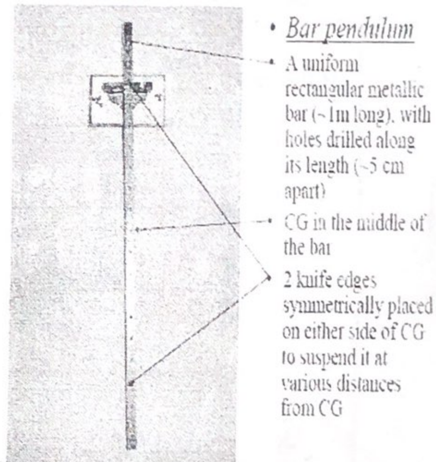
Section: G Group: 01 Trimester: Spring 25 Date of Submission: ______________

Experiment No. 02

Name of the Experiment: Determination of the value of the Acceleration due to Gravity (g) with the help of a compound (bar) pendulum.

Theory:

Compound pendulum is a rigid body of any shape free to turn about a horizontal axis. (See figure)



The time period (T) of a compound pendulum is given by,

$$T = \sqrt{\frac{K^2 + l^2}{gl}} \quad \ldots\ldots\ldots (1)$$

where,
l = the distance of the point of suspension from the center of gravity,
K = Radius of gyration of the pendulum about an axis passing through the Center of Gravity (C.G.)

Since the periodic time of a simple pendulum is given by $T = \sqrt{\frac{L}{g}}$, the period of the rigid body (compound pendulum) is the same as that of a simple pendulum of length,

$$L = \frac{l^2 + K^2}{l} = l + \frac{K^2}{l} \quad \ldots\ldots\ldots (2)$$

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 equation (2),

$$l^2 - lL + K^2 = 0 \quad \ldots\ldots\ldots (3)$$

By solving the above equation, the two distinct roots obtained will be l_1 and l_2 for which the body has equal times of vibration. From the theory of quadratic equations,

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

As the sum and the products of two roots are positive, the two roots are both positive. This means that there are two positions of the center of suspension on the same side of C.G. about which the periods (T) would be the same. On the other side of the C.G., similarly there will be two more points of suspension, 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 periods of the pendulum are the same (T). The distance between two such points, asymmetrically situated on either side of the C.G., will be the length (L) of the simple equivalent pendulum. If the period of oscillation about these points are T, then from the expression, $T = \sqrt{\frac{L}{g}}$, we get,

$$g = 4\pi^2 \frac{L}{T^2} \quad \ldots\ldots\ldots (4)$$

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 measured.

Apparatus:

- Bar pendulum
- Meter scale
- Stop watch

Experimental Data:

(A) Determination of the Period (T) and Distance (d) of the knife-edge from one fixed end

At the top	Hole no.	Distance of knife-edge (d) from the fixed end (cm.)	Time of 10 oscillations (sec.)	Mean time taken (sec.)	Time period T (sec.)
On one side of C.G.	1	10	19:60 19:50	19.55	1.955
	2	15	17:15 17:21	17.18	1.718
	3	20	15:79 15:69	15.74	1.574
	4	25	15:33 15:41	15.37	1.537
	5	30	15:38 15:48	15.43	1.543
	6	35	15:37 15:53	15.45	1.545
	7	40	15:72 15:90	15.81	1.581
	8	45	16:09 16:04	16.06	1.606
On other side of C.G.	1	10	19:08 19:08	19.08	1.908
	2	15	16:83 16:80	16.82	1.682
	3	20	15:75 15:85	15.80	1.580
	4	25	15:44 15:31	15.375	1.5375
	5	30	15:33 15:13	15.23	1.523
	6	35	15:39 15:33	15.36	1.536
	7	40	15:90 15:70	15.8	1.58
	8	45	16:15 16:03	16.09	1.609

(B) Determination of the value of 'g' from graph

No. of Obs.	Length AC (cm.)	Length BD (cm.)	Length of Eq. Simple Pendulum, $L=\frac{AC+BD}{2}$ (cm.)	Corresponding value of time period (T) from graph (sec.)	$g=4\pi^2\frac{L}{T^2}$ (cm./sec.^{2})	Mean value of g (cm./sec.^{2})
1	59	59	59	1.56	957.11	
2	58	57	57.5	1.55	944.85	954.32
3	60	60	60	1.57	960.97	

Calculation:

$g_1=4\pi^2\frac{L}{T^2}=$ 957.11 cms^{-2}

$g_2=4\pi^2\frac{L}{T^2}=$ 944.85 cms^{-2}

$g_3=4\pi^2\frac{L}{T^2}=$ 960.97 cms^{-2}

Therefore, $g=$ 954.32 cms^{-2}

Result:

The acceleration due to gravity is, $g=$ 954.32 cms^{-2}

Discussions:

Q: What is acceleration due to gravity? What is the physical significance of acceleration due to gravity?

Acceleration due to gravity is the acceleration an object gains when it is in free full, meaning pulled towards by gravity. Acceleration is a change in velocity and velocity in turn is a measure of speed and direction of motion.

Q: What are center of suspension and center of oscillation of a compound pendulum? What is simple equivalent length?

Point in physical pendulum on line through point of suspension and center of mass which moves as if all mass of pendulum were contentrated there. Center of oscillation of compound or physical pendulum is point on line passing through the pendulum's center of mass and perpendicular to axis of rotation.

Q: If a body is released from the roof top of UIU which is 25m above from the earth surface, calculate the time required for the body to touch the ground with g you have found in this experiment.

$h = 25m = 2500$ cm $\quad g = 958.32 cms^{-2}$

$$s = \frac{1}{2} g t^2$$

$$t^2 = \frac{2 \cdot 2500}{958.32} = \frac{5000}{958.32} \approx 5.218$$

$$t = \sqrt{5.218} \approx 2.285$$

Ans : 2.28 second

Q: What are the advantages of Compound Pendulum over Simple Pendulum?

Ans : A simple pendulum is an idealized system. It's requirements like the object should be a heavy particle, Suspension string should be perfectly inextensible etc. which can't be achieved perfectly. On the other hand a compound pendulum is a rigid body of any shape capable of vibrating about a horizontal axis passing through it. So it does not have such ideal conditions. Hence it is accurate.