Lab 05 – Circular Motion

Introduction/Background

An object moving with a constant speed (which is the magnitude of velocity) in a circle has to be accelerating, because the velocity vector is changing directions. Such motion is called uniform circular motion. For uniform circular motion of a mass *m*, in a circle with radius *r*, with a constant speed *v*, the acceleration experienced by the mass points towards the center of the circle, and has a magnitude

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

Therefore, the sum of all the forces on the mass must point towards the center of the circle and have a magnitude equal to

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

Sometimes, we want to talk about the angular velocity, ω, of circular motion. This is the number of radians per second that an object moves through. The formula for this is

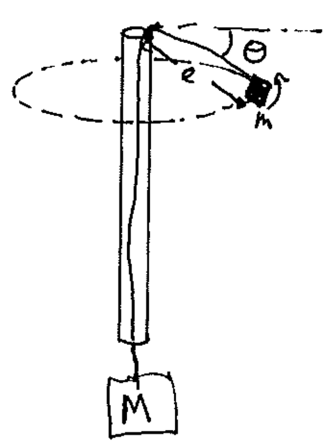
$$\omega = \frac{v}{r}.$$

This angular velocity is sometimes called the angular frequency of motion, and is related to the time, *T*, that it takes for the mass to move around a full circle. This time is called the period of motion. The relation between angular velocity and period is

$$T = \frac{2\pi}{\omega}.$$

So if we know the total force on a mass that is moving in circular motion, we should be able to find the period of motion by combining the above 3 equations properly.

Description of Experiment In your labpaq kit, there is a glass tube, many washers, and some monofilament fishing line (use the monofilament if you can instead of string because it cuts down considerably on the friction that can play havoc with this). Cut a length of about 1 m of the fishing line. Thread it through the glass tube. Tie one washer to one end, and tie 2 to 5 identical washers to the other end (make sure you note this number). Measure the mass of the washers on each end of the line with your digital scale. Hold the glass tube vertically and let the end of the string with more washers come out the bottom. Spin the end of the line with the single washer around in a circle (see figure). Measure the time it takes for the single washer to spin in 10 circles. Measure the length of the string that comes out the top of the glass tube.



Special Instructions for Report

The analysis of this experiment is tricky, so here is a little guidance. This should go in the calculation section. First of all, draw a free body diagram for both the moving mass and the hanging mass. If there is no friction, the tension force will be the same for both masses. If the hanging mass is M, then the tension force is Mg in magnitude. Now look at the moving mass. The vertical components of force are $T\ sin\theta$ and mg, where θ is the angle the line to the moving mass is with respect to horizontal. The horizontal component has to be what makes it move in a circle. Using this information, see if you can get that $\theta = \sin^{-1}\left(\frac{m}{M}\right)$. Now see if you can also use this information to get that the length of line from the top of the tube is $l = \frac{ng}{\omega^2}$, where n is the number of washers on the heavy side of the line. Show your work. Feel free to write it out on paper and scan or photograph it.

Solve for the angular frequency in the above equation, with uncertainty. This is your predicted angular frequency.

Using your measurement of the period of motion, find what the angular frequency is. This is the measured angular frequency. To find the uncertainty in this, do the following: suppose you measured the time for 10 periods of the washer to be 12.0 +/- 0.5 s. Then this is 10 T. Therefore, T would be 1.20 +/- 0.05 s. Propagate this uncertainty in T to ω.

Report your predicted angular frequency and your measured angular frequencies with uncertainties.

Questions:

1) Is your predicted angular frequency consistent with the measured angular frequency (hint: use z' test)?
2) Discuss any errors that were not accounted for in your analysis. Are there any that may be significant?