PHSX 221L **Simple Harmonic Motion** **Name:**______________________

Object:

1. To measure the spring constant of a spring, and then to check the dependence of the period of oscillation on spring constant and on mass.
2. To study the motion of a simple small-angle pendulum and check the dependence of the period of motion on the length of the pendulum and gravity.
3. To measure the torsional constant of a rod, and then to check the dependence of the period of oscillation of a torsional pendulum on the torsional constant and on the rotational inertia of the disc.

Theory: Many mechanical systems (those that obey some form of Hooke's Law, $F = -kx$), when analyzed using Newton's laws of motion, are found to result in an equation of motion where the acceleration and the displacement functions of time differ only by a negative constant: $\ddot{x} + \omega^2 x = 0$. The solution of this differential equation predicts a periodic motion described by a sine (or a cosine) function with a well-defined period. For each of the following cases derive the differential equation, and determine the period of the oscillation.

- A mass on a spring
- A simple pendulum
- A torsional pendulum

Apparatus: Include a labled diagram of the apparatus used in each case.

Procedure:

For the mass and spring:

1. Measure the spring constant k by using Hooke's law and finding the slope of a graph of suspended weight versus stretch distance.
2. Measure the period of oscillation for each of several different masses (include 1/3 the mass of the spring each time).
3. Plot a graph of the period squared versus mass. Compute the slope of this graph and compare with theory.

For the simple pendulum:

1. Measure the period of oscillation for several different string lengths (with small amplitude of oscillation).

2. Plot a graph of the period squared versus string length. Compute the slope of this graph and compare with theory.

3. Vary the angle of swing of a "seconds pendulum" (0.993 m long) up to 90° in 10° increments to experimentally determine the dependence of the period on it.

4. Vary the mass of the bob to experimentally determine the dependence of the period on it.

For the torsional pendulum:

1. Measure the torsional constant κ of the rod by using the rotational version of Hooke's Law: $\tau = -\kappa\theta$ and finding the slope of a plot of τ versus θ.

2. Measure the period of oscillation for each of several different rotational inertias of the disc (create different I's by adding hoops to the disc).

3. Plot a graph of the period squared versus rotational inertia. Compute the slope of this graph and compare with theory.

Questions:

1. Does the period of a simple small-angle pendulum depend on the angle of swing? Should it? What if the angle of swing is not kept small? In the large-angle case is it still simple harmonic motion?

2. Does the period of a simple pendulum depend on the mass of the bob? Should it?

3. Note that instead of plotting period squared, you could do a least squares fit of your data (the pendulum, for example, would be L vs. T this time) expecting a parabolic fit. You should be able to match the constants obtained by the least squares parabolic fit ($L = AT^2 + BT + C$) with the appropriate information obtained on your graphs above.

4. Estimate how accurately g could be measured using a simple pendulum.

Conclusions: Summarize and evaluate your experiment. Include mention of likely sources of error and how you dealt with them.