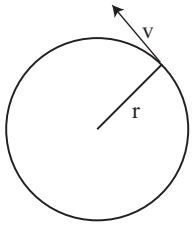
Name: (Writer) _____ Date_____
(Partners) _____ Section _____

PHYS 231 Lab Exercise: Uniform Circular Motion

Objective: To study the motion of a body moving with constant speed in a circular path.

Introduction: Consider a mass *m* tied to a string of length *r* and whirls in a horizontal circular orbit with a constant speed, *v*. Even though the speed is constant, the velocity is continuously changing since the direction of motion is continuously changing. Thus the body has acceleration



$$a_c = \frac{v^2}{r} \qquad (1)$$

called *centripetal acceleration* and is directed toward the center of the circular path. The tension through the string which keeps the mass moving in circular path and is an example of a *centripetal force*,

$$F_c = m\,a_c = m\,\frac{v^2}{r} \qquad (2)$$

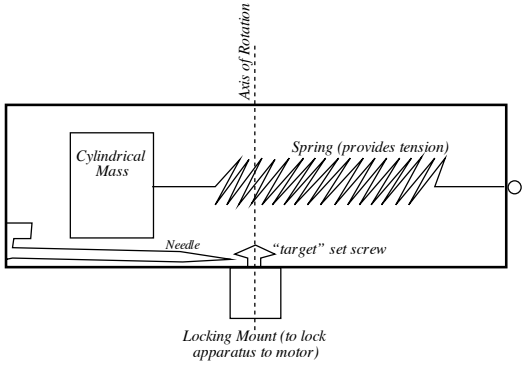
is directed along the radial direction.

We have found that many forces can act as centripetal forces, causing a change in the direction of the velocity vector, but not its magnitude. Today we will explore this force, specifically investigating the case of Uniform Circular Motion.

Apparatus: Centripetal-force apparatus, slotted weights, hanger, vernier caliper.

Procedure: **Part I: Getting to Know the Centripetal Force Apparatus**

In today's lab exercise, you will be using a "centripetal force apparatus" (illustrated below). With it, we can rotate a housing about a vertical axis at varying speed. Inside the housing sits a spring pulling a cylindrical mass tightly toward one side of a horizontal rest. Immediately below the mass, at the bottom of the housing, rests a needle.



WARNING: *In all cases today, before plugging in the motor, make sure that the speed switch is set to "off." Plugging in the motor at some other setting could result in damage to the motor and a very disgruntled instructor.*

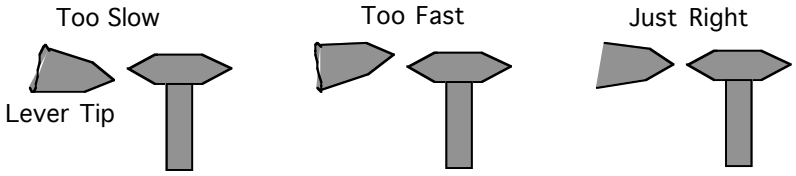
Name: (Writer) _____ Date_____
(Partners) _____ Section _____

a) Plug in the motor, making sure the speed switch is set to "off" when you do so. **Check and <u>make sure all parts are tightly attached</u> before plugging in the motor.**

b) Switch on the adjustable speed motor. Once you **carefully** increase the angular velocity of the motor, you should notice the cylindrical mass moves outward while the apparatus rotates, stretching the spring.

What is providing the centripetal force on the mass? _____

c) As you dial the speed faster and faster, the spring stretches farther. When the spring stretches to a critical distance, the needle below the mass pops up. It quickly overshoots the "target'" set-screw. *Try to fine-tune the spin speed so that the needle points (on average) right toward the target set screw (as shown below). You will likely have to continuously and very carefully adjust the spin speed of the motor in order to achieve this careful balance.*



Part II: Determining the Magnitude of Centripetal Acceleration

a) Measure the speed of rotation with the revolution counter and a stopwatch. First record the reading of the counter. At the proper instant engage the counter and set the stopwatch going. At the end of one minute, disengage the counter and record the reading.

b) Repeat the procedure and take four more readings of the number of revolutions over one minute.

c) Remove the apparatus, suspend it on a supporting stand, and determine the weight necessary to make the needle and set-screw coincide. Include the masses of the rotating cylinder and of the hanger in computing the total force (*i.e.* – weight) needed to stretch the spring. Make two independent determinations of the force necessary to stretch the spring. Calculate the mean force.

d) Measure the radius of rotation of the mass, using the vernier caliper, by measuring the distance from the axis of rotation to the center of the mass. <u>Do this before removing the weight.</u>

e) Using the radius of revolution and the number of revolutions per second, compute the velocity of the mass when the apparatus was spinning using the equation:

$v_{av} = \Delta x/\Delta t = (2\pi r)n/\Delta t$ where n is the number of revolutions

f) Calculate centripetal force and the gravitational force required to stretch the spring by the same amount. Compare two forces.

g) Change the tension of the spring and repeat the entire experiment.

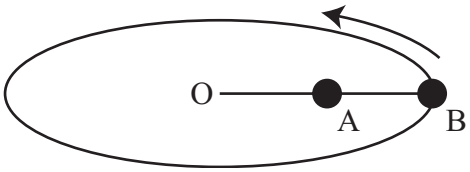
Discussion: Please answer the following questions:

a) Is it possible for an object to have an acceleration when the velocity of the object is constant? How about when the speed of the object is constant?

b) Can a car round a curve at a constant velocity? How about at a constant acceleration?

c) Consider two people, one at the equator, and another one at the north pole. Which has the greater centripetal acceleration?

d) Suppose we have two identical balls connected to two identical strings. The arrangement is whirled around in a horizontal circle as shown below. As it's whirled faster and faster which string is likely to break first.



e) The moon constantly accelerates towards the earth, yet it never falls into the earth. How can this happen?

Name: (Writer) _____ Date_____
(Partners) _____ Section _____

DATA SHEET

(You may record the data in an *Excel* spreadsheet if you prefer, but please record the same data)

Mass of the revolving cylinder = _____

Radius of the circular motion = _____

Minimum Tension (or just first Tension used)				
Timer Interval	Initial counter reading	Final counter reading	# of Revolutions	Velocity
				Average=

Compute the centripetal force in this case: _____

Mass you need hang to stretch same amount = _____
(measure twice and take average)

Compute the gravitational force (weight) in this case: _____

Name: (Writer) _____ Date_____
(Partners) _____ Section _____

Minimum Tension (or just first Tension used)				
Timer Interval	Initial counter reading	Final counter reading	# of Revolutions	Velocity
				Average=

Compute the centripetal force in this case: _____

Mass you need hang to stretch same amount = _____
(measure twice and take average)

Compute the gravitational force (weight) in this case: _____

Name: (Writer) _____ Date_____
(Partners) _____ Section _____