To determine the value of 'g' using bar pendulum

AIM: To determine the value of 'g' by a bar pendulum.

APPARATUS: Bar pendulum, a small metal wedge, a spirit level, a telescope, a stop-watch, a metre rod, a rigid support ~~find~~ fixed on the wall.

THEORY: The bar is allowed to oscillate about a horizontal knife edge passing through each of holes in turn, beginning with that nearest to one end and the time period is noted in each case. If T is corresponding time period, then

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

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

The radius of gyration

$$K = \sqrt{ll'}$$

$$I = MK^2$$

PROCEDURE: (1) Balance the bar on the sharp wedge and mark its C.G at G.

(2) Fix the knife edged in the outermost holes on either end of the bar parallel to each other with their sharp edges pointing towards G.

(3) Check with the spirit level that the glass plates G fixed on the rigid bracket on the wall on the horizontal. Suspend the pedulum by placing the knife edge on the side A perpendicular to the slot in the bracket and see that the pendulum hangs vertically.

(4) Adjust the eye-piece of the telescope so that the cross-wires are clearly visible through it. Focus the

telescope on the bar from about one metre distance and see that the point of intersection of the crosswire coincides with the line AB or a reference line drawn on the pendulum.

(5) Display the bar slightly and release it. It will began to vibrate. Note the time for 20 vibrations and also measure the length from the point G upto the bottom of the first hole.

(6) Suspend the pendulum on the knife edge on B side of pendulum and take the observation as in step 5 above.

(7) Now insert the knife edges in holes 2, 3, ... on the either side of the CG and note the time for 20 vibrations in each case and measure the corresponding distances from G.

(8) Plot a curve between distance from CG and the corresponding time period T (time for one vibration)

(9) Draw two horizontal line ABCDE and A'B'C'D'E' and do the calculations.

(10) Find the mass of the pendulum to determine the moment of inertia.

PRECAUTIONS AND SOURCES OF ERROR :

(1) The knife-edges should be horizontal and the bar pendulum should hang vertically.

(2) Amplitude of vibration should be small ($<5°$).

(3) The time of oscillation should be noted after 5 or 6 oscillations so that any irregularity of motion subside.

(4) Time should be noted with the help of a good stop-watch using a telescope.

(5) The knife-edges should be sharp.

(6) The support should not be jerky.

(7) Smooth and good-sized curve should be drawn.

RESULT :

(i) The acceleration due to gravity (g) = $9.591 \pm 0.083\ ms^{-2}$

(ii) % error in 'g' = 2.84 %

(iii) max^m log error = $0.083\ ms^{-2}$

$g \pm \Delta g = 9.591 \pm 0.083\ ms^{-2}$

'g' from graph l^2 vs $T^2 l$ = $9.2\ m/s^2$

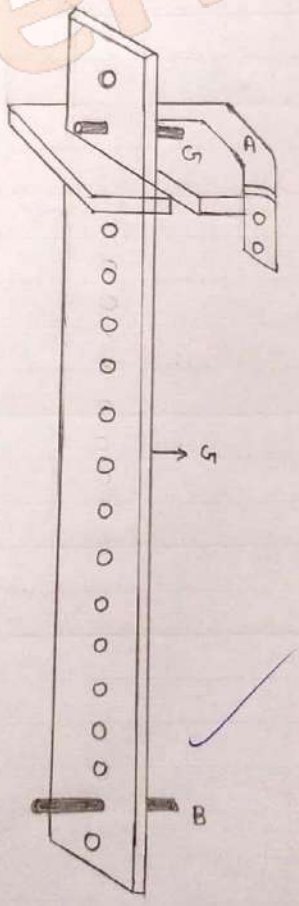
AIM : To plot graph between the distance of knife edges from the centre of gravity and time period of a compound pendulum.

From graph find,

(a) acceleration due to gravity.

(b) radius of gyration.

DIAGRAM :



FORMULA USED:

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

OBSERVATIONS:

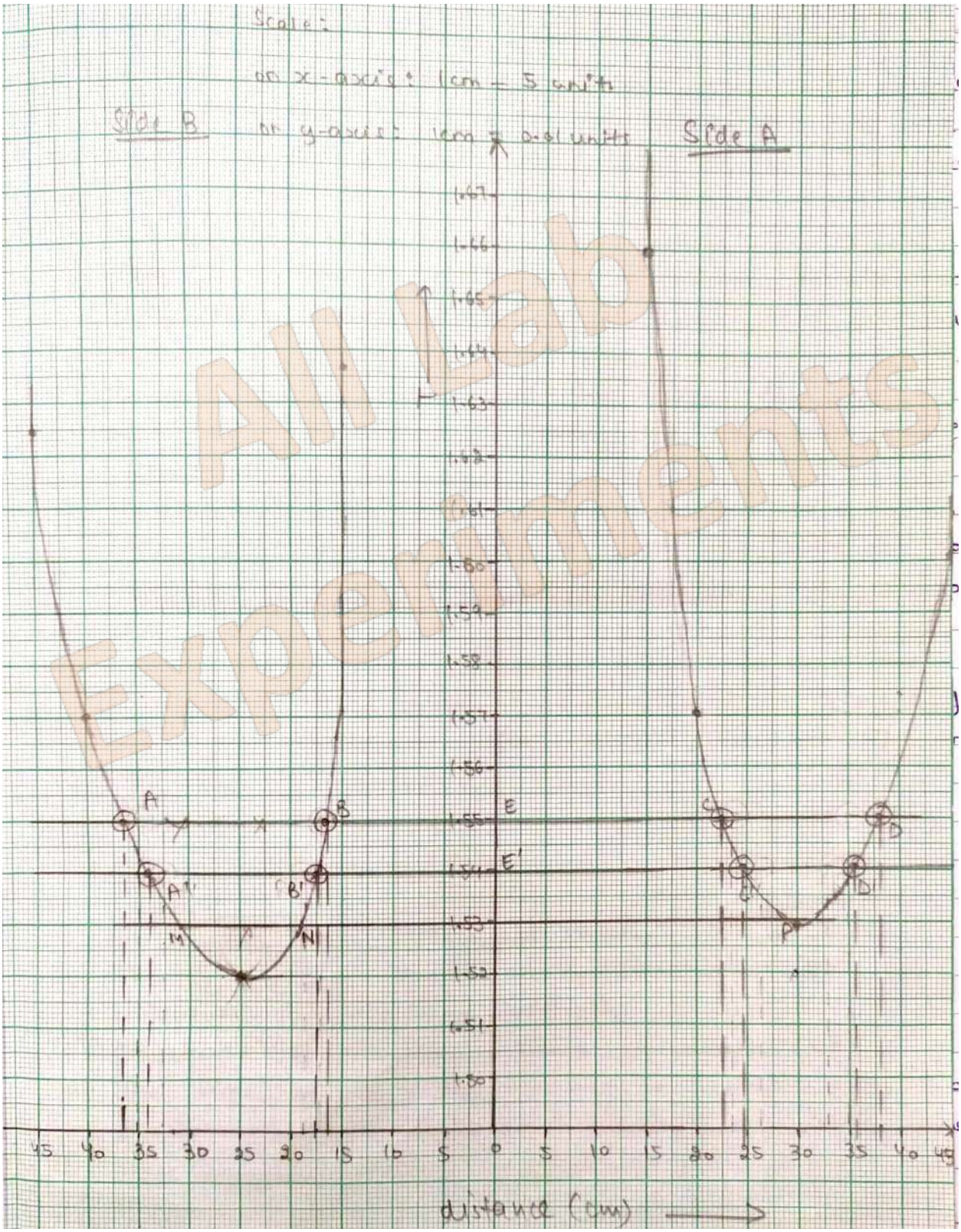
Least count of stop-watch = 0.01 sec

For the holes on side A:

S.No	distance (cm)	T_1 (s)	T_2 (s)	T_3 (s)	Mean = T(s)	Time period (T/20) (s)
1.	45	31.44	32.50	32.18	32.04	1.602
2.	40	31.25	31.56	31.63	31.48	1.574
3.	35	31.04	31.00	31.00	31.01	1.550
4.	30	30.62	30.56	30.50	30.55	1.527
5.	25	30.41	30.02	30.37	30.26	1.514
6.	20	31.41	31.31	31.72	31.48	1.574
7.	15	33.28	33.18	33.28	31.48	1.662
8.	10	38.10	38.10	38.22	38.15	1.907
9.	5	52.52	51.96	51.91	52.13	2.607

For the holes on side B:

S.No	distance (cm)	T_1 (s)	T_2 (s)	T_3 (s)	Mean = T(s)	Time period (T/20) (s)
1.	45	32.65	32.38	32.41	32.48	1.624
2.	40	31.19	31.72	31.78	31.56	1.570
3.	35	31.00	31.13	30.93	31.30	1.551
4.	30	30.56	30.56	30.75	30.62	1.531
5.	25	30.40	30.37	30.38	30.38	1.519
6.	20	31.37	31.60	31.25	31.40	1.57
7.	15	32.65	32.59	33.06	32.76	1.638
8.	10	36.62	38.00	37.84	37.48	1.374
9.	5	50.16	50.65	50.33	50.52	2.159



S.No	l (m)	l^2 (m^2)	T (sec)	T^2 (sec^2)	$T^2 l$ ($sec^2 m$)
1.	0.45	0.2025	1.602	2.5664	1.155
2.	0.40	0.16	1.574	2.4774	0.990
3.	0.35	0.1225	1.550	2.4025	0.840
4.	0.30	0.09	1.527	2.3317	0.699
5.	0.25	0.0625	1.514	2.2924	0.573
6.	0.20	0.04	1.574	2.4774	0.495
7.	0.15	0.0225	1.662	2.7622	0.413
8.	0.10	0.01	1.907	3.6366	0.363
9.	0.05	0.0025	2.607	6.7964	0.339

CALCULATIONS:

(a) For acceleration due to gravity:-

(i) From line ABCD

$$L = \frac{AC+BD}{2} = \frac{60.7+50.4}{2} = 55.55\,cm = 0.5555\,m$$

$$T = 1.55\ sec$$

$$g = \frac{4\pi^2 L}{T^2} = \frac{4\times(3.14)^2\times 0.5555}{(1.55)^2}$$

$$g = 9.113\ ms^{-2}.$$

(ii) From line MNP

$$L = \frac{MP+NP}{2} = \frac{60.3+55.7}{2} = 58\,cm = 0.58\,m$$

$$T = 1.55\ sec$$

$$g = \frac{4\pi^2 L}{T^2} = \frac{4\times(3.14)^2\times 0.58}{(1.55)^2}$$

$$g = 9.521\ ms^{-2}.$$

(b) For radius of gyration k

(i) From line ABEDD in the graph

$$l = \frac{AE+ED}{2} \quad \text{and} \quad l' = \frac{BE+EC}{2}$$

$$l = \frac{36+36}{2} \qquad l' = \frac{22+17}{2}$$

$$l = 36\ cm \qquad l' = 19.5\ cm$$

$$\therefore k = \sqrt{ll'} = \sqrt{36 \times 19.5}$$

$$k = 26.495\ cm$$

(ii) From line A'B'E'C'D' in the graph

$$l = \frac{A'E' + E'D'}{2} \quad \text{and} \quad l' = \frac{B'E' + E'C'}{2}$$

$$l = \frac{33+36}{2} \qquad l' = \frac{22+25}{2}$$

$$l = 34.5\ cm \qquad l' = 19$$

$$\therefore k = \sqrt{ll'} = \sqrt{19 \times 34.5}$$

$$k = 25.602\ cm$$

Percentage error:

$$\% \text{ error} = \frac{\Delta g}{g} \times 100$$

$$= \frac{9.8 - 9.521}{9.8} \times 100$$

$$= 2.84\ \%$$

Log error :-

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

$$\log g = \log 4 + 2\log\pi + \log L - 2\log T$$

$$\log g = \log L - 2\log T$$

For maximum error

$$\log g = \log L + 2\log T$$

$$\frac{\Delta g}{g} = \frac{\Delta L}{L} + \frac{2\Delta T}{T}$$

$$\frac{\Delta g}{g} = \left(\frac{0.005}{0.58} + \frac{0.0002}{1.55}\right)$$

$$\Delta g = (0.0086 + 0.00012) \times g$$

$$\Delta g = 0.00872 \times 9.521$$

$$\Delta g = 0.083\ ms^{-2}$$

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