = the moment of inertia about its axis, C = couple per unit twist of the suspended wire.
   Rearranging $(I/T^2) = (C)/(4\Pi^2)$
   Since "C" (couple per unit twist) is a constant for a given wire; I/T^2 is a constant.

LASER DIFFRACTION

1. What is meant by diffraction?
   Bending of waves round the edges of an obstacle is called diffraction.

2. What is the condition for diffraction?
   Size of the obstacle should be comparable with that of the wave length of the light source. Since grating constant and wave length are of the same order (10^{-6}metre), diffraction takes place within the grating.

3. Distinguish between diffraction and dispersion?
   Diffraction: Bending of light round the edges of an obstacle is called diffraction. In this case lower the wave length lesser will be the deviation.
   Dispersion: When white light passes through a prism it splits into its constituent colors. This phenomenon is called dispersion. In this case lower the wave length higher will be the deviation.

4. Distinguish between polychromatic & monochromatic source.
   Polychromatic source a source having different wave lengths. Ex. Mercury vapour lamp.
   Monochromatic source is a source having single wave length. Ex Sodium vapour lamp.

5. What does LASER stands for?
   The term LASER stands for Light Amplification by Stimulated Emission of Radiation.

6. What are the characteristics of laser radiation?
   Laser radiations have high intensity, high coherence, high monochromaticity and high directionality with less divergence.

7. What is population inversion?
   When the number of atoms are more in higher energy state than in the lower energy state, this condition is known as population inversion, it is essential for stimulated emission.

8. What is pumping in a laser?

It is the process in which atoms are excited to higher energy states by continuously supplying energy.

9. What is meant by the term coherence?
The state of vibration, same phase or constant phase difference is known as coherence.

10. What is an active medium?
A solid, liquid, or gaseous medium in which population inversion can be achieved is called an active medium.

11. What is the action of an optical resonator?
It gives the directionality to the laser beam and amplifies the laser beam.

SPRING CONSTANT

1. What is Oscillatory motion?
When a body executes back and forth motion which repeats over and again about a mean position, then the body is said to have Vibrational/oscillatory motion.

2. What is Simple Harmonic Motion?
A body is said to be undergoing Simple Harmonic Motion (SHM) when the acceleration of the body is always proportional to its displacement and is directed towards its equilibrium or mean position.

3. What is time period?
The time taken by the particle executing simple harmonic motion to complete one oscillation is called the time period.

4. What is frequency?
The number of oscillations that a body completes in one second is called the frequency.

5. What is spring constant?
Spring constant is the restoring force per unit extension in the spring.

6. For what applications should parallel springs be used and why?
$K=K_1+K_2+\dots\dots\dots+K_n$. This will ensure that the overall spring constant will be high, and therefore this configuration is used whenever we need a very high spring constant. (Good Shock absorbers in vehicles)

7. Why should springs be used in series?
$1/K= 1/K_1+1/K_2+\dots\dots+1/K_n$. This ensures that, the overall spring constant K is lower than each individual spring constant. This will increase the amplitude of oscillations. Which can be used in sensors.

8. What determines the value of the spring constant for a particular material?
It depends on the elastic properties of the material.

HALL EFFECT

1. What is Hall Effect, Hall voltage and Hall field?
If a metal or a semiconductor carrying a current I is placed in a transverse magnetic field B, a potential difference is produced in the direction normal to both the current and magnetic field directions. This phenomenon is called Hall Effect. The corresponding potential difference generated is called Hall voltage and the electric field generated is called the Hall field.

2. Define Hall co-efficient.
It is numerically equal to Hall electric field induced in the specimen crystal by unit current when it is placed perpendicular in a magnetic field of 1 W/m^2.

3. Define mobility.
It is the ratio of average drift velocity of charge carriers to applied electric field.

4. What is Fleming's Left Hand Rule?
Stretch thumb, first finger, middle finger at right angles to each other such that fore finger points in the direction of magnetic field, middle finger in the direction of current then thumb will point in the direction of the force acting on it.

5. How does mobility depend on electrical conductivity?
It is directly proportional to conductivity.

6. Which type of charge has greater mobility in semiconductors?
In semiconductors, electron has greater mobility than holes.

7. What happens to the hall coefficient when number of charge carriers are decreased?
Hall coefficient increases with decrease in number of charge carriers per unit volume.

8. What are the applications of Hall Effect?
It is used to verify whether a substance is a semiconductor, conductor or insulator. Nature of charge carriers and mobility of charge carriers can bestudied. This experiment can be used to measure magnetic field strength.

OPTICAL FIBER

1. What is the basic principle of an optical fiber?
Optical fiber works based on the principle of total internal reflection [TIR]

2. What is an optical fiber?
An optical fiber is a wave guide system through which light signals are carried over longer distances without loss of energy.

3. What is Numerical aperture (NA)?
The light gathering capacity of an optical fiber is called Numerical Aperture.

NA= Sinθ Where θ=acceptance angle.

4. What is an acceptance angle of an optical fiber?
It is the maximum angle of incidence at the core of an optical fiber so that the light can be guided through the fiber. Acceptance angle $\theta = \sin^{-1}(NA)$.

5. Why optical fibers do not pick up electricity?
Optical fibers are made by pure non-metallic materials hence they won't allow electricity.

6. What is Total Internal Reflection (TIR)?
Total internal reflection is the phenomenon in which complete reflection of a light ray occurs into the same medium, when a propagated wave strikes a medium boundary at an angle larger than a critical angle with respect to the normal to the surface.

7. What is an acceptance angle?
The angle θ_0 is called the wave guide acceptance angle or the acceptance cone half-angle which is the maximum angle from the axis of optical fiber at which light ray may enter the fiber so that it will propagate in core by total internal reflection.

8. What is an attenuation in optical fiber?
The total power loss offered by the total length of the fiber in the transmission of light is called attenuation.

9. What are the different types of optical fiber?
The optical fibers are classified under three categories. They are 1) Single Mode Step Index Fiber, 2) Step Index Multi Mode Fiber and 3) Graded index Multi Mode Fiber

DIELECTRIC CONSTANT

1. What is Capacitor?
A Capacitor is a passive component used to store energy in the form of an electrostatic field.

2. What are passive elements?
The circuit element which cannot deliver any electrical power and does not performs the operations like amplification, rectification etc., are called passive elements.

3. What are active elements?
The circuit elements which can deliver electrical power to the system and can perform the operations like amplification, rectification, etc., are called active elements.

4. What is meant by capacitance of a capacitor?
It is defined as the ratio of charge on either conductor to the potential difference between the conductors forming the capacitor. It is the ability of the device to hold charge

5. How Capacitance of the capacitor can be increased?

Capacitance of a capacitor can be increased by i) introducing a dielectric material of high density between the two parallel plates of the capacitor 2) increasing the area of the plates and decreasing the gap between the plates.

6. How is the value of the capacitance of a parallel plate capacitor determined from its dimensions?
In SI units $C = \varepsilon A/d$, where C is the capacitance, ε is the absolute permittivity of the material between the plates, A is the area of one of each plate, and d is the distance between the plates.

7. What is the charge on the capacitor when the voltage across it is V?
$Q = CV$ coulomb, when C is expressed in farad and V in volt.

8. With respect to the discharge of a capacitor, define time constant
The time constant is the time in which the charge on the capacitor decays to 1/e of its maximum value.

9. With respect to the charging of a capacitor, define time constant
The time constant is the time in which the charge on the capacitor decays to 1 – 1/e of its initial value

10. What would happen time of leakage if the capacitor is very large or very small?
The time of leakage is determined by the time constant τ ($\tau = CR$) of the circuit. For R approximately equal to a few MΩ, if C is very large, say, 1F then the leakage time will be very large (approximately equal to 10^6 s.). On the other hand, if C is very small (approximately equal to 10^{-3} μF), the time of leakage will be very small (approximately equal to millisecond) and cannot be measured by a stop watch Thus, when R is of the order of a few MΩ, C is required to be 1μF or so.

11. Are the time constant for charging and discharging the capacitor the same in your experiment?
No. The time constant for discharging the capacitor is larger than that for its Charging.

12. Define Static Dielectric constant?
The static dielectric constant is the factor by which the capacitance of a capacitor is increased when vacuum is substituted by a dielectric medium which fills the entire region where electric field would be set up on subjecting the capacitor to a static electric potential.

13. What are the factors that Dielectric constant depends?
Dielectric constant mainly depends on the nature of the material and does not depends on the size or shape of a capacitor or dielectric material

14. What is polarization of dielectrics?
The process of acquiring charges by a dielectric when placed in an electric field is called polarisation.

15. What is the unit of Dielectric constant?
Dielectric constant is a dimension less constant hence it has no unit.

16. Give examples of Dielectric material

Paper, wax, mica, ceramics, some electrolytes, etc.

17. What is Dielectric Strength?
The limiting electric field above which the dielectric breakdown occurs is called Dielectric strength.

18. Give applications of Dielectrics?
Dielectrics can be used as a dielectric medium in capacitors, as an insulator in power transmission, as a heating material in microwave oven (cooking rice in microwave oven).

FERMI ENERGY

1. What is Fermi energy of a metal?
It is the energy of the highest occupied level at absolute zero temperature..

2. What is meant by Fermi factor?
It is the probability of occupation of given energy state by a charge carrier.

3. What is meant by Fermi temperature T_F? What is the relation between E_F& T_F?
It is the temperature at which the average thermal energy of the free electrons in a solid becomes equal to the Fermi energy at 0°K. $E_F = k_B T_F$

4. What is meant by Fermi velocity?
It is the velocity of those electrons which occupy the Fermi level. It is given by
$E_F = \frac{1}{2}\, m v_F^2$

5. What is Fermi Dirac distribution?
It gives distribution of electrons / fermions among the various available energy levels of a material under thermal equilibrium conditions.

6. What are the factors on which E_F depend?
E_F depends on the material and the temperature.

7. How many electrons will be there in each energy level?
According to Pauli's exclusion principle, there will be two electrons in each energy level.

8. State Pauli's exclusion principle?
It states that no two electrons can have all the four quantum numbers same.

9. What is meant by free electron?
Free electron is the electron which moves freely in the absence of external field. These electrons collide with each other and also with the lattice elastically and hence there is no loss in energy.

STEFAN'S LAW

1. What is a 'black body'?
   Black body is a body which absorbs all wavelengths which are incident on it and emits all those wavelengths on heating. This total energy emitted or absorbed is independent of the nature of the body and depends on its temperature.

2. How does this law differ from Newton's law of cooling?
   Newton's law of cooling is applicable only when the difference of temperature between the body and the surroundings is very small. There is no such conditions for Stefan's law.

3. Can the value of Stefan's constant be determined from this method?
   Yes, taking the value of 'n' as 4, the value of σ can be calculated from the value of the intercept C of the graph.

4. What for Stefan's law is used?
   It has the advantage like finding the temperature of Sun.

5. What are the limitations of Stefan's law?
   This method is even though not very precise and accurate, it has some advantages. The bulb is never truly a black body and at steady state, the power radiated is never equal to V.I exactly. The working theory in this method is to some extent approximate, nevertheless, the method is very simple and the accessories are easy to procure. It gives an approximate idea about Stefan's Law, Stefan's constant and the verification of the law.

6. State Stefan's law.
   It states that total radiant energy emitted per second per unit surface area of a perfectly black body is proportional to the fourth power of its absolute temperature.

7. State Kirchoff's law of black body radiation.
   It states that at any temperature, the ratio of emissive power to the absorptive power of a given wavelength is same for all black bodies. A good emitter is a good absorber of heat.

8. What is emissive power and absorptive power?
   Emissive power: At a particular temperature and for a given wavelength, it is defined as the radiant energy emitted per unit time per unit surface area of the body within a unit wavelength range.
   Absorptive power: At a particular temperature and for a given wavelength, it is defined as the ratio of the radiant energy absorbed per second per unit surface area of the body to the total energy falling per unit time on the same area.

9. State Wien's law?
   The wavelength corresponding to the maximum energy emitted from a black body is inversely proportional to its absolute temperature ($\lambda_{max}T$ = Constant).

10. Explain the energy distribution in a black body radiation spectrum?
    The energy radiated by a black body is not uniformly distributed over the entire wavelength range emitted by the body but it is maximum for a particular wavelength and

decreases on either side. The value of wavelength at which the energy radiated peaks depends on the temperature of the black body.

11. Mention the properties of black body radiation?
    Black body radiation has all the property of electromagnetic radiation.

12. What are the modes of transmission of heat?
    Conduction, convection and radiation. Conduction is the mode of transmission of heat in which heat travels from the hot part of the body to its cold part without actual motion of heated atoms. Convection is the mode of transmission of heat from one part of the medium to the other by the bodily motion of heated atoms. Radiation is mode of transmission of heat from one body to another without the intervening medium.

13. Distinguish between Heat and Temperature?
    Sensation of hotness is called heat. Degree of hotness is called temperature.