Kuwait University	Course 125 Phys. Lab. I
Physics Department	Experiment 10: Simple Pendulum

Objectives

- To determine the acceleration due to gravity by a simple pendulum.
- To study the relation between the length and the period of the simple pendulum.

Equipment to be used

- Experimental setup: 1 m stand, massless string, a spherical mass or bob (Figure 1)
- Measuring devices:

  meter scale or ruler

  stop watch

References :

Douglas C. Giancoli, Physics Principles with applications, Thrid Edition, Chapter 16.

Theory

The motion of a simple pendulum repeats itself at regular time intervals and therefor it is called a **Periodic** or **Harmonic Motion**. This physical system consists of a particle of mass m (called the *bob* of the pendulum) suspended from an unstretchable, massless string of length L as shown in Figure 1. The bob is free to swing back and forth in the plane of the page, to the left and right of a vertical line through the point at which the upper end of the string is fixed.

The forces acting on the bob (as shown in the figure) are its weight (F_w) and the tension (T) in the string. Resolving (F_w) into a radical component ($mg\ cos\ \theta$) and a tangential component ($mg\ sin\ \theta$) that is tangent to the path taken by the bob, we get to realise that the tangential component is a restoring force. It always acts opposite to the displacement of the bob, and thus it brings the bob back toward its central location therefor:

$$T \ = \ mg\ cos\ \theta \tag{1}$$

$$F \ = \ -ma \ = \ -mg\ sin\ \theta \tag{2}$$

where the minus sign indicates that (F) acts opposite to the dicplacement. Now we know that for a small angle (θ) we have ($sin\ \theta\ = \theta$) in radians, and from the figure we see that ($sin\ \theta = x/L$) therefor from equation(2) we can conclude that:

$$a \ = \ \frac{d^2x}{dt^2} \ = \ - \ \frac{gx}{L} \tag{3}$$

Solving this second order ordinary differential equation we find that for such motion, the displacement x of the bob from its origin is given as a function of time by:

$$x \ = \ x_m\ cos\ (\omega t \ + \ \phi) \tag{4}$$

Where (x_m) is a constant representing the maximum amplitude of the motion, (ω) is a constant representing the angular frequancy of the motion measured in radians per second:

$$\omega \ = \ 2\pi f \ = \ \frac{2\pi}{T} \tag{5}$$

(f) is the frequancy of the motion which is a measure of number of oscillations executed by the bob in one second, and (T) is the period of the motion which is a measure of the time needed to complete a full oscillation:

$$T \ = \ 2\pi \ \sqrt{\frac{L}{g}} \tag{6}$$

From equation (6) we are going to analyze the relation between the length (L) of the pendulum and the period (T) and use it to calculate the acceleration due to gravity (g).

Procedure

A1. Set up the pendulum as in the figure with length (L) not less than 1 meter , the length should be measured from the center of the bob to the point of suspension.

A2. Move the bob from the origin position but keep (θ) very small.

A3. As soon as you release the bob, **Start the stopwatch** and **measure** the time it takes the bob to complete 20 oscillations. **Record** your data for (T_{20}) in data Table 1. (if the swing becomes elliptical you must repeat the swinging agian to be in a vertical plane).

A4. Calculate the period (T), (T^2) and (L/T^2) and **Record** your data in Table 1.

A5. Repeat steps A3 - A4 five more times for the different lengths illusterated in data Table 1.

A6. Calculate the average value of the accelaration due to gravity g using your data from (Table 1).

A7. Plot the graph of length L of the pendulum versus T^2 and use the slope to determine the value of g.

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Laboratory Assignment

1. Does the period of the simple pendulum change when the mass of the bob changes? Explaint.

2. Does the period of the simple pendulum change when the size or the amplitude of the swing is changed? Explain.

3. What could be the effect if the amplitude θ is chosen to be large?

4. Where on the figure does the bob have the highest potential energy? and where does it have the highest kinatic energy? Explain why?

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Worksheet for Experiment 10

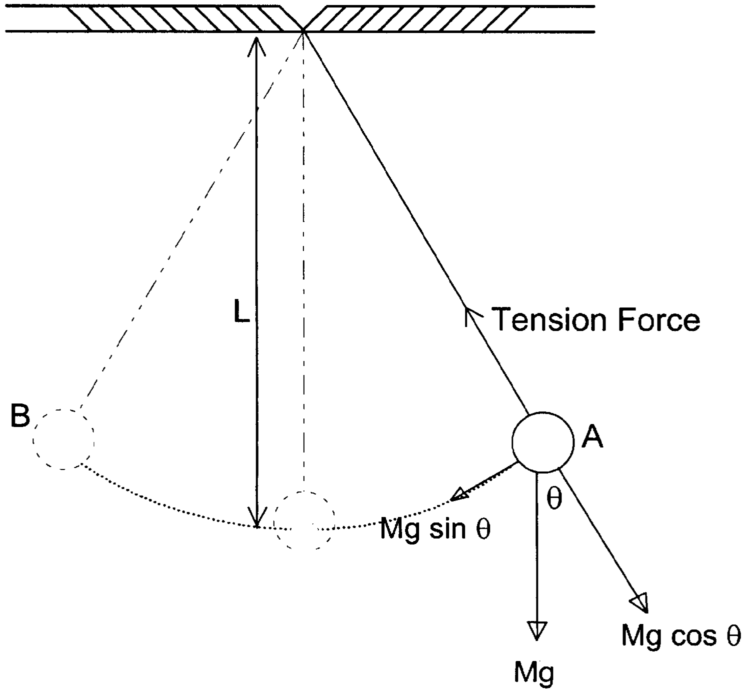
Table 1:

Length L	T_{20}	T	T^2	L/T^2	$g = \frac{4\pi^2 L}{T^2}$
1 m					
1.2 m					
1.4 m					
1.6 m					
1.8 m					
2 m					

The average value of g (from table) =....................................

The value of g (from the graph) = ...

Discussion:



L
Tension Force
B
A
θ
Mg sin θ
Mg
Mg cos θ