PRACTICAL MANUAL

HIGHER SECONDARY
FIRST YEAR

PHYSICS

PREPARED BY

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Exp No: 1 MOMENT OF INERTIA OF A SOLID SPHERE OF KNOWN MASS USING VERNIER CALIPER

Aim :

To determine the moment of inertia of a solid sphere of known mass using Vernier caliper

Apparatus Required:

Vernier caliper, Solid sphere

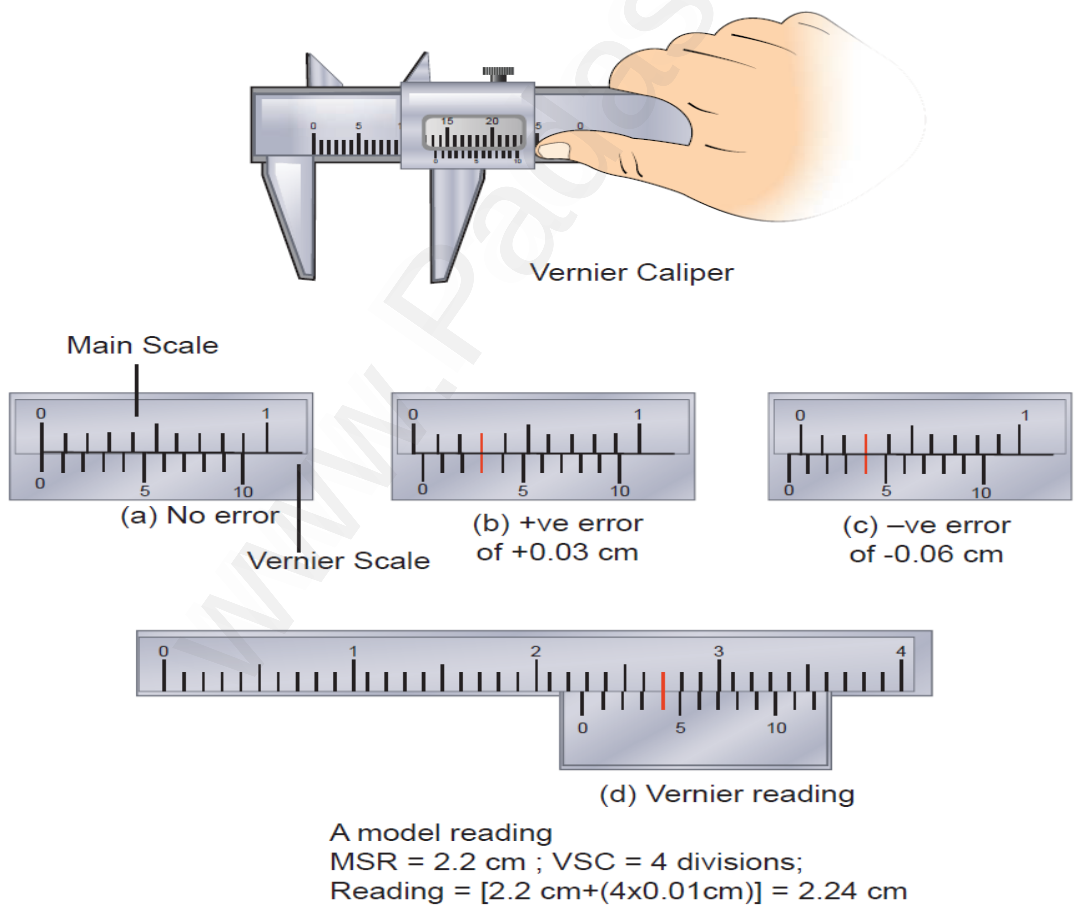
Formula:

Moment of inertia of a solid sphere about its diameter, $I_d = \frac{2}{5} MR^2$

Where M → Mass of the sphere (known value to be given) in kg

R → Radius of the sphere in metre

Diagram:



Procedure:

1. The Vernier caliper is checked for zero error and zero correction.
2. The sphere is kept in between the jaws of the Vernier caliper and the main scale reading (MSR)is noted.
3. Vernier scale division which coincides with the main scale division (VSC) is noted.
4. Multiply this VSC by Least Count(LC) gives the Vernier Scale Reding (VSR).
5. Observations are to be recorded for different positions of the sphere and the average value of the diameter is found. From this value radius of the sphere, R is calculated.
6. Using the known value of the mass of the sphere,M and calculated radius of the sphere,R the moment of inertia of the given sphere about its diameter can be calculated using the given formula.

Least Count (LC):

$$\text{Least Count, LC} = \frac{\text{1 Main Scale Division (MSD)}}{\text{Total Vernier Scale Divisions}}$$

One main scale division (MSD) = 0.1cm

Number of Vernier scale division = 10

$$LC = \frac{0.1}{10}\ \text{cm} = 0.01\text{cm}$$

Zero Error: **No Error**

Zero Correction: **No Correction**

Observation:

S.No.	MSR ($\times 10^{-2}$ m)	Vernier Scale coincidence,VSC (div)	VSR = VSC x LC ($\times 10^{-2}$ m)	TR = MSR +VSR ($\times 10^{-2}$ m)	Diameter of the sphere, 2R = TR± ZC ($\times 10^{-2}$ m)
01	1.9	10	0.10	2.0	2.0
02	1.9	10	0.10	2.0	2.0
03	1.9	10	0.10	2.0	2.0
04	1.9	10	0.10	2.0	2.0
05	1.9	10	0.10	2.0	2.0
06	1.9	10	0.10	2.0	2.0
Mean Diameter ,2R					**2.0 $\times 10^{-2}$ m**
Radius of the sphere ,R					**1.0 $\times 10^{-2}$ m**

Calculation:

1.To find the radius of the sphere

1.MSR = 1.9 x10^{-2} m VSC = 10 VSR = VSC x LC = 10 x 0.01 = 0.1 x10^{-2} m **TR = (MSR+VSR) x10^{-2} m** = (1.9+0.1) x10^{-2} m = 2.0 x10^{-2} m **2R = (TR± ZC) x10^{-2} m** = 2.0 x10^{-2} m	2.MSR = 1.9 x10^{-2} m VSC = 10 VSR = VSC x LC = 10 x 0.01 = 0.1 x10^{-2} m **TR = (MSR+VSR) x10^{-2} m** = (1.9+0.1) x10^{-2} m = 2.0 x10^{-2} m **2R = (TR± ZC) x10^{-2} m** = 2.0 x10^{-2} m	3.MSR = 1.9 x10^{-2} m VSC = 10 VSR = VSC x LC = 10 x 0.01 = 0.1 x10^{-2} m **TR = (MSR+VSR) x10^{-2} m** = (1.9+0.1) x10^{-2} m = 2.0 x10^{-2} m **2R = (TR± ZC) x10^{-2} m** = 2.0 x10^{-2} m
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$$\text{Mean Diameter, } 2R = \frac{2.0+2.0+2.0+2.0+2.0+2.0}{6} = \frac{12.0}{6} = 2.0 \text{ x } 10^{-2} \text{ m}$$

$$\text{Mean Radius, } R = \frac{2.0 \text{ x } 10^{-2}}{2} = 1.0 \text{ x } 10^{-2} \text{ m}$$

2.To find the Moment of inertia

Mass of the sphere, M = $27.75 \text{ x } 10^{-3}$ kg, Radius of the sphere, R = 1.0 x10^{-2} m

$$I_d = \frac{2}{5}MR^2 = \frac{2}{5} \text{ x } 27.75 \text{ x } 10^{-3} \text{ x } (1.0 \text{ x}10^{-2})^2$$

$$I_d = \frac{55.5}{5} \text{ x } 10^{-7} = 11.1\text{x } 10^{-7} \text{ kgm}^2$$

Result:

The moment of inertia of the given solid sphere about its diameter usingVernier caliper,

I_d = 11.1 x 10^{-7}kgm^2

Exp No:2 NON – UNIFORM BENDING – VERIFICATION OF RELATION BETWEEN LOAD AND DEPRESSION USING PIN AND MICROSCOPE

Aim:

To verify the relation between the load and depression using non-uniform bending of a beam.

Apparatus Required:

A long uniform beam (usually a metre scale), two knife – edge supports,mass hanger, slotted masses, pin, Vernier microscope.

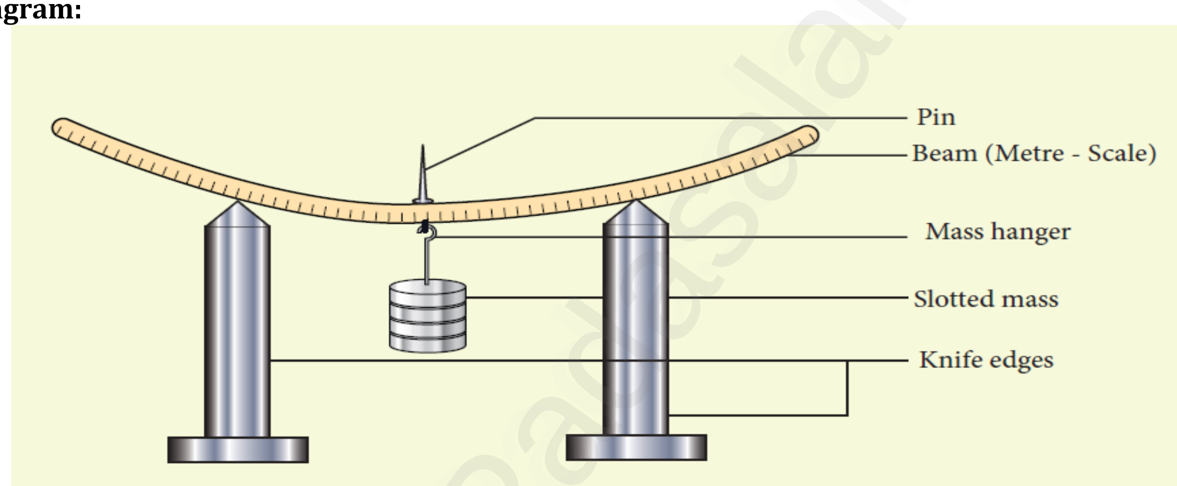
Formula:

$$\frac{M}{s} = \text{constant}$$

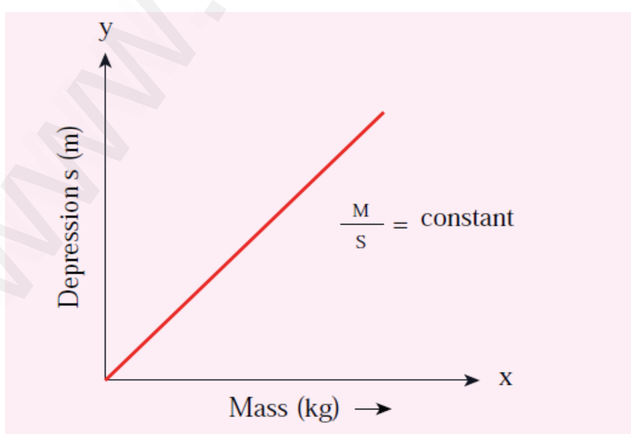
where M → Load applied (mass) (kg) ,

s → depression produced in the beam for the applied load(m)

Diagram:



Model Graph:



Relation between Mass and depression

A graph between M and s can be drawn by taking M along X- axis and s along Y – axis. This is a straight line.

Procedure :

1. Place the two knife – edges on the table and a metre scale on top of the knife edges.
2. Suspend the mass hanger at the centre. A pin is attached at the centre of the scale where the hanger is hung.
3. Place a vernier microscope in front to get a clear view of the pin.
4. Make the horizontal cross-wire on the microscope to coincide with the tip of the pin.
5. Note the vertical scale reading of the vernier microscope
6. Add the slotted masses one by one in steps of 0.05 kg (50 g) and take down the readings.
7. Then start unloading by removing masses one by one and note the readings.
8. Subtract the mean reading of each load from dead load reading. This gives the depressions for the corresponding load M. (Mass hanger is the dead load)

Observation:

To find $\frac{M}{S}$

S.No	Load,M (10^{-3} kg)	Microscope Reading (m)			Depression For M,S (10^{-2}m)	$\frac{M}{s}$ (kg m^{-1})
		Increasing Load	Decreasing Load	Mean		
1	50	9.413	9.381	9.397	-	-
2	100	9.314	9.290	9.302	0.095	52.63
3	150	9.237	9.186	9.211	0.186	53.76
4	200	9.109	9.109	9.109	0.288	52.08
5	250	9.019	9.019	9.019	0.378	52.91
Mean						52.84

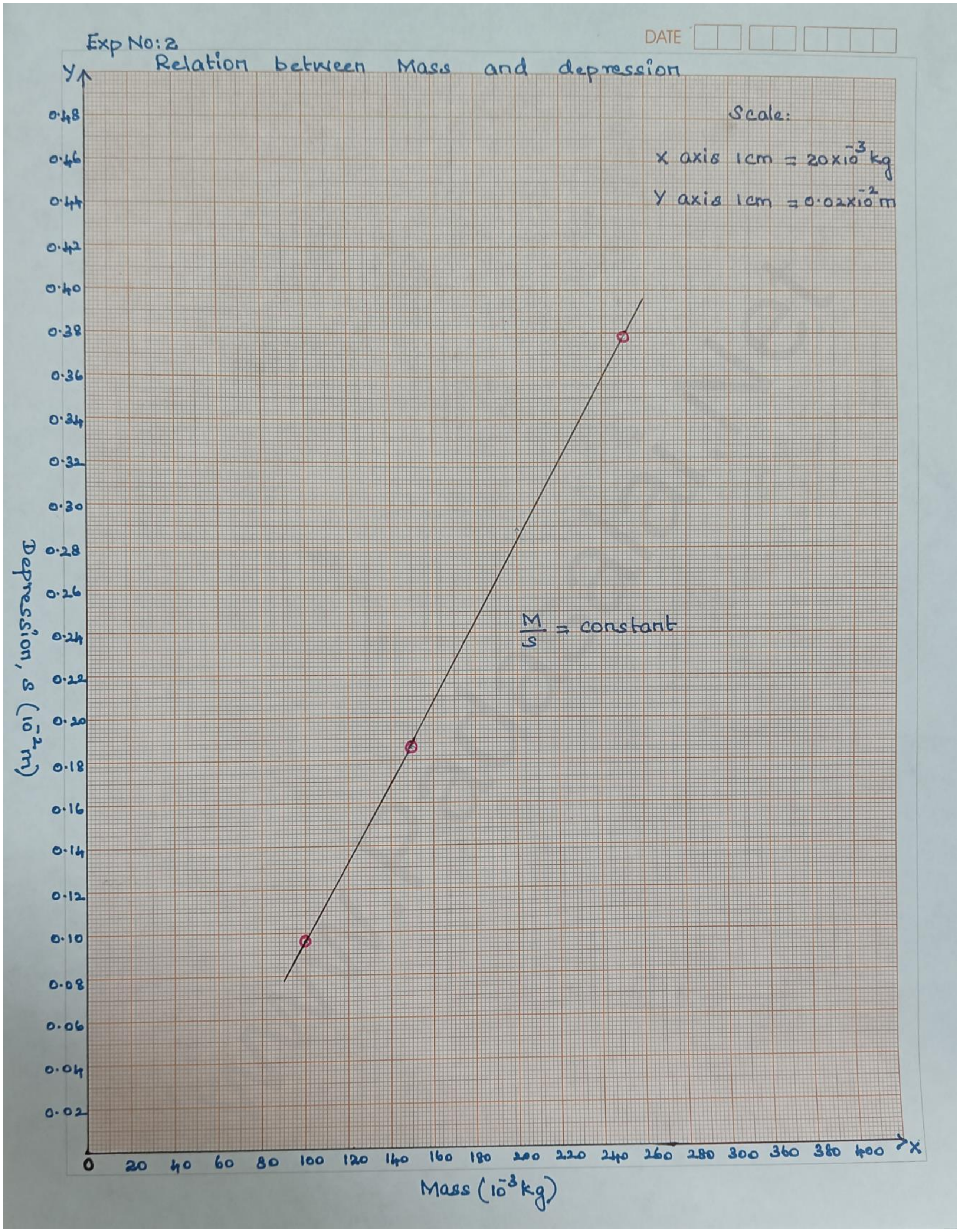
Calculation:

1. M = 50 x 10^{-3} kg s = 0.095 x 10^{-2} m $\frac{M}{s} = \frac{50 \times 10^{-3}}{0.095 \times 10^{-2}}$ = 52.63 kg m^{-1}	2. M = 100 x 10^{-3} kg s = 0.186 x 10^{-2} m $\frac{M}{s} = \frac{100 \times 10^{-3}}{0.186 \times 10^{-2}}$ = 53.76 kg m^{-1}
3. M = 150 x 10^{-3} kg s = 0.288 x 10^{-2} m $\frac{M}{s} = \frac{150 \times 10^{-3}}{0.288 \times 10^{-2}}$ = 52.08 kg m^{-1}	4. M = 200 x 10^{-3} kg s = 0.378 x 10^{-2} m $\frac{M}{s} = \frac{200 \times 10^{-3}}{0.378 \times 10^{-2}}$ = 52.91 kg m^{-1}

$$\text{Mean} = \frac{52.63 + 53.76 + 52.08 + 52.91}{4} = \frac{211.38}{4} = 52.84 \text{ kgm}^{-1}$$

Result:

- The ratio between mass and depression for each load is calculated. This is found to be constant.
- Thus the relation between load and depression is verified by the method of non-uniform bending of a beam.


Exp No: 2
Relation between Mass and depression
Scale:
X axis 1cm = 20×10⁻³ kg
Y axis 1cm = 0.02×10⁻² m
M/S = constant
Depression, S (10⁻² m)
Mass (10⁻³ kg)
DATE

Exp No: 3 **SPRING CONSTANT OF A SPRING**

Aim:

To determine the spring constant of a spring by using the method of vertical oscillations

Apparatus Required:

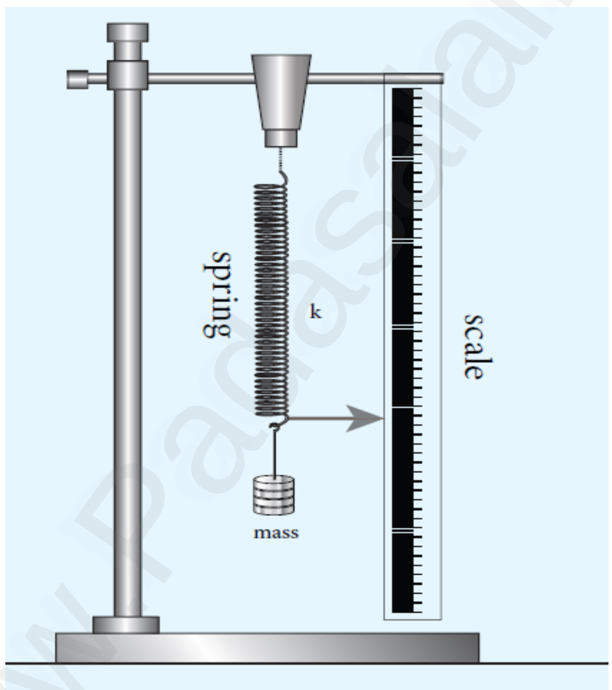
Spring, rigid support, hook, 50 g mass hanger, 50 g slotted masses, stop clock,metre scale, pointer

Formula:

Spring constant of the spring, K = $4\pi^2\left(\frac{M_2 - M_1}{T^2_2 - T^2_1}\right)$ kgs^{-2} (or) Nm^{-1}

where M_1, M_2 → Selected loads in kg

T_1, T_2 → Time period corresponding to masses M_1 and M_2 respectively in seconds



Procedure:

1. A spring is firmly suspended vertically from a rigid clamp of a wooden stand at its upper end with a mass hanger attached to its lower end. A pointer fixed at the lower end of the spring moves over a vertical scale fixed.
2. A suitable load M (eg; 100 g) is added to the mass hanger and the reading on the scale at which the pointer comes to rest is noted. This is the equilibrium position.
3. The mass in the hanger is pulled downward and released so that the spring oscillates vertically on either side of the equilibrium position.
4. When the pointer crosses the equilibrium position a stop clock is started and the time taken for 20 vertical oscillations is noted. Then the period of oscillation T is calculated.

5. The experiment is repeated by adding masses in steps of 50 g to the mass hanger and period of oscillation at each time is calculated.
6. For the masses M_1 and M_2 (with a difference of 50 g), if T_1 and T_2 are the corresponding periods, then the value $\frac{M_2 - M_1}{T^2_2 - T^2_1}$ is calculated and its average is found.
7. Using the given formula the spring constant of the given spring is calculated.

Observation:

S. No.	Load,M x 10^{-3} kg	Time Taken for 20 Oscillations			Time Period T (s)	T^2 (s^2)	$\frac{M_2 - M_1}{T^2_2 - T^2_1}$ x 10^{-3} kgs^{-2}
		Trial 1 (s)	Trial 2 (s)	Mean (s)			
01	150	16.5	16.5	16.5	0.825	0.681	-----
02	200	18.5	18.5	18.5	0.925	0.856	0.286
03	250	20.5	20.5	20.5	1.025	1.051	0.256
04	300	22.5	22.5	22.5	1.125	1.265	0.234
05	350	24.0	24.0	24.0	1.200	1.440	0.286
					Mean		0.265

Calculation:

1. $M_1 = 150 \times 10^{-3}$ kg, $M_2 = 200 \times 10^{-3}$ kg
$T_1^2 = 0.681\ s^2$, $T_2^2 = 0.856\ s^2$

$$\frac{M_2 - M_1}{T_2^2 - T_1^2} = \frac{(200 - 150)x10^{-3}}{0.856 - 0.681} = \frac{50x10^{-3}}{0.175} = 0.286\ kgs^{-2}$$

2. $M_1 = 200 \times 10^{-3}$ kg, $M_2 = 250 \times 10^{-3}$ kg
$T_1^2 = 0.856\ s^2$, $T_2^2 = 1.051\ s^2$

$$\frac{M_2 - M_1}{T_2^2 - T_1^2} = \frac{(250 - 200)x10^{-3}}{1.051 - 0.856} = \frac{50x10^{-3}}{0.195} = 0.256\ kgs^{-2}$$

3. $M_1 = 250 \times 10^{-3}$ kg, $M_2 = 300 \times 10^{-3}$ kg
$T_1^2 = 1.051\ s^2$, $T_2^2 = 1.265\ s^2$

$$\frac{M_2 - M_1}{T_2^2 - T_1^2} = \frac{(300 - 250)x10^{-3}}{1.265 - 1.051} = \frac{50x10^{-3}}{0.214} = 0.234\ kgs^{-2}$$

4. $M_1 = 300 \times 10^{-3}$ kg, $M_2 = 350 \times 10^{-3}$ kg
$T_1^2 = 1.265\ s^2$, $T_2^2 = 1.440\ s^2$

$$\frac{M_2 - M_1}{T_2^2 - T_1^2} = \frac{(350 - 300)x10^{-3}}{1.440 - 1.265} = \frac{50x10^{-3}}{0.175} = 0.286\ kgs^{-2}$$

$$\text{Mean} = \frac{0.286 + 0.256 + 0.234 + 0.286}{4} = \frac{1.062}{4} = 0.265\ kgs^{-2}$$

$$\text{Spring constant of the spring, } k = 4\pi^2\left(\frac{M_2 - M_1}{T_2^2 - T_1^2}\right) = 4\,x\,(3.14)^2\,x\,0.265$$

$$= 4\,x\,3.14\,x\,3.14\,x\,0.265 = 10.45\ kgs^{-2}\ (or)\ Nm^{-1}$$

Result:

The spring constant of the given spring **K = 10.45 Nm^{-1}**

Exp No: 4 ACCELERATION DUE TO GRAVITY USING SIMPLE PENDULUM

Aim:

To measure the acceleration due to gravity using a simple pendulum.

Apparatus Required:

Retort stand, pendulum bob, thread, metre scale, stop watch

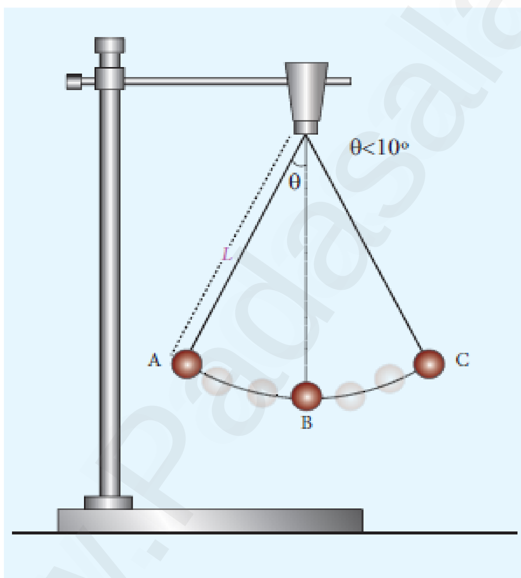
Formula:

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

where T → Time period of simple pendulum (second)

L → Length of the pendulum (metre)

Diagram



Procedure:

1. Attach a small brass bob to the thread
2. Fix this thread on to the stand.
3. Measure the length of the pendulum from top to the middle of the bob of the pendulum. Record the length of the pendulum in the table below.
4. Note the time (t) for 20 oscillations using stop watch.
5. The period of oscillation T = t/20
6. Repeat the experiment for different lengths of the pendulum 'L'. Find acceleration due to gravity g using the given formula.

Observation:

To find the acceleration due to gravity 'g'

S.No	Length of the pendulum, L (x 10^{-2} m)	Time taken for 20 oscillations, t (s)			Period of oscillations, T = t/20 (s)	T^2 (s^2)	L/T^2 (ms^{-2})
		Trial 1	Trial 2	Mean			
1	40	25	25	25	1.25	1.56	0.256
2	50	28	28	28	1.40	1.96	0.255
3	60	32	32	32	1.60	2.56	0.234
4	70	34	34	34	1.70	2.89	0.242
5	80	36	36	36	1.80	3.24	0.247
6	90	38	38	38	1.90	3.61	0.250
Mean							0.250

Calculation:

1. L = 40 x 10^{-2} m, t = 25 s

$$T = \frac{t}{20} = \frac{25}{20} = 1.25\ s$$
$$T^2 = 1.25^2 = 1.56\ s^2$$
$$\frac{L}{T^2} = \frac{40 \times 10^{-2}}{1.56} = \frac{0.4}{1.56}$$
$$= 0.256\ ms^{-2}$$

2. L = 50 x 10^{-2} m, t = 28 s

$$T = \frac{t}{20} = \frac{28}{20} = 1.40\ s$$
$$T^2 = 1.40^2 = 1.96\ s^2$$
$$\frac{L}{T^2} = \frac{50 \times 10^{-2}}{1.96} = \frac{0.5}{1.96}$$
$$= 0.255\ ms^{-2}$$

3. L = 60 x 10^{-2} m, t = 32 s

$$T = \frac{t}{20} = \frac{32}{20} = 1.60\ s$$
$$T^2 = 1.60^2 = 2.56\ s^2$$
$$\frac{L}{T^2} = \frac{60 \times 10^{-2}}{2.56} = \frac{0.6}{2.56}$$
$$= 0.234\ ms^{-2}$$

4. L = 70 x 10^{-2} m, t = 34 s

$$T = \frac{t}{20} = \frac{34}{20} = 1.70\ s$$
$$T^2 = 1.70^2 = 2.89$$
$$\frac{L}{T^2} = \frac{70 \times 10^{-2}}{2.89} = \frac{0.7}{2.89}$$
$$= 0.242\ ms^{-2}$$

5. L = 80 x 10^{-2} m, t = 36 s

$$T = \frac{t}{20} = \frac{36}{20} = 1.80\ s$$
$$T^2 = 1.80^2 = 3.24$$
$$\frac{L}{T^2} = \frac{80 \times 10^{-2}}{3.24} = \frac{0.8}{3.24}$$
$$= 0.247\ ms^{-2}$$

6. L = 90 x 10^{-2} m, t =38 s

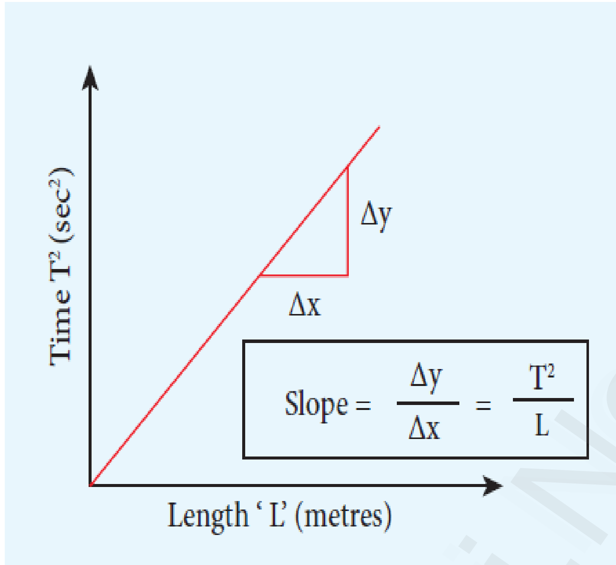
$$T = \frac{t}{20} = \frac{38}{20} = 1.90\ s$$
$$T^2 = 1.90^2 = 3.61$$
$$\frac{L}{T^2} = \frac{90 \times 10^{-2}}{3.61} = \frac{0.9}{3.61}$$
$$= 0.250\ ms^{-2}$$

$$\text{Mean} = \frac{0.256 + 0.255 + 0.234 + 0.242 + 0.247 + 0.250}{6} = \frac{1.484}{6} = 0.25\ ms^{-2}$$

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

$$= 4\pi^2 \times 0.25 = 4 \times (3.14)^2 \times 0.25$$
$$= 4 \times 9.86 \times 0.25 = 9.86\ ms^{-2}$$

Model Graph:

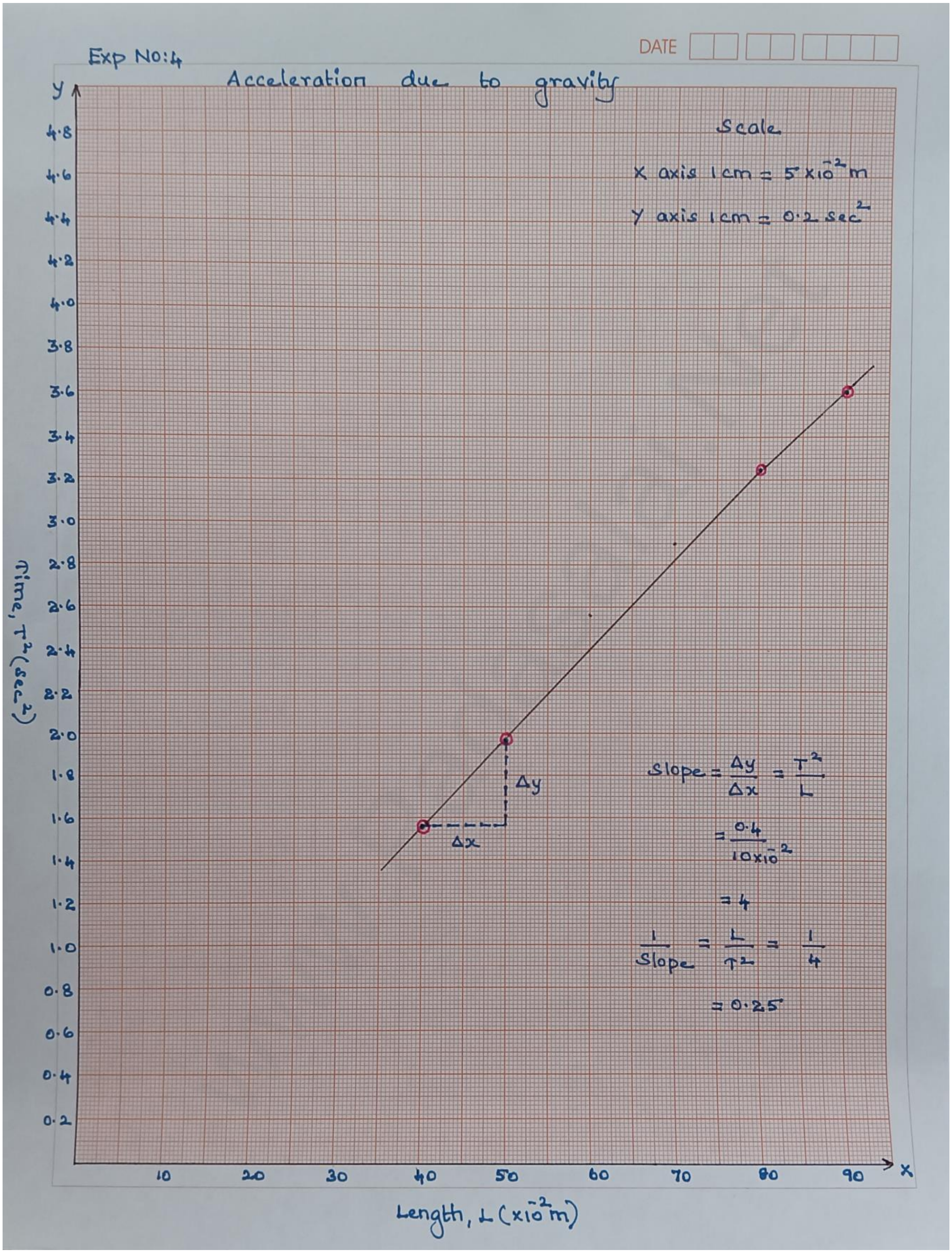


Result :

The acceleration due to gravity 'g' determined using simple pendulum is

i) By calculation, **g = 9.86ms^{-2}**

ii) By graph, **g = 9.86ms^{-2}**


Exp No:4
DATE
Acceleration due to gravity
Scale
X axis 1cm = 5x10⁻² m
Y axis 1cm = 0.2 sec²
Time, T² (sec²)
Length, L (x10⁻² m)
Δy
Δx
Slope = Δy/Δx = T²/L
= 0.4/10x10⁻²
= 4
1/Slope = L/T² = 1/4
= 0.25
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
10
20
30
40
50
60
70
80
90
x
y

Exp No: 5 VELOCITY OF SOUND IN AIR USING RESONANCE COLUMN

Aim :

To determine the velocity of sound in air at room temperature using the resonance column.

Apparatus Required:

Resonance tube, three tuning forks of known frequencies, a rubber hammer, thermometer, plumb line, set squares, water in a beaker.

Formula:

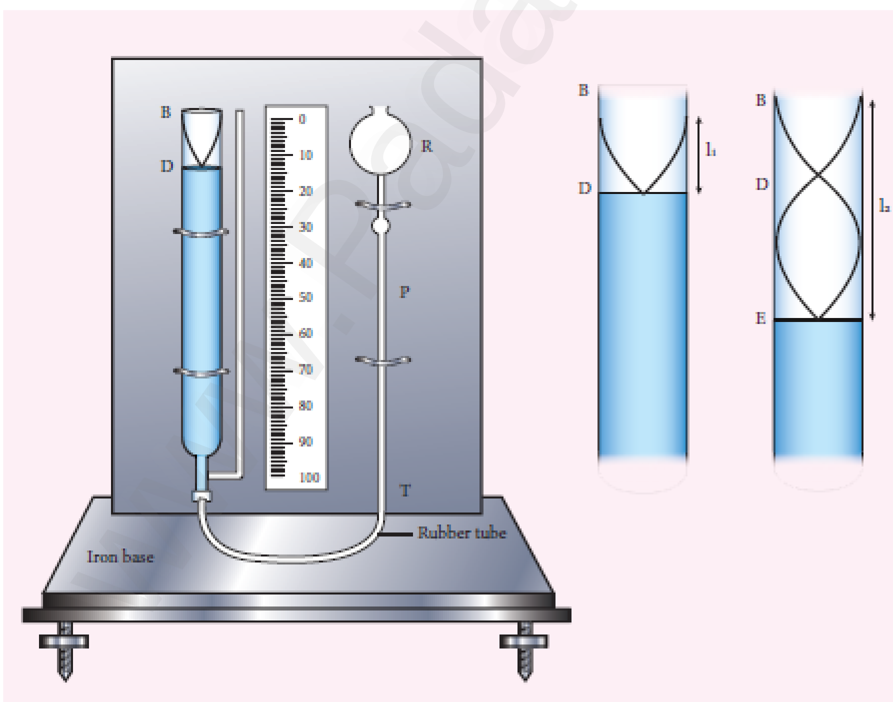
Speed of sound in air, $V = 2v(l_2 - l_1)$ m s^{-1}

where

l_1, l_2 → The length of the air column for the first and second resonance respectively (m)

v → Frequency of the tuning fork (Hz)

Diagram:



Procedure :

1. The inner tube of the resonance column is lowered so that the length of air column inside the tube is very small.
2. Take a tuning fork of known frequency and strike it with a rubber hammer. The tuning fork now produces longitudinal waves with a frequency equal to the natural frequency of the tuning fork.Place the vibrating tuning fork horizontally above the tube. Sound waves passdown the total tube and reflect back at the water surface
3. Now, raise the tube and the tuning fork until a maximum sound is heard.
4. Measure the length of air column at this position. This is taken as the first resonating length, l_1
5. Then raise the tube approximately about two times the first resonating length.Excite the tuning fork again and place it on the mouth of the tube.
6. Change the height of the tube until the maximum sound is heard.
7. Measure the length of air column at this position. This is taken as the second resonating length l_2
8. We can now calculate the velocity of sound in air at room temperature by using the relation.$V = 2v(l_2 - l_1)$
9. Repeat the experiment with forks of different frequency and calculate the velocity.
10. The mean of the calculated values will give the velocity of sound in air at room temperature.

Observations:

S.No	Frequency of tuning fork,v (Hz)	First resonating length,l_1 ($x10^{-2}m$)			Second resonating length,l_2 ($x10^{-2}m$)			$l_2 - l_1$ ($x10^{-2}m$)	V =2v ($l_2 - l_1$) ms^{-1}
		Trial 1	Trail 2	Mean	Trial 1	Trail 2	Mean		
01	512	13.2	13.2	13.2	46.0	46.0	46.0	0.328	335.9
02	480	17.3	17.3	17.3	51.6	51.6	51.6	0.343	329.3
03	426	17.6	17.6	17.6	55.6	55.6	55.6	0.38	323.8
								Mean	329.7

Calculation:

1. v = 512 Hz $l_1 = 13.2 \times 10^{-2}$m $l_2 = 46.0 \times 10^{-2}$m $l_2 - l_1 = (46.0 - 13.2) \times 10^{-2}$m $= 32.8 \times 10^{-2}$m = 0.328 $V = 2v\,(l_2 - l_1)$ = 2 x 512 x 0.328 = 335.9 ms^{-1}	2. v = 480 Hz $l_1 = 17.3 \times 10^{-2}$m $l_2 = 51.6 \times 10^{-2}$m $l_2 - l_1 = (51.6 - 17.3) \times 10^{-2}$m $= 34.3 \times 10^{-2}$m = 0.343 $V = 2v\,(l_2 - l_1)$ = 2 x 480 x 0.343 = 329.3 ms^{-1}	3. v = 426 Hz $l_1 = 17.6 \times 10^{-2}$m $l_2 = 55.6 \times 10^{-2}$m $l_2 - l_1 = (55.6 - 17.6) \times 10^{-2}$m $= 38 \times 10^{-2}$m = 0.38 $V = 2v\,(l_2 - l_1)$ = 2 x 426 x 0.38 = 323.8 ms^{-1}
$\text{Mean} = \frac{335.9 + 329.3 + 323.8}{3} = \frac{989}{3} = 329.7\ \text{ms}^{-1}$		

Result:

Velocity of sound in air at room temperature, v = **329.7 m s^{-1}**

Exp No:6 **VISCOSITY OF A LIQUID BY STOKE'S METHOD**

Aim:

To determine the co-efficient of viscosity of the given liquid by stoke's method

Apparatus Required:

A long cylindrical glass jar, highly viscous liquid, metre scale, spherical ball, stopclock, thread.

Formula:

Coefficient of viscosity of liquid, $\eta = \frac{2r^2(\delta - \sigma)g}{9v}$ Nsm^{-2}

where r is the radius of the spherical ball(m)

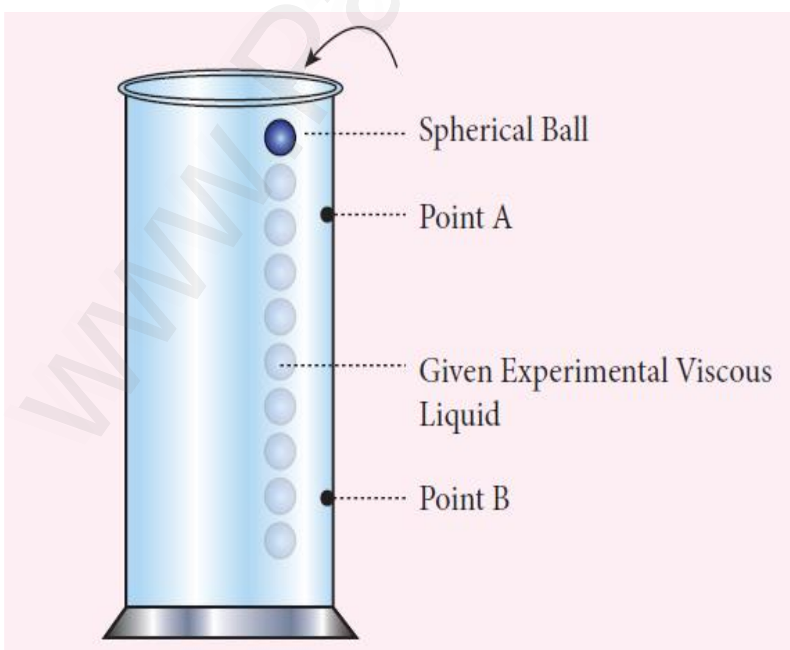
δ is the density of the steel sphere(kgm^{-3})

σ is the density of the liquid(kgm^{-3})

g is the acceleration due to gravity($9.8\ ms^{-2}$)

v is the mean terminal velocity (ms^{-1})

Diagram:



Procedure:

1. A long cylindrical glass jar with markings is taken.
2. Fill the glass jar with the given experimental liquid.
3. Two points A and B are marked on the jar. The mark A is made well below the surface of the liquid so that when the ball reaches A it would have acquired terminalvelocity V.
4. The radius of the metal spherical ball is determined using screw gauge.
5. The spherical ball is dropped gently into the liquid.
6. Start the stop clock when the ball crosses the point A. Stop the clock when the ball reaches B.
7. Note the distance between A and B and use it to calculate terminal velocity.
8. Now repeat the experiment for different distances between A and B. Make sure thatthe point A is below the terminal stage.

Observations:

Distance covered by the spherical ball,**d = 0.5 m**

Radius of spherical ball, **r = 1.90x10^{-3}m**

1)To find the terminal velocity:

S. No.	Distance coveredby the spherical ball, d(m)	Time taken,t (s)	Terminal velocity, (v= d/t) ms^{-1}
01	0. 5	7.2	0.06944
02	0. 5	7.3	0.06849
03	0.5	7.0	0.07143
04	0.5	6.8	0.07353
05	0.5	6.7	0.07463
06	0.5	7.0	0.07143
Mean			0.0715

Calculation:

1.d = 0.5 m, t = 7.2 s $V = \frac{d}{t} = \frac{0.5}{7.2} = 0.06944\ ms^{-1}$	2.d = 0.5 m, t = 7.3 s $V = \frac{d}{t} = \frac{0.5}{7.3} = 0.06849\ ms^{-1}$	3.d = 0.5 m, t = 7.0 s $V = \frac{d}{t} = \frac{0.5}{7.0} = 0.07143\ ms^{-1}$
4.d = 0.5 m, t = 6.8 s $V = \frac{d}{t} = \frac{0.5}{6.8} = 0.07353\ ms^{-1}$	5.d = 0.5 m, t = 6.7 s $V = \frac{d}{t} = \frac{0.5}{6.7} = 0.07463\ ms^{-1}$	6.d = 0.5 m, t = 7.0 s $V = \frac{d}{t} = \frac{0.5}{7.0} = 0.07143\ ms^{-1}$

$$\text{Mean} = \frac{0.06944 + 0.06849 + 0.07143 + 0.07353 + 0.07463 + 0.07143}{6} = \frac{0.42895}{6} = 0.0715\ ms^{-1}$$

2)To find Coefficient of viscosity of liquid:

$$\eta = \frac{2r^2(\delta - \sigma)g}{9v} \text{ Nsm}^{-2}$$

$$\eta = \frac{2 \text{ x } (1.9 \text{ x } 10^{-3})^2 \text{ x } (7860 - 961) \text{ x } 9.8}{9 \text{ x } 0.0715}$$

$$= \frac{0.4881}{0.6435}$$

$$= 0.759 \text{ Nsm}^{-2}$$

Result:

The coefficient of viscosity of the given liquid by stoke's method, η= **0.759 N s m^{-2}**

Exp No.7 SURFACE TENSION OF A LIQUID BY CAPILLARY RISE METHOD

Aim:

To determine the surface tension of a liquid by capillary rise method.

Apparatus Required:

A beaker of Water, capillary tube, vernier microscope, two holed rubber stopper, a knitting needle, a short rubber tubing and retort clamp.

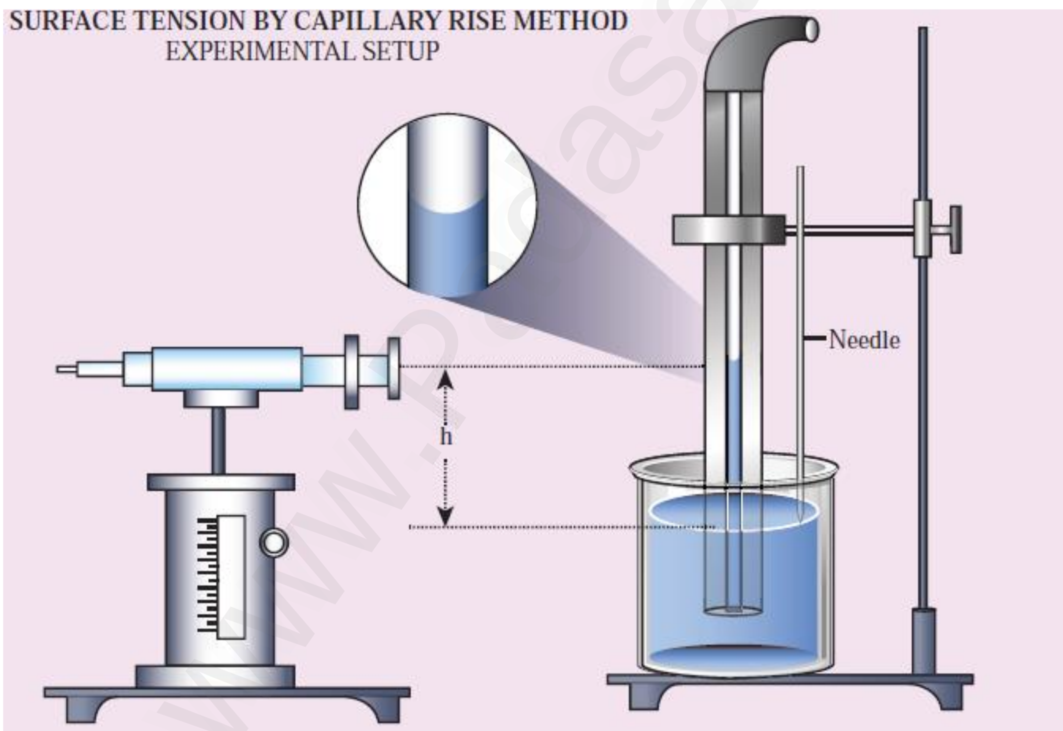
Formula:

$$\text{Surface tension of the liquid, } T = \frac{hr\sigma g}{2}\ Nm^{-1}$$

$h \rightarrow$ height of the liquid in the capillary tube (m)
$r \rightarrow$ radius of the capillary tube (m)

$\sigma \rightarrow$ Density of water ($kg\ m^{-3}$) ($\sigma = 1000\ kg\ m^{-3}$)

$g \rightarrow$ Acceleration due to gravity ($g = 9.8\ m\ s^{-2}$)



Procedure:

1. A clean and dry capillary tube is taken and fixed in a stand.
2. A beaker containing water is placed and the capillarytube is dipped inside the beaker so that a little amount of water is raised inside.
3. Fix a needle near the capillary tube so that the needle touches the water surface.
4. A Vernier microscope is focused at the water meniscus level and the corresponding reading is taken after making the cross wire coincidence.

5. Vernier microscope is focused to the tip of the needle and its reading is noted.
6. The difference between the two readings of the vertical scale gives the height (h) of the liquid raised in the tube.
7. Now to find the radius of the tube, lower the height of the support bas e and remove the beaker, rotate the capillary tube so that the immersed lower end face towards you.
8. Focus the tube using Vernier microscope to clearly see the inner walls of the tube.
9. Let the vertical cross wire coincide with the left side inner walls of the tube. Notedown the reading (L_1).
10. Turn the microscope screws in horizontal direction to view the right side inner wall of the tube. Note the reading (R_1). Thus the radius of the tube can be calculated as $r = \frac{1}{2}(l_1 - R_1)$
11. Finally calculate the surface tension using the given formula.

Observations:

i)To measure height of the liquid (h):

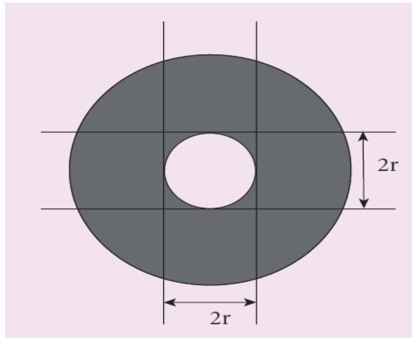
Least count of vernier microscope, L.C = 0.001 cm

S.No.	Microscope Reading								Height of the liquid,h (cm)
	For the position of lower meniscus of liquid				For the position of lower tip of the needle				
	MSR (cm)	VC (Div)	VSR= VCxLC (cm)	TR =MSR +VSR (a) cm	MSR (cm)	VC (Div)	VSR= VCxLC (cm)	TR = MSR +VSR (b) cm	
01	5.15	39	0.039	5.189	4.05	16	0.016	4.066	1.123
02	5.30	26	0.026	5.326	4.15	5	0.005	4.155	1.171
03	5.65	4	0.004	5.654	4.50	49	0.049	4.549	1.105
								Mean	**1.133**

Calculation:

1.	2.	3.
MSR = 5.15 cm VSR = 0.039 cm TR =MSR +VSR TR, a =5.15 +0.039 = 5.189 cm MSR =4.05 cm VSR = 0.016 cm TR =MSR +VSR TR, b =4.05 +0.016 = 4.066 cm h = a – b = 5.189 -4.066 = 1.123cm	MSR = 5.30 cm VSR = 0.026 cm TR =MSR +VSR TR, a =5.30 +0.026 = 5.326 cm MSR = 4.15 cm VSR = 0.005 cm TR =MSR +VSR TR, b =4.15+0.005 = 4.155 cm h = a – b = 5.326 -4.155 = 1.171cm	MSR = 5.65 cm VSR = 0.004 cm TR =MSR +VSR TR, a =5.65 +0.004 = 5.654 cm MSR = 4.50 cm VSR = 0.049 cm TR =MSR +VSR TR, b =4.50 +0.049 = 4.549 cm h = a – b = 5.654 -4.549 = 1.105cm

$$\text{Mean} = \frac{1.123 + 1.171 + 1.105}{3} = \frac{3.399}{3} = 1.133 \text{ cm}$$



RADIUS OF THE CAPILLARY TUBE

ii)To find Radius of the capillary tube(r):

S.No	Microscope Reading								Radius ofthe capillary tube, $r = \frac{1}{2}(l_1 - R_1)$ cm
	For the position of inner leftwallof the tube, l_1				For the position of inner rightwall of the tube, R_1				
	MSR (cm)	VC (Div.)	VSR= VCxLC (cm)	TR = MSR + VSR (a) cm	MSR (cm)	VC (Div.)	VSR= VCxLC (cm)	TR = MSR+VSR (b) cm	
1	4.50	6	0.006	4.506	4.25	30	0.03	4.280	0.1130
2	10.30	4	0.004	10.304	10.05	15	0.015	10.065	0.1195
								Mean	0.11625

Calculation:

1. l_1 = 4.506 cm, R1 = 4.280 cm

$$r = \frac{1}{2}(l_1 - R_1)$$
$$= \frac{1}{2}(4.506 - 4.280) = \frac{1}{2}(0.226) = 0.113 \text{ cm}$$

2. l_1 = 10.304 cm, R1 = 10.065 cm

$$r = \frac{1}{2}(l_1 - R_1)$$
$$= \frac{1}{2}(10.304 - 10.065) = \frac{1}{2}(0.239) = 0.1195 \text{ cm}$$

$$\text{Mean} = \frac{0.1130 + 0.1195}{2} = \frac{0.2325}{2} = 0.11625 \text{ cm}$$

iii)To find surface tension of the liquid(r):

Radius of the capillary tube, r = 0.11625×10^{-2}m

Density of the liquid, σ = 1000 kg m^{-3}

Acceleration due to gravity, g = 9.8 m s^{-2}

$$\text{Surface tension of the liquid, } T = \frac{hr\sigma g}{2} \text{ Nm}^{-1}$$
$$= \frac{1.133 \times 10^{-2} \times 0.11625 \times 10^{-2} \times 1000 \times 9.8}{2}$$
$$= \frac{0.1290}{2} = 0.0645 \text{ Nm}^{-1}$$
$$= 64.5 \times 10^{-3} \text{ Nm}^{-1}$$

Result:

Surface tension of the given liquid by capillary rise method, T = **64.5×10^{-3} Nm^{-1}**

Exp No: 8 NEWTON'S LAW OF COOLING USING CALORIMETER

Aim:

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

Apparatus Required:

Copper calorimeter with stirrer, one holed rubber cork, thermometer, stop clock, heater / burner, water, clamp and stand

Newton's Law of Cooling:

Newton's law of cooling states that the rate of change of the temperature of anobject is proportional to the difference between its own temperature and the ambient temperature. (i.e., the temperature of its surroundings)

Formula:

$$\frac{dT}{dt} \alpha (T - T_0)$$

where

$\frac{dT}{dt}$ → Rate of change of temperature (°C)

T → Temperature of water (°C)

T_0 → Room Temperature (°C)

Diagram

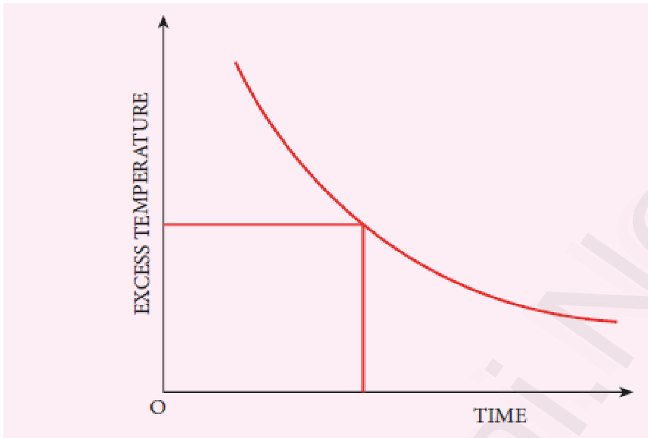
EXPERIMENTAL SETUP OF NEWTON'S LAW OF COOLING

Procedure

1. Note the room temperature as (T_0) using the thermometer.
2. Hot water about 90°C is poured into the calorimeter.
3. Close the calorimeter with one holed rubber cork
4. Insert the thermometer into calorimeter through the hole in rubber cork
5. Start the stop clock and observe the time for every one degree fall of temperature from 80°C
6. Take sufficient amount of reading, say closer to room temperature.

7. The observations are tabulated.
8. Draw a graph by taking time along the x axis and excess temperature along y axis.

Model Graph:



RELATION BETWEEN TIME AND TEMPERATURE

Room temperature, T_0 = 30 °C

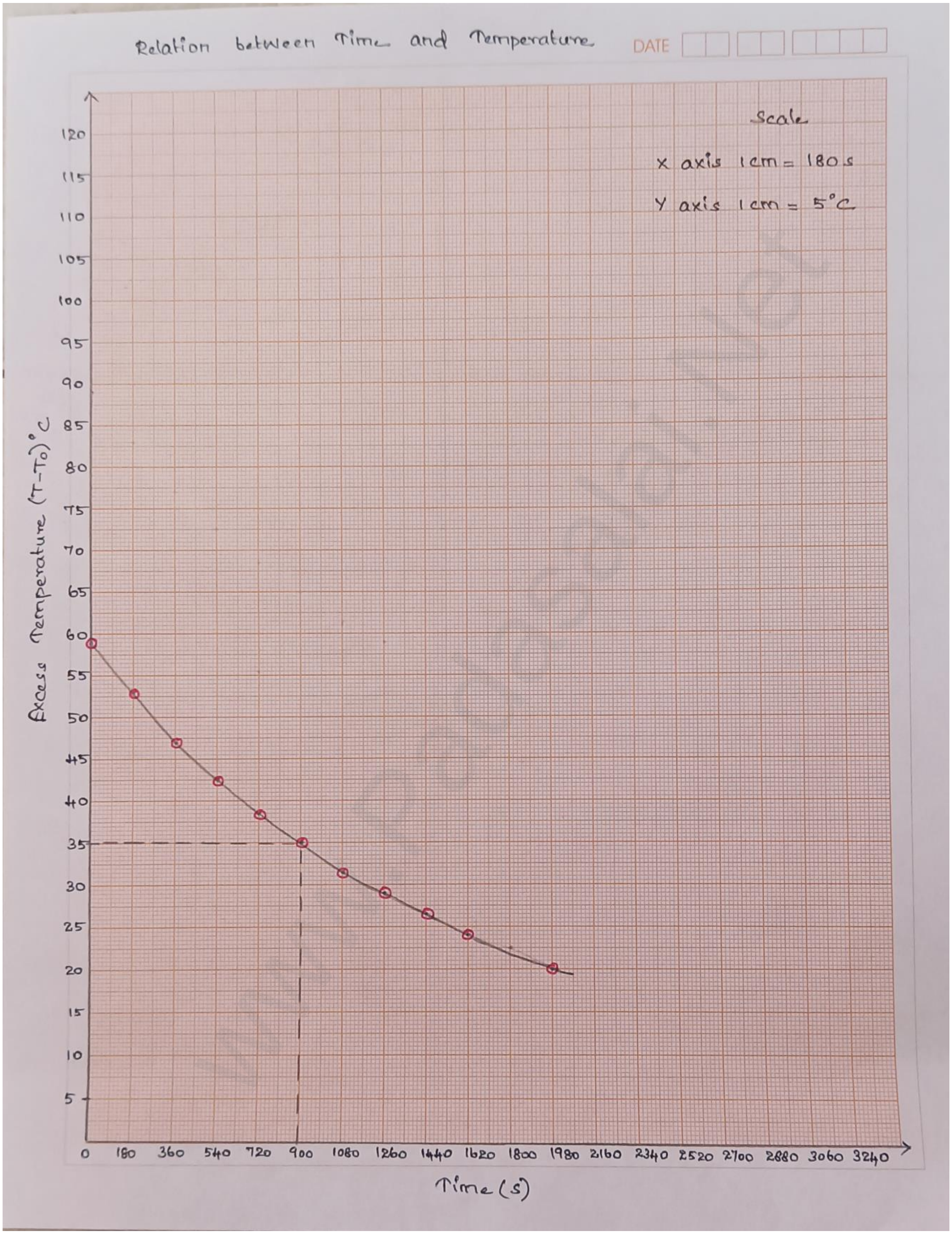
Observations:

Measuring the change in temperature of water with time

Time (s)	Temperature of water (T) °C	Excess temperature $(T - T_0)$ °C
0	89	59
180	83	53
360	77	47
540	72.5	42.5
720	68.5	38.5
900	65	35
1080	61.5	31.5
1260	59	29
1440	56.5	26.5
1620	54	24
1800	52.5	22.5
1980	50	20

Result:

The cooling curve is plotted and thus Newton's law of cooling is verified.


Relation between Time and Temperature
DATE
Scale
X axis 1cm = 180 s
Y axis 1cm = 5°C
Excess Temperature (T-T0)°C
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
180
360
540
720
900
1080
1260
1440
1620
1800
1980
2160
2340
2520
2700
2880
3060
3240
Time (s)

Exp No:9 STUDY OF RELATION BETWEEN FREQUENCY AND LENGTH OF A GIVEN WIRE UNDER CONSTANT TENSION USING SONOMETER

Aim:

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

Apparatus Required:

Sonometer, six tuning forks of known frequencies, Metre scale, rubber pad, paper rider, hanger with half – kilogram masses, wooden bridges

Formula:

The frequency n of the fundamental mode of vibration of a string is given by

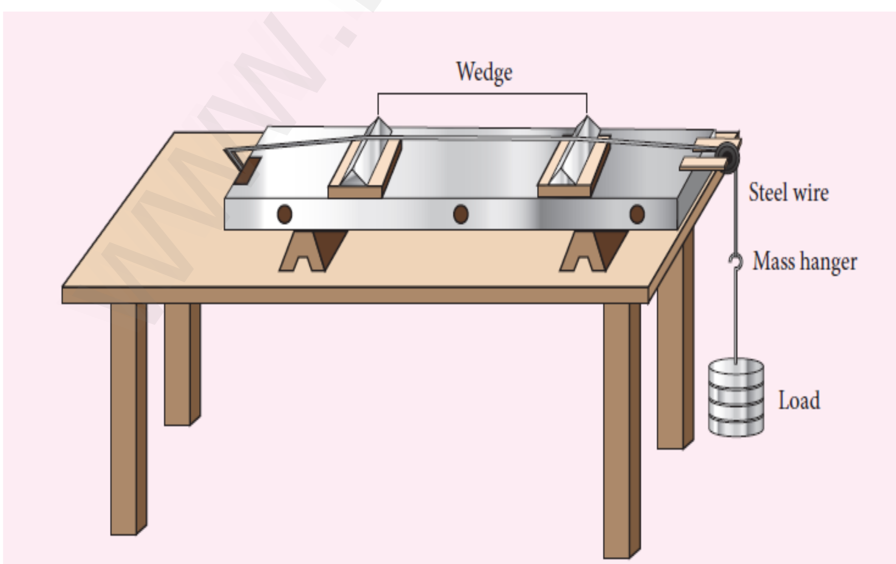
$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}\ \text{Hz}$$

For a given m and fixed T,

$$n \propto \frac{1}{l} \text{ (or) } nl = \text{constant}$$

where n → Frequency of the fundamental mode of vibration of the string (Hz)
m → Mass per unit length of the string ($kg\ m^{-1}$)
l → Length of the string between the wedges (m)
T → Tension in the string (including the mass of the hanger) = Mg (N)
M → Mass suspended, including the mass of the hanger (Kg)

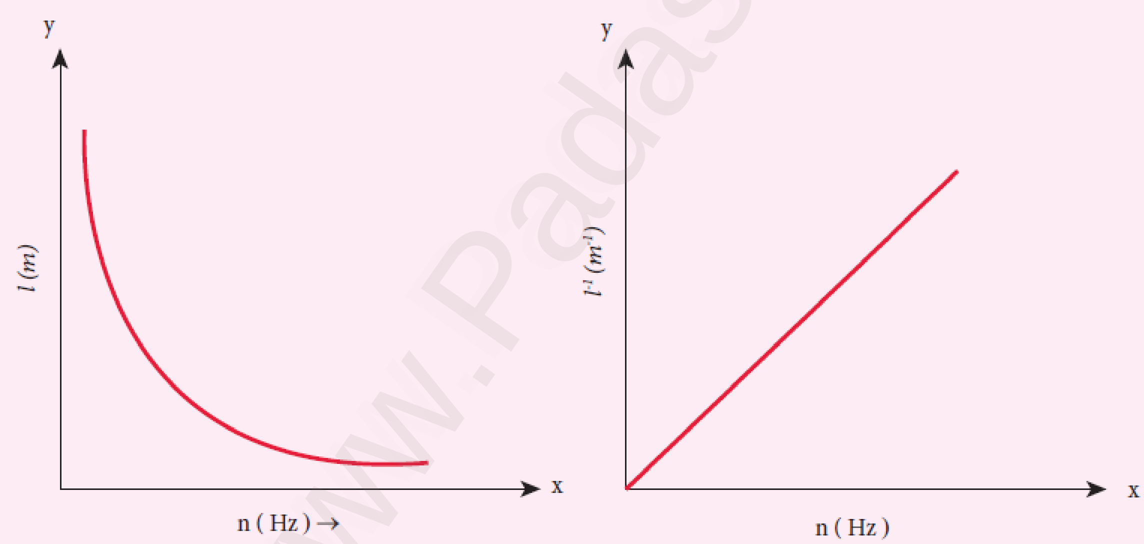
Diagram



Procedure:

1. Set up the sonometer on the table and clean the groove on the pulley to ensure minimum friction
2. Stretch the wire by placing suitable mass in the hanger
3. Set the tuning fork into vibrations by striking it against the rubber pad. Plug the sonometer wire and compare the two sounds.
4. Adjust the vibrating length of the wire by sliding the bridge B till the sounds appear alike.
5. For the final adjustment, place a small paper rider R in the middle of the wire AB.
6. Sound the tuning fork and place its shank stem on the bridge A or on the sonometer box and slowly adjust the position of bridge B until the paper rider is agitated violently indicating resonance.
7. The length of the wire between the wedges A and B is measured using meterscale. It is the resonant length. Now the frequency of vibration of the fundamental mode equals the frequency of the tuning fork.
8. Repeat the above procedure for other tuning forks by keeping the same load in the hanger.

Model Graph



Graph 1: Relation between frequency and length

Graph 2: Relation between frequency and inverse of length

Observations:

Variation of frequency with length			
Frequency of the tuning fork, n (Hz)	**Resonant length, l (x 10^{-2}m)**	$\frac{1}{l}$ (m^{-1})	**nl (Hz m)**
n_1 = 288	32.5	3.07	93.60
n_2 = 320	30.1	3.32	96.32
n_3 = 341	27.6	3.62	94.12
n_4 = 480	19.5	5.13	93.40
		Mean	94.36

Calculation:

1. n = 288 Hz, l = 32.5 x 10^{-2}m

   nl = 288 x 32.5 x 10^{-2}

   = 93.60 Hzm

   $$\frac{1}{l} = \frac{1}{32.5 \text{ x } 10^{-2}} = 3.07 \text{ m}^{-1}$$

2. n = 320 Hz, l = 30.1 x 10^{-2}m

   nl = 320 x 30.1 x 10^{-2}

   = 96.32 Hzm

   $$\frac{1}{l} = \frac{1}{30.1 \text{ x } 10^{-2}} = 3.32 \text{ m}^{-1}$$

3. n = 341 Hz, l = 27.6 x 10^{-2}m

   nl = 341 x 27.6 x 10^{-2}

   = 94.12 Hzm

   $$\frac{1}{l} = \frac{1}{27.6 \text{ x } 10^{-2}} = 3.62 \text{ m}^{-1}$$

4. n = 480 Hz, l = 19.5 x 10^{-2}m

   nl = 480 x 19.5 x 10^{-2}

   = 93.40 Hzm

   $$\frac{1}{l} = \frac{1}{19.5 \text{ x } 10^{-2}} = 5.13 \text{ m}^{-1}$$

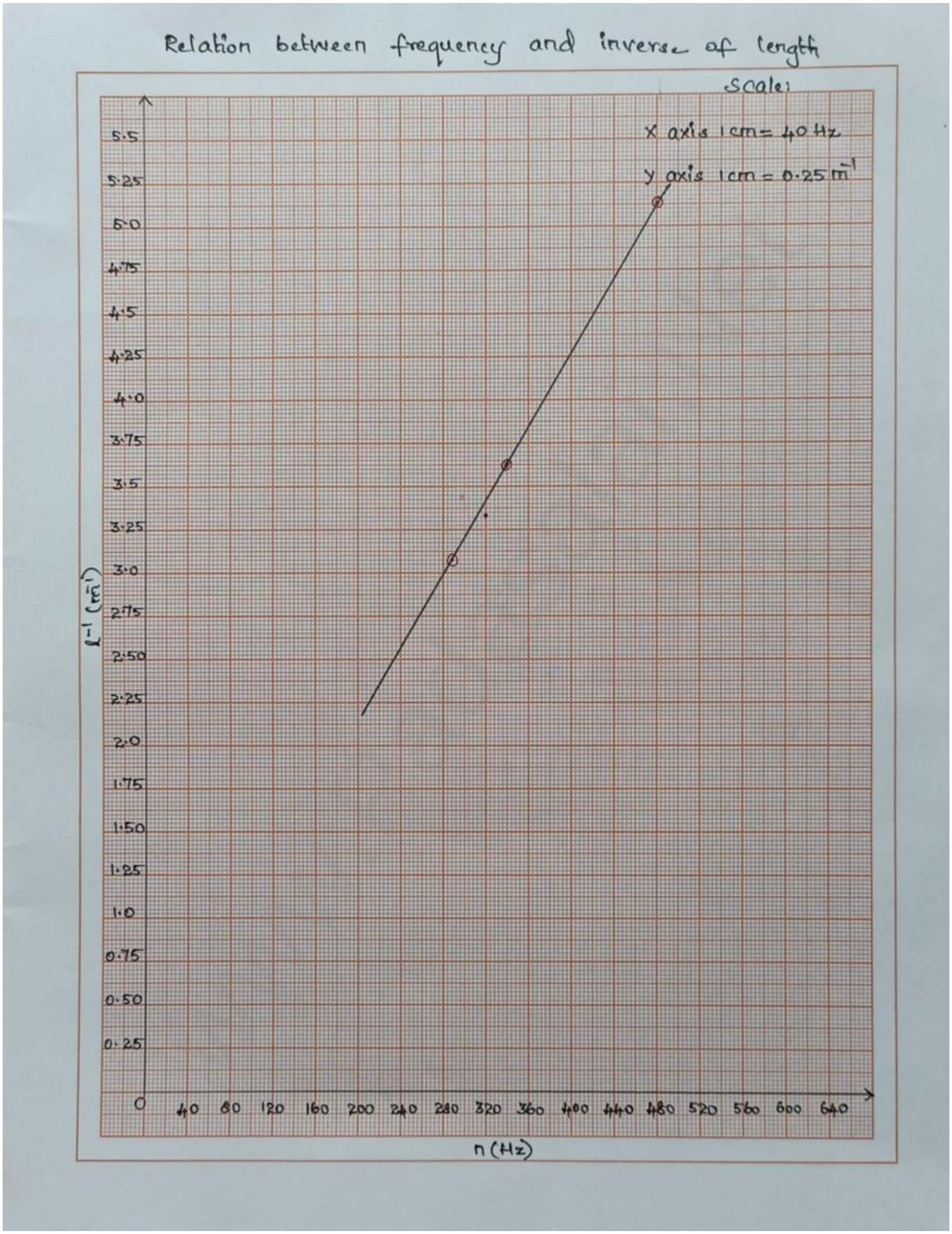
$$\text{Mean} = \frac{93.60 + 96.32 + 94.12 + 93.40}{4} = \frac{377.44}{4} = 94.36 \text{ Hzm}$$

Result:

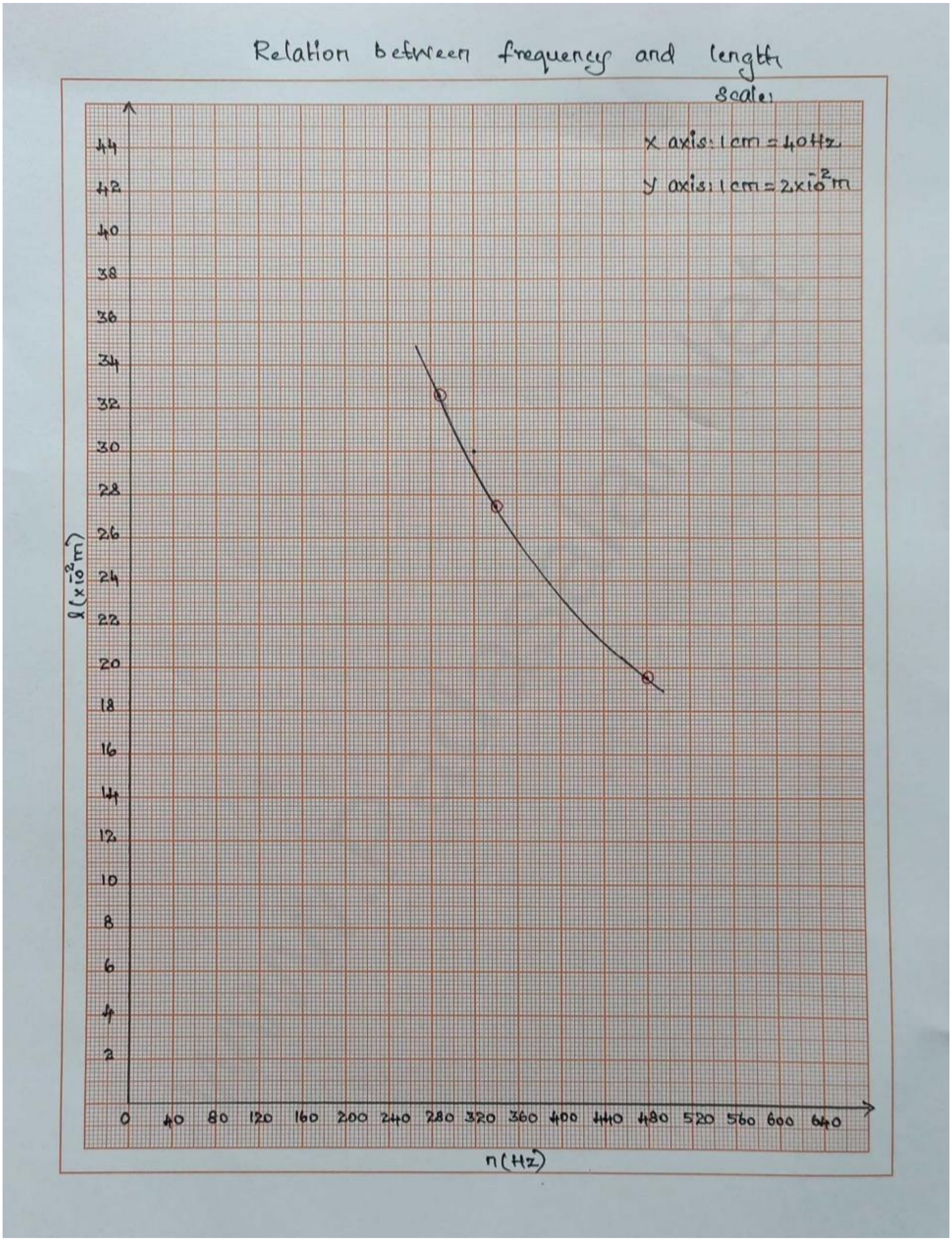
For a given tension, the resonant length of a given stretched string varies as reciprocal of the frequency

$$n \ \alpha \ \frac{1}{l} \text{ (or) } nl = \text{constant}$$

The product *nl* is a constant and found to be ***94.36*** (Hz m)



Relation between frequency and inverse of length
Scale:
X axis 1cm = 40 Hz
y axis 1cm = 0.25 m⁻¹
l^{-1} (m^{-1})
n (Hz)
0
40 80 120 160 200 240 280 320 360 400 440 480 520 560 600 640
0.25 0.50 0.75 1.0 1.25 1.50 1.75 2.0 2.25 2.50 2.75 3.0 3.25 3.5 3.75 4.0 4.25 4.5 4.75 5.0 5.25 5.5


Relation between frequency and length
Scale:
x axis: 1cm = 40Hz
y axis: 1cm = 2x10^-2 m
l (x10^-2 m)
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
640
n(Hz)

Exp No:10 STUDY OF RELATION BETWEEN LENGTH OF THE GIVEN WIRE AND TENSION FOR A CONSTANT FREQUENCY USING SONOMETER

Aim:

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

Apparatus Required:

Sonometer, tuning forks of known frequencies, Metre scale, rubber pad, paper rider, hanger with half – kilogram masses, wooden bridges

Formula:

The frequency n of the fundamental mode of vibration of a string is given by

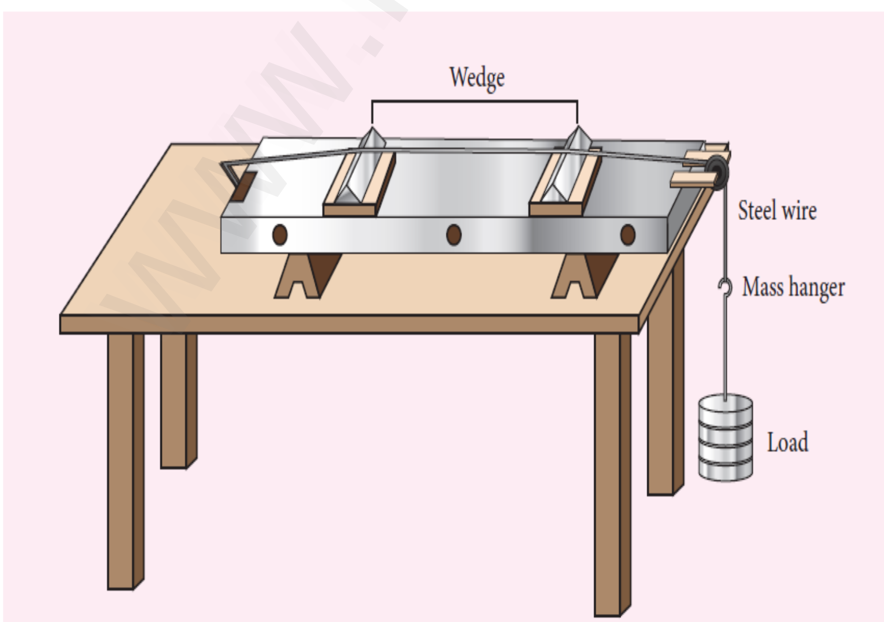
$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \text{ Hz}$$

If n is a constant, for a given wire (m is constant)

$$\frac{\sqrt{T}}{l} = \text{constant}$$

where n → Frequency of the fundamental mode of vibration of the string (Hz)
m → Mass per unit length of the string ($kg\ m^{-1}$)
l → Length of the string between the wedges (m)
T → Tension in the string (including the mass of the hanger) = Mg (N)
M → Mass suspended, including the mass of the hanger (Kg)

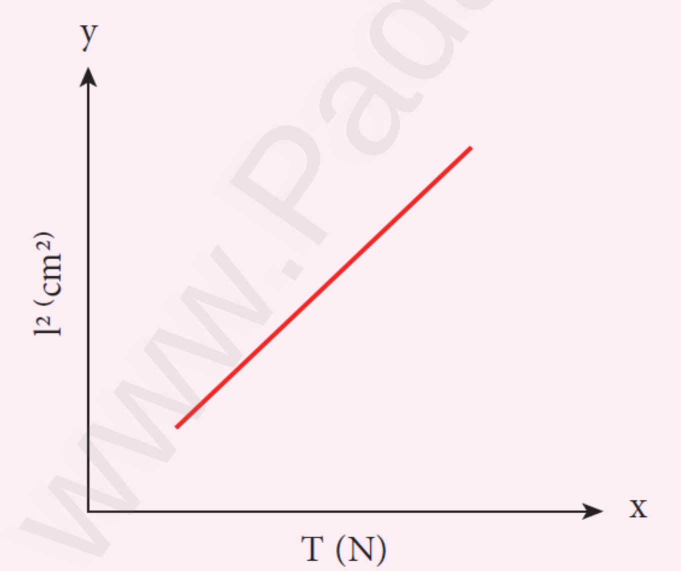
Diagram



Procedure:

1. Set up the sonometer on the table and clean the groove on the pulley to ensure that it has minimum friction.
2. Set a tuning fork of known frequency into vibration by striking it against the rubber pad. Plug the sonometer wire and compare the sound due to the vibration of tuning fork and the plugged wire.
3. Adjust the vibrating length of the wire by the adjusting the bridge B till the two sounds appear alike.
4. Place a mass of 1 kg for initial reading in the load hanger.
5. For final adjustment place a small paper rider R in the middle of the wire AB.
6. Now, strike the tuning fork and place its shank stem on the bridge A and then slowly adjust the position of the bridge B till the paper rider is agitated violently indicating resonance.
7. Measure the length of the wire between wedges at A and B which is the fundamental mode corresponding to the frequency of the tuning fork.
8. Increase the load on the hanger in steps of 0.5 kg and each time find the resonating length as done before with the same tuning fork.
9. Record the observations in the tabular column.

Model Graph:



Relation between tension T (N) and length l^2 (cm^2)

Observations:

Frequency of tuning fork = 320 Hz

Variation of resonant length with tension						
S.No	Mass, M (kg)	Tension, T = Mg(N)	$\sqrt{T}$	Vibrating length, l ($\times 10^{-2}$ m)	l^2 ($\times 10^{-4}$ m^2)	$\frac{\sqrt{T}}{l}$
1	2.0	19.6	4.43	27.5	756.25	16.11
2	2.5	24.5	4.95	30.1	906.01	16.44
3	3.0	29.4	5.42	32.6	1062.76	16.63
4	3.5	34.3	5.86	35.3	1246.09	16.60
					Mean	16.45

Calculation:

1. M = 2.0 kg, g = 9.8 ms^{-2}

   T = Mg = 2 x 9.8 = 19.6 N

   $\sqrt{T} = \sqrt{19.6} = 4.43$

   l = 27.5 x 10^{-2} m

   l^2 = 756.25 x10^{-4} m^2

   $\frac{\sqrt{T}}{l} = \frac{4.43}{27.5 \times 10^{-2}} = 16.11$

2. M = 2.5 kg, g = 9.8 ms^{-2}

   T = Mg = 2.5 x 9.8 = 24.5 N

   $\sqrt{T} = \sqrt{24.5} = 4.95$

   l = 30.1 x 10^{-2} m

   l^2 = 906.01 x10^{-4} m^2

   $\frac{\sqrt{T}}{l} = \frac{4.95}{30.1 \times 10^{-2}} = 16.44$

3. M = 3.0 kg, g = 9.8 ms^{-2}

   T = Mg = 3 x 9.8 = 29.4 N

   $\sqrt{T} = \sqrt{29.4} = 5.42$

   l = 32.6 x 10^{-2} m

   l^2 = 1062.76 x10^{-4} m^2

   $\frac{\sqrt{T}}{l} = \frac{5.42}{32.6 \times 10^{-2}} = 16.63$

4. M = 3.5 kg, g = 9.8 ms^{-2}

   T = Mg = 3.5 x 9.8 = 34.3 N

   $\sqrt{T} = \sqrt{34.3} = 5.86$

   l = 35.3 x 10^{-2} m

   l^2 = 1246.09 x10^{-4} m^2

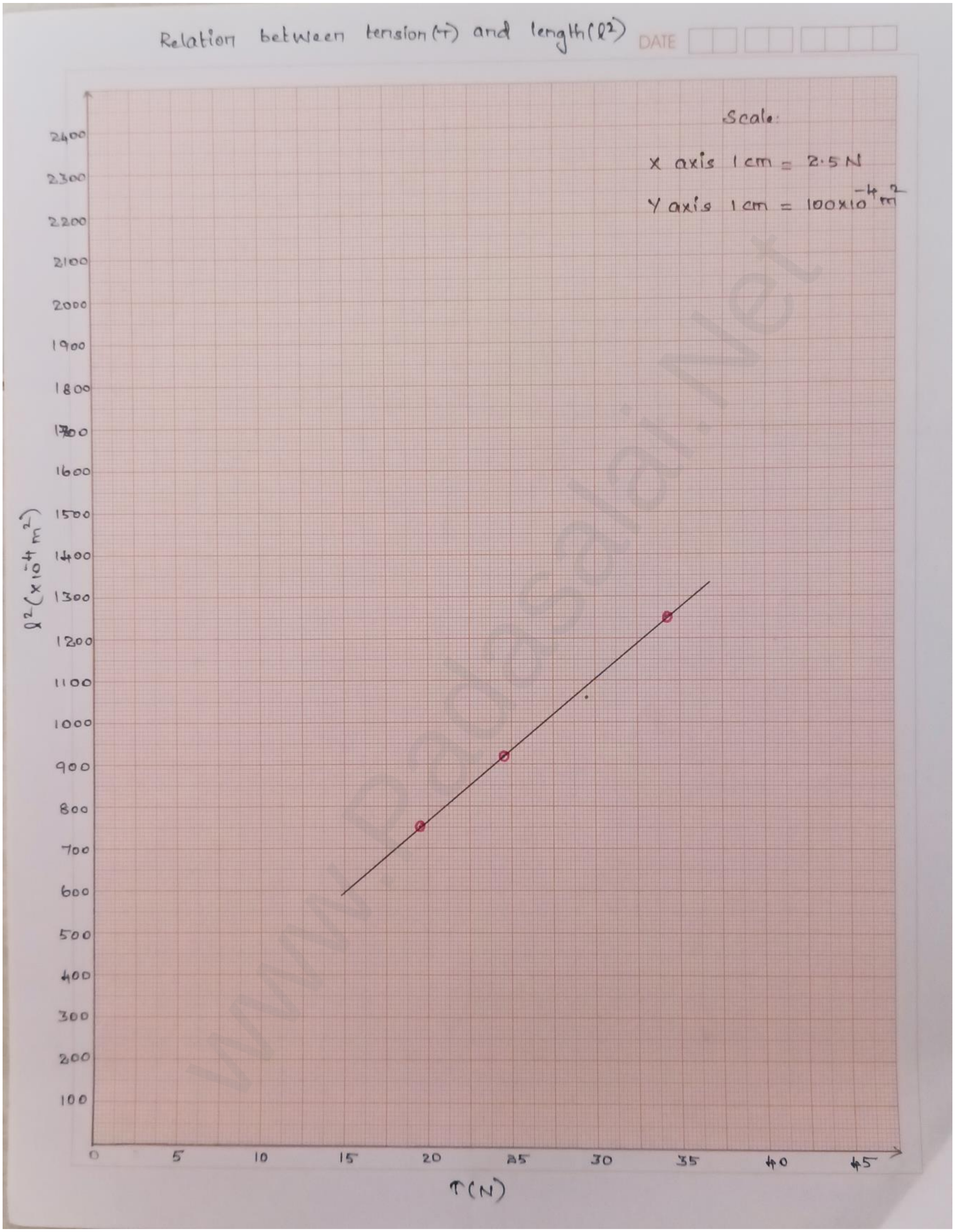
   $\frac{\sqrt{T}}{l} = \frac{5.86}{35.3 \times 10^{-2}} = 16.60$

$$\text{Mean} = \frac{16.11 + 16.44 + 16.63 + 16.60}{4} = \frac{65.78}{4} = 16.45$$

Result:

The resonating length varies as square root of tension for a given frequency of vibration of a stretched string.

$\frac{\sqrt{T}}{l}$ is found to be constant.



Relation between tension (T) and length (l^2)
DATE
Scale:
X axis 1 cm = 2.5 N
Y axis 1 cm = $100 \times 10^{-4} m^2$
$l^2 (\times 10^{-4} m^2)$
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
5
10
15
20
25
30
35
40
45
T (N)