Physics Laboratory Manual
B.Sc Physics, Semester I

(As per Pondicherry University Syllabus)

Department of Physics
Mahatma Gandhi Government Arts College
Mahe, Puducherry

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Academic Year (2027-18) onwards

List of Experiments

AS PER PONDICHERRY UNIVERSITY SYLLABUS

- **Experiment 1** Compound pendulum - determination of g, radius of gyration and moment of inertia.
- **Experiment 2** Young's modulus - non-uniform bending – Scale and Telescope.
- **Experiment 3** Surface tension of a liquid and interfacial surface tension (water & kerosene) - method of drops.
- **Experiment 4** Rigidity modulus - torsional oscillations without masses.
- **Experiment 5** Specific heat capacity of a liquid - method of cooling.
- **Experiment 6** Spectrometer- refractive index of a liquid - hollow prism.
- **Experiment 7** Potentiometer - calibration of low range voltmeter (0 - 1.5 V).
- **Experiment 8** P.O. Box - Determination of the unknown resistance and specific resistance using a post office box.

DO'S AND DON'TS IN THE LAB

- Students should carry observation notes (Rough copy).
- Data in laboratory notebook (Fair copy) should always be entered only after getting confirmation on rough copy from concerned faculty.
- Laboratory Notebook should be kept up to date and to be submitted every week.
- Students should be aware of the operation of equipments.
- Students should take care of the laboratory equipments/ Instruments.
- The readings must be shown to the concerned faculty for verification.
- Students should ensure that **all switches are in the OFF position** to remove the connections **before leaving the laboratory**.
- All patch cords and tools should be placed properly in their respective positions.
- Don't come late to the Lab.
- Don't make or remove the connections with power ON.
- Don't leave the lab without the permission of the concerned faculty.

Exp no. 1 : Compound pendulum

Aim of the experiment : To determine

- (a) the value of acceleration due to gravity 'g' at the given place by using a compound pendulum.
- (b) the radius of gyration and hence the moment of inertia of the compound pendulum about an axis passing through its center and perpendicular to its length.

Apparatus: The compound pendulum, stop watch, etc.

Theory:
A compound pendulum, also known as a physical pendulum, is a body of any arbitrary shape pivoted at any point so that it can oscillate in a plane when its centre of mass is slightly displaced on one side and is released.

If L is the length of the equivalent sample pendulum having time period of oscillation T, then

$$T = 2\pi\sqrt{\frac{L}{g}} \tag{1}$$

which implies

$$g = 4\pi^2\frac{L}{T^2} \tag{2}$$

Here, Moment of inertia $I = mK^2$, where m is the mass and *K* is the radius of gyration.

Procedure:
The pendulum is suspended by the knife edge through first hole and a pointer is arranged in front of the pendulum. The pendulum is then pulled towards one side a little and released, so that it starts oscillating with small amplitude in the vertical plane. The time for 25 oscillations is determined using the stop watch carefully. The center of gravity of the bar is detrmined by balancing on a knife edge. The distance of the point at which the bar is balaned is noted and its distance from the edge is measured.

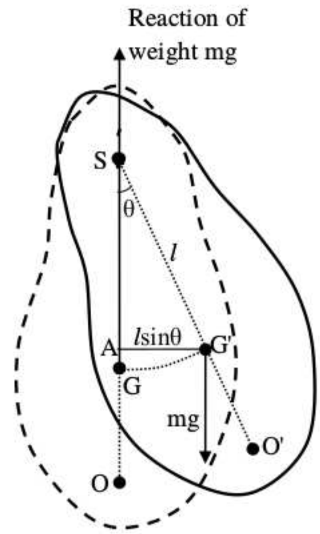

Figure 1: A compound pendulum in oscillation.

A graph is drawn, by plotting the distance of the hole from the edge along x -axis and the period on y-axis. Draw the horizontal line ABCDE parallel to the X-axis. Here A, B, D and E represent the point of intersections of the line with the curves. Note that the curves are symmetrical about a vertical line which meets the X-axis at the point G, which gives the position of the center of gravity (C.G.) of the bar. This vertical line intersects with the line ABCDE at C.
Determine the length AD and BE from the graph and find the length L of the equivalent simple pendulum from $L = \frac{(AD+BE)}{2}$.
The time period T corresponding to the line ABCDE is also noted from the graph and the value of $\frac{L}{T^2}$ is calculated. More lines can be drawn parallel to ABCDE to measure $\frac{L}{T^2}$ values.Then the value of g is calculated using the average value of $\frac{L}{T^2}$ in the formula given above in theory.
Locate the positions of the minimum peiod of the two curves. The line parallel to the x-axis joining these two positions gives the values of 2K in the scale of x-axis, where K is the radius of gyration of the bar pendulum about an axis passing though its centre of gravity and perpendicular to its length. Thus PQ = 2K. Therefore, $\frac{PQ}{2} = K$ gives the values of radius of gyration.

Observation and Calculation:

Therefore, putting the values of $\frac{L}{T^2}$ in the following equation, we have

$$g = 4\pi^2 \frac{L}{T^2}$$
$$g = \frac{\ldots\ldots\ldots}{\ldots\ldots\ldots}$$
$$g = \ldots\ldots\ldots \frac{m}{sec^2}$$

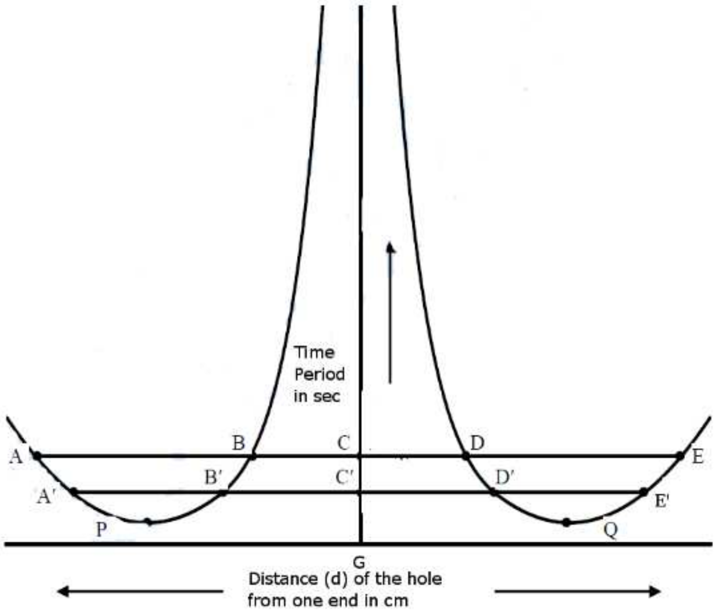

Figure 2: Graph showing variation of time period with the distance of knife edge from one end of the bar.

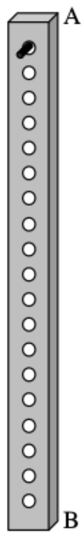

Figure 3: A compound pendulum in laboratory set up.

Table 1: Table for calculating the value of time period T for different values of distance of the knife edge from the end

Sl. no.	Distance of knife edge from one end	Time for 30 oscillations(sec)			Period of oscillation $T = \frac{t}{50}$
		1	2	Mean	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Table 2: Table for calculating the value of $\frac{L}{T^2}$ from the graph

Period (sec)	Length of Equivalent Simple Pendulum (cm)			$\frac{L}{T^2} \frac{cm}{sec^2}$
	AD	BE	Mean	

Similarly, from the graph we have

PQ = ...cm
K = $\frac{PQ}{2}$ = ...cm=..........m
mass of the pendulum m = ...kg

Therefore, the moment of inertia of the compound pendulum about an axis passing through its center and perpendicular to its length

$$I = mK^2 \; kgm^2$$

I = ... kgm^2

Result :

Therefore, the experimentally calculated value of

- acceleration due to gravity is .... $\frac{m}{sec^2}$
- Radius of gyration is .... m
- And, the moment of inertia of the compound pendulum about an axis passing through its center and perpendicular to its length is .... kgm^2

Exp no. 2 : Young's modulus (non-uniform bending)

Aim : To determine the Young's modulus of the material of a bar by subjecting it to non-uniform bending and measuring the depression at centre of the bar by using pin and microscope.

Apparatus : A long uniform bar, two knife edges, a travelling microscope, pin, weight hanger and slotted weights, etc.

Theory : Let a bar AB be supported by two knife-edges K_1 and K_2 and loaded at the middle C with a weight W = Mg as shown in Fig.6. The length of the bar between the knife-edges is L and the reaction at each knife-edge is $\frac{W}{2}$, acting upwards. The depression is maximum at the middle. Let this maximum depression be s. Therefore, the depression at the middle of the bar is given by

$$s = \frac{WL^3}{48YI} \tag{3}$$

Here,
W = mg, m = mass of the slotted weight, g = acceleration due to gravity.
Y = Young's modulus for the material of the beam
I =$\frac{bd^3}{12}$, b = breadth of the beam, d = depth of the beam

Therefore

$$Y = \frac{MgL^3}{4sbd^3} \tag{4}$$

Measuring depression of the mid–point (s) for a given load M and knowing L, b, d and g, the value of Y of the material of the beam can be obtained using equation 4.

Procedure :

The bar is placed symmetrically on two knife edges A and B. The length (L) between the edges is measured. The weight hanger is suspended at the center of the expeimental bar. A pin is fixed vertically at the midpoint of

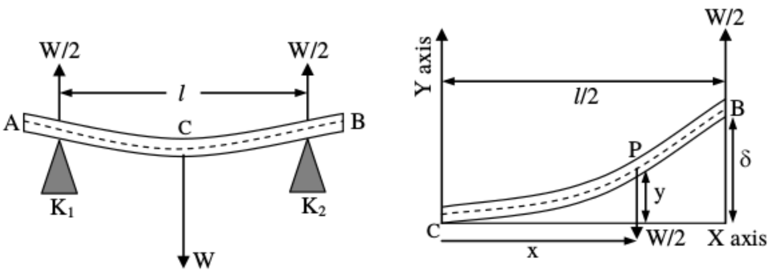

Figure 4: **(a)** A schematic diagram showing depression produced in a bar loaded in the middle. **(b)** An inverted diagram showing the reactions produced at the loaded end of the bar.

the bar. A travelling microscope is focused such that the horizontal wire is at the tip of the pin. Now the bar is brought into an elastic mode by loading and unloading it with slotted weights, step by step several times. A sufficient dead load is placed in the weight hanger. Let 'w_0 ' be the dead weight on the weight hanger and the microscope is focused such that the tip of the pointer is at the horizontal wire. The reading of the travelling microscope is noted carefully. Now, the load on the weight hanger is increased in equal steps of 50 gm and the travelling microscope reading is noted for each step. The readings of the travelling microscope is noted again by unloading the weight in equal steps of 50 gm.
This procedure is repeated for different lengths of the cantilever (bar). Now, using the table, the mean value of shift (s) for a constant load M is calculated.

Observation and Calculation :

One main scale division (MSD) = 0.05 cm
No. of division on Vernier scale : 50 nos.
Least count = $\frac{1MSD}{N}$
Least count = $\frac{0.05}{50} = 0.001cm$
Mass for which depression (shift) in the cantilever is being calculated, M = 150 gm

Table 3: Table for calculating the average value of $\frac{L^3}{s}$

Length (L)(m)	Load (gm)	Microscope reading on loading			Microscope Reading on unloading			Mean s (m)	Depression (shift) for M gm (cm)	Mean shift (s) for M gm (cm)	$\frac{L^3}{s}$
		MSR	VSR	Total	MSR	VSR	Total				
	w_0										
	$w_0 + 50$										
	$w_0 + 100$										
....	$w_0 + 150$										
	$w_0 + 200$										
	$w_0 + 250$										
	w_0										
	$w_0 + 50$										
	$w_0 + 100$										
....	$w_0 + 150$										
	$w_0 + 200$										
	$w_0 + 250$										

For vernier calliper :

One main scale division (MSD) = ... cm

No. of division on Vernier scale : ..... nos.

Least count = $\frac{1MSD}{N}$

Least count = $\frac{(......)}{(.....)} = (.......)cm$

Mean (b) = ... (cm)

Table 4: Table for calculating the value of breadth (b) of the bar using vernier calliper

Sl. no.	MSR (cm)	VSR (div)	Total = $MSR + (VSR \times L.C)$ (cm)	Mean b (cm)
1				
2				
3				
4				
5				

For screw gauge :

One main scale division (MSD) = ... cm

No. of division on Vernier scale : ...... nos.

Least count = $\frac{1MSD}{N}$

Least count = $\frac{(.....)}{(.....)} = (.......)cm$

Table 5: Table for calculating the value of depth (d) of the bar using a screw gauge

Sl. no.	PSR (mm)	HSR (div)	Corrected HSR (div)	Total d = $PSR + (Corr.HSR \times L.C)$ (mm)	Mean d (mm)
1					
2					
3					
4					
5					

Mean (d) = ... (mm)

Therefore, putting the values of $\frac{L3}{s}$, b and d in equation 4, we have

$Y = \frac{Mg}{4bd^3}(\frac{L^3}{s})$

$Y = \frac{.......}{........}$

$Y = ... \frac{N}{m^2}$

Result:

Therefore, the experimentally calculated value of Young's modulus of the given cantilever is .... $\frac{N}{m^2}$

Exp no. 3 : Surface tension of a liquid (method of drops)

Aim : To determine the Surface tension of a liquid and interfacial surface tension (water & kerosene) - method of drops.

Apparatus: A uniform capillary tube, funnel, stand with ring clamp, beaker, water, kerosine, common balance.

Theory:
Surface tension is the property of a fluid by virtue of which it behaves like a stretched membrane. Surface tension is the tension of the surface film of a liquid caused by the attraction of the particles in the surface layer by the bulk of the liquid, which tends to minimise surface area. It is expressed as the ratio of the surface force F to the length L along which the force acts.Its unit is N/m.
Surface tension of a liquid is given by

$$T = \frac{mg}{3.8r} \tag{5}$$

where r is the radius of the capillary tube through which liquid drops are falling.
Similarly, the interfacial surface tension is given by

$$T' = \frac{m'g}{3.8r}(1 - \frac{\sigma}{\rho}) \tag{6}$$

Procedure :
A clean beaker is weighed with the help of a common balance. 25 drops of water (H_2O) is collected by using a cappilary tube and funnel. Now, the weight of the beaker with 25 drops of water is measured using the common balance.This process is repeated with (25+25)= 50, (50+25)= 75 and (75+25)=100 drops in the beaker and corresponding weights are measured. Now, the beaker is cleaned and filled with kerosine oil and weight of the beaker is noted. After that, water (50 drops) is added to the beaker filled

Table 6: Table for calculating the average value of 25 water drops

Load	Mass (gm)	Mass of 25 drops (gm)	
Mass of empty beaker		....	
Mass of empty beaker + 25 drops of water			
Mass of empty beaker + 50 drops of water			
Mass of empty beaker + 75 drops of water			
Mass of empty beaker + 25 drops of water			

Table 7: Table for calculating the average value of 25 water drops

Load	Mass (gm)	
Mass of empty beaker + kerosine (ω_0)		
Mass of empty beaker + Kerosine + 50 drops of water (ω)		

with kerosine. Weight of the beaker filled with kerosine and 50 drops of water is noted carefully.
Now the diameter of the tube is measured using a screw gauge. Height of the water column (h_1) and liquid column (h_2) is measured with the help of an apparatus Hares Apparatus.

Observation and Calculation :
For water :
From table 6, Average mass of 25 drops = ... gm
Mass of one drop, $\frac{M}{25}$ = ... gm = ... kg
For liquid :
From table 7, Mass of one drop, ω' = $\frac{\omega-\omega_0}{50}$ gm = ...kg
Therefore, Surface tension of a liquid is

Table 8: Table for calculating the radius of the capillary tube using screw gauge

Sl. no.	PSR (mm)	HSR (div)	Total = $PSR + (HSR \times L.C)$ (mm)	Mean r (mm)
1				
2				
3				
4				
5				

$$T = \frac{mg}{3.8r}$$

Table 9: Table for calculating the height of liquid column using Hares apparatus

Sl. no.	Height of water column (h_1)(cm)	Height of liquid column (h_2)(cm)	$\frac{h_1}{h_2} = \frac{\sigma}{\rho}$	Mean $\frac{h_1}{h_2}$
1				
2				
3				
4				
5				

Similarly, the interfacial surface tension is

$$T' = \frac{m'g}{3.8r}(1 - \frac{\sigma}{\rho})$$

Result : The surface tension of water is .... N/m and interfacial surface tension is .... N/m.

Expt no. 4 : Rigidity modulus (torsional oscillations without masses)

Aim : To determine the rigidity modulus of the material of the suspension wire using torsion pendulum.

Apparatus : The torsion pendulum consisting of the suspension wire, the heavy disc and stop watch etc.

Theory :

A body suspended by a thread or wire which twists first in one direction and then in the reverse direction, in the horizontal plane is called a torsional pendulum. The first torsion pendulum was developed by Robert Leslie in 1793. A simple schematic representation of a torsion pendulum is given below in the figure.

The period of oscillation of torsion pendulum is given as,

$$T = 2\pi\sqrt{\frac{I}{C}} \tag{7}$$

Where I is the moment of inertia of the suspended body ($I = \frac{MR^2}{2}$ for a disc of radius R) and C is the couple per unit twist of the torsional wire.

But we have an expression for couple per unit twist C as,

$$C = \frac{\pi\eta r^4}{2l} \tag{8}$$

Where l is the length of the suspension wire, r is the radius of the wire and η is the rigidity modulus of the suspension wire. From the above equations the expression for rigidity modulus of the material of the suspension wire is,

$$\eta = \frac{8\pi I}{r^4}\frac{l}{T^2} \tag{9}$$

Procedure :

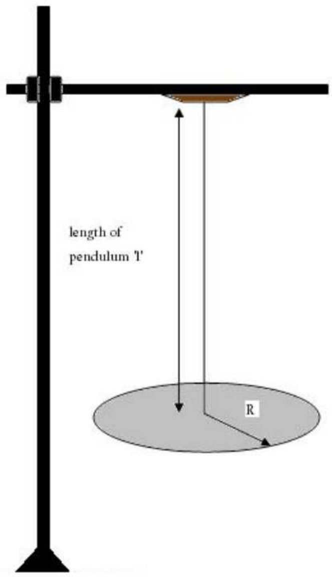

Figure 5: **(a)** A schematic diagram of a experimental set up of a torional pendulum.

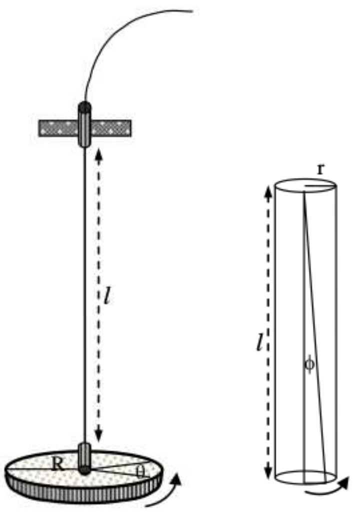

Figure 6: **(a)** A schematic diagram of a torsional pendulum.

- The radius of the suspension wire is measured using a screw gauge. The length of the suspension wire is adjusted to suitable values like 0.25m, 0.3m, 0.35m, 0.4m etc.
- The disc is set in oscillation. Find the time for 10 oscillations twice and determine the mean period of oscillation T
- Calculate moment of inertia of the disc using the expression, $I = \frac{1}{2}MR^2$.
- Determine the rigidity modulus from the given mathematical expression

Observation and Calculation :

From table 11, Radius of the suspension wire, r =....... m
Radius of the disc, R = ...m
Mass of the disc, M = ...kg
Moment of inertia of the disc, $I = \frac{1}{2}MR^2$ = ... kgm^2

Table 10: Table for calculating the value of η from time period T and length l

Length (m)	Time for 10 oscillations t (sec)			$\eta = \frac{8\pi I}{r^4}(\frac{l}{T^2})$	Mean η
	1	2	Mean (T)		

Table 11: Table for calculating the radius of the suspension wire using screw gauge

Sl. no.	PSR (mm)	HSR (div)	Total = $PSR + (HSR \times L.C)$ (mm)	Mean r (mm)
1				
2				
3				
4				
5				

Result:

The experimentally measure value of modulus of rigidity is .... $\frac{N}{m^2}$.

Expt no. 5 : Specific heat capacity of a liquid (method of cooling)

Aim : To detrmine the Specific heat capacity of a liquid using the method of cooling.

Apparatus :
A spherical calorimeter, a thermometer, stop clock, given liquid, water, etc.

Theory :
Newton's law of cooling states that the rate of cooling of a body is proportional to the mean difference of temperature between the body and its surroundings. If θ_1 is the initial temperature of the body, θ_2 is the temperature after a time 't' seconds and θ_o be the temperature of the surroundings we can write,
Rate of cooling is given by

$$\frac{\theta_1 - \theta_2}{t} \propto \frac{\theta_1 + \theta_2}{2} - \theta_o \tag{10}$$

Since the rate of cooling of the body is proportional to its rate of loss of heat,

$$Mc(\frac{\theta_1 - \theta_2}{t}) = K[\frac{\theta_1 + \theta_2}{2} - \theta_o] \tag{11}$$

where, M is the mass of the body, 'c' is its specific heat capacity and K is a constant.
Let the calorimeter is first filled with hot water. If t_w is the time taken by the calorimeter and water to cool from θ_1 to θ_2, then

$$\frac{m_c c_c(\theta_1 - \theta_2) + m_w c_w(\theta_1 - \theta_2)}{t_w} = K[\frac{\theta_1 + \theta_2}{2} - \theta_o] \tag{12}$$

where, m_c is the mass of calorimeter, c_c is the specific heat capacity of the calorimeter, m_w mass of water and c_w is specific heat capacity of water. If the calorimeter is filled with the given hot liquid and is allowed to cool from

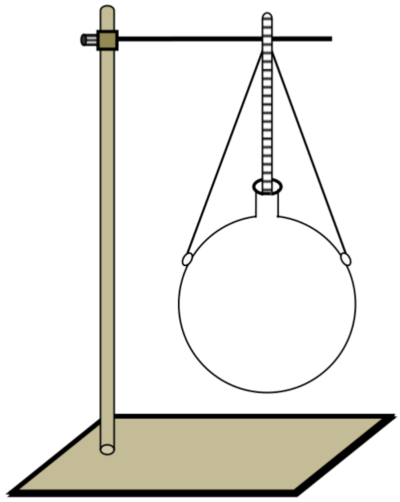

Figure 7: A schematic diagram of experimental set up of the calorimeter.

the same range of temperature and t_l be the corresponding time taken, we can write,

$$\frac{m_c c_c(\theta_1 - \theta_2) + m_l c_l(\theta_1 - \theta_2)}{t_l} = K[\frac{\theta_1 + \theta_2}{2} - \theta_o] \tag{13}$$

where, m_l is mass of liquid and c_l is its specific heat capacity.
Therefore, from equation 12 and 13 we have

$$\frac{m_c c_c(\theta_1-\theta_2)+m_w c_w(\theta_1-\theta_2)}{t_w} = \frac{m_c c_c(\theta_1-\theta_2)+m_l c_l(\theta_1-\theta_2)}{t_l}$$

Simplifying, we have

$$c_l = \frac{(m_c c_c + m_w c_w)\frac{t_l}{t_w} - m_c c_c}{m_l} \tag{14}$$

Usually $\frac{t_l}{t_w}$ is determined by plotting the cooling curves for water filled calorimeter and liquid filled calorimeter as shown in the fig.b.

Procedure :

The mass m_c of a clean dry spherical calorimeter is determined by a common balance. It is then almost filled with hot water of temperature nearly 90^o. It is then suspended in air as shown in figure 7. A sensitive thermometer is inserted in the calorimeter. When the temperature falls to 80^o, start a stop watch and the time temperature observations are made at regular intervals of temperature or time. The time may be noted at a regular fall of temperature of 1^oC till the temperature falls to about 60^oC. Let the calorimeter

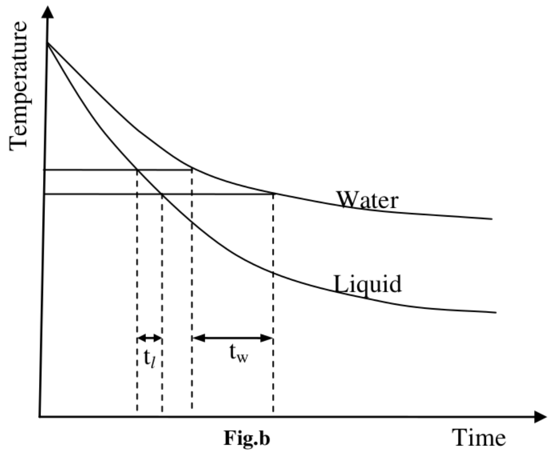

Figure 8: A comparison graph showing variation of Temperature T with time for liquid and water.

is cooled to room temperature. Then the mass of the calorimeter and water is determined. Let it be m_2. The water is poured out and the calorimeter is dried. It is then filled with the hot liquid and the time-temperature observations are made for the same temperature range (80^oC to 60^oC) as in the case of water. The calorimeter is again cooled to room temperature and the mass of calorimeter plus liquid, m_3 , is determined.
The time-temperature observations are plotted on the same graph paper as shown in figure 8. Find out $\frac{t_l}{t_w}$ for a certain temperature. Finally, the specific heat capacity c of the given liquid is calculated using equation 14.

Observation and calculation :

Weight of empty calorimeter, m_c = m_1 = ... gm
Weight of the calorimeter filled with water, m_2 = ...gm
Weight of the calorimeter filled with liquid, m_3 = ...gm
Mass of water, m_w = $m_2 - m_1$ = ...gm = ...kg
Mass of water, m_l = $m_3 - m_1$ = ...gm = ...kg
Specific heat capacity of (copper) calorimeter, c_c = ... $Jkg^{-1}K^{-1}$
Specific heat capacity of water, c_w = ... $Jkg^{-1}K^{-1}$

The time-temperature observations are plotted on the same graph paper as shown in figure 8. The $\frac{t_l}{t_w}$ for a certain temperature is calculated. Putting

Table 12: Table for recording drop in temperature with time for liquid and water

Temperature (^oC)	Time recorded in stop watch (for water)	Time recorded in stop watch (for liquid)
80		
79		
78		
77		
76		
....		
60		

the values in equation 14, specific heat capacity of liquid,

$$c_l = \frac{(m_c c_c + m_w c_w)\frac{t_l}{t_w} - m_c c_c}{m_l}$$
$$c_l = \frac{(........)}{(.........)}$$
$$c_l = (........)\ Jkg^{-1}K^{-1}$$

Result:
Therefore, the experimentally calculated value of Specific heat capacity of liquid is .... $Jkg^{-1}K^{-1}$.

Expt no. 6 : Spectrometer (refractive index of a liquid using hollow prism)

Aim : To determine the refractive index of a liquid using a hollow prism by finding out the prism angle and the angle of minimum deviation.

Apparatus required :
Spectrometer, sodium vapor lamp, spirit level, hollow prism, reading lens etc.

Theory :
If A is the prism angle of a prism and D is the angle of deviation as shown in the figure 9, then the refractive index for the material of the prism is given by

$$\mu = \frac{sin(\frac{A+D}{2})}{sin(\frac{A}{2})} \tag{15}$$

Procedure :

- Least count of the spectrometer is determined carefully.
- Preliminary adjustments of the spectrometer are done.
- The hollow prism is mounted on the prism table such that reflecting edge of the prism is at the center of the collimator as shown in the figure 9. The reflected image of the slit from both the faces of the prism is obtained in the telescope.
- Now, the telescope is to be adjusted such that the vertical cross wire is at the center of the image. The MSR and VSR readings of the spectrometer for reflected images for both the sides of the prism is noted carefully.

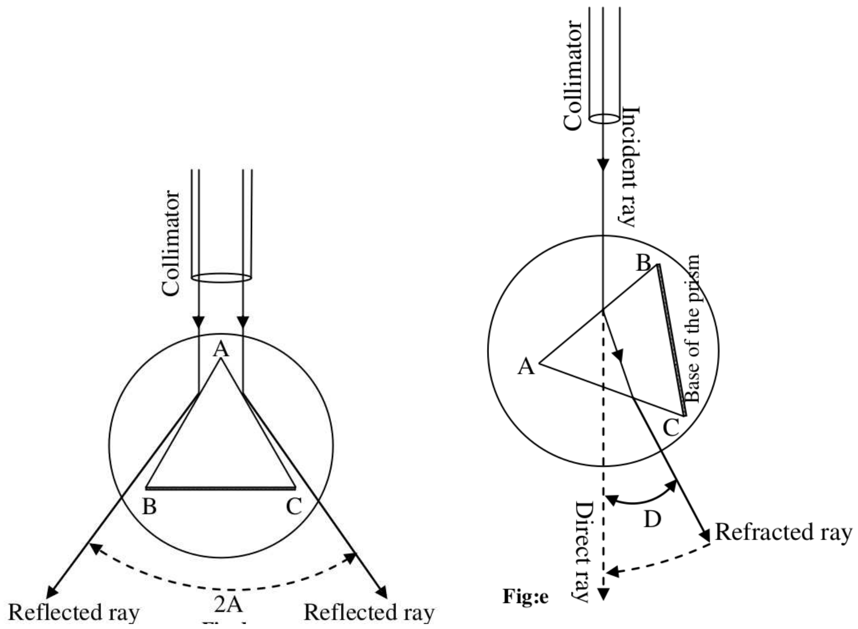

Figure 9: A schematic diagram showing the prism angle A and angle of deviation D

Figure 10: A schematic diagram of the spectrometer position

- The hollow prism is filled with water and the refracted image of the slit is obtained as shown in the figure 9 for the hollow prism filled with water. The spectrometer reading for refracted ray through the hollow prism filled with water is noted down.
- Similarly, readings for the direct ray is also noted carefully by removing the hollow prism from the prism table.

Observation and Calculation :

Table 13: Table for calculating the value of the prism angle A

Reading of reflected image	Vernier I			Vernier II		
	MSR	VSR	Total	MSR	VSR	Total
From one face						
From the other face						
Difference						

Therefore, Mean 2A = $\frac{Diff(vernierI)+Diff(VernierII))}{2}$ = $\frac{(......)}{2}$ = $(.......)$
which gives $A = (......)$

Table 14: Table for calculating the value of the angle of deviation D

Reading of refracted image	Vernier I			Vernier II		
	MSR	VSR	Total	MSR	VSR	Total
Refracted Ray						
Direct Ray						
Difference						

Therefore, Mean D = $\frac{Diff(vernierI)+Diff(VernierII))}{2}$ = $\frac{(......)}{2}$ = $(.......)$

Now, putting the values of prism angle A and angle of deviation D in the equation 15, we have

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

Result :
The experimentally measured value of refractive index of the material of the prism (liquid) is ....

Expt no. 7 : Potentiometer (calibration of low range voltmeter (0 - 1.5 V))

Aim : To calibrate the given low range voltmeter using a potentiometer.

Apparatus required : A potentiometer, key, high resistance, a rheostat, daniel cell (DC), voltmeter, galvanometer.

Theory :
If a standard cell of voltage E balances a length 'L' of the potentiometer wire, then potential difference per unit length of the potentiometer is $\frac{E}{L}$ volts. Let us assume that 'l' is the balancing length of the potentiometer corresponding to the voltmeter reading V_o volts. The calculated value of the potential difference V is

$$\frac{E}{L} = \frac{V}{l}$$
$$V = \frac{El}{L}$$

The difference between the calculated value of potential difference (V) and voltmeter reading (V_o) gives the correction of the volmeter reading.

Procedure :
Connections are made as per the circuit diagram given (Fig 12).

- **To find the potential fall across the potentiometer :** A primary circuit is made by connecting the positive of a battery to the end A of the potentiometer and its negative to the end B through a key. A secondary circuit is made by connecting the positive pole of Daniel cell and its negative to the jockey through a galvanometer and high resistance. The balancing length l_o metre when e.m.f. of the Daniell cell is

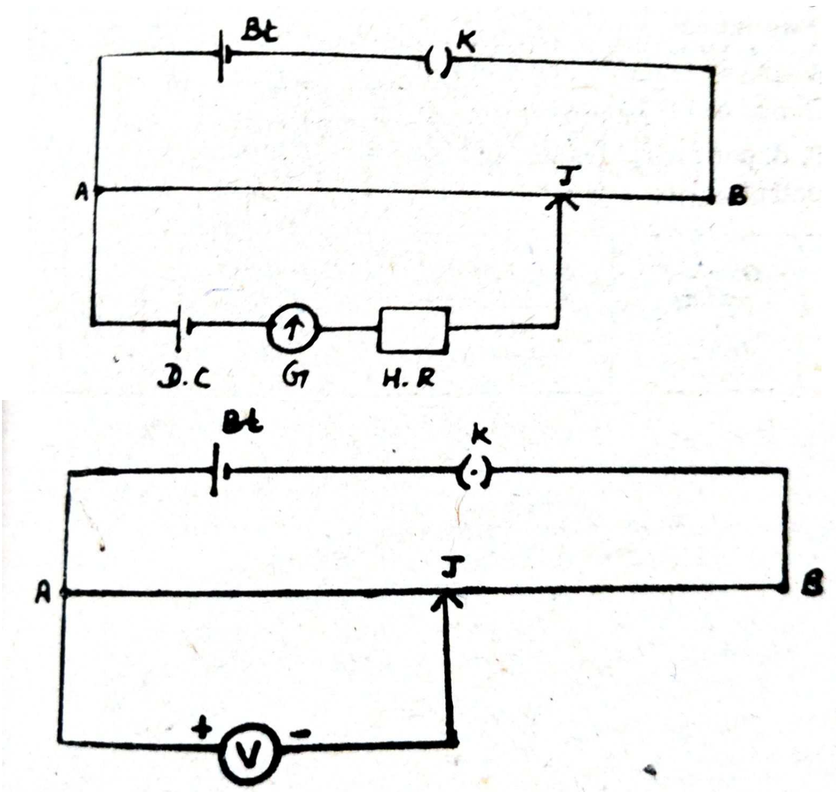

Figure 11: Circuit Diagram for calibration of a low range voltmeter using a potentiometer.

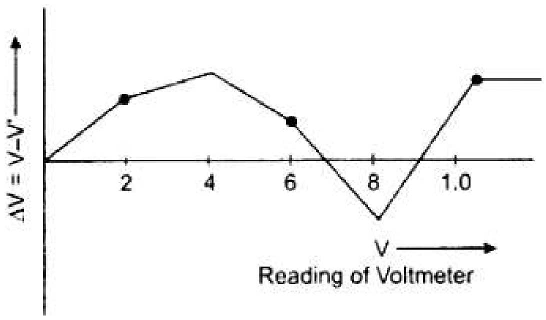

Figure 12: Calibration graph of a low range voltmeter using a potentiometer.

balanced on the potentiometer wire is found. Then, the potential fall across metre length of the potentio meter wire is $\frac{1.08}{l_o}\ \frac{volt}{m}$.

- **To calibrate the given voltmeter:** The primary circuit of the potentiometer is left undistrubed. The secondary is made by replacing the Daniell cell, galvanometer and high resistance by the given low range voltmeter, taking care to see that its positive is connected to the end and its negative to the jockey. The position of the jockey is adjusted so that the voltmeter reads V volts on pressing the jockey. The length AJ / metre is measured.
  Then, correct reading of the voltmeter is

  $$\text{Potential fall across } l \text{ metre} = \frac{1.08}{l_o} \times l \text{ volts}$$

  Therefore,

  $$V' = \frac{1.08}{l_o} \times l \text{ volts}$$

  Then the correction to be applied to the observed reading is $(V' - V)$ volts.

The experiment is repeated for different values of V and in each caes the correction $(V' - V)$ is calculated.

Observation and Calculation :

Table 15: Table for calibration of a low range voltmeter

Sl. no.	Voltmeter reading V_o (volt)	Balancing Length (l) cm	Calculated value of voltage $V = \frac{El}{L}$	Correction $(V - V_o)$
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Results :
The calibration graph for the low range voltmeter is draw by plotting voltmeter reading along x-axis and corresponding correction in volmeter reading along y-axis.

Expt no. 8 : Determination of the unknown resistance and specific resistance using a post office box

Aim : To detrmine the unknown resistance and specific resiatnace of a given wire (coil) using P.O. Box.

Apparatus :

P.O. Box, Galvanometer, the given wire (coil), lanclanche cell, etc.

Theory :

The post office box works on the principle of Wheatstone bridge. P, Q, R and S be the four resistances of the Wheatstone bridge as shown in figure 13. Here, P, Q and R are the known resistances and S is the unknown resistance. A galvanometer is connected between B and D. When the galvanometer current is zero (null condition), the relation between P, Q, R and S is

$$\frac{P}{Q} = \frac{R}{S}$$
$$S = R(\frac{Q}{P})$$

Where, S is the unknown resistance to be determined experimentally. P, Q and R are the known resistances in the ratio arms.
Specific resistance of the given wire is given by $\rho = \frac{S4\pi r^2}{L}$
where r is the radius of the given wire (m) and
L is the length of the wire (m).
Procedure :

- Connections are made as per the circuit diagram (Fig 14).
- From each arm of P and Q, 10 Ω resistance plugs are taken out. Keeping the resistance of the third arm R zero, first the key of the battery circuit K_1 is pressed and then the key K_2 of the galvanometer circuit is pressed and the deflection of the galvanometer is observed. Now withdrawing the INF (infinity) plug the deflection of the galvanometer is observed again. In this case, if the deflection of the galvanometer

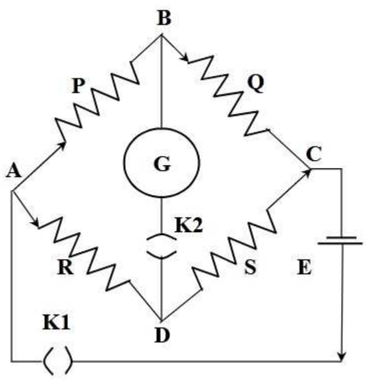

Figure 13: A Wheatstone bridge.

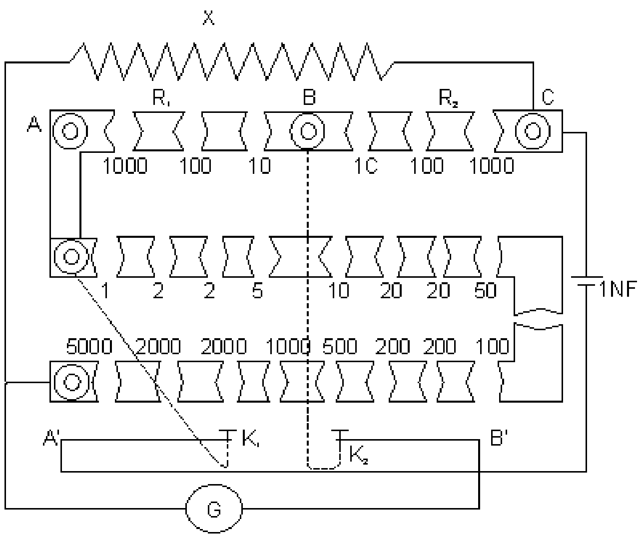

Figure 14: The Post Office Box.

is opposite to the first deflection, then it is considered that the circuit connection is correct.

- Starting from the higher values of resistance of the third arm, deflections of the galvanometer are noticed by reducing the value of resistance progressively. When the galvanometer gives zero deflection for P = Q = 10 ohms, the unknown resistance S will be equal to the third arm resistance (S=R). If the deflection is not made zero, then due to the two successive resistances the deflection will be opposite. In this situation, the value of the unknown resistance S is between these values.
- Now in arm P instead of 10 Ω, 100 Ω resistances are inserted. As before the resistance of the second arm, Q is kept at 10 Ω. So $\frac{Q}{P}$ ratio will be $\frac{1}{10}$, hence in balanced condition (zero deflection of the galvanometer), $R = 10 \times S$. Now as before resistance plugs from the third arm R are withdrawn so that galvanometer deflection becomes zero. In this situation, unknown resistance $S = \frac{R}{10}$.
- Similarly, 1000 Ω resistance is inserted in arm P and in Q arm 10 Ω resistance is inserted and the experiment is performed as before.

Observation and Calculation :
For Sl. no. 1 from Table 16

$$S = R \times \frac{Q}{P}$$

$$S = (.........) \times \frac{10}{10} = ...$$

For Sl. no. 2 from Table 16

$$S = R \times \frac{Q}{P}$$

$$S = (.........) \times \frac{10}{100} = ...$$

For Sl. no. 1 from Table 16

$$S = R \times \frac{Q}{P}$$

$$S = (.........) \times \frac{10}{1000} = ...$$

Table 16: Table for determining the unknown resistance of the given wire

Sl no.	Resistance (Ω)			Direction of deflection of the galvanometer	Inference	Unknown resistance (S Ω)
	P	Q	R			
1						
2						
3						

Therefore, the radius of the given wire is .... m (from Table 17).

Length of the given wire is .... m.

Value of the unknown resistance S is .... Ω (from Table 16).

Specific resistance of the given wire is

$$\rho = \frac{S 4\pi r^2}{L}$$

$$\rho = \frac{(.........)4\pi(.......)^2}{(.......)}\ \Omega m$$

Result: Therefore, the value of the unknown resistance of the given wire is ....Ω and specific resistance is .... Ωm.

Table 17: Table for calculating the radius of the given wire using screw gauge

Sl. no.	PSR (mm)	HSR (div)	Total = $PSR + (HSR \times L.C)$ (mm)	Mean r (mm)
1				
2				
3				
4				
5				