LAB SYLLABUS

PHY 112

General Physics Lab

Experiment on

1. Measuring diameter, length and thickness and hence find out the volume of a hollow cylinder
2. To measure the diameter of a pen with a screw gauge and to find its average cross section.
3. Determination of ‘g’ by using bar pendulum.
4. Determination of the refractive index by a rectangular glass slab.
5. Determine of minimum angle of deviation and refractive index of a glass prism.
6. Determination of moment of inertia of a flywheel about its axis of rotation.
7. To determine the speed of sound in air by using the laws of resonance for an open tube.
8. To determine the thickness of a glass plate with Spherometer.
9. Determination of Unknown resistance and hence verify the law of series and parallel circuit.
10. To determine the density of the material of the capillary tube using a travelling microscope.

Experiment no: 1

Name of the experiment: Measuring diameter, length and thickness and hence find out the volume of a hollow cylinder

Our Objective

- To know the use of the Slide Calipers.
- To measure the diameter, length, thickness and finally the volume of a small cylindrical body.

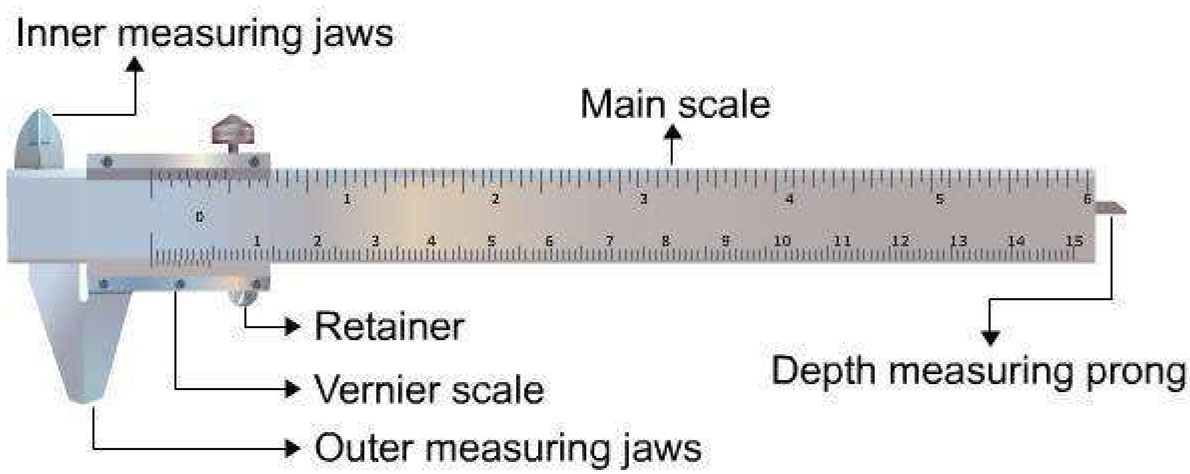
The Theory:

Description of a Slide Calipers

A calliper is a device used to measure the distance between two opposing sides of an object. It can be as simple as a compass with inward or outward-facing points. First the tips of the calliper are adjusted to fit across the points to be measured and the calliper is then removed and the distance between the tips is measured using a ruler.

The modern Slide calliper was invented by Joseph R. Brown in 1851. It was the first practical tool for exact measurements that could be sold at an affordable price to ordinary machinists. The Slide Calliper consists of a main scale fitted with a jaw at one end. Another jaw, containing the vernier scale, moves over the main scale. When the two jaws are in contact, the zero of the main scale and the zero of the Vernier scale should coincide. If both the zeros do not coincide, there will be a positive or negative zero error.

1. **Main Scale**



The main scale consists of a steel metallic strip graduated in centimeters at one edge and in inches at the other edge . It carries the inner and outer measuring jaws. When the two jaws are in contact, the zero of the main scale and the zero of the Vernier scale should coincide. If both the zeros do not coincide, there will be a positive or negative zero error.

2. **Vernier Scale**

A vernier scale slides on the strip. It can be fixed in any position by the retainer. On the Vernier scale, 0.9 cm is divided into twenty equal parts.

3. **Outer Measuring Jaws**
The outer measuring jaws helps to take the outer dimension of an object

4. **Inner Measuring Jaws**
The inner measuring jaws helps to take the inner dimension of an object.

5. **Retainer**
The retainer helps to retain the object within the jaws of the Vernier calipers.

6. **Depth Measuring Prong**
The depth measuring prong helps to measure the depth of an object.

Vernier Constant(V.C.)

The V.C. or the smallest reading which you can get with the instrument can be calculated as;

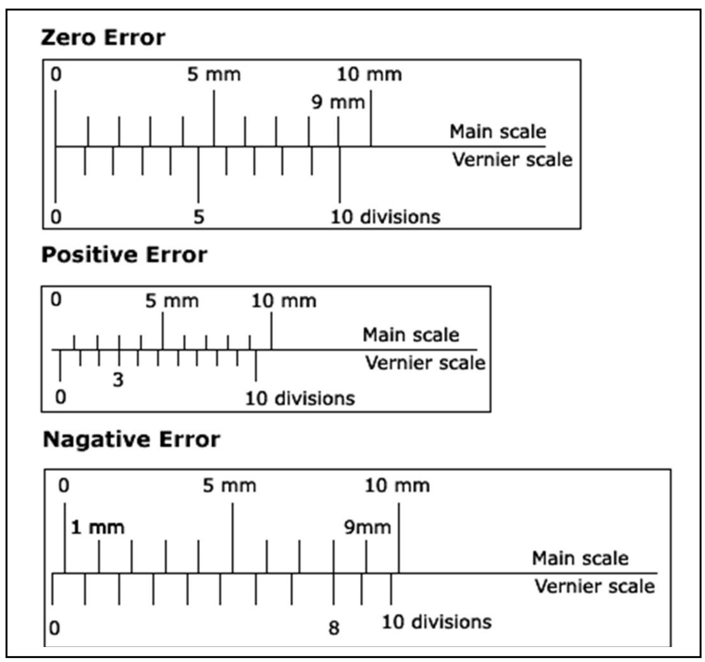
$$V.C = \frac{One\ main\ scale\ division}{number\ of\ division\ in\ vernier\ scale}$$

Zero error in Slide Calipers:

Errors are produced in an instrument due to its constant use. If the zero of the vernier exactly coincides with the zero of the main scale then there is no zero error (when the two jaws are in contact). There are two types of zero errors – negative error and positive error.

(i) Positive Error: When the two jaws are in contact and the zero of the vernier lies right to the zero of the main scale, the error is positive and the zero correction is negative.

For example, under this circumstances if the third division on the vernier coincides with any division on the main scale, then the zero can be calculated as follows:
Zero error = + 2 divisions
Zero correction = − 3 × (LC) = − 3 × 0.01 cm = − 0.03 cm



(ii) Negative Error: When the two jaws are in contact and the zero of the vernier lies left to the zero of the main scale, then the error is negative and the zero correction is positive. For example, under this circumstance if the eighth division on the vernier coincides with any division on the main scale, then main scale, then

Calculating the Reading

When a body is between the jaws of the Vernier Caliper;
If the zero of the vernier scale lies ahead of the a'th division of the main scale, then the main scale reading (MSR) is;
MSR= a cm
If b'th division of Vernier scale coincides with any division of the main scale, then the Vernier scale reading (VSR) is;
VSR= (b× V.C.)
Total reading= MSR+VSR={a+(b× V.C.)

Finding the Volumes

Volume of a hollow cylinder = Outer volume of the cylinder- inner volume of the cylinder

This can be expressed as;

$$V = \pi r^2 l - \{\pi (r-t)^2 l\}$$

Where

r = Outer radius of the cylinder = $\frac{Diameter}{2}$
l = length of the cylinder
t = thickness.

Apparatus: Slide calipers, a hollow cylinder.

Procedure:

Measuring diameter, length and thickness

1) We determined the smallest division of the main scale (both in cm scale and inch scale) with reference to a measuring scale.

2) Vernier scale was slid over the main scale so that the zero line of the vernier scale coincides with the main scale division. Main scale division was found out with which the last vernier scale division coincides. We counted the total number of divisions in both vernier and main scale between these two points of coincidence. It was recorded. To be sure, these number may be rechecked by moving the vernier to some other position. Then vernier constant was calculated.

3) Two lower jaws of the calipers were placed in contact. If the vernier zero coincides with the main scale zero there is no instrumental error. If they do not coincide there is an instrumental error. Then we have to determine the instrumental error, positive or negative.

4) Movable jaws were drawn out and the cylinder was placed between the jaws. The two jaws were made to touch the end of the cylinder diameter wise. taking care to see that they are not pressed too hard or too loose. We took the main scale reading just short of the vernier zero line and counted vernier division between the vernier zero line and the line which coincided with any of the main scale division. The product of the vernier reading and the vernier constant gives the length of the fractional part (taking account of the zero error), gives the diameter of the cylinder. At least three readings were taken; average diameter was measured and arranged in a tabular form.

5) To measure length and thickness we fixed the lower jaws as per length and thickness respectively repeating the 4^{th} procedure and took at least three observations for each quantity. Average length and thickness were measured and arranged in a tabular form.

<u>Table:</u> Measurements for diameter, length and thickness

Name of the quantity	No. of obs	Main scale reading (a) cm	Vernier scale division (b)	V.C. in cm	Excess by vernier 0r Vernier scale reading d= b× V.C. cm	Total Reading (a+d) in cm	Mean reading In cm
DIAMETER *(D)*	1			.005			
	2						
	3						
LENGTH *(l)*	1						
	2						
	3						
THICKNESS *(t)*	1						
	2						
	3						

Calculation:

$$V.C = \frac{One\ main\ scale\ division}{number\ of\ division\ in\ vernier\ scale}$$

$= \frac{1\ mm}{20} = 0.05mm = 0.005\ cm$

Volume, $V = \pi r^2 l - \{\pi(r-t)^2 l\}$

=………………….. *in cm*^{3}

Discussion:

(i) The jaws must not be pressed too hard or too loose.

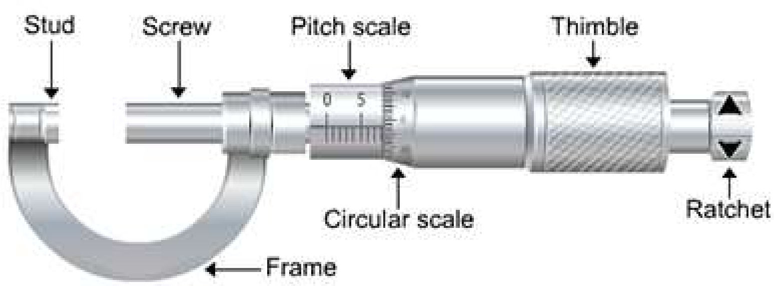
Experiment NO: 2

Name of the experiment: ***Determination of diameter of a pen using screw gauge and hence finding the area of cross section.***

Apparatus:

1. Screw Gauge
2. A Pen

Theory: The screw gauge is an instrument used for measuring accurately the diameter of a thin wire or the thickness of a sheet of metal. It consists of a U-shaped frame fitted with a screwed spindle which is attached to a thimble.



Parallel to the axis of the thimble, a scale graduated in mm is engraved. This is called pitch scale. A sleeve is attached to the head of the screw.

The head of the screw has a ratchet which avoids undue tightening of the screw. On the thimble there is a circular scale known as head scale which is divided into 50 or 100 equal parts. When the screw is worked, the sleeve moves over the pitch scale.

A stud with a plane end surface called the anvil is fixed on the 'U' frame exactly opposite to the tip of the screw. When the tip of the screw is in contact with the anvil, usually, the zero of the head scale coincides with the zero of the pitch scale.

Pitch of the Screw Gauge

The pitch of the screw is the distance moved by the spindle per revolution. To find this, the distance advanced by the head scale over the pitch scale for a definite number of complete rotation of the screw is determined.

The pitch can be represented as;

$$\text{Pitch of the screw} = \frac{\text{Distance moved by screw}}{\text{No. of full rotations given}} \ldots\ldots\ldots\ldots\ldots(1)$$

Least Count of the Screw Gauge

The Least count (LC) is the distance moved by the tip of the screw, when the screw is turned through 1 division of the head scale.

The least count can be calculated using the formula;

$$\text{Least count} = \frac{\text{Pitch}}{\text{Total number of divisions on the circular scale}} \ldots\ldots\ldots\ldots\ldots(2)$$

Zero Error and Zero Correction

To get the correct measurement, the zero error must be taken into account. For this purpose, the screw is rotated forward till the screw just touches the anvil and the edge of cap is on the zero mark of the pitch scale. The Screw gauge is held keeping the pitch scale vertical with its zero down wards.

When this is done, anyone of the following three situations can arise:

1. The zero mark of the circular scale comes on the reference line. In this case, the zero error and the zero correction, both are nil.
2. The zero mark of the circular scale remains above the reference line and does not cross it. In this case, the zero error is positive and the zero correction is negative depending on how many divisions it is above the reference line.
3. The zero mark of the head scale is below the reference line. In this case, the zero error is negative and the zero correction is positive depending on how many divisions it is below the reference line.

To find the diameter of the pen

With the pen between the screw and anvil, if the edge of the cap lies ahead of the N^{th} division of the linear scale.

Then, linear scale reading (P.S.R.) = N.

If nth division of circular scale lies over reference line.

Then, circular scale reading (H.S.R.) = n x (L.C.) (L.C. is least count of screw gauge)

Total reading (T.R.) = P.S.R. + corrected H.S.R. = N + (n x L.C.).

2. If D be the mean diameterthen, area of cross-section of the Pipe is

$$A = \pi(d/2)^2$$

To find the diameter and hence to calculate the area of the Pen

Place the wire between the anvil and the screw and note down the PSR and HSR as before.

The diameter of the wire is given by;

$$T.R = PSR + (\text{corrected HSR} \times L.C) = N + (n \times L.C) \ldots\ldots\ldots\ldots.(3)$$

If r is radius of the wire, and l be the mean length of the wire.

Then, Area of the Pen, $A = \pi(d/2)^2$

Procedure:

Write yourself

Observation:

No:	Linear scale reading, X (mm)	Circuler scale reading, m	Least count L.C	Value of circuler scale reading, Y= m×L.C	Diameter D=X+Y (mm)	Mean Diameter (mm)	Radius, r (mm)
1							
2							
3							
4							
5							

Calculation:

Area of cross section of the pen = πr^2

$$= 3.1416 \times (\ldots\ldots)^2$$

$$= \ldots\ldots\ldots\ldots\ldots \; mm^2$$

<u>Result</u>: The diameter of the Pen = ……….. mm

<u>Result Discussion:</u>

Write yourself

Experiment NO: 3

Name of the experiment: ***Determination of 'g' by using bar pendulum.***

Apparatus:

3. Bar pendulum
4. Small metal wedge
5. Beam compass
6. Sprit level
7. Telescope
8. Stop watch
9. Meter rod

Theory: A bar pendulum is the simplest form of a compound pendulum. It is the form of a rectangular bar with holes drilled along its length at equal separation. If a bar pendulum of mass is oscillates with a very small amplitude θabout a horizontal axis passing through it. Then if angular acceleration $\frac{d^2\theta}{dt^2}$ is proportional to the angular displacement of 'g'. The motion is simple harmonic & the time period T is given by

$$T = 2\pi\sqrt{\frac{I}{MgL}} \text{ ---------------- (i)}$$

where 'I' denotes the intentional of the pendulum about the horizontal axis though its center of suspension and 'L' is the distance between the center of suspension and C.G. of bar pendulum.

Bar Pendulum:

i. A uniform rectangular metallic bar, with hole drilled along its length.
ii. C.G. is the middle of the bar.
iii. 2 knife edge symmetrically placed on either side of C.G. to suspend it various distance from C.G.

According to theorem of parallel axis, if I_G the moment of inertia of the pendulum about an axis through C.G. ten the moment of inertia I about parallel axis at a distance L from C.G. is given by

$$I = I_G + Ml^2 = MK^2 + Ml^2 \text{ ---------------- (ii)}$$

where 'K' is the radius of gyration of the pendulum about axis through C.G. using equation (ii) in (i)

$$\Rightarrow \qquad T = 2\pi\sqrt{\frac{MK^2 + MI^2}{MgL}} = 2\pi\sqrt{\frac{M(K^2 + I^2)}{MgL}} = 2\pi\sqrt{\frac{K^2 + I^2}{gL}} = 2\pi\sqrt{\frac{\frac{K^2}{L} + L}{g}} = 2\pi\sqrt{\frac{L}{g}}$$

Where, L is the equivalent simple pendulum given by L = $\frac{K^2}{L} + L$

$$\text{Therefore, } g = 4\pi^2 \frac{L}{T^2}$$

Procedure:

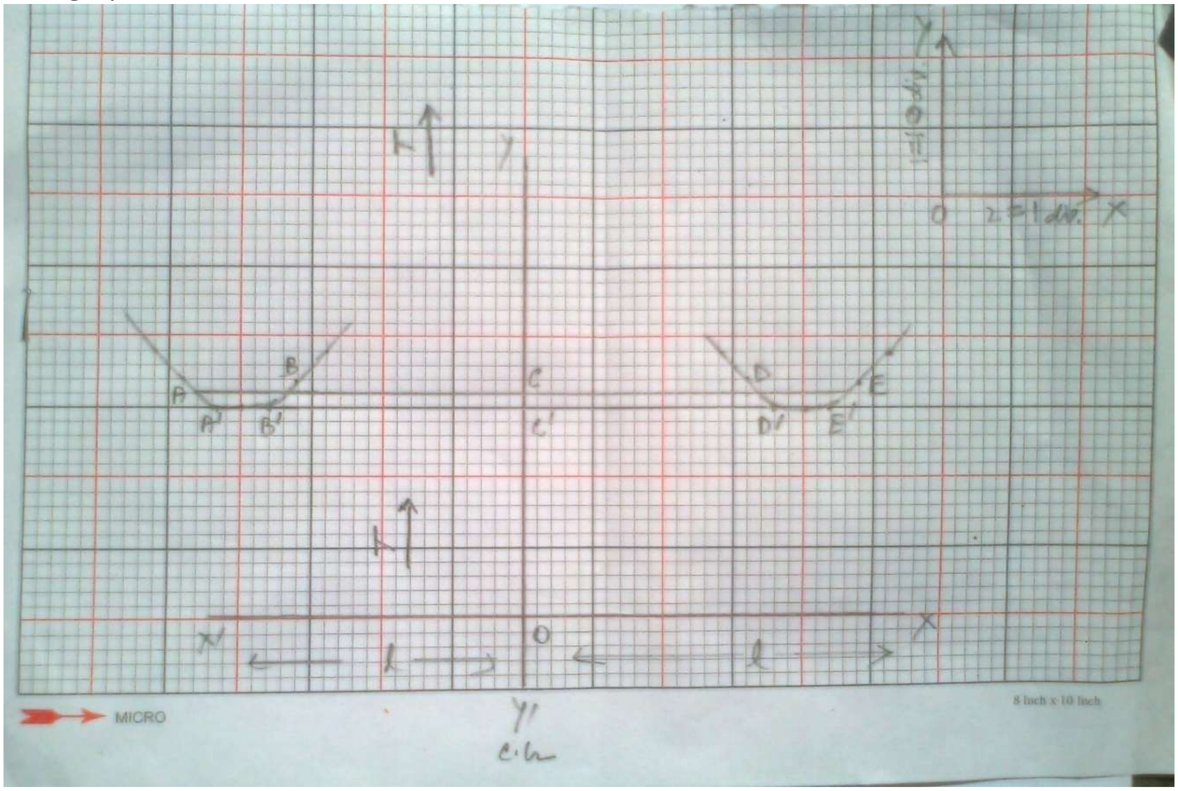
1. Balance the bar on a sharp wedge & mark the point of C.G.
2. Fix the knife edges in the outer most holes at either end of the bar pendulum. The knife edges should be horizontal & lie symmetrically with respect to center of gravity of the bar pendulum.
3. Check with sprit level that the glass plates fixed on the suspension wall bracket are horizontal.
4. Suspend the pendulum vertically by resting the knife edges at end A of the bar on the glass plate.
5. Adjust the eye piece of the telescope so that the cross wires are clearly visible through it. Focus the telescope on the lower end of the bar and put a reference mark on the wall behind the bar to denote it equilibrium point.
6. Displace the bar slightly to one side of the equilibrium position let it oscillate the amplitude not exceed 5 degrees.
7. Use the stop-watch to measure the time for 20 oscillations.
8. Measure the distance L from C.G. to knife edge.
9. Record the result in table. Repeat the measurement of the time for 20 oscillations.
10. Suspend the pendulum on knife edge of side B & repeat the measurement in steps 6-9 above.

Observation: Table: - Measurement T & L

Serial No	Side A			Side B		
	Time for 10 oscillations(t)	T = $\frac{t}{10}$	l (cm)	Time for 10 oscillations	T = $\frac{t}{10}$	l (cm)
1	35		45			45
2			40			40
3			35			35
4			30			30
5			25			25
6			20			20

7			15			15
8	20(8)		10			10
9			5			5

Now graph is-



<u>Calculation:</u> Plot a graph showing how the time period T depends on the distance from the center of suspension to C.G. (l). Figure (1) shows the expected variation of time period with distance of the point of suspension.

Acceleration due to gravity (g), draw horizontal line on the graph corresponding to two periods T_1& T_2, as shown in fig-1, for the line ABCDE.

$$\therefore L_1 = \frac{AD + BE}{2}$$

$$= \frac{....+....}{2}$$

$$= ......\ \text{cm}$$

$$\therefore T_1 = ...\ \text{sec}$$

Here, using the formula for g as given in,

$$g_1 = 4\pi^2 \frac{L_1}{{T_1}^2}$$

$$= 4\text{x}\,(3.14)^2\ \text{x}\ \frac{......}{(.....)^2}$$

$$= ......\ \text{ms}^{-2}$$

For the line A'B'C'D'E'

$$\therefore L_2 = \frac{A'D' + B'E'}{2}$$

$$= \frac{\ldots\ldots + \ldots\ldots}{2}$$

$$= \ldots\ldots \text{ cm}$$

$$\therefore T_2 = \ldots\ldots \text{sec}$$

$$\text{Now, } g_2 = 4\pi^2 \frac{L_2}{{T_2}^2}$$

$$= 4\text{x } (3.14)^2 \text{ x } \frac{\ldots\ldots}{(\ldots\ldots)^2}$$

$$= \ldots\ldots \text{ ms}^{-2}$$

Results:

1. The measured acceleration due to gravity, g = …… ms^{-2}
2. Actual value is 9.81 ms^{-2}
3. Percentage of error :

Error = (…… – 9.81) = ……

When gravity is ……..ms^{-2} then the error is …….

When gravity is 1 ms^{-2} then the error is $\frac{\ldots\ldots}{\ldots\ldots}$

$\therefore$When gravity is 100 ms^{-2} then the error is $\frac{\ldots\ldots \times 100}{\ldots\ldots}$

= …….

So, the percentage of error is ………%

Result Discussion:

Experiment NO: 4

Name of the experiment: Determination of the refractive index by a rectangular glass slab.

Theory: When a ray light passes from vacuum of air into another transport medium, it is refracted. The ration of the sine angle of incidence to the site of the angle refraction is a constant is called the refractive index of the transport medium.
The ray of the light PO is incident at point O and refracted through OR, and if a perpendicular N_1ON_2 is drawn on the point of incidence i = $\angle PON_1$ and r = $\angle RON_2$.

$$n = \frac{\sin i}{\sin} = \frac{\sin \angle PON_1}{\sin \angle RON_2} = \frac{PQ/_{OR}}{SR/_{OR}} = \frac{PQ}{SR}$$

where, n = Refractive index of the medium.
i = Angle of incidence.
r = Angle of refraction.

Apparatus:
1. A rectangular glass slab.
2. Drawing board.
3. Pins.
4. White paper.
5. Compass.
6. Set-square etc.

Procedure:
1. A piece of white paper is fixed the drawing board with the help of the pins and then the glass slab is placed on the paper. With a sharp pencil, the outline of the slab ABCD (fig. 1) is drawn.
2. Now two pins P_1 and P_2 are fixed vertically on the same side of fixed vertically on the same side of AB. So that P_1P_1' straight line meets at point O making an angle with the line AB. Now perpendicular N_1ON_2 is drawn at point O.
3. Then two other pins T_1 and T_1' are fixed on CD making a straight line with the images of P_1P_1'.
4. Repeating the same process pins P_2P_2' and P_3P_3' and T_2T_2' and T_3T_3' are fixed.
5. Now removing the glass slab and the pins the lines $P_1P_1'O$, $P_2P_2'O$ and $P_3P_3'O$ are drawn. All these are incident rays. The lines T_1T_1', T_2T_2' and T_3T_3' all are emergent rays.
6. If the line T_1T_1' is extended, it meets CD at a point. Then the straight line drawn from point O to this point is the refracted ray corresponding to the incident ray P_1P_1'. By repeating same process, the corresponding refracted rays of the incident rays P_2P_2' and P_3P_3' are drawn.
7. With the help of a protractor the angles of incidence and the angles of refraction are measured.
8. Putting the data in the table the refractive index is determined after making necessary calculations.

Observation and Tabulation: Table for determining the refractive index-

No. of observation	Angle of incidence (i) degree	sin i	Angle of refractive (r) degree	sin r	Refractive index, n	Average refractive index, n
1						
2						
3						

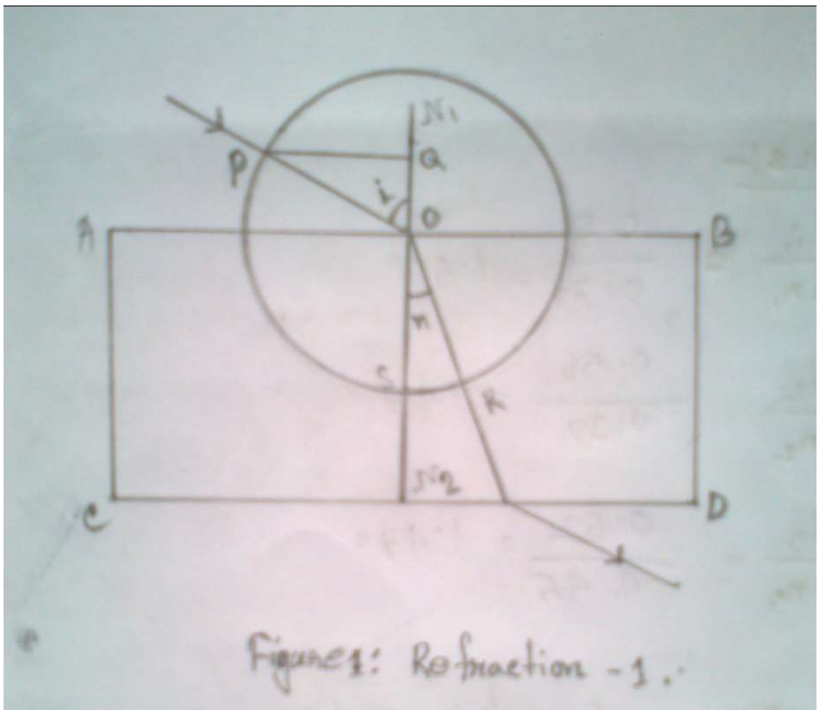


Figure1: Refraction -1.

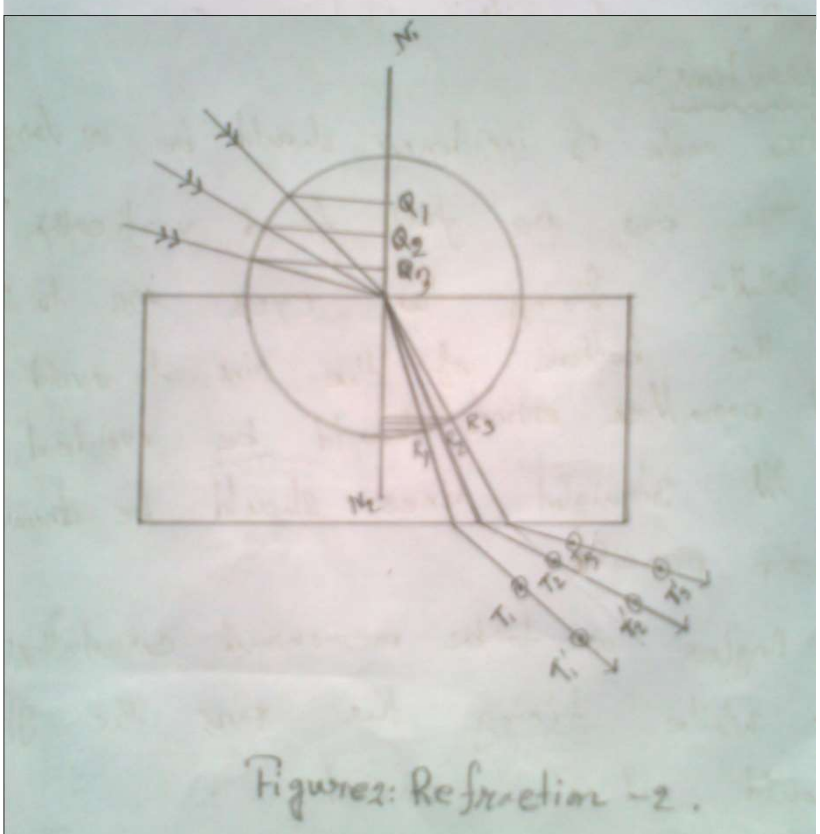


Figure2: Refraction -2.

Calculation:

$$n = \frac{\sin i_1}{\sin r_1} = \frac{}{} =$$

$$n = \frac{\sin i_2}{\sin r_2} = \frac{}{} =$$

$$n = \frac{\sin i_3}{\sin r_3} = \frac{}{} =$$

Result: The refraction index of glass in air, n =

Precautions:

1. The angle incidence should be as large as possible.
2. The pins are just fixed vertically.
3. While fixing the eyes are to be kept at the bottom of the pins to avoid error and parallax error should be avoided.
4. All straight lines should be drawn by sharp pencil.
5. Angles are to be measured carefully.
6. While fixing the pins the glass slab should not be moved.

Result Discussion:

Experiment NO: 5

Name of the experiment: Determination of minimum angle of deviation and refractive index of a glass prism.

Theory: The medium which is limited by two down word smooth parts is called the prism. When the incidence ray fall on it, it creates some angle and refracted from it.
The ray PO is incident at point O and refracted through OR_1 and if a perpendicular N_1ON_2 is drawn on the point on the incidence $i = \angle PON_1$and $r = \angle RON_2$.
From this we can write,

$$\mu = \frac{\sin\left(\frac{A+D_m}{2}\right)}{\sin^{A}/_{2}}$$

Here,

μ = Refractive index
A = Prism angle
D_m = Deviation

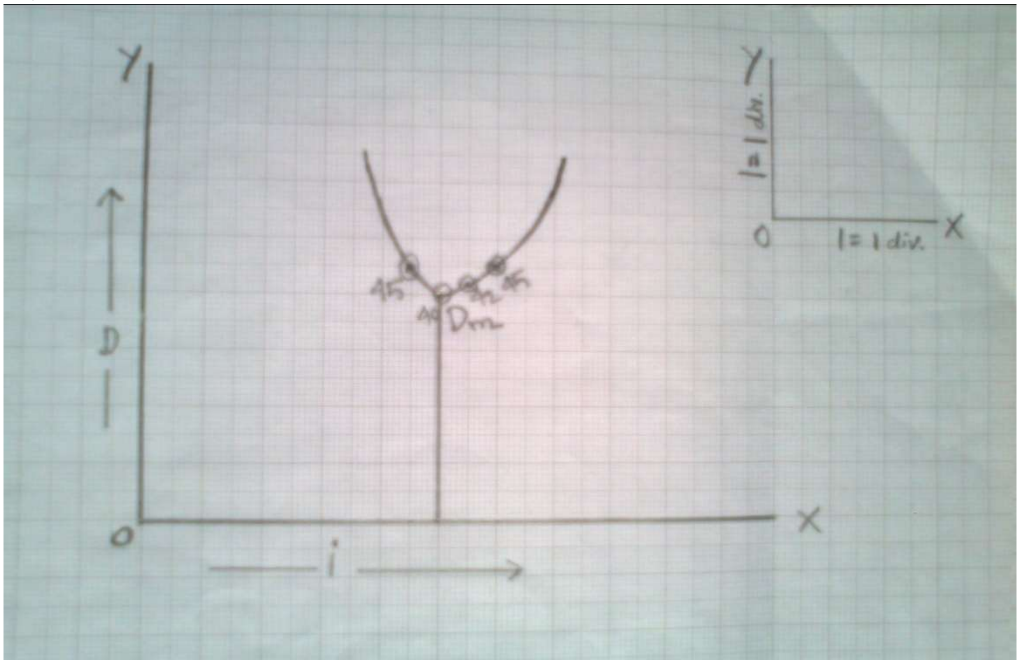
Apparatus:

1. Glass prism.
2. Drawing board.
3. Pins.
4. White paper.
5. Compass.
6. Set-square etc.

Procedure:

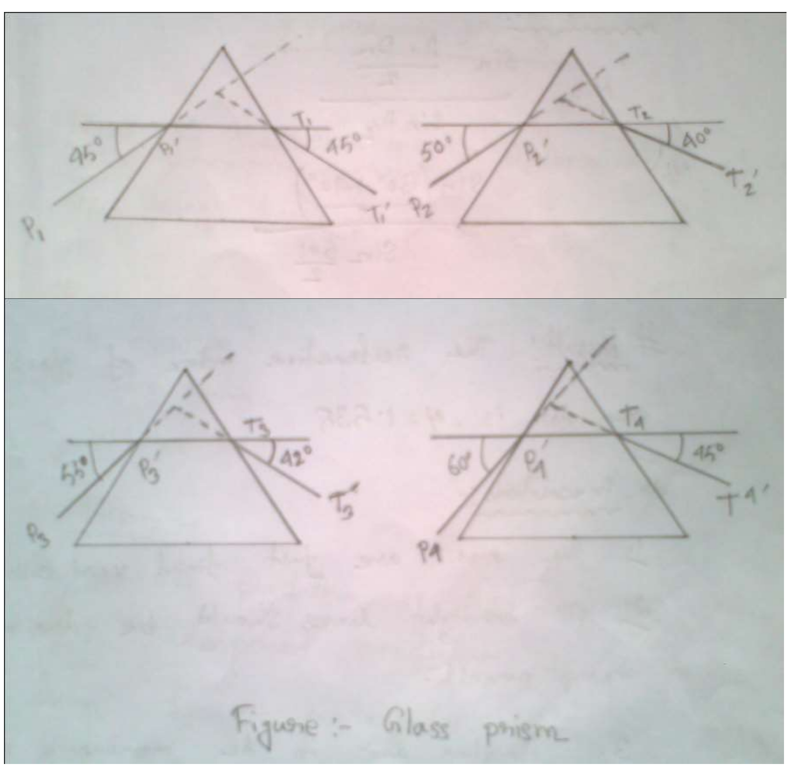
1. A piece of white paper is fixed on the drawing board with the help of pins and then the glass prism is placed on the paper. With a sharp pencil the line of the slab ABCD is drawn.
2. Now two pins P_1 and P_1' are fixed vertically on the side of AB. So that P_1P_1' straight line meets at point. O making an angle with the line AB. Now perpendicular N_1ON_2 is drawn at point O.
3. Then two other pins T_1T_1' are fixed on CD making a straight line with the images of P_1P_1'.
4. Repeating the same process pins P_2P_2', P_3P_3' and P_4P_4' and T_2T_2', T_3T_3' and T_4T_4' are fixed.
5. Now removing the prism and the pins the lines are drawn. All the incident and refractive rays.
6. Then we measured all the angles for the incident angle 45, 50, 55, 60 for the refractive angle.
7. All the values are putting on the table. The incidents angle i, and the deviation angle, D.
8. Then drawn a graph for measuring minimum angle of deviation D_m.

Now the graph is –



<u>Observation and Tabulation:</u>

No of observation	Incident angle, i	Deviation angle, D	Minimum angle of deviation, D_m	$\mu = \frac{\sin\left(\frac{A+D_m}{2}\right)}{\sin A/2}$
1	45	45	40	1.532
2	50	40		
3	55	42		
4	60	45		



Calculation:

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

$$= \frac{\sin\left(\frac{}{}\right)}{\sin\ /2}$$

$$= \frac{\sin}{\sin}$$

$$= \frac{}{} =$$

Result: The refractive index of glass prism on air is, μ =

Precautions:

1. The pins are just fixed vertically.
2. All straight lines should be drawn by sharp pencil.
3. Angles are to be measured carefully.

Result Discussion:

Experiment No: 6

Name of the experiment: Determination of moment of inertia of a flywheel about its axis of rotation

Theory

The flywheel is a big sized wheel. Most of its mass is distributed over the peripheral region. A thick cylindrical rod, called the axle, passes through the centre of mass of the wheel. The axis of the axle is perpendicular to the circular surface of the flywheel. The axle is kept horizontally by means of a holder hung on the wall. The wheel with the axle can rotate about the axis of the axle. There is a peg joined with axle. Objective of this experiment is to deturmine the moment of inertia of the flywheel about the axis of rotation, i.e., the axis of the axle.

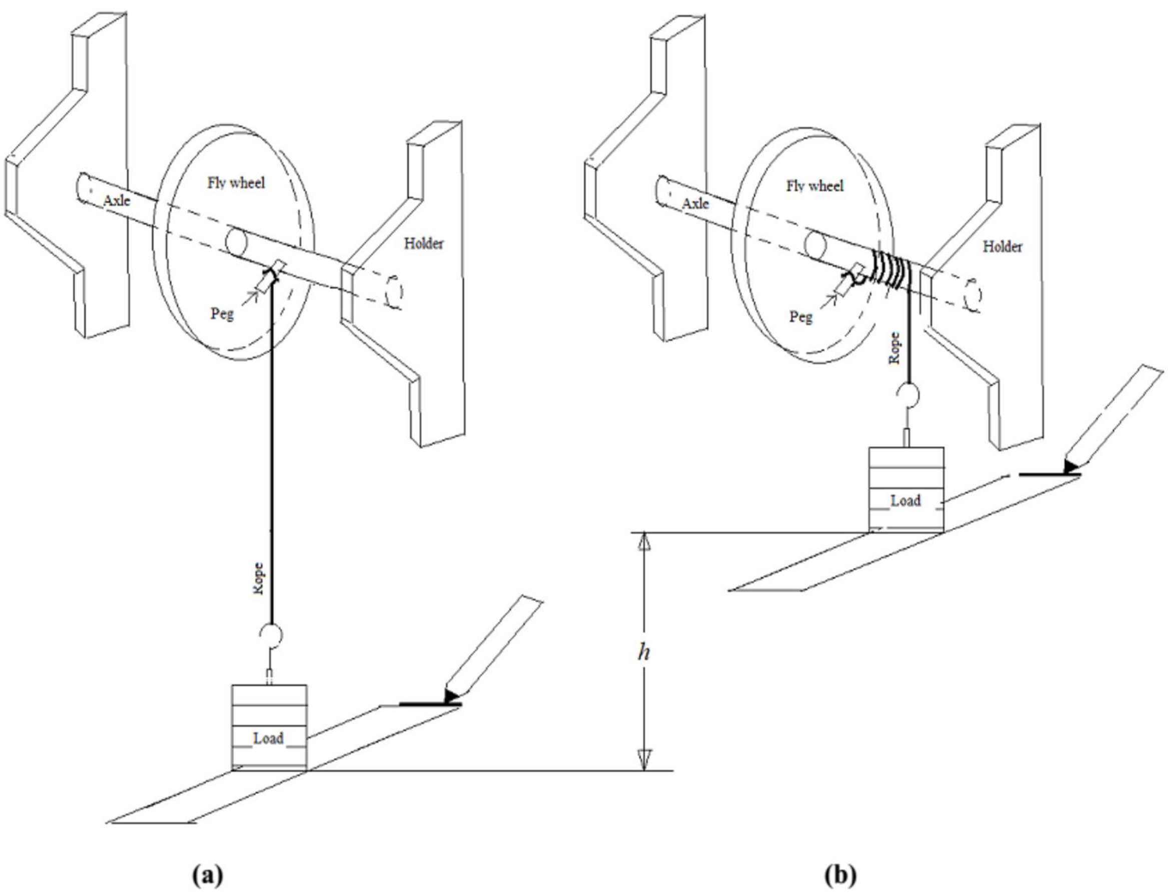


Figure1: (a) Flywheel when the rope and load is about to be detached from the axle. (b) The same flywheel after rotating it for n_l number of times (here n_1 is 6)

There is a small peg on the axle, as shown in figure 1. We make a loop on one end of a rope round this peg. A load of mass, M, is connected to the other end of the rope. We hold the flywheel in such a way that the load is about to be detached from the axle (figure 1 b). Then we keep a straight meter scale at the bottom surface of the load, see where on the wall the end of the meter scale touches and put a mark over there. Next, we rotate the flywheel for n_1 times. Consequently the load moves upward. Again, we keep the straight meter scale at the bottom surface of the load; we see where on the wall the end of the meter scale touches and put a mark over there. The separation between the two marks is h.

Now, if the flywheel is made free to rotate, then its angular velocity increases uniformly and the linear velocity of the load also increases uniformly. The flywheel completes n_1 revolutions after the release of the load and the load traverses a distance h vertically.

The work done by gravity on the load = M g h

A part of this work is used to increase rotational kinetic energy of the flywheel, and part of it supplies the linear kinetic energy to the load and the rest is used to work against the friction between the flywheel and the holder.

Let, I is the moment of inertia of the flywheel about its axis of rotation..

When the load is just detached from the axle, the angular velocity of the flywheel be ω and the linear velocity of the load is v. So the rotational kinetic energy of the flywheel = $\frac{1}{2}I\omega^2$, and the kinetic energy of the load = $\frac{1}{2}Mv^2$

Let, the work done against friction to complete a single revolution = W_f , therefore, the work done against friction to complete n_1 revolutions = n_1W_f

So, we can write,

$$Mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}Mv^2 + n_1W_f \tag{1}$$

Neglecting the thickness of the rope the ω , v and the radius of axle, r, are related by:

$$v = \omega\, r$$

Hence, from equation (1)

$$Mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}M\omega^2 r^2 + n_1W_f \tag{2}$$

Let, t is the time between the moment of detachment of the load from the axle and the moment when the flywheel comes into rest. In time t the flywheel completes n_2 revolutions.

During this second part of the motion of the flywheel, all of the rotational kinetic energy will be used to work against the friction which is n_2W_f , and hence

$$\frac{1}{2}I\omega^2 = n_2 W_f \tag{3}$$

Since in one complete revolution the angular displacement is 2π radian, in n_2 revolutions, total angular displacement is $2\pi n_2$ radian. The average angular velocity, $\overline{\omega} = \frac{2\pi n_2}{t}$

Now, during this second part of the motion, the angular velocity decreases uniformly form $\omega_{initial} = \omega$ to $\omega_{final} = 0$

So, average angular velocity, $\overline{\omega} = \frac{\omega_{initial} + \omega_{final}}{2} = \frac{\omega + 0}{2} = \frac{\omega}{2}$

Therefore, $\frac{\omega}{2} = \frac{2\pi n_2}{t}$

$$\Rightarrow \quad \omega = \frac{4\pi n_2}{t} \tag{4}$$

From equations (2) and (3) it follows that

$$I = \frac{2Mgh - M\omega^2 r^2}{\omega^2\left(1 + \frac{n_1}{n_2}\right)} \tag{5}$$

By using equations (4) and (5) we can determine the moment of inertia of the flywheel about its axis of rotation by measuring *M, h, r,* n_1 and n_2.

Apparatus

Fly-wheel, load, rope, stop-watch, meter scale, slide calipers and a piece of foam (most probably the upper portion of a broken seat) where the load will fall down

Procedure

1. Put the loop at one end of the rope round the peg (Figure 1 a) on the axle and a load of mass M=800 gm at other end.

2. Hold the flywheel in such a way that the load is about to be detached from the peg (figure 1 b). Then keep a straight meter scale at the bottom surface of the load, see where on the wall the end of the meter scale touches and put a mark over there. Next rotate the flywheel for a certain number of times (say for 6 times). It is the value of n_1. Write it down in the Table 1 of data sheet. The load moves upward. Again keep a straight meter scale at the bottom surface of the load, see where on the wall the end of the meter scale touches and put a mark over there. The separation between the two marks is h. Measure h by using a meter scale. Write it down in the Table 1 of data sheet.

3. Take the stop watch in your hand. Make the flywheel free to rotate. At the moment when the rope is just detached from the axle's peg, then turn on the stopwatch and begin counting the number of revolutions the flywheel makes until it comes to rest.

4. When the flywheel comes to rest, then turn off the stopwatch. The time recorded in the stopwatch is the value of, t. Write it down in the Table 1 of the data sheet. The number of revolutions what you have counted is n_2. Write it down in the Table 1.

5. Now repeat the whole process for the mass of the load, $M = 700$ gm and $M = 600$ gm

6. Measure the diameter of the axle by using a slide calipers. Use Table 2 to record the data. Find out the radius, r of the axle. Write it down in the data table. To know how to use a slide calipers please see the Appendix A (provided in the soft copy available in the server).

7. Find out the value of I for each case.

8. Take the average value of I for the final result.

Using equations (2), (3) and (4) show that, $$I = \frac{\left(ght^2 - 8\pi^2 n_2^2 r^2\right)M}{8\pi^2\left(n_2^2 + n_1 n_2\right)}$$

Table 1: Table for determination of n_1, h, n_2 and t

No.of Obs.	Mass, M (gm)	Height h (cm)	No of revolution n_1	Mean n_1	No of revolution n_2	Mean n_2	Time t (sec	Mean t (sec)	Moment of inertia of the flywheel about its axis of rotation, $I = \frac{\left(ght^2 - 8\pi^2 n_2^2 r^2\right)M}{8\pi^2\left(n_2^2 + n_1 n_2\right)}$ (gm cm^2)	Mean I (gm-cm^2)
1										
2										
3										
1										
2										
3										

Table 2: Data for the measurement of the radius of axle, *r*

(a) Least count of vernier callipers

$$= \frac{\text{the magnitude of the smallest division on the main scale}}{\text{the total number of small divisions on the vernier scale}}$$

S.NO	Main Scale reading (M) (cm)	No of vernier scale divisions coinciding(n)	Vernier Scale reading (n*VC) = y	D= M+y (cm)
1.				
2.				
3.				
4.				
5.				
6.				

Mean observed diameter $d= (d_1 + d_2 + d_3 \ldots\ldots\ldots d_{6)} / 6$

- *Substitute the values and calculate the mean diameter*

Mean corrected diameter = d±M.E= …………….. cm

So the radius of the axle, *r = d/2 =* _______________ *cm*

Calculations

I_1 =……………………………………………………

I_2= ………………………………………………..

I_3 = ………………………………………………..

Average, I=……………………….

Result:The moment of inertia of the flywheel about its axis or rotation is deduced to be _______________

Precaution:

Result Discussion:

Experiment No: 7

Name of the experiment: To determine the speed of sound in air by using the laws of resonance for an open tube.

Apparatus:

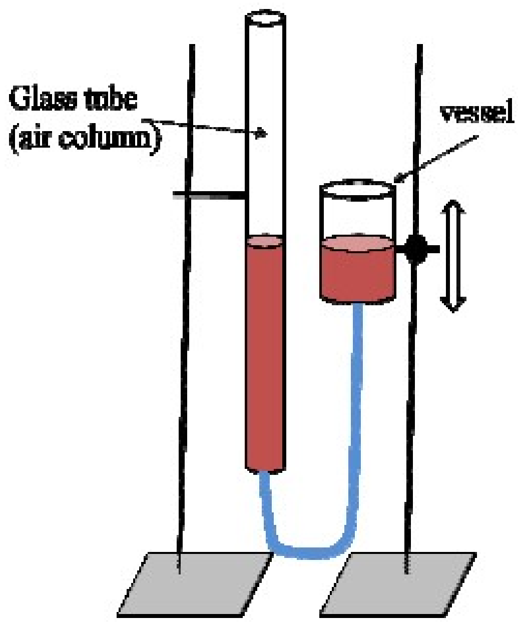


Figure 1

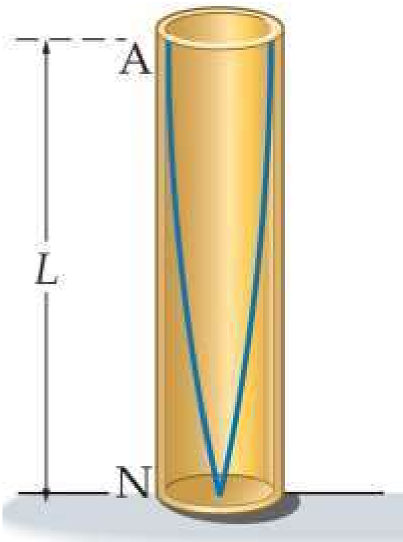
The apparatus is consisted of two main parts as given in figure. The first part is a movable vessel and the second part is a glass tube which is connected to the vessel by a flexible hose. The idea of this apparatus is to fill both parts with water, and then control the water level in the tube by changing the height of the vessel. This procedure creates open an open-closed tube for which the length is adjustable. The length of the actual tube will be the distance between the open end and the level of water) the empty part of the tube is called "*air column".*

Theory:

When a tuning fork produces waves close to the open end of an air column (figure 2), the waves travel inside the column. At the closed end the waves are reflected back. Such waves are called *"standing waves".* The interference between the ingoing and outgoing waves near the open end of the tube may

$$L = \frac{\lambda}{4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

be constructive or destructive. The condition of having the first possible constructive interference is when the length of the column is ¼ the wavelength of the standing wave. That is



where*L is the length of the air column and is the wavelength of the wave. More details* about this subject should be thought to you in classes.

It is know that the relationship between the wavelength , speed of waves *v and* frequency *f is given by*

$$v = f\lambda \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

From equations 1 and 2,

$$L = \frac{v}{4}\frac{1}{f} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Equation 3 implies that the relationship between *L and 1/f is linear. The speed of waves* can be calculated from the slope of the line resulting from this relationship.

ound waves travel in air with a speed which depends on the temperature of the air. The equation which governs this behavior is given by

v = 331.6 + 0.61 t……………(4)

Procedure:

1- The vessel is raised up until the water level in the tube is close to the open end.

2- A tuning fork was stroked and was hold it just above the tube (it was recommended to start with the fork with the highest frequency)

3- The vessel was lowered slowly so that the water level in the tube goes down (in this case the length of the air column was increased). While the water level went down the resonance was heard to occur

4- The air column length which had the strongest resonance was found. This value as *L in* the data sheet was recorded (the vibration of the tuning fork was made sure during the whole process.

5- Another fork was fork (with different frequency) was used and steps 3 and 4 were repeated.

6-Each frequency with the corresponding air column length was recorded in the table given in the answer sheet.

7- *L versus 1/f was plotted and the slope was calculated. The value of slope was used in the equation 3 to* determine *v, the speed of sound in air. This was the experimental value of v.*

8- equation 4 was used to calculate the theoretical value of *v*

9- Calculate the percentage error of *v was calculated.*

Table:

F (Hz)	L_1 (m)	L_2 (m)	L_3 (m)	L average (m)	1/f (sec)

Calculation:

L versus 1/f values according to equation 3 was plotted

The slope of the line = ……………………………………………………………

So, the speed of sound = …………………………………………………………m/s (This is the experimental value of *v)*

The room air temperature *t = ………* ^{o}C

The theoretical value of $v = 331.4 + 0.61\, t =$ …………… *m/s*

The percentage error =…………………………………………………………………

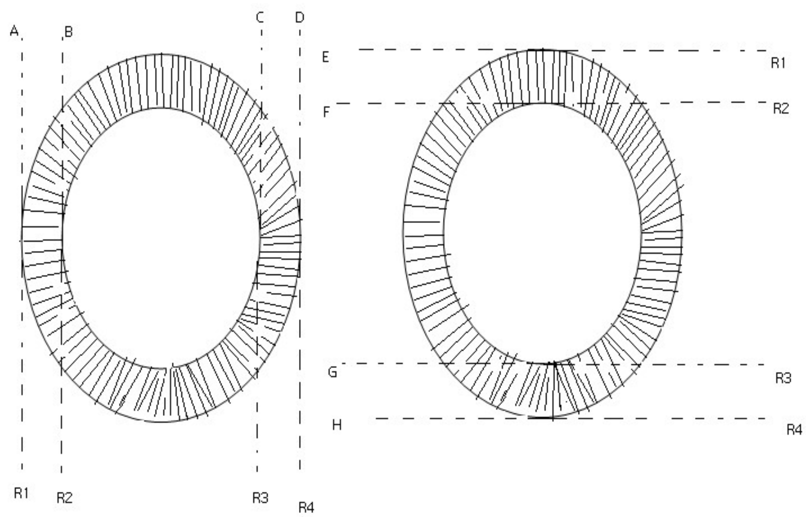
Result: The speed of sound = …………………………………………………………m/

Precautions:

Result Discussion:

Name of the experiment: 9

Name of the Experiment: To determine the density of the material of the capillary tube using a travelling microscope.



Apparatus:

Capillary tube, travelling microscope, stand, physical balance etc.

Formula:

The density of the material of the tube is given by,

$$\rho = \frac{M}{\pi(R2 - r2)L} \text{kg/ m3}$$

Where,

M=mass of the capillary tube kg,

R=external Radius of the capillary tube (m),

r =internal radius of the capillary tube,

L=length of the capillary tube.

Procedure:

The given capillary tube is isolated horizontally on a stand and step in position by means of wax. The travelling microscope is focused on the capillary tube such that the image of the cross section of the tube is clearly seen. The microscope is adjusted such that the vertical crosswire is tangential to the cross section of the capillary tube at the point aA and the reading R_1 is taken on the horizontal scale. The travelling microscope is then adjusted for vertical traverse and the readings R_1, R_2, R_3 and R_4 corresponding to the points B, C and D are taken on the horizontal scale. The travelling microscope is then adjusted for vertical transverse and the readings R_1, R_2, R_3 and R_4 corresponding to the points E,F,G and h are taken on the vertical scale. The reading is tabulated and the mean external and internal radius of the capillary tube is calculated.

Then length of the capillary tube is measured by coinciding the point of intersection of the cross wire with the end of the tube. The mass m of the capillary tube is determined using a physical balance. The density of the material of the capillary tube is then calculated using the formula.

$$\rho = \frac{\mathrm{M}}{\pi(\mathrm{R2}-\mathrm{r2})\mathrm{L}}\,\mathrm{kg/\ m3}$$

Observation:

Least count of the travelling microscope,

Value of one main scale division =………..cm

No of vernier scale division=…………

L.C=$\frac{\text{value of 1 MSD}}{\text{Total number of VSD}}$=……..cm

To determine the external radius R and internal r

Position of TM	TM readings in cm	External diameter D= R_4- R_1 in cm	Internal diameter d= R_3- R_2 in cm	External radius R=D/2 in cm	Internal radius r=D/2 in cm
Vertical traverse	R_1				
	R_2				
	R_3				
	R_4				
Horizontal traverse	R_1				
	R_2				
	R_3				
	R_4				

R_{mean}=…………………….cm

R_{mean}=…………………….cm

To determine length of the tube

Trial No	Reading at one end of the tube 'a' in cm	Reading at the other end of the tube 'b' in cm	Length of the tube L=a~b in cm
1			
2			
3			
4			

Mean length L=……………………….cm

Calculation:

Mass of the capillary tube=………………..kg

$$\rho = \frac{M}{\pi(R2-r2)L}\,\mathrm{kg/\ m3}$$

Result:

The density of the material of the given capillary tube =…………………….kg/m^3

Result Discussion: