AP Physics: Lab #7
Centripetal Force

Name ______________________ Hour ______

Lab Partners ____________________________________

Purpose:

* Calculate the centripetal force required to maintain the circular path of an object.
* Analyze factors affecting centripetal force.

Equipment:

Circular motion apparatus
50 g and 20 g bobs
Pulley on support beam
Electronic balance
Stopwatch
Meter stick

Introduction:

An object moving with a constant speed in a circular path experiences an acceleration due to the constant change in direction of its velocity. This acceleration is directed towards the center of the circle and depends on both the tangential velocity *v* of the object and the radius *r* of the circle. The magnitude of this centripetal acceleration is given by the equation:

$$a_c = \frac{v^2}{r}$$

In order for the object to maintain its circular path, a force is required to cause a constant change in velocity. This force is exerted towards the center of the circle, in the same direction as the centripetal acceleration. It can be provided by friction, tension, or, as in this activity, a spring. In accordance with Newton's 2^{nd} Law, the magnitude of the centripetal force is given by the equation:

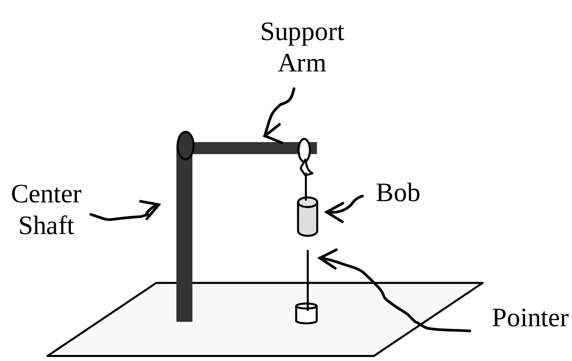
$$F_c = m \cdot a_c \quad \text{or} \quad F_c = \frac{m \cdot v^2}{r}$$

In this experiment, the required centripetal force for a revolving mass will be calculated from measurements of mass, velocity, and radius. The actual centripetal force will also be determined directly from the spring.

Procedures:

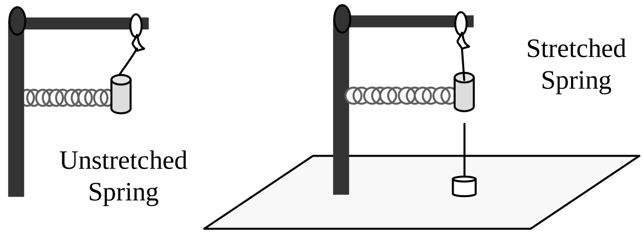
Measure the mass of the 50 g bob and record this amount in Data Table A. Then hang the 50 g bob from the support arm of the circular motion apparatus.

Adjust the position of the bob so that it hangs directly over the pointer. Measure the radius of circular motion from the center shaft to the point where the bob attaches to the support arm. Record this amount in Data Table A.



Attach the spring to the 50 g bob and then connect the spring to the center shaft. The spring should be tight enough so that the bob is pulled towards the center shaft. To check the alignment of the spring, pull the bob slightly outwards so that it is again above the pointer, as shown in the diagrams on the next page. The spring should be connected to the center shaft at the correct height so that it is horizontal when the bob is in position above the pointer.

Procedures: *(cont)*

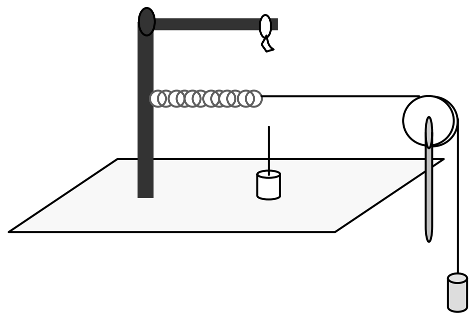


Rotate the bob by twirling the center shaft between your thumb and forefinger. Adjust the rate of rotation until the spring is stretched enough so that the bob passes directly over the pointer. When this rotation rate has been achieved, measure the total time for 50 revolutions. During this time, continue to rotate the system so that the bob passes over the pointer. Small deviations from the correct position will be averaged out over the large number of revolutions. Record the time required for 50 revolutions in Data Table A.

Repeat the procedure for 2 additional trials with the 50 g bob, recording all times in Data Table A.

Replace the 50 g bob with the 20 g bob and reconnect the spring. Repeat the procedure for 3 trials with the 20 g bob, recording all times in Data Table B.

When the circular motion apparatus is revolving, the force pulling the bob in a circle is provided by the spring. The force on the spring causes it to stretch from its original position to the pointer. To evaluate the results of your centripetal force measurements, you will directly measure the amount of force needed to stretch the spring from its original position to the pointer. Unhook the spring from the bob and remove the bob from the circular motion apparatus, leaving the spring in position. Position a pulley so that it is horizontally level with the spring. Attach a string to the spring and run the string over the pulley. Then attach masses to the string until the spring stretches to its position over the pointer. Record this amount of mass in Data Table C.



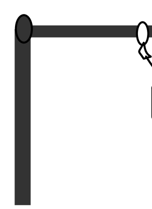
Calculations:

1. Calculate the average time for Data Tables A and B. Use the average times for all additional calculations.
2. Calculate the tangential velocity of the revolving bob.
3. Calculate the centripetal acceleration of the revolving bob.
4. Calculate the centripetal force required to keep the bob in circular motion above the pointer.
5. Calculate the measured amount of centripetal force, found directly from the mass amount in Data Table C.
6. For Data Tables A and B, calculate the percentage difference between the calculated centripetal force and the measured centripetal force found in Data Table C.

Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- Draw a free body diagram of the bob as it revolves in Data Table A. Include the type and amount of each force. What is the amount of the net force on the bob?
- If the bob is rotated without the spring connected, it will move away from the center shaft, as shown in the diagram at right. Is this movement caused by a net force or the lack of a net force? Use Newton's 1st Law to explain your answer.
- Assuming that the same spring is used for all trials, how should the tangential velocity of the bob change if the mass of the bob is cut in half? Do your measurements confirm this trend?



Data Table A:

Trial	*Mass*	*Radius*	*Time*	*Tangential Velocity*	*Centripetal Acceleration*	*Centripetal Force*
1						
2						
3						
Avg						

Percent Difference = ___________

Data Table B:

Trial	*Mass*	*Radius*	*Time*	*Tangential Velocity*	*Centripetal Acceleration*	*Centripetal Force*
1						
2						
3						
Avg						

Percent Difference = ___________

Data Table C:

Mass = ___________

Centripetal Force = ___________

Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 5 pts
Calculations – 7 pts
Analysis – 8 pts