The Simple Pendulum

Goal:

To determine the acceleration due to gravity using the motion of simple pendulum.

Apparatus Used:

Spherical pendulum bob, long string, supporting rod (stand) and pendulum clamp, meter stick, vernier calipers and clock. Figure 1 shows a schematic diagram of the simple pendulum apparatus.

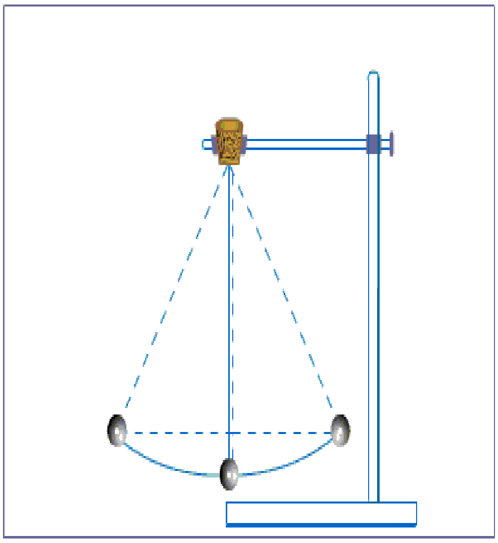

Figure1: Simple Pendulum

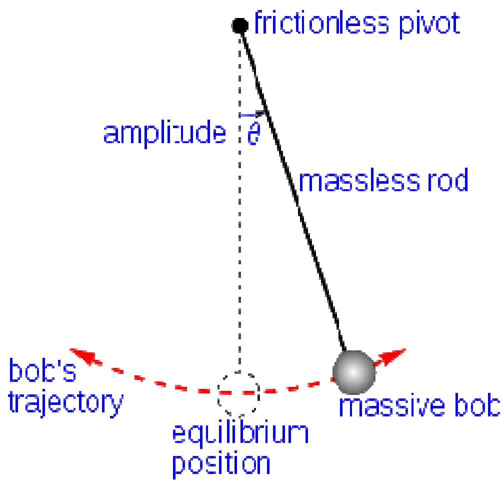

Figure2: Motion of the Simple Pendulum

Theory:

If the bob (having the mass *m*) is displaced to one side by an angle less than 15 degrees from the vertical position and then released, the bob vibrate back and forth about its equilibrium position as shown in the figure 2. The forces acting on the bob are its weight ($w = mg$) and the tension(S) in the string. The weight acts vertically and can be resolved into two components, one is acting parallel and the other is perpendicular to the string. The component of the weight perpendicular to the string is the restoring force acting on the mass, which tends to return it to its equilibrium position. Now the restoring force (F) is

$$F = -mg \sin\theta \qquad (1)$$

Where the minus sign indicates that F is in an opposite direction to the angular displacement θ. If θ is very small, then $\sin\theta \approx \theta$ .Then the equation (1) is written as

$$F = -mg\,\theta \qquad (2)$$

For small angular displacements from the equilibrium position, the restoring force is proportional to the negative displacement. Now the resulting motion of the simple pendulum is therefore a Simple Harmonic Motion.

The time period (T) of simple pendulum is the amount of time required for the pendulum to complete a full oscillation (one complete vibration), then

$$T = 2\pi\sqrt{\frac{L}{g}} \qquad (3)$$

Where, L is the length of the pendulum measured to the center of the spherical bob and g is the acceleration due to gravity.

Notice that the mass of the suspended bob does not appear in equation 3. This implies that mass of the bob does not influence the period of the oscillation. If two pendulums having the same length, standing side by side but with bobs of very different masses, they will have identical (same) periods.
Now, squaring equation (3)

$$T^2 = 4\,\pi^2\,L\,/\,g \qquad (4)$$

$$T^2\,/\,L = 4\,\pi^2\,/\,g \qquad (5)$$

Equation (5) says that, for a simple harmonic motion, the ratio of the square of its period to the length of the pendulum is a constant. This means that if the pendulum length is increased, the period will also increase.

A plot of the T^2 as a function of the L produces a straight line, for which slope is

$$\text{Slope} = 4\,\pi^2/\,g \qquad (6)$$

If we solve equation (4) for g, then we obtain

$$g = 4\,\pi^2\,L\,/\,T^2 \qquad (7)$$

Thus, the graph of the period squared against length can be used to determine experimentally the acceleration due to earth's gravity (g) near the earth's surface.

Procedure:

1. First, measure the diameter of the bob with the vernier calipers and convert into the radius of the bob. Record this value in your data sheet in meters.

2. Clamp one end of string to a rigid support in such a way that insures that the point of suspension remain fixed throughout a complete cycles.

3. Attach the other end of the string with the bob.

4. Measure the distance from the supporting point to the top of the bob, be careful not to stretch the string in measuring it. Convert this distance to meter and record it in your data sheet as the length of the string.

5. Calculate the length L of the pendulum and record it in your data sheet **(the length of the pendulum is the length of string plus the radius of the bob).**

6. Displace the bob to one side, through an angle of not more than 15°, and release it, allowing the pendulum to vibrate back and forth. On your data sheet, record the total time it takes the pendulum to make 20 vibrations. **Note: The clock should be start at the zero count and stopped at the 20 counts.**

7. Calculate the experimental time period T of the pendulum by dividing the total time by the number of vibrations; record this value on your data sheet.

8. Calculate the square of the experimental period T^2 of the pendulum and record this value on your data sheet.

9. Change the length of the pendulum (L). For example, make the length of the pendulum string 60 cm, 80 cm, 100 cm, 120 cm and 140 cm.

10. Repeat the Steps 5 – 8, and record all your results

11. Plot the graph as length of pendulum (L) on x-axis and square of time period (T^2) on y-axis, and calculate the slope of the resulted line. Record the slope value in your data sheet.

12. Use equation (7) to calculate the experimental value of g. Record this value on your data sheet.

13. The standard value of g is 9.8 m/s^2 .Calculate the percentage error in your experimental result and record it in your data sheet.

Student Name:

I D Number: Group:

ANSWER SHEET

The Simple Pendulum (acceleration *g* due to the earth's gravity):

Complete the table below:

Diameter of the bob =   cm =   m

Radius of the bob   =   cm =   m

Length of the string (m)	Length of pendulum (m)	Number of vibrations (n)	Total time (t) in second	Time period T (= n / t) in second	Square of the time period T^2(s^2)

Table:

Plot the graph L versus T^2 values according to equation (4).

The slope of the line = $\Delta T^2 / \Delta L$ =……………………….…………………………….

The acceleration g due to earth's gravity = …………………………………………….

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The percentage error =…………………………………………………………..……

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