EXPERIMENT 1

Object:

Determination of the value of acceleration due to gravity 'g' by compound pendulum

Apparatus:

A bar pendulum with holes at equal intervals, meter rod, knife edges, stop watch.

Working formula:

The time period of compound pendulum is given by

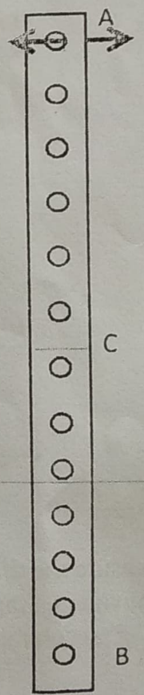
$$T = 2\pi\sqrt{\frac{l}{g}}$$

where l is the length of equivalent simple pendulum, and 'g' is the acceleration due to gravity above equation can be simplified to obtain the value of 'g'.

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

Procedure:

(i) Mark the position of the center of gravity of the rod by balancing it horizontally on the wooden edge.
(ii) Measure the distance of each hole between A and C.
(iii) Suspend the bar through the holes using a knife edge.
(iv) Give slight displacement on either side, the bar oscillates. Make sure it oscillates in a one plane.
(v) Find time for ten oscillations.
(vi) Find the time period by dividing the time by 10.
(vii) Repeat steps (v) and (vi) three times for each hole.
(viii) Now invert the rod and measure the distance of each hole between B and C.
(ix) Repeat steps (iii) to (vii) for each of the holes between B and C.



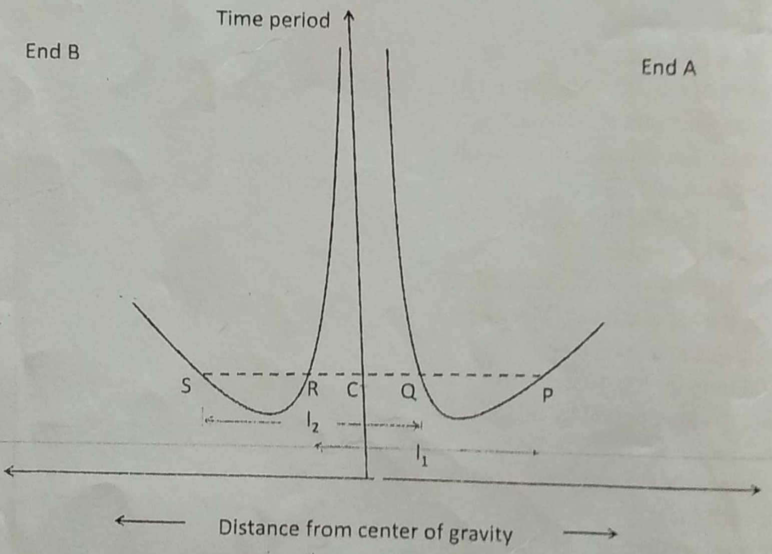
Observations:

T_l he least count of the stop watch = 0.01 Sec

End 'A'						End 'B'					
length / cm	time for ten vibrations /sec			Mean $t=(t1+t2+t3)/3$ sec	time period $T_1=t/10$ sec	length / cm	time for ten vibrations / sec			Mean $t=(t_1+t_2+t_3)/3$ sec	time period $T_2=t/10$ sec
	t_1	t_2	t_3				t_1	t_2	t_3		
43.3	16.7	15.5		16.1	1.61	42.5	15.56	17.01		16.28	1.628
35.5	14	15.08		14.52	1.452	34.5	15	15.02		15.01	1.501
27.4	14.65	14.8		14.43	1.443	26.7	14.90	15.10		14.5	1.45
19.6	15.9	15.4		15.68	1.568	19.2	15.45	15.69		15.57	1.557
12	16.9	15.69		16.29	1.629	11	18.39	18.18		18.29	1.829
4.4	26.8	26.38		26.29	2.629	3.3	28	29.5		28.75	2.875

Calculations:

Plot a graph between distance from center of gravity (along horizontal-axis) and time period (along vertical axis). Draw both parts of the graph on the same paper with same scale. Take y-axis in the middle, on right side plot the data obtained from the holes between A and C, and on left side plot the data obtained from the holes between B and C.



Measure the distances SQ (l_2), and PR (l_1). Take the average of l_1 and l_2, this gives the length of equivalent simple pendulum. Substitute the values in the working formula and evaluate the value of 'g' acceleration due to gravity.

CALCULATIONS :-

$l_1 = (PR) = 59.9\ cm$ $\quad T = 1.6\ s.$

$l_2 = (QS) = 57.9\ cm.$

$$L = \frac{l_1 + l_2}{2}.$$

$$= \frac{59.9 + 57.9}{2}.$$

$$L = 58.9\ cm$$

R The VALUE OF g :-

rmula :-

$$T = 2\pi \sqrt{\frac{l}{g}}.$$

OR. $$g = 4\pi^2 \frac{l}{T^2}$$

$$g = 4(3.142)^2 \frac{(58.9)}{(1.6)^2}$$

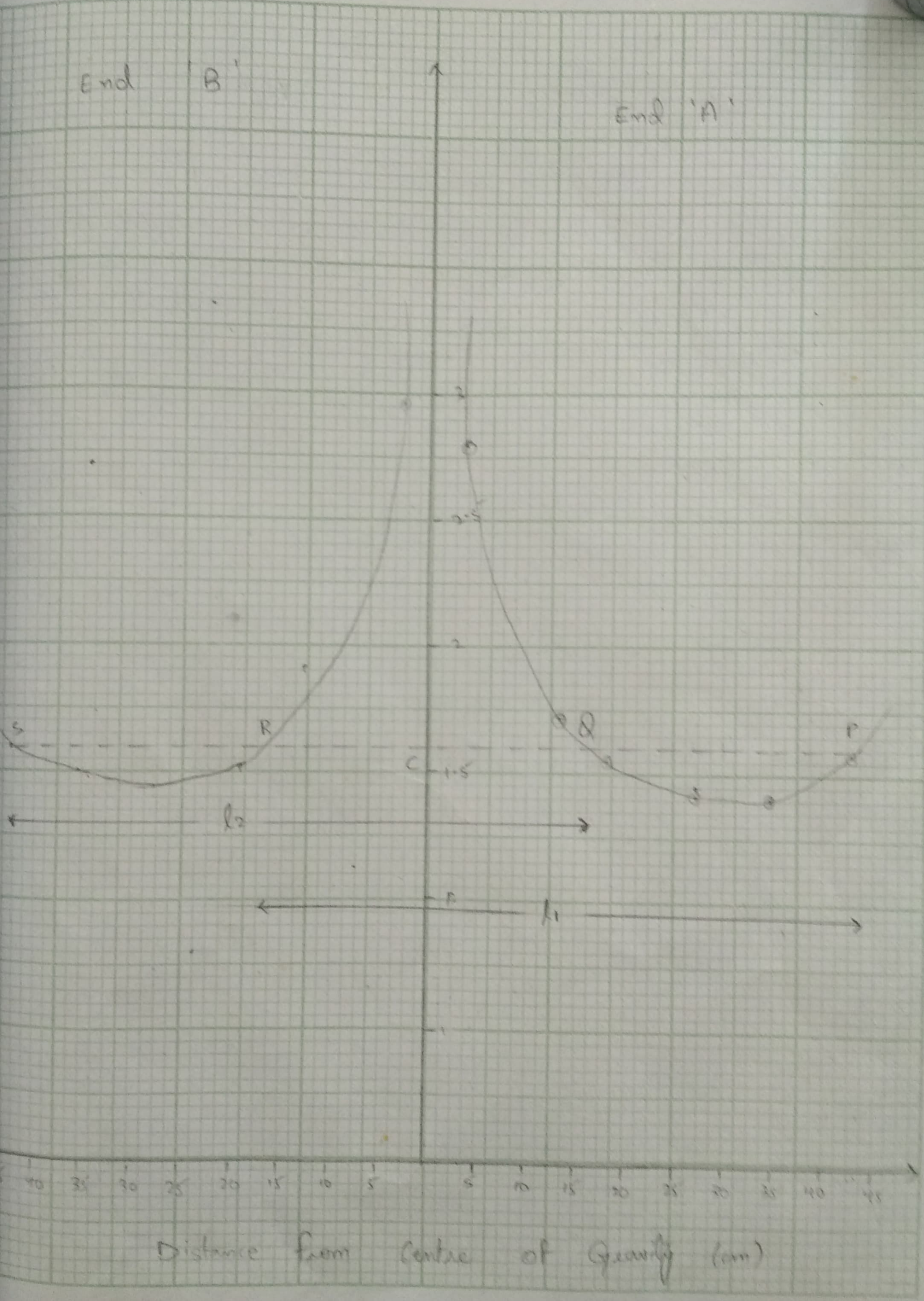
$$g = 908\ cm/s^2.$$

RCENTAGE ERROR :-

$$\varepsilon = \frac{(\text{calculated Value} - \text{Actual Value})}{\text{Actual Value}} \times 100.$$

$$= \frac{(908 - 981)}{981} \times 100.$$

$$\varepsilon = 7.4\ \%.$$


End 'B'
End 'A'
S
R
Q
P
C
1.5
2
2.5
3
l_2
l_1
40 35 30 25 20 15 10 5
5 10 15 20 25 30 35 40 45
Distance from Centre of Gravity (cm)

Result:

The value of acceleration due to gravity is found to be 908 cm/sec^2.

Percentage error:

$$\varepsilon = \frac{(calculated\ value - actual\ value)}{actual\ value} x100$$

The actual value of acceleration due to gravity is 981 cm/sec^2.

Precautions and Sources of errors:

1. The stand should be rigid.
2. The motion of the pendulum should be in one plane.
3. Amplitude of the vibration must be small.
4. Support and knife edge should be firm.
5. Air may cause buoyancy and drag.

EXPERIMENT 2

Object:

Determine the value of acceleration due to gravity 'g' using Kater's Pendulum.

Apparatus:

Stop watch, Kater's pendulum, meter rod

Working formula:

The acceleration due to gravity is found by the following formula

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

This formula is similar to that of simple pendulum, here L is the distance between knife edges when time period about them is equal.

Procedure:

(i) Fix the wooden and metallic cylinders at ends A and B.
(ii) Fix the knife edges near the wooden and metallic cylinders.
(iii) Note down the distance 'd' between the knife edges. Suspend the pendulum on knife edge near end A.
(iv) Displace the Kater's pendulum and note down the time t_1 for 20 vibrations.
(v) Calculate time period T_1, by dividing t_1 by 20.
(vi) Repeat steps (iv) and (v) three times and calculate the average value of T_1.
(vii) Now suspend the pendulum on knife edge near end B.
(viii) Displace the Kater's pendulum and note down the time t_2 for 20 vibrations.
(ix) Calculate time period T_2, by dividing t_2 by 20.
(x) Repeat steps (viii) and (ix) three times and calculate the average value T_2.
(xi) Now move both knife edges towards center of gravity by equal amount (say 5 cm each)
(xii) Repeat steps (iii) to (xi) for different distances between knife edges.

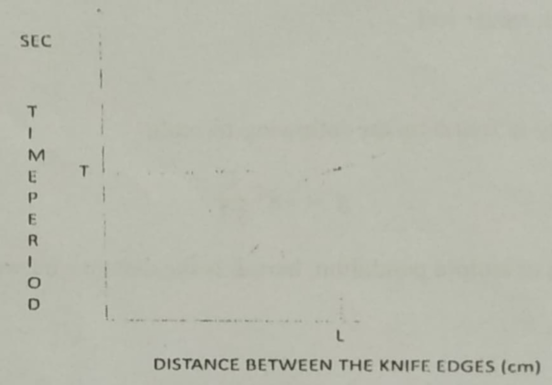
Observations:

Least count of the stop watch = 0.01 sec.

Distance between knife edges 'L' /cm	End 'A'					End 'B'				
	Time for 20 vibrations /sec			Mean t /sec	$T_1 = \frac{t}{20}$ /sec	Time for 20 vibrations /sec			Mean t /sec	$T_2 = \frac{t}{20}$ /sec
	t_1	t_2	t_3			t_1	t_2	t_3		
~~90~~ 100	17.87	18.62		18.295	1.8295	18.16	18.36		18.26	1.826
~~80~~ 80	17.62	17.73		17.675	1.7695	17.67	17.39		17.53	1.753
~~70~~ 60	16.47	16.97		16.72	1.672	16.47	16.58		16.525	1.6525
~~60~~ 40	15.85	15.93		15.89	1.589	15.72	15.86		15.79	1.579
~~50~~										

Calculations:

Plot graphs between distance L *(along x-axis)* and time period T *(along y-axis)* for both end A and B. Draw both the graph on the same paper. Both the plots would be straight lines, these lines intersect at a point (L , T). Find the corresponding values of T *and* L. Place these values in the working formula and calculate the value of 'g'.



Result:

The value of acceleration due to gravity is found to be 11.05.4 cm/sec^2.

Precautions and Sources of error:

1. The knife edges must be sharp
2. Amplitude of oscillations must be small.
3. Support must be rigid.
4. The time of vibration must be noted carefully.
5. Errors due to buoyancy and air drag.

CULATIONS :-

From Graph :

Distance between Knife Edges = 100 cm.

Time period = 1.89 sec.

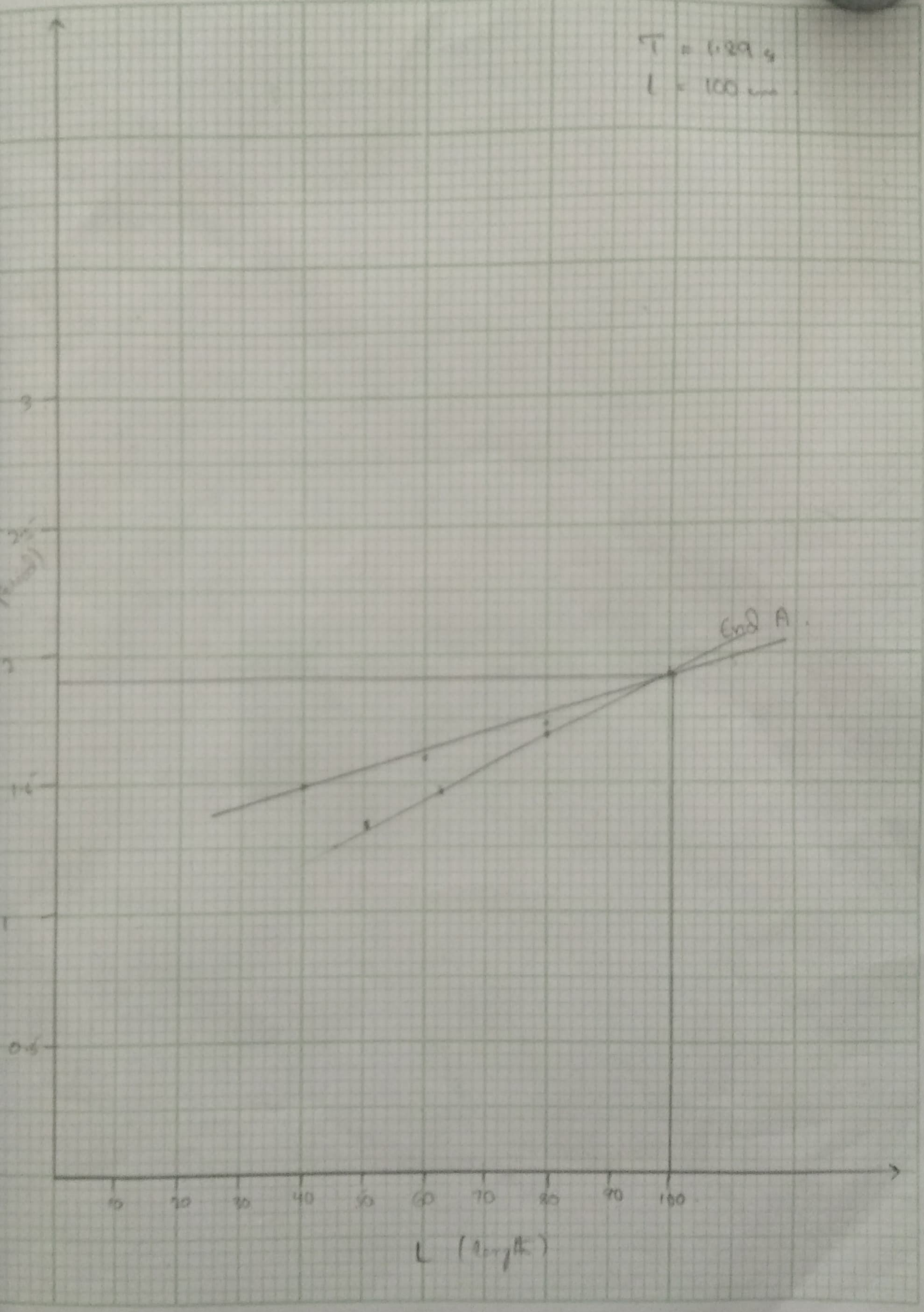
FORMULA

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

SOLUTION :-

$$g = \frac{4\pi^2 (100)}{(1.89)^2}$$

$$\boxed{g = 1105.4 \text{ cm/s}^2}$$



T = 1.89 s
l = 100 cm
End A
2
1.5
1
0.5
10
20
30
40
50
60
70
80
90
100
L (length)

EXPERIMENT 3

Object

Determine the modulus of rigidity of a metallic rod by static method

Apparatus:

A metallic rod, a pulley, weight box, thread, screw gauge,

Working formula:

The modulus of rigidity 'η' of a metallic rod is given by

$$\eta = \frac{360MgLR}{\pi^2 r^4(\theta_2 - \theta_1)}$$

$g = 980$ cm/s^2
$L = 30$
$R = 8.4351$
$r = 0.2398$

where 'η' is the modulus of rigidity

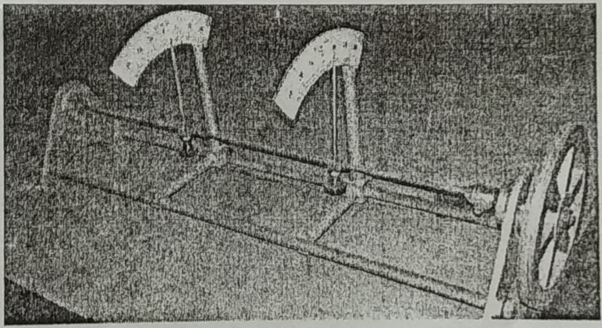
'M' is the mass suspended

'g' is the acceleration due to *gravity*

'L' is the length of the rod between the pointers

'R' is the radius of the pulley

'θ_2' and 'θ_1' are the angles of twist produced at two positions L cm apart.



Procedure:

1. With the help of screw gauge measure the diameter of the metallic rod at three different positions, find mean diameter 'D" and then the mean radius 'r' by $r = D/2$.
2. With the help of thread measure the circumference of the pulley by winding the thread along the circumference of the pulley. Then find the radius of the pulley by $R = C/2\pi$, where C is the circumference of the pulley.
3. Fix the two pointers at suitable positions, note down the length between the pointers.
4. Note down the least count of the screw gauge.
5. Hang the pan through the pulley tangentially. Note down the mass of the pan.

100 1.8

6. Put 50 gm weight in the pan. The tangential force will produce twist in the metallic rod.
7. Note down the values (θ_1 *and* θ_2) of both the pointer along the scale.
8. Repeat steps (5) and (6) five or six times, by increasing the 50 g weight in the pan each time.
9. Now decrease the mass in the pan each time takeout a 50s gm weight out of the pan.
10. Note down the values (θ_1 *and* θ_2) of both the pointer along the scale.
11. Repeat steps (9) and (10) till the pan becomes empty.
12. Repeat the whole experiment for another length between the pointers.

Observations:

Mass of the pan 'm_1'= 500 g

Radius of the pulley

Circumference of the pulley 'C'= length of the thread = 53 cm

Radius of the Pulley 'R' = C/2π = 8.4351 cm

Radius of the Rod

Least count of the screw gauge = 0.001 cm

S. No.	Main Scale Reading MSR/cm	Circular Scale Reading CSR/divisions	Diameter of the Rod MSR+CSR*least count	Mean diameter d/cm	Radius of the Rod r = d/2 cm
1	0.5	3	0.503	0.479	0.2395
2	0.45	18	0.468		
3	0.45	16	0.466		

S. No.	Length between pointers cm	Mass in the pan m_2 g	Total mass suspended $M = m_1 + m_2$ g	Weight increasing θ_1	Weight increasing θ_2	Weight decreasing θ_1	Weight decreasing θ_2	*Mean* θ_1	*Mean* θ
1	30	0	500	2	7	2	7	2	7
2		1000	1500	4	13	4	14	4	13.5
3		2000	2500	5	20	6	21	5.5	20.5
4		3000	3500	7	26	7	27	7	26.5
5		4000	4500	8	30	8	30	8	30

Mass of pan = 500g

MSR + FP

MSR + (CSR × LC)

Calculate the modulus of rigidity of a metallic rod by static ...

CALCULATIONS:-

DATA:-

Given:

(i) $M_1 = 500g$, $\theta_1 = 2$, $\theta_2 = 7$

(ii) $M_2 = 1500g$, $\theta_1 = 4$, $\theta_2 = 13.5$

(iii) $M_3 = 2500g$, $\theta_1 = 5.5$, $\theta_2 = 20.5$

(iv) $M_4 = 3500g$, $\theta_1 = 7$, $\theta_2 = 26.5$

(v) $M_5 = 4500g$, $\theta_1 = 8$, $\theta_2 = 30$

$g = 980\ cm/s^2$, $R = 8.4351\ cm$, $\pi = 3.142$, $r = 0.2395\ cm$

Required:

(i) $\eta_1 = ?$

(ii) $\eta_2 = ?$

(iii) $\eta_3 = ?$

(iv) $\eta_4 = ?$

(v) $\eta_5 = ?$

Formula:

$$\eta = \frac{360 MglR}{\pi^2 r^4 (\theta_2 - \theta_1)}$$

Solution:

(i) $$\eta_1 = \frac{360(500)(980)(30)(8.4351)}{(3.142)^2(0.2395)^4(7-2)}$$

$$\boxed{\eta_1 = 2.749 \times 10^{11}\ dynes/cm^2}$$

(ii) $$\eta_2 = \frac{360(1500)(980)(30)(8.4351)}{(3.142)^2(0.2395)^4(13.5-4)}$$

$$\boxed{\eta_2 = 4.339 \times 10^{11}\ dynes/cm^2}$$

(iii) $$\eta_3 = \frac{360(2500)(980)(30)(8.4351)}{(3.142)^2(0.2395)^4(20.5-5.5)}$$

$$\boxed{\eta_3 = 4.580 \times 10^{11}\ dyne/cm^2}$$

(iv) $$\eta_4 = \frac{(360)(3500)(980)(30)(8.4351)}{(3.142)^2(0.2395)^4(26.5-7)}$$

$$\boxed{\eta_4 = 4.933 \times 10^{11}\ dynes/cm^2}$$

(v) $$\eta_5 = \frac{(360)(4500)(980)(30)(8.4351)}{(3.142)^2(0.2395)^4(30-8)}$$

$$\boxed{\eta_5 = 5.622 \times 10^{11}\ dynes/cm^2}$$

Mean:

$$\eta = \frac{\eta_1 + \eta_2 + \eta_3 + \eta_4 + \eta_5}{5}$$

$$\boxed{\eta = 4.4446 \times 10^{11}\ dynes/cm^2}$$

Precautions and Sources of Errors:

1. The radius of rod and pulley must be measured accurately.
2. Pointer must be fixed firmly with the rod, so that they should response to very small twist in the rod.
3. Pointer position must be read carefully.
4. Radius of the rod and of pulley must be measured three time from different locations.

Calculation:

Calculate the modulus of rigidity of rod using working formula and observed data.

Result:

The modulus of rigidity of the metallic rod by static method is found to be $\underline{4.4458 \times 10^{4}}$ $dynes/cm^2$

EXPERIMENT 5

Object:

To determine the frequency of AC supply.

Apparatus:

Micrograph, thread of uniform thickness, a pan, pulley, weight box, optical pins with stand, meter rod

Working formula:

The frequency of AC supply can be found by micrograph with the help of following formula

$$\nu = \frac{1}{2l}\sqrt{\frac{Mg}{m}}$$

where ν is the frequency of AC supply

l is the length of one loop

M is the mass suspended, it is sum of mass of pan and mass in pan

m is the mass per unit length of the thread

g is the acceleration due to gravity

Procedure:

1. Take a suitable length of a thread, measure its weight and divide it by the length of the thread, this is mass per unit length.
2. Tie one end of the thread with vibrating rod of the micrograph, the other is tied to a pan.
3. The thread is stretched and is passed over a pulley such that the pan hangs freely in the air.
4. Note down the mass m_1 of the pan.
5. Put $m_2 = 10$ gm weight in the pan, the tension in the thread increases and thread becomes more stretched and parallel to the table.
6. Switch on micrograph, stationary waves are produced along the thread, adjust the position of vibrograph so that the loops become stable and have maximum amplitude.
7. Leave first and last loop, place optical pins at the node positions, count the number of loops and find their length. Find the length of one loop by dividing total length by the number of loops.
8. Repeat steps (5) to (7) for $m_2 = 15, 20, 25, 30\ gm$ weights.

Calculations:

1. With the help of following formula calculate frequency of AC supply for each reading

$$\nu = \frac{1}{2l}\sqrt{\frac{Mg}{m}}$$

2. Find the average value of frequency of AC supply.

Observations:

Mass per unit length of the thread $= m =$ 1.67×10^{-3} gm/cm

Mass of pan $= m_1 =$ 15 gm

Acceleration due to gravity $= 981\ cm/sec^2$

S. No.	Mass in pan m_2 / gm	Total mass suspended $M = m_1 + m_2$ gm	Number of loops 'n'	Length of 'n' loops L / cm	Length of one loop $l = L/n$ cm	Frequency of AC supply hertz
1	0	15	4	90.6	22.65	65.4
2	5	20	3	72.3	24.1	71
3	10	25	2	56.0	28	68.4
4	15	30	2	59.4	29.7	70.6
5	20	35	1	37.4	37.4	60.6

Result:

The frequency of AC supply is found to be = 67.28 Hertz.

Precautions and Sources of Error:

1. Pulley should be frictionless or should have minimum friction.
2. Pulley must be parallel to the thread.
3. Pan must not swing like pendulum.
4. Pan should not touch the table.
5. There should be no air drag.
6. Thread must be of uniform density.
7. Thread should be in line with the vibrating rod.
8. The weight in pan should be of suitable value, so that there should not be sag in the thread.
9. For well define loops the amplitude of vibrations must be large.
10. There should be no voltage fluctuations.

CALCULATIONS:-

DATA:-

$m = 1.67 \times 10^{-3}$ gm/cm

$g = 981$ cm/s^2

$m_1 = 15$ gm

(i) $m_2 = 0$ gm ; $M = 15$ gm ; $n = 4$; $L = 90.6$ cm ; $l = 22.65$ cm ;

(ii) $m_2 = 5$ gm ; $M = 20$ gm ; $n = 3$; $L = 72.3$ cm ; $l = 24.1$ cm

(iii) $m_2 = 10$ gm ; $M = 25$ gm ; $n = 2$; $L = 56.0$; $l = 28$ cm

(iv) $m_2 = 15$ gm ; $M = 30$ gm ; $n = 2$; $L = 59.4$; $l = 29.7$ cm

(v) $m_2 = 20$ gm ; $M = 35$ gm ; $n = 1$; $L = 37.4$; $l = 37.4$ cm

FORMULA:-

$$\nu = \frac{1}{2l}\sqrt{\frac{Mg}{m}}$$

TO FIND:-

ν = Average value of frequency.

SOLUTION:-

(i) $$\nu_1 = \frac{1}{2(22.65)}\sqrt{\frac{(15)(981)}{1.67 \times 10^{-3}}} = 65.52 \text{ Hz}.$$

(ii) $$\nu_2 = \frac{1}{2(24.1)}\sqrt{\frac{20(981)}{1.67 \times 10^{-3}}} = 71.11 \text{ Hz}.$$

(iii) $$\nu_3 = \frac{1}{2(28)}\sqrt{\frac{25(981)}{1.67 \times 10^{-3}}} = 68.14 \text{ Hz}.$$

(iv) $$\nu_4 = \frac{1}{2(29.7)}\sqrt{\frac{30(981)}{1.67 \times 10^{-3}}} = 71.05 \text{ Hz}$$

(v) $$\nu_5 = \frac{1}{2(37.4)}\sqrt{\frac{35(981)}{1.67 \times 10^{-3}}} = 60.61 \text{ Hz}.$$

$$\text{Average frequency} = \frac{\nu_1 + \nu_2 + \nu_3 + \nu_4 + \nu_5}{5}$$

$$= \frac{65.52 + 71.11 + 68.14 + 71.05 + 60.61}{5}$$

$$\boxed{\nu = 67.28 \text{ Hz}}$$

EXPERIMENT 6

Object:

Verify inverse square law using photo cell

Apparatus:

Photocell, 60 and 100 watt light bulbs, meter scale, micro-ammeter

Working formula:

$$I \propto \frac{1}{r^2}$$

where r is the distance of photocell surface from light bulb

I is the intensity of light

Procedure:

1. Set the photocell on optical bench, and connect it to the micro-ammeter.
2. Fix 60 watt bulb in the lamp box, and keep the lamp box at a distance of 20 or 25cm from the photocell.
3. Note down the reading on micro-ammeter.
4. Now move the lamp box away from photocell through 5 cm, note down the corresponding reading on micro-ammeter.
5. Repeat step (4) ten to 15 times, each time increase the distance between lamp box and photocell by 5 cm.
6. Now decrease the distance through 5 cm, and note down the corresponding reading of micro-ammeter.
7. Repeat step (6) till the lamp box is at initial distance.
8. Repeat the whole experiment for 100 watt light bulb.

Calculation:

1. Plot two graphs for 60 and 100 watt light bulbs between current I and $1/r^2$. Both graphs should be plotted on the same graph paper.
2. For a suitable value of r find the corresponding values of currents I_1 and I_2 from the graph for 60 and 100 watt light bulbs and calculate I_1/I_2.

Precautions and Sources of Error:

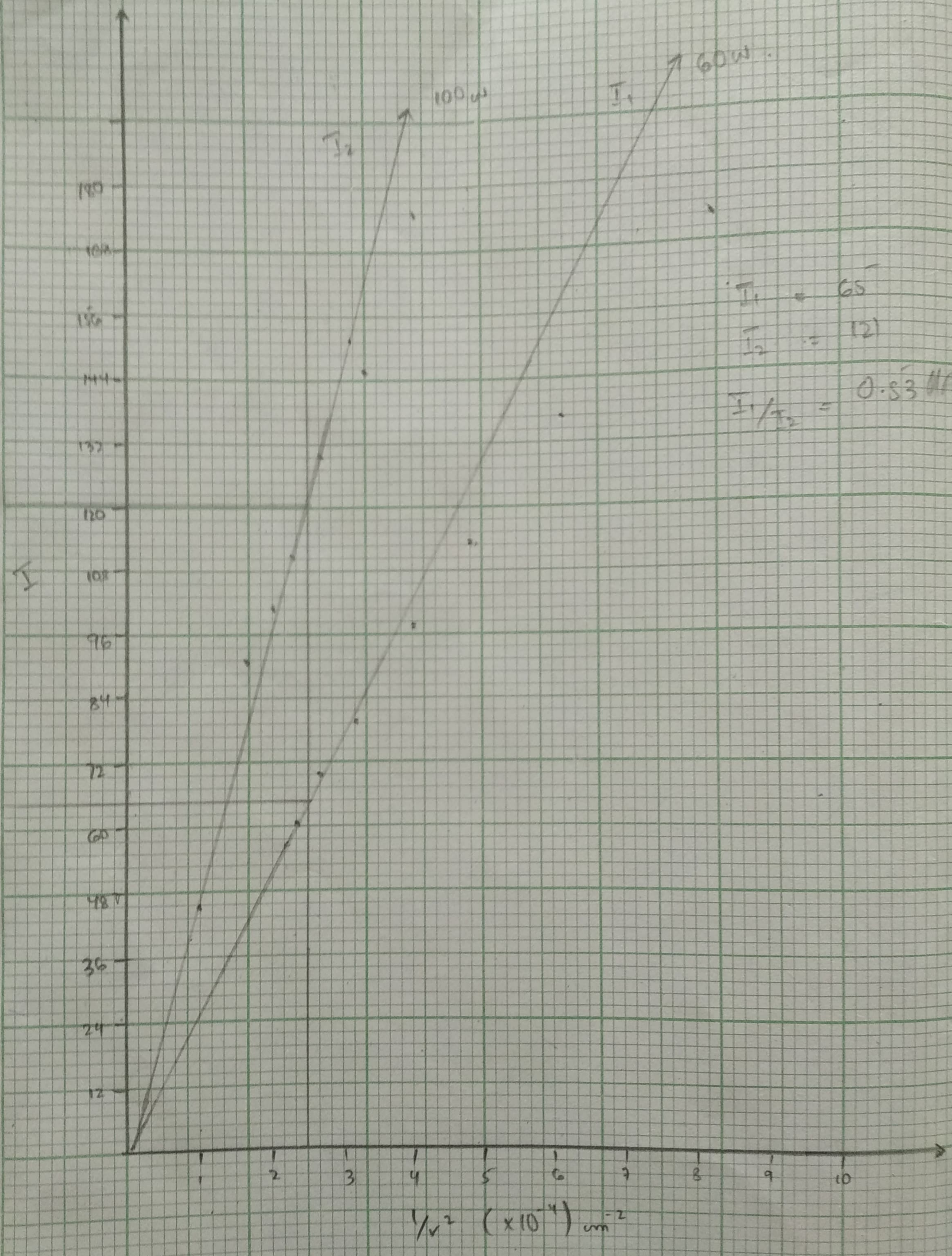
1. Light bulb and photocell must be at same height.
2. Except light from lamp box no other light should fall on the photo cell, for this purpose the experiment must be performed in dark room.
3. Opening of lamp box and photocell must be aligned properly.
4. Distance must be measured accurately.
5. For calculation of I_1/I_2, distance 'r' must be taken other than tabulated in observation columns.

Observations:

S.No.	Distance between bulb and photocell r / cm	$\frac{1}{r^2}$ cm^{-2}	Micro-ammeter readings: 60 watt light bulb, Increasing distance μA	60 watt light bulb, Decreasing distance μA	60 watt light bulb, Mean I_1 μA	100 watt light bulb, Increasing distance μA	100 watt light bulb, Decreasing distance μA	100 watt light bulb, Mean I_2 μA
1	100	1×10^{-4}	45	45	45	65	55	60
2	95	1.10×10^{-4}	50	45	47.5	70	60	65
3	90	1.23×10^{-4}	55	50	52.5	75	65	70
4	85	1.38×10^{-4}	55	50	52.5	80	75	77.5
5	80	1.56×10^{-4}	60	50	55	85	80	82.5
6	75	1.77×10^{-4}	60	55	57.5	95	90	92.5
7	70	2.04×10^{-4}	65	60	62.5	100	100	100
8	65	2.36×10^{-4}	60	60	60	110	110	110
9	60	2.77×10^{-4}	80	70	75	130	130	130
10	55	3.3×10^{-4}	80	80	80	140	145	145
11	50	4×10^{-4}	100	95	97.5	175	175	175
12	45	4.9×10^{-4}	115	110	112.5			
13	40	6.2×10^{-4}	140	135	137.5			
14	35	8.1×10^{-4}	175	170	172.5			
15								

Result:

1. The graph between current I and $1/r^2$ is Straight line.
2. The intensity is inversely proportional to the distance from the source and receiver.
3. The value of I_1/I_2 is found to be = 0.53.



$I_1 = 65$

$I_2 = 121$

$I_1/I_2 = 0.53$