Circular Motion

Introduction

Consider an object of mass, m, moving in a circle of radius, r, under the influence of an applied force, $\vec{F}$, constant in magnitude and directed toward the center of the circle. Such an object moves with constant speed, v. Furthermore, the object undergoes acceleration, $\vec{a}$, which is also directed toward the center of the circle and has a constant magnitude, a, given by

$$a = \frac{v^2}{r} \, . \tag{3}$$

Thus, according to Newton's Second Law, $\vec{F} = m\vec{a}$, the magnitude of the applied force, F, satisfies the following relationship,

$$F = m\frac{v^2}{r} \, . \tag{4}$$

In this experiment an object is constrained to move in a circle by an applied force, constant in magnitude and directed toward the center of the circle. The applied force, the radius of the circle, the mass of the object, and its speed are obtained either directly or indirectly from the data collected during the experiment. The values of these quantities are then used to test the consistency of the experiment with the theoretical relationship given in Eq. 4.

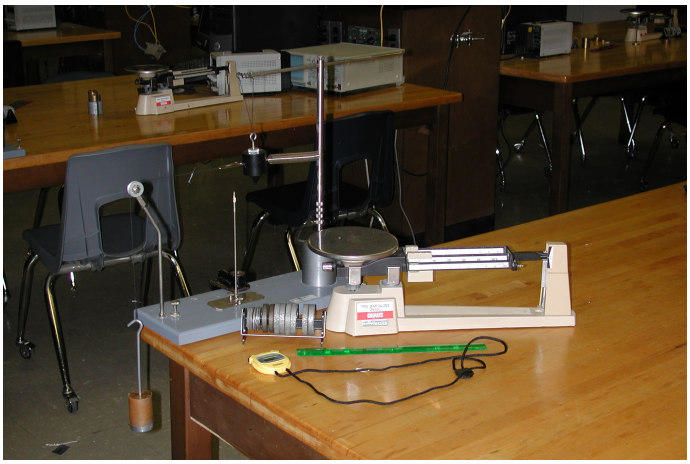

Figure 1: Centripetal Motion Apparatus

Procedure

Case 1

1. Adjust the radius indicator of the centripetal motion apparatus (See Figure 1.) to its maximum value.

2. Measure the radius r of the circle along which the object will travel. Record its value in Table 2.

3. Measure the mass m of the object which will undergo centripetal motion. Record its value in Table 2.

4. Determine the magnitude of the force F_{exp} required to maintain the radius of the circle, as follows. Attach the weight holder to the object which will undergo centripetal motion. Add sufficient mass to elongate the spring so that the object is positioned over the radius indicator. Record the total mass M in Table 2.

5. Measure the time for the object to make 50 revolutions at the selected radius. Perform this measurement two additional times and obtain the average. Record these values in Table 1. Record the average value T_{50} of the measurements in Table 2.

6. Calculate the period of rotation T where $T = T_{50}/50$. Record its value in Table 3.

7. Calculate the speed v of the object, where $v = \frac{2\pi r}{T}$. Record its value in Table 3.

8. Calculate the experimental value of the force F_{exp} where $F_{\text{exp}} = Mg$. Record its value in Table 3.

Case	T_1 (s)	T_2 (s)	T_3 (s)
1			
2			

Table 1: Data

Case	r (m)	m (kg)	M (kg)	T_{50} (s)
1				
2				

Table 2: Data

9. Calculate the theoretical value of the force F_{theo} where $F_{\text{theo}} = m\frac{v^2}{r}$. Record its value in Table 3.

10. Calculate the standard error (SE) in the force:

$$\text{SE} = |F_{\text{exp}} - F_{\text{theo}}| \ .$$

Record its value in Table 3. Do the results of the experiment appear to be in agreement with the theoretical relationship given in Eq. 4?

Case 2

After adjusting the radius indicator of the centripetal motion apparatus to its minimum value, repeat steps two through ten, recording the results in Tables 1, reftable1 and 3.

Case	T (s)	v (m/s)	F_{exp} (nt)	F_{theo} (nt)	SE
1					
2					

Table 3: Calculations