SIMPLE PENDULUM

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Abstract

Simple Pendulum is the most basic experiment of mechanics at school level which deals with concept of gravitation, conversion of energy, phenomenon of oscillation etc. This experiment also deals with concept of measurement.

Introduction: A *simple pendulum* consists of a point mass m suspended from a string of negligible mass and length l. Its other end is fixed to a rigid support O. For small displacements from the equilibrium position (shown in the Figure 1), the point mass m executes simple harmonic motion with time period, T (time taken for one oscillation):

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where g is the acceleration due to gravity.

Apparatus: Pendulum bob, cork divided into two halves, rhetort stand, fine cotton thread, stop clock, meter scale.

Procedure:

1) Determine the least count of vernier scale, micrometer screw gauge and the clock

a) Least count of vernier:= ____________________________

b) Least count of micrometer screw gauge:= ________________

c) Least count of the stop-clock = ______________

[This step is to understand how different instruments have least counts of different kinds. Even though the basic equation is same for all the instruments, it is better if students are exposed to the concept of least count and the usage of vernier scale. If possible teachers can even expose the students to the idea of different measurements of the same object, when carried out repeatedly]

2) Measurement of length of the pendulum:

a) *Radius of the bob*:

Trial No.	Diameter
1	
2	
3	
4	
5	

Average diameter, D = _______________

Average Radius, r = _______________

3) Take a long string and pass one end through the hook of the bob and the upper end through the cork which is held by the clamps of the stand. Adjust the length of the pendulum, L_1.

[Here students tend to take a short cut where they tie the thread to the rhetort stand rather than the cork. It leads to a situation where the point of suspension of the thread is not stationary and fixed. However, if the thread is passed through a cork slit, then this point is fixed in location. Thus measurement of length of string will be measured error free.]

4) Allow the pendulum to oscillate by a small distance (amplitude) in one single plane.
[Students usually tend to bring in the concept of angle $\theta \leq 15^\circ$. But this is not a sacrosanct number. It can be established that smaller the angle better is the approximation $\theta \approx \sin\theta$ and hence even small angles of θ around 5° is a very good oscillation. It is essential to understand that $\theta \leq 15^\circ$ is kind of an upper limit.]

5) Determine the time period t_1 for N oscillations (N >10) in 3 trials and calculate the average time t.

[If one takes a reading for 45 oscillations and 3 readings of 15 oscillations each, are the two situations same? It is up to the reader to determine the difference between two situations]

6) Repeat step 3, 4, and 5 for total of 6 more different lengths (L_2, - L_7) and respective 6 different oscillation times (T_2, - T_7).

Obs. No.	Length of the String l cm	Length of the pendulum	Time for N = ______oscillations				Time Period, $T = \frac{t}{N}$
			t_1 **(s)**	t_2 **(s)**	t_3 **(s)**	Mean t (s)	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

[In order to understand a linear or non-linear relationships between two different variables, it has been established that at least 7 data points are required to study the behavior with confidence. Teacher should observe the way students start counting their oscillations. It is a good practice that same person should operate the pendulum and the stop-watch. Coordination between two different people can introduce some random delays. On many occasions students are not clear on the concept oscillation. Teachers have to ensure that student consider a full cycle as oscillation, i.e. If the bob begins oscillation from a mid point, the bob travels to one extreme position, then to the next extreme position and the oscillation is complete when bob returns to the mid point.]

8) Calculations:

Obs. No.	Length L in cm	Time Period, T in s	T^2
1			
2			
3			
4			
5			
6			
7			
8			
9			

10			

Q1) Draw a graph between time period T and length L

Q2) Draw a graph between T and L^2

Q3) Draw a graph between L and T^2

Q.4) Draw a graph between T and $\sqrt{L}$

Q5) Which of the 4 graphs shows a linear relationship?

[If time permits, it is a good idea to see what the four graphs look like. If the equation is not know then it would be the way to identify the relationship between time period and length of pendulum. Also if vernier and micrometer are both available then students can be asked the reason for choosing micrometer to measure the diameter of the bob. It is not accuracy but the convenience of holding the bob. Otherwise the least count of instrument to measure length of the string is much larger than the accuracy that can be established by measuring the diameter of bob by micrometer screw gauge.]

Q6) If $T=2\pi\sqrt{\frac{l}{g}}$, then which graph can be used to obtain the value of g?

Q7) Obtain the value of g.

Q8) What does the intercept of your graph represent?

Q9) If the length of the string was equal to $\frac{L_3+L_4}{2}$, how much would be the time period?