

# Physics

## Practical Handbook



### Tangent galvanometer

Magnetic field induction  $B$  developed at the centre of the coil due to current  $I$

$$B = \left( \frac{\mu_0 I}{2r} \right) \cdot n \quad \dots(1)$$

According to Tangent law,

$$B = B_H \tan \theta \quad \dots(2)$$

Comparing equation (1) and (2)

$$\left( \frac{\mu_0 I}{2r} \right) \cdot n = B_H \tan \theta$$

$$\therefore I = \left( \frac{2rB_H}{\mu_0 n} \right) \cdot \tan \theta$$

$$\text{where, } k = \frac{2rB_H}{\mu_0 n} = \text{constant}$$

$$\therefore I \propto \tan \theta$$



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# **Std. XII Sci.**

## **Physics Practical Handbook**

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# PREFACE

Physics is the study of matter and energy and the interaction between them. It reveals the magic behind the wonderful existence of natural phenomenon. Hi-tech gadgets, modern machinery, gigantic skyscrapers, speedy trains, superior infrastructure are some of the marvels of physics. Practical physics has laid the groundwork in the fields of engineering, technology and medical diagnostics. In practical physics the student obtain laboratory skills, design experiments and apply instrumentation such as electronic circuits to observe and measure natural phenomena.

To master the science of physics practical one needs to have a complete and thorough knowledge of all the experiments. Hence we bring to you “**Std. XII Sci. : PHYSICS PRACTICAL HANDBOOK**” a handbook which covers all the experiments of Std. XII. This handbook written according to the needs and requirement of the board exam helps the student to score high. It includes different sets of experiments with proper steps and neat and labeled diagrams. These experiments help the student to understand the practical applications of many principles and laws involved in Std. XII. The handbook also includes all the useful tables given at the end.

And lastly, we would like to thank all those who have helped us in preparing this book. There is always room for improvement and hence we welcome all suggestions and regret any errors that may have occurred in the making of this book.

*A book affects eternity; one can never tell where its influence stops.*

*Best of luck to all the aspirants!*

Your's faithfully

Publisher

# SYLLABUS

## List of Practicals

1. To determine Young's modulus of elasticity of the material of a given wire.
2. To find the force constant and effective mass of helical spring by plotting  $T^2$  --m graph using method of oscillations.
3. To determine the surface tension of water by capillary rise method.
4. To study the relationship between the temperature of a hot body and time by plotting a cooling curve.
5. To study the relation between frequency and length of a given wire under constant tension using sonometer.
6. To study the relation between the length of a given wire and tension for constant frequency using sonometer.
7. To find the speed of sound in air at room temperature using a resonance tube.
8. To find resistance of given wire using metre bridge and hence determine the specific resistance of its material.
9. To verify the laws of combination (series/parallel) of resistance using a metre bridge.
10. To compare the emf of two given cells using potentiometer.
11. To determine the internal resistance of given cell using potentiometer.
12. To determine resistance of galvanometer using metre bridge.
13. To draw the I-V characteristic curves of a p-n junction diode in forward bias and reverse bias.
14. To study the characteristics of common-emitter npn or pnp transistor and to find out the values of current and voltage gains.
15. To draw the characteristic curve of a zener diode and to determine its reverse break down voltage.

**List of Activities**

1. To study dissipation of energy of a simple pendulum by plotting a graph between square of amplitude and time.
2. To study the effect of detergent on surface tension by observing capillary rise.
3. To study the factor affecting the rate of loss of heat of a liquid.
4. To study effect of load on depression of a suitably clamped meter scale loaded (i) as its end (ii) in the middle.
5. To measure the resistance and impedance of an inductor with or without iron core.
6. To study the variation in potential drop with length of a wire for a steady current.
7. To draw the diagram of a given open circuit comprising at least a battery, resistor/rheostat, key, ammeter and voltmeter. Mark the components that are not connected in proper order, correct the circuit and also the circuit diagram.
8. To study effect of intensity of light (by varying distance of the source) on an L.D.R.
9. To identify a diode, an LED, a transistor, and IC, a resistor and a capacitor from mixed collection of such items.
10. Use of multimeter to (i) identify base of transistor (ii) distinguish between npn and pnp type transistors, (iii) see the unidirectional flow of current in case of a diode and an LED (iv) check whether a given electronic component (e.g. diode, transistor or IC) is in working order.
11. To observe polarization of light using two polaroids.
12. To assemble a household circuit comprising three bulbs, three (on/off) switches, a fuse and a power source.

GROUP - A

01

# Young's Modulus 'Y' By Searle's Method

## EXPERIMENT

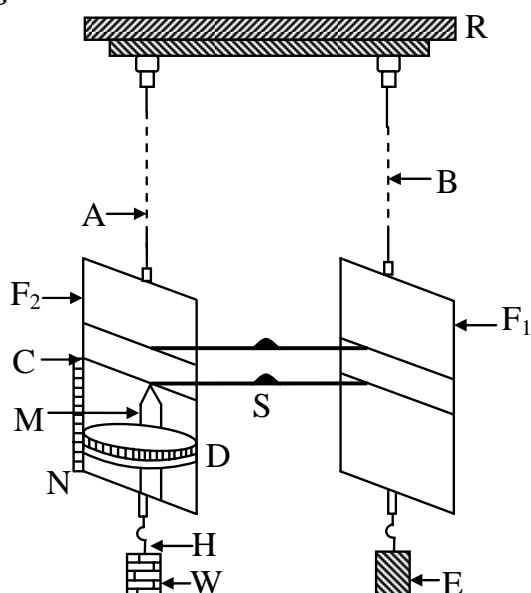
### Aim:

To determine Young's modulus of elasticity of the material of a given wire by Searle's method.

### Apparatus:

Two long (nearly 2 m or more) identical wires of the same material and diameter, Searle's apparatus, micrometer screw gauge, slotted weights each of 500 g, metre scale, etc.

### Diagram:



- R – Rigid support
- A, B – Wires of same material and diameter
- F<sub>1</sub>, F<sub>2</sub> – Metal frames
- S – Spirit level
- M – Micrometer screw
- D – Circular disc
- C – Support for screw
- E – Dead load
- H – Hanger to which the weights (W) are attached
- N – Main scale

### Formula:

$$Y = \frac{MgL}{\pi r^2 e} = \frac{gL}{\pi r^2} \left( \frac{M}{e} \right)$$

[ $\pi = 3.142$ ]

$$Y = \frac{gL}{\pi r^2} \cdot \left( \frac{1}{\text{Slope}} \right)$$

Where, Y = Young's modulus of the material of wire

M = Mass suspended from experimental wire

g = Acceleration due to gravity

L = Original length of experimental wire

r = Radius of the experimental wire

e = Extension produced in wire.



**Procedure:**

- i. Arrange the experimental set up as shown in diagram. Attach a zero load (slotted hanger itself) and dead load (E) to the frames of the experimental wire and dummy wire respectively so that the wires become free of kinks and remain vertically straight.
- ii. With the help of micrometer screw gauge, find the correct diameter of the wire at three different places. At every place two readings of the micrometer are taken while holding it in one position and another perpendicular to it by rotating through  $90^\circ$ .
- iii. In all, six readings of the diameter of the wire are taken. Hence mean diameter and radius of the wire is found out.
- iv. Adjust the spirit level so that the air bubble is at the centre. Note down the reading of the micrometer screw (M) attached to it. This is zero reading. (This contains main scale reading and circular scale reading.)
- v. Using a meter scale measure the length L of the experimental wire (A) from the point of suspension to the point fixed on the frame.
- vi. Add half kg weight to experimental wire, wait for two minutes. Bring the air bubble in the Spirit level at the centre. Note the main scale and circular scale reading of the micrometer (M) of searle's apparatus.  
Repeat the above procedure, each time by adding half kg weight to the hanger.
- vii. Take six readings for six different weights. Care should be taken that elastic limit is not crossed.
- viii. Decrease the load in same steps of half kg weight and note the corresponding reading for a given load for unloading. Find the mean of the two readings corresponding to loading and unloading.
- ix. Find the extension (elongation) produced in the wire for every load.

**Observations:**

- i. L.C. of micrometer (M) attached to Searle's apparatus, No. of divisions on circular scale  

$$N = 100, \text{pitch (P)} = \frac{x}{5} = \frac{0.5 \text{ cm}}{5} = 0.1 \text{ cm}$$

$$\text{L.C.} = \frac{P}{N} = \frac{0.1 \text{ cm}}{100} = 0.001 \text{ cm}$$
- ii. L.C. of micrometer for diameter of wire, No. of divisions on circular scale =  $N = 100$   

$$\text{Pitch (P)} = \frac{x}{5} = \frac{0.5 \text{ cm}}{5} = 0.1 \text{ cm}$$

$$\text{L.C.} = \frac{P}{N} = \frac{0.1 \text{ cm}}{100} = 0.001 \text{ cm}$$

$$\text{Zero error of micrometer} = Z = \pm \dots \text{ cm}$$
- iii. Original length of the experimental wire (A) =  $L = \dots \text{ cm}$

**Observation table:**

**i. For radius of the wire:**

Obs. No	M.S.R a (cm)	C.S.D b	C.S.R $c = b \times \text{L.C.}$	T.R a + c (cm)	Corrected diameter $d = (a + c) - Z$ (cm)
1.					
2.					
3.					
4.					
5.					
6.					

Mean corrected diameter =  $d = \dots\dots \text{cm}$

$$\therefore \text{Radius} = r = \frac{d}{2} = \dots\dots \text{cm}$$

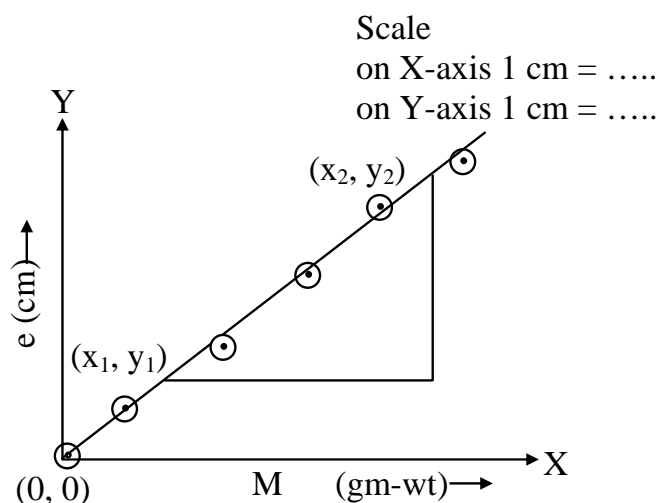
**ii. For extension of wire:**

Obs. No.	Load M (gm-wt)	Loading				Unloading				Mean reading 'a' (cm)	Extension for each load e (cm)	Extension for 1000 gm-wt e' (cm)
		M.S.R x (cm)	C.S.D. n	C.S.R $y = n \times \text{L.C}$ (cm)	T.R. $x + y$ (cm)	M.S.R. x (cm)	C.S.D n	C.S.R $n \times \text{L.C}$ $= y$ (cm)	T.R. $x + y$ (cm)			
1.	0									$a_0 =$	$a_0 - a_0 =$	
2.	500									$a_1 =$	$a_1 - a_0 =$	$a_2 - a_0 =$
3.	1000									$a_2 =$	$a_2 - a_0 =$	$a_3 - a_1 =$
4.	1500									$a_3 =$	$a_3 - a_0 =$	$a_4 - a_2 =$
5.	2000									$a_4 =$	$a_4 - a_0 =$	$a_5 - a_3 =$
6.	2500									$a_5 =$	$a_5 - a_0 =$	

Mean extension  $e' = \dots\dots \text{cm}$

**Graph:**

The graph of extension 'e' against load 'M' is plotted with (0, 0) origin.



$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\therefore \frac{1}{\text{slope}} = \frac{x_2 - x_1}{y_2 - y_1}$$

**Calculations:**

i.  $Y = \frac{gL}{\pi r^2} \times \frac{1000}{e'}$

ii.  $Y = \frac{gL}{\pi r^2} \left( \frac{1}{\text{slope}} \right)$

**Result:**

- Young's modulus of the material of the wire (by calculation) = .....dyne/cm<sup>2</sup>
- Young's modulus of the material of the wire (by graph) = .....dyne/cm<sup>2</sup>

**Precautions:**

- Measure the diameter of the wire accurately.
- Rotate the circular scale of Searle's apparatus in one direction for loading and in opposite direction for unloading to avoid error due to backlash.
- Readings of loading and unloading should be taken within elastic limit.
- Once the wire is loaded or unloaded wait for complete extension of the wire.

**Space for calculation:**

02

Determination of Force Constant and Mass of Helical Spring

EXPERIMENT

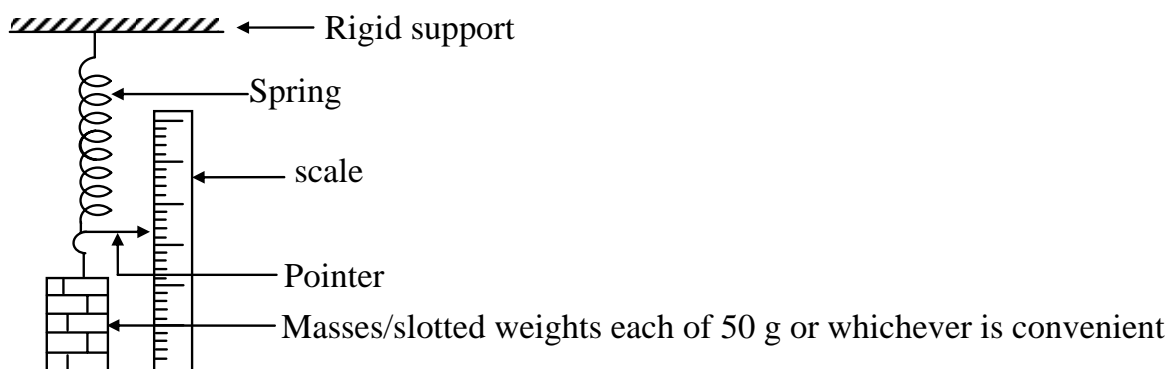
**Aim:**

- To find the force constant.
- Effective mass of helical spring by plotting  $T^2$ -m graph using method of oscillations.

**Apparatus:**

Spring supported from rigid support, pointer, scale, masses each of 50 g slotted weights with hanger each of 50 g (or whichever is convenient), stop watch.

**Diagram:**



**Formula:**

- $F = kx$  where,  $F$  = External force  
 $x$  = corresponding extension produced  
 $k$  = force constant
- Mass of the helical spring =  $M_s = 3$  (Intercept on x-axis of  $T^2$  - m graph)

**Procedure:**

- Fix one end of the spring to a rigid support and attach a pointer to the other end which can move along a vertical scale.
- Hang the hanger with total weight 250 g and note the reading of the pointer. This is initial reading  $x_0$ .
- Take three readings less than the initial reading by decreasing weights in the hanger in equal steps. Note down the corresponding reading ( $x$ ) of the pointer in each case.
- Take three readings greater than the initial reading in the hanger in equal steps. Note down the corresponding reading ( $x$ ) of the pointer in each case.
- Hence determine extension in each case.
- Hang the hanger alone, if required add masses in the hanger, say total mass 100 g.
- Displace the mass ( $m$ ) (along with hanger) slightly by pulling gently and oscillate the spring in the vertical plane.
- Measure the time required for suitable number of oscillations (say 10 or 15 or 20). Repeat this for two more times.
- Hence determine periodic time ( $T$ ) for that mass ( $m$ ).
- Increase the mass ( $m$ ) in the hanger in equal steps of 50 g and find out periodic time ( $T$ ) for each mass ( $m$ ). Hence  $T^2$  in each case.

03

# Determination of Surface Tension of Water

## EXPERIMENT

### Aim:

To determine the surface tension of a water using capillary rise method.

### Apparatus:

Travelling microscope, capillary tube, beaker containing water (liquid), stand, pin, with wax, etc.

### Diagram:

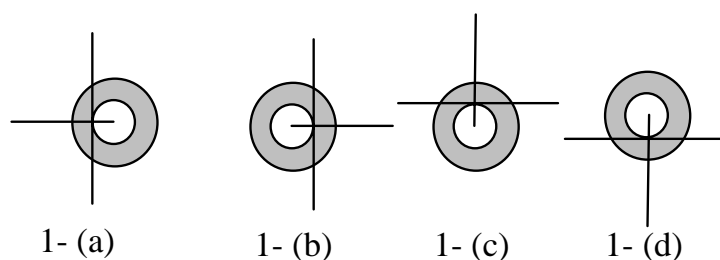


Diagram - 1

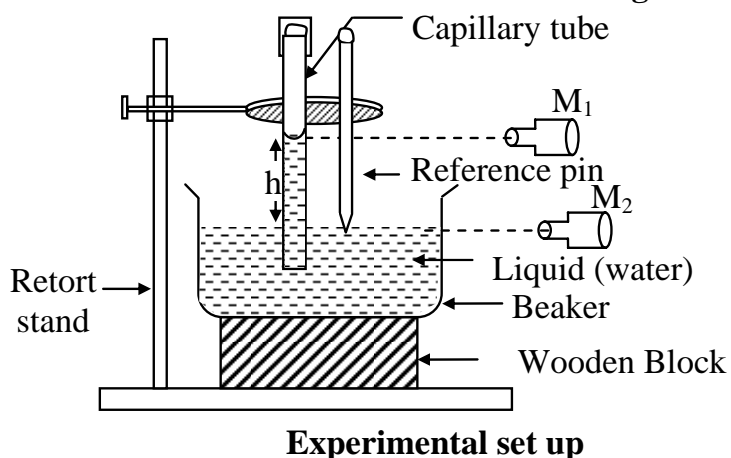


Diagram - 2

$M_1$  - Travelling microscope focussed on liquid meniscus  
 $M_2$  - Travelling microscope focussed on tip of reference pin

### Formula:

$$T = \frac{r\rho g}{2\cos\theta}$$

Where,  $T$  = Surface tension of liquid (water)

$r$  = Radius of the capillary tube

$h$  = Height of water column

$\rho$  = Density of water

$g$  = Acceleration due to gravity =  $980 \text{ cm/s}^2$

$\theta$  = Angle of contact between water and solid

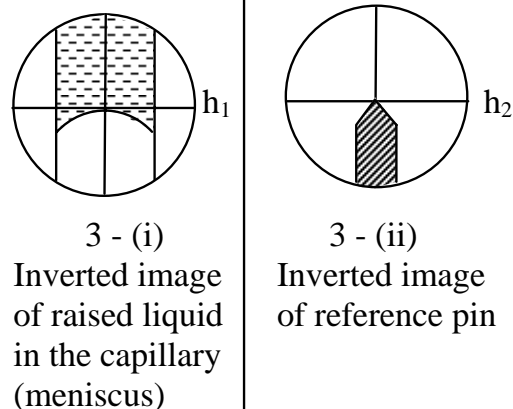


Diagram - 3

**Procedure:**

**I. To measure radius 'r' of the capillary tube:**

- i. Hold the capillary tube horizontal in the clamp of a retort stand and focus the travelling microscope on its bore at one end. Adjust the travelling microscope to such position that one of the cross wires (See diagram 1 - a) i.e. vertical cross wire is tangential to the bore at one point. Note down this reading 'a' with proper scale of the travelling microscope.
- ii. Now move the travelling microscope in such a way that the cross wire is tangential to diametrically opposite point on the bore with respect to 1 - (a) position. See diagram 1 - (b). Note down the reading 'b' of same scale of the travelling microscope.
- iii. Move the travelling microscope in such a way that horizontal cross wire is tangential to the bore at one point (See diagram 1 - (c)). Note this reading 'c' on the proper scale of travelling microscope.
- iv. Lastly move the travelling microscope in such a way that the horizontal cross wire is tangential to the bore which is diametrically opposite to point of 1 - (c). Note down this reading 'd' on the proper scale of travelling microscope.

**II. To measure the height of water column 'h':**

- i. Take clean dry capillary tube whose radius is to be found out. Fix this capillary tube in a hole drilled in a piece of cork. A long thin needle (or a pin with wax can also be used as reference pin) called reference pin is also passed through the cork. Reference pin is very close to the capillary tube and parallel to it. The cork is then clamped firmly.
- ii. A clean beaker filled with water upto its rim is placed over the wooden block of proper height.
- iii. Now adjust the position of capillary tube and the reference pin in such a way that capillary tube dips in water and tip of the pin just touches the surface of the water. This arrangement is shown in diagram - 2.
- iv. Remove air bubbles in the capillary if required with the help of rubber tube attached to the upper end of capillary tube.
- v. Move the travelling microscope and adjust it in  $M_1$  position. Focus the microscope on the meniscus in the capillary. This is shown in diagram 3 - (i). Care should be taken that horizontal cross wire is tangential to meniscus. Note down the reading ( $h_1$ ).
- vi. Take away the beaker without disturbing the cork with capillary tube and reference pin. Bring the travelling microscope in front of the pin. Focus it on this pin. Adjust the cross wire (cross point) touching the tip of the pin. This is shown in diagram 3 - (ii). Note down the reading ' $h_2$ '.
- vii. Repeat for  $h_1$  and  $h_2$  again for twice or thrice by dipping the capillary tube to different levels in the water.

**Observations:**

$$\text{L.C. of travelling microscope} = \frac{\text{Smallest division on M.S}}{\text{Total number of divisions on V.S}}$$

$$\text{Value of smallest division on M.S} = M = \dots \text{ cm}$$

$$\text{Total number of divisions on V.S} = N = \dots$$

$$\text{L.C} = \frac{M}{N} = \dots \text{ cm}$$

04

# Verification of Newton's law of cooling

## EXPERIMENT

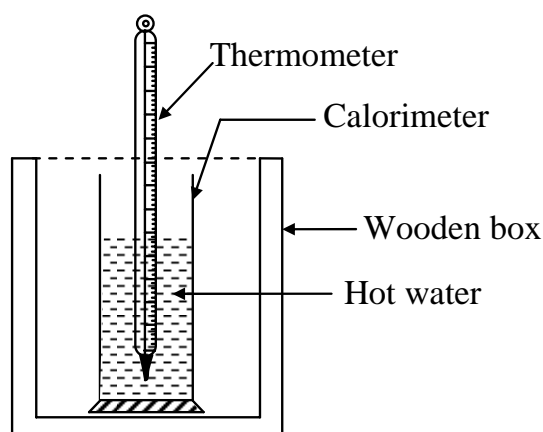
### Aim:

To study the relationship between the temperature of a hot body and time by plotting a cooling curve.

### Apparatus:

A calorimeter, thermometer, wooden enclosure (or double walled enclosure), a stop watch, arrangement of heating water.

### Diagram:



### Formula:

$$\frac{d\theta}{dt} = k (\theta - \theta_0)$$

Where,  $\frac{d\theta}{dt}$  = Rate of fall of temperature

$\theta$  = Temperature of (hot) body

$\theta_0$  = Temperature of surrounding (Room temperature)

$k$  = constant of proportionality

### Procedure:

- Fill the calorimeter to nearly two third of its capacity with hot water at about 75 °C to 85 °C [ $(\theta - \theta_0)$  should be small].
- Place the calorimeter in the enclosure. Insert a thermometer in the hot water.
- Record the temperature ( $\theta$ ) of the hot water at regular intervals of one minute as it cools. Note down the readings of temperature while cooling for 30 to 40 minutes. During this period the temperature ( $\theta$ ) of hot water falls by about 30 °C.
- Plot a graph of temperature  $\theta$  against time  $t$  as shown in graph - 1. This is a cooling curve. Draw tangents at five different points approximately equidistant, on this curve with the help of plane mirror. For this, first draw normal and then perpendicular to the normal i.e. tangent with the help of plane mirror. Find the slope of the tangents  $\left[ \frac{d\theta}{dt} \right]$  at five different temperatures and complete the second observation table of  $\theta$  and  $\left| \frac{d\theta}{dt} \right|$ .

06

# Sonometer (II) – Relation between the length of a given wire and tension

## EXPERIMENT

### Aim:

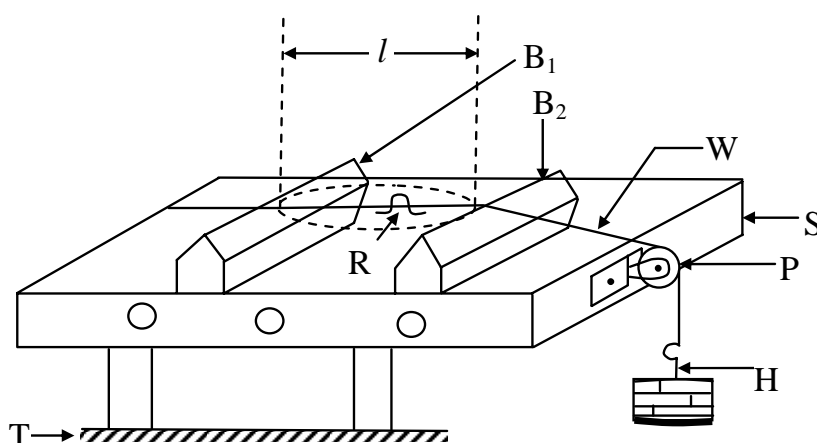
To study the relation between the length of a given wire and tension for constant frequency using sonometer.

(i.e.  $\frac{\sqrt{T}}{l}$  or  $\frac{T}{l^2}$  = constant, if n and m are constant.)

### Apparatus:

A tuning fork, sonometer, rubber pad, paper rider, a set of slotted weights.

### Diagram:



T – table  
H – hanger with weights  
P – pulley  
W – wire  
B<sub>1</sub> B<sub>2</sub> – movable bridges  
S – sonometer  
R – Paper rider

### Formula:

$$n = \frac{1}{2l} \sqrt{\frac{T}{m}}$$

where, m = Mass per unit length of sonometer wire

n = Frequency of tuning fork

l = Vibrating length of the sonometer wire

T = Tension in the wire = Mg

$$\therefore m = \frac{1}{4n^2} \left( \frac{T}{l^2} \right)$$

$$\text{or } n = \sqrt{\frac{1}{4m} \cdot \frac{T}{l^2}}$$



**Procedure:**

- Keep sonometer wire under tension (T) about one kg-wt including weight of the hanger.
- Start with the smallest distance between the bridges. Keep paper rider on the wire midway between the bridges.
- Hold the given tuning fork by the stem and strike it lightly with rubber pad. Keep it on the box of sonometer.
- Adjust the distance between the bridges so that can vibrate in unison with the given tuning fork. For a particular length of the wire, the rider flutters and falls off. This happens when natural frequency of the wire becomes equal to that of the frequency of tuning fork for that tension.
- Measure the vibrating length  $l$  of the wire. Repeat the procedure twice for one value of tension to get more accurate vibrating length.
- Repeat the above procedure for five different tensions.
- Plot the graph of  $l^2$  against T.

**Observations:**

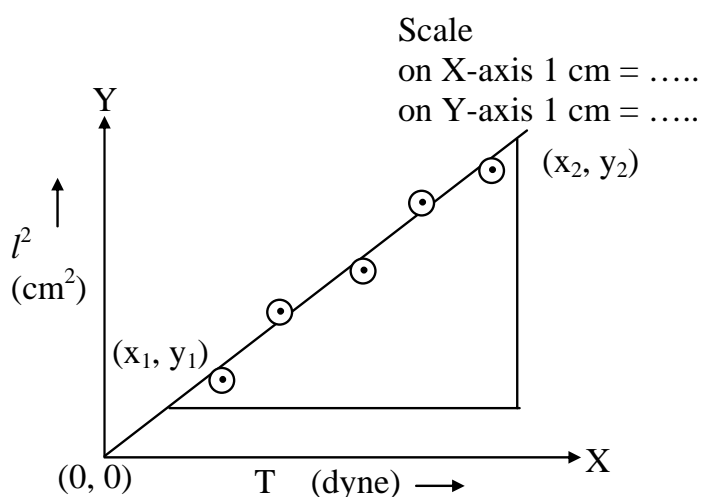
Frequency of tuning fork = .... Hz

**Observation table:**

Obs. No.	Mass M (g)	Tension T = Mg (dyne)	Vibrating length of the wire			$l^2$ (cm <sup>2</sup> )	$\frac{T}{l^2}$ (dyne/cm <sup>2</sup> )
			$l_1$ (cm)	$l_2$ (cm)	Mean $l$ (cm)		
1.							
2.							
3.							
4.							
5.							

Mean  $\frac{T}{l^2} = \dots\dots\dots$  dyne/cm<sup>2</sup>

**Graph:**



$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\therefore \frac{1}{\text{slope}} = \frac{x_2 - x_1}{y_2 - y_1}$$

**Calculations:**

i.  $m = \frac{1}{4n^2} \left( \frac{T}{l^2} \right)_{\text{mean}} \dots\dots\dots \text{g/cm}$

ii.  $m = \frac{1}{4n^2} \left( \frac{1}{\text{slope}} \right) \dots\dots \text{g/cm}$

**Result:**

- i. Mass per unit length of the wire (or linear density) by calculation =  $m = \dots\dots \text{g/cm}$ .
- ii. Mass per unit length of the wire (or linear density) by graph =  $m = \dots\dots \text{g/cm}$
- iii. The graph of  $l^2$  against  $T$  is a straight line passing through the origin. This verifies second law of sonometer.  $T \propto l^2$  ( $n, m$  are constant)

**Precautions:**

- i. Paper rider should always be kept on the wire midway between the two bridges.
- ii. Strike the tuning fork gently on the rubber pad and hold it at its stem when setting into vibrations.
- iii. Keep the wire initially at sufficient tension.
- iv. Avoid air disturbance.

**Space for calculation:**

07

# Use of Resonance Tube

## EXPERIMENT

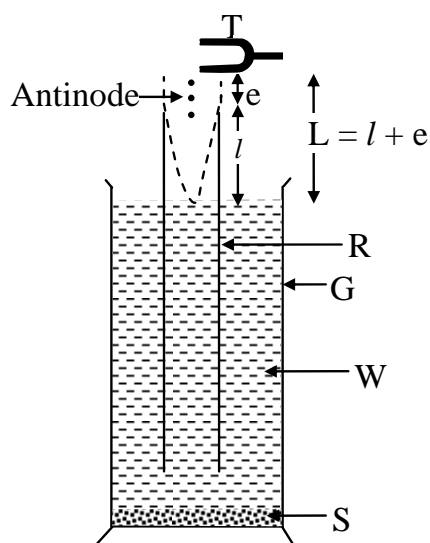
### Aim:

- To determine velocity of sound in air at room temperature.
- To find out unknown frequency of tuning fork.

### Apparatus:

A long glass jar filled with water and sand (little amount) at the bottom, resonance tube, set of tuning forks, retort stand, meter scale, vernier calliper, rubber pad, etc.

### Diagram:



T – Tuning fork  
R – Resonance tube  
G – Glass jar  
S – Sand  
W – Water

### Formula:

- End correction =  $e = 0.3 d = \dots\dots\dots\text{cm}$  where 'd' is diameter of resonance tube.
- $V = 4(nL)_{\text{mean}}$   
Where  $n$  = Frequency of tuning fork  
 $L$  = Correct vibrating air column.
- $V = 4 \left( \frac{1}{\text{Slope}} \right)$
- $n_x = \frac{(nL)_{\text{mean}}}{L_x}$

### Procedure:

- Measure the inner diameter (d) of the resonance tube with the help of the upper jaws of the vernier calliper. Take three readings. Hence calculate end correction.
- Hold the resonance tube vertical with the help of retort stand in the glass jar as shown in diagram.
- Strike the tuning fork of highest frequency gently on the rubber pad and hold it near the mouth of the resonance tube, so that the prong of the tuning fork vibrate in vertical plane. Adjust the length of the vibrating air column of the resonance tube so that maximum sound called resonance is heard. Clamp the tube.

- iv. Measure the length of the air column from the surface of the water level to the open end of the resonance tube using meter scale.
- v. Repeat the procedure twice for one tuning fork.
- vi. Repeat complete procedure for rest of the tuning forks. Remember start taking readings with highest frequency and lowest vibrating air column also for unknown frequency.
- vii. Find the correct vibrating length of the air column for each frequency.

**Observations:**

L.C of vernier calliper = L.C.

$$\text{L.C.} = \frac{\text{value of the smallest division on M.S.}}{\text{No. of divisions on V.S.}} = \frac{0.1}{10} \text{ cm}$$

$$\therefore \text{L.C.} = 0.01 \text{ cm}$$

$$\text{End correction} = e = 0.3 d = \dots\dots \text{cm}$$

**Observation table:**

**i. For inner diameter of the tube:**

Obs. No.	M.S.R a (cm)	V.S.D b (cm)	V.S.R. c = b × L.C (cm)	T.R. a + c = d (cm)
1.				
2.				
3.				

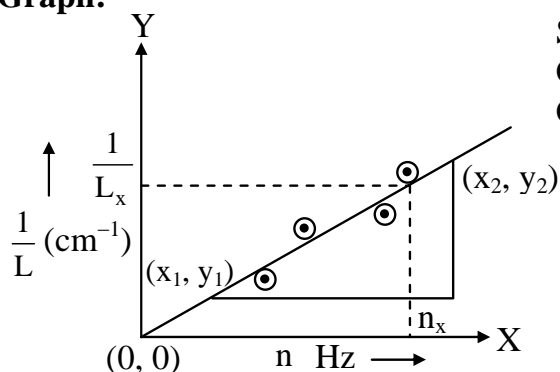
$$\text{Mean } d = \dots\dots\dots \text{ cm}$$

**ii. For resonating length:**

Obs. No.	Frequency n (Hz)	Vibrating length			Corrected length L = l + e (cm)	$\frac{1}{L}$ (cm <sup>-1</sup> )	nL (Hz - cm)
		$l_1$ (cm)	$l_2$ (cm)	Mean l (cm)			
1.							
2.							
3.							
4.							
5.	$n_x$				$L_x =$	$\frac{1}{L_x} =$	

$$\begin{aligned} \text{Mean (nL)} &= \dots\dots \text{ Hz - cm} \\ &= \dots\dots \text{ cm/s} \end{aligned}$$

**Graph:**



Scale

On x-axis 1 cm = ....

On y-axis 1 cm = ....

$$\text{Slope} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\therefore \frac{1}{\text{slope}} = \frac{x_2 - x_1}{y_2 - y_1}$$

**Calculations:**

i.  $4(nL) = v$

ii.  $n_x = \frac{(nL)_{\text{mean}}}{L_x}$

iii.  $4\left(\frac{1}{\text{slope}}\right) = v$

**Result:**

- Velocity of sound at room temperature (by calculation) =  $v = \dots \text{ cm/s}$
- Velocity of sound at room temperature (by graph) =  $v = \dots \text{ cm/s}$
- Unknown frequency (by calculation) =  $n_x = \dots \text{ Hz}$
- Unknown frequency (by graph) =  $n_x = \dots \text{ Hz}$

**Precautions:**

- Strike the tuning fork gently on rubber pad.
- Hold the vibrating tuning fork just above the mouth of the resonance tube.
- Do not bring ear close to the tube.
- Hold the resonance tube exactly vertical.

**Space for calculation:**