Experiment No. - ……

Aim/Objectives: -

To determine the acceleration due to gravity (g) using a bar pendulum (compound pendulum).

Apparatus required: -

S. No.	Name of equipment	Specifications	Quantity	Remark
1	A uniform bar pendulum	About 1 meter long with holes drilled at equal intervals along its length	1	
2	A knife edge	With a rigid wall bracket or stand	1	
3	A precise stopwatch	-	1	
4	A metre scale	-	1	
5	A spirit level	To check the knife edge is horizontal	1	

Theory: -

A **bar pendulum**, also known as a **compound pendulum**, is a rigid, uniform metal bar with several holes drilled at equal intervals along its length. It is suspended from one of these holes on a horizontal knife edge and allowed to oscillate freely in a vertical plane under the action of gravity.

Unlike a simple pendulum, the mass of a bar pendulum is distributed throughout the entire bar. Therefore, its motion depends on both the **gravitational force** and the **moment of inertia** of the bar. When the bar is displaced through a small angle and released, it performs **Simple Harmonic Motion (SHM)** because the restoring torque is proportional to the angular displacement.

By measuring the time period of oscillation for different pivot positions, the acceleration due to gravity (**g**) can be determined accurately while also understanding the concepts of rotational motion, centre of gravity, and moment of inertia.

The time period of oscillation is given by

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

where I is the moment of inertia of the bar about the axis of suspension, m is its mass, g is the acceleration due to gravity, and l is the distance from the axis of suspension to the centre of gravity.

Using the parallel axis theorem, $I = I_G + ml^2$, where $I_G = mK^2$ is the moment of inertia about the CG and K is the **radius of gyration**. Substituting this in gives the more useful working form:

$$T = 2\pi\sqrt{\frac{K^2 + l^2}{gl}}$$

Comparing the compound pendulum formula with the simple pendulum formula T = 2π√(L/g), we can define:

$$L = \frac{K^2 + l^2}{l} = l + \frac{K^2}{l}$$

This L is called the **length of the equivalent simple pendulum** — a simple pendulum of this length would oscillate with exactly the same time period as the bar. Rearranging the formula gives the equation to determine the acceleration due to gravity:

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

Experimental Set-up: -

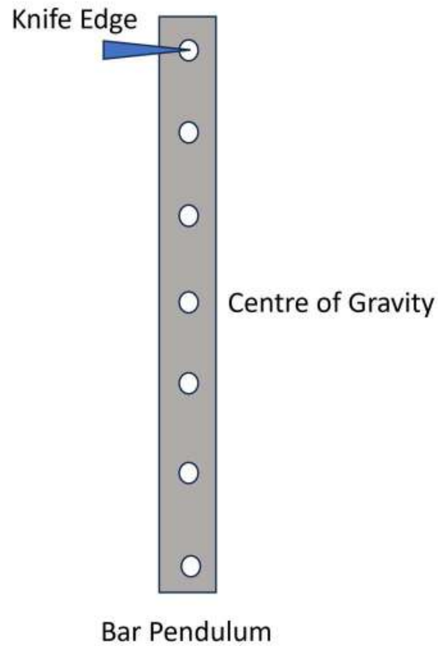

Figure 1: Schematic diagram of the Bar Pendulum setup.

Experimental Procedure: -

1. Find the **centre of gravity (C.G.)** of the bar pendulum by balancing it horizontally on a knife edge. Mark the C.G. point.
2. Fix the knife edge firmly on the wall bracket.
3. Suspend the bar pendulum from the first hole near one end using the knife edge.
4. Give the pendulum a small angular displacement and release it gently. Allow it to oscillate freely in a vertical plane.
5. Wait until the oscillations become steady. Then measure the time taken for **20 complete oscillations** using a stopwatch.
6. Measure the distance $l$between the point of suspension and the centre of gravity using a metre scale.
7. Repeat the same procedure for each hole on both sides of the centre of gravity.
8. Calculate the **time period (T)** for one oscillation for each hole using:

$$T = \frac{\text{Time for 20 oscillations}}{20}$$

9. Plot a graph with **distance coordinate** on the **X-axis** and **time period (T)** on the **Y-axis**.
10. Draw a horizontal line parallel to the X-axis so that it intersects the graph at four points.
11. Measure the distances **AC** and **BD** from the graph.
12. Calculate the effective length using:

$$L = \frac{AC + BD}{2}$$

13. Read the corresponding value of the **time period (T)** from the graph.
14. Calculate the **acceleration due to gravity (g)** using the given formula.
15. Compare the experimental value of **g** with the standard value and record the result.

Observation Table: -

Least count of the stopwatch: ……… seconds

Total number of oscillations recorded per hole: ……….

Hole No.	Distance of point of suspension from CG, l (cm)	No. of Oscillations	Time for 20 Oscillations, t (s)	Time Period, T = t/20 (s)
1				
2				
3				
4				
5				
6				
7				
.				
.				

Graph: -

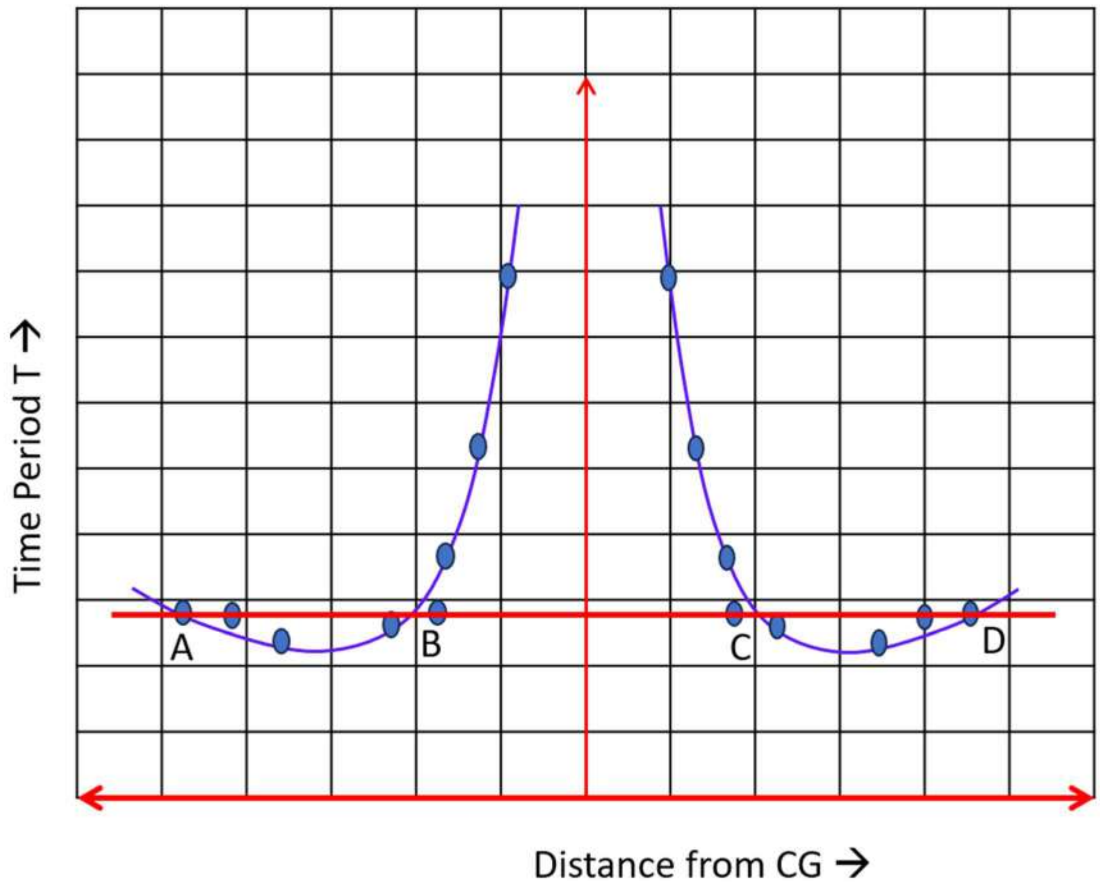

Figure: Graphical representation of Time Period (T) vs. Distance Coordinate

Calculations:

From the plotted graph:

$L = \frac{AC+B}{2}$ = ……. and

T = ………………… (Value of T at the point of intersection of drawn horizontal line at the axis along time period)

Calculation for 'g':

Using the formula: $g = \frac{4\pi^2 L}{T^2}$

Substituting the obtained graphical values:

g = …………..

Results

The acceleration due to gravity (g) determined experimentally using the bar pendulum is found to be ………… cm/s² (or ……… m/s²).

Percentage Error: -

$$\% \, Error = \frac{Calculated\, Value - Standard\, Value}{Standard\, Value}$$

$$= \ldots\ldots\ldots\ldots$$

Precautions: -

- The pendulum should be displaced through an angle less than **5°**.
- The knife-edge should be sharp, clean, and free from rust.
- Oscillations should occur in only one vertical plane.
- Timing should begin only after the pendulum starts oscillating uniformly.
- Record the time for a large number of oscillations (generally 20 or 30).
- Repeat each observation at least three times.
- Use average values for calculations.
- Measure distances carefully without parallax error.
- Ensure that the support stand remains rigid during the experiment.
- Do not apply any external force while releasing the pendulum.