Compound Pendulum

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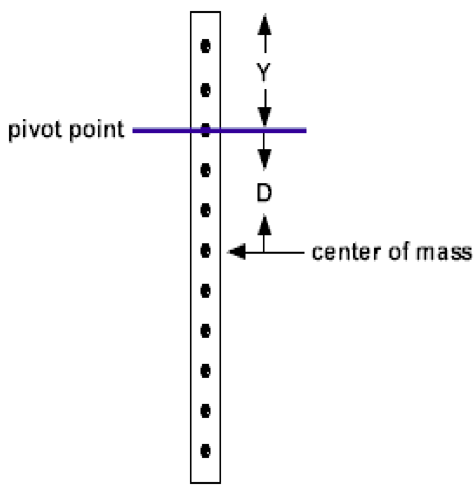
Objective:

1.To determine the value of acceleration due to gravity by using the compound pendulum

Basic Principle:

A compound pendulum or physical pendulum is a rigid body which is suspended from one end and the other is free to rotate. Unlike Simple Pendulum, where the whole mass is concentrated at the bob of the pendulum, in compound pendulum the whole mass is distributed over the entire body. Simple pendulum is a special case of compound pendulum where all the mass is concentrated in bob and the string is massless. Bar pendulum is an example of compound pendulum which is composed of rod of length one meter and has 19 equally spaced holes. The distance between the two holes is 5 centi-meter



In the given figure we can see a bar pendulum with center of mass and a pivot point. Now let say the bar pendulum is supported at one end and the other end make free to rotate. If the bar is given a small jerk, it will start pushing at that side until it reaches a maximum height. After this the body weight will come into action and a restoring torque will be produced which will push the body toward the mean body. The restoring torque produced will be the cross product of the perpendicular distance from the pivot point to the end of the rod and the end of the rod. The figure below demonstrates the whole process.

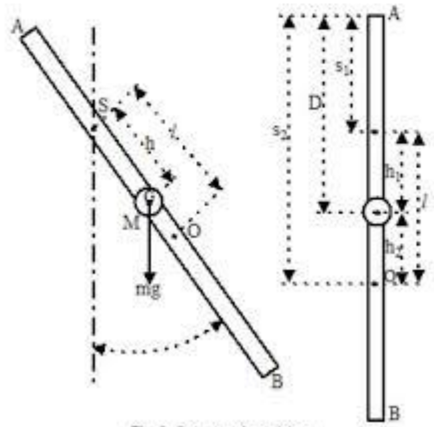


Fig. 1. Compound pendulum

The torque produce in the rod is just given by

$$\tau = -mglsin\theta \quad ....1$$

Also, we know that;

$$\tau = I\alpha \quad .....2$$

Combining the two equations we have;

$$I\alpha = -mglsin\theta .....3$$

$$Id\theta^2/dt^2 = -mglsin\theta$$

Where I is the moment of inertia through the axis A. For very small angles we know that sin of angle = angle so,

$$Id\theta^2/d^2t = -mgsin\theta ....4$$

Eq (3) is representing the simple harmonic motion. The time period of the oscillation is just given by the following equation:

$$T = 2\pi\sqrt{I/mgl} ...5$$

By parallel axis theorem we have $I=I_G + ml^2$. Inserting the value of I in the equation we finally get a relation for the time period which is just similar to the equation yield by a Simple Pendulum.

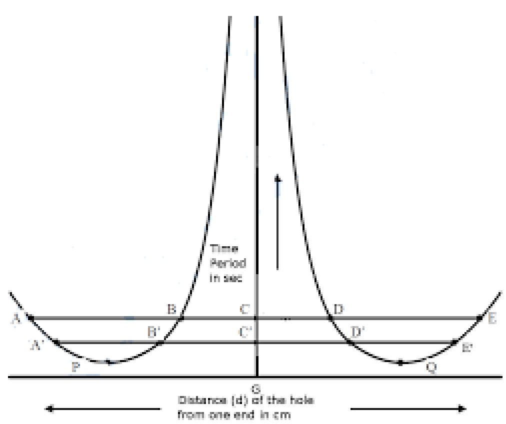
$$T = 2\pi\sqrt{L/g} ...6$$

The length L for a bar pendulum can be founded by plotting the graph for the both sides of the both sides of the bar pendulum and finding the two lengths add them and we get L.

$$L = l_1 + l_{2.}$$

Procedure:

1. Take the bar pendulum. Number the holes from 1-19. The 10th hole will be the C.g hole. Lable one end of the pendulum as A and other, end as B.
2. Suspend the bar pendulum from the first hole through inserting the knife edge at the hole 1 and fix it on the support. The end B is free to rotate now. Make sure that the end B is lying straight down the end A.
3. Now give the bar pendulum a small jerk through 5°and note down the time for twenty oscillations with the help of stopwatch.
4. Now insert the knife edge in the hole 2 and note down the time for twenty oscillations. Repeat the same procedure till the 9th hole.
5. After that insert the knife edge in the hole number 19 and fix it on the G-clamp. In this way the end B will become fix and the end A will be free to rotate.
6. Note down the time periods for twenty oscillations till 11th hole.
7. Measure the distances(d) of each hole from the axis of rotation in each case with the help of Meter Ruler and note down it.
8. Draw a graph of the distances (d) and the time period of all the holes. The distance d will be on x-axis and time period on y-axis. The y-axis should touch the graph at the center of gravity hole distance i.e at the half. The nature of the graph will be some like that given below:



Draw a horizontal line as shown in the graph. There will be four points of intersection as here are A, B, D, E. Find the distance AB and DE. Take their average and this will give you the length L used in the equation of the time period.

Find also the time period with respect to these points on the y-axis and compute the value of g.

Draw several horizontal lines on the graph. Find the value of g for each and the compute the mean value of g.

Table 1 for data of d-T graph.

Number of Hole.	Distance d of the hole from on end(cm)	Time period t for twenty oscillations.	Mean value of t.	Time period T. T=t/20
1				
2				
3				
4				
5				
6				
7				
8				
9				
10	-------------------	--------------------	--------------------	--------------------
11				
12				
13				
14				
15				
16				
17				
18				

TABLE 2 TO FIND VALUE OF g:

Number of Observation and line.	L(cm)	T(s)	$g=4\pi^2 L/T^2$	Mean g (cm/s^2)
1.ABDE	L=AB+DE/2			

%error= $\frac{g-9.81}{9.81} * 100$.

Precautions:

1. Make sure that there is no rotational motion associated with the pendulum.
2. The jerk should be very small and of very small amplitude up to 5°.
3. Stopwatch should be precise and maximum effort shall be made to make time reading accurate.
4. The air resistance shall be negligible in the experimental area.