Centripetal Force

Purpose: To verify Newton's second law of motion for the case of uniform circular motion.

Equipment: Centripetal force apparatus, metric scale, vernier caliper, stop watch, slotted weight set, triple beam balance.

Introduction:

The centripetal force apparatus is designed to rotate a known mass through a circular path of known radius. By timing the motion for a definite number of revolutions and knowing the total distance that the mass has traveled, the velocity can be calculated. Thus the centripetal force, F, necessary to cause the mass to follow its circular path can be determined from Newton's second law.

$$F = \frac{mv^2}{r}$$

Where m is the mass, v is the velocity, and r is the radius of the circular path. Here we have used the fact that for uniform circular motion, the acceleration, a, is given by:

$$a = \frac{v^2}{r}$$

Procedure:

1. For each trial the position of the horizontal crossarm and the vertical indicator post must be such that the mass hangs freely over the post when the spring is detached. After making this adjustment, connect the spring to the mass and practice aligning the bottom of the hanging mass with the indicator post while rotating the assembly.
2. Measure the time for 50 revolutions of the apparatus. Keep the velocity as constant as possible by keeping the pointer on the bottom of the mass aligned with the indicator post. A white sheet of paper placed as a background behind the apparatus can be helpful in getting the alignment as close as possible. Using the same mass and radius, measure the time for three different trials. Record all data.
3. Using the average time obtained above, calculate the velocity of the mass. From this calculate the centripetal force exerted on the mass during its motion.
4. Independently determine the centripetal force by attaching a hanging weight to the mass until it once again is positioned over the indicator post (this time at rest). Since the spring is being stretched by the same amount as when the apparatus was rotating, the force stretching the spring should be the same in each case. Calculate this force and compare with the centripetal force obtained in part 3 by finding the percent difference.
5. Add 100 g to the mass and repeat steps 2, 3 and 4 above.
6. Add another 100 g and repeat.
7. The following data should be calculated and recorded in a neat table:
    a. Mass and radius for each trial.
    b. Average number of revolutions/sec (frequency) for each trial.
    c. Linear speed for each trial.
    d. Calculated and measured centripetal force for each trial and their percent difference.