

**Lab Manual**  
**OF**  
**APPLIED PHYSICS - I**



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**DEPARTMENT OF BASIC SCIENCE**

**& HUMANITIES**

**C.V RAMAN POLYTECHNIC**

**BHUBANESWAR**



## **C. V. Raman Polytechnic , Bhubaneswar**

Name of the Lab: **Applied Physics Lab**

Practical : **Applied Physics Lab**

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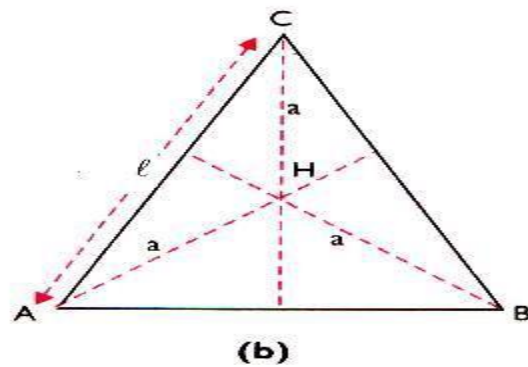
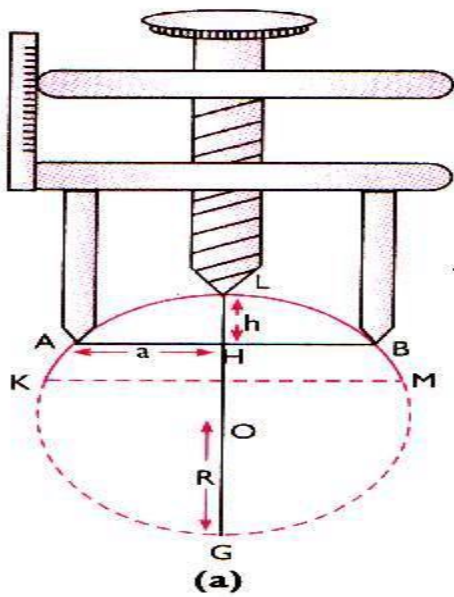
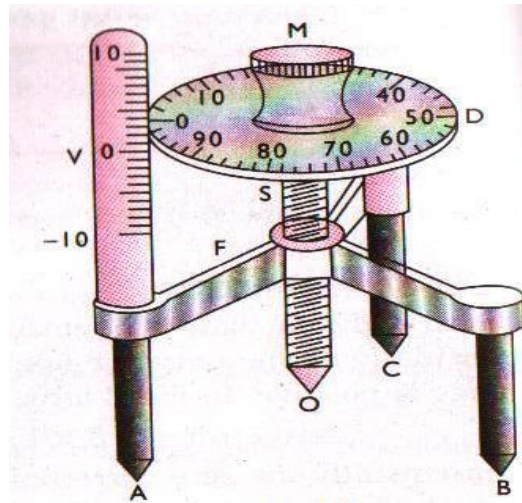
### EXPERIMENT NO 1

**Object: To measure radius of curvature of given curved surface using spherometer.**

Apparatus: Spherometer, convex (curve) surface , a big size plane glass slab.

Procedure:

1. Raise the central screw of the spherometer and press the spherometer gently on the practical note book so as to get pricks of the three legs. Mark these prick as A B and C.
2. Measure distance between the pricks (points) by joining the points as to form a triangle ABC.
3. Note these distances (AB,BC AC) on notebook and take their mean.
4. Find the value of one vertical (pitch) scale division.
5. Determine the pitch and the least count of the spherometer and record it stepwise.
6. Raise the screw sufficiently upwards.
7. Place the spherometer on the convex surface so that its three legs rest on it.
8. Gently turn the screw downwards till the screw tip just touches the convex surface.(The tip of the screw will just touch its image in the convex glass surface)
9. Note the reading of the circular (Disc) scale which is in line with the vertical (pitch) scale. Let it be a (It will act as reference).
10. Remove the spherometer from over the convex surface and place over a large size plane glass slab.
11. Turn the screw downwards and count the number of complete rotation ( $n_1$ ) made by the disc (one rotation become complete when the reference reading crosses the past the pitch scale).
12. Continue till the tip of the screw just touches the plane surface of the glass slab.
13. Note the reading of the circular scale which is finally in the line with the vertical (pitch) scale . Let it be b.
14. Find the number of circular (disc) scale division in the last incomplete rotation.
15. Repeats the step 6 to 14 , three times. Record the observation in tabular form.



**Observations.**

1. Distance between two legs of the spherometer in triangle ABC marked by legs of the spherometer

AB = ..... cm

BC = ..... cm

AC = ..... cm

Mean value of  $l = (AB + BC + CA) / 3 = \dots\dots\dots$  cm

2. Least count of spherometer.

1 pitch scale division = 1mm  
 Number of full rotations given to screw=5  
 Distance moved by the screw =5 mm  
 Hence pitch  $p=5\text{mm}/5=1\text{mm}$   
 Number of divisions on circular (disc)scale =100  
 Hence , Least count= $1\text{mm}/100= 0.01\text{mm}=0.001\text{cm}$

Table for sagitta (h).

Serial No. Of Observation	Circular (Disc) scale Reading		Number of complete rotations on plane ( $n_1$ ) glass sheet	No of disc scale divisions in incomplete rotation $x=(a-b)$ or $(100+a)-b$	Total Reading $h = n_1xp+x$ X (L C) mm
	On convex surface initial (a)	On plane glass sheet Final (b)			
(a)	(2a)	(2b)	(3)	(4)	(5)
					$h_1 =$ $h_2 =$

Calculations:

1. Find value of h in each observation and record it in column 5.
2. Find mean of value of h recorded in column 5  
Mean value of  $h = (h_1 + h_2 + h_3) / 3$  mm = .....mm = .....cm.
3. Calculate  $R = l^2 / 6h + h/2$  cm = .....cm.

Result :

The radius of curvature of the given convex (curve ) surface is .....cm.

Precaution:

1. The screw should move freely without friction.
2. The screw should be move in same direction to avoid back –lash error of the screw.
3. Excess rotation should be avoided.

Sources of error.

1. The screw may have friction.
2. The spherometer may have back-lash error.
3. Circular (Disc) scale division may not be of equal size.

## EXPERIMENT 2

**Object:- To determine the value of “g” using simple pendulum.**

Apparatus required:- A metallic spherical bob with a hook, clamps stand, split cork, fine and inextensible thread, stop clock/watch, vernier calipers, meter scale, a chalk piece etc

Formula used:-

$$(i) \quad T = 2\pi \sqrt{L/g}$$

Where T =time period of oscillations.

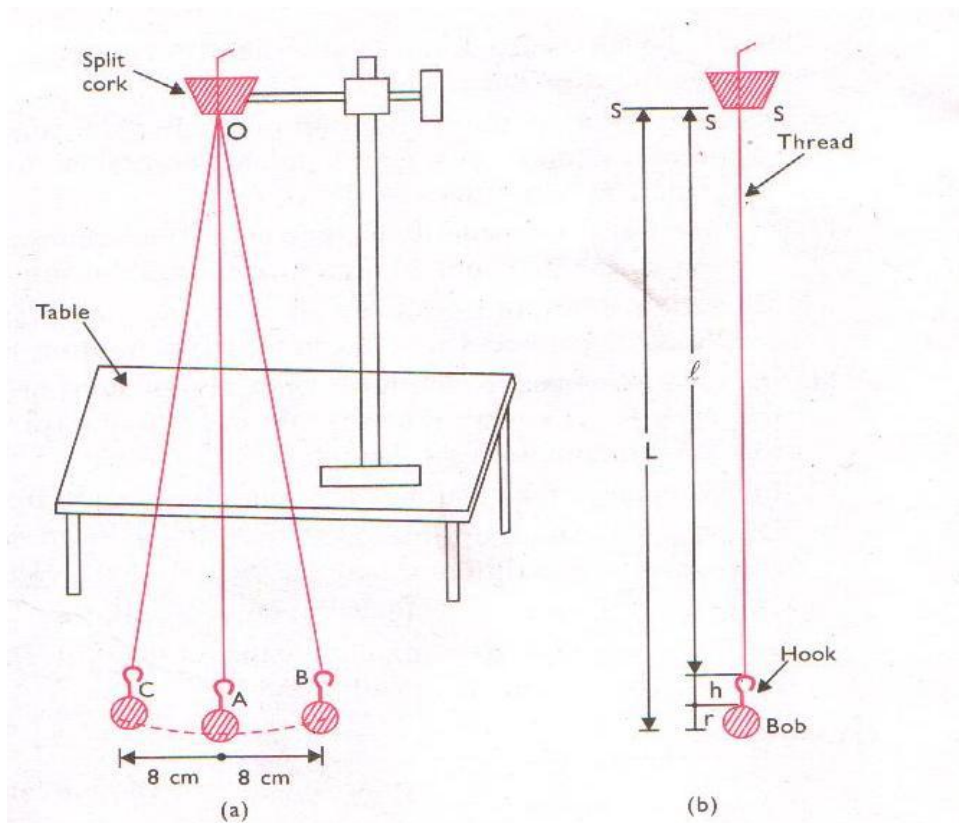
L=effective length of pendulum

G=acceleration due to gravity

(ii) A second a pendulum is the pendulum whose oscillation period is 2s.

Methods:-

1. Take a vernier calipers and find its vernier constant. Also find its zero error, if any ,with its proper sign.
2. Measure the diameter of given metallic bob along different axes and find the mean diameter of bob. Apply appropriate zero correction and determine the corrected diameter of the bob. Let it be d. Then find radius of bob  $r = D/2$ ,
3. Either using vernier calipers or a meter scale note the length of the hook attached to the pendulum bob let it be 'h'.
4. Take a then inextensible but strong cotton thread of length about 2m. Tie one end of the thread tightly to the hook of the bob. Pass other end of the thread through the two split half pieces of cork. Hold the cork firmly in the clamp stand and ensure that the cut of cork piece is at right angle to the edge of the table.
5. Place the stand on the table/stool, in such a way that the pendulum bob is just 2-3cm above the floor of laboratory.
6. Mark a line, with a piece of chalk, just below the pendulum bob and parallel to the edge of the table. Mark a point A just below the bob in its equilibrium position and two other points B and C on mutually opposite sides of point A on the line at a distance of about 8-10 cm.
7. Adjust the length of thread below the cork piece so that sum of the length of thread +length of hook+ radius of pendulum bobs.
8. Displace the pendulum bob by hand from its mean position. A to the marked point B on the line parallel to the edge of the table. Gently release it so that the bob starts vibrating to and fro about its mean position. A along the straight line ABC and there is no spinning motion of the pendulum bob, If it is so then it is alright.
9. Note the least count of your stop clock/watch. also note zero error, if any present in the stop clock/watch with its proper sign. Then find the value of zero correction. Zero correction is negative of the zero error.
10. Just like step 8 displace the bob to mark B on line marked and gently release it so that it starts vibration to and fro.  
B)Start the stop clock/watch.
11. Observe the motion of pendulum bob. After starting of stop clock, the bob goes to point B, returns to its mean position A, then goes to left extreme position C and finally returns back to mean position A and again start moving start moving towards right, count 1.
12. In this way let the pendulum completes 19 vibrations. Now be alert. as soon as the pendulum complete and find the corrected time taken by the pendulum to complete 20 vibrations.
13. Increase the effective length of pendulum in steps of 10 cm each to 90 cm, 100 cm..... And repeat the steps 10-13 every time so as to measure the corresponding values of time taken by the pendulum for 20 vibrations for each length.
14. In the manner take readings for pendulum to complete 20 vibrations.
15. Dividing the values of times for 20 vibrations by 20 determine the value of time period T of pendulum corresponding to different lengths. Also find the values of T square.



Observations

Vernier constant of vernier calipers (V.C.) = .....cm  
 Zero error of vernier calipers (with sign) = .....cm  
 Zero error correction of vernier calipers (with sign) = .....cm  
 Observed diameter of the pendulum bob  
 (i).....cm (ii).....cm (iii).....cm  
 Mean value of observed diameter of pendulum bob = .....cm  
 Corrected diameter of pendulum bob  $D =$  .....cm  
 Radius of pendulum bob  $r =$  .....cm  
 Length of the hook of pendulum bob  $h =$  .....cm  
 Least count of stop clock/watch = .....s  
 Zero error present in stop clock = .....s  
 Zero correction in stop clock = .....s

Calculation

1. From the observed data plot a graph by taking length of pendulum  $L$  along X-axis and the time period of oscillation  $T$  along Y-axis. The graph obtained is parabolic.
2. Plot a graph by taking length of pendulum  $L$  along X-axis and  $T$  square along Y-axis. The graph obtained is shown, The graph is a straight line inclined to either axes. It shows that  
 $T$  square proportional to the  $L$

3. From L-T square graph determine the length of the pendulum corresponding to  $T^2 = 4 \text{ s}^2$  the time period of pendulum is  $T = 2$ . This length corresponds to the length of the second's pendulum.

Precautions.

1. The thread used should be weightless, strong and inextensible.
2. The point of suspension should be fixed. It is possible when the clamp stand is rigid.
3. Lower faces of split cork should be in same level.
4. Length of the pendulum should be counted from the point of suspension to the centre mass of the pendulum bob.
5. The pendulum bob should vibrate should be small.



## EXPERIMENT 4

**Objective :** To determine surface tension of water by capillary rise method.

**Apparatus Required:**

A capillary tube of uniform and narrow bore, a metallic plate to hold the capillary tube and fitted with a needle of adjustable height , a clamp stand , an adjustable turn table , a flat bottomed glass dish, a travelling microscope , magnifying glass , a thermometer etc.  
Diagram:

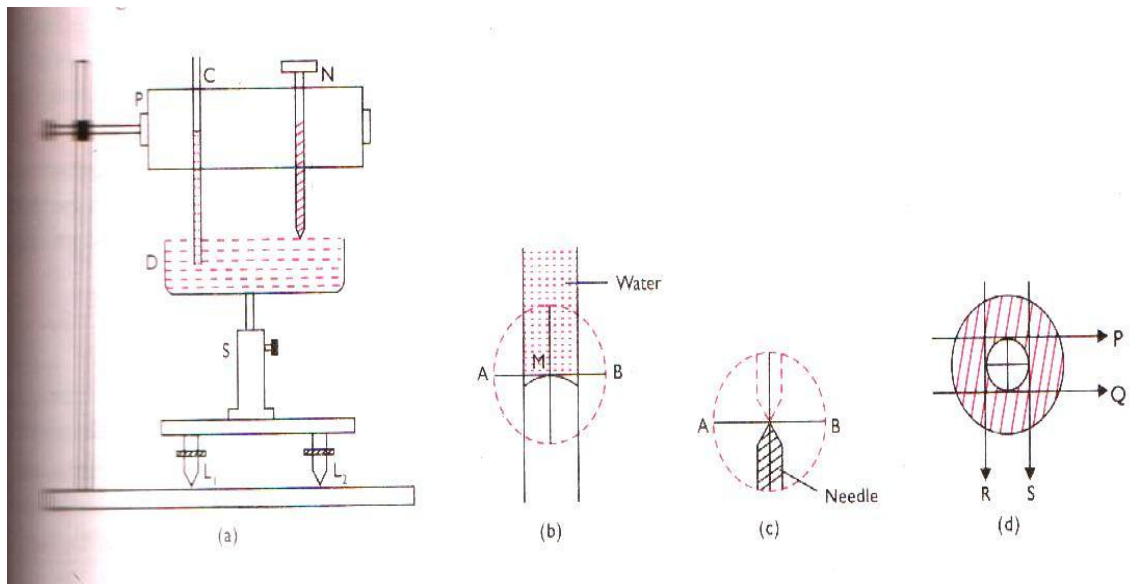
**Formula :** Surface tension of water  $S = h\rho g/2$

Where  $h$  = height to which water rises in capillary tube

$r$  = radius of bore of capillary tube

$\rho$  = density of water at room temperature

$g$  = acceleration due to gravity



**Procedure:**

1. Take a capillary tube of uniform and fine bore( diameter of the bore must be less than 1 mm). Clean the capillary tube first with alkaline solution and then with mild acidic solution.
2. Take a flat bottomed glass dish and clean it also. Wash the dish as well as capillary tube with water.
3. Take a turn table whose glass height can be adjusted . Place it on the table and put the glass dish on it. Raise the turn table by about 2-3 cm from its minimum height position. Fill the dish with tap water such that the free surface of water lies just below the edge of dish .
4. Mount the capillary tube on a metal plate P. A needle N with sharp tip is also mounted on the plate P. Moreover the height of needle N may be adjusted.
5. Fix the metal plate with capillary tube and needle in a sturdy clamp stand keeping the capillary tube and needle vertical. Adjust the portion of clamp on the vertical stand so that the capillary tube is partly dipped in water taken in the dish D. Adjust the needle N so that its tip just touches the water surface . If the adjustment is correct then tip of needle will just coincide with tip of its inverted image formed due to reflection from water surface.

6. Take a travelling microscope and check that it can move both horizontally as well vertically. Clean the microscope.
7. Find the vernier constant along the horizontal as well as vertical scale of microscope. Generally it is 0.001 cm.
8. Raise the microscope to a suitable height, keeping its axis horizontal. Adjust the position of the eyepiece of microscope carefully so that the crosswires are clearly visible. Moreover one of the crosswires should be horizontal and the other vertical.
9. Place the microscope near the adjustable turn table . Adjust the height of microscope so that one can see water meniscus in capillary tube through the microscope. Using rack and pinion arrangement move the microscope tube forward or backward till sharp, inverted image of water meniscus is clearly visible. Using fine adjustment screw on vertical pillar of microscope set its position such that image of meniscus M just lies on the horizontal crosswire. Take this reading of the microscope on the vertical scale by noting the reading of main scale as well as vernier scale. Let the reading be 'y'.
10. Gently lower the adjustment turn table to its minimum height taking care that metal plate containing capillary tube and needle is not at all disturbed. Now lower the microscope so as to focus it on the free pointed needle tip. Again note the reading on the vertical scale of travelling microscope . let the reading be ' $y_0$ '. Then the height 'h' up to which water has risen in the given capillary tube is given by  $h=y- y_0$ .
11. Repeat steps 9 to 10 at least three times and then find the mean value of 'h'.

## EXERIMENT NO 6

**Objective:** To determine refractive index of the material of the prism using graph.

**Apparatus required:** Drawing board, white sheet of paper ,prism , drawing pins, pencil, half meter scale, office pin, graph paper and protector.

**Drawing:**

**Theory:** The refractive index ( $\eta$ ) of material of the prism is given by

$$\eta = \frac{\sin((A + D_m)/2)}{\sin(A/2)}$$

where  $D_m$  angle of minimum deviation,  
and  $A$  angle of prism.

**Procedure:**

1. Fix white sheet of paper on the drawing board with the help of drawing pins.
2. Draw a straight line  $XX'$  parallel to the length of the paper neatly in the middle of the paper.
3. Mark point  $Q_1, Q_2, Q_3$  .....on the straight line  $XX'$  at suitable diatance of about 5 cm.
4. Draw normals  $N_1Q_1, N_2Q_2$ ..... on points  $Q_1, Q_2, Q_3$  as shown in figure.
5. Draw straight lines  $R_1Q_1, R_2Q_2, R_3Q_3$ .....making angles of  $35^\circ, 45^\circ$  ..... $60^\circ$  ( write value of the angles on the paper) respectively with the normals.
6. Mark one corner of the prism as  $A$  and take it as the edge of the prism for all the observation.
7. Put the prism with its refracting face  $AB$  in the line  $XX'$  and point  $Q_1$  in the middle of  $AB$ .
8. Mark the boundary of the prism.
9. Fix two or more office pin  $P_1$  and  $P_2$  vertically on the line  $R_1Q_1$  . The distance between the pin should be 10 mm or more .
10. Look the image of point  $P_1$  , and  $P_2$  through face  $AC$ .
11. Close your left eye and bring open right eye in line with the two images.
12. Fix two office pin  $P_3$  , and  $P_4$  vertically , and 10 cm apart such that the open right eye sees pins  $P_3$  , and  $P_4$  and image of  $P_2$  and  $P_1$  in one straight line.
13. Remove pins  $P_3$  , and  $P_4$  and encircle their pricks on the paper.
14. Repeat steps 7 to 13 with points  $Q_2, Q_3$  ..... for  $i=40^\circ, 45^\circ$  ..... $60^\circ$ .

To measure  $D$  in different cases.

15. Draw straight lines through points  $P_4$  , and  $P_3$  (pin pricks) to obtain emergent rays  $S_1T_1, S_2T_2$  and  $S_3T_3$  .....
16. Produce  $T_1 S_1, T_2 S_2$  and  $T_3 S_3$ .....inward in the boundary of the prism to meet produced incidence rays  $R_1Q_1, R_2Q_2, R_3Q_3$  at points  $F_1, F_2, F_3$ .....
17. Measure the angle  $K_1F_1S_1, K_2F_2S_2$  and  $K_3F_3S_3$  ... These gives angle of deviation  $D_1, D_2, D_3$  .....
18. Write the value of these angle on the paper.

To measure  $A$

19. Measure the angle  $BAC$  in the boundary of the prism. These gives angle  $A$ .

20. Record your observation as given below.

**Observations.**

Angle of prism A=.....

Serial No. Of observation	Angle of incidences (i)	Angle of deviation (D)

**Calculation:**

Plot a graph between angle of incidence  $i$  and angle of deviation  $D$  by taking  $i$  along X-axis and  $D$  along Y-axis. From this graph, find the value of angle of minimum deviation  $D_m$  corresponding to the lowest point of the graph.

Let the value of angle of minimum deviation  $D_m = \dots\dots\dots$

Then index ( $\eta$ ) of material of the prism is

$$\eta = \frac{\sin((A + D_m) / 2)}{\sin(A/2)}$$

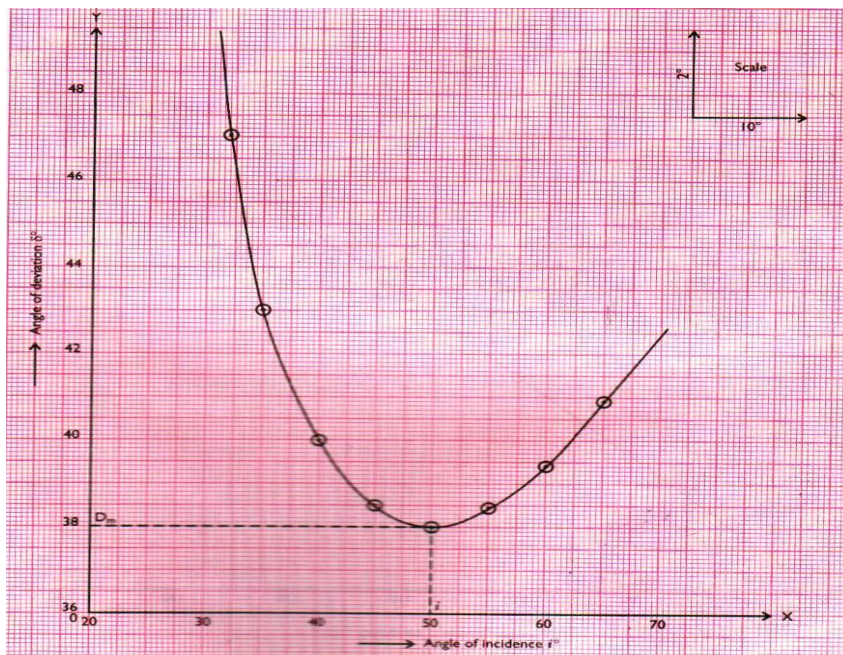


Fig. 10 Graph between  $i$  and  $\delta$  for a glass prism

**Result:**

- (i) I-D graph indicates that as the angle of incidence ( $i$ ) increases, the angle of deviation ( $D$ ) first decreases, attains a minimum value  $D_m$  and then again starts increasing for further increase in angle of incidence.
- (ii) Angle of minimum deviation  $D_m = \dots\dots\dots$
- (iii) Refractive index of the material of the prism ( $\eta$ ) =  $\dots\dots\dots$

**Precaution :**

- (i) The angle of incidence should lie between 35 deg to 60 deg.
- (ii) The pin should be fixed vertical

## EXPERIMENT NO 7

**Object:-** To determine focal length of concave mirror & convex lens.

**Appratus required:-** Optical bench, three uprights, two pointed needles, a convex lens, spirit level, T-rod.

**Theory and formula:-** let an object be placed at a distance  $u$  from the convex lens and its image is formed at a distance  $v$  from the lens on opposite side, then

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Where,  $f$  is the focal length.

Taking  $u$  as  $-ve$  and  $v$  as  $+ve$  for real image.

Then  $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

Or  $f = \frac{uv}{(v+u)}$

### Procedure:

1. Place the optical bench on a plane horizontal surface by taking help of spirit level. Place the upright on the optical bench.
2. Find the rough focal length of convex lens by producing the image of a bright distant object, on the wall or paper screen. The real image is obtained on the wall if the object is placed at a distance greater than the rough focal length of the lens.
3. Mount the given convex lens at the centre and the needles on its either sides on the two other uprights. Mark the two needles as object and image. Adjust the height of the needles so that the tips of the needles reach the middle of the lens.
4. Take the T-rod and measure its actual length on the scale of the optical bench. Now keep the T-rod such that its one end touches the tip of the object pin and other end to the optical centre of the lens (which is the middle of the lens.) Measure the distance between the length of T-rod and distance between pin and lens on the scale. Similarly, find the Bench error for the image pin.
5. Now, place the object pin between  $F$  and  $2F$  and look for its real inverted image from the other side of the lens. Move the image pin and remove the parallax between object and image pin. Record position of lens and both the pins.
6. Take 6 or 7 sets of readings by moving the object pin by 2 or 3 cm.
7. Correct the bench error for each reading by moving and calculate focal length for each set of reading.
8. Determine the mean focal length.

### Observations:

Table for bench Error

Correction for	Actual length of T-rod	Position of Lens	Position of Lens	Distance of Lens	Bench error
u-pin					
v-pin					

Observation for Focal length

S.No.	Position of Uprights			Observed Distance		Corrected Distance	
	Object PQ cm	Lens OL cm	Image P'Q' cm	Object OP cm	Image OP' cm	$u = OP' - \alpha$ cm	$v = OP' - \beta$ cm
1.							
2.							
3.							

Calculation: From the formula  $f = \frac{uv}{(u+v)}$ .

- 1.
- 2.

3.

Mean  $f$  = Average  $f$

**Result:** The focal length of the given convex lens is .....cm.

% Error = (Standard value- Experimental value )/Standard value. X 100.

**Precautions.**

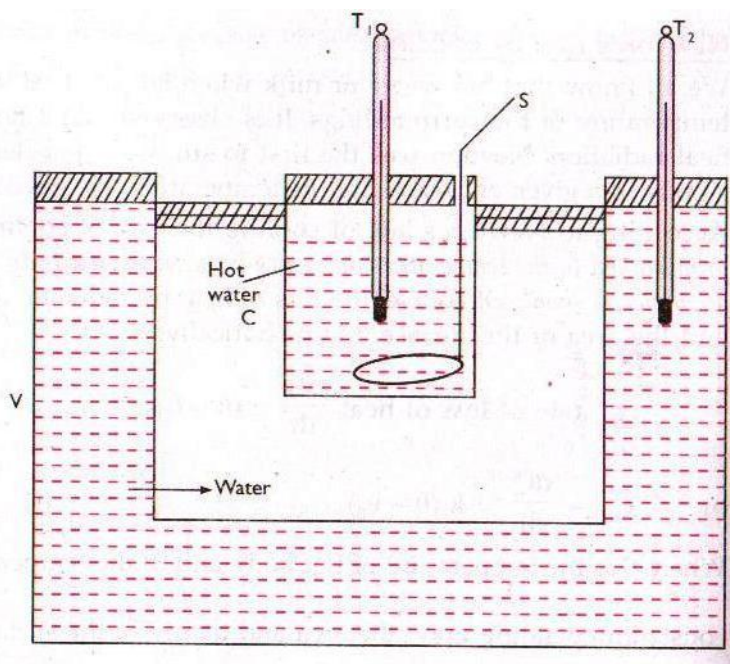
1. The parallax should be removed from tip to tip.
2. Index correction for  $u$  and  $v$  should be carefully made and applied separately.
3. The upright should be vertical , stable and not shaky.
4. The height of pins should so adjusted that they may reach the middle of lens (optical centre of the lens).
5. Lens should have less focal length and be thin.
6. The principal axis of the lens should be parallel to the length of the optical bench.
7. While removing the parallax, the eye should be kept at least about 25 to 30 cm away from the image pin.

## EXPERIMENT NO 9

**Objective :** To determine mechanical equivalent of heat by using Joules calorimeter.

**Apparatus required:** Newton's laws of cooling apparatus consisting of a calorimeter with a stirrer and a lid and a double walled bigger vessel, two half degree thermometers, stop clock , arrangement for heating of water.

Diagram:



**Formula** used As per Newton's law of cooling the rate of fall in temperature

$$d\theta/dt = -K(\theta - \theta_0) \quad \text{and} \quad \log_e(\theta - \theta_0) = -Kt + C$$

Where  $\theta$  = temperature of hot water at time  $t$ ,

$\theta_0$  = temperature of the surrounding and  $K$  and  $C$  are two constants.

**Procedure:**

1. Take the apparatus for studying cooling of a hot liquid (i.e. a double walled metallic vessel) and thoroughly clean it. Between the two walls of the vessel. Pour ordinary tap water so as to fill it completely. Place the apparatus on a table.
2. Suspend the two thermometer from a stand and compare their readings. Taking the reading of one of these thermometers to be correct, find the correction to be applied to the other thermometer.
3. Suspend the thermometer  $T_2$ , to which the correction is to be applied, in water taken in the double walled vessel.
4. Heat water in a water bath so that its temperature is about 40 deg C above the room temperature. Pour this hot water in the calorimeter C so that the calorimeter is nearly filled 3/4<sup>th</sup> of its height. Put the calorimeter in its place i.e. in the centre of double walled vessel. Place the lid over the calorimeter. Through in lid pass the correct thermometer  $T_1$  and a stirrer S into the calorimeter. However, thermometer should not touch the walls of calorimeter. Moreover, ensure that lid of the calorimeter is tight enough.
5. Note the temperature of water in the double walled enclosure.

6. Note the temperature of hot water and simultaneously start the stop clock. Gently stir the hot water and note the reading of thermometer  $T_1$  after every one minute time interval. After 6 reading you may increase the time interval between successive reading to 2 minutes and so on.
7. In this manner continue to take the readings of the temperature of water taken in the calorimeter, till water temperature is about 5 deg C above the room temperature.
8. Finally again take the reading of thermometer  $T_2$  so as to note the temperature of water in the double walled enclosure. Mean of the initial and final temperature recorded by  $T_2$  is noted and correction is applied in it. The temperature so obtained is the mean corrected value of the temperature of surrounding. Let it be  $\theta_0$
9. Find the value of temperature difference  $(\theta - \theta_0)$  for various observations and then find the values of  $\log(\theta - \theta_0)$  for each observation.
10. Plot graphs (i) between  $(\theta)$  and  $t$  by taking time  $t$  along X-axis and temperature of hot water  $(\theta)$  along Y-axis.

**Observation:**

Room temperature recorded by thermometer  $T_1 = \dots\dots\dots^\circ\text{C}$  ( Being used in calorimeter)

Room temperature recorded by thermometer  $T_2 = \dots\dots\dots^\circ\text{C}$  ( Being used for enclosure)

Therefore, correction to be applied in reading of thermometer  $T_2 = \dots\dots\dots^\circ\text{C}$ .

Initial temperature of water taken in enclosure =  $\dots\dots\dots^\circ\text{C}$

Final temperature of water taken in enclosure =  $\dots\dots\dots^\circ\text{C}$

Mean observed value of temperature of enclosure =  $\dots\dots\dots^\circ\text{C}$

Mean corrected value of temperature of enclosure  $\theta_0 = \dots\dots\dots^\circ\text{C}$

Table for time (t) and  $\text{Log}(\theta - \theta_0)$

S. No.	TIME t in Minute	Temperature of warm water $\theta^\circ\text{C}$	$(\theta - \theta_0)^\circ\text{C}$	$\text{Log}(\theta - \theta_0)$
1				
2				
3				
.				
.				

**Calculations :**

- (i) Taking time  $t$  (minute) along X-axis and temperature of warm water  $\theta^\circ\text{C}$  along Y –axis plot a graph . The graph is the cooling curve of given hot liquid (hot water). The graph is exponential curve.
- (ii) Taking time  $t$  (minute) along X-axis and  $\text{Log}(\theta - \theta_0)$  along y-axis plot a graph. The graph obtained is a straight line curve having –ve slope .

**Result :** The cooling curve enclosed.



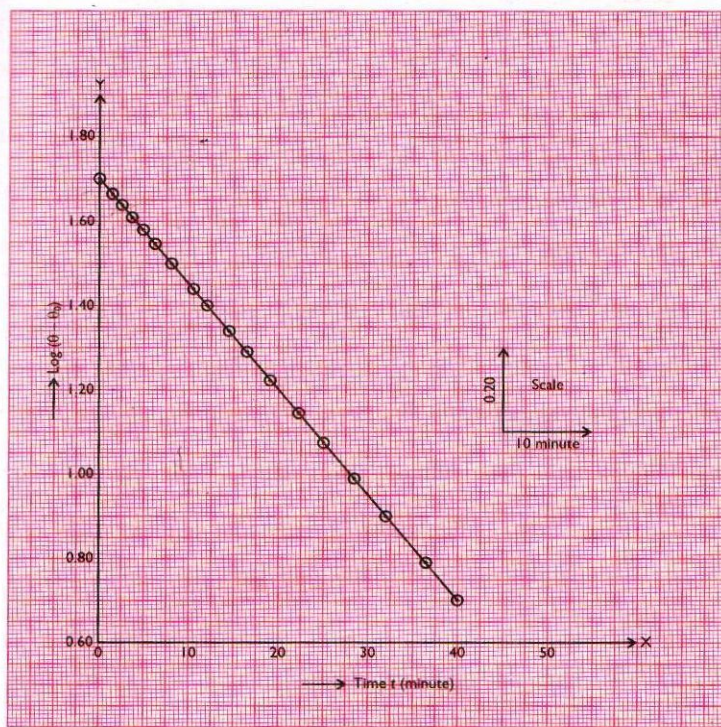


Fig. 10.3 Graph of  $\log(\theta - \theta_0)$  and time  $t$

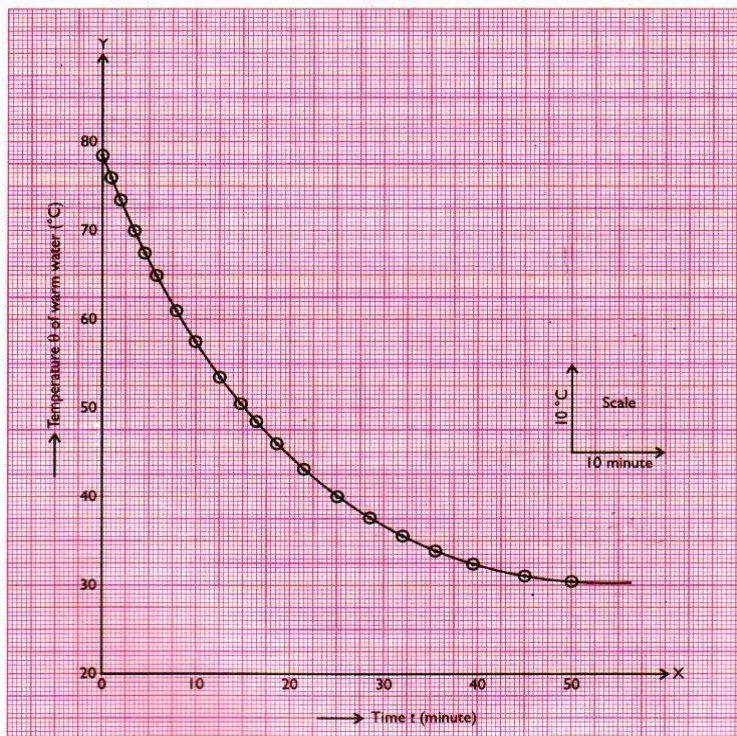


Fig. 10.2 Graph of temperature  $\theta^\circ\text{C}$  and time  $t$

**Precaution:**

1. The space between the two walls of the double walled vessel should be filled with running tap water so that its temperature is same as the room temperature.
2. The initial reading of two thermometers should be checked and if these differ then suitable correction in reading of one thermometer should be applied considering other thermometer as the correct.
3. The outer surface of the calorimeter should be dull black so that it loses heat at a faster rate.
4. The calorimeter should not touch the walls of the double walled vessel.
5. Bulbs of the thermometers should be immersed in water but should not touch the wall or bottom of calorimeter / double walled enclosure.
6. The lid must fit tightly in the calorimeter otherwise some water may evaporate during the course of experiment.
7. The initial temperature of hot water should never be more than 40 °C above the room temperature.
8. Stirring of hot water in calorimeter should be continuous and gentle.