Standard Operating Procedure

General Experiments

For I B.Sc Physics Students

Prepared by
Dr. M. Seetha
Assistant Professor
Dr. V.D. Nithya
Assistant Professor

DEPARTMENT OF PHYSICS

KONGUNADU ARTS AND SCIENCE COLLEGE

COIMBATORE

Index

List of Experiments

1. Compound Pendulum

Aim:

To determine the acceleration due to gravity, radius of gyration and the moment of inertia of a compound pendulum.

Apparatus required:

1. Compound pendulum setup
2. Stopwatch or timer
3. Metre scale

Formula:

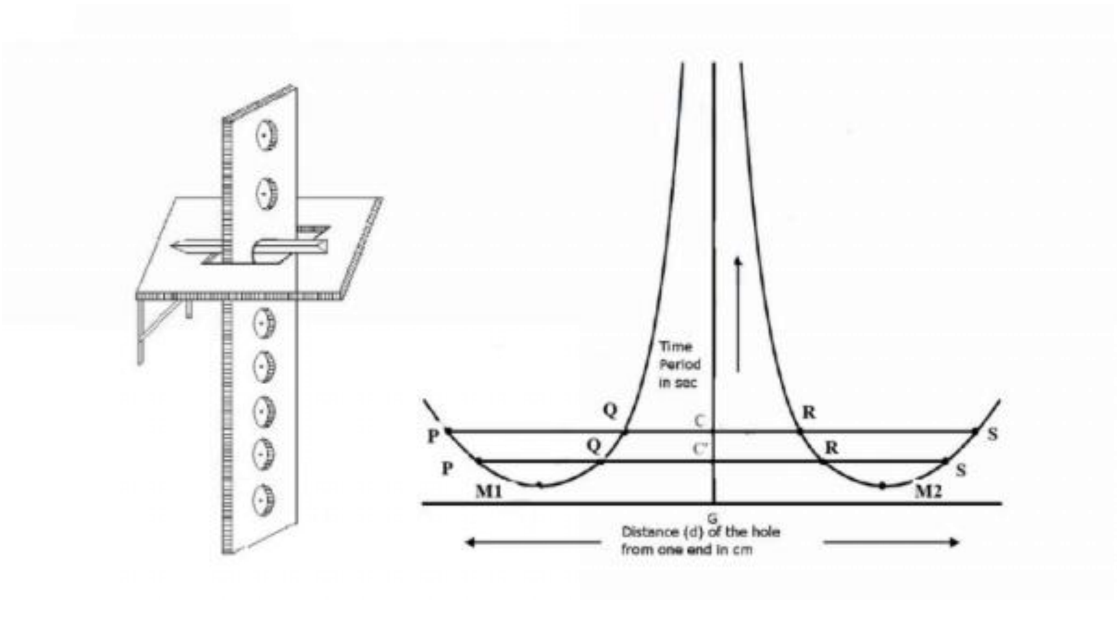
(i) Acceleration due to gravity $g = 4\pi^2 \left(\frac{L}{T^2}\right)$ (m s^{-2})

(ii) Radius of Gyration $K = \frac{m1 \sim m2}{2}$ (m)

(iii) Moment of Inertia $I = MK^2$ (Kg m^2)

where T is the time period (s), L is the length of the equivalent simple pendulum (m), I is the moment of inertia of the compound pendulum (Kg m^2) and M is the mass of the compound pendulum (Kg).

Diagram:



Experimental Procedure:

1. The pendulum is initially suspended by passing knife-edge through the first hole from one end.
2. Start the pendulum swinging, ensuring it is not influenced by any external forces.
3. Using the stopwatch or timer, measure the time taken for a certain number of oscillations (For example: 20 oscillations). Repeat this for two times as trial 1 and trial 2. Mean value is calculated.
4. Calculate the time period for one oscillation (T) using the average time measured.
5. Repeat steps for different distances by suspending the pendulum through all the holes on one side of the centre of gravity of the compound pendulum.
6. The bar is then inverted and suspended by passing the knife edge through different holes from the other end. At each distance, the period of oscillation is found and tabulated.
7. Plot a graph with distance in x-axis and time period in y-axis where a double branched curve is obtained.
8. A line is drawn parallel to X-axis that intersects the curve at four points P, Q, R and S at particular time period T. Repeat it for various time periods.
9. From the measured values of PR and QS, the value of L/T^2 is measured from which the acceleration due to gravity is calculated using the formula.
10. The points M_1 and M_2 that corresponds to minimum period of oscillation is noted from the graph. Using these values, radius of gyration R is evaluated.
11. From the R value, moment of inertia I could be found out.

Tabulation:

Number of hole from end A	Distance of holes from one end (metre)	Time taken for 20 oscillations (sec)			Period of one oscillation T (sec)
		Trial-I	Trial-II	Mean	

S.No.	**Period T (sec)**	**PR (cm)**	**QS (cm)**	**Length of equivalent pendulum L= (PR+QS)/2 (cm)**	**L/T^2 (m/sec^2)**

Result:

1. Acceleration due to gravity, g = …………. ms^{-2}
2. Radius of gyration R =……………….. m
3. Moment of inertia, I= …………….Kg m^2

2. Young's modulus - Non-uniform bending using an optical lever

Aim:

To determine the Young's modulus of a given material by subjecting it to non-uniform bending using single optical lever.

Apparatus Required:

1. Specimen of the given material (e.g., a long rectangular bar)
2. Optical lever setup (consisting of a light source, mirror, and scale)
3. Weights and weight hanger
4. Vernier caliper
5. Screw gauge
6. Ruler
7. Telescope

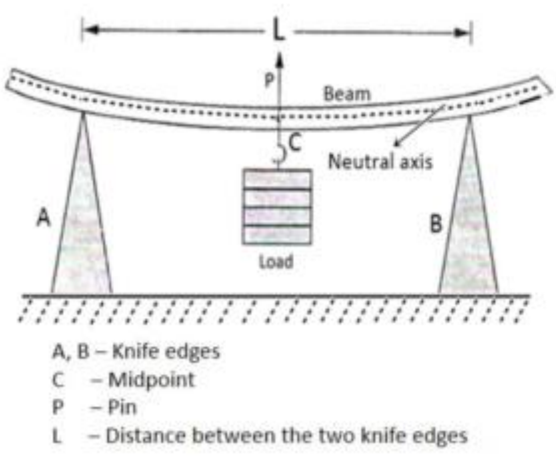
Formula:

The Young's modulus, E, of a material can be determined using the formula,

$$E = \frac{gL^3 D}{2bd^3 e}\left[\frac{M}{x}\right]$$

where E is the Young's modulus (N m-^{2}), M is the mass applied to the specimen, g is the acceleration due to gravity, L is the length of the specimen, b is the width of the specimen, d is the thickness of the specimen, and x is the shift for mass, e is the effective length of the optic lever and D is the distance between mirror and scale.

Diagram:



Experimental Procedure:

1. Set up the optical lever apparatus with the light source, mirror, and scale. Make sure the scale is aligned with the optical lever setup.
2. Measure the dimensions of the specimen using the vernier caliper and screw gauge. Note the length (L), width (b), and thickness (d) of the specimen.
3. Attach the specimen to the apparatus, ensuring it is securely clamped or supported at both ends using the knife edges.
4. A scale and telescope is placed in front of the mirror at a distance of 1 meter. The telescope is focussed to view the reflected image of the scale in the mirror.
5. Place weights on a weight hanger and attach it to the specimen at a centre of the support. Note the mass (m) applied to the specimen.
6. The experiment is repeated by varying the weights and at each time the scale reading at the telescope is noted.
7. Similarly, the telescope reading is measured during unloading. The shift, x is calculated.
8. The effective length e of the optic lever is measured by pressing the optic lever on paper.
9. Calculate the Young's modulus, E using the measured x, e, b, d, M and L values.

Tabulation

Load **X 10^{-3} Kg**	**Telescope Reading (cm)**		**Mean** **(cm)**	**Shift** **x** **for M=…gm**
	Loading	**Unloading**		

Breadth of the material using vernier caliper:

Least Count (LC)= … cm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..cm

Main scale reading (MSR) cm	Vernier scale coincidence (VSC) div	Observed Reading OR = MSR + (VSC x LC) cm	Corrected Reading CR = OR ± ZC cm

Thickness of the material using screw guage:

Least Count (LC)= … mm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..mm

Pitch Scale Reading (P.S.R) mm	Head Scale Coincidence (H.S.C) div	Observed Reading OR = PSR + (HSC x LC) mm	Corrected Reading CR = OR ± ZC mm

Result:

The Young's modulus, E, of the given material of the bar by non-uniform bending using optic lever is ……………. N m^{-2}.

3. Young's modulus by the cantilever depression method

Aim:

To determine the Young's modulus of a given material using the cantilever depression method.

Apparatus Required:

1. Specimen of the given material (e.g., wooden scale)
2. Weights and weight hanger
3. Vernier caliper
4. Screw gauge
5. Ruler
6. Pin and Microscope

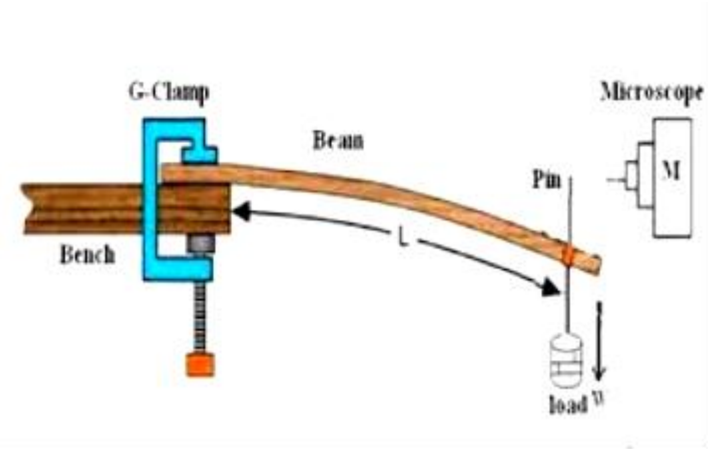
Formula:

The Young's modulus, E, of a material can be determined using the formula:

$$E = \frac{4MgL^3}{bd^3y}$$

where E is the Young's modulus (N/m^2), L is the length of the cantilever, b is the width of the cantilever, d is the thickness of the cantilever, g is acceleration due to gravity and y is the mean depression.

Diagram:



Experimental Procedure:

1. Measure the dimensions of the cantilever using the vernier caliper and screw gauge. Note the length (L), width (b), and thickness (d) of the cantilever.
2. Attach the cantilever to a rigid support, ensuring it is securely fixed at one end and free to move vertically at the other end.
3. Attach a weight hanger to the free end of the cantilever, and start with a small weight to the cantilever.
4. With the dead load (W) suspended, the microscope is adjusted such that the cross wire coincides with the image of the tip of the pin placed on the top of the suspended weight.
5. Reading on the vertical scale of the microscope is noted.
6. The experiment is repeated by loading weights. Similar procedure is carried out during unloading.
7. From the mean value, depression of y is evaluated.
8. Calculate the Young's modulus, E, from the mean value of depression of y.

Tabulation:

Load X 10^{-3} Kg	**Microscope Reading (cm)**		**Mean (cm)**	**Depression y for M=…gm**
	Loading	**Unloading**		

Breadth of the material using vernier caliper:

Least Count (LC)= … cm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..cm

Main scale reading (MSR) cm	Vernier scale coincidence (VSC) div	Observed Reading OR = MSR + (VSC x LC) cm	Corrected Reading CR = OR ± ZC cm

Thickness of the material using screw guage:

Least Count (LC)= … mm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..mm

Pitch Scale Reading (P.S.R) mm	Head Scale Coincidence (H.S.C) div	Observed Reading OR = PSR + (HSC x LC) mm	Corrected Reading CR = OR ± ZC mm

Result:

The Young's modulus, E, of the material of the bar by cantilever depression method is……….. N m^{-2}.

4. Rigidity modulus by the static torsion method

Aim:

To determine the rigidity modulus (G) of a given material using the static torsion method.

Apparatus Required:

1. Cylindrical rod
2. Torsion apparatus
3. Known weights
5. Vernier caliper
6. Screw gauge
7. Ruler
8. Telescope

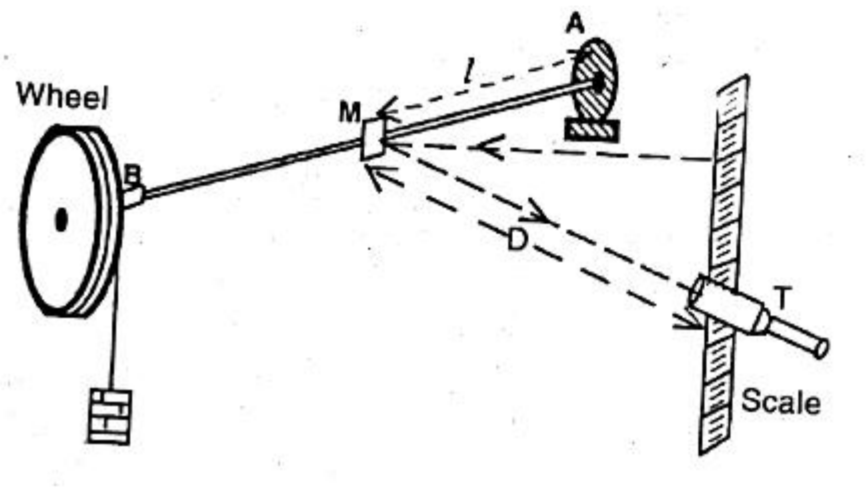
Formula:

The rigidity modulus, G, of a material can be determined using the formula:

$$G = \frac{4MgRLD}{\pi r^4 s}$$

where G is the rigidity modulus (N m^{-2}), R is the radius of wheel, D is the distance of mirror from scale, s is change in scale reading, L is the length of the rod from fixed end to the mirror and r is the mean radius of the rod.

Diagram:



Experimental Procedure:

1. Measure the dimensions of the cylindrical rod using the vernier caliper and screw gauge. Note the radius (r) and the length (L) of the cylindrical rod.
2. Fix one end of the cylindrical rod securely to the torsion apparatus.
3. Attach the torsion head to the other end of the cylindrical rod.
4. Apply a known weight to the torsion head, causing the rod to twist.
5. The reading of the scale division coinciding with the horizontal cross wire is noted.
6. The reading corresponding to clockwise loading and clockwise unloading are noted.
7. Similarly, the telescope reading for anti-clockwise loading and anti-clockwise unloading are measured.
8. From the tabulated readings, mean shift in the telescope reading due to the addition of load is determined.
9. Calculate the rigidity modulus, G, using the formula mentioned above.

Tabulation:

Load kg	**Telescope Reading (m)**						**(A~B)/2 (m)**	**Change in reading for m kgs**
	Clockwise			**Anti-clockwise**				
	Loading	**Unloading**	**Mean**	**Loading**	**Unloading**	**Mean**		

Thickness of the material using screw guage:

Least Count (LC)= … mm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..mm

Pitch Scale Reading (P.S.R) mm	Head Scale Coincidence (H.S.C) div	Observed Reading OR = PSR + (HSC x LC) mm	Corrected Reading CR = OR ± ZC mm

Result:

The rigidity modulus, G, of the material of the rod using the static torsion method is ……….Nm^{-2}.

5. Rigidity modulus by the torsional pendulum method

Aim:

To determine the rigidity modulus (G) of a given material using the torsional pendulum.

Apparatus Required:

1. Cylindrical wire
2. Torsional pendulum apparatus
3. Known masses for applying torque
4. Screw gauge
5. Ruler

Formula:

The rigidity modulus, G, of a material can be determined using the formula:

$$G = \frac{8\pi l \times 2m}{a^4}\left(\frac{d_2^2 - d_1^2}{T_2^2 - T_1^2}\right)$$

Moment of inertia

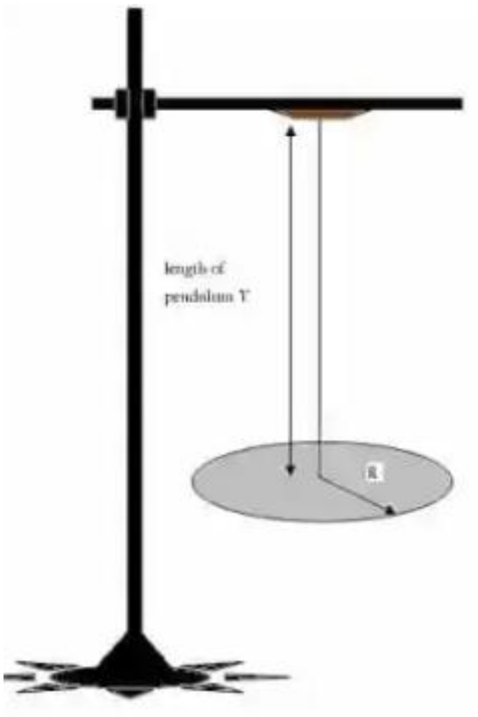
$$I = \frac{T_o^2}{T_2^2 - T_1^2} 2m(d_2^2 - d_1^2)$$

Moment of inertia by direct method

$$I = \frac{MR^2}{2}$$

where G is the rigidity modulus (N m^{-2}), l is the length of the torsion wire, m is the mass of disc, a is the radius of the wire, T_1 is the time period when two masses are kept at a distance d_1, T_2 is the time period when two masses are kept at a distance d_2, To is the period of torsional oscillation for the wire of disc alone without the masses, d_1 is the distance between the centre of the mass and the suspension wire position and d_2 is the distance between centre of the mass and suspension wire kept apart from the wire.

Diagram:



Experimental Procedure:

1. Measure the dimensions of the cylindrical wire using screw gauge where l is the length of the torsion wire, m is the mass of disc and a is the radius of the wire.
2. Fix one end of cylindrical wire to the torsion rod, and the other end to a rigid support, ensuring that the wire is straight and untwisted.
3. Two symmetrical masses are placed on the disc at a distance d_1 from the centre.
4. The disc is turned about the axis of the wire such that it executes torsional oscillations about the vertical axis. The time period for 10 oscillations (T1) is noted.
5. Next, the weights are moved to extreme ends at a distance d_2 from the centre of the wire and time period for 10 oscillations (T2) is noted.
6. The experiment is repeated for different length of wires and the readings are tabulated.
7. Calculate the rigidity modulus, G using the formula mentioned above.
8. For the measurement of I, the time period of oscillations (T_o) for without masses are noted.

Tabulation:

S.No.	Length of the wire m	Time taken for 10 oscillations (without mass) sec			Time taken for 10 oscillations with mass at a distance of d_1 sec			Time taken for 10 oscillations with mass at a distance of d_2 sec			$\frac{l}{T_2^2 - T_1^2}$ m/s[2]	$\frac{T_o^2}{T_2^2 - T_1^2}$ sec
		Trial I	Trial II	T_o	Trial I	Trial II	T_1	Trial I	Trial II	T_2		

Thickness of the material using screw guage:

Least Count (LC)= … mm Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..mm

Pitch Scale Reading (P.S.R) mm	Head Scale Coincidence (H.S.C) div	Observed Reading OR = PSR + (HSC x LC) mm	Corrected Reading CR = OR ± ZC mm

Result:

1. The Rigidity modulus, G, of the wire is ………………… Nm^{-2}.
2. Moment of Inertia of the disc is ………..Kg m^2
3. Moment of Inertia of the disc by direct method is ………..Kg m^2

6. Coefficient of viscosity of highly viscous liquids using Stokes' method

Aim:

To determine the viscosity of a highly viscous liquid using Stokes' method.

Apparatus Required:

1. Tall jar of large diameter
2. Large quantity of highly viscous liquid such as glycerine or castor oil
3. Steel spheres of different sizes
4. Screw gauge
5. Stop watch
6. Powerful magnet

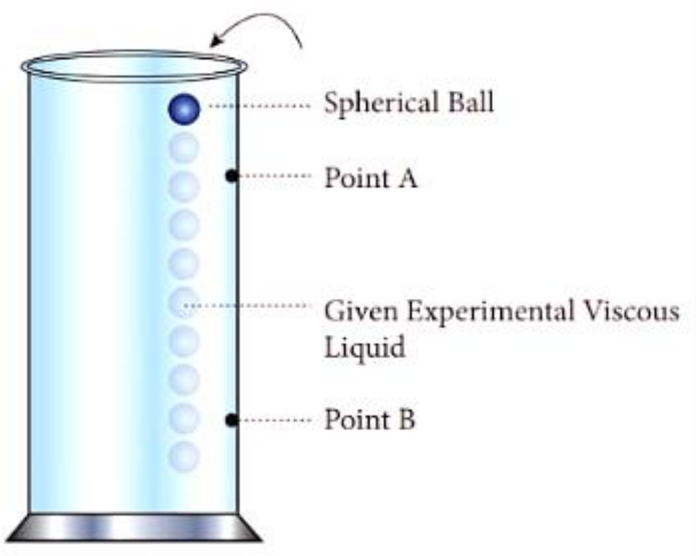
Formula:

The viscosity of the liquid can be determined using Stokes' Law:

$$\eta = \frac{2}{9}\frac{a^2 g}{v}(\rho-\sigma)$$

where η is the viscosity of the liquid (Nsm^{-2}), g is the acceleration due to gravity, a is the radius of the sphere, v is the terminal velocity, ρ is the relative density of the sphere, σ is the relative density of the liquid.

Diagram:



Experimental Procedure:

1. Fill the jar with the highly viscous liquid, ensuring that there are no air bubbles in the liquid.
2. A strip of paper is passed along the length of the jar with marks A and B at a distance of 50 cm from each other.
3. Gently place a sphere on the surface of the liquid and allowed to fall through the liquid in the centre of the jar.
4. Time taken for the sphere to travel from A to B is noted.
5. The procedure is repeated for different sized metal spheres.
6. From the values of distance travelled by the sphere (s) and time taken (t), the terminal velocity s/t is calculated.
7. Calculate the viscosity of the liquid using the formula mentioned above.

Tabulation:

Trial	Distance travelled after terminal stage S	Time taken T	Terminal velocity s/t

Thickness of the material using screw guage:

Least Count (LC)= … mm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..mm

Ball	Pitch Scale Reading (P.S.R) mm	Head Scale Coincidence (H.S.C) Div	Observed Reading OR = PSR + (HSC x LC) mm	Corrected Reading CR = OR ± ZC mm

Result:

The coefficient of viscosity η of the highly viscous liquid using Stokes' method is ….. N s m^{-2}.

7. AC frequency by the sonometer

Aim:

To determine the frequency of the AC main supply using the sonometer.

Apparatus Required:

1. Sonometer: A wooden or metal box with a wire stretched over it, a bridge or slider to vary the tension in the wire, and a movable bridge to change the effective length of the wire.
2. Low voltage AC source
3. Electromagnet
4. Meter scale
5. Screw gauge
6. Known and unknown weights.

Formula:

The frequency of the the AC supply is

$$n = \frac{1}{2}\sqrt{\frac{M}{l^2}\frac{g}{m}} \quad \text{(Hz)}$$

Where

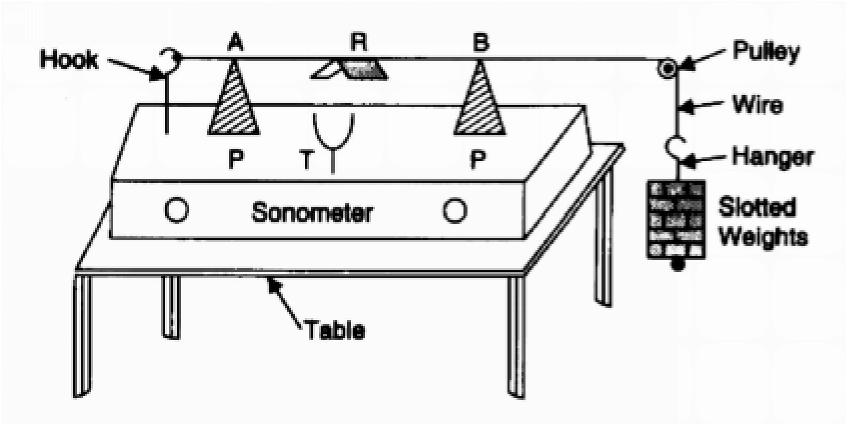
g is the acceleration due to gravity (m/s^2)

l is the length of the vibrating segment (cm)

M is the mass applied to the string (kg)

m is the linear density or mass per unit length of the wire.

Diagram:



Experimental Procedure:

(i) One end of the sonometer wire is fixed, while the other passes over a smooth frictionless pulley and is stretched under a constant low tension weight.

(ii) Connect the primary of the step down transformer to A.C mains, while the secondary to the two ends of the sonometer wire.

(iii) Place the electromagnet in the middle of the wire such that the magnetic field is applied in a horizontal plane and at right angles to the length of the wire.

(iv) Hang a mass M from one end of the wire and adjust the distance between two bridges symmetrically with respect to magnet till the wire appears to be vibrating with the maximum amplitude (It can be checked with the paper rider).

(v) Note the distance between the two bridges.

(vi) Repeat the experiment by increasing weights.

(vii) Measure the diameter of the wire using screw gauge.

(viii) Graph can be plotted with M vs l^2, from the slope of the graph A.C. frequency can be calculated.

(ix) Mass of an unknown body can also be calculated using the graph.

Tabulation:

S.No.	**Load Applied (kg)**	**Length of the vibrating segment, l ($\times 10^{-2}$ m)**	**l^2 ($\times 10^{-4}$ m^2)**	**M/ l^2 (kg m^{-2})**

Thickness of the material using screw guage:

Least Count (LC)= … mm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..mm

Pitch Scale Reading (P.S.R) mm	**Head Scale Coincidence (H.S.C) Div**	**Observed Reading OR = PSR + (HSC x LC) mm**	**Corrected Reading CR = OR ± ZC mm**

Result:

1. The frequency of AC supply using sonometer N is ………Hz
2. The frequency of AC supply by graphical method using sonometer N is …Hz
3. The unknown mass of the body is………………. Kg
4. The unknown mass of the body by graphical method is………………. Kg

8. Thermal conductivity using the Lee's disc method.

Aim:

To determine the thermal conductivity of a bad conductor using Lee's disc method.

Apparatus Required:

1. Lee's disc apparatus: It consists of a metal disc with two concentric rings, an electric heater, a temperature sensor, and a power supply.
2. Thermometer or temperature sensor
3. Heat source: Bunsen burner or electric heater
4. Stopwatch or timer
5. Bad conductor: To minimize heat loss from the disc to the surroundings.
6. Vernier Caliper
7. Screw gauge
8. Wooden or metal stand

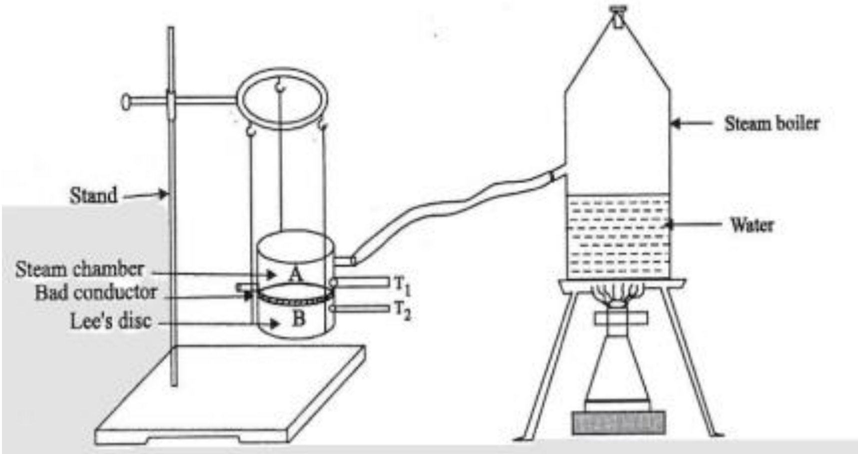
Formula:

The formula to determine the thermal conductivity κ using Lee's disc method is:

$$\kappa = \frac{MSRd}{\pi r^2 (\theta_1 - \theta_2)} \left(\frac{2h+r}{2h+2r}\right) \quad (\text{W m}^{-1}\ \text{K}^{-1})$$

Where M is the mass of brass disc (kg), S is the specific heat capacity (J/Kgm), R is the rate of fall of temperature (°C), r is the radius of brass disc, d is the thickness of the bad conductor, θ_1 is the steady temperature of the chamber, θ_2 is the steady temperature of metallic disc and h is the thickness of the brass disc.

Diagram:



Experimental Procedure:

1. Measure the dimensions of the Lee's disc using vernier caliper and screw gauge. Note the inner and outer radii of the disc.
2. Set up the Lee's disc apparatus on a stable wooden or metal stand.
3. Ensure that the disc is clean and free from any dust or dirt.
4. Place a thin layer of insulating material on the disc to minimize heat loss to the surroundings.
5. Connect the electric heater to a power supply or use a Bunsen burner as the heat source.
6. Insert a thermometer or temperature sensor into the disc to measure the temperature.
7. Start the heat source and allow the disc to reach a steady-state temperature.
8. Measure and note the steady-state temperature difference (ΔT) across the disc.
9. After reaching the steady state temperature, remove the bad conductor and allow the two metal discs A and B to be in contact with each other for a temperature raise of about 10°C from the steady state temperature.
10. Now remove the metal disc A from B. Now record the time (t) taken for change in temperature.
11. Plot a graph between time and temperature, R can be calculated from the slope of the curve.
12. Calculate the thermal conductivity (κ) using the formula mentioned above.

Tabulation:

Temperature (°C)	**Time (minutes)**	**Time (seconds)**

Breadth of the material using vernier caliper:

Least Count (LC)= … cm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..cm

Main scale reading (MSR) Cm	Vernier scale coincidence (VSC) div	Observed Reading OR = MSR + (VSC x LC) cm	Corrected Reading CR = OR ± ZC cm

Thickness of the material using screw guage:

Least Count (LC)= … mm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..mm

Pitch Scale Reading (P.S.R) Mm	Head Scale Coincidence (H.S.C) div	Observed Reading OR = PSR + (HSC x LC) mm	Corrected Reading CR = OR ± ZC mm

Result:

The thermal conductivity of the bad conductor using the Lee's disc method is ……………W m^{-1} K^{-1}.

9. Specific heat capacity-Newton's Law of Cooling

Aim:

To determine the specific heat capacity of a liquid by Newton's law of Cooling.

Apparatus Required:

1. Spherical calorimeter
2. Thermometer
3. Heater
4. Power supply
5. Stopwatch or timer
6. Measuring cylinder
7. Weighing balance
8. Water
9. The substance whose specific heat capacity is to be determined (Oil).

Formula:

The formula to determine the specific heat capacity using Joule's calorimeter is:

$$s_2 = \frac{ECt}{(w_2 - w_1)(\theta_2 + x - \theta_1)} - \frac{w_1 s_1}{w_2 - w_1} \ (\mathrm{J\ K^{-1}\ kg^{-1}})$$

W_1 is the mass of empty calorimeter

W_2 is the mass of calorimeter with liquid

θ_1 is the initial temperature

θ_2 is the final temperature

x is the radiation correction

C is ammeter reading

E is voltmeter reading

t is the time of passage of current

s_1 is the specific heat capacity of calorimeter

Diagram:

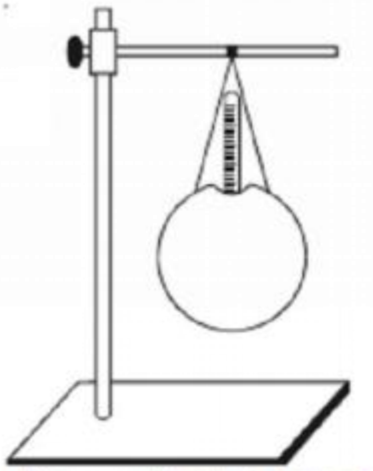


Fig. Newton's law of cooling

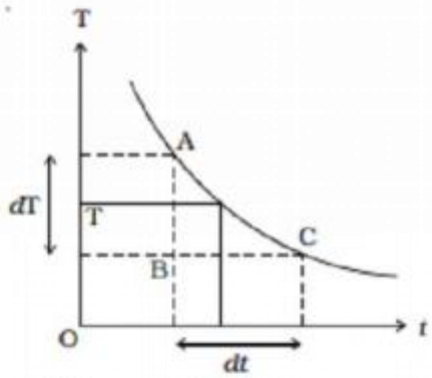


Fig. Cooling curve

Experimental Procedure:

1. Measure the mass (m) of the substance whose specific heat capacity is to be determined.
2. Fill the calorimeter with a known mass (M) of water and measure its fall in temperature.
3. Add the heated substance (oil) into the calorimeter.
4. Note down the fall in temperature.
5. Calculate the change in temperature ($\Delta T = T_f - T_i$).
6. Calculate the specific heat capacity (c) using the formula mentioned above.

Result:

The specific heat capacity of a liquid by Newton's law of Cooling is ……J K^{-1} Kg^{-1}.

10. Refractive index of a solid prism using a spectrometer

Aim:

To determine the refractive index of a solid prism using a spectrometer.

Apparatus Required:

1. Solid prism
2. Spectrometer
3. Monochromatic light source (sodium vapour lamp).

Formula:

The formula to determine the refractive index of a solid prism is

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

where μ is the refractive index, A is the angle of prism, and D is the angle of minimum deviation.

Diagram:

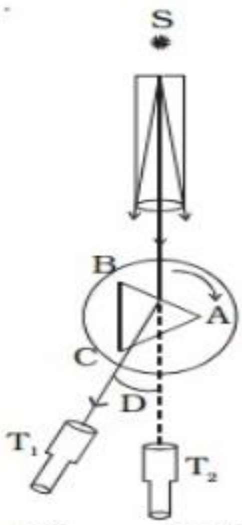


Fig. Angle of minimum deviation

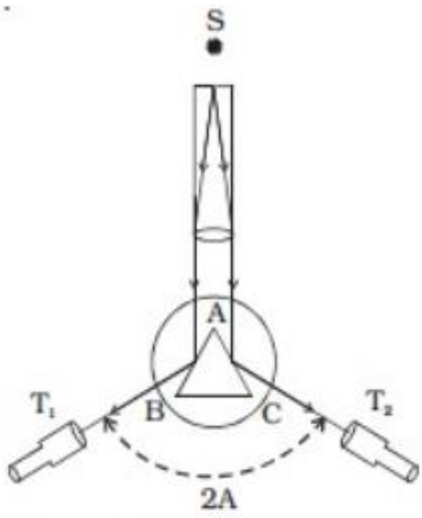


Fig. Angle of the prism

Experimental Procedure:

1. Set up the spectrometer and sodium vapour lamp on a table and adjust its height so that the collimator and telescope are at the same level.
2. The initial adjustments for telescope (distant object method), collimator (clear slit) and prism table (horizontality to be checked with spirit level) are done.
3. The prism is placed on prism table such that the refracting edge bisects the parallel beam from the collimator.
4. Telescope is turned to catch the reflected image from one face of the prism and made to fix at that position.
5. The vertical cross-wire is adjusted to coincide with the image of the slit.
6. The vernier readings are noted on both sides.
7. Similarly, the vernier reading for reflected image from other face of the prism is noted.
8. From the difference between the two readings of same vernier, 2A values are obtained.
9. Finally, the value of A is determined.
10. Next the value of D is determined by placing the prism in such a way that light is incident on one face of the prism.
11. The refracted image is captured using the telescope.
12. The prism table is rotated such that refracted image moves towards the direct ray and at a stage the image stops and turns back.
13. This is the minimum deviation position where the prism table is fixed.
14. The refracted ray reading of the telescope is noted.
15. The difference between direct ray reading and refracted ray reading gives the minimum deviation D.

Tabulation:

Angle of Prism						
Image	**Vernier-I (Degree)**			**Vernier-II (Degree)**		
	MSR	**VC**	**TR**	**MSR**	**VC**	**TR**
Reflected image from Face I						
Reflected image from Face II						

Angle of Minimum Deviation						
Image	**Vernier-I**			**Vernier-II**		
	MSR	**VC**	**TR**	**MSR**	**VC**	**TR**
Reflected image from Face I						
Direct image						

Result:

1. Angle of prism A is…..
2. Angle of minimum deviation is…….
3. Refractive index (μ) of the solid prism is……..

11. Refractive Index of a Liquid Prism Using a Spectrometer

Aim:

To determine the refractive index of a liquid prism using a spectrometer.

Apparatus Required:

1. Spectrometer
2. Monochromatic light source (sodium vapor lamp).
3. Liquid prism

Formula:

The formula to determine the refractive index of a solid prism is

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

where μ is the refractive index, A is the angle of prism, and D is the angle of minimum deviation.

Diagram:

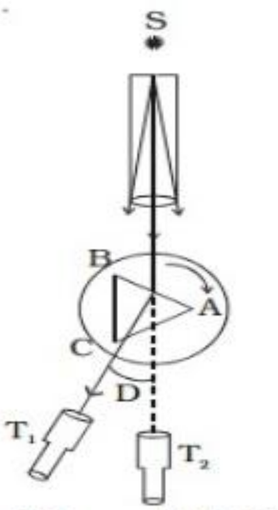


Fig. Angle of minimum deviation

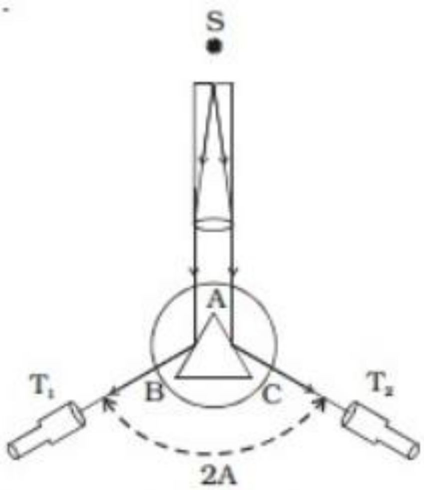


Fig. Angle of the prism

Experimental Procedure:

1. Set up the spectrometer and sodium vapour lamp on a table and adjust its height so that the collimator and telescope are at the same level.
2. The initial adjustments for telescope (distant object method), collimator (clear slit) and prism table (horizontality to be checked with spirit level) are done.
3. The hollow prism is filled with liquid whose refractive index is to be determined.
4. Place the liquid prism cell on the rotating prism table of the spectrometer and align it carefully.
5. Turn on the monochromatic light source.
6. Rotate the prism table until the telescope and collimator are aligned with the normal to the liquid prism.
7. The prism is placed on prism table such that the refracting edge bisects the parallel beam from the collimator.
8. Telescope is turned to catch the reflected image from one face of the prism and made to fix at that position.
9. The vertical cross-wire is adjusted to coincide with the image of the slit.
10. The vernier readings are noted on both sides.
11. Similarly, the vernier reading for reflected image from other face of the prism is noted.
12. From the difference between the two readings of same vernier, 2A values are obtained.
13. Finally, the value of A is determined.
14. Next the value of D is determined by placing the prism in such a way that light is incident on one face of the prism.
15. The refracted image is captured using the telescope.
16. The prism table is rotated such that refracted image moves towards the direct ray and at a stage the image stops and turns back.
17. This is the minimum deviation position where the prism table is fixed.
18. The refracted ray reading of the telescope is noted.
19. The difference between direct reading and refracted reading gives the minimum deviation D.

Tabulation:

Angle of Prism						
Image	**Vertier-I (Degree)**			**Vernier-II (Degree)**		
	MSR	**VC**	**TR**	**MSR**	**VC**	**TR**
Reflected image from Face I						
Reflected image from Face II						

Angle of Minimum Deviation						
Image	**Vernier-I**			**Vernier-II**		
	MSR	**VC**	**TR**	**MSR**	**VC**	**TR**
Reflected image from Face I						
Direct image						

Result:

1. Angle of prism A is…..
2. Angle of minimum deviation is…….
3. Refractive index (μ) of the liquid is……..

12. Refractive index of a solid prism (i-d curve) using a spectrometer

Aim:

To determine the refractive index of a solid prism using a spectrometer by drawing i-d curve.

Apparatus Required:

1. Solid prism
2. Spectrometer
3. Monochromatic light source (sodium vapour lamp).

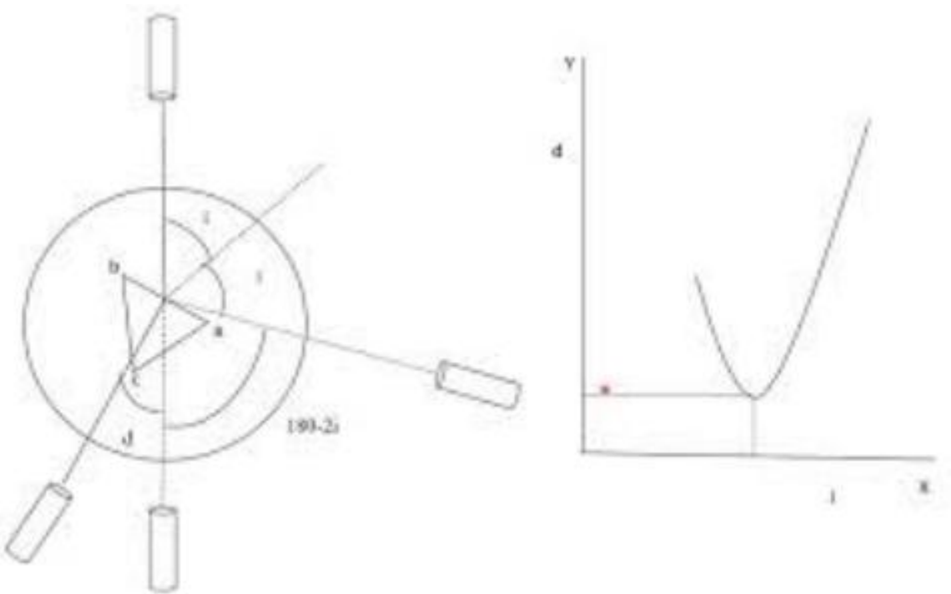
Formula:

The formula to determine the refractive index of a solid prism is

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

where μ is the refractive index, A is the angle of prism, and D is the angle of minimum deviation.

Diagram:



Experimental Procedure:

1. Set up the spectrometer and sodium vapour lamp on a table and adjust its height so that the collimator and telescope are at the same level.
2. The initial adjustments for telescope (distant object method), collimator (clear slit) and prism table (horizontality to be checked with spirit level) are done.
3. Now fix the angle of incidence (i) for which the angle of deviation is to be identified.
4. The rotation of the telescope for the corresponding angle of incidence is calculated using the formula $\theta = 180 - 2i$. Accordingly the telescope is fixed for the corresponding i.
5. Now, place the prism over the prism table and catch the angle of incidence by rotating the prism table for the fixed position of the telescope.
6. After catching the angle of incidence in the fixed position, the telescope is moved to catch the angle of deviation.
7. Note down the readings of angle of deviation for the corresponding angle of incidence.
8. Plot a graph between i and d. For a particular value of d, A can be calculated
9. The dip of the curve gives the value of D.
10. Using the above formula, calculate the value of μ.

Tabulation:

Angle of incidence, i	Angle of rotation $\theta = 180 - 2i$	Refracted Reading		Angle of deviation		Mean angle of deviation D
		V_A	V_B	V_A	V_B	

Result:

1. Angle of prism A is…..
2. Angle of minimum deviation D is…….
3. Refractive index (μ) of the liquid is……..

13. Potentiometer- Calibration of low range voltmeter

Aim:

To calibrate a given low range voltmeter using potentiometer.

Apparatus Required:

1. Potentiometer
2. Low range voltmeter
3. Daniel cell
4. High resistance
5. Galvanometer
6. Jockey
7. 2V battery

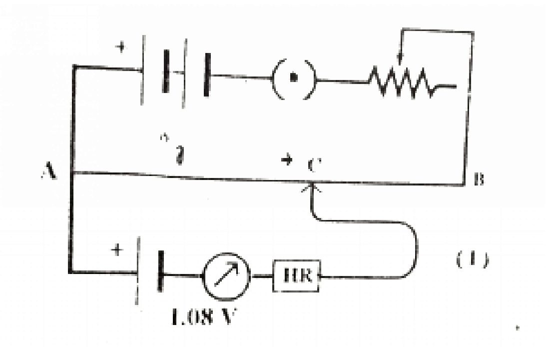
Formula:

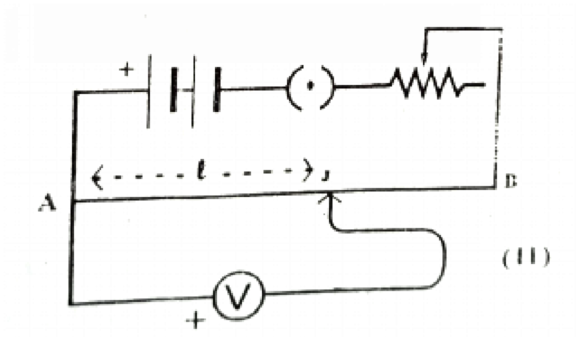
Calculated voltage

$$V' = \left(\frac{1.08}{l_o}\right) l \quad \text{(volt)}$$

Where lo is the balancing length for Daniel cell of emf 1.08V, l is the balancing length corresponding to the voltmeter reading.

Diagram





Experimental Procedure:

1. The connections are made as shown in the circuit diagram 1 to find out the balancing length for the Daniel cell.
2. By sliding the jockey over the potentiometer wire, the null deflection in the galvanometer is noted i.e. the balancing length for Daniel cell (lo).
3. Now the connections are made as shown in circuit diagram 2 to calibrate the low range voltmeter.
4. The jockey is adjusted to read the voltmeter reading for low range values and the balancing length (l) are tabulated.
5. Using the above formula, the corresponding voltages are calculated.
6. Both the calibration and correction graphs are drawn as shown in the model graph.

Tabulation

Voltmeter reading, V **Volt**	**Balancing length** **l** **m**	$V' = \left(\frac{1.08}{l_o}\right) l$ **volt**	**Correction voltage** **(V'-V)** **Volt**

Result:

The low range voltmeter is calibrated and the calibration and corrections graphs are drawn.

14. Potentiometer- Calibration of low range ammeter

Aim:

To calibrate a given low range ammeter using potentiometer.

Apparatus Required:

1. Potentiometer
2. Low range ammeter
3. Daniel cell
4. High resistance
5. Galvanometer
6. Jockey
7. 2V battery
8. 6V battery
9. Rheostat
10. Standard resistance

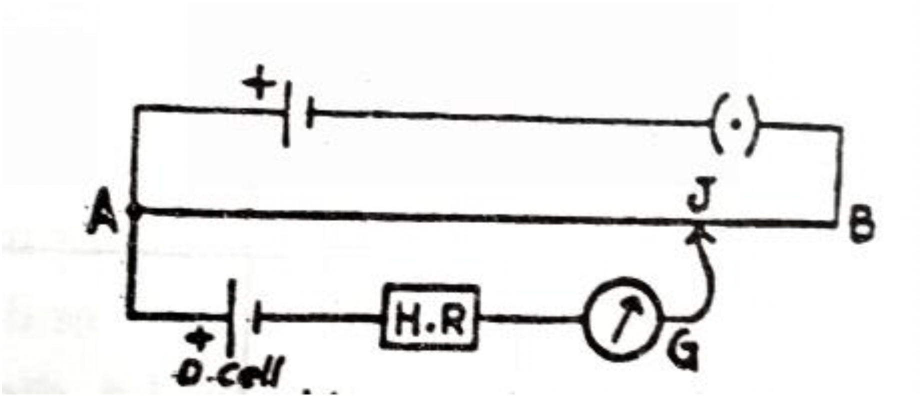
Formula:

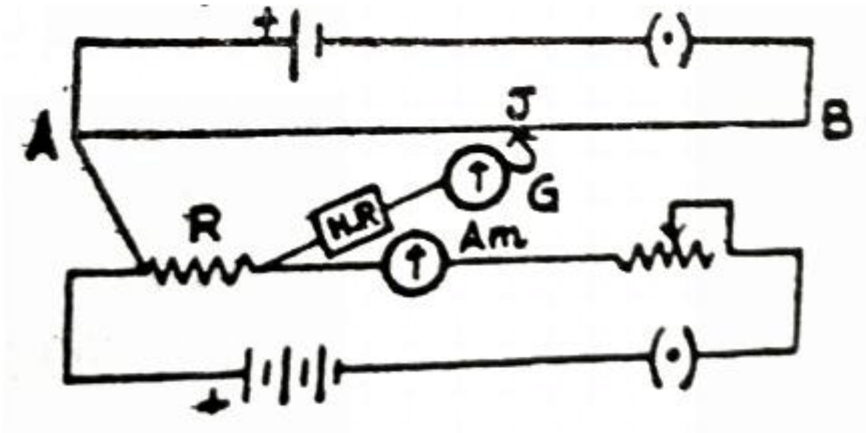
Calculated voltage

$$C' = \left(\frac{1.08}{Rl_o}\right) l \quad \text{(volt)}$$

Where lo is the balancing length for Daniel cell of emf 1.08V, l is the balancing length corresponding to the voltmeter reading and R is the resistance.

Diagram





Experimental Procedure:

1. The connections are made as shown in the circuit diagram 1 to find out the balancing length for the Daniel cell.
2. By sliding the jockey over the potentiometer wire, the null deflection in the galvanometer is noted i.e. the balancing length for Daniel cell (lo).
3. Now the connections are made as shown in circuit diagram 2 to calibrate the low range ammeter.
4. The rheostat is adjusted to read the ammeter reading for low range values and the balancing length (l) are identified with the help of null deflection in the galvanometer.
5. Using the above formula, the corresponding current values are calculated.
6. Both the calibration and correction graphs are drawn as shown in the model graph.

Tablulation:

Ammeter reading, C_o Volt	Balancing length l m	$C' = \left(\frac{1.08}{Rl_o}\right) l$ Volt	Correction voltage ($C'-C_o$) volt

Result:

The low range ammeter is calibrated and the calibration and corrections graphs are drawn.

15. Characteristics of a semiconductor diode

Aim:

To study the variation of current through a semiconductor diode with applied voltage when it is (a) Forward biased and (b) Reverse biased.

Apparatus Required:

1. Semiconductor diode (BY 126 or IN 4001)
2. Ammeter
3. Voltmeter
4. Rheostat
5. 2V battery

Formula:

Resistance in forward biased condition,

$$R_{FB} = V/I \ \ (\text{ohms})$$

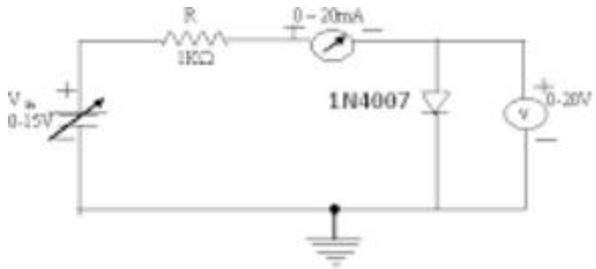
Resistance in reverse biased condition,

$$R_{RB} = V/I \ \ (\text{K ohms})$$

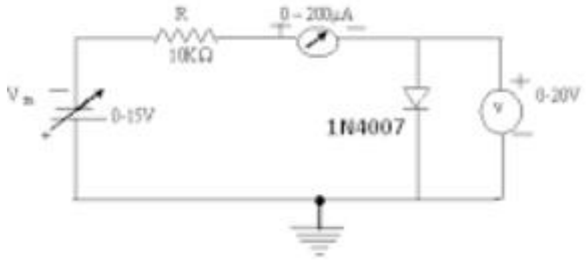
Where V is the applied voltage in forward or reverse bias and I is the measured current in forward or reverse bias conditions.

Diagram

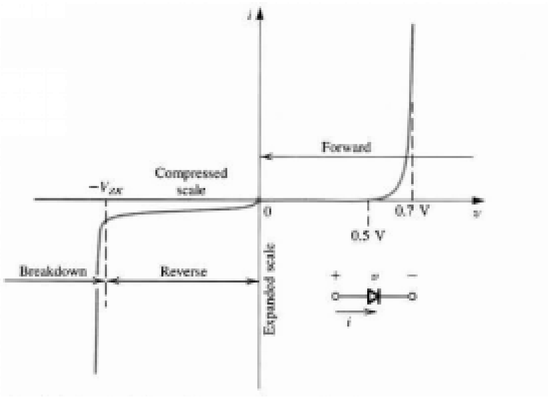
Forward Bias



Reverse Bias



Model Graph



Experimental Procedure:

1. The connections are made as shown in the circuit diagram 1.
2. Now the diode is in the forward biased condition.
3. Increase the voltage in the circuit by adjusting the rheostat, the current in the forward bias condition will increase according to the voltage. The readings are tabulated.
4. The connections are made as shown in the circuit diagram 2.
5. Now the diode is in the reverse biased condition.
6. While increasing the voltage in the circuit by adjusting the rheostat, the current in the reverse bias condition will increase according to the voltage. The readings are tabulated.
7. A graph can be plotted between V and I as shown in the model graph.
8. From the slopes, resistance in the forward and reverse biased conditions are calculated.

Tablulation:

Applied Voltage Volt	Current through diode	
	Forward bias mA	Reverse bias μA

Result:

Resistance in forward biased condition is ……ohms

Resistance in reverse biased condition is ……K ohms

16. Moment of Magnet- Tan C position

Aim:

To determine the moment of a magnet using it in the Tan C position.

Apparatus Required:

1. Deflection magnetometer
2. Bar magnet
3. Ruler

Formula:

Pole strength of the magnet,

$$m = \frac{4\pi B_H \tan\theta}{d_1\left\{\frac{1}{d_1^3} - \frac{1}{d_2^3}\right\}} \quad \text{(Weber)}$$

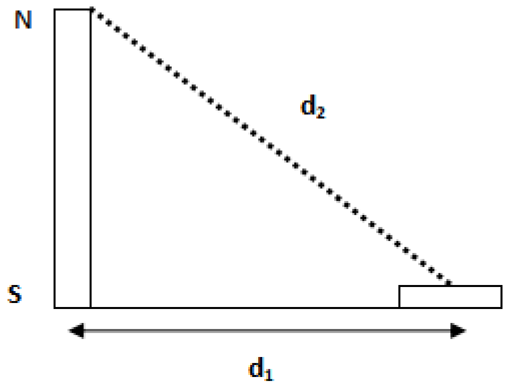
where $d_2 = (d_1^2 + L^2)^{1/2}$, L is the total length of the magnet

The moment of the magnet is given by

$$M = m \times L \text{ (weber metre)}$$

Where B_H is the horizontal component of the earth flux density and d_1 & d_2 are the distance of the ends of the centre of the compass bar

Diagram



Experimental Procedure:

1. The deflection magnetometer is placed such that its arms are along the east-west direction.
2. The given magnet is placed vertically on the eastern arm with its lower end is in level with the magnetometer needle. The position is called Tan C position.
3. The distance of the lower end of the magnet from the centre of the compass box is adjusted so that the deflection produced lies between 30° and 60°.
4. Repeat the experiment by reversing the magnet.
5. Repeat the experiment by placing the magnet on the west arm. Note down the θ values for three different distances.
6. Take the mean value of θ and calculate the value of pole strength and magnetic moment using the above formulae.

Tabulation:

<table>
<tr><th rowspan="4">Distance d_1 metre</th><th rowspan="4">Distance d_2 metre</th><th colspan="8">Deflection</th><th rowspan="4">Mean θ</th><th rowspan="4">m Weber</th></tr>
<tr><th colspan="4">Magnet to the East</th><th colspan="4">Magnet to the West</th></tr>
<tr><th colspan="2">Direct</th><th colspan="2">Reversed</th><th colspan="2">Direct</th><th colspan="2">Reversed</th></tr>
<tr><th>θ_1</th><th>θ_2</th><th>θ_3</th><th>θ_4</th><th>θ_5</th><th>θ_6</th><th>θ_7</th><th>θ_8</th></tr>
</table>

Result:

1. The moment of the magnet is ……Weber meter.
2. The pole strength of the magnet is …… Weber.

17. LASER Parameters – Divergence and Wavelength

Aim:

To determine the divergence and wavelength of the given LASER source.

Apparatus Required:

1. LASER source
2. Grating
3. Screen
4. Ruler

Formula:

Angle of Divergence

$$\varphi = \frac{(a_2 - a_1)}{2(d_2 - d_1)} \text{ (Degrees)}$$

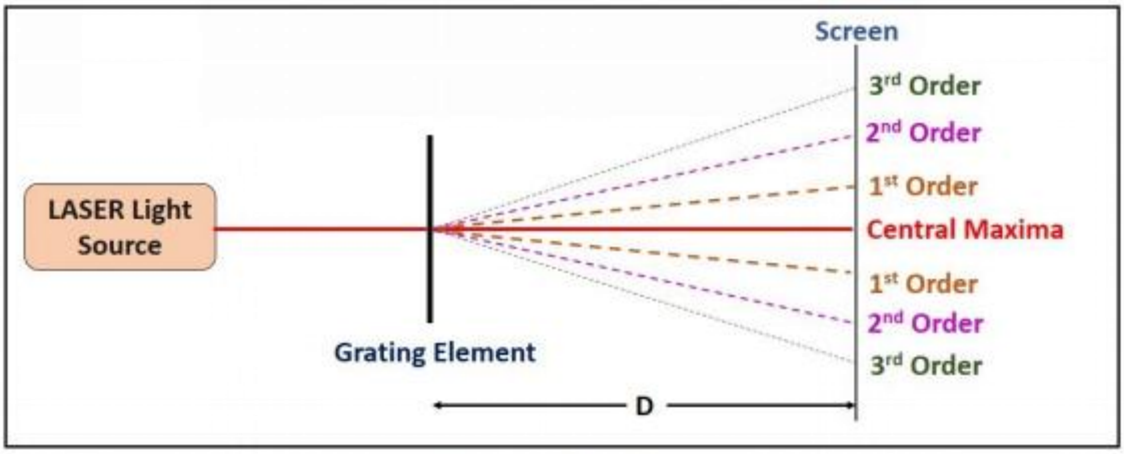
Where a_1 is the diameter of the laser spot at a distance d_1 from the laser source and a_2 is the diameter of the laser spot at a distance d_2 from the laser source

Wavelength of the laser light

$$\lambda = \frac{\sin\theta_m}{Nm}$$

Where m is the order of diffraction, θm is the angle of diffraction corresponding to the order m and N is the number of lines per meter of the grating.

Diagram



Experimental Procedure:

1. Laser light is allowed to incident on the screen at a defined distance d_1.
2. Mark the diameter of the laser spot appears on the screen (a_1)
3. Repeat the same procedure for a different distance d_2.
4. Note down the values in table 1 and calculate the angle of divergence using the above formula 1.
5. Mount a diffraction grating in-between the screen and the source.
6. Now the diffraction pattern will appear on the screen.
7. With the help of the ruler, mark the order and distances of the diffraction.
8. Note down the values in table 2 and calculate the wavelength of the given laser light using the formula 2.

Tabulation:

Angle of Divergence

d_1 cm	a_1 cm	d_2 cm	a_2 cm	$\varphi = \frac{(a_2-a_1)}{2(d_2-d_1)}$ (Degrees)

Wavelength of laser light

S.No	Order of Diffraction	Distance of different orders from the central spot	Mean x	Angle of diffraction	$\lambda = \frac{\sin\theta_m}{Nm}$

	m	x metre		metre	$\theta = \tan^{-1}(x/b)$	
		Left	Right			

Result:

1. The angle of divergence is …… (Degree).
2. The wavelength of the given monochromatic source is …… (m).

18. Metre Bridge

Aim:

To determine the specific resistance of the given coil of wire.

Apparatus Required:

1. Metre bridge
2. Resistance box
3. Coil of wire
4. Leclanche cell
5. High resistance
6. Galvanometer
7. Jockey

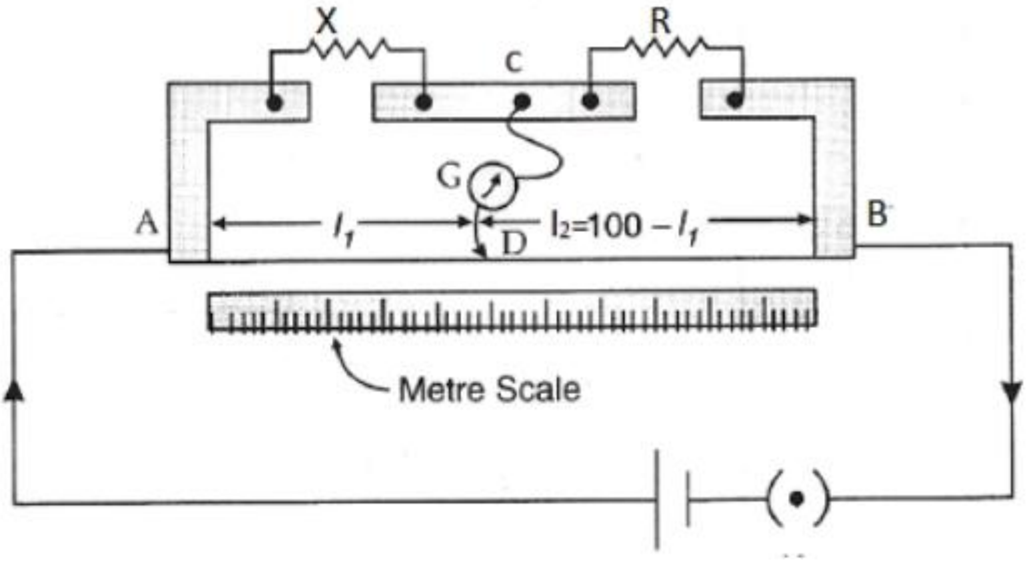
Formula:

The specific resistance of the material of wire

$$\rho = \frac{\pi \, x \, r^2}{L} \ (\Omega \text{ m})$$

Where X is the resistance of the wire, r is the radius of the wire and L is the length of the wire.

Diagram



Experimental Procedure:

1. Initially, the unknown resistance X is connected in the left gap of the metre bridge and resistance box is connected in the right gap as shown in the circuit diagram.
2. Make the other necessary connections as shown in the circuit diagram.
3. Now the jockey is allowed to slide over the metre bridge wire from left to right to identify the balancing length for the corresponding resistance kept in the resistance box.
4. Repeat the same for different resistances and note down the balancing length l_1 and l_2 in the table.
5. Now reverse the position of R and X in the circuit and find out the balancing length for different R values.
6. Again note down the balancing length l_1 and l_2 in the table.
7. Find out the value of X as mentioned in the table. From the mean value of X, calculate the specific resistance ρ of the given material.

Tabulation:

S.No	R Ohm	X in left gap		X= R (l_1/l_2) Ohm	X in right gap		X= R (l_1'/l_2') Ohm
		l_1 metre	l_2 metre		l_1 metre	l_2 metre	

Thickness of the material using screw guage:

Least Count (LC)= … mm   Zero Error (Z.E)= ….. Zero Correction (Z.C)= …..mm

Pitch Scale Reading (P.S.R) mm	Head Scale Coincidence (H.S.C) div	Observed Reading OR = PSR + (HSC x LC) Mm	Corrected Reading CR = OR ± ZC Mm

Result:

1. Resistance of the wire is …… Ω
2. Specific resistance of the wire is …… Ω m.

19. Post Office Box

Aim:

To determine the temperature coefficient of resistance of the given coil of wire.

Apparatus Required:

1. Post office box
2. Given coil of wire
3. Leclanche cell
4. Galvanometer
5. Thermometer
6. Heat source: Bunsen burner or electric heater

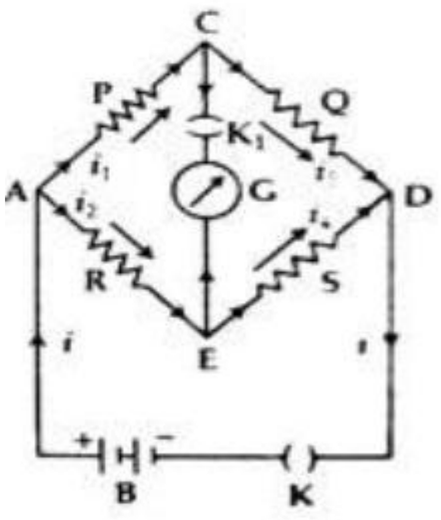
Formula:

The temperature coefficient of resistance of the material of wire

$$\alpha = \frac{X_2 - X_1}{X_1 t_2 - X_2 t_1} \ K^{-1}$$

Where X_1 and X_2 are the resistances at temperatures t_1°C and t_2°C

Diagram



Experimental Procedure:

1. The unknown resistance X is connected between C and D and the leclanche cell is connected between A and C.
2. A sensitive galvanometer is connected between B and D.

3. Variable resistance boxes P and Q were connected between A and B & B and C.
4. At room temperature, keep the resistance Q at a constant value 10 ohms.
5. Increase the value of P from 10 ohms and note down the readings.
6. Now increase the temperature of the coil to 100°C by keeping it in a constant temperature bath.
7. Repeat the same procedure followed at room temperature and note down the readings.
8. Calculate the temperature coefficient of resistance of the material using the above formula.

Tabulation:

Temperature °C	**P** **Ohm**	**Q** **ohm**	**R** **ohm**	**X** **ohm**
Room Temperature				
100°C				

Result:

The temperature coefficient of resistance of the given material is ……. K^{-1}.