Physics 201 Lab 3
Centrifugal Force

Feb 4, 2013

Equipment

- Scissors
- Physics string
- Stopwatches
- Rotational apparatus
- Hanging weight sets

Initial Set-up

When an object of mass m is placed in a frame rotating with an angular velocity of ω, it experiences a centrifugal force given by:

$$F = mr\omega^2$$

where r is the distance of the mass from center of rotation. Further, if T represents the period of the rotation we have $\omega = 2\pi/T$. This allows us to rewrite the previous equation as

$$F = 4\pi^2 mr/T^2$$

Today we will be verifying this equation.

First you must level the rotational apparatus. This experiment requires the apparatus to be extremely level. If the track is not level, the experimental results will be wildly different from the theoretical results.

Carry out the following steps:

- Purposely make the apparatus unbalanced by attaching the black 300 gram square mass onto the end of the aluminum track that is nearest the brass object with 3 hooks (see Figure 1).
- Adjust the leveling screw on one of the legs of the base until the end of the track with the square mass is aligned over the leveling screw on the other leg of the base.
- Now rotate the track 90° so it is parallel to one side of the A-shaped base and adjust the other leveling screw until the track will stay in this position.
- The track is now level and it should remain at rest regardless of its orientation. Once level, do not move the base of your apparatus! Remove the 300 gram square mass and set it aside. You will no longer need it for the rest of the experiment.

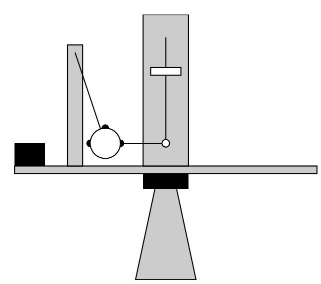

Figure 1: Centripetal apparatus initial leveling

Now we practice timing. Try to spin the rotating platform at a nearly constant rate. Measure the time it takes to make ten complete rotations. You can see the marker bob up and down – try to keep it in the same position during the whole measurement. Divide this time by ten to obtain the period of motion. You will be doing this quite a bit, so practice until you are comfortable. This will take at least two people – one to spin, the other to count and use the stop watch. Remember to start counting with zero so that when you count one it corresponds to one revolution.

First Trial

Attach a clamp-on pulley and a small hanging mass to the end of the apparatus arm. Calculate the weight of the hanging mass. We will be using later in our calculation.

Now adjust the radius on the side post. The 3-hooked-object must hang perfectly vertically. While pressing down on the side post to assure that it is vertical, tighten the thumb screw on the side post to secure its position. Record this radius.

On the center post, adjust the spring bracket vertically until the string from which the 3-hooked object hangs is aligned with the vertical line on the post. If there is too much slack in the string, wind the extra string securely around the hook it is fastened to.

Align the indicator bracket on the center post with the orange marker. This is done by sliding the bracket vertically and tightening the thumb screw when it is at the correct level.

Once these adjustments have been made, remove the mass that is hanging over the pulley, and remove the clamp-on pulley.

Rotate the apparatus, increasing the speed until the orange indicator is centered in the indicator bracket on the center post. This indicates that the string supporting the hanging object is once again vertical thus the 3-hooked-object is at the desired radius. The centripetal force the spring provides is equal to the earlier weight of the hanging mass.

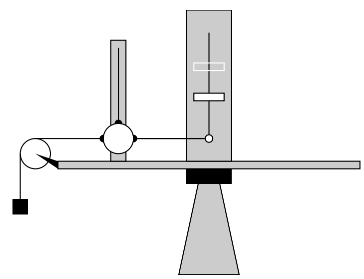

Figure 2: Centripetal apparatus with weight and no rotation—note lower marker location

Maintaining this speed, use a stopwatch to time ten revolutions. Use this information to calculate the speed of the 3-hooked-object.

Remove the 3-hooked-object from the apparatus and measure its mass.

Use these values to verify the equation $F = mr\omega^2$.

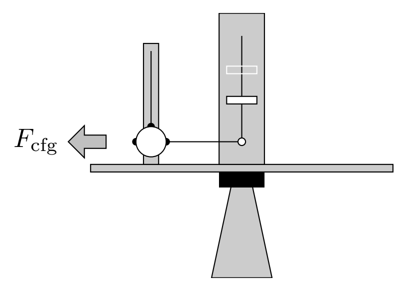

Figure 3: Centripetal apparatus while rotating—note the same lower marker location as before

Additional Trials

If the mass of the 3-hooked-object were changed to half of its current value, what happens to the centripetal force? Since the spring is set up for a particular force, what will the required speed be to create equilibrium?

Now carry out the experiment by removing the two outside masses from the 3-hooked object, effectively reducing its mass by half. Verify the equation $F = mr\omega^2$ is obeyed once again.

Repeat the experiment using a different radius for the 3-hooked-object.