Circular Motion Lab

> "An object that moves in a circle at constant speed *v* is said to undergo **uniform circular motion**. Examples are a ball on the end of a string revolved around one's head." –Douglas Giancoli

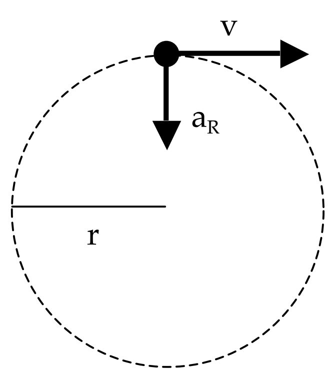
Purpose

This lab will allow us to examine the relationship between mass, velocity, radius, and centripetal force.

Theory

It turns out that when objects (like a mass on a string swinging around your head) undergo **uniform circular motion** they are moving with a constant *speed* (notice I didn't say velocity) and also constant acceleration. Because the mass on the end of the string is always changing direction, the velocity of the mass is always changing (remember that velocity is a vector quantity), and therefore the mass is accelerating. The velocity of the mass is always changing direction toward the center of the circle. It follows then that the mass is always accelerating toward the center of the circle. That "center-seeking", radial, or **centripetal** acceleration (a_R) is given by the following expression:

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



See page 63 of the text for an excellent proof.

We all know that **F=ma**, so if you know the centripetal acceleration you also know the centripetal force.

Materials

- A piece of string, 1 to 1.5 meters long
- Several washers or nuts to use as weights
- Masking tape
- Meter stick
- Stopwatch
- Calculator

Procedure

- This lab requires you to swing masses on the end of a string with uniform circular motion to examine what happens as you change three quantities: the mass, the length of the string, and the velocity. That is, what happens to the centripetal force when you change *v*, *r*, and *m*? It makes sense to divide this lab into three parts that will examine each of these.

- To get started, tie a knot at the end of your string that will act as a stop. It is important to make a good stop so that your masses do not fly off when you start swinging your string. We don't want anyone getting hurt.

- To calculate velocity, use your stopwatch and the equation for the circumference of a circle ($2\pi r$). Remember that to calculate velocity you don't need to time just one revolution. In fact, it would be smart to time 10-20 revolutions to find your velocity.

- I have created a chart that will help you organize your data. In the column labeled **"Feel" of the Force**, you will enter words like "greater, less, same." You will put a word there that describes how the force of the rope in your hand feels compared to the initial force. Do an initial trial first to have a baseline, and then for each trial record whether the force is less, greater, or the same.

- You may work through the three parts of this lab in any order you wish.

Part 1: How Mass Affects F_C

In this experiment you will see how mass affects the centripetal force, Fc. You must hold the radius and velocity as constant as possible for this part so that you are only seeing what effect a change in mass produces. This will be hard to do and it may take a couple of trials to get it right. Experiment with different amounts of mass and try to feel how the force varies on your hand. Does the rope pull more or less on your hand when the mass at the end of the rope is increased?

Part 2: How Velocity Affects F_C

In this experiment you must hold mass and radius constant. Spin the weight around in a circle and vary the velocity at which you spin it. Record how the amount of force on your varies with velocity.

Part 3: How Radius Affects F_C

In this experiment you must hold mass and velocity as constant as possible. This will be hard to do and it may take a couple trials to get it right. First, measure a couple of lengths out from your knot and wrap some tape around the rope to mark the spots. Don't go over 1.5 m, for the sake of safety. Spin the mass at different radii by changing the location of where you grab the rope. Once again, it is crucial that velocity is constant – pay attention to this.

Part 1 (Δ mass)	**Mass (g)**	**Velocity (m/s)**	**Radius (m)**	**“Feel” of the Force**	**Calculated Fc (N)**
Initial					
Trial #1					
Trial #2					
Trial #3					

Part 2 (Δ velocity)	**Mass (g)**	**Velocity (m/s)**	**Radius (m)**	**“Feel” of the Force**	**Calculated Fc (N)**
Initial					
Trial #1					
Trial #2					
Trial #3					

Part 3 (Δ radius)	**Mass (g)**	**Velocity (m/s)**	**Radius (m)**	**“Feel” of the Force**	**Calculated Fc (N)**
Initial					
Trial #1					
Trial #2					
Trial #3					

Sample calculations for velocity and F_C: