Measurement of g: Use of a simple pendulum

Apparatus

The apparatus for this experiment consists of a support stand with a string clamp, a small spherical ball with a 150 cm length of light string, a meter stick, a vernier caliper, and a timer. The apparatus is shown in figure 1.

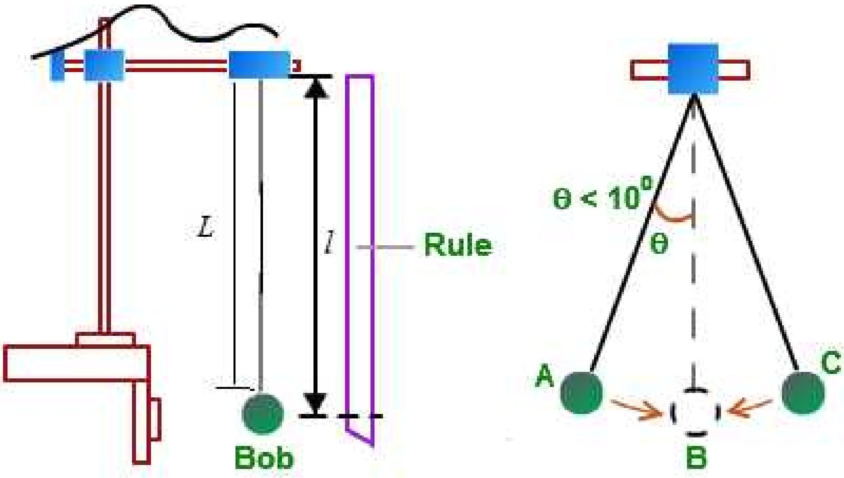


Figure 1.

Theory:

A simple pendulum consists of a small mass (a bob) attached at the end of a massless string. The smallness of the bob and the massless string assumption simplifies the mathematical solution to the problem, and with additional assumption that the amplitude of the oscillations is also small, yields the following value for the period (T) of the pendulum: $T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow T^2 = \left(\frac{4\pi^2}{g}\right)l$

Where l is the length of the pendulum, and g is $9.8\,m/s^2$. Note that pendulum's period squared T^2 is proportional to its length l. The period T for a simple pendulum does not depend on the mass or the initial angular displacement.

Procedure

(1) Measure the diameter of the ball with Vernier caliper and calculate its radius.

(2) Adjust the length of the pendulum to about .110 cm. The length of the simple pendulum is the distance from the point of suspension to the center of the ball. Measure the length of the string L from the point of suspension to the top of the ball using a meter stick. Add the radius of the ball to the string length L and record that value as the length of the pendulum: $l = L + r$.

(3) Displace the pendulum about 5^o from its equilibrium position and let it swing back and forth. Using the stop watch, measure the total time that it takes to make 20 complete oscillations. *One oscillation is the cycle of the pendulum's motion starting from its initial position, and coming back to the same position*. Then the period T for **one** oscillation is just the number recorded divided by 20.

(4) Record that time in your table, and repeating it for other pendulum lengths.

Measurements and calculations:

Diameter of the ball = d = (cm)

Radius of the ball = r = (cm)

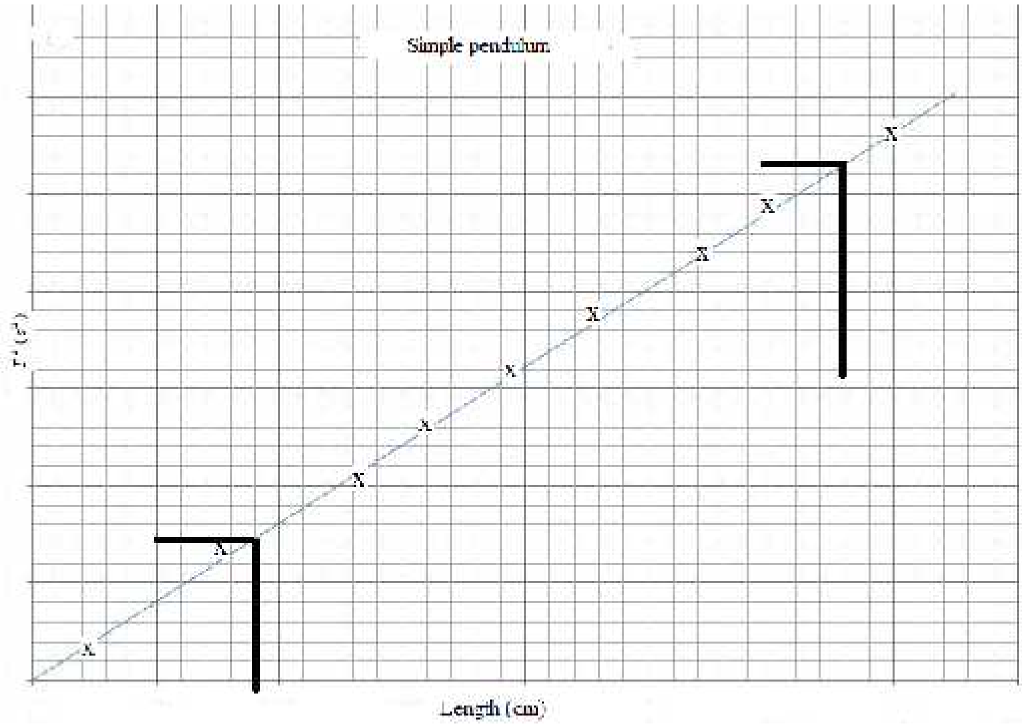
Length of the string = $l = L + r = ----$ (cm)

Length of the string l (cm)	Time taken for 20 Oscillations in seconds			Period of Oscillation (s) $T = \frac{1}{20}$	T^2 (s^2)
110	t_1	t_2	Average t		
100					
90					
80					
70					
60					
50					
40					
30					
20					

$$T = 2® \sqrt{\frac{l}{g}} \Rightarrow T^2 = \left(\frac{4®^2}{g}\right) l \qquad (1)$$

Graph:

- Using suitable scale plot a graph between l (Length along x-axis versus T^2 (time period square along the y-axis). use the best fit line for calculation of slop from the data.



- From the graph find the slop by selection two points on the straight line (not use the data point for slop calculation). $slop = p = \frac{y_2 - y_1}{x_2 - x_1}\left(\frac{s^2}{cm}\right) =$

- From equation (1), $slop = \frac{4\text{®}^2}{g}$, hence $p = \frac{4\text{®}^2}{g} \Rightarrow g = \frac{4\text{®}^2}{p} =$

Standard deviation (error propagation)

Use: $\pm_t = 0.005\,s$ and $\pm_l = 0.2\,mm$ (reading error)

$$\pm_g = g\left[\left(\frac{1}{l}\right)^2 \cdot \pm_l{}^2 + \left(\frac{2}{T}\right)^2 \cdot \pm_T{}^2\right]^{1/2}$$

$$Acceleration\,due\,to\,gravity = g \pm \pm_g =$$

$$\%\,error = \frac{\left|g_{th} - g_{\exp}\right|}{g_{th}} \times 100 =$$