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Experiment No. — 1

Object :—

To determine the moment of Inertia of flywheel about its own axis of rotation.

Apparatus Required :—

flywheel, meterscale, Vernier Callipers, stopwatch, set of waits & a thread.

formula used —

The moment of Inertia I of the flywheel is given by —

$$I = \frac{mr\left(\frac{gt^2 n_1}{4\pi n_2^2} - r\right)}{\left(1 + \frac{n_1}{n_2}\right)}$$

Where, m is the mass of suspendet rodd at the end of string, r is radius of suspendet rod & n_1 is number of revolutions made by the wheel before the mass is detached from the wheel & n_2 is number of revolution made by the flywheel to come to rest after the mass is detached & t is time taken by the wheel in n_2 revolutions & g is acceleration due to gravity, r is radius of suspendet rod.

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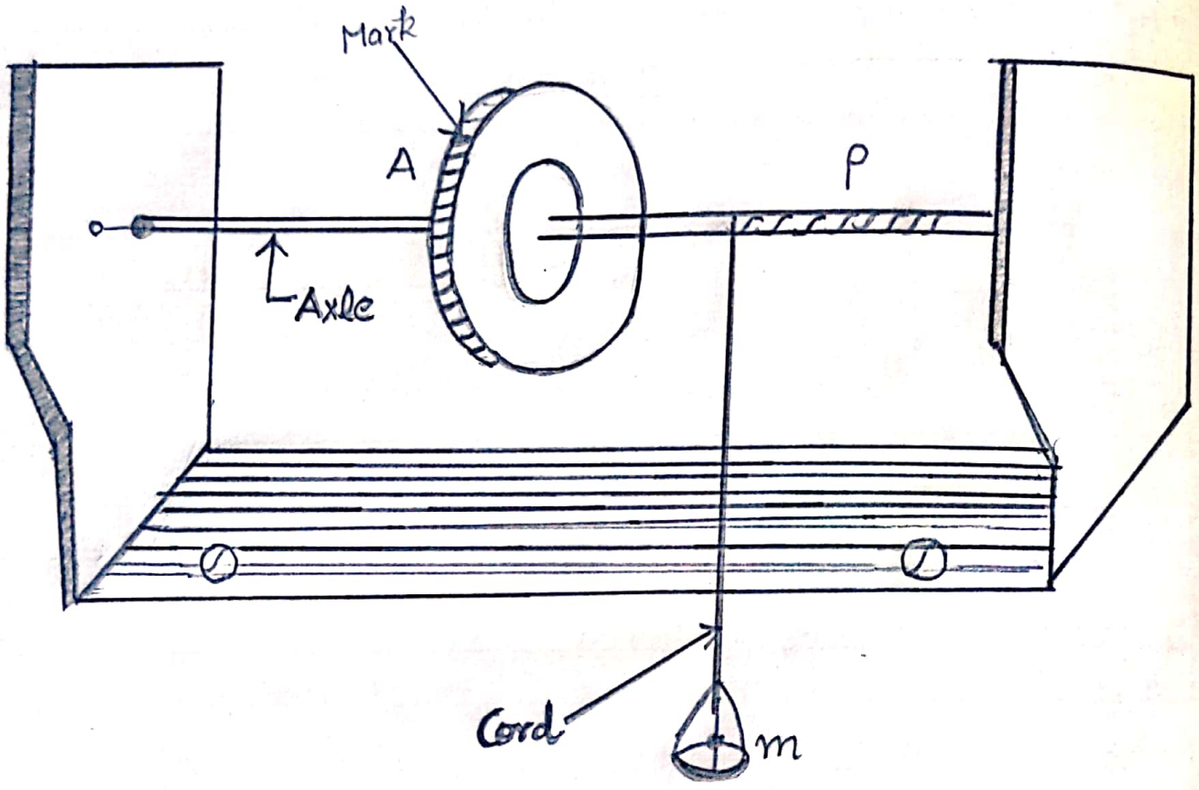

Fig Flywheel

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Observation table :—

S. No.	Total mass	No. of mass of the round axis n_1	No. of revolution of flywheel to come to rest after n_2	Mean of n_2	Time taken in revolution t sec	Mean of t
1.	250 gm	5	45	47	80 sec	83 sec
	250 gm	5	47		81 sec	
	250 gm	5	48		85 sec	
2.	350 gm	5	53	58	86 sec	94 sec
	350 gm	5	61		98 sec	
	350 gm	5	61		97 sec	
3.	500 gm	5	78	78	112 sec	112 sec
	500 gm	5	78		107 sec	
	500 gm	5	78		116 sec	

Teacher's Signature : .....

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Calculation :—

From the observation table —

(1) $m = 250\ gm = 0.250\ kg$

Radius of the axis $= 1.02\ cm = 0.0102\ m$

$g = 9.8\ m/s^2$, $n_1 = 5$, $n_2 = 47$, $t = 83\ Sec$

The M.I of a flywheel $I_1 = \dfrac{mr\left(\dfrac{gt^2 n_1}{4\pi n_2^2} - r\right)}{\left(1 + \dfrac{n_1}{n_2}\right)}$

$$I_1 = \frac{0.250 \times 0.0102 \left(\dfrac{9.8 \times 83 \times 83 \times 5}{4 \times 3.14 \times 47 \times 47} - 0.0102\right)}{\left(1 + \dfrac{5}{47}\right)}$$

$$I_1 = \frac{0.00255 \left(\dfrac{337561}{27745.04} - 0.0102\right)}{\left(\dfrac{52}{47}\right)}$$

$$I_1 = \frac{0.00255 \left([337561/27745.04] - 0.0102\right)}{1} \times \frac{47}{52}$$

$$I_1 = \frac{860.058905096}{27745.04 \times 1.10638297872}$$

$$I_1 = \frac{0.030998654228272}{1.10638297872}$$

$$I_1 = 0.0280180144\ kg\text{-}m^2$$

Teacher's Signature : .....

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2- From the observation table —

$m = 350\ gm = 0.350\ kg$

Radius of the axis $= 0.0102\ m$

$g = 9.8\ m/sec^2$, $n_1 = 5$, $n_2 = 58$, $t = 94\ sec$

The moment Inertia of a flywheel

$$I = \frac{mr\left(\frac{gt^2n_1}{4\pi n_2^2} - r\right)}{\left(1 + \frac{n_1}{n_2}\right)}$$

$$I_2 = \frac{0.350 \times 0.0102\left(\frac{9.8 \times 94 \times 94 \times 5}{4 \times 3.14 \times 58 \times 58} - 0.0102\right)}{\left(1 + \frac{5}{58}\right)}$$

$$I_2 = \frac{0.00357\left(\frac{432964}{4225 1.84} - 0.0102\right)}{\left(\frac{63}{58}\right)}$$

$$I_2 = \frac{0.00357\left(10.2472223694 - 0.0102\right)}{1} \times \frac{58}{63}$$

$$I_2 = \frac{0.00357 \times 10.1452223694 8734}{1} \times \frac{58}{63}$$

$$I_2 = 0.033645680 1\ Kg-m^2$$

The moment of inertia of flywheel

$$I_2 = 0.033645680 1\ Kg-m^2$$

Teacher's Signature : .....

From the observation table —

$m = 500\ gm = 0.500\ kg$

Radius of the axis $(r) = 0.0102\ m$

$g = 9.8\ m/s^2$, $n_1 = 5$, $n_2 = 78$, $t = 112\ Sec$

The moment of Inertia of flywheel —

$$I = \frac{mr\left(\frac{gt^2 n_1}{4\pi n_2^2} - r\right)}{\left(1 + \frac{n_1}{n_2}\right)}$$

$$I_3 = \frac{= 0.50 \times 0.0102 \left(\frac{9.8 \times 112 \times 112 \times 5}{4 \times 3.14 \times 78 \times 78} - 0.0102\right)}{\left(1 + \frac{5}{78}\right)}$$

$$I_3 = \frac{0.0051 \left(\frac{814656}{76415.04} - 0.0102\right)}{83/78}$$

$$I_3 = \frac{0.0051 \times (8.043652139683496 - 0.0102)}{1.064102564102564}$$

$$I_3 = \frac{0.0051 \times 8.033452139683496}{1.064102564102564}$$

$$I_3 = \frac{0.004097060591 2385}{1.064102564102564}$$

The moment of Inertia of flywheel -

$$I_3 = 0.0385024\ Kg - m^2$$

Teacher's Signature : .....

Mean of I :—

$$I = \frac{I_1 + I_2 + I_3}{3}$$

$$I = \frac{0.0280180144 + 0.033645680 + 0.0385024}{3}$$

$$I = \frac{0.1001660945}{3}$$

$$I = 0.0344 \ Kg\text{-}m^2$$

Result :—

The moment inertia of flywheel is -

$$I = 0.0344 \ Kg\text{-}m^2$$

Sources of Error & Precautions :—

1. There should be uniform winding on the axle.
2. The string loop should be loose.
3. Friction should be made small by ball bearings.
4. The diameter of the axle should be majored at various points.
5. Mass should fall freely.
   Mass must start with zero velocity.

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Experiment No.—2

Object :—

To determine the moment of Inertia of an irregular rigid body about an axis passing through its centre of gravity & perpendicular to its plane by dinamical method (Inertia table).

Apparatus Required :—

Inertia table irregular body whose moment of Inertia is to be determine, regular body whose moment of inertia can be calculated by majoring its dimentions & mass, stopwatch, spirit level physical balance with wait box & Vernier Callipers.

Formula Used—

the moment of inertia I_1 of the irregular body is determine with the help of following formula—

$$I_1 = I_2 \times \frac{T_1^2 - T_0^2}{T_2^2 - T_0^2}$$

(i) Where I_2 is moment of Inertia of the regular body.
(ii) T_0 is time period of inertia table.
(iii) T_1 is time period with the irregular body on the inertia table.
(iv) T_2 is time period with the regular body on the inertia table.

Teacher's Signature : .....

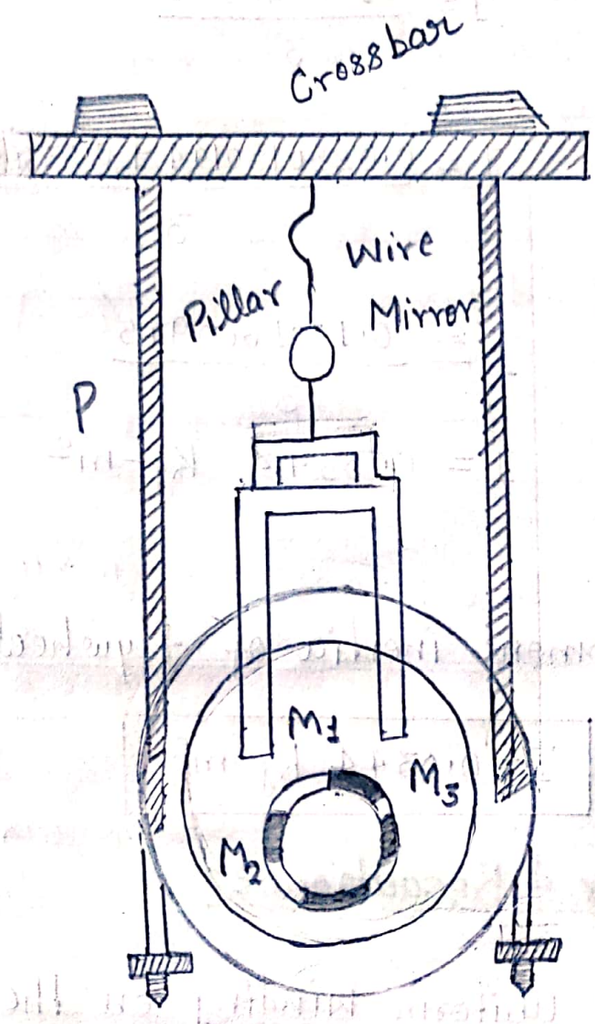
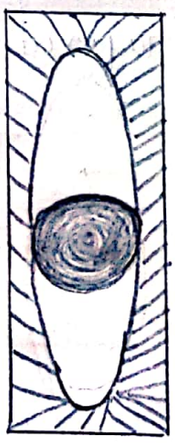
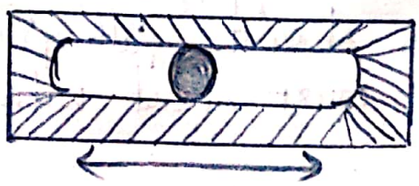


Fig — Irregular Rigid body



Spirit Level



Base Screws

If the regular body is disc then —

$$I_2 = \frac{1}{2} MR^2$$

Where M is mass of the disc & R is radius of the disc.

Observation table :—

1. **For without mass :—**

S.No.	No. of oscillation	Time t (sec)	Total time Period	Mean (sec) (T_0)
1.	10	123	12.3	$\frac{62.3}{5}$
2.	15	182	12.1	
3.	20	262	13.1	= 12.46
4.	25	313	12.5	
5.	30	370	12.3	

2. **For regular body :—** mass = 560 gm , Radius = 4.375 cm

S.No.	No. of oscillation	Time t (sec)	Time Period	Mean (sec) (T_1)
1.	10	109	10.9	$\frac{57.5}{5}$
2.	15	111	11.4	
3.	20	232	11.6	= 11.5
4.	25	294	11.7	
5.	30	357	11.9	

Teacher's Signature : .....

Calculation →

The moment of Inertia of Inregular rigid body –

$$I = I_2 \times \frac{T_1^2 - T_0^2}{T_2^2 - T_0^2} \quad \text{— (1)}$$

To find I_2 –

$$I_2 = \frac{1}{2} m R^2$$

$$= \frac{1}{2} \times 560 \times 4.375 \times 4.375$$

$$= \frac{10718.75}{2} = 5359.375$$

$$= 5359.375 \ g/cm^2$$

$$I_2 = 0.05359375 \ Kg/m^2$$

Then Put the value of I_2 in equⁿ (1) –

$$I = 0.05359375 \times \frac{(11.5 \times 11.5) - (12.46 \times 12.46)}{(12.26 \times 12.26) - (12.46 \times 12.46)}$$

$$I = 0.05359375 \times \frac{23}{4.95}$$

$$I = 0.05359375 \times 4.646464$$

$$I = 0.2490 \ Kg/m^2$$

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*. For Irregular body :—

S.No.	No. of oscillation	Time(t) (sec)	Time period	Mean (sec) (T_2)
1.	10	123	12.3	$\frac{61.3}{5}$
2.	15	184	12.2	
3.	20	246	12.3	$= 12.26$
4.	25	308	12.3	
5.	30	368	12.2	

Result :—

Moment of inertia of irregular body is $0.2490\ kg/m^2$

Sources of Error & Precautions :—

① - The inertia table should be set horizental.
② - The table should be rotated by a few degree only.
③ - Periodic time should be noted very carefully.
④ - There should not be any kink in the wire.
⑤ - There should not be any up & down as well as Too & Fro motion of the table.

Teacher's Signature : .....

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Experiment No.-3

Object :—

To study the variation of T with L for a bar pendulum (Compound Pendulum) & then to determine —

① - The value of acceleration due to gravity (g) in the laboratory.
② - The position of centre of gravity of a bar.
③ - Radius of gyration K of the bar about an axis passing through CG & perpendicular to its length.

Apparatus Required :—

Bar Pendulum, stopwatch, meterscale & knife edge fixed to a rigid support.

Formula used :—

The value of g can be calculated with the help of following formula —

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

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

$$\boxed{g = \frac{4\pi^2 L}{T^2}} \quad m/sec^2$$

where, L → Distance between centres of oscillation & suspentions. T is periodic table.

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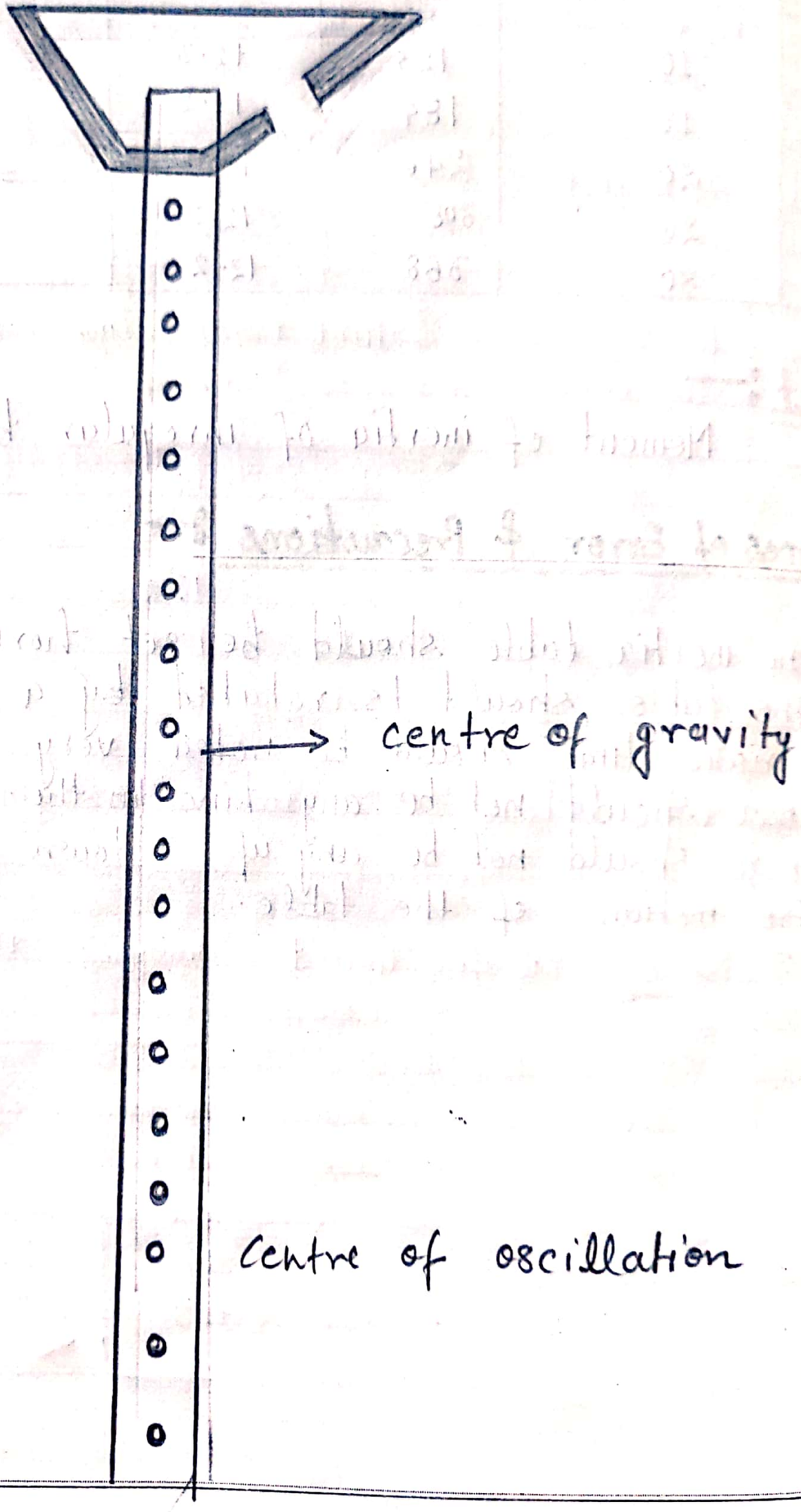

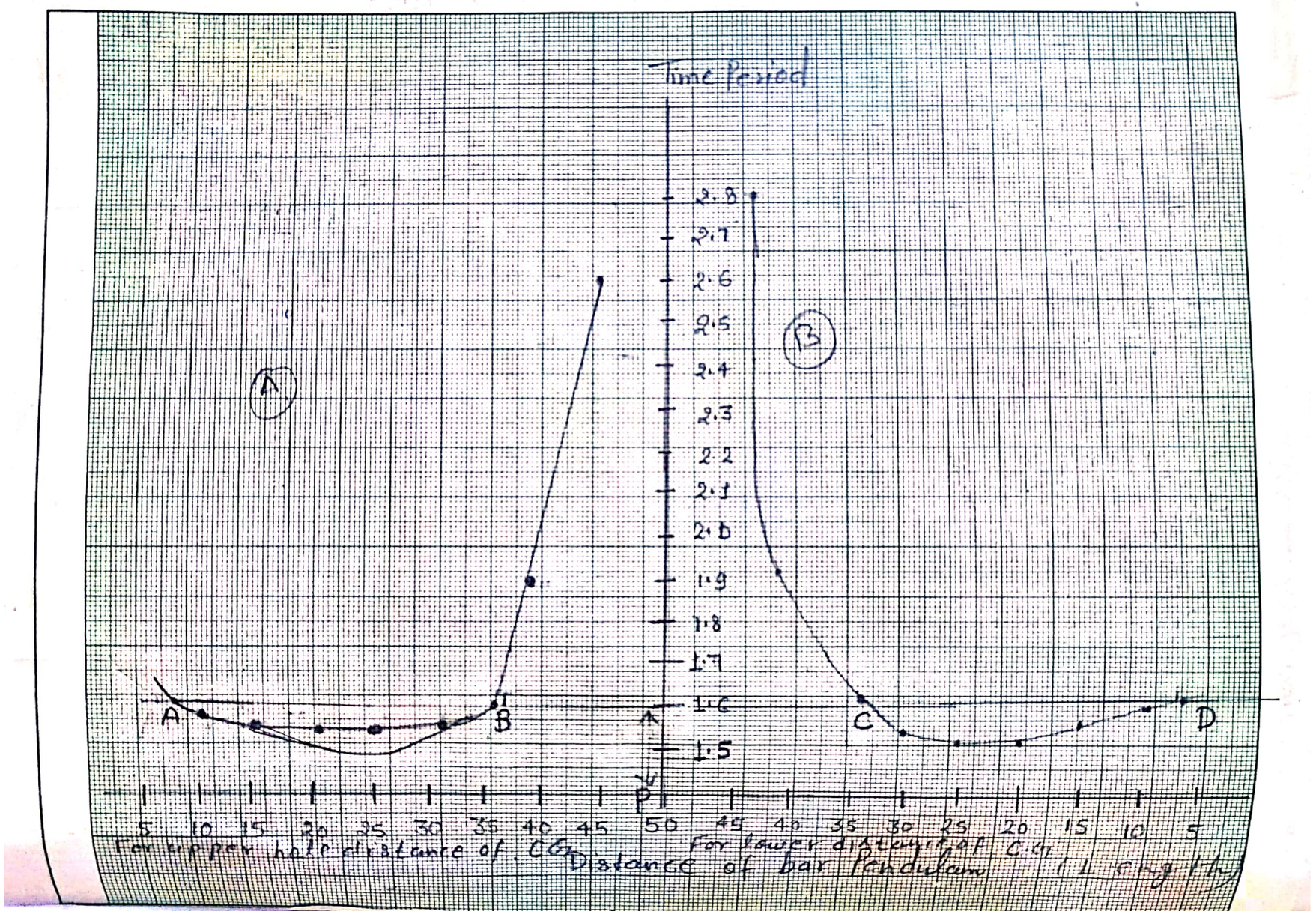

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Observation table :— (A) –

S. No.	No. of hole	No. of oscillation	Distance of hole	Time (t) (sec)	Total Time t/20
1.	1	20	5	31.57	1.5785
2.	2	20	10	31.58	1.583
3.	3	20	15	30.89	1.5445
4.	4	20	20	30.28	1.514
5.	5	20	25	30.69	1.5345
6.	6	20	30	31.39	1.5695
7.	7	20	35	33.71	1.6855
8.	8	20	40	38.66	1.933
9.	9	20	45	52.58	2.629

(B) —

S. No.	No. of hole	No. of oscillation	Distance of hole	Time t (sec)	Total time t/20
1.	1	20	5	31.39	1.5695
2.	2	20	10	30.79	1.5395
3.	3	20	15	30.31	1.5155
4.	4	20	20	30.20	1.51
5.	5	20	25	29.98	1.49
6.	6	20	30	30.08	1.504
7.	7	20	35	33.57	1.6785
8.	8	20	40	39.76	1.988
9.	9	20	45	56.98	2.849

Teacher's Signature : .....

Calculation:—

From the graph

$T = 1.55$ sec $AC = 65$ $BD = 65$ cm

Length $L = \frac{AC + BD}{2} = \frac{65+65}{2} = \frac{130}{2} = 65\text{cm} = 0.65\text{ m}$

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

$$g = \frac{4 \times 3.14 \times 3.14 \times 0.65}{(1.55)^2}$$

$$g = \frac{25.63496}{2.4025}$$

$$g = 10.67012 \text{ m/sec}^2$$

then Error $\% = \frac{\Delta g}{g} \times 100\%$

$$= \frac{10.67012 - 9.8}{9.8} \times 100\%$$

$$= \frac{0.87012}{9.8} \times 100\%$$

Error $= 0.0887877\ \%$

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Position of C.G the bar Pendulum :—

the distance of C.G of the bar from the end from where all the distance have been measured.

the radius of gyration (K) :—

From dimensions of the bar—

$$K = L/\sqrt{2}$$

Where L → the length of bar.

$$K = \frac{1}{1.414} = 0.707213578 \text{ meter}$$

Result :—

the value of g is 10.67012 m/sec^2 & the radius of gyration is 0.707213578 meter.

Sources of Error :—

① - the knife edge should be horizental & should be placed in the groove made on Horizental.

② - Amplitude of oscillation should be small.

③ - the time should recorded when the swings are regular.

④ - Vibrations of pendulum should be vertical plane.

Teacher's Signature : .....

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Experiment No. -4

Object :-

To determine the modulus of rigidity of a wire by Maxwell's Nedle.

Apparatus Required :-

Maxwell's Nedle, screwgauge, used wire, meterscale, stopwatch, physical valance & weitbox.

Used Formula :-

The modulus of rigidity of material of wire is given by -

$$\eta = \frac{2\pi l (M_S - M_H) L^2}{r^4 (T_2^2 - T_1^2)} \quad N/m^2$$

Where $l \rightarrow$ the length of the experimental wire.
$L \rightarrow$ the length of Gross tube.
$r \rightarrow$ the radius of wire
$M_H \rightarrow$ the mass of each hollow cylinders.
$M_S \longrightarrow$ the mass of each solid cylinders.
$T_1 \longrightarrow$ the time period when solid cylinders are placed in the middle

$T_2 \longrightarrow$ The time period when hollow cylinder are placed in the middle.

$r \longrightarrow$ Radius of wire.

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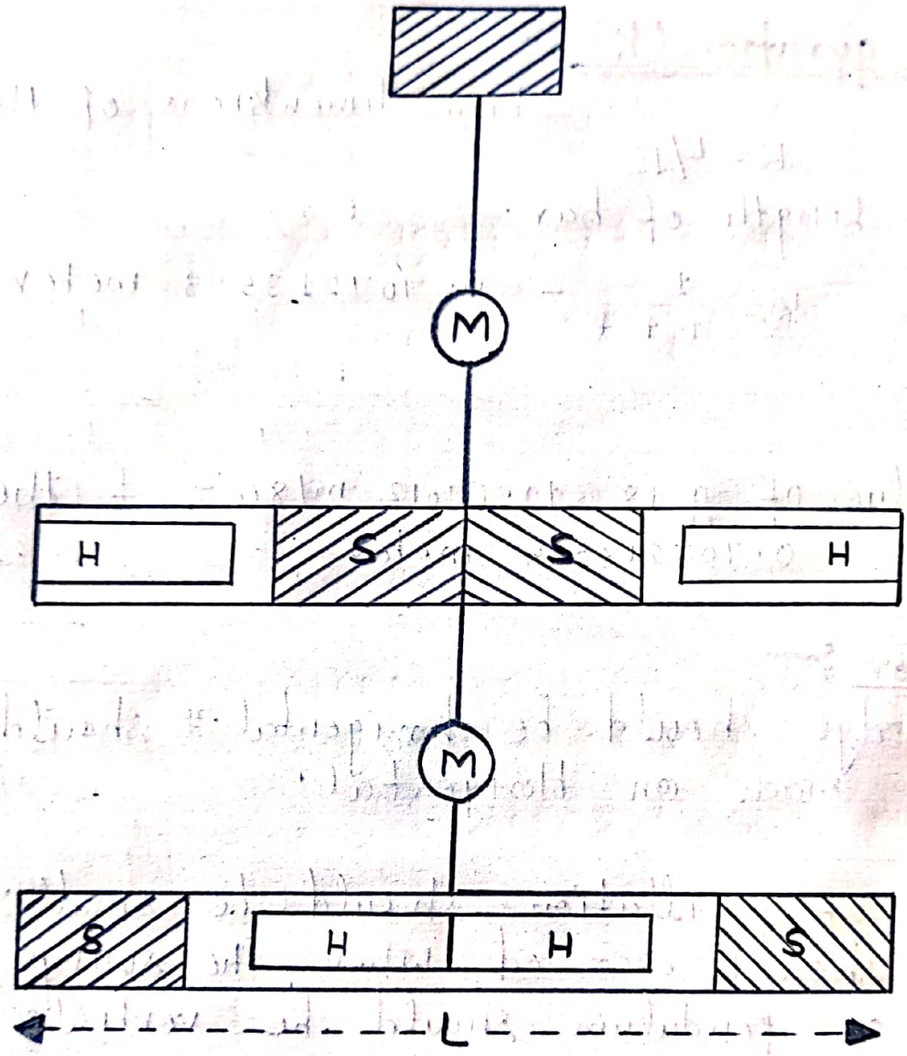

Fig. — Maxwell's Needle

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Observation table :—

(A)– When solid cylinder are placed in the middle —

S.No.	No. of oscillation	Time t (Sec)	Time Period	Mean Time Period (T_1) (Sec)
1.	5	18	3.6	
2.	10	37	3.7	3.625
3.	15	54	3.6	
4.	20	73	3.6	

(B)– When hollow cylinder are placed in the middle :—

S.No.	No. of oscillation	Time t (Sec)	Time Period	Mean Time Period (T_2) Sec
1.	5	24	4.8	
2.	10	47	4.7	4.745
3.	15	71	4.73	
4.	20.	95	4.75	

Teacher's Signature : .....

Calculation :—

$L = 37$ cm

$l = 46$ cm

$M_S = 344$ gram

$M_H = 140$ gram

$r = 0.02375$ cm

From observation Table —

$T_2 = 4.745$ sec

$T_1 = 3.625$ sec

Now

$$\eta = \frac{2\pi l (M_S - M_H) L^2}{r^4 (T_2^2 - T_1^2)}$$

$$\eta = \frac{2 \times 3.14 \times 46 [344 - 140] \times (37)^2}{(0.02375)^4 \left[(4.745)^2 - (3.625)^2\right]}$$

$$\eta = \frac{806772 50.88}{2.98262007421}$$

$$\eta = 0.000270491208 6 \times 10^{11}$$

$$\eta = 2.70491208 6 \times 10^{7} \text{ dyne/cm}^2$$

$$\eta = 0.2704912086 \times 10^{7} \text{ N/m}^2$$

Result :—

The modulus of the rigidity of material of wire is 0.270491208×10^7 N/m^2.

Precautions :—

① – The wire should be fairly thin & long.
② – It should be free from the kinks.
③ – The wire should be twisted through a very small angle.
④ – The motion of the nidle should be purely rotation.
– & No portion of cylinders should projects outwards.

Experiment No.-5

Object :-

To determine the height of building by Sextant.

Apparatus Required :-

Sextant measuring tape, chalk.

Formula Used :-

$$h_1 = \frac{d}{\cot\theta_2 - \cot\theta_1}$$

where h_1 is the height of building above the eye level (mark), d is the distance between the two points of observation on ground, θ_2 is the angular elevation of object at first or nearest point of observation, θ_1 is the angular elevation of object at the second or farthest point of observation.

$$H = h_1 + h_2$$

H is the total height of distant object from the ground, h_2 is the height of mark M from the ground.

h_1 is the height of building above the eye level (mark).

Teacher's Signature : .....

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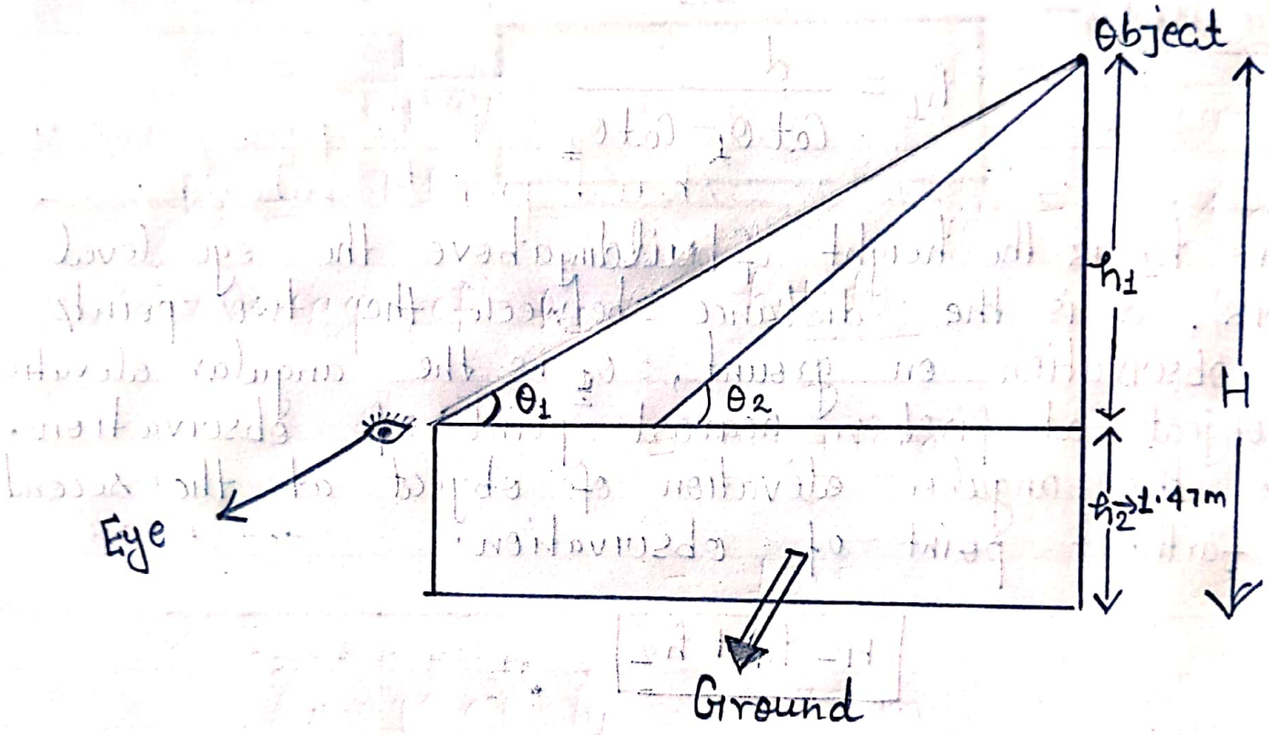
Observation table :—

1. Distance between the two points of observation = d = 1m

Left reading θ_1	Right reading θ_1	Mean (θ_1)	Left reading θ_2	Right right θ_2	Mean (θ_2)
29°40′	30°20′	30°	28°20′	28°40′	28°30′

2. Distance between the two points of observation = d = 2m

Left reading θ_1	Right right θ_1	Mean (θ_1)	Left reading θ_2	Right reading θ_2	Mean (θ_2)
29°40′	30°20′	30°	27°40′	27°20′	27°30′



Calculation:-

For Table I –

(i) – $h_1 = \frac{d}{\cot\theta_2 - \cot\theta_1}$

$h_1 = \frac{1}{\cot 28°30' - \cot 30°}$

$h_1 = \frac{1}{1.8417 - 1.732}$

$h_1 = \frac{1}{0.1097}$

$h_1 = 9.1\ m$

For Table II –

(ii) – $h_1' = \frac{d}{\cot\theta_2 - \cot\theta_1}$

$h_1' = \frac{2}{\cot 27°30' - \cot 30°}$

$h_1' = \frac{2}{1.923 - 1.732}$

$h_1' = \frac{2}{0.191}$

$h_1' = 10.4\ m$

Average of $h_1 = \frac{h_1 + h_1'}{2}$

$= \frac{9.1 + 10.4}{2}$

$= \frac{19.5}{2}$

Average of $h_1 = 9.75\ m$

$h_2 = 1.47\ m$

$H = h_1 + h_2$

$= 9.75 + 1.47$

$\boxed{H = 11.22\ m}$

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Result :—

The height of the second floor of building is 11.22 m.

Precautions :—

The scale should be verticle.
The entencity of two images should be same.
The height of reference mark and axis of telescope should be the same.

Experiment No. 6

Object :—

To determine the poisson's ratio of rubber tube by using rubber tube.

Apparatus Used :—

Rubber tube, meter scale, Varnier Calipers, weight with hanger.

Formula Used :—

$$\text{Poisson's ratio} = \frac{\text{lateral stress}}{\text{longitudinal strain}}$$

$$\sigma = -\frac{\Delta D/D}{\Delta l/l}$$

Where,

ΔD = Change in diameter
D = Original diameter
Δl = Change in length
l = Original length.

Negative sighn indicates that change in diameter and change in length are in opposite side.

Observation Table :—

Original length of rubber = 1m

Teacher's Signature : .....

Calculation:—

1. 500 gram —

$$\sigma = \frac{\Delta D/D}{\Delta l/l} = \frac{0.183/3}{0.5/100} = \frac{0.183 \times 100}{3 \times 0.5} = 12.2$$

2. 1000 gram:—

$$\sigma = \frac{\Delta D/D}{\Delta l/l} = \frac{0.185 \times 100}{1 \times 3} = 6.16$$

3. 1500 gram:—

$$\sigma = \frac{\Delta D/D}{\Delta l/l} = \frac{0.203 \times 100}{3 \times 1.5} = \frac{20.3}{4.5} = 4.51$$

4. 2000 gram:—

$$\sigma = \frac{\Delta D/D}{\Delta l/l} = \frac{0.217 \times 100}{3 \times 2} = 3.61$$

5. 2500 gram:—

$$\sigma = \frac{\Delta D/D}{\Delta l/l} = \frac{0.219 \times 100}{3 \times 2.5} = \frac{21.9}{7.5} = 2.92$$

Mean of poisson's ratio:—

$$\sigma = \frac{12.2 + 6.16 + 4.51 + 3.61 + 2.92}{5}$$

$$= \frac{29.4}{5}$$

$$\boxed{\sigma = 5.88}$$

or original diameter D = 30 m
= 3 cm

Sr. No.	weight(m) (gm)	change in length (Δl) (cm)	change in diameter (mm) (ΔD)	Poisson ratio (σ)	Mean (σ)
1.	500	0.5	1.83	12.2	
2.	1000	1	1.85	6.16	
3.	1500	1.5	2.03	4.51	5.88
4.	2000	2	2.17	3.61	
5.	2500	2.5	2.19	2.92	

Result:—

The value of poisson's ratio of rubber tube 5.88.

Precaution's and source of error:—

1. The diameters of rubber tube measured very carefully.
2. The weight should be placed or removed from the hanger very gently.
3. There should be no air bubble inside the tube.
4. The rubber tube should not be extendent beyond elastic limit.

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Experiment No. 7

Object :—

To determine the coeficient of viscosity η of water by paiseuille's Method.

Apparatus used :—

A constant level, water, wire fiated on a board a meanu meter, a capillary tube, stop watch, a measuring cylinder and meter scale.

Formula used :—

The coeficient of viscosity of liquied is given by :—

$$\eta = \frac{\pi p r^4}{8 V l}$$

where,

$p = h\rho g$ = Prussure.

$$\eta = \frac{\pi (h\rho g) r^4}{8 V l}$$

Where,

r = redius of capillary tube.
l = length of capillary tube
v = Valume of water callected per second.
ρ = dincity of liquid
h = differint of liquid level in the meanu meter.

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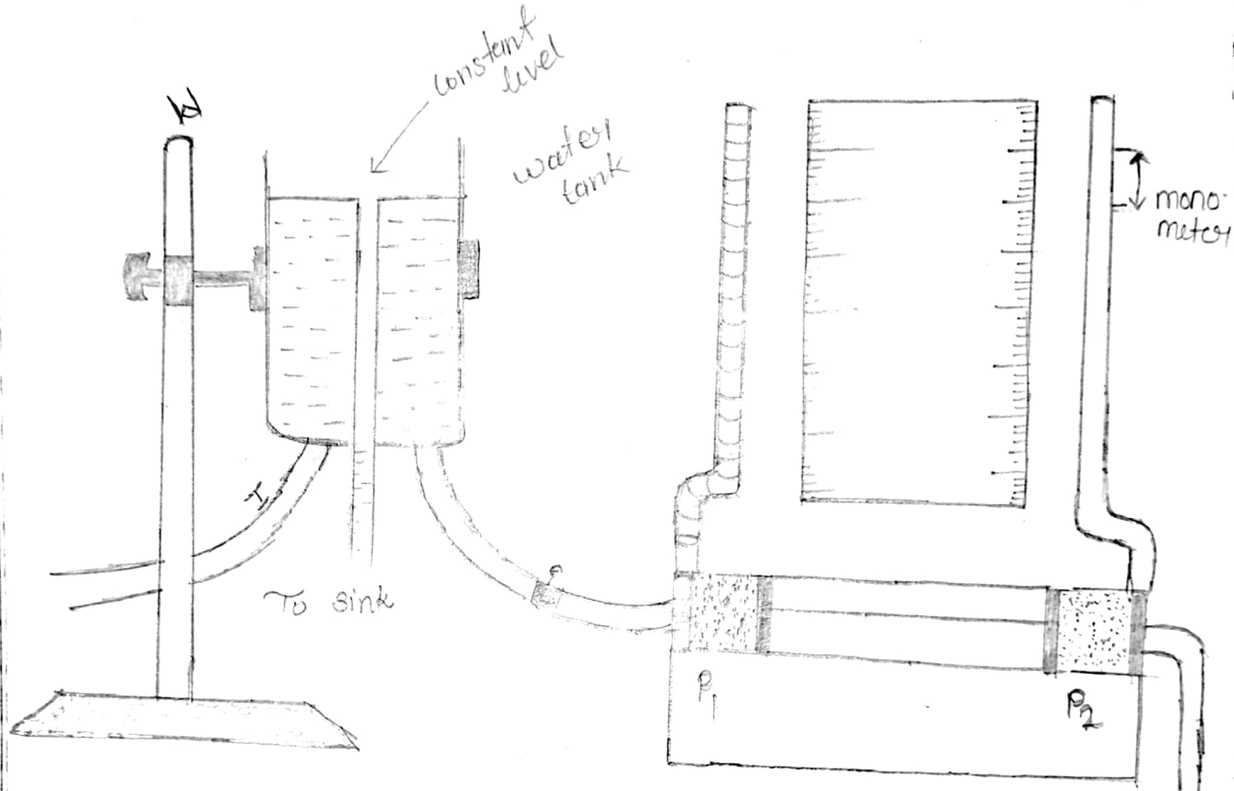

Calculation :— Effective length of the capillary tube $l = 34.5\,cm$

$$\eta = \frac{\pi \rho g h r^4}{8Vl} = \frac{3.14 \times 1 \times 980 \times 3.1 \times (0.08125)^4}{8 \times 0.193 \times 34.5}$$

$$\eta = \frac{0.4182937965717}{53268} = 0.0078526 \text{ poise or dyne-sec/cm}^2$$

$$\boxed{\eta = 7.8526 \times 10^{-3} \text{ dyne-sec/cm}^2}$$

g = acceleration due to gravity.

Observation Table :—

Sr.N.	Water level in one limb x (cm)	Water level in other limb y (cm)	difference x-y = h(cm)	Volume of water collected	time taken	Volume of water per second.	Mean
1.	33.4	29.1	4.3	30	120.6	0.25	
2.	30	26.9	3.1	30	141	0.21	0.193
3.	26.8	24.9	1.9	30	241.8	0.12	

Diameter of the capillary tube = 0.16275cm

Radius of capillary tube = 0.081375cm

Volume per second (V/S) = 0.193 ml/sec.

h = 3.1 cm.

Result :—

The coefficient of viscosity of water is 7.8526×10^{-3} dyne-sec/cm^2.

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Precautions and source of error :—

1. The radius of capillary tube should be measured very carefully.
2. The capillary should be placed horizontally to avoid the effect of gravity.
3. The temperature of water should be noted very carefully.

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