Date:	**MEASURING INSTRUMENTS**

(A) VERNIER CALIPERS

AIM: To measure internal and external diameters of a given hollow cylinder.

APPARATUS: Vernier Calipers and the hollow cylinder

PARTS OF A VERNIER CALIPER:

1. **Outside jaws** : used to measure external diameter or width of an object
2. **Inside jaws** : used to measure internal diameter of an object
3. **Depth probe** : used to measure depths of an object or a hole
4. **Main scale** : scale marked every mm (bottom); scale marked in inches and fractions (top)
5. **Vernier scale** gives interpolated measurements in 0.1 mm or fractions of an inch
6. **Retainer**: used to block movable part to allow the easy transferring of a measurement

PROCEDURE:

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

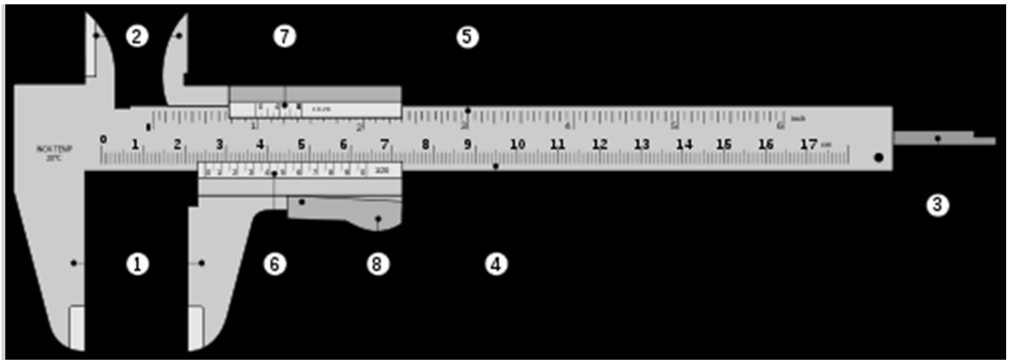


Figure 1 : VERNIER CALIPER

OBSERVATIONS:

Least Count: It is the smallest length that can be measured accurately by the vernier caliper

$$\text{Least Count} = \frac{\text{Value of one main scale division}}{\text{Total No. of vernier scale divisions}}$$

$$= \frac{1\text{mm}}{10} = 0.1\text{mm} = 0.01\text{cm}$$

Determination of least count:

Least Count (LC) = 1 main scale division – 1 vernier scale division.

i.e., (LC) = 1MSD – 1VSD

10 VSD = 9 MSD

1 MSD = 1 mm

10 VSD = 9 mm

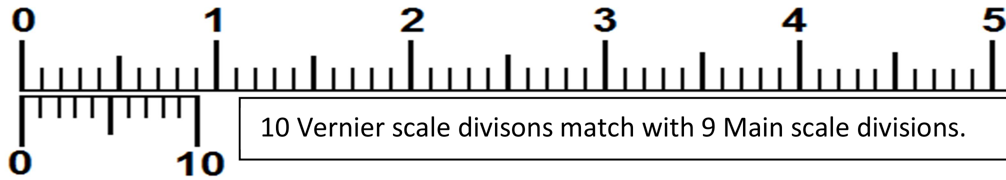
1 VSD $= \frac{9\text{mm}}{10}$

LC = 1 MSD – 1 VSD

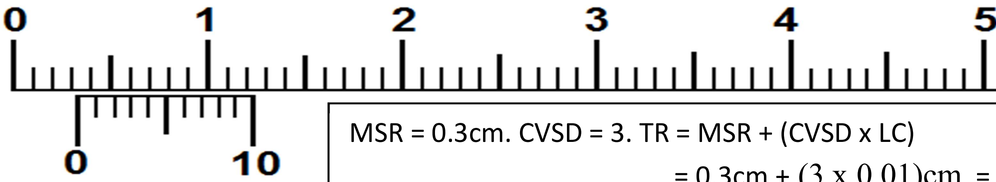
$= 1\text{ mm} - \frac{9\text{mm}}{10} = 0.1\text{mm} = 0.01\text{cm}$

LC = 0.01 cm

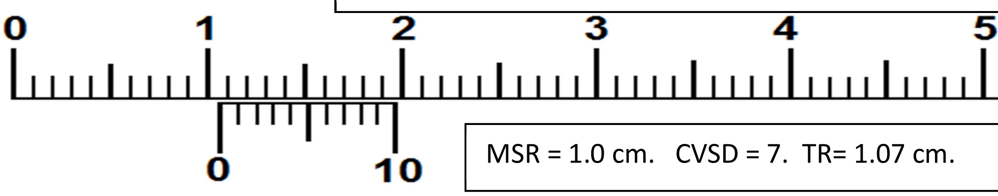
Examples :



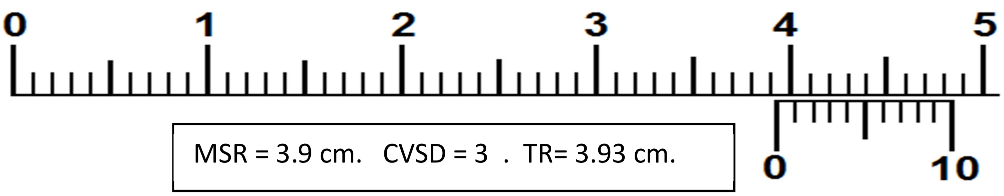
10 Vernier scale divisons match with 9 Main scale divisions.



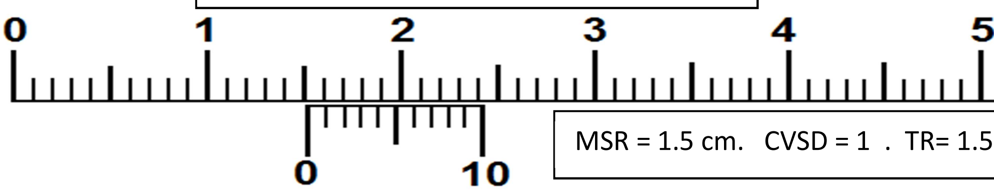
MSR = 0.3cm. CVSD = 3. TR = MSR + (CVSD x LC)
= 0.3cm + (3 x 0.01)cm = 0.33 cm.



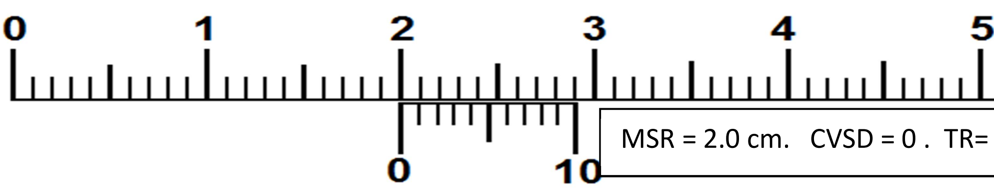
MSR = 1.0 cm. CVSD = 7. TR= 1.07 cm.



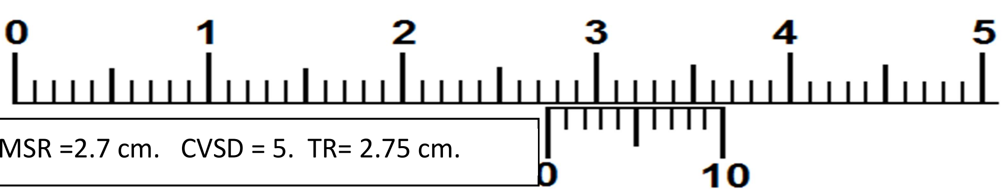
MSR = 3.9 cm. CVSD = 3 . TR= 3.93 cm.



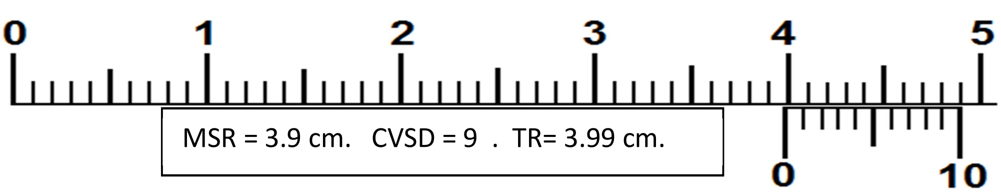
MSR = 1.5 cm. CVSD = 1 . TR= 1.51 cm.



MSR = 2.0 cm. CVSD = 0 . TR= 2.00 cm.



MSR =2.7 cm. CVSD = 5. TR= 2.75 cm.



MSR = 3.9 cm. CVSD = 9 . TR= 3.99 cm.

Table 1 : To find the external diameter of the hollow cylinder:

Least Count (LC) = $\frac{\boldsymbol{Value\ of\ one\ main\ scale\ division}}{\boldsymbol{Total\ no.of\ vernier\ scale\ divisions}}$ =

Sl. No.	MSR	CVSD	TR = MSR+ (CVSDXLC)
Unit	cm	div	cm
			Mean =

Table 2 : To find the internal diameter of the hollow cylinder:

Least Count (LC) = $\frac{Value\ of\ one\ main\ scale\ division}{Total\ no.of\ vernier\ scale\ divisions}$ =

Sl. No.	MSR	CVSD	TR = MSR+ (CVSDXLC)
Unit	cm	div	cm
			Mean =

RESULT: The internal and external diameters of the given hollow cylinder were determined.

(B) SCREW GAUGE

AIM: To find the thickness, radius of the given objects.

APPARATUS REQUIRED: Screw Gauge, and the given object.

PROCEDURE:

1. First determine the ZE
2. Note down the pitch scale reading (PSR)
3. Note down the division of the head scale that coincides with the pitch line (HSD)
4. The total reading (TR) is given by **TR = PSR +[(HSD+ ZC)] x LC**

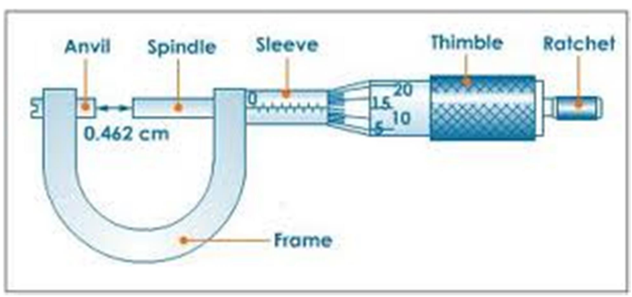
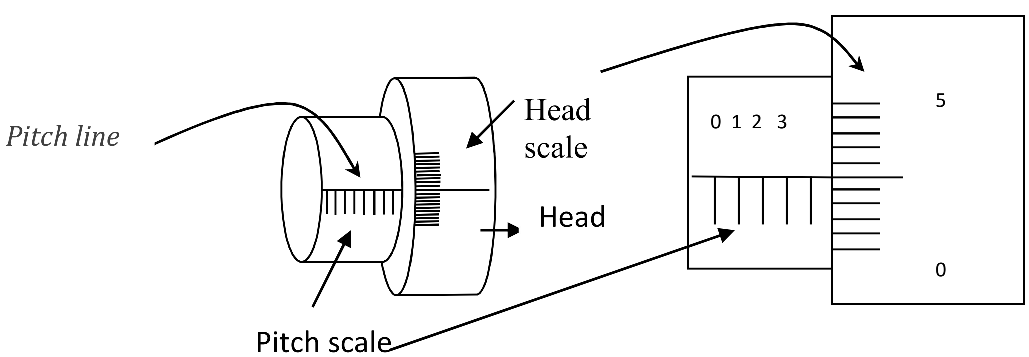


Figure: Screw gauge

PARTS OF A SCREW GAUGE:



The screw gauge has two scales – **pitch scale** and **head scale.** The pitch scale is graduated in mm while the head scale has no units.

OBSERVATIONS:

Least Count: The least count (LC) of the screw gauge is the ratio of the pitch to the total number 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.

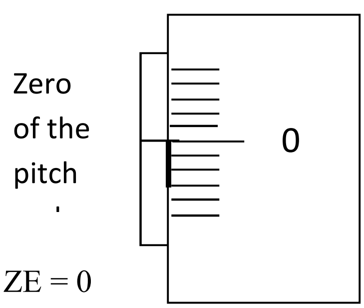
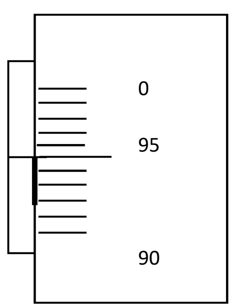
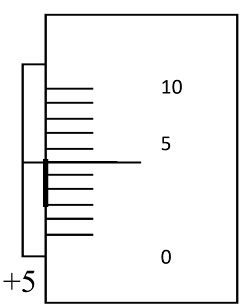
$$\text{Pitch} = \frac{\text{Distance moved on the pitch scale}}{\text{No. of rotations given to the head screw}}$$

For the screw gauge given the pitch scale is usually 1mm.

The head scale is **usually** divided into 100 divisions.

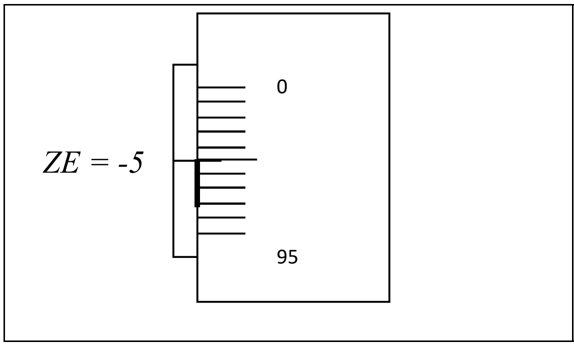
$$\text{Therefore}\quad LC = \frac{\text{Pitch}}{\text{Total no. of head scale division}} = \frac{1\text{mm}}{100} = 0.01\text{mm}$$

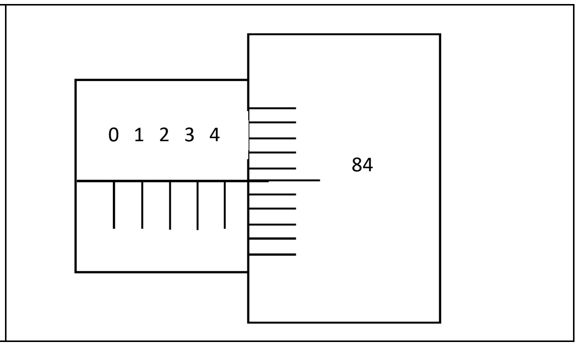
The head of the screw gauge is rotated until the plane faces that hold the object touch each other. Check to see whether the zero of the head scale coincides with the pitch line. If it does there is no zero error, but if it does not then note down the zero error (ZE).

 ZE = 0 If the zero of the head scale coincides with the pitch line then ZE = 0	ZE = -5  If the zero of the head scale lies above the pitch line then ZE is negative	ZE = +5  If the zero of the head scale lies below the pitch line then ZE is positive

Example, referring to the diagram below:

For example, referring to the diagram below





Zero Error = -5 ; Hence Zero Correction = + 5.

PSR = 4mm HSD = 84 TR = PSR + (HSD + ZC) x LC = 4 + (84 + 5) x 0.01 = 4.89mm

Tabular Column:

Table 1 : To find the thickness of the glass plate:

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

Zero Error (Z.E) = ________________ Zero Correction (Z.C) = __________________

Sl. No.	PSR	HSD	Corrected HSD CHSD = HSD + ZC	TR = PSR+ (CHSD X LC)
Unit	mm	div	div	mm
			Mean =	

Table 2 : To find the radius of the given wire:

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

Zero Error (Z.E) = ________________ Zero Correction (Z.C) = _________________

Sl. No.	PSR	HSD	Corrected HSD CHSD = HSD +ZC	TR = PSR+ (CHSD X LC)
Unit	mm	div	div	mm
			Mean =	

RESULT: The dimensions of the given object were determined.

(C) TRAVELLING MICROSCOPE

AIM: To determine the internal and external diameter of the given capillary tube using a travelling Microscope.

APPARATUS REQUIRED: Travelling Microscope.

1. Main scale: scale marked by half an mm.

2. Vernier scale gives interpolated measurements to 0.01mm or better.

A travelling microscope is used to determine small distance to an accuracy of 0.001 cm. The measurement principle is based on the principle of vernier. In a typical travelling microscope, the main scale divisions are of magnitude 0.05 cm (0.5 mm) each and the vernier scale contains 50 divisions. This makes the Least Count to be 0.05/50 = 0.001 cm.

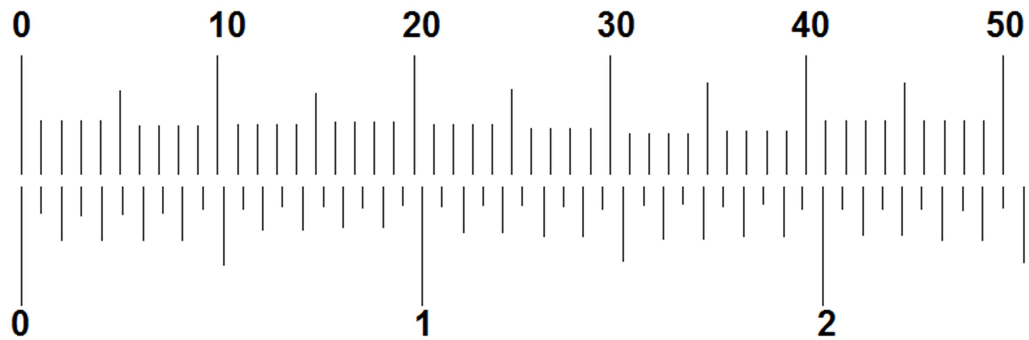
PROCEDURE:

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

(1) First note down whether the zero of the vernier scale coincides with a main scale reading. If it does then it is the main scale reading (MSR).
(2) If it does not coincide, then see between which two main scale readings the zero of the vernier lies.
(3) Note down the lower of the two reading as the main scale reading (MSR)
(4) Check which division of the vernier coincides with a main scale reading. Take the value of this division on the vernier as the coinciding vernier division (CVSD).
(5) The total reading (TR) is then given by TR = MSR + (CVSD x LC)cm.

Figure: Travelling Microscope

OBSERVATIONS:



Enlarged image of vernier scale.

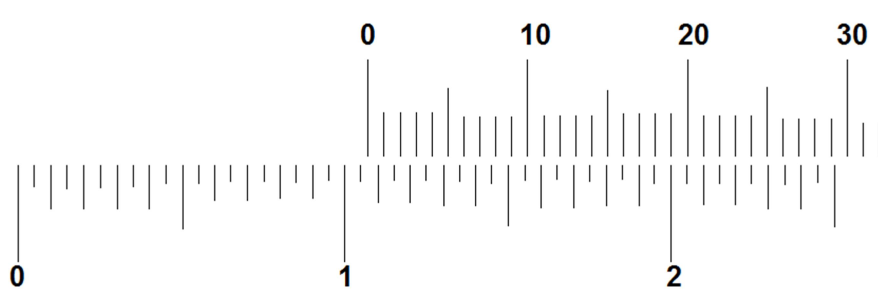
Least count: It is the smallest length that can be measured accurately by the travelling microscope.

$$\text{Least Count} = \frac{\text{Value of one main scale division}}{\text{Total no. of vernier scale division}}$$

$$= \frac{0.5\text{mm}}{50} = 0.01\text{mm} = 0.001\text{cm}$$

LC = 0.001cm.

Result: Using a travelling microscope, the internal and external diameter of the given capillary tube was determined.



For example referring to the figure drawn above

MSR = 1.05cm,   CVSD = 19,

TR = MSR + (CVSD x LC) = 1.05 + (19 x 0.001) = 1.05 + 0.019 = 1.069cm

Table 1 : To measure the internal and external diameter of the given capillary tube:

Least Count (LC) = $\frac{Value\ of\ one\ main\ scale\ division}{Total\ no.of\ vernier\ scale\ divisions}$ =

Sl. No.	MSR	CVSD	TR = MSR+ (CVSDXLC)
Unit	cm	div	cm
External left			
Internal left			
Internal right			
External right			
Internal diameter =		External diameter =	

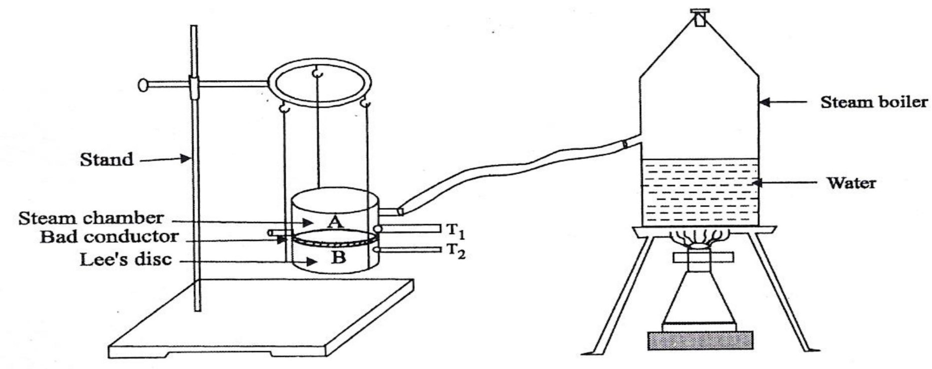


Figure 1: Lee's disc apparatus.

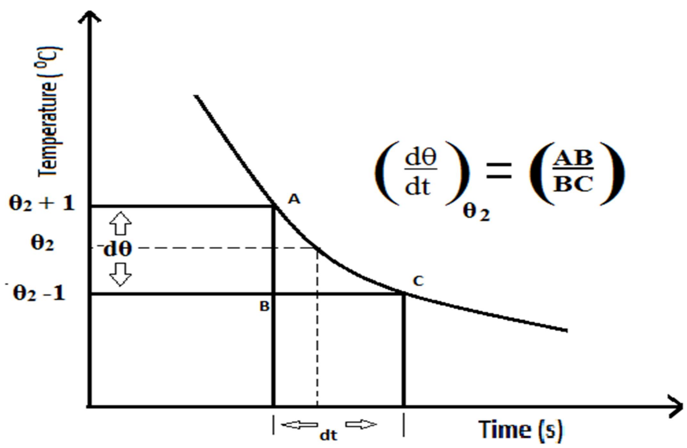


Figure. 2. Model graph for Temperature Vs Time.

Ex.No.1	THERMAL CONDUCTIVITY OF A BAD CONDUCTOR USING LEE'S DISC APPARATUS
Date:	

AIM

To determine the thermal conductivity of the given bad conductor using Lee's disc apparatus.

APPARATUS REQUIRED

Lee's disc, bad conductors (card board disc of uniform thickness, glass or ebonite), two thermometers, stop clock, steam boiler, screw gauge, vernier calipers.

PRINCIPLE

At the steady state, the quantity of heat conducted across the bad conductor disc per second is equal to the quantity of heat radiated per second from the bottom surface and side surface of the lower Lee's disc.

FORMULA

$$K = \frac{MS\left(\frac{d\theta}{dt}\right)_{\theta_2} d}{\pi r^2 (\theta_1 - \theta_2)} \frac{(r + 2h)}{(2r + 2h)} \text{ watt metre}^{-1} \text{ kelvin}^{-1}$$

Symbol	Explanation	Unit
M	Mass of the metallic disc (940 g)	kg
S	Specific heat capacity of the material of the Lee's disc(370 J/kg/K)	$Jkg^{-1}K^{-1}$
$\left(\frac{d\theta}{dt}\right)_{\theta_2}$	Rate of cooling at steady temperature θ_2°C	°C/Sec
θ_1	Steady temperature of the steam chamber	°C
θ_2	Steady temperature of the metallic Lee's disc	°C
d	Thickness of the bad conductor (Card board)	meter
r	Radius of the metallic Lee's disc	meter
h	Thickness of the metallic Lee's disc	meter

Table 1 : To find the rate of cooling of the metallic Lee's disc $\left(\frac{d\theta}{dt}\right)_{\theta_2}$

Steam temp. of the steam chamber (θ_1) = -----°C.   Steady temp. of the metallic disc (θ_2) = -----°C

Sl. No.	Temperature (θ)	Time (t)
Unit	°C	sec
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11(θ_2)		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		

Table 2 : To find the thickness of the bad conductor (d) using screw gauge :

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

Zero Error (Z.E) = ________________   Zero Correction (Z.C) = _________________

Sl. No.	PSR	HSD	Corrected HSD = HSD +ZC	TR = PSR+ (CHSD X LC)
Unit	mm	div	div	mm

Mean=

PROCEDURE

The Lee's disc apparatus is suspended from a stand as shown in the Fig. The given bad conductor (card board) is placed in between the metallic disc and the steam chamber. Two thermometers T_1 and T_2 are inserted in the respective holes.

Steam from the steam boiler is passed into the steam chamber until the temperature of the steam chamber and the metallic disc are steady. The steady temperature (θ_1) of the steam chamber and (θ_2) of the metallic disc recorded by the thermometers are noted.

Now the bad conductor is removed and the steam chamber is placed in direct contact with the metallic disc. The temperature of the disc rapidly rises. When the temperature of the disc rises about 10°C above θ_2 °C (Steady temperature of the disc), the steam chamber is carefully removed, after cutting off the steam supply.

When the temperature of the disc reaches 10°C above the steady temperature of the disc i.e., (θ_2+10) °C, a stop clock is started. Time for every 1°C fall of temperature is noted until the metallic disc attains a temperature (θ_2 - 10) °C.

The mean radius of the disc is measured using vernier caliper or by finding the circumference of the disc using a thread ($2\pi r$). The mean thickness of the cardboard and that of the metallic Lee's disc are found using screw gauge. The mass of the metallic disc is also found using a common balance. The readings are tabulated. Substituting all the parameters in the formula, the coefficient of thermal conductivity of the bad conductor can be calculated.

GRAPH

A graph is drawn taking time along the X – axis and temperature along the Y – axis. The cooling curve is obtained (Fig.). To obtain the rate of cooling $\left(\frac{d\theta}{dt}\right)_{\theta_2}$ from this graph, a triangle is drawn by taking 1°C above and 1°C below the steady temperature θ_2. Then, the slope AB/BC gives the rate of cooling $\left(\frac{d\theta}{dt}\right)$ at θ_2. From these readings and using the given formula the thermal conductivity of the given bad conductor is calculated.

Table 3 : To find the thickness of the metallic disc (h) using screw gauge :

Sl. No.	PSR	HSD	Corrected HSD = HSD +ZC	TR = PSR+ (CHSD X LC)
Unit	mm	div	div	mm

Mean =

CALCULATION

Mass of the metallic disc M=---------------g = -----------X10^{-3}kg

Specific heat capacity of the metallic disc S=-----------------------------------J/kg/K

Radius of the metallic disc r=--------------cm = -------------X10^{-2} meter

Thickness of the metallic disc h=---------------mm = ---------- X10^{-3} meter

Thickness of the card board d=----------------mm = --------- X10^{-3} meter

Steady state temperature of steam chamber θ_1=--------------°C = ------------K

Steady state temperature of the disc θ_2=--------------°C = ------------K

Rate of cooling $\left(\frac{d\theta}{dt}\right)_{\theta_2}$ at steady state temperature θ_2 °C= --------------°C/s (from graph)

$$K = \frac{MS\left(\frac{d\theta}{dt}\right)_{\theta_2} d}{\pi r^2 (\theta_1 - \theta_2)} \frac{(r + 2h)}{(2r + 2h)} \text{ W m}^{-1} \text{ K}^{-1}$$

=

=

RESULT

Thermal conductivity of the given bad conductor = ------------------------------ W m^{-1} K^{-1}

SAMPLE VIVA QUESTIONS

1. What is thermal conductivity? What is its unit?

   Ans : It is defined as the quantity of heat conducted per second normally across unit area of cross-section of the material per unit temperature difference. It denotes the heat conducting power. Its unit is Watt / meter / Kelvin.

2. Does the value of thermal conductivity depend on the dimension of the specimen?

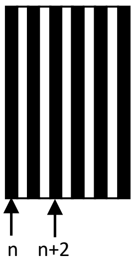
   Ans : No, it depends only on the material of the specimen.

3. Is there any reason to take the specimen in the form of a disc?

   Ans : A thin disc is taken because its area of cross section is large, while thickness is small. It increases the quantity of heat conducted across its faces.

4. Can this method be used for good conductors?

   Ans : No, in that case, due to large conduction of heat, the temperature recorded by T_1 and T_2 will be very nearly the same.



Fringe pattern obtained by forming air wedge.

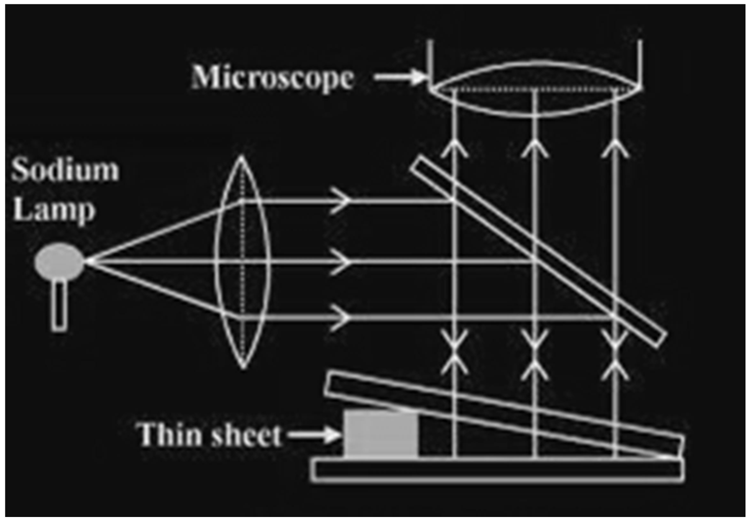


Figure 1: Air wedge apparatus

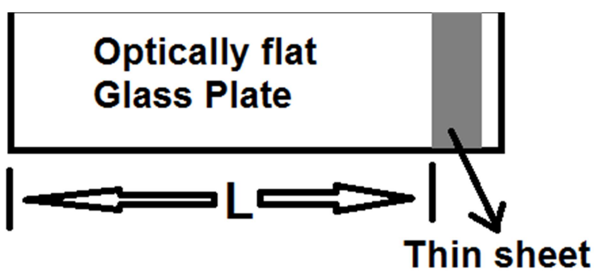


Figure 2. To measure the length L of the air wedge.

Ex.No.2	INTERFERENCE AT A WEDGE
Date:	

AIM

To determine the thickness of a thin paper piece by setting up interference fringes at an air wedge.

APPARATUS REQUIRED

Two (optically flat) thick glass plates, sodium vapour lamp, travelling microscope, a thin paper piece, reflecting glass plate, reading lens and a scale.

PRINCIPLE

When a piece of paper is placed between two optically plane glass plates, a wedge shaped air film is formed between the two plates. If a parallel beam of monochromatic light is made to incident normally on the wedge (upper glass plate), the beam gets refracted through the upper glass plate. Two reflected rays from the upper and lower positions of the air film form two coherent sources. As the two portions in the reflected beam, are derived from the same incident beam and have path difference, they produce interference. The interference pattern, when viewed through a travelling microscope, appears as equally spaced alternate dark and bright straight fringes, parallel to the edge of the wedge.

FORMULA

Thickness of the given material,

$$t = \frac{\lambda L}{2\beta} \text{ meter.}$$

Symbol	Explanation	Unit
t	thickness of the paper	meter
λ	wavelength of sodium light(589.3)	nm
L	length of the air wedge	meter
β	fringe width	meter

Observations: Least count of the Traveling Microscope (T.M):

Least Count (LC) = $\frac{Value\ of\ one\ main\ scale\ division}{Total\ no.of\ vernier\ scale\ divisions}$ =

Table 1. Travelling Microscope readings for different fringes

Fringe Number	Microscope Reading		
	MSR	CVSD	TR = MSR + (CVSD x LC)
Unit	cm	div	cm
n			
n+2			
n+4			
n+6			
n+8			
n+10			
n+12			
n+14			
n+16			
n+18			
n+20			

Table 2. To find the fringe width (β) using Travelling Microscope:

Fringe Number	Microscope reading	Fringe Number	Microscope reading	Width of 10 fringes
	TR		TR	
	cm		cm	cm
n		n+10		
n+2		n+12		
n+4		n+14		
n+6		n+16		
n+8		n+18		
n+10		n+20		

Average width of 10 fringes is X = _____________ x10^{-2}m.

The fringe width (β) is X/10 = _____________ x10^{-2}m.

Experimental Setup

The given optically plane glass plates and the reflecting glass plate are cleaned well by using muslin cloth before starting the experiment. The optically plane glass plates are kept one above the other. A thin rectangular paper piece is inserted between the glass plates at one extreme end, such that the piece of paper is perpendicular to the length of the glass plate. Now a wedge shaped air film is formed in between the plates. The thickness of the air film gradually increases, from the point of contact of glass plate, till the inner edge of the paper piece.

Now illuminate the air wedge by a parallel beam of sodium light using reflecting glass plate by making an angle of inclination 45˚ to the horizontal as shown in the diagram. The whole setup is kept below the objective of the travelling microscope such that the illuminated portion of the air wedge comes under the field of view of travelling microscope. Then focus the travelling microscope using rack and pinion screw such that the alternate dark and bright interference fringes are clearly seen.

Procedure to measure the fringe width

The least count of travelling microscope is determined by finding the ratio of the value of one main scale division to the total number of vernier scale divisions.

The vertical cross wire is adjusted to be at the center of any one of the dark fringes. The reading on the main scale and the coinciding vernier scale division are noted. Let this fringe be the n^{th} dark fringe.

Next, the reading corresponding to the dark fringes n+2, n+4, n+6 up to n+22 are noted. The microscope may be moved either to the left or right side for this purpose.

The readings are tabulated in the observation column and the width of 10 dark fringes is calculated. The average width of 10 dark fringes and hence the fringe width, β, is calculated.

The length of the air wedge between the point of contact of the glass plates and the inner edge of the paper piece is measured using traveling microscope / scale.

The thickness of the given paper is calculated using the formula.

RESULT

Thickness of the given object (t) = ________________μm.

CALCULATION

Length of the air wedge L= ________________ $\times 10^{-2}$ m.

Wave length of the sodium light λ = ________________ nm.

Fringe width β = ________________ $\times 10^{-2}$ m

$$t = \frac{\lambda L}{2\beta} =$$

$$=$$

$$=$$

SAMPLE VIVA QUESTIONS.

1. What is an air wedge?

When a monochromatic light is made to fall normally on the optical flat consisting of a thin paper piece between the two optical flats which forms an air film in wedge shape is called air wedge.

2. Name the phenomena on which this experiment is based.

Ans: Interference of Light.

3. Define Interference.

Ans: When the two waves superimpose over each other, resultant intensity is modified. The modification in the distribution of intensity in the region of superposition is called interference.

4. Is there any loss of energy in interference phenomenon?

Ans: No, there is only redistribution of energy (energy from dark places is shifted to bright).

5. What are interference fringes?

Ans: They are alternately bright and dark patches of light obtained in the region of superposition of two wave trains of light.

6. What is the necessity of keeping the inclined glass plate at an angle 45^0?

Ans: To make the light to fall normally on the air wedge apparatus. When the rays fall normally, the angle of incidence and angle of reflection are equal to zero. This is done for the convenience of the experiment.

7. What is the shape of fringes in wedge shaped film?

Ans: The fringes in wedge – shaped film are straight line fringes.

8. How are the straight fringes formed?

Ans: Straight fringes are formed due to the interference in thin air film formed between the lower surface of the upper glass plate (optical flat) and upper surface of the lower glass plate.

9. When white light is used to illuminate the slit, what is the color of fringes?

Ans: When white light is used to illuminate the slit, the edge of wedge is dark, with separate colored fringes from violet to red.

10. What are the applications of the air wedge experiment?

Ans: a. It is used to determine the wavelength of the monochromatic source

b. It is used to determine the thickness of a thin paper.

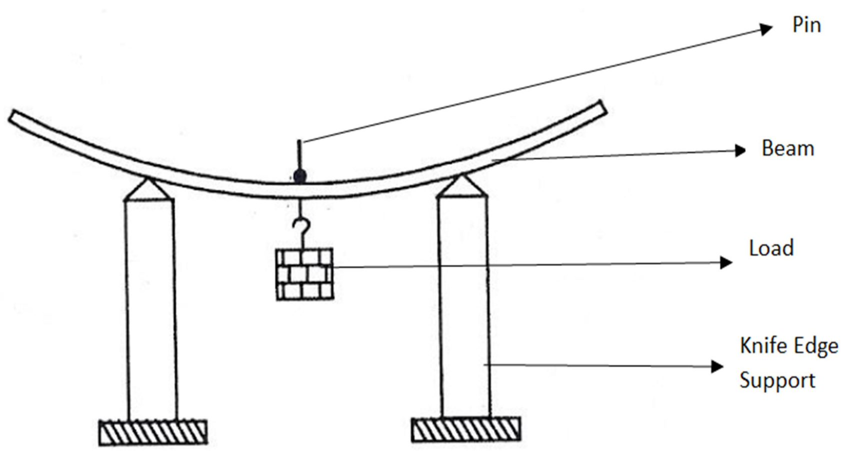


Figure 1: Setup to find Young's modulus of elasticity by non-uniform bending of beam.

Table 1: Microscope reading for different loads:

Least Count (LC) = $\frac{\textit{Value of one main scale division}}{\textit{Total no.of vernier scale divisions}}$ =

S. No.	Load	Microscope Reading						Mean (TR)
		Load increase			**Load decrease**			
		MSR	CVSD	**TR** =MSR + (CVSD x LC)	MSR	CVSD	**TR** = MSR + (CVSDx LC)	
Unit	x 10^{-3} kg	cm	div	cm	cm	div	cm	cm
1	W							
2	W + 50							
3	W + 100							
4	W + 150							
5	W + 200							

Ex.No.3	YOUNG'S MODULUS ---- NON-UNIFORM BENDING
Date:	

AIM

To find the Young's modulus of the material of a uniform bar (meter scale) by non-uniform bending.

APPARATUS REQUIRED

Travelling Microscope, two knife edge supports, weight hanger with set of weights, pin, meter scale, screw gauge, Vernier calipers.

PRINCIPLE

In non-uniform bending method, the load is applied at the center of the beam and the bent beam doses not form an arc of a circle.

FORMULA

Young's Modulus of the beam

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

Symbol	Explanation	Unit
Y	Young's modulus of the beam	N/m^2
M	Mass of the slotted weight	Kg
g	Acceleration due to gravity	m/sec^2
l	Length of the beam between the knife edges	m
b	Mean breadth of the beam	m
d	Mean thickness of the beam	m
δ	Depression at the center of the beam for the load M kg	m

Table 2: To find depression 'δ' :

M = ______________ x 10^{-3} kg

Load	Mean TR	Load	Mean TR	Depression δ for M kg
x 10^{-3} kg	cm	x 10^{-3} kg	cm	cm
W		W + 50		
W + 50		W + 100		
W + 100		W + 150		
W + 150		W + 200		
Average depression δ for 50 g = x10^{-2} m				

Table 3: To find breadth of the beam (b) using Vernier calipers:

Least Count (LC) = $\frac{\textit{Value of one main scale division}}{\textit{Total no.of vernier scale divisions}}$ =

Sl.No.	MSR	CVSD	TR = MSR+ (CVSD X LC)
Unit	cm	div	cm
			Mean (b) = x10^{-2} m

Table 4: To find the thickness (d) of the beam using screw gauge:

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

Zero Error (Z.E) = ________________ Zero Correction (Z.C) = __________________

Sl.No.	PSR	HSD	Corrected HSD = HSD + Z.C	TR = PSR+ (CHSD X LC)
Unit	mm	div	div	mm
				Mean (d) = x10^{-3} m

PROCEDURE

A long uniform beam is placed symmetrically on the knife edges so that equal lengths of it project beyond the knife edges on either side. The weight hanger is suspended exactly from the midpoint of the beam as shown in the figure. A pin pointing upwards is fixed vertically at the centre of the beam. A travelling microscope is adjusted horizontally and focused to the tip of the pin. A preliminary experiment is done by adding equal weights one by one and removing them one by one so that the beam is brought to elastic mode.

RESULT

Young's modulus (Y) of the material of the given bar (meter scale) = ____________________ N/m^2.

SAMPLE VIVA QUESTIONS.

1. State Hooke's law if elasticity.

Ans. Stress is proportional to strain within elastic limits.

2. In scientific jargon in what unit is the modulus of elasticity expressed?

Ans. Pascal

3. Supposing the breadth, length and the thickness of the cantilever are altered, is there a variation in the Young's modulus?

Ans. No, because it is a constant for a given material.

4. What is Yield point?

Ans. 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, this point is called Yield point.

5. What is stress and what is strain?

Ans. Restoring force per unit area is stress and fractional deformation is called strain.

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

Ans. Yes

7. What is the dimension of strain?

Ans. It is a dimensionless quantity.

Calculation:

Distance between two knife edges l = ____________________ $\times 10^{-2}$ m

Depression for load applied δ = ____________________ $\times 10^{-2}$ m

Load applied M = ____________________ kg

Breadth of the beam b = ____________________ $\times 10^{-2}$ m

Thickness of the beam d = ____________________ $\times 10^{-3}$ m

Young's modulus of the material of the beam,

$$Y = \frac{Mgl^3}{4bd^3\delta}$$

=

=

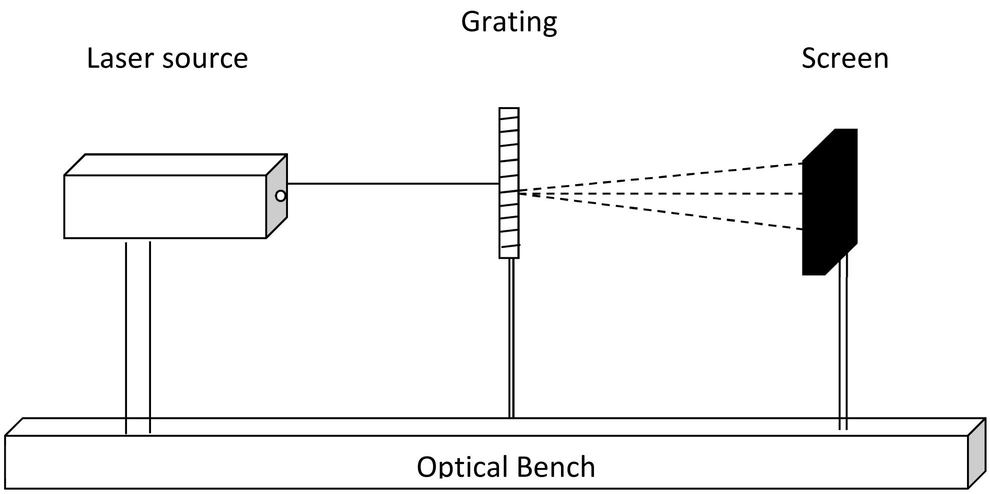
Y = ____________________ N / m^2

8. What is a cantilever?

Ans. It is a homogenous beam whose length is more compared to its transverse dimensions.

9. Of the stress and strain which is independent.

Ans Strain is independent and stress is dependent.



Precaution: An unfocused 1-mW He Ne laser has brightness equal to sunshine on a clear day (0.1 watt/cm^2) and is just as dangerous to stare at Sun directly. Hence don't look at the laser directly.

Diffraction pattern

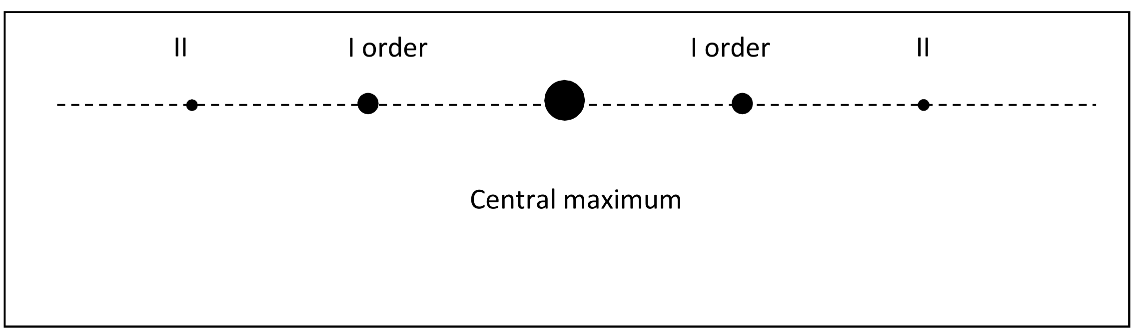


Figure 1. Schematic representation of Experimental Setup

Ex.No.4	LASER DIFFRACTION
Date:	

AIM

To determine the grating constant of a given grating and hence calculate the number of lines per unit length (LPI) using laser diffraction method.

APPARATUS REQUIRED

Optical bench with suitable accessories, He-Ne Laser source, diffraction grating, measuring scale and screen.

PRINCIPLE

Diffraction of light is the phenomenon of bending of light waves around opaque obstacles, whose dimensions are comparable with the wavelength of the light used.

FORMULA

a) Grating Constant of the given diffraction grating.

$$d \sin\theta = n\lambda \quad \text{or}$$

$$d = \frac{n\lambda}{\sin\theta} \quad \text{in nm.}$$

Symbol	Explanation	Unit
d	Grating constant or distance between two consecutive rulings	nm
n	Order of diffraction	--
λ	Wavelength of the light used	nm
θ	Angle of diffraction	degree

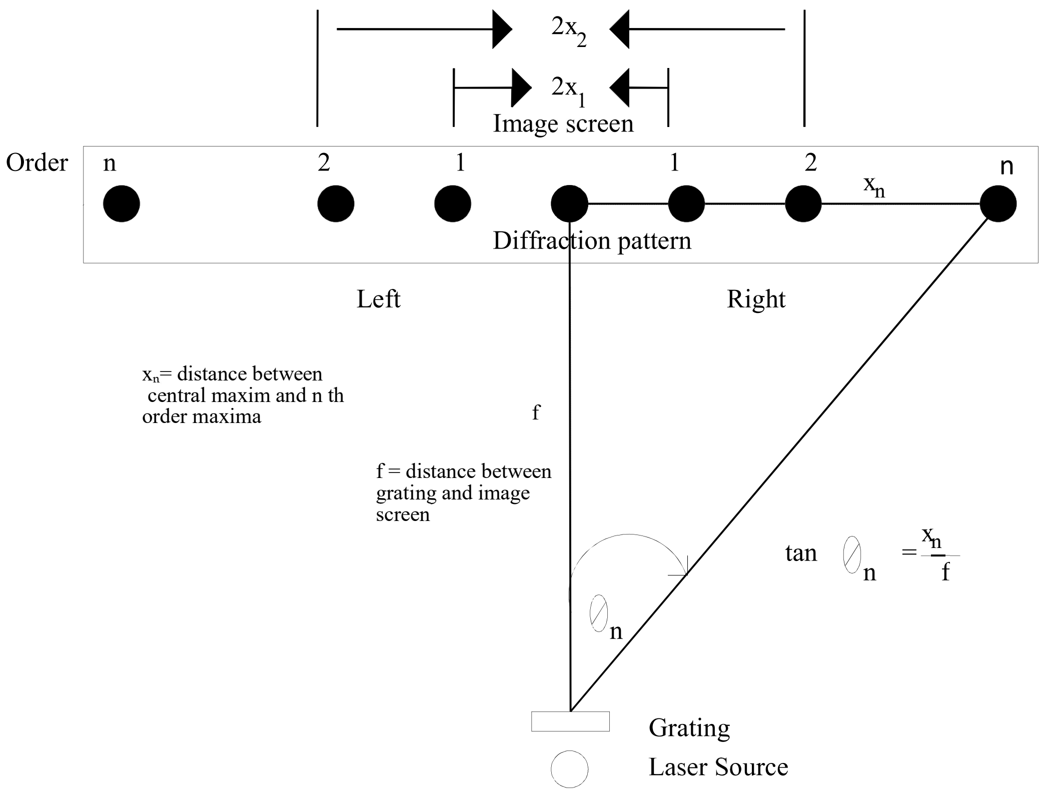


Figure 2. Measurement of Diffraction Angle.

$$\theta_n = \tan^{-1}\left(\frac{x_n}{f}\right)$$

Symbol	Explanation	Unit
θ_n	diffraction angle of n^{th} order	degree
x_n	Distance of n^{th} order diffraction pattern from the centre 0^{th} order diffraction	cm
f	Distance between screen and grating	cm

b) Number of lines per inch

$$N = 1/d$$

Symbol	Explanation	Unit
N	No. of lines per inch (LPI)	
d	Grating constant	nm

DESCRIPTION

Interference and diffraction are the main phenomena which demonstrate the wave nature of the light. There are many optical devices, where these phenomena can be observed. Diffraction grating is one of them, Diffraction grating is an optically plane glass plate over which a large number of fine parallel straight lines are ruled at equal intervals. The rulings are made by means of a sharp diamond point with the help of a driving engine. This engine moves back and forth in a straight line and shifts the diamond point, by equal distance laterally after completing each movement (The lines are ruled perpendicular to the length of the plate). The lined portion acts as obstacle and the space between will acts as a slit. The laser light bends round the corners of the line.

The grating that we make use of in the laboratory is usually the one with 500 lines per inch. When light from a helium-neon laser strikes at right angles to the diffraction grating it is diffracted on each side in multiple orders.

PROCEDURE

The He-Ne laser is kept horizontally and switched on (extreme care should be taken to avoid direct exposure of laser light on eyes).

Trail (1) : Distance between grating and screen (f) = ------------------cm.

Stick the diffraction pattern (located spots) here.

Order of diffraction (n)	Readings of the diffracted image			Grating constant $d = \frac{n\lambda}{\sin\theta}$
	Distance $2x_n$	Distance x_n	Diffraction angle $\theta_n = \tan^{-1}\left(\frac{x_n}{f}\right)$	
Unit	cm	cm	degrees	nm
1				
2				
3				

Table 1: Finding out Grating constant

Trail (2) : Distance between grating and screen (f) = ------------------cm.

Stick the diffraction pattern (located spots) here.

Order of diffraction (n)	Readings of the diffracted image			Grating constant $d = \frac{n\lambda}{\sin\theta}$
	Distance $2x_n$	Distance x_n	Diffraction angle $\theta_n = \tan^{-1}\left(\frac{x_n}{f}\right)$	
Unit	cm	cm	degrees	nm
1				
2				
3				

The grating is held normal to the laser beam. This is done by adjusting the grating in such a way that the reflected laser beam coincides with beam coming out of the laser source.
After adjusting for normal incidence, the laser light is exposed to the grating and it is diffracted by it. On the screen, placed on the other side of the grating, the diffracted laser spots are seen. The distances of different orders from the center spot (x_n) are measured.

The distance between the grating and screen (f) is measured. The experiment may be repeated for different 'f' values say (70 cm, 75cm, 80 cm etc,). Using the formula, 'θ' is calculated. The wave length of the laser light source is given. The grating constant (d) and number of lines per length (N) of the given diffraction grating were found using the formula.

RESULT

a) The grating constant of the given diffraction grating (d) = ______________ nm.

b) Number of lines per Inch (N) = ______________ LPI.

SAMPLE VIVA QUESTIONS.

1. What is LASER?

Ans. It is the Acronym of Light Amplification by Stimulated Emission of Radiation. It is a device which produces a powerful, monochromatic collimated beam of light in which the waves are coherent.

2. What is diffraction?

Ans. Diffraction is a phenomenon of bending of waves around the edges of an obstacle when the size of the obstacle is comparable to the wavelength of the light.

3. Distinguish between Interference and Diffraction.

Ans. Interference is due to the resultant effect of overlapping of light waves, originating from two coherent sources. Diffraction is due to the resultant effect of overlapping of light waves originating from every point on the exposed part of the same wave front. The fringe width in Interference could be either constant or varying .In diffraction the fringe width always varies.

CALCULATION

Number of lines per inch of the grating, N = $\frac{1}{d}$ =

(Note: Convert m into inches. 1 inch = 2.54 cm)

4. What is transmission grating?

Ans. Grating is an optically plane glass plate on which a very large number of equally spaced parallel straight rulings are made with a diamond point. Since diffraction effects are observed by way of transmission of light, it is called as plane transmission diffraction grating.

5. Define grating constant?

Ans.The distance between two corresponding positions of two consecutive rulings is called the grating constant. (width of the slit + width of the line).

6. How do you distinguish between diffraction and refraction?

Ans. Since bending effect varies with wavelength, the constituent colors in the white light of undergo deviations to different extents depending on their own wavelength according to the relation d sinθ =n λ, resulting in the diffraction spectrum. Here the bending effect is more for longer wavelength; say yellow deviates more than the blue light.

In refraction the deviation **d α n α1/λ,** hence blue light deviates more than the yellow light. Because of this inverse effect the spectrum obtained by a diffraction grating is in the reverse order compared to that obtained by a prism.

7.What is the difference between ordinary light and laser light?

Ans

Ordinary light	Laser light
Incoherent light.	highly coherent.
High divergence	Low divergence
Emits in all directions.	Unidirectional

OBSERVATIONS:

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

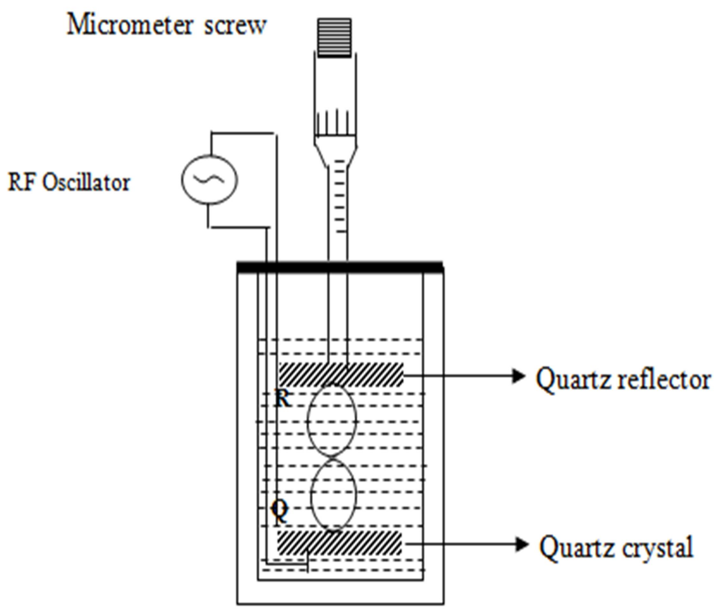


Figure 1. Ultrasonic Interferometer Setup

Ex.No.5	ULTRASONIC INTERFEROMETER
Date:	

AIM

To measure the velocity of ultrasonic waves in liquid and hence to calculate the compressibility of the given liquid.

APPARATUS

A double walled cylindrical vessel containing liquid, RF power oscillator and a crystal (frequency = 2MHz), quartz crystal plate fitted with micrometer screw and micro ammeter (AC).

PRINCIPLE

An Ultrasonic interferometer is a simple device to measure the ultrasonic velocity in liquid with high degree of accuracy .The principle used in the measurement of velocity is based on acoustic resonance. Ultrasonic waves of known frequency (f) are produced by a quartz crystal fixed at the bottom of the cell. These generated waves move up in the liquid column and are reflected by a movable similar crystal placed above and parallel to the first quartz crystal. Stationary waves are formed inside the liquid due to the superposition of the incident and reflected waves. If the separation between these plates is exactly integral multiple of half wavelength; standing waves are formed in the medium. This acoustic resonance gives rise to an electrical reaction on the generator driving the quartz crystal and the anode current of the generator becomes maximum. Velocity of ultrasonic waves can be calculated using the relevant formula.

Ultrasonic interferometer basically contains two units:

1. **High frequency generator:** which is designed to excite the quartz crystal fixed at the bottom of the measuring cell at its resonant frequency to generate ultrasonic waves in the experimental liquid.

Table 1: Micrometer reading corresponding to maximum anode current

Liquid used:___________________________

Micro meter reading (mm)				Micro meter reading (mm)				Length of 10 loops. D $=X_1 \sim X_2$
Serial No of the loop	PSR	HSD	TR (X_1)	Serial No of the loop	PSR	HSD	TR (X_2)	
Unit	mm	div.	mm		mm	div	mm	mm
n				n+10				
n+1				n+11				
n+2				n+12				
n+3				n+13				
n+4				n+14				
n+5				n+15				
n+6				n+16				
n+7				n+17				
n+8				n+18				
n+9				n+19				

Mean D =____X10 $^{-3}$ m

Length of single loop = $\lambda/2 = (D/10)_{mean} = d =$ ______ m

Hence the wavelength = $\lambda = 2d =$ __________ m

2. **Measuring cell:** it is a specially designed doubled walled cell for maintaining the temperature of the experimental liquid constant throughout the experiment. A fine micrometer screw has been provided at the top, which can lower or raise the reflector plate in the liquid in the cell through a known distance.

FORMULA

$$v = \lambda f \quad m/s$$

Symbol	Explanation	Unit
v	velocity of ultrasonic waves in liquid	m/s
λ	wavelength of ultrasonic wave	m
f	frequency of the given crystal (f =2 MHz.)	Hz

$$\beta = 1 / \rho v^2$$

Symbol	Explanation	Unit
β	Compressibility of the liquid	m^2/N
ρ	density of the given liquid	kg m^{-3}
v	velocity of the ultrasonic wave in liquid	m/s

PROCEDURE

1. The apparatus is as shown in the figure. Unscrew the knurled cap of cell and lift it away from double walled construction of the cell. In the middle portion of it pour experimental liquid and screw the knurled cap.
2. Insert the cell in the base socket and clamp it with the help of a screw provided on its side.[Above two arrangements are made before the apparatus is given to the students.]

Calculation: $v = \lambda f =$ $=$;

$$\beta = \frac{1}{\rho v^2} = \qquad = \qquad ;$$

3. Connect the high frequency generator with cell by co-axial cable provided with the instrument.
4. For initial adjustment two knobs are provided on high frequency generator, one is marked with "ADJ" to adjust the position of the needle on the ammeter and the knob marked "GAIN" is used to increase the sensitivity of the instrument for greater deflection.
5. Move the micrometer for an initial reading of say 10mm. Now lower the micrometer slowly till the anode current in the ammeter on the high frequency generator shows a maximum current. Note down the reading on the micrometer. **Let this reading be for n^{th} loop.**
6. Micrometer screw is further moved slowly in the **same direction** till the micrometer again shows the maximum reading for the loop n+1. The experiment is repeated up to the loop n+19. For each maximum current position the micrometer reading is noted and the readings are tabulated.
7. Determine velocity of ultrasonic waves (V) by using the relevant formula.

RESULT: The ultrasonic velocity of a given liquid is __________ ms^{-1}

The compressibility of the liquid = _______________ m^2/N.

SAMPLE VIVA QUESTIONS

1.What are ultrasonic waves? **Ans:** They are sound waves whose frequencies are higher than the human audibility limit i.e., 20 KHz.

2. What is piezoelectricity? **Ans:** When certain crystals like quartz, tourmaline are sliced in a particular fashion, and their opposite faces are subjected to pressure, positive and negative charges appear on the faces perpendicular to the direction of application of the force. If the pressure is changed to tension, the polarity of the charges will also be reversed. This phenomenon is called Piezoelectricity.

3. What happens when the frequency of the applied electric field coincides with the natural frequency of the crystal? **Ans:** Acoustic resonance occurs at which the amplitude of vibration of the crystal becomes maximum.

4. What are the factors on which frequency of vibration of quartz crystal depend?
Ans: The dimensions of the crystal and the crystal cut determine the resonant frequency of the vibration of the crystal. The frequency of vibration is inversely proportional to the thickness.

5. Mention some applications of piezoelectric crystals?

Ans: Piezo electric crystals are used in crystal microphones, frequency control of oscillators, electronic wrist watches, digital instruments, etc…

6. What is the function of Radio Frequency (RF) oscillator?

Ans: The RF oscillator generates and supplies the alternating voltage to the crystal and forces it to vibrate in the ultrasonic range of frequencies in this experiment.

7. Mention some uses of ultrasonic waves?

Ans: Ultrasonic waves are used (i) to communicate with under water submarines (ii) in echo depth sounding to locate the position of the bottom of the sea. (iii) To destroy diseased tissues in animal body, (iv) to detect internal flaws in a metal stretch.

8. What is acoustic grating?

Ans: When incident and reflected ultrasonic waves superpose to produce stationary oscillations in a liquid column. The column behaves like a grating. At nodes the liquid will be under maximum compression which renders its density to become high due to which it becomes almost opaque. At anti nodes the liquid will be pushed away due to intense vibrations and rarefies the liquid i.e., it becomes transparent. This refers to as acoustic grating.

Table 1: Determination of 'f' in transverse mode.

Trail	Mass in the pan m	Tension T = (m +S)g	$\sqrt{T}$	No. of loops	Total length	Length of each loop l	$\left(\frac{\sqrt{T}}{l}\right)$
Unit	g	N	N		$X10^{-2}m$	$X10^{-2}m$	N / m
1	20						
2	40						
3	60						

Mean =

Table 2: Determination of 'f' in longitudinal mode .

Trail	Mass in the pan m	Tension T = (m +S)g	$\sqrt{T}$	No. of loops	Total length	Length of each loop l	$\left(\frac{\sqrt{T}}{l}\right)$
Unit	g	N	N		$X10^{-2}m$	$X10^{-2}m$	N / m
1	20						
2	40						
3	60						

Mean =

Ex.No.6	FREQUENCY DETERMINATION – MELDE'S APPARATUS
Date:	

AIM

To determine the frequency of the electrically maintained tuning fork in the longitudinal and transverse modes.

APPARATUS REQUIRED

Electric Tuning Fork, battery eliminator 2-12 V DC, 3A, weight box, pulley, string.

PRINCIPLE

When an electrically maintained tuning fork vibrates, the string attached to it vibrates with a frequency equal to the frequency of the fork in the transverse mode of vibration and twice the frequency of the fork in the longitudinal mode of vibration.

FORMULA

Frequency of the tuning fork

a) Transverse mode of vibration $$f=\left(\frac{1}{2\sqrt{\mu}}\right)\left(\frac{\sqrt{T}}{l}\right) \text{Hz}$$

b) Longitudinal mode of vibration $$f=\left(\frac{1}{\sqrt{\mu}}\right)\left(\frac{\sqrt{T}}{l}\right) \text{Hz}$$

where, $\mu=\frac{M}{L}$ Kg/m T = (m + S) g Newton.

Symbol	Explanation	Unit
f	Frequency of the tuning fork	Hz
μ	Linear density of the string (1.17×10^{-4}) (mass per unit length of the string)	kg/m
T	Tension in the string	N
l	Length of the single loop	meter
M	Total mass of the string	kg
L	Total length of the string	meter
m	Mass in the scale pan	kg
S	Mass of the scale pan (20)	g
g	Acceleration due to gravity (9.8)	m/s^2

CALCULATION

a) Transverse mode of vibration

$$f = \left(\frac{1}{2\sqrt{\mu}}\right)\left(\frac{\sqrt{T}}{l}\right) \text{Hz} \qquad =$$

b) Longitudinal mode of vibration

$$f = \left(\frac{1}{\sqrt{\mu}}\right)\left(\frac{\sqrt{T}}{l}\right) \text{Hz} \qquad =$$

PROCEDURE

The tuning fork is electrically maintained to vibrate by connecting in series with a battery, plug key etc. When a current is passed through the electromagnet inserted, it draws the prongs towards it. This breaks the contact between the spring and the screw and the current stops. The electromagnet can no longer attract the prongs, which therefore, fly back to their original positions and the contact is again established. The prongs are again drawn inwards. This process repeats and the prongs vibrate. The frequency of vibration is a constant, depending on the parameters related to the fork.

A long flexible thread is attached to the end of a prong and the thread is passed over a frictionless pulley (P) fixed near the edge of the table. A scale pan is attached to the end of the thread and weights can be placed in the pan to keep the thread stretched.

By making the thread parallel to the length of the prongs, transverse waves can be produced in the thread. If the thread is perpendicular to the length of the prongs, longitudinal waves will be set up in the thread.

TRANSVERSE MODE OF VIBRATION OF THE STRING :

The length of the string is **parallel** to the prong of the tuning fork to which one end of the string is attached. When excited, the fork vibrates in a direction perpendicular to the length of the string. The circuit is carefully adjusted so that we get well defined loops in the string. The total length of the finite number of well defined loop is measured and the average length of one loop is found. The experiment is repeated for different number of loops formed on the thread by adjusting the mass m.

LONGITUDINAL MODE OF VIBRATION OF THE STRING:

The length of the string is **perpendicular** to the prong of the tuning fork. When excited, the fork vibrates in a direction parallel to the length of the string. The circuit is carefully adjusted so that we get well defined loops in the string. The total length of the finite number of well defined loops is measured and the average length of one loop is found. The experiment is repeated for different number of loops formed on the thread by adjusting the mass m.

- The scale pan is removed from the string and its mass 'S' is found in a balance.

- A known length of the specimen thread is weighed in a balance and its mass 'M' is determined.
- The length 'L' of the vibrating thread from the point where it touches the pulley is measured with a meter scale.

- Thus linear density μ, the mass per unit length of the thread is calculated.

- 'T' is the tension in the thread given by T = (m+S) g.

RESULT

a) The frequency of the given tuning fork in the transverse mode = _______________ Hz.

b)) The frequency of the given tuning fork in the longitudinal mode = _____________ Hz.

SAMPLE VIVA QUESTIONS

1. What do you mean by frequency?

   Ans. Frequency is the number of vibrations per second.

2. Define resonance.

   Ans. Vibration of a body with its natural frequency under the influence of another vibrating body is called resonance.

3. What is a progressive wave?

   Ans. A disturbance created in an elastic medium propagates outwards through the medium in the form of a wave known as progressive wave.

4. How many types of progressive waves are there?

   Ans. There are two types of progressive waves … longitudinal wave & transverse wave. The type of wave is based on how the particles of the elastic medium vibrate with respect to the direction of propagation of the wave.

5. What is the difference between longitudinal wave & transverse wave?

   Ans. In a transverse wave the particles vibrate perpendicularly, but in a longitudinal wave they vibrate parallel with respect to the direction of propagation of the wave.

6. What do you mean by standing wave?

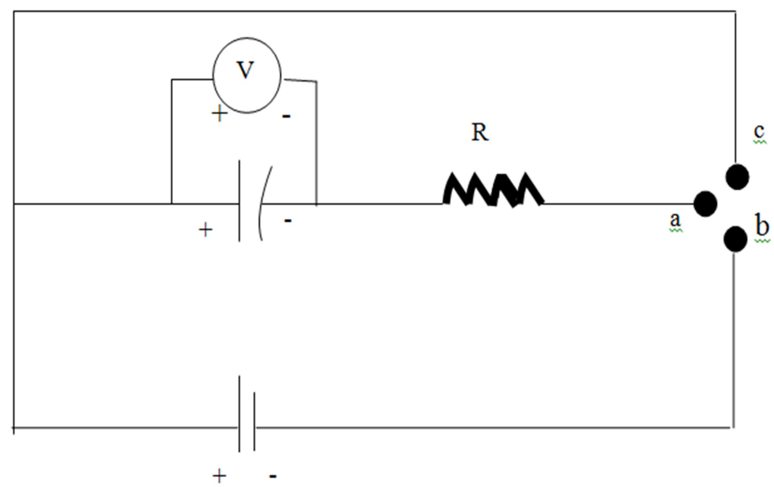
   Ans. When two propagating waves that have the same amplitude and frequency but travelling in the opposite direction superimpose a standing wave is formed. The nodes and antinodes remain fixed in position.

7. In this experiment which type of wave is passing through the string?

   Ans. In both the modes only transverse waves pass through the string.

8. Why is the frequency in the longitudinal mode different from the one in the transverse mode?

   Ans. In the longitudinal mode the string completes only half an oscillation for one, but in a transverse mode it completes one full oscillation for one complete vibration of the source.



CIRCUIT DIAGRAM

Table 1: To measure voltages during charging and discharging.

R = ___ Ω **Battery voltage =___________ V**

Time in seconds(s)	Voltage during charging (V)	Voltage during discharging (V)
0		
5		
10		
15		
20		
25		
30		
35		
40		
45		
50		

Ex.No.7	MEASUREMENT OF DIELECTRIC CONSTANT
Date:	

AIM

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

APPARATUS

Battery (10V), electrolytic capacitor, digital multi meter, two way key and stop clock.

PRINCIPLE

In an electrical circuit containing a capacitor and resistance the growth as well as decay of voltage are opposed by the induced emf. Therefore, it takes some finite time for voltage to reach its maximum value when the circuit is switched on. Similarly when the circuit is switched off the electric voltage takes again some finite time to become zero.

FORMULA

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

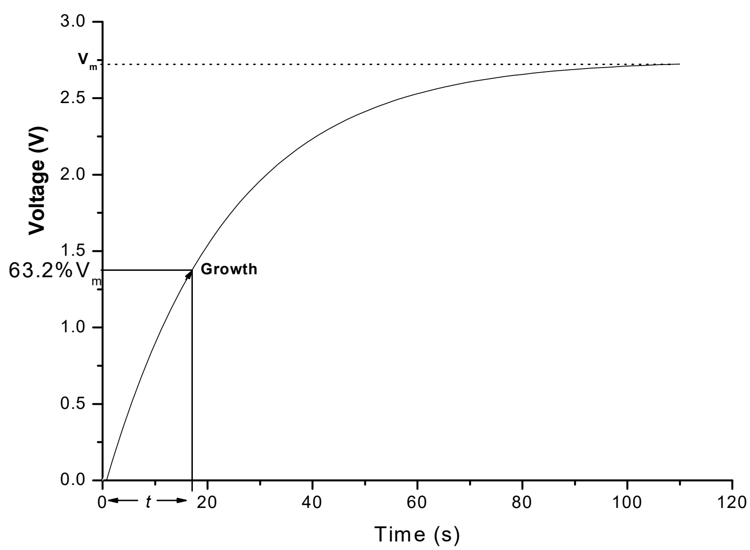
1. $C = \frac{\tau}{R}$ Farad

2. $\varepsilon_r = \frac{Cd}{\varepsilon_0 A} \times 10^{-6}$

Table 2: To measure voltages during charging and discharging.

R = ___ Ω **Battery voltage =___________ V**

Time in seconds(s)	Voltage during charging (V)	Voltage during discharging (V)
0		
5		
10		
15		
20		
25		
30		
35		
40		
45		
50		



Symbol	Explanation	Unit
C	Capacitance of the capacitor.	F
τ	Time constant.	sec
ε_r	Relative permittivity or the dielectric constant of the dielectric.	
d (C1)	Thickness of the dielectric. (0.53×10^{-3})	m
ε_0	Absolute permittivity of free space (8.854×10^{-12}).	F/m
A (C1)	area of each plate. (12.5×10^{-3})	m^2
A/d (C2)	1/50	m

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 five 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 (τ) of the circuit and is given by

$$\tau = RC \qquad \text{-------------- (1)}$$

DISCHARGING: When the voltage across the capacitor is maximum, the two way key K is opened along **a b** and closed immediately along **a c.** Then voltage decreases with time, for every five 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)

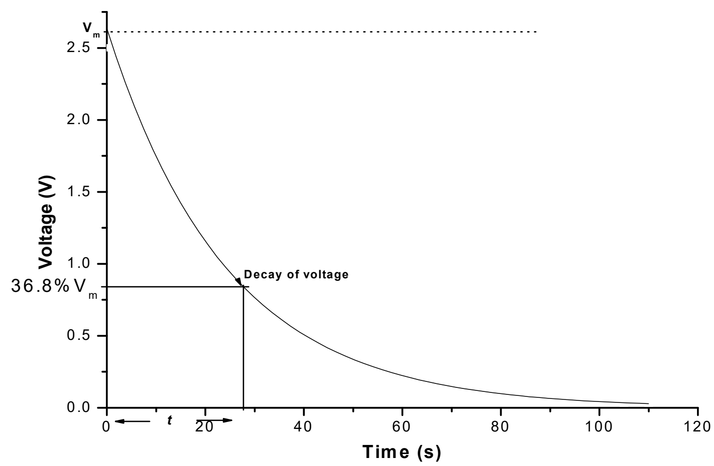
$$\tau = RC \qquad \text{-------------- (2)}$$

The value of $C = \frac{\tau}{R}$ obtained from equations 1 & 2 should be calculated separately. The average value of the capacitance is determined.

Note: R1 = 10 K Ω, **R2** = 15 K Ω and R3 = 18 K Ω.

Model Graph: 1 Charging:

$\tau =$ ___________s $\qquad$ $C = \dfrac{\tau}{R}$ = _____________F



Model Graph: 2 Discharging:

$\tau =$ ___________s $\qquad$ $C = \dfrac{\tau}{R}$ = ________________F

Calculations:

RESULT:

1. Capacity of parallel plate capacitor C = ________________ F
2. Dielectric constant of the given dielectric material ε_r = _____

SAMPLE VIVA QUESTIONS

1. What is Capacitor?

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

2. What are passive elements?

Ans. 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?

Ans. 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?

Ans. It is defined as the ratio of charge on either conductor to the potential difference between the conductors forming the capacitor.

5. How Capacitance of the capacitor can be increased?

Ans. Capacitance of a capacitor can be increased by introducing a dielectric material between the two parallel plates of the capacitor.

6. How is the value of the capacitance of a parallel plate capacitor determined from its dimensions?

Ans. In SI units $C = \varepsilon A/d$, where C is the capacitance, ε is the permitivity of the material between the plates, A is the area of one of the plates, and d is the distance between the plates.

7. What is the charge on the capacitor when the voltage across it is V?

Ans.: $Q = CV$ coulomb, when C is expressed in farad and V in volt.

8. With respect to the discharge of a capacitor, define time constant

Ans. 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

Ans. 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?

Ans: The time of leakage is determined by the time constant (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?

Ans No. The time constant for discharging the capacitor is larger than that for its Charging.

12. Define Static Dielectric constant?

Ans: 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?

Ans. 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?

Ans. The process of acquiring charges by a dielectric when placed in a dielectric medium is called polarisation.

15. What is the unit of Dielectric constant?

Ans. Dielectric constant is a dimension less constant hence it has no unit.

16 Give examples of Dielectric material

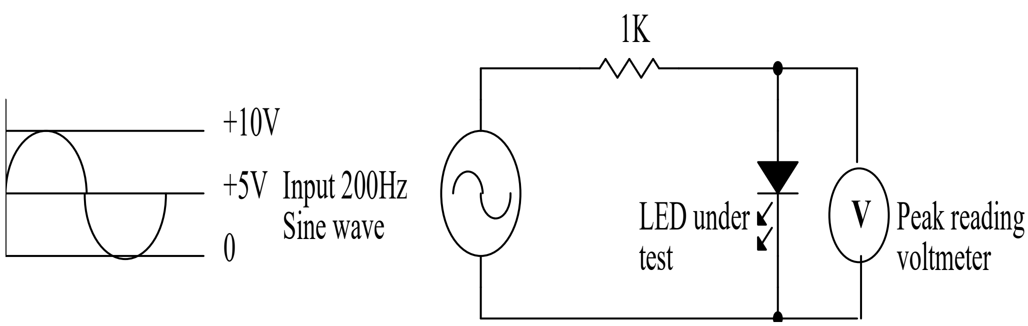
Ans. Paper, wax, mica, ceramics, some electrolytes, etc.

17. What is Dielectric Strength?

Ans. The limiting electric field above which the dielectric breakdown occurs is called Dielectric strength.

18. Give applications of Dielectrics?

Ans. 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).



CIRCUIT DIAGRAM

Ex.No.8	PLANCK's CONSTANT
Date:	

AIM

a) To determine the value of Planck's constant by using known wavelength LED light sources.
b) To determine the unknown wavelength of the infrared LED (IR LED).

APPARATUS REQUIRED

Planck's constant experimental setup consisting of 0-10V peak to peak sine wave generator, digital peak reading voltmeter, six different know wavelength LED lights.

PRINCIPLE

The energy emitted by a resonator (black body radiator) is in discrete values or in quanta.

FORMULA

(a) Planck's constant is given by,

$$E = h\nu = \frac{hc}{\lambda} \quad -------- (1)$$

$$E = ev \quad ------------ (2)$$

Equating eqn. (1) and (2)

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

$$h = \frac{eV\lambda}{c} \text{ Js.}$$

(b) Wavelength of the IR LED is given by,

$$\lambda_{IR} = \frac{(\lambda v)_{avg}}{V_{IR}} \text{ nm}$$

Symbol	Explanation	Unit
h	Planck's Constant (6.625×10^{-34})	Js
e	Electronic Charge (1.602×10^{-19})	C
V	Knee voltage across the LED	volt
λ	Wavelength of the light emitted	nm

c	Velocity of light (3 x 10^8)	m/s
λ_{IR}	Wavelength of the light emitted for IR	nm
V_{IR}	Knee voltage across the LED for IR	volt

Table 1. Measurement of Knee voltage for known wavelength

Color	Wavelength (λ)	Knee voltage(V)	λV
Unit	**nm**	**volt**	**X10^{-9} mV**
Blue	**360**		
Green	**560**		
Yellow	**590**		
Red	**612**		
Average λV =			

Table 2. Measurement of Knee voltage for unknown(IR) wavelength:

Color	Wavelength (λ_{IR})	Knee voltage(V_{IR})
Unit	**nm**	**volt**
Infrared (IR)		

PROCEDURE

The experiment consists of two parts

- *Part A, Knee voltage determination using peak reading voltmeter.*
- *Part-B, Determination of IR LED wavelength.*

Part A, Knee voltage determination using peak reading voltmeter

1. The circuit is rigged as shown in Figure. The input to the LED is an ac signal. The rectified output appears across the LED is a unidirectional pulsating. Hence, a peak reading meter is used to read voltage across the LED.
2. Using a digital peak reading voltmeter the voltage across the LED is measured and recorded in Table-1 for given color LED light.
3. Trial is repeated by changing the LED and the corresponding knee voltage is noted in Table-1.
4. The product of wavelength and knee voltage is determined and its average value is calculated.
5. Planck's constant is calculated using the formula.

Part-B, Determination of IR LED wavelength:

The IR LED is now connected and the knee voltage is noted. Using the graph in figure the wavelength corresponding to V_{IR} is noted. The wavelength is also calculated using the formula.

Calculation:

$$\lambda_{IR} = \frac{(\lambda v)_{avg}}{V_{IR}} \text{ nm}$$

=

$$h = \frac{eV\lambda}{c}$$

=

Results

a) The experimental value of Planck's constant was found to be h = ________________ Js.

b) The wavelength of the given IR LED was found to be λ_{IR} = ___________________ nm.

Sample viva questions:

1. What is the value of Planck's constant?
Ans. The value of h is 6.626×10^{-34} Js.

2. What are the factors on which its value depends?
Ans. It is a universal constant and does not depend on any factor.

3. What is quantum theory of light?
Ans. According to quantum theory light the light energy is emitted or absorbed in discrete quantities of energy called quanta. Energy of each quantum is hν.

4. What is an LED? What are the materials used for the design of LED?
Ans. LED is an acronym for Light emitting diode; it is a special type of semiconducting device which emits light when forward biased. The materials used are Gallium arsenide or Gallium phosphide.

5. What do you mean by turn on voltage?
Ans. Turn on voltage is the minimum voltage required to turn the LED on. (LED just starts to glow). It is the measure of energy gap of the semiconductor.

6. Is the supply voltage and turn on voltage same or different? Explain
Ans. The turn on voltage is not the same as supply voltage as there is current limiting resistor connected in series to the LED in the circuit.

7. What is the nature of the expected graph?
Ans. It is a linear graph. Slope of the straight line gives us the value of Planck's constant.
($E = h\nu$. ie of the form $y = mx$)

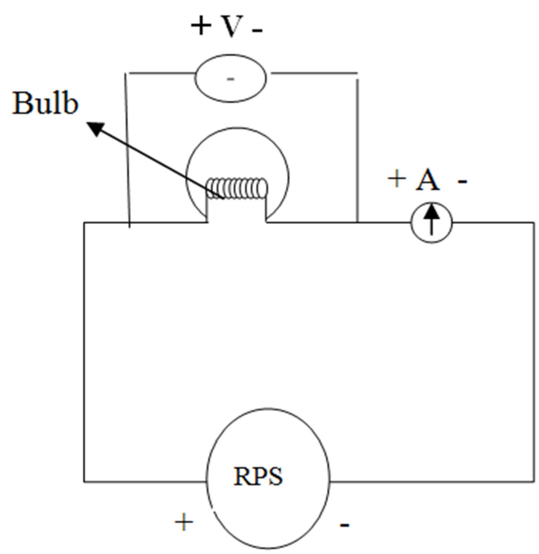
8. What is the difference between light emitted by LASER and LED?
Ans. In Laser, energy emitted is due to stimulated emission and it is highly coherent, monochromatic and highly directional whereas in LED energy is emitted due to spontaneous emission and it is incoherent.

9. Explain the working of LED?
Ans. When a pn junction is forward biased, minority carries are injected across the junction. Some of these minority carriers recombine with the majority carriers and the energy is released. When an electron in conduction band combines with a hole in valence band, band gap energy is

released in the form of a photon. This is spontaneous emission of light photon. The junction behaves as LED. This luminescence mechanism is known as injection electroluminescence.

10. What are the applications of LED?

Ans. LEDs are used as indicators, as light sources in fiber-optic communication. A number of LEDs may be grouped to form a display (e.g. seven segment displays) in digital circuits.



CIRCUIT DIAGRAM

Ex.No.9	VERIFICATION OF STEFAN's LAW
Date:	

AIM

To verify Stefan's law of radiation.

APPARATUS REQUIRED

Regulated power supply (RPS), electric bulb (12 V, 10 W) and a dc ammeter (0-10A).

PRINCIPLE

Rate of energy dissipated per unit area of a perfect black body is proportional to the fourth power of its absolute temperature (Stefan's law). By passing electric current through the filament of electric bulb, the power (P = VI) and resistance R= (V/I) is found by measuring V the potential difference across the bulb and I the current through the circuit. By plotting a graph of log P Vs log R, the slope is evaluated from which Stefan's law is verified.

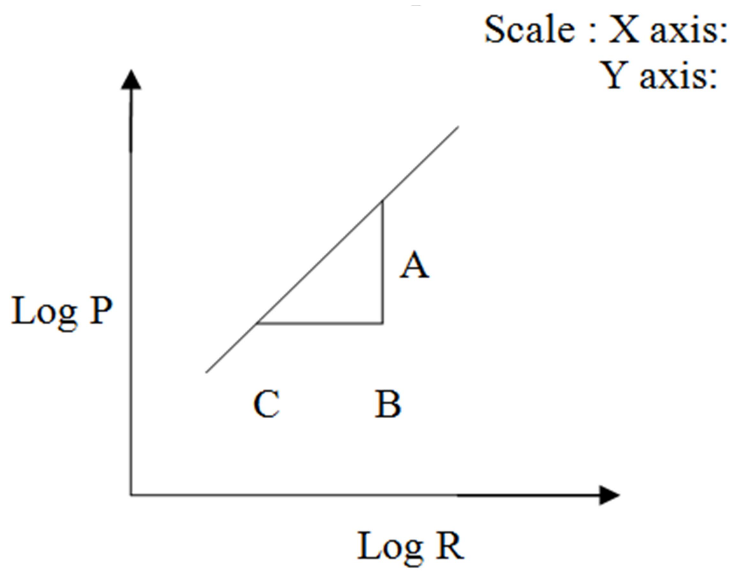
FORMULA

$E \propto T^4$ or $E = \sigma T^4$

Symbol	Explanation	Unit
E	energy dissipated per second per unit area by the black body	W/m^2
σ	Stefan's constant ($5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$)	$Wm^{-2}K^{-4}$
T	temperature of the black body	K

PROCEDURE

The electrical connections are made as shown in the circuit diagram. By varying the applied voltage using the regulated power supply (RPS), the potential difference across the bulb (V) and the current in the circuit (I) are measured. (It is important to take readings after the bulb begins to



MODEL GRAPH

Table 1: To measure V and I :

Trial No.	Voltage, V	Current, I	R = V/I	P = VI	Log P	Log R
Unit	Volt	mA	Ω	W		
1	**1**					
2	**2**					
3	**3**					
4	**4**					
5	**5**					
6	**6**					
7	**7**					
8	**8**					
9	**9**					
10	**10**					

glow.) The power, P, dissipated across and the resistance R of the filament of the bulb for each value of current is determined. A graph is plotted with log P against log R. The slope 'n' of the straight line is calculated. If the slope has a value 4, the Stefan's law is verified.

- $P = VI = \varepsilon\, \sigma\, A\, T^4$ where 'A' is the surface area of the filament, 'σ' is the Stefan's constant, 'T' is the absolute temperature (of the bulb) and 'ε' is the emissivity of the bulb.
- Let, $P = \varepsilon\sigma A T^n$. By showing n= 4, the Stefan's Law can be verified.

  $\text{Log } P = \text{Log } (\sigma) + \text{Log } (A) + n \text{ Log } (T) + \log (\varepsilon)$

  But $T \propto R$ (resistance of the bulb filament)

  Therefore $\text{Log } P = \text{Log } (\sigma) + \text{Log } (A) + n \text{ Log } (R) + \log (\varepsilon)$

  $$\text{Log } P = n \log (R) + \text{Constant}$$
- This equation is in the form of y = mx + c where y = Log P, m = n and c = Constant. Therefore a plot of Log P versus Log R is a straight line with the slope = n =AB/BC.

Calculation: Slope =

RESULT: Slope = _______.

Hence Stefan's law is verified.

SAMPLE VIVA QUESTIONS

1. What is heat?

Ans. Heat is a form of energy that can be transferred from one point to another.

2. Name the different kinds of transmission of heat?

Ans. a) conduction, b) convection and c) radiation.

3. What is thermal conduction?

Ans. The process of transmission of heat without the actual movement of the particles of the body is called conduction. Example: metals get heated by this method.

4. What is convection?

Ans. The process of transmission of heat by the actual movement of the constituent particles of the body is called convection. Example: Liquids and gases get heated by this method.

5. What is radiation?
Ans. The process of transmission of heat from one place to another place without aid of intervening medium is called radiation. Example: radiation of heat from Sun and Stars.

6. Which are the sources of radiation?
Ans. All the bodies that are above the absolute zero (0K = -273°C) are sources of radiation.

7. What is a perfect Black body?
Ans. A body which absorbs the entire radiations incident on it and emits all the radiations when it is heated.

8. What are black body radiations?
Ans. The radiations which are emitted by the black body are called black body radiations.

9. State Stefan's law of radiation.
Ans. Stefan's law states that "The amount of energy radiated per second per unit area of the surface of the perfectly Black body is directly proportional to fourth power of its absolute temperature". $E = \sigma T^4$

10. Is the bulb really a black body? If not what modification is necessary in the Stefan's formula?
Ans. No, Bulb is not a perfect black body. The corrected formula is $E = e\sigma T^4$ where e is the emissivity of the surface of the filament, σ is Stefan's constant and T is the absolute temperature of the bulb.

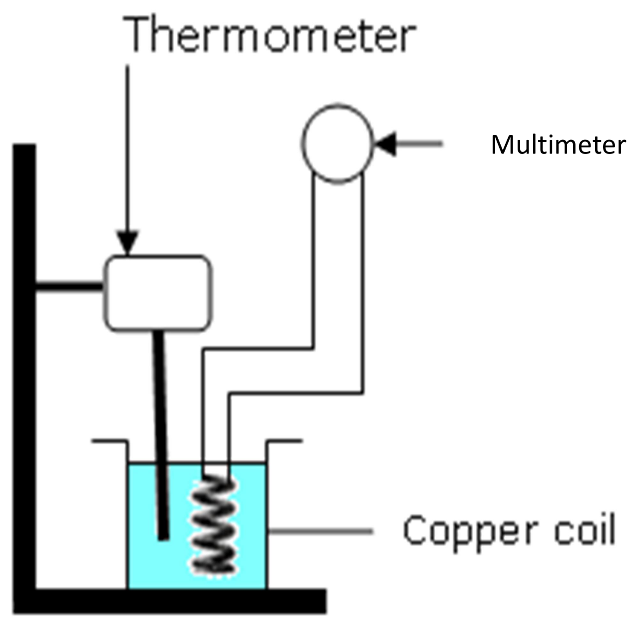
11. What is emissive power and absorptive power?
Ans. Emissive power: It is defined as the amount of heat radiated by a unit surface of the body in one second when the temperature difference between the body and the surrounding is 1°C.

Absorptive power: It is defined as the ratio of the amount of heat energy absorbed to the amount of heat energy incident on it.

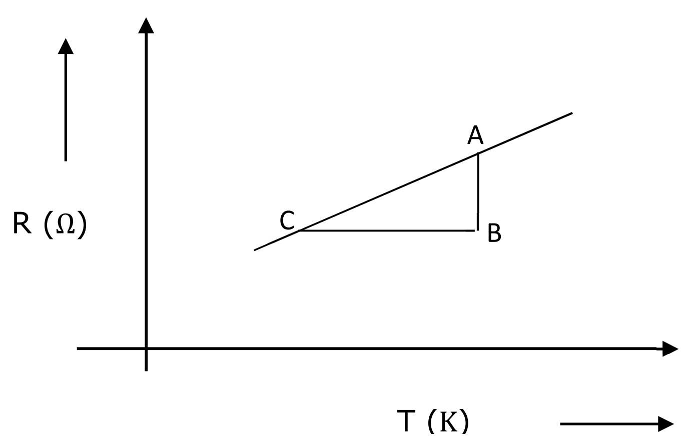
12. Name laws of Black body radiation?

Ans. a) Stefan's law. b) Stefan's Boltzmann law. c) Wein's law. d) Wein's displacement law. e) Rayleigh jeans law. d) Planck's law.

Circuit Diagram



Model Graph



Ex.No.10	FERMI ENERGY OF COPPER
Date:	

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

APPARATUS: Copper coil, Thermometer, multimeter, Beaker.

PRINCIPLE: The energy of the highest occupied level at zero degree absolute is called the Fermi energy (EF) and the energy level is referred to as the Fermi level. Fermi energy gives us information about the velocities of the electrons which participate in the electrical conduction.
Pauli's exclusion principle "it states that no two electrons can have the same four quantum numbers". That is, if n, l, and ml are the same, ms must be different such that the electrons have opposite spin

FORMULA:
(1) The Fermi energy of copper is calculated using the formula,

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

where, D is Density of copper = 8.96×10^3 kg/m^3,

l is the Length of the copper wire = 11 m,

A is the area of cross-section of the wire which is found using the formula, $A = \frac{\pi d^2}{4}$ in m^2,

d is the diameter of the Copper wire=0.25 mm,

S is the slope in Ω/K.

TABULAR COLUMN:

Sl.No.	**Temperature T (^{0}C)**	**Temperature T (K)**	**Resistance R (Ω)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

PROCEDURE:

1. The circuit connections are made as shown in fig 2.1. The copper coil is immersed into the beaker and the beaker is filled with boiling water & a thermometer is introduced into water.

2. Starting with the temperature of 85°C, the resistance (R) of the copper coil is measured using multimeter and the temperature of the water is measured using a Digital thermometer.

3. The resistance of the copper coil is measured for every 5°C fall in temperature (T) of water up to 60°C. A graph of Resistance (R) Versus Temperature (T) is plotted (as in fig 2.2). The slope (S) is determined and hence Fermi energy of E_F of copper is calculated.

RESULT: The Fermi energy of Copper is given by E_F=__________e V.

Sample Questions:

1. What is Fermi energy?
2. Define Fermi factor ?
3. Define eV?
4. What is a free electron?
5. What is Pauli's exclusion principle?