

# Combining Theoretical, Simulated, and Experimental Physics

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## 1 Theoretical Prediction: Pendulum

1. A *pendulum* is a device we can use to measure the effect of gravity, and to study forces in general.
2. Let the horizontal displacement of a pendulum be  $x(t)$ , with a maximum displacement  $x_0$ , in units of cm. Further, let  $\omega$  and  $\phi$  have units of radians/s and radians, respectively. The motion of a pendulum (Fig. 1) theoretically follows Eq. 1:

$$x(t) = x_0 \cos(\omega t + \phi) \quad (1)$$

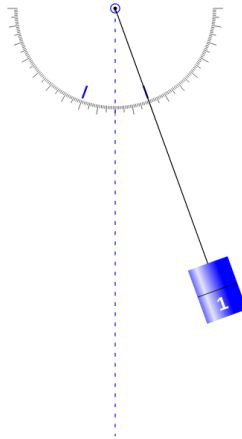


Figure 1: A pendulum is a mass  $m$  that swings on a chord of length  $L$  with angular frequency  $\omega = \sqrt{g/L}$ , where  $g$  is the acceleration due to gravity.

3. Suppose  $\phi = 0$ ,  $\omega = 2\pi/3$  rad/s, and  $x_0 = 4$  cm. (a) What is the displacement at  $t = 3/2$  seconds? (b) When is  $x(t) = 0$ ? (c) What is the maximum positive displacement?
4. The *period* of the pendulum is the time duration required to observe the pendulum return to the same state. Point your browser to the following link: <https://phet.colorado.edu/en/simulations/pendulum-lab>. Using the Intro tab of this PhET, and a spreadsheet program, create a table of the *period* of the pendulum in seconds, versus the *length* of the pendulum in centimeters. Sketch a graph of the data below.

## 2 Lab Measurement

1. Using the pendulum at your lab table, *collect the same data points as your simulation*.
2. Graph the simulated and observed period ( $T$ ) on the same graph. Add the following theoretical expectation, using  $g = 9.81 \text{ m s}^{-2}$ , and letting  $L$  be the pendulum length in *meters*.

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

3. Discuss how well your lab data, simulation data, and theoretical expectation match.