Radial Force & Riding the Bewkes Elevator

Fall 2008

Introduction

In the first part of this experiment, you will predict – and then measure – the radial force needed to make a mass travel in a circular orbit. In the second part, you will measure the acceleration of the Bewkes Hall elevator using a bathroom scale.

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 radial force from Newton's second law.

1. Disconnect the spring from "Bob". Your instructor will show you how to check the balance between Bob and the counterweight. Also be sure that the base is level. ***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.

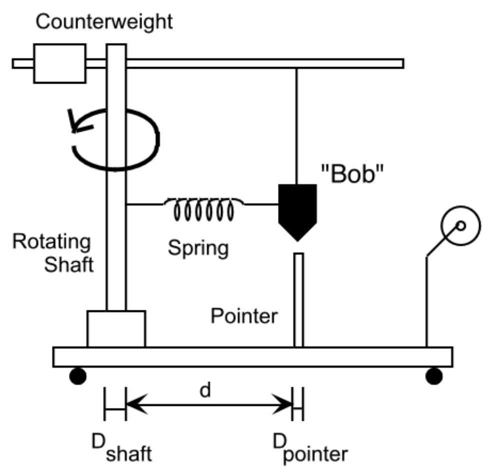


Figure 1: Rotating Bob

Predicting the Radial Force

3. Determine the radius of the orbit, R_{orbit}, from the *radii* of the rotating shaft and the pointer, and the closest distance between them – note that this is not simply the measurement of *d* (see sketch).
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). Collect *at least* 10 trials, then calculate the average period, $\langle T \rangle$. Record the data in your report using a table for your period measurements.
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 speed, *v* and radial acceleration, *a* of Bob, and record in your report:

$$v = \frac{2\pi R_{orbit}}{\langle T \rangle} \qquad a = \frac{v^2}{R_{orbit}}$$

7. Use your FBD and Newton's laws to predict $\vec{F}_{dynamic}$. Be careful of your units! **Note:** You should report the *range* of your average period, e.g. $\langle T \rangle$ = ____ ± ____ *sec*, so that you can calculate $F_{dynamic}$ = ____ ± ____ *N*.
8. Your analysis may be helped by considering the spread in the measured periods. Calculate the percent difference between the minimum and maximum period observed.

Measuring the Radial Force

9. 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!).
10. Add masses until the spring is stretched so that Bob is lined up *above* the pointer.
11. **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 $\vec{F}_{static}$.

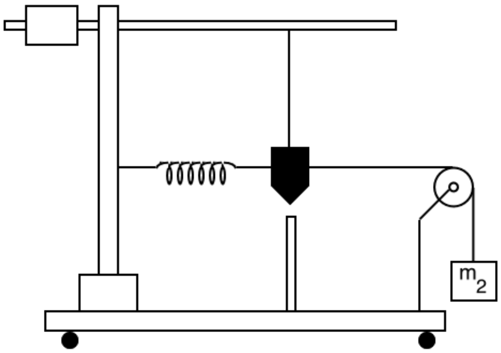
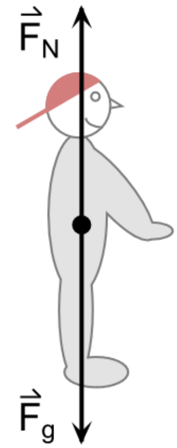


Figure 2: Static Bob

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 $\vec{F}_{static}$.

Additional Exercise: Riding the Bewkes Elevator



In this experiment, you will measure the acceleration for the Bewkes Hall elevator using a bathroom scale. This is similar to example N6.5 in Moore.

1. Using an ordinary bathroom scale, determine your mass at rest (in *kg*) from your "weight" (in *lb*). Recall that 1 *kg* equals 2.2 *lbs*, and weighs 9.8 *N*.
2. Take your scale and ride up and down in the elevator, recording your maximum and minimum "weights" (you'll want to take several measurements of each trip). You'll collect data for *four* excursions: starting and stopping for the trip up, starting and stopping for the trip down. Record your measurements in the worksheet.
3. In your report, draw a *large* FBD for the static case (at rest in the lab); try to draw the force vectors to the same scale relative to each other. On the worksheet you'll find four "bodies", one for each trip. Add force vectors to these bodies, again scaling them relative to each other.
4. From your FBDs and your measured weights, calculate $\sum \vec{F}_z$, and then your acceleration going up and down ($a_{z,up}$, $a_{z,down}$), for both starting and stopping. Draw an up or down arrow in the appropriate worksheet column to indicate the *direction* of the velocity and acceleration in each case.
5. Discuss your results; be sure that you have shown how your calculations were performed (be sure to include a sample calculation). Is the acceleration of the elevator the same going up and going down? ***Hint***: if your measured acceleration is greater than ***g***, then you're doing something wrong!