Experiment 11: Simple Harmonic Motion

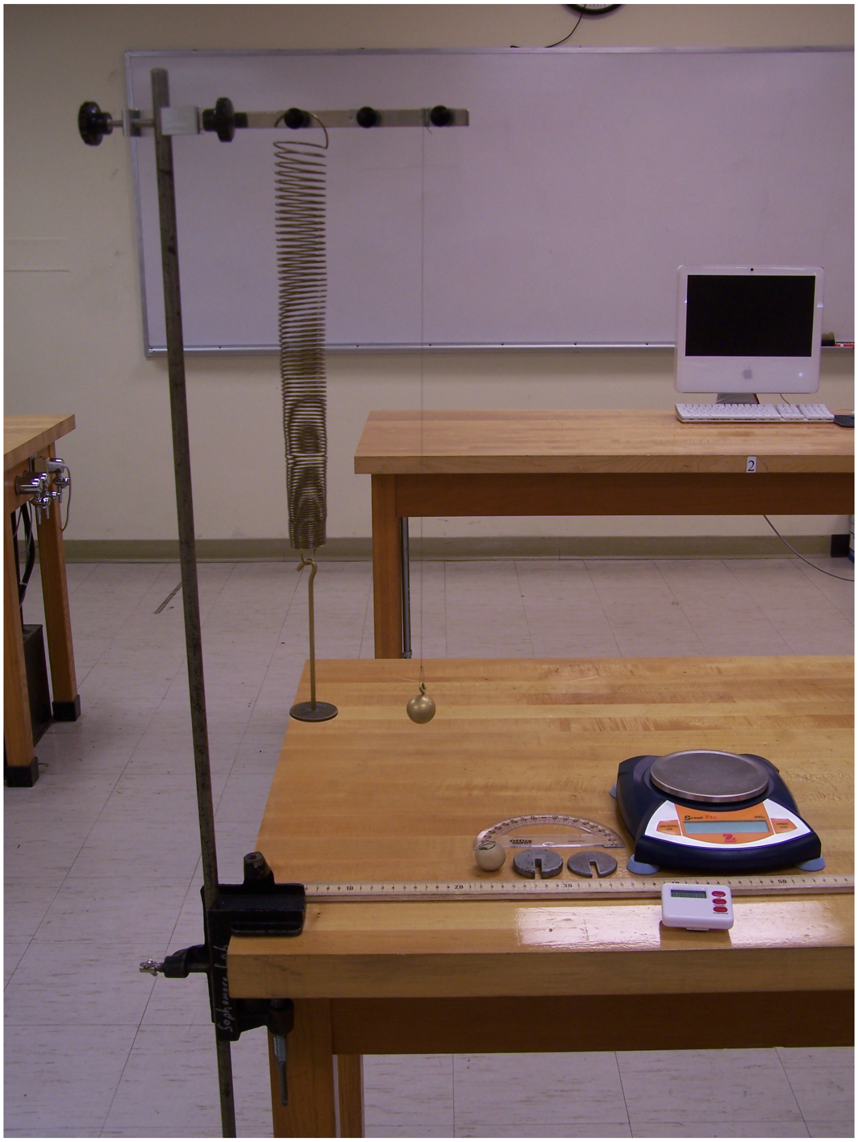

Figure 11.1

EQUIPMENT

Spring
Metal Ball
Wood Ball
(*Note: sharp hooks*)
Meter Stick
Digital Balance
Stopwatch
Pendulum Clamp and Rod
String
Masses: (2) 100g, (1) 50g
Mass Hanger
Table Clamp
Protractor

Advance Reading

Text: Simple harmonic motion, oscillations, wavelength, frequency, period, Hooke's Law.

Lab Manual: Appendix C

Objective

To investigate simple harmonic motion using a simple pendulum and an oscillating spring; to determine the spring constant of a spring.

Theory

Periodic motion is "motion of an object that regularly returns to a given position after a fixed time interval." *Simple harmonic motion* is a special kind of periodic motion in which the object oscillates sinusoidally, smoothly. Simple harmonic motion arises whenever an object is returned to the equilibrium position by a *restorative force* proportional to the object's displacement.

$$F = -kx \tag{11.1}$$

The illustrative example above is *Hooke's Law*, which describes the restorative force of an oscillating spring of stiffness k (spring constant).

For an ideal, massless spring that obeys Hooke's Law, the time required to complete an oscillation (period, T, seconds) depends on the spring constant and the mass, m, of an object suspended at one end:

$$T = 2\pi\sqrt{\frac{m}{k}} \tag{11.2}$$

The inverse of period is the frequency of oscillation. Recall that frequency, f, is the number of oscillations completed by a system every second. The standard unit for frequency is hertz, Hz (inverse second, s^{-1}).

The period of oscillation of an ideal, simple pendulum depends on the length, L, of the pendulum and the acceleration due to gravity, g:

$$T = 2\pi\sqrt{\frac{L}{g}} \tag{11.3}$$

When setting the pendulum in motion, small displacements are required to ensure simple harmonic motion. Large displacements exhibit more complex, sometimes chaotic, motion. Simple harmonic motion governs where the *small angle approximation* is valid:

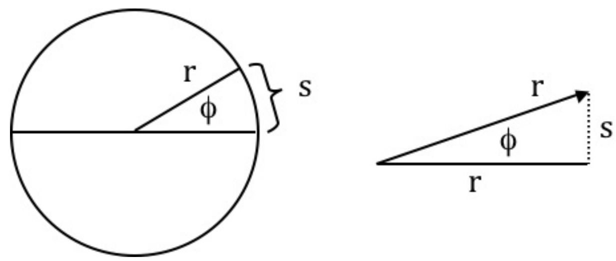

Figure 11.2: Small Angle Approximation

The arc length, s, of a circle of radius r is:

$$s = r\phi \tag{11.4}$$

When ϕ is small, the arc length is approximately equal to a straight line segment that joins the two points. Therefore, the following approximations are valid:

$$\phi \approx \sin\phi \approx \tan\phi \tag{11.5}$$