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

Name	: Md. Arif Hossain.
Roll No	: 201628007.
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Group	: 03.
Signature of Teacher	:

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

Submitted by

Name : Md. Arif Hossain.
Roll : 201628007.
Session: L-01 ; T-01.
Dept. : Nuclear Science and Engineering (NSE).

Abstract:

The compound pendulum is a very easy and useful technique for determination of the value of 'g' acceleration due to gravity. The experimental value of g was found 1008.89 cm/s^2 with the help of compound pendulum. The standard value of g is 981 cm/s^2. So, ~~there~~ is a percentage of error of 2.79 %. This technique is very useful to determine the value of g.

Introduction: The term 'Compound pendulum' means a rigid body with distributed mass able to freely pivot about a ~~bo~~ horizontal axis which does not coincide with ~~the~~ centre of gravity. [1]. It has several uses. It is an important for determination of 'g' acceleration due to gravity, Time period means for one complete cycle, the number of swings. The time period depends on the ~~the~~ length of the pendulum and also to a slight degree on the amplitude, the width of the pendulum's swing. [2]. Using this and the centre of oscillation and time-period, we can determine the the value of 'g', acceleration due to gravity, The process of ~~the~~ compound pendulum for determination of 'g' accelaration due to gravity is very useful and easy method.

Theory : $\boxed{3}$ Compound pendulum is a rigid body of any shape free to turn about a horizontal axis. In the figure, G is the centre of gravity of the pendulum of mass M, which performs oscillations about a horizontal axis through O. When the pendulum is at an angle θ to the vertical, the equation of motion of the pendulum is $I\omega = mgl\sin\theta$ where ω is the angular acceleration produced, l is the distance OG and I is the moment of inertia of the pendulum about the axis of oscillations. For small amplitude of vibrations, $\sin\theta = \theta$, so that

$I\omega = mgl\theta$.

Hence the motion is simple harmonic, with period of vibrations,

$$T = 2\pi\sqrt{\frac{I}{mgl}}.$$

If k is the radius of gyration of the pendulum about an axis through G parallel to the axis of oscillation through O, from the parallel Axes Theorem,

$I = M(k^2+l^2)$, so,

$$T = 2\pi\sqrt{\frac{k^2+l^2}{gl}} = 2\pi\sqrt{\frac{\frac{k^2+l^2}{l}}{g}} \quad \text{——} (1)$$

Since, the periodic time of a simple pendulum is given by $T = 2\pi\sqrt{L/g}$, the period of the rigid body is the same as that of simple pendulum of length, $L = \frac{k^2+l^2}{l}$ ——— (2)

This length L is known as the length of the simple equivalent pendulum. The expression for L can be written as a quadratic in (l), Thus from (2),

$$l^2 - lL + k^2 = 0 \quad \text{———} (3)$$

This gives two values of l for which the body has equal times of vibration, From the theory of quadratic eqn's

$$l_1 + l_2 = L \text{ and } l_1 l_2 = k^2$$

As the sum and products of two roots are positive, the two roots are both positive. This means that there are two positions of the centre of suspension on the same side of C.G. about which the periods (T) would be same. Similarly there will be two more points of suspension on the other side of the C.G., about which the time periods (T) will again be the same. Thus, there are altogether four points, two on either side of the C.G. about which the time period of the pendulum are the same (T). The distance betn two such points, assymetrically situated on either side of the C.G., will be the length (L) of the simple equivalent pendulum. If the length OG in figure is l_1 and we measure the length $GS = k^2/l_1$ along

OG produced, then obviously $\frac{k^2}{l_1} = l_2$ or, $OS = OG + GS = l_1 + l_2 = L$. The period of oscillation about either O or S is the same.

From the expression $T = 2\pi\sqrt{\frac{L}{g}}$ we get,

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

By finding L graphically, and determining the value of the period T, the acceleration due to gravity (g) at the place of the experiment can be determined.

Apparatus: A bar pendulum, a small metal wedge, a compass, stop-watch etc.

Figure:

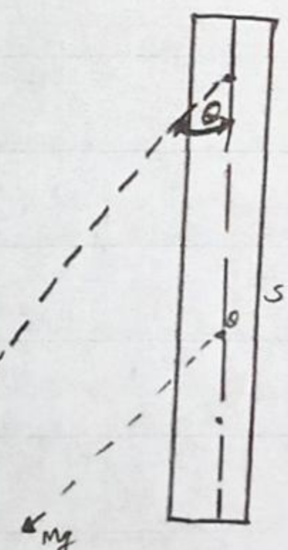
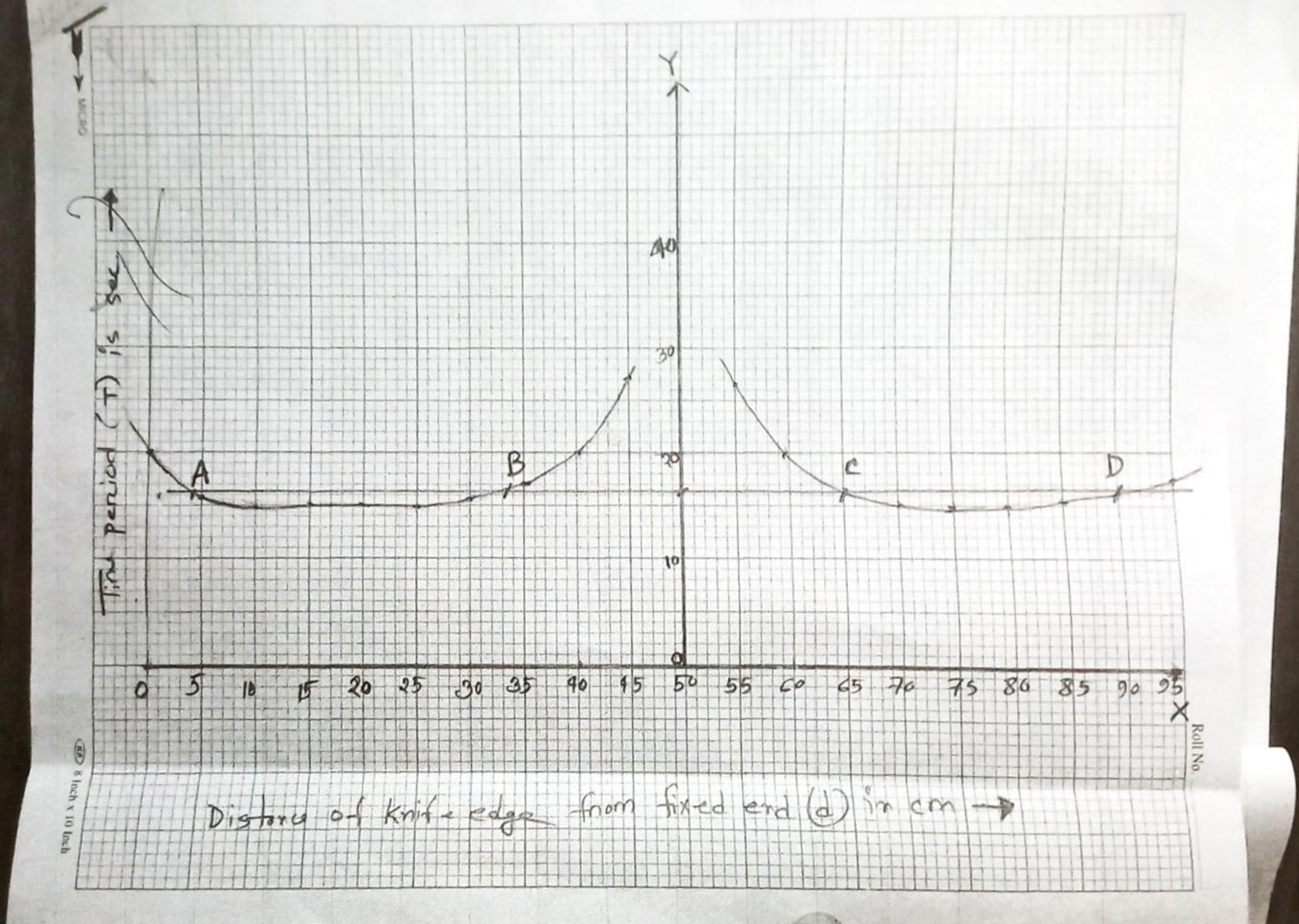


Figure: A compound pendulum.

Experimental data: Table for observation data to determine 'g'.

At the top	Hole no.	Distance from 'A' (cm)	Time for 10 oscillations (s)	Time period 'T' (s)
End	01.	5	15·75	1·575
A	02.	10	15·67	1·567
	03.	15	15·50	1·55
	04.	20	15·17	1·517
	05.	25	15·10	1·51
	06	30	15·91	1·591
	07	35	17	1·7
	08	40	19·56	1·956
	09	45	27	2·7
End B	11	55	26·67	2·667
End	12	60	19·5	1·95
B	13	65	16·72	1·672
	14	70	15·80	1·58
	15	75	15·10	1·51
	16	80	14·80	1·48
	17	85	15·44	1·544
	18	90	15·57	1·557
	19	95	15·87	1·587


Time period (T) is sec →
Y
X
A
B
C
D
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
10
20
30
40
Distance of knife edge from fixed end (d) in cm →
Roll No.
MICRO
8 Inch x 10 Inch

Discussion : In the experiment, the percentage of error is 2.76 %. So, there may have been some mistakes while conducting the experiment. Such as —

(i) Distances are to be measured from the end 'A' more correctly.

(ii) In measuring time, an accurate stop-watch should be used.

(iii) Graph paper used should have sharp lines and accurate squares and should be sufficiently large to draw smooth and large curves.

(iv) Amplicude of the oscillations musta not be more than 5°.

(v) The oscillations should be counted more correctly and acqurately.

(vi) Error due to the yielding of support, air resistance, irregular knife-edge should be avoided.

(vii) During oscillations, there may have arised some error due to the frictions.

Conclusion: The compound pendulum is one of the useful techniques for determination of the value of g acceleration due to gravity. The value of g acceleration due to gravity by this experiment is found 1008.89 cm/s^2 with an error 2.79 %. It finds ~~the~~ almost correct value of g acceleration due to gravity withing a short time and easily.

References:

[01] http://www.tech.plym.ac.uk/compound pendulum.

[02] http://www.physics.nisen.ac.in/lab manuals/compound pendulum.

[03] Giasuddin Ahmed and Shahabuddin, "Practical Physics" page-(78-80).

Name: md. Anif Hossain.
Roll: 2016 28007.

Name of the experiment: Determining the value of 'g', acceleration due to gravity, by means of a compound pendulum.

Working formula:

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

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

Apparatus: A Bar pendulum, a small metal wedge, a compass etc.

Experimental data:

Data for compound pendulum oscillation

Table-01: ~~Recording observation data to determine~~ 'g'.

At the Top	Hole no.	Distance from 'A' cm	Time for 10 oscillations (s)	Time period 'T' (s)
End A	1	5	15.75 sec	1.575
	2	10	15.67 sec	1.567
	3	15	15.50 sec.	1.55
	4	20	15.17	1.517
	5	25	15.10	1.510
	6	30	15.91	1.591
	7	35	17	1.7
	8	40	19.56	1.956
	9	45	27	2.7

At the top	Hole no.	Distance from 'A' (cm)	Time for 10 oscillations (s)	Time period 'T' (s)
End B	11	55	26.67	2.667
End B	12	60	19.5	1.95
	13	65	16.72	1.672
	14	70	15.80	1.58
	15	75	15.10	1.51
	16	80	14.80	1.48
	17	85	15.49	1.549
	18	90	15.57	1.557
	19	95	15.87	1.587

Calculation: (For graph)

Mean length, $L = \frac{AC + BD}{2}$

$= \frac{60 + 55}{2}$ cm

$= 57.5$ "

Hence,

AC = 60 c

BD = 55 c

Corresponding time period from the graph, T = 1.5

$\therefore g = 4\pi^2 \times \frac{57.5}{(1.5)^2} = 1008.89 \text{ cm/s}^2$

Percentage of error = $\frac{\text{Standard value} \sim \text{Experimental value}}{\text{standard value}} \times 100\%$

$= \frac{981 \sim 1008.89}{981} \times 100\%$

$= 2.76\%$

Result: The value of 'g' is 1008.89 cm/s² an error of 2.76%.