PHSX 221L **Centripetal Force** **Name:**______________________

Object: To measure the centripetal force which acts on a body when it is undergoing uniform circular motion, and to compare with theory.

Theory: An object moving at constant speed v in a circular path experiences an acceleration toward the center of the circle with a magnitude of

$$a_c = \frac{v^2}{r} \tag{1}$$

where r is the radius of the circle. Newton's Second Law states that such an acceleration is associated with a centripetal (center-seeking) force:

$$F_c = m\frac{v^2}{r}. \tag{2}$$

If the moving body makes one revolution in T seconds or f revolutions per second, then the speed v is given by

$$v = \frac{2\pi r}{T} = 2\pi r f. \tag{3}$$

This can also be expressed in terms of the angular speed, $\omega(= 2\pi f)$, as $v = r\omega$, where ω comes in radians per second. The centripetal force can now be written as

$$F_c = 4\pi^2 f^2 mr = mr\omega^2. \tag{4}$$

Note: The centrifugal (center-fleeing) forces you've heard about are fictitious forces (you can't identify the object exerting them) and only show up in accelerating reference frames. In the laboratory (inertial) frame of reference you should think only of centripetal forces.

Apparatus: The apparatus consists of a rotator connected to a motor. The object under consideration is a small metal cylinder inside the rotator. When rotated at the proper speed the object is held in by the stiff spring (*i.e.* the centripetal force) instead of by the metal bracket. You control the rotation speed and know it is rotating at the proper speed when the cylinder just nudges a pointer needle.

Procedure:

1. Include diagrams of the apparatus used.
2. For each of at least four different spring tension settings, vary the speed of rotation until the mass moves out and just touches the pointer, stretching the spring in the process.
3. Count the number of rotations in a time T (about 30 seconds).
4. Use f or ω (from the counter and from T) to obtain the computed value of F_c.
5. The measured value of F_c is obtained by removing the spring assembly from the rotator and hanging weights on it to stretch the spring to the pointer. The tension in the spring is equal to the hanging weight (include the mass of the object that rotated; the value should be stamped on it) and is theoretically F_c.
6. Plot spring tension as a function of either f^2 or ω^2.

Analysis:

1. Compare the computed centripetal force with the measured tension force for each trial. (Compute percent difference.)
2. Does your graph of spring tension versus f^2 or ω^2 form a straight line? (A least squares analysis can tell you how well your data fits a straight line. Find r or r^2 from your spreadsheet or calculator; this tells you the goodness of fit.) Should it? If so, what should the slope be? How close is the least squares slope to the theoretical value of the slope from Equation 4?

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