University Physics 1
Centripetal Force
Lab 6
October 19, 2004
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Purpose

The purpose of this experiment is to investigate centripetal forces and rotational motion.

Equipment

1. Centripetal Force Apparatus
2. String
3. Set of masses
4. Mass hanger
5. Stopwatch
6. Vernier Caliper

Background

The provided apparatus is intended for the study and verification of the law of force for uniform circular motion. It consists essentially of a heavy mass bifilarly supported from a crossarm attached to a vertical shaft. The shaft is supported in a metal housing a on a wooden base. Radial and thrust bearings permit the shaft to rotate freely without wobbling. The crossarm is counterbalanced. An adjustably positioned, vertical rod mounted on the base serves as a radius indicator. A ball-bearing pulley mounted on a rod near one end of the base is used in measuring the force exerted by a spring with which the mass is coupled to the shaft.

The apparatus could need assembly (it is used in different configurations in other experiments). Complete assembly instructions follow. Most of these instructions will likely not be needed - but they do allow you to check for correct assembly.

Attach the metal housing and shaft to the wooden base with the three flat-headed screws. Secure the crossarm to the vertical shaft and attach the counterbalance to one end of the crossarm.

Mount the indicator rod on the wooden base and secure with the thumbscrews. Note that its position may be adjusted radially. Attach the pulley and its support rod to the base.

Cut a two-foot length of cord and make a firm knot in one end. Thread the cord downward through the hole in one end of the small cross rod and then upward through the hole in the other end. Holding the free end of the cord, hang the heavy mass on the pointed tip of the mass clears the indicator by 1 or 2 mm. Secure the cord by wrapping it under the ends of the small cleat on the crossarm.

Orient the mass on the screw eye so that when it is hanging freely the small lugs on opposite sides of the mass are in line together with the knurled nut. Connect the mass to the vertical shaft by the coiled spring. Attach the weight pan to the mass by a length of cord passing over the pulley, using the small metal hook for fastening the cord to the mass. Add weights to the pan until the mass is hanging vertically downward, and adjust the height of the pulley until the cord is approximately horizontal. Disconnect the weight pan from the mass and adjust the leveling screws in the base until the rotating shaft is vertical. When the shaft is vertical there will be no tendency for the system to rotate after it has been stopped in any angular position. The apparatus is now ready for use.

Theory

When a body is caused to revolve in a circle with uniform velocity the resultant inward force on the body is called *centripetal* force. The centripetal force produces an inward radial acceleration, a, given by Newtons Second Law.

$$\vec{F} = m\vec{a} \tag{1}$$

in which m is the mass of the revolving object. Since $a = v^2/r$ and $v = 2\pi nr$,

$$F = 4\pi^2 mn^2 r \tag{2}$$

where r is the radius of the circular path and n is the number of revolutions per second.

Equation (2) is the working equation for this apparatus. If m is in grams and r is in cm, F will be in dynes. If m is in kilograms and r is in meters, F will be in newtons.

Procedure

The object of this experiment is to verify Equation (2) for several values of m and r by comparing the computed value of the centripetal force using this equation with the static forces required to displace the mass to the same radial position. While the exact method of accomplishing this is left to the student the following suggestions may be helpful.

1. In any given trial the position of the crossarm and radial indicator must be such that the heavy mass hangs freely exactly over the indicator when the spring is detached. Therefore,

when changing the radius of rotation both indicator and crossarm must be moved correspondingly. It will be observed that the location of the counterbalance on the crossarm is not critical.

2. The radius of rotation is the distance from the center of the top of the radius indicator to the axis of the vertical shaft. To obtain this value add one-half the diameter of the shaft, as measured with a vernier caliper, to the distance from the shaft to the center of the top of the indicator, as measured with the metal scale.

3. Determine the mass of the revolving object with a trip scale or laboratory balance. To change this value add slotted weights. Place these weights on the mass with the open end of the slot outward and secure in place with the knurled nut. Up to 100 gm may be added.

4. A piece of white paper located to provide a light background is helpful in seeing that the rotating mass passes exactly over the indicator. Rotate the system by applying torque with the fingers on the knurled portion of the shaft. With a little practice the rotation rate can be adjusted to keep the mass passing directly over the indicator.

5. For an accurate determination of n, the rate of rotation, the time of 50 or more complete revolutions should be measured with the stop watch. It is desirable to make three or more trials and average the results. It is permissible to "boost" the system to keep the mass over the indicator.

6. It is suggested that Equation (2) be tested for several values of the radius of rotation and likewise for two or more values of the mass. Your measurements should tell you how the value of the centripetal force remains varies for different values of m when r remains constant, and how the centripetal force varies with$r$.

7. The following form is suggested for recording results for comparison.

Table 1: Centripetal Force Data

Trial	Mass	Radius	r.p.s.	Force Computed	Force Measured	% difference