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 ω and ϕ have units of radians/s and radians, respectively. The motion of a pendulum (Fig. 1) theoretically follows Eq. 1:

$$x(t) = x_0 \cos(\omega t + \phi) \tag{1}$$

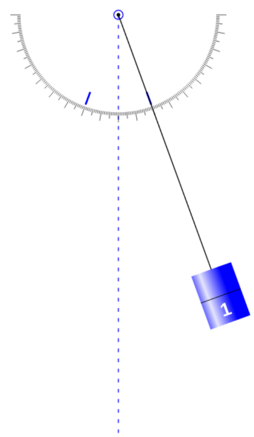

Figure 1: A pendulum is a mass m that swings on a chord of length L with angular frequency $\omega = \sqrt{g/L}$, where g is the acceleration due to gravity.

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 $g = 9.81$ m s^{-2}, and lettiong 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.