Centripetal Force
Fall 2008

Introduction

The purpose of this experiment is to predict – and then measure – the centripetal force needed to make a mass travel in a circular orbit.

The Equipment: Meet "Bob"

The apparatus allows you to spin a known mass around in a circle: you can measure the radius of the circle and the speed of the mass and thereby infer the centripetal force from Newton's second law.

1. Disconnect the spring from "Bob". Your instructor will show you how to level the base and check the balance between Bob and the counterweight. ***It is important to check the balance and level carefully.***
2. Remove Bob from the supporting string, measure his mass, then reattach it to the string. Adjust the pointer until it is directly under Bob, and if necessary adjust the height of Bob (with the supporting string) to be *no more than* 1 mm above the pointer.

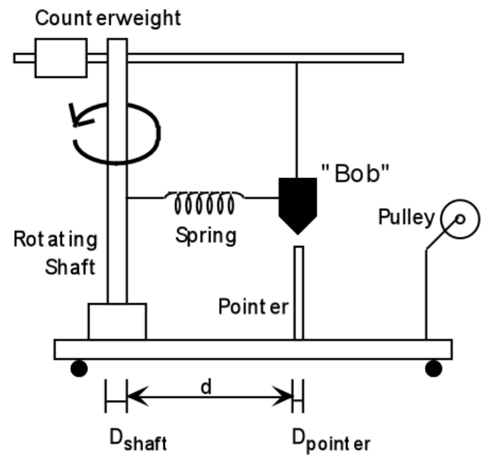

Figure 1: Rotating Bob

Predicting the Centripetal Force

3. Determine the radius of the orbit, R_{orbit}, from the diameters of the rotating shaft and the pointer, D_{shaft} and $D_{pointer}$, and the closest distance between them, d (see sketch):

$$R_{orbit} = \frac{D_{shaft}}{2} + \frac{D_{pointer}}{2} + d$$

4. Reconnect the spring and set the photogate to "pulse" mode, 0.1 *ms*, memory on. Spin Bob at a rate that stretches the spring until Bob is directly above the pointer. Measure the period of one rotation, T - while doing your best to hold the speed at which the pointer and Bob are aligned (this will take some practice). Record the timings in a table (10 trials are sufficient), then calculate the average period, $\langle T \rangle$. *Keep Bob spinning during your measurements; don't stop and restart the rotation!*

5. ***Draw an FBD for a rotating Bob***. Call the force of the spring on Bob $\vec{F}_{dynamic}$, the force needed to move Bob in a circle at the fixed speed.

6. Calculate the tangential speed and centripetal acceleration of Bob, and record in your data table:

Recall that

$$v_{tangent} = R_{orbit}\omega = R_{orbit} 2\pi f$$

so,

$$v_{tangent} = \frac{R_{orbit} 2\pi}{\langle T \rangle}$$

$$a_c = \frac{v_{tangent}^2}{R_{orbit}}$$

7. Use your FBD and Newton's laws to predict $\vec{F}_{dynamic}$.

Measuring The Centripetal Force – *Indirectly*

8. Connect the mass hanger to Bob with the paper clip, and check that the string pulls straight over the pulley. Also check that the pulley rotates freely (if it doesn't then you're adding an additional force to the system!).
9. Add masses until the spring is stretched so that Bob is lined up *above* the pointer.
10. **Draw a second FBD for this *static* system** (Bob *and* the suspended mass), and use it with the data above and g = 9.80 m/s^2 to find the force of the spring on Bob (when the spring is stretched to the same length as when spinning). Call this force $\vec{F}_{static}$.

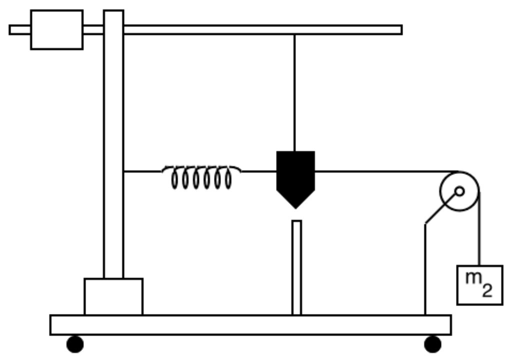

Figure 2: Static Bob

Discussion

- Restate your values for $\vec{F}_{dynamic}$ and $\vec{F}_{static}$, and calculate the percent difference between them.
- Discuss the reasons there might be a discrepancy between $\vec{F}_{dynamic}$ and $\vec{F}_{static}$. Be sure to consider the spread in your measured periods (calculate the %difference between the max and min periods).