Hindi Vidya Prachar Samiti's

RAMNIRANJAN JHUNJHUNWALA COLLEGE

Ghatkopar (West), Mumbai-400 086, Maharashtra, INDIA.

F.Y.B.Sc (Sem-I)

Handbook

DBT STAR College Scheme

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Ghatkopar (W), Mumbai-400 086.

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UNIVERSITY of MUMBAI

DEPARTMENT OF PHYSICS

SEMESTER : I

HAND BOOK

PHYSICS : USPH P1

2017 – 2018

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F. Y. B. Sc. PHYSICS

SEMESTER - I

Contents

SKILLS

Use of Vernier Caliper

Aim : To learn the use of Vernier Caliper.

Apparatus : Vernier Calipers, cylinder, scale.

Formula : $Least\ Count\ of\ Vernier\ Calipers = \frac{smallest\ division\ on\ main\ scale}{total\ number\ of\ divisions\ on\ vernier\ scale}$

Procedure : 1) Determine the least count of Vernier Calipers.
2) Measure the diameter of the cylinder and breadth of the scale accurately by using vernier calipers.

Observations :

L. C. of vernier calipers =________ cm

Diameter of the wire

Obs. no.	M. S. R. A	(V.S.D.) x (L. C.) B	Total Reading D = A + B
	cm	cm	cm
1.			
2.			
3.			

mean D = ...cm

Radius of the cylinder r = D/2 = ...cm

Breadth of the scale

Obs. No.	M. S. R. A	(V.S.D.) x (L. C.) B	Total Reading b = A + B
	cm	**cm**	**cm**
1.			
2.			
3.			

mean b = _________ cm

Result : (i) Radius of cylinder (r) = ____________ cm.
(ii) Breadth of the scale (b) = ____________ cm.

SKILLS
Use of Micrometer Screw Gauge

Aim : To learn the use of micrometer screw gauge.

Apparatus : Micrometer screw gauge, wire, scale.

Formula : $Least\ Count\ of\ Micrometer\ Screw\ Gauge = \frac{Pitch}{total\ number\ of\ divisions\ on\ circular\ scale}$

$$Pitch = \frac{Distance\ moved\ on\ main\ scale\ in\ 10\ rotation}{10}$$

Procedure : 1) Determine the least count and zero error of micrometer screw gauge.

2) Measure the diameter of the wire and thickness of the scale accurately by considering zero correction.

Observations : Zero error (Z. E.) = _______ div

Least count (L.C) = _______ cm

Diameter of the wire

Obs. no.	M. S. R. A	(C.S.D. – Z.E.) X L. C. B	Diameter d = A + B
	cm	cm	cm
1			
2			
3			
4			
5			

mean d = ...cm

Thickness of the scale

Obs. no.	M. S. R. A	(C.S.D. – Z.E.) X L. C. B	thickness t = A + B
	cm	cm	cm
1			
2			
3			
4			
5			

Result : (i) Diameter of the wire d = ____________ cm.

(ii) Thickness of the scale t = ____________ cm.

SKILLS

Travelling Microscope.

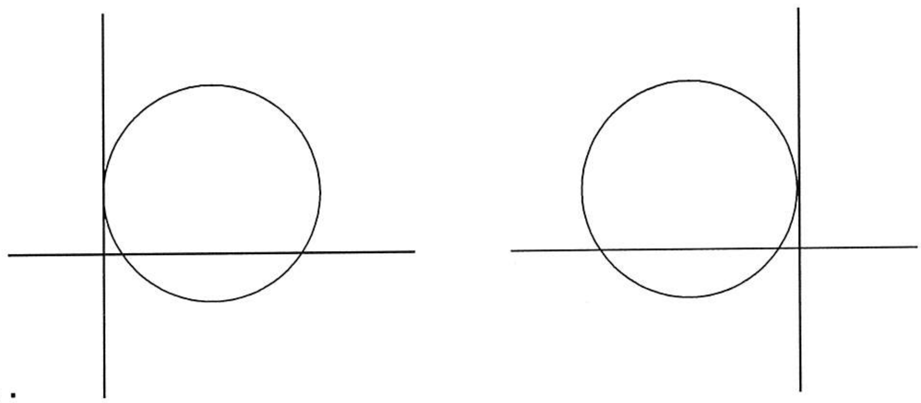
Aim : **To study the use of a Travelling Microscope.**

Apparatus : Travelling Microscope, capillary tube, lamp.

Formula :

$$\text{Least Count of Travelling Microscope} = \frac{\text{Smallest division of Main Scale}}{\text{Total number of divisions on Vernier Scale}}$$

Diagram :



Procedure :

1) Determine the least count of the given travelling microscope.
2) Place the bore of the capillary close to the objective of the travelling microscope.
3) Allow light from a lamp to fall ***on*** the bore of the capillary.
4) Move the objective of the microscope away from the capillary, till a clear and sharp image of the bore is obtained.
5) Adjust the vertical cross wire of the microscope to be tangent to one end of the bore. Note down the main scale reading (M.S.R.) as well as the vernier scale division (V.S.D.) on the horizontal vernier scale.

   Total reading = M.S.R. + (V.S.D. **x** L.C.)

6) Move the vertical cross wire to be tangent to the diametrically opposite end of the bore. This can be done by moving the travelling microscope horizontally by means of the horizontal screw. Note the reading as in step 5.
7) The difference between the above two readings gives the diameter of the bore.

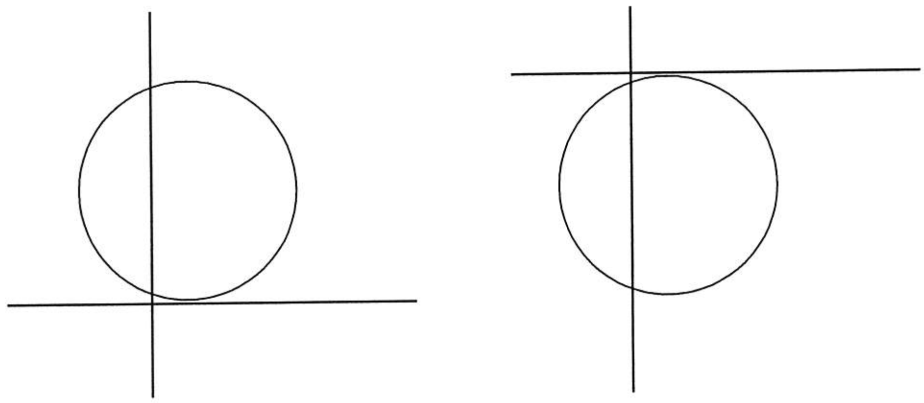
Observations :

L. C. = ...cm.

	Left Reading			Right Reading			
	M.S.R.	V.S.D. x L.C.	T.R. 'A'	M.S.R.	V.S.D. x L.C.	T.R. 'B'	Diameter A ~ B
	cm	cm	cm	cm	cm	cm	cm
1							
2							
3							
4							
5							

Result : Studied the use of a travelling microscope and obtained the diameter of the bore = ________________cm.

Note : If the horizontal cross wires is a tangent take readings on the vertical scale.



SKILLS

Spectrometer

Aim : **To study the adjustments of Spectrometer for obtaining parallel light using Schuster's Method .**

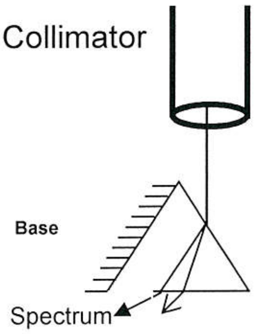
Apparatus : Spectrometer, Spirit level, Mercury source, Prism etc.

Formula :

$$\textit{Least Count of Spectrometer} = \frac{\textit{Smallest division on Main Scale}}{\textit{Total number of divisions on Vernier Scale}}$$

Procedure : **(A) Level the spectrometer using spirit level.**
(B) Schuster's method to focus the Spectrometer for parallel light :

1) Focus the cross wires by adjusting the eyepiece of the telescope. Illuminate the slit of the collimator with the given source of light.
2) Place the prism with one edge facing the collimator. View along the arrow shown with the naked eye. The spectrum will be visible.



3) Rotate the telescope and view the spectrum through it. Turn the prism table and follow the spectrum by rotating the telescope. At one position the spectrum turns. This is the minimum deviation position.
4) Keep the minimum deviation position on any one side of the cross wire, so that the spectrum crosses the vertical cross wire twice on moving the prism table.
5) Choose a particular colour, say, the yellow line . Rotate the refracting edge towards *the telescope.* When the yellow line reaches minimum deviation, turns and comes on the cross wire , focus the telescope so that the lines are sharp.
6) Rotate the refracting edge towards the collimator. When the yellow line reaches minimum deviation, turns and comes on the cross wire , focus the collimator so that the lines are sharp.
7) Repeat step (5) and (6), a number of times till no more focusing is required. Now the spectrometer is adjusted for parallel light using Schuster's method.
8) Remove the prism , rotate the telescope and view the slit directly. Fix the telescope such that the intersection of the cross wires coincide with the slit. This is the direct reading.

Observations :

Direct Reading

L.C. = ...

Window A			Window B		
M. S. R.	**V. S. R. x L. C.**	**T. R. 'A'**	**M. S. R.**	**V. S. R. x L. C.**	**T. R. 'B'**

Calculation : Determine the difference between window A and window B reading

A ~ B = ________________

Result : **Studied the adjustment of Spectrometer for obtaining parallel light.**

SKILLS

Use of Digital Multimeter (DMM)

Aim : To learn the use of digital multimeter.

Apparatus : Digital multimeter, dc voltage source, ac voltage source, carbon resistance.

PART : (A) Measurement of Resistance

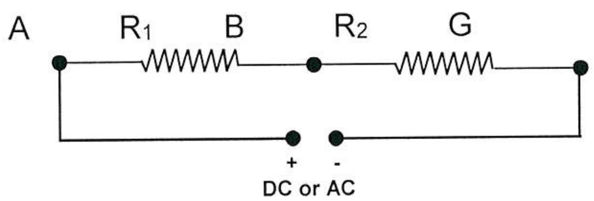
1. From the color code determine the value of resistances.
2. Keep the range selector on resistance range.
3. Keep the black wire on common socket and red wire on Ω socket.
4. Connect the given resistances across the DMM and note resistance value.
5. If 1 appears on the screen, this indicates over range.
6. Select now a suitable range so that accurate measurement of resistance can be recorded.
7. Verify the value of the resistances recorded in the DMM with the values obtained by using color code.

Observations :

Obs. No.	Resistance value using color code	Resistance value measured by DMM
	Ω	Ω
1		
2		
3		

PART : (B) Measurement of dc Voltage

1. Connect the dc power supply between A and G.
2. Keep the range selector on dc voltage range.
3. Keep the black wire in common socket and red wire in volt socket.
4. Adjust the knob of dc voltage source till you obtain V = 2 volt on DMM screen. Choosing (0 – 20V) range. Note down the dc voltage.
5. Select the range (0 – 2V) in DMM and note down the voltage across resistance R_1. ($R_1 = R_2 = 1\ k\Omega$)
6. Repeat step 5 for range (0 – 20V) in DMM.



Observations :

Obs. No.	Range	dc voltage (V)
1	0 – 2V	
2	0 – 20V	

PART : (C) Measurement of ac voltage (R. M. S. value)

1. Connect the ac power supply between A and G. Choose frequency of ac source (signal generator) as 1 kHz.
2. Keep the range selector on ac voltage range.
3. Keep the black wire of DMM in common socket and red wire in volt socket.
4. Adjust the knob of ac voltage source till you obtain V = 10 volt on DMM screen. Choosing (0 – 20V) range. Note down the ac voltage. (Note down it is the rms value.)
5. Select the range (0 – 20V) in DMM and note down the voltage across resistance R_1. ($R_1 = R_2 = 10\ k\Omega$)
6. Repeat step 5 for range (0 – 200V) in DMM.

Observations :

Obs. No.	Range	ac voltage (V)
1	0 – 20V	
2	0 – 200V	

Result : Studied the use of DMM to measure resistance, dc voltage, and ac voltage.

SKILLS

Plotting of Graph

Aim: To plot a graph for the given data and do the necessary calculations.

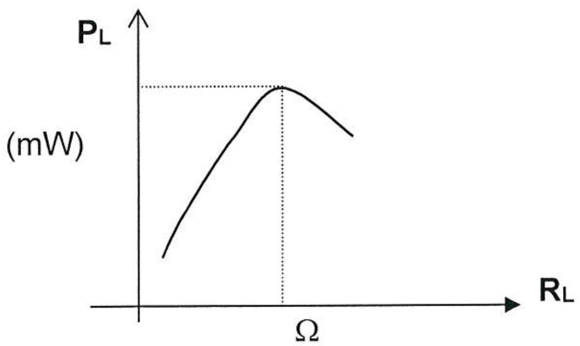
Graph : I

The data for the power P_L delivered by a voltage source at different loads R_L was studied and observations were tabulated as follows:

R_L	P_L
Ω	mW
10	24.6
20	40.0
30	49.6
40	55.6
50	59.2
60	61.2
70	62.2
80	62.5
90	61.6
100	61.6
150	56.7
200	51.0
250	49.9

Procedure:

1) Choose a suitable scale on both the axes so that the graph occupies most of the available space. Write the scale on the right hand top corner of the graph paper.
2) Mark each point on the graph as a dot and encircle it.
3) Select a point on the curve at which the power is maximum. The corresponding load resistance is determined.
4) The maximum power is delivered to the load if the source resistance is equal to the load resistance.



Result : Graph is plotted for the given data. The source resistance is ....Ω

Graph : II

The data for the rate of cooling **$d\theta / dt$** of water at various temperature θ was studied and observations were tabulated as follows:

$d\theta / dt$	θ
^oC / min	^oC
1.4	55
1.8	60
2.0	65
2.2	70
2.6	75

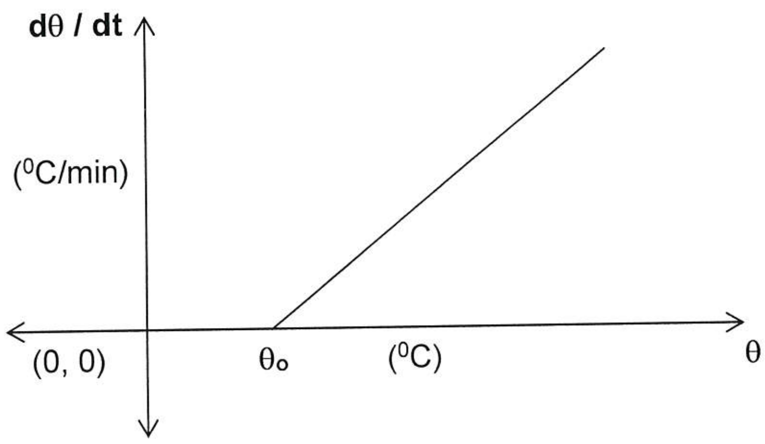
The relation between **$d\theta / dt$** and θ is given by the equation:

$d\theta / dt = k (\theta - \theta_o)$ where θ_o = room temperature

This is the equation of a straight line with an x – intercept of θ_o

Procedure:

1) Since we have to determine the intercept on the axis we have to take (0, 0) as the origin O. Choose the x-axis as θ and the y-axis as **$d\theta / dt$** .
2) Choose a suitable scale on both the axis so that the graph occupies most of the available space. Write the scale on the right hand top corner of the graph paper.
3) Mark each point on the graph as a dot and encircle it.
4) Draw a straight line in such a way that all the points are symmetrically distributed on either side of the line.
5) Determine the intercept θ_o on the x-axis.



Result : Graph is plotted for the given data.
Room temperature θ_o =……… ^oC

SKILLS

Absolute and Relative error calculation

The difference between the measured quantity and its 'true' value is known as an 'error'. Very often the true value or exact value of the quantity is not known. The arithmetic mean of the large number of readings would then be near the true value of the quantity measured. This value is often called as the "best value" and the range from the best value within which true value is expected to be confined is called the error or uncertainty.

Thus if $\bar{x}$ is the best value / true value in the measurement of x, then, the error is $e = x - \bar{x}$

If the deviation are too small then $e = \Delta x$ can be of the order of L. C. of the measuring instrument.

Δx is known as absolute error or maximum possible error. (In case, measurement x has random error, then large no. of readings are taken and Δx is the standard error)

Therefore relative error is defined as the ratio of absolute or maximum possible error to the measured quantity ie $\Delta x / x$.

Estimation of the error in the result :

The final result of an experiment is often dependent on many quantities measured in the course of experiment. The error in the result is to be estimated by combining the error in the measurements of individual quantities in appropriate ways.

Example, if final result (R) depend on quantities A and B then maximum possible error in R is ΔR will be combination of ΔA and ΔB.

Some standard result for relative error :

If $R = A \pm B$ then $\frac{\Delta R}{R} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$

$$R = AB \text{ or } A/B \quad \text{then} \frac{\Delta R}{R} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

$$R = A^n \text{ or } A^{-n}, \text{ then} \frac{\Delta R}{R} = \frac{n\Delta A}{A}$$

$$R = \ell n\, A, \quad \text{then } \frac{\Delta R}{R} = \frac{\Delta A}{A \ell n A}$$

$$R = (\exp A) \text{ ie } \left(e^A\right), \quad \text{then} \frac{\Delta R}{R} = \Delta A$$

Final result : Quote the result and its error to the same number of significant digits.

It is often useful to give, in addition the error as a percentage ie $\% \, error = \frac{\Delta R}{R} \times 100$

Exercises :

1. Estimate relative error $\left(\frac{\Delta Z}{Z}\right)$ and absolute error (ΔZ) in each of the following.

a) $Z = A^2,\quad A = 25 \pm 1$

b) $Z = A - 2B,\quad A = 100 \pm 3,\quad B = 45 \pm 2$

c) $Z = \frac{A}{B}\left(C^2 + D^2\right),\quad A = 0.100 \pm 0.003\quad B = 1.00 \pm 0.05$

$C = 50.0 \pm 0.5\quad D = 100 \pm 8$

d) $Z = A\,\ell n\, B,\quad A = 10.00 \pm 0.06\quad B = 100 \pm 2$

e) $Z = 1 - \frac{1}{A^2},\quad A = 50 \pm 2$

Q. 2. A rectangular bar of mass M has dimensions a, b, c. The moment of inertia I about an axis passing through the centre is $I = \frac{M}{12}\left(a^2 + b^2\right)$

The following measurement are made :

$M = 135.0 \pm 0.1\ g$

$a = 8.0 \pm 0.1\ cm\qquad b = 1.0 \pm 0.1\ cm\qquad c = 0.254 \pm 0.001\ cm$

What is the absolute error or maximum possible error in

i) Density ρ of the material.

ii) The moment of inertia. Also calculate percentage error in each case. Write the result up to correct significant figures.

Q.3. When a torsion wire of radius r and length ℓ is fixed at one end and subjected to a couple of moment C at the other end, the angular displacement φ is given by $\varphi = \frac{2\ell C}{\eta \pi r^4}$, where η is the modulus of rigidity of material of wire.

Following values are obtained :

$\frac{\varphi}{C} = 4.00 \pm 0.12\ \ rad\ N^{-1} m^{-1}$, $r = 0.100 \pm 0.002 cm$, $\ell = 50.0 \pm 0.1 cm$.

Calculate the value of η and maximum possible error in it. State the result in appropriate form what is the percentage error in η ?

Q.4. Estimate relative error and absolute error in the calculation of geometric moment of inertia of a bar having breadth b = 2.54 cm and thickness d = 0.513 cm.

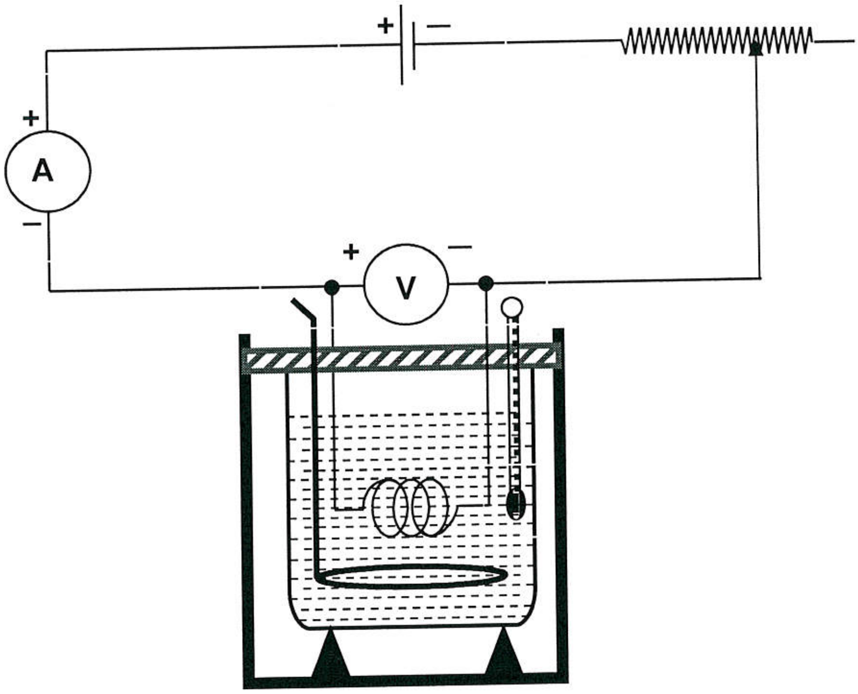
$$I = \frac{bd^3}{12}$$

J by Electrical Method

Aim : To determine the mechanical equivalent of heat **J** by electrical method.

Apparatus : Joule's calorimeter, ammeter(0 – 2.0 A), voltmeter(0-10 V), stop clock, thermometer, dc supply, wires, etc.

Circuit Diagram :



Formula :

$$J = \frac{V\,I\,t}{(M_c S_c + M_w S_w)(\theta_2 - \theta_1)}$$

J : mechanical equivalent of heat

V : potential difference across the coil

I : current through the coil

M_c : mass of calorimeter and stirrer

S_c : specific heat of material of calorimeter

M_w : mass of liquid (water)

S_W : specific heat of water

θ_1 : initial temperature of water

θ_2 : Final temperature of water (temperature of water after t seconds)

t : time for which current is passed

Procedure :

1. Find the mass of the empty calorimeter with stirrer M_c.
2. Take sufficient quantity of water in the calorimeter to immerse the coil. Find the mass **M** again.
3. Make the connections and adjust the rheostat for a current **I** of atleast 1.0 A. Note the corresponding voltmeter reading **V** and switch off the supply.
4. Immerse the coil in the calorimeter containing water. Note down the initial temperature θ_1 °C.
5. Switch on the voltage source and simultaneously start the stop clock.
6. Take care that the thermometer bulb does not touch the coil but is well immersed in the water.
7. Keep stirring the liquid continuously till the temperature rises by about ***5 to 6*** °C above the initial temperature.
8. Switch off the voltage source and note the time t for which the current is passed. Note the final temperature of water θ_2.
9. Calculate **J** using the above formula.

Observations :

1. Potential Difference		**V** =	 V
2. Current		**I** =	.... A
3. Mass of calorimeter and stirrer		M_c =	.... g
4. Mass of calorimeter + stirrer +liquid(water)		**M** =	.... g
5. Mass of liquid(water)	$M - M_c$ =	M_w =	.... g
6. Specific heat of material of calorimeter		S_c =	0.1 cal /g °C
7. Specific heat of water		S_w =	1 cal /g °C
8. Initial temperature of water		θ_1 =	.... °C
9. Final temperature of water		θ_2 =	.... °C
10. Time for which current is passed		**t** =	.... s

Calculations : $J = \dfrac{V I t}{(M_c S_c + M_w S_w)(\theta_2 - \theta_1)}$ = ... Joule/calorie

Result :

Mechanical equivalent of heat **J** = ________________ Joule/calorie.

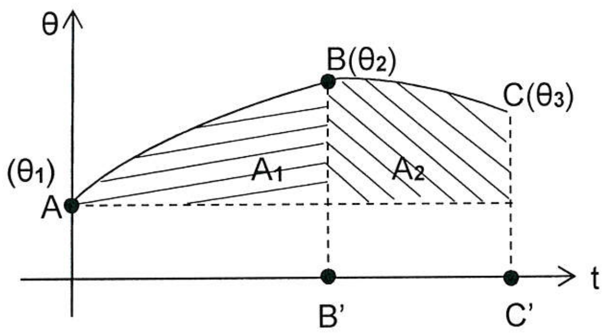
Note: while performing the experiment we have neglected radiation correction.

J by electrical method (applying radiation correction by graphical method)

Aim : To determine joule's constant J by applying radiation correction.

Procedure :

1. Connect the circuit as shown in the diagram. Adjust the current to 1 A. switch off the current.
2. Note the initial temperature of water θ_1. Switch on the current and simultaneously start the stop watch. Note down the temperature θ of water at regular time intervals t of half a minute. Stir the water continuously but slowly.
3. Note the reading of the current I and potential difference V.
4. When the temperature rises, 10^0C above the initial teperature, put off the current but do not stop the stop watch.
5. Note the maximum temperature θ_2 of water and calorimeter and time t in seconds for which the current was passed.
6. Take the readings of the time and temperature continuously. Take the readings of temperature at an interval of 1 min., till the temperature falls down by about 3^0C. (θ_3) (Keep on stirring the water slowly all the time)
7. Plot a graph of temperature (θ) against time (t) and from the graph find radiation correction $\Delta\theta$. Hence calculate J.



Calculate :

N_1 : total number of mm squares in the area A_1

N_2 : total number of mm square in the area A_2

Radiation Correction : $\Delta\theta = \frac{N_1}{N_2}(\theta_2 - \theta_3)$

$$J = \frac{VIt}{(m_c s_c + m_w s_w)(\theta_2 + \Delta\theta - \theta 1)} = ...J/cal$$

BIFILAR PENDULUM

Aim : To Determine the moment of inertia **I** of the given rectangular bar about the vertical axis passing through the mid-point of the bar.

Apparatus : A rectangular bar, stop clock, meter scale, index pin, vernier callipers, thread, balance etc.

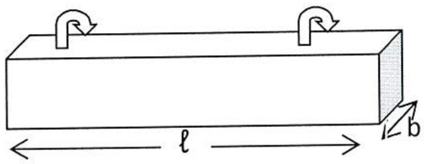
Part : A

Procedure :

To determine the moment of inertia I of the given bar by measurement

1) Determine the length ℓ of the bar using a meter scale.
2) Determine the breadth b of the bar using vernier calipers.
3) Calculate the moment of inertia I using the formula.

$$I = m\left(\frac{\ell^2 + b^2}{12}\right)$$



Observation :

1) Mass of the recatangular bar $m =$ ______ g
2) Length of the rectangular bar $\ell =$ ______ cm

Least count of vernier calipers = ______ cm

Breadth of the bar **b**			
b1	**b2**	**b3**	Mean **b**
cm	cm	cm	cm

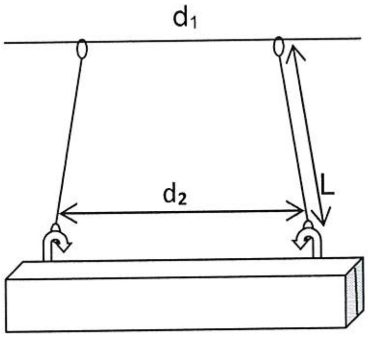
Calculation : Moment of inertia $I = m\left(\frac{\ell^2 + b^2}{12}\right)$

Part : B

To experimentally determine the moment of inertia I of the given rectangular bar

Procedure :

1) Select two hooks symmetrically near the two ends of the bar.
2) Take two strings having the same length **L.** Tie the lower end of the string to the hooks and suspend the bar from the other end from a stand as shown below. Since the strings have the same length, the bar becomes horizontal. Measure the length **L** of the string using a meter scale.
3) Measure the distance $\mathbf{d_1}$ between the upper ends of the string and the distance $\mathbf{d_2}$ between the lower ends of the string using a meter scale. Adjust $\mathbf{d_1}$ so that $\mathbf{d_1 \approx d_2}$ We have to keep $\mathbf{d_1}$ and $\mathbf{d_2}$ constant throughout the experiment.



Index pin

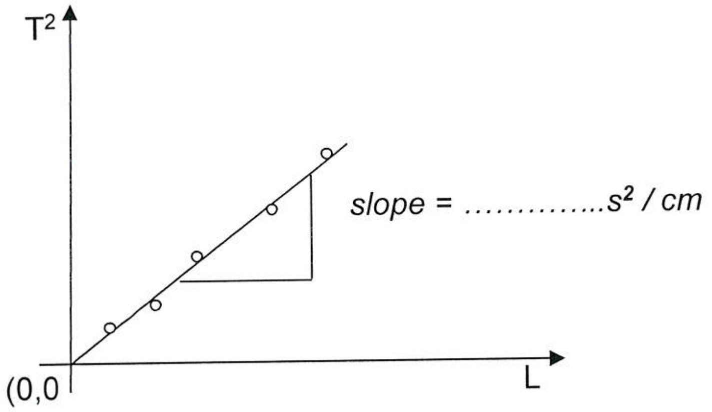
4) Mark a vertical reference mark on the bar with chalk in front of the bar. Look at the mark through the index pin such that the index pins and the reference mark are in the same straight line.
5) Give a small angular displacement to the bar the horizontal plane. See that the amplitude of the oscillation is small.
6) Find the time for 20 oscillation using a stop-clock. Hence determine the time period **T** of the Pendulum.
7) Repeat step 6 for six different lengths **L.** (increase by 4 to 5 cm).
8) Plot a graph of $\mathbf{T^2}$ against **L** and hence determine the slope.

Observation :

Obs. No.	Length of suspension	Time for 20 oscillations			Time Period	T^2	T^2 / L
	L	t^1	t^2	Mean t	T= t / 20		
	cm	s	s	s	s	s^2	s^2 / cm
1							
2							
3							
4							
5							
6							

mean T^2 / L = ________ s^2 / cm.

Graph :



Calculation : Moment of inertia $I = \frac{m\,g\,d_1 d_2}{16\pi^2}\left[\frac{T^2}{L}\right] mean = ...g\,cm^2$

$$I = \frac{m\,g\,d_1 d_2}{16\pi^2}(slope) = ...g\,cm^2$$

$$Mean\ I = ...g\,cm^2$$

Result :

1. **Moment of inertia of the given rectangular bar (by measurement) I = ... g cm^2.**
2. **Moment of inertia of the given rectangular bar (by experiment) I = ... g cm^2.**

Young's Modulus Y using Flat Spiral Spring

Aim : To determine Young's Modulus **Y** of the material of a flat spiral spring.

Apparatus : Flat spiral spring, rod with adjustable masses, stop-clock, pin, vernier caliper, micrometer screw gauge etc.

Formula : Young's Modulus.

$$Y = \left\{\frac{32\pi^2 NR}{r^4}\right\}\left\{\frac{I}{T^2}\right\}$$

N : number of turns of the spring.
R : mean radius of the spring
r : radius of the wire of the spring.
T : periodic time of horizontal oscillation
I : moment of Inertia of the rod with masses about the axis of rotation

$I = I_0 + 2m_0x^2$

I_0 : moment of inertia of the rod about the axis of rotation

m_0 : mass of each of the movable disc

x : distance of the centre of mass of m_0 from the axis of rotation

Part- A

Determination of N, R, r of the spring

Procedure:

1. Count the number of turns **N** of the spring.
2. Using vernier caliper take three readings to find the mean inner diameter **D** of the spring and hence determine the mean radius **R**.
3. Using micrometer screw gauge, take readings at three different straight portion of the wire of the spring to find the mean diameter **d** of the wire and hence determine the radius **r** of the wire.

Observations :

1. Number of turns of the spring **N** = ...
2. Mass of each movable disc m_0 = ... g
3. Determination of radius **R** of the spiral spring :

Least count of vernier caliper = ... cm

Inner diameter of the spring D				Radius
D1	D2	D3	Mean **D**	R = D/2
cm	cm	cm	cm	cm

4. Determination of radius r of the wire of the spring.

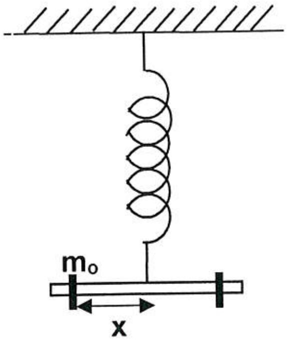
Least count of micrometer screw gauge = ... Cm

Diameter of wire of the spring d				Radius
d1	d2	d3	Mean d	R = D/2
cm	cm	cm	cm	cm

Part - B

To determine the Young's Modulus Y

Procedure :



1. One end of the spiral spring is fixed to a rigid support. Fix a long cylindrical rod to the free end of the spring in which two identical discs each of mass m_0 can be placed at various distances **x** from the axis of the spring. Adjust the discs so that both of them are at the same distance x from the axis of the spring.
2. Fix a pin vertically at one end of the rod and focus the telescope on the tip of the pin.
3. Set the spring into torsional oscillations and measure the time t for 20 oscillations. Take two readings and hence find mean **t**. Determine the time period **T** of the oscillations.
4. For four more distances **x** of the two discs from the axis of the spring, repeat step (3).

Observations:

Obs. no.	x	x^2	Time for 20 oscillations		mean **t**	$T = \frac{t}{20}$	T^2	$\Delta T^2 / \Delta x^2$
			t_1	t_2				
	cm	cm^2	s	s	s	s	s^2	S^2 / cm^2
1.								
2.								
3.								
4.								
5.								

$(\Delta T^2 / \Delta x^2)_{mean}$ = …….s^2/cm^2

[$\Delta T^2 / \Delta x^2$ is to be calculated taking the difference between different x^2 values and corresponding T^2 values (say, observation numbers (3 and 1), (4 and 2), (5 and 3)]

Calculations :

Young's modulus $Y = \left\{\frac{32\pi^2 NR}{r^4}\right\}\left\{\frac{2m_0}{(\Delta T^2 / \Delta x^2)_{mean}}\right\}$

Result :

Young's Modulus of the material of the flat spiral spring Y = ………. dyne/cm^2.

Surface Tension of a liquid

Aim: To determine the surface tension by capillary rise method for a given liquid (water)

Apparatus: Beaker, retort stand, travelling microscope, cork piece, wooden block, reading lens, capillary tube, thin needle or pin and liquid (water).

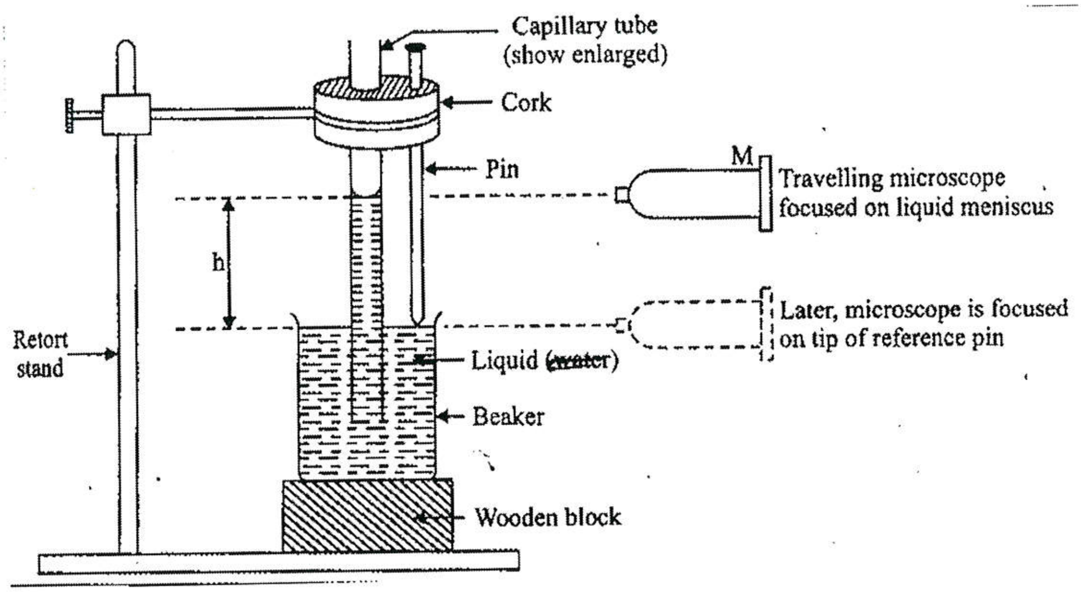


Fig.

Procedure:

(T) First determine the least count of travelling microscope.

(ii) To measure the height of liquids column 'h'

1. Fix the capillary tube in a hole drilled in a piece of cork. A long thin needle or reference pin is attached to the capillary tube using wax. The cork is then held firmly in the clamp of a retort stand.
2. A clean beaker is filled with the liquid and placed over a wooden block of proper height.
3. Fix the cork in the clamp of the retort stand in such a way that the capillary tube and the needle remain vertical. Adjust the position of the clamp and beaker in such a way that capillary tube dips in and the water freely rises in the capillary while tip of the needle just touches the surface of the water (Fig.) (outside the capillary tube).
4. Move the eye piece of the travelling microscope in or out until the cross-wires are seen distinctly i.e. focus on cross-wires.
5. Focus the microscope on liquid in the capillary tube. Move the travelling microscope vertically until the horizontal cross-wire is tangential to the liquid meniscus. You are required to focus the horizontal wire of the cross wire as seen through the eye piece (Fig.) Note the reading 'X' on the vertical scale of the travelling microscope.

6. Remove the stand and take away the beaker carefully without disturbing the needle and the capillary tube. Bring the travelling microscope in front of the needle and lower it until the horizontal cross-wire touches the image of the tip of the needle [Fig.]. Note the travelling microscope reading 'Y' on the vertical scale.
7. Take two or three more readings by dipping the capillary tube to a different level in the liquid.
8. The above procedure is repeated for different liquids

Observation :

L.C. of travelling microscope = _________ cm

Radius of the given capillary tube = _________ cm

(T) Measurement of height for water column :

Obs. No	Travelling microscope reading						Height of the column h (X –Y) cm	Mean (h) cm
	Focused on the liquid meniscus			Focused on the tip of the reference pin				
	M.S.R. (a) cm	V.S.R. (b) cm	T.R. (a + b) X cm	M.S.R. (a) cm	V.S.R. (b) cm	T.R. (a + b) Y cm		
1								
2								
3								

Formula: $T = \frac{rh\rho g}{2\cos\theta}$

Calculation:

From measured 'h' and for water since $\theta = 0$, using the above formula, Surface Tension (T) can be calculated.
Also ρ = 1 gm/cc and g = 980 cm/s^2.

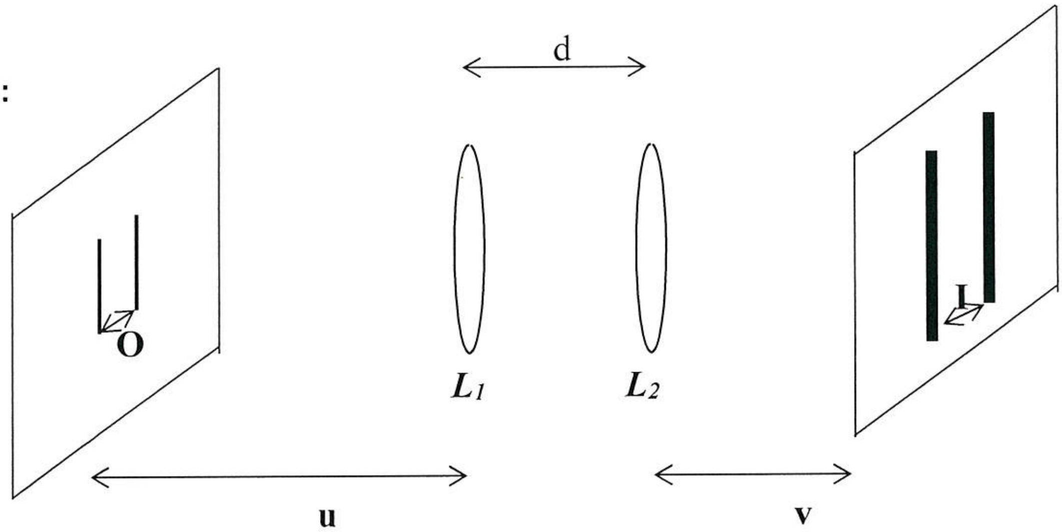
Result: Surface Tension for the given liquid (Water) is _________ dynes/cm

Combination of Lens

Aim : To find the equivalent focal length of a lens system by using diminished and magnified images of the object.

Apparatus : Object, lenses, screen, metre scale, etc.

Diagram :



Procedure :

1. Illuminate the given object. Measure the size **O** of the object.
2. Keep a fixed distance **d** between the two lenses L_1 and L_2.
3. Place the illuminated object in front of the lens L_1 of the given lens system. Measure the distance **u** of the object from the lens L_1.
4. Vary the distance of the screen from the lens L_2, so as to get a sharp image on the screen. Measure the distance **v** of the screen from the lens L_2. Measure the size **I** of the image.
5. Find the magnification $m = \frac{size\ of\ image}{size\ of\ object} = \frac{I}{O}$
6. Repeat step 3, 4 and 5 for eight different values of **u** , so as to get both diminished and magnified images.
7. Plot a graph of $(1 + m)$ against **v** and $(1 + \frac{1}{m})$ against **u.** Find the focal lengths, f_1 and f_2 and intercepts x_1 and x_2 from the respective graphs.

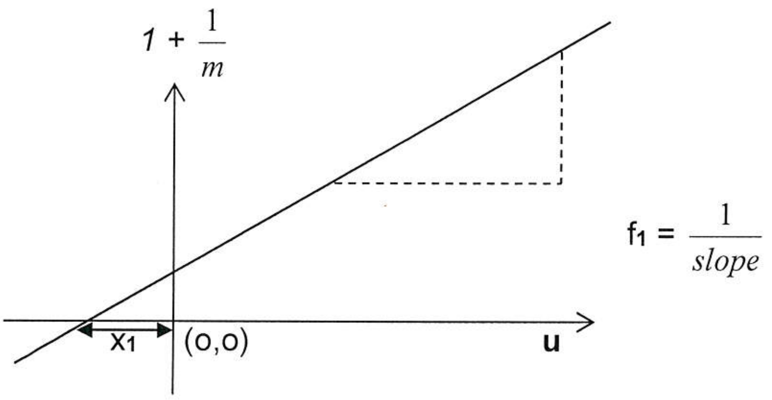
Observation :

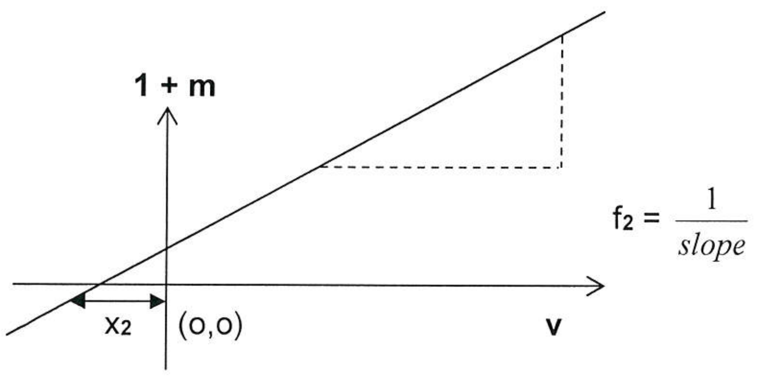
Size of the object O = ...cm.

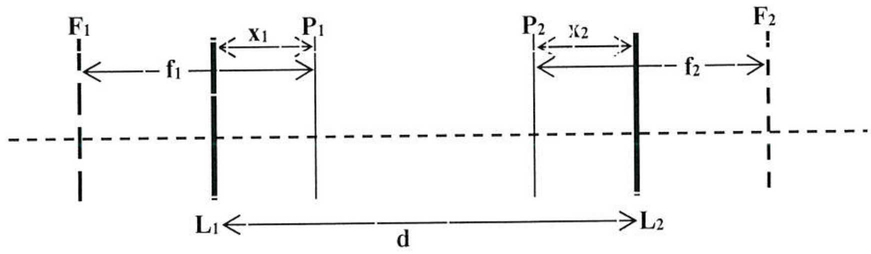
Distance between the two lenses d = ...cm.

Obs. No.	Object distance u	Image distance v	Size of Image I	Magnification m = I / O	1+m	$1 + \frac{1}{m}$
	cm	cm	cm			
1						
2						
3						
4						
5						
6						
7						
8						

Graph :







Result : 1) Mean equivalent focal length of the lens system f $= \dfrac{f_1 + f_2}{2}$ **= ....cm.**

2) Distance between *L1* and first Principal plane P1 is **x1 =........cm.**

3) Distance between *L2* and second Principal plane P2 is **x2 = ...cm.**

N. B. For air as the medium between the lens, the principal points and the nodal points are the same. These focal points, principal points and the nodal points are called cardinal points.

Use of Spectrometer to find Refractive Index (μ)

Aim : To find the refractive index of the material of prism using spectrometer .

Apparatus : Spectrometer, Mercury source, Prism, spirit level etc.

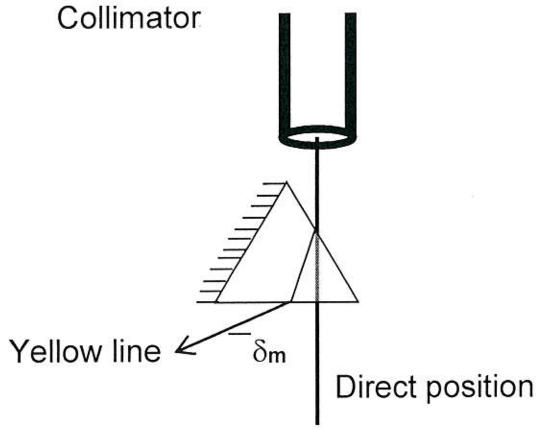
Formula : $$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Procedure : (A) Level the spectrometer using spirit level.

(B) Schuster's method - focusing spectrometer for parallel light :

1) Focus the cross – wires by adjusting the eyepiece of the telescope. Illuminate the slit of the collimator with the given source of light.

2) Place the prism with one edge facing the collimator. View along the arrow shown with the naked eye. The spectrum will be visible.



3) Rotate the telescope and view the spectrum through it. Turn the prism table and follow the spectrum by rotating the telescope. At one position the spectrum turns. This is the minimum deviation position.

4) Keep the minimum deviation position on any one side of the cross wire, so that the spectrum crosses the vertical cross wire twice on moving the prism table.

5) Choose a particular colour, say, the yellow line . Rotate the refracting edge towards the telescope. When the yellow line reaches minimum deviation, turns and comes on the cross wire , focus the telescope so that the lines are sharp.

6) Rotate the refracting edge towards the collimator. When the yellow line reaches minimum deviation, turns and comes on the cross wire , focus the collimator so that the lines are sharp.

7) Repeat step (5) and (6) a number of times till no more focusing is required. Now the spectrometer is adjusted for parallel light using Schuster's method.

(B) To find the angle of minimum deviation δ_m :

1) Adjust the position of the telescope to see the yellow line stop, turn and come back. Clamp the telescope at this position.
2) Rotate the prism table slowly to see the exact position at which the yellow line stops to turn. Clamp the prism table at this turning point.
3) Now adjust the position of telescope with the fine motion screw in such a way that the intersection point of the cross wires coincides with the yellow line. This is the exact position of minimum deviation.
4) Note the corresponding spectrometer readings on window A and B as **X** and **Y** respectively for this position of the telescope.
5) Remove the prism and turn the telescope to be in line with the collimator so that the point of intersection of cross wires coincides with the image of the slit seen directly.
6) Note the corresponding spectrometer readings on both windows A and B as **X** $^{/}$ and **Y** $^{/}$ respectively. This is the direct reading.
7) Determine the minimum deviation δ_m and hence find the refractive index μ of the material of the given prism.

Observation : L. C. of the spectrometer = ------------

Refracting Angle **A** = 60^0

Minimum Deviation Position		Direct Reading		$\delta_{m1} = X \sim X'$	$\delta_{m2} = Y \sim Y'$	Mean δ_m
X	*Y*	X $^{/}$	Y $^{/}$			

Calculations :

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

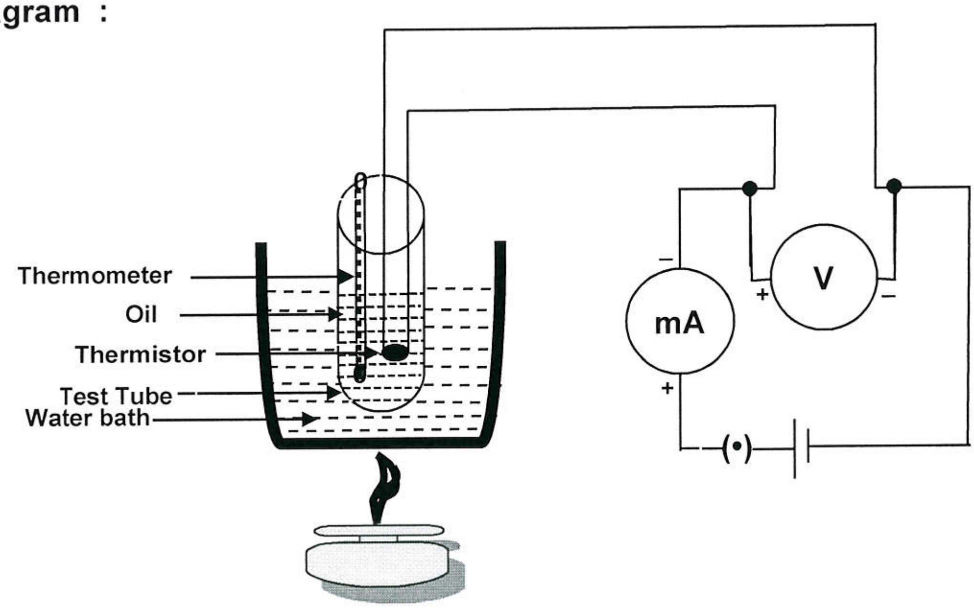
Result : **Refractive Index of the material of the given prism is** μ = ________

Thermistor Characteristics

Aim : To study the thermal characteristics of the given thermistor.

Apparatus : Thermistor, dc power supply, milliammeter, voltmeter (0 – 3V), water, bath, burner etc.

Circuit diagram :



Procedure :

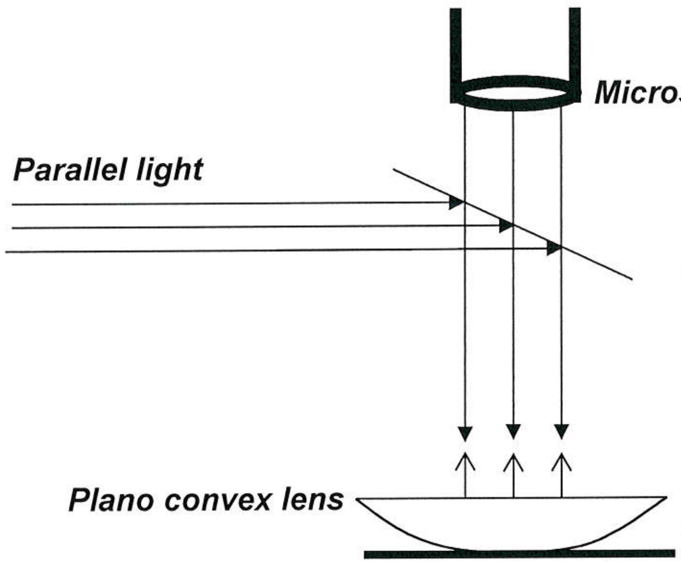
1. Place the thermistor in a test tube containing oil. Immerse the test tube in water bath.
2. Keep the thermometer in the test tube.
3. Connect the circuit as shown in the circuit diagram.
4. Apply a voltage V of 1 volt and measure the corresponding current I, keeping the thermistor at room temperature.
5. Increase the temperature θ in steps of 5^0 C of the thermistor by heating the water up to 55^0 C.
6. Also take the corresponding current I and voltage V while cooling the thermistor to the same temperature.
7. Calculate the resistance R of the thermistor at different temperatures θ.
8. Plot a graph of resistance R against temperature θ.

Newton's Rings

Aim : To determine the radius of curvature **R** of a given convex lens by Newton's rings.

Apparatus : Plano convex lens, blackened glass plate , monochromatic source, plane glass plate, travelling microscope, etc

Experimental Setup :



Formula :

$$R = \frac{1}{4\lambda}\left(\frac{D_{n_2}^2 - D_{n_1}^2}{n_2 - n_1}\right)$$

Procedure :

1) Place a plano-convex lens on the blackened glass plate with the convex surface of the lens touching the glass plate. A thin film of air is enclosed between the lower surface of the lens and the upper surface of the plate.

2) Adjust the Na-vapour source so that a parallel beam of light falls on the glass plate.
3) Hold the glass plate at **45°** with the horizontal, so that it reflects a part of the incident light towards the air film.
4) View the refracted beam from the air film with the help of a travelling microscope. Focus to get circular bright and dark rings.
5) From the center, move the microscope towards one side , say the 15^{th} ring. The central ring is not counted. To avoid the backlash error move back by five rings. Take this as the $\mathbf{n^{th}}$ (10^{th}) dark ring.
6) Moving towards the center , take the readings corresponding to various dark rings as stated in the observation table.

7) Cross the center and take readings in the same direction as before corresponding to the same ring number on the other side.

8) Determine the diameter D_n of each ring.

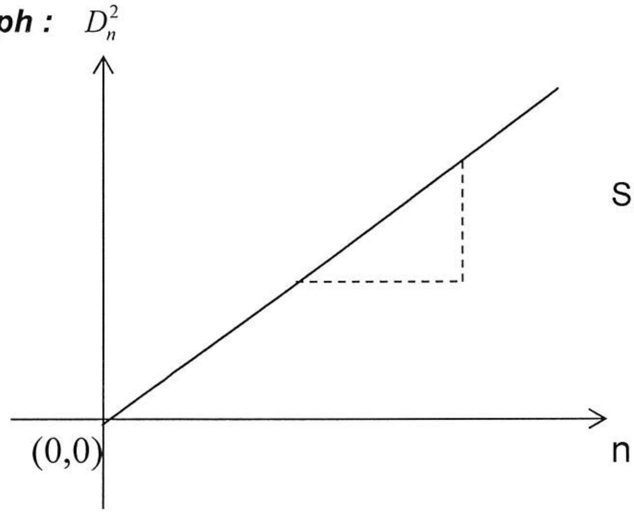
9) Plot a graph of D_n^2 against n. Find the slope and thus calculate the radius of curvature of the given lens.

Observations :

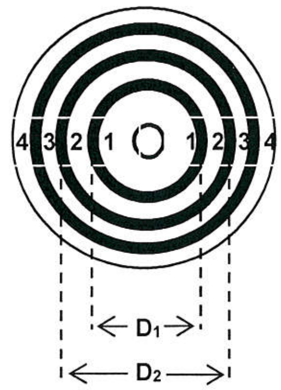
L. C. of travelling microscope = ……… cm

Ring no. n	Left reading			Right reading			Diameter $D_n = A \sim B$	D_n^2
	M.S.R.	V.S.D.x L.C.	Total Reading A	M.S.R.	V.S.D.x L.C.	Total Reading B		
	cm	cm	cm	cm	cm	cm	cm	cm^2
14								
12								
10								
8								
6								
4								
2								

Graph :



Slope =



Calculations :

$$R = \frac{1}{4\lambda}(\text{ slope })$$

Given λ = 5893 A° = 5893 x 10^{-8} cm

Result : Radius of curvature of the given lens is R = ………..cm.

Graph :- D_n^2 Vs n

Question No.

(70)

4

Question No.