LAB SECTION: ____________________________ NAME: ____________________________

EXPERIMENT 4: UNIFORM CIRCULAR MOTION

Introduction: In this lab, you will calculate the force on an object moving in a circle at approximately constant speed. To calculate the force you will use Newton's Second Law combined with the acceleration of an object moving in a circle at constant speed. You will then compare that calculated force with a measured value.

You will measure the time t required for 30 revolutions of a hanging object; the object will be held in a circular path of known radius r by a horizontal spring attached to the axis of rotation. The time T for one revolution is then $t/30$ and the speed v of the moving object is easily calculated from distance (the circumference of the circle $2\pi r$) divided by time:

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

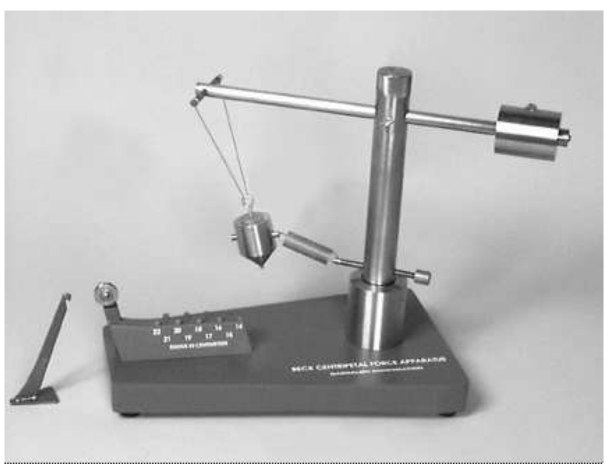
Since the object will have been moving in a circle at approximately constant speed v, the amount of acceleration of the moving object is gotten by

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

Finally, multiplying by m, the measured mass of the object, will give the calculated total amount of force on the moving object.

Procedure

Shown below is a photograph of the apparatus.



You will be asked to perform five trials of this experiment. For the first three trials, keep the circle radius fixed and use three different values of the mass of the moving object. For the last two trials, use two new values for the circle radius. For each trial, you will have to make three separate measurements of the time for 30 revolutions and take the average of those three. Here is the procedure for each of the five trials.

1. Disconnect the spring from the bob and let the bob hang straight down. Add selected masses to the top of the bob to produce the desired mass for the hanging object. With no added masses, the mass of the bob is 349 g. Record the amount of the added masses in Data Table 4.1 (zero added masses is a possible choice).
2. Establish the radius of the circle in which the bob is to move by loosening the screw in the horizontal arm and moving the arm until the bob hangs directly over the proper centimeter mark on the base of the apparatus. Choose a radius between 15 and 21 cm. Tighten the screw so that the arm will not slip when the shaft is spun. Record the working radius in Data Table 4.1.
3. Attach the spring to the bob. Attach a horizontal string to the other side of the bob, pass the string over the pulley, and suspend a mass hanger on this string. Put just enough mass on the hanger so that the bob is pulled back over the selected centimeter mark. The mass of the hanger is 50 g. Record the amount of mass added to the hanger (not including the mass of the hanger) in Data Table 4.1.
4. Remove the added masses from the hanger, then remove the mass hanger from the horizontal string, and finally remove the horizontal string from the bob and get the string out of the way.
5. Spin the shaft faster and faster until the bob is moving in a circle of correct radius. When this is done correctly, the moving bob will pass precisely over the selected centimeter mark once per revolution. Practice spinning the shaft, keeping the bob in a circle of constant radius for at least 30 turns.
6. Use the stopwatch to measure the time for 30 revolutions. One student should get the bob going at the right speed and do the counting out loud; a second student should man the stopwatch. Count down to zero and then up to 30 (-4, -3, -2, -1, 0, 1, 2, 3, etc.); the stopwatch should be started at the count of zero and stopped at the count of 30. Record the total time for 30 revolutions; repeat three times and take the average of the three values.

Guide to Symbols in the Table

m_{add} = mass added to bob

$m = m_{add}$ + bob mass of 349 g

m_{onH} = mass added to hanger

$m_{tot} = m_{onH}$ + hanger mass of 50 g

r = radius of circle

t_1 = time for 30 revs (1st count)

t_2 = time for 30 revs (2nd count)

t_3 = time for 30 revs (3rd count)

t_{avg} = avg of t_1, t_2, and t_3

T = time for one rev. = $t_{avg}/30$

v = bob speed = $2\pi r/T$ with r in m

$a = v^2/r$ with r in m

$F_{calc} = ma$ with m in kg

$F_{meas} = m_{tot}(9.8 \text{ m/s}^2)$ with m_{tot} in kg

% error = 100% × $|F_{calc}$ - $F_{meas}|/F_{meas}$

Data Table 4.1

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
m_{add} (g)					
m (g)					
r (cm)					
m_{onH} (g)					
m_{tot} (g)					
t_1 (s)					
t_2 (s)					
t_3 (s)					
t_{avg} (s)					
T (s)					
v (m/s)					
a (m/s^2)					
F_{calc} (N)					
F_{meas} (N)					
% error					

Results

1. Does the measured spring force (F_{meas}) equal the calculated spring force (F_{calc}) in each of your trials? Do you consider them equal or not equal? Why or why not?

2. In this experiment, a spring force was used to keep the moving object traveling in a circular path. The size of a spring force should be proportional to the amount of stretch in the spring. Does this claim agree qualitatively with the data in your five trials? Why or why not?

3. For trials 1-3, make a small table of m (in kg instead of grams) and the reciprocal of v^2 (in $\mathrm{s}^2/\mathrm{m}^2$). Include proper labels with units in your table headings.

4. For trials 1-3, make a graph of the reciprocal of v^2 versus total bob mass m (m on the horizontal axis).

5. There are only three data points, but you should find that your graph is approximately a straight line; the reciprocal of the slope of this line should be nearly equal to F_{meas} (in N) times the selected radius r (in meters rather than cm) for any of trials 1-3. Is this true? Why should this be true? HINT: Consider Newton's Second Law (in symbols) applied to the motion of the bob.

6. Assuming that Newton's Second Law is a correct model, is this lab also a confirmation of the logic that we did in lecture to produce v^2/r as a method of calculating the amount of acceleration for an object moving in a circle of radius r at constant speed v? Why or why not?