Experiment No. 01

Name of the Exp: Determination of acceleration due to gravity (g), by a compound pendulum.

Theory: When a rigid body oscillates freely in a vertical plane with respect to horizontal axis then it is called compound pendulum. If the pendulum oscillates with a small angular amplitude, then it's angular velocity

$$w = \sqrt{\frac{mgl}{I}}$$

$$or, \quad \frac{2\pi}{T}\sqrt{\frac{mgl}{ml^2 + mk^2}} \quad ------(i)$$

Hence,

- $I = ml^2 + mk^2 =$ moment of inertia.
- T = Time period of the pendulum.
- m = Mass of the pendulum.
- l = Distance between the point of oscillation and the center of mass.
- k = Radius of gyration of the pendulum with respect to horizontal axis pass
- through the center of mass.
- g = acceleration due to gravity of the place.

Squaring equation (i) we get

$$\frac{4\pi^2}{T^2} = \frac{mgl}{m(l^2 + k^2)}$$

$$or, \quad l^2 = \frac{T^2 g}{4\pi^2} l + k^2 = 0 \quad ------(ii)$$

Equation (ii) is a second order equation. So, l has two values, l_1 & l_2

Therefore,

$$l_1 + l_2 \frac{T^2 g}{4\pi^2} \quad \& \quad l_1 l_2 = k^2$$

As addition and multiplication of l_1 & l_2 are both positive, so l_1 & l_2 both positive, so l_1 & l_2 both are positive.

Let, the equivalent distance between two points of a simple pendulum, $L = l_1 + l_2$

Therefore,

$$T = 2\pi\sqrt{\frac{l_1+l_2}{g}}$$

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

$$or,\ g = \frac{4\pi^2 L}{T^2} \quad -----(iii)$$

Determining the value of $L = l_1 + l_2$ & T from the graph, we get the value of g.

Apparatus:

1. A compound pendulum.
2. Stopwatch.
3. Telescope.
4. Meter scale.
5. Knife edge.
6. A piece of wood.

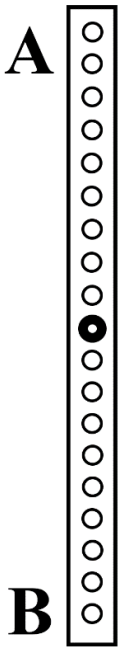
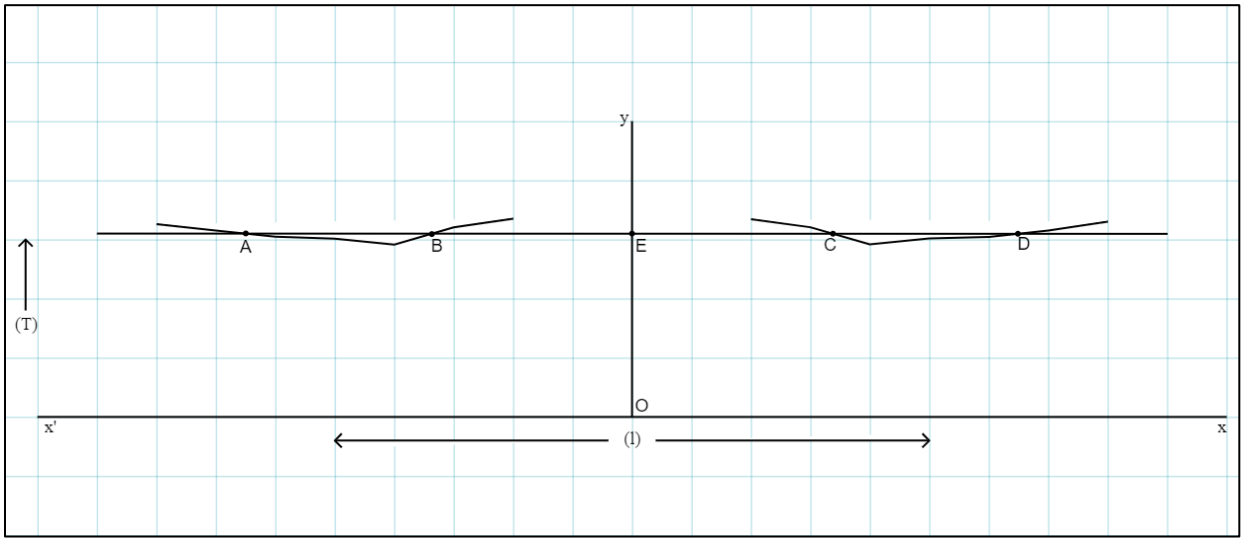


Fig. A Compound Pendulum

Table 1 (Determination of *l* & *T*)

Side	No. of hole with respect to center of mass	Distance of hole from the center of mass	Time for 20 oscillations (t sec)			Time period $T = \frac{t}{20}$ sec
			1st	2nd	Avg t sec	
A	9	45	33.03	32.85	32.94	1.647
	8	40	31.56	31.70	31.63	1.581
	7	35	30.53	30.47	30.50	1.525
	6	30	30.12	30.05	30.08	1.504
	5	25	29.22	29.15	29.18	1.459
	4	20	32.02	32.12	32.07	1.603
	3	15	33.62	33.55	33.58	1.679
B	9	45	32.75	32.80	32.77	1.638
	8	40	31.45	31.62	31.53	1.576
	7	35	30.44	30.51	30.47	1.523
	6	30	30.15	30.13	30.14	1.507
	5	25	29.19	29.23	29.21	1.460
	4	20	32.13	32.07	32.10	1.605
	3	15	33.54	33.59	33.56	1.678

Graph for (*l* ~ *T*)



For, 1 unit of (x) in graph = 1 unit. & For, 1 unit of (y) in graph = 10 unit

Procedure:

1. At first, we determined the center of mass of the metal plate keeping it on the knife edge.
2. We determined the distance of the holes of A & B sides from the center of mass.
3. Pulling the bar to any side with an angle ($\theta<5°$) and after leaving it oscillates. Now we determine the time of 20 oscillations and dividing the time by 20 we get time period *T*.
4. Like this, entering the knife edge in the hole in 8,7 and 6 so on, we determined time period *T*.
5. Following the same procedure, we determined time period for *B* side.
6. Now establishing the distance on X axis and time (*T*) on Y axis we got same graph on both sides.
7. Then drawing a parallel line of X as it intersects the graph on A, B, C and D and on Y axis on E.

From the graph, we get

$$AC = l_1 + l_2 = 32.5 + 17 = 49.5cm$$

$$and\ \ BD = l_1 + l_2 = 32.4 + 16.9 = 49.3cm$$

$$Therefore,\ \ Avg, \frac{l_1 + l_2}{2} = \frac{49.5 + 49.3}{2} = 49.4cm = L$$

Using the value in Equation (*iii*) we get

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

$$= 4\pi^2 \frac{49.4}{1.55^2} = 811.75$$

Result: We got the value of acceleration due to the gravity.

$$g = 811.75cms^{-2} = 8.12ms^{-2}(almost)$$

Precautions and Discussion:

1. The angular amplitude of the pendulum was taken within 5°.
2. The stopwatch was used correctly to determine the time period.

3. The knife edge was hanged horizontally.
4. The pendulum was taken at that place where the air resistance was lesser.
5. The graph paper was neat and clean.