# Uniform Circular Motion

In this laboratory, we investigate uniform circular motion.
Make sure that you have the following pieces of equipment.

- large rotating arm apparatus

- mass M with pointy bottom

- weights and weight hanger

A hanging object with mass M will be moved in a circle while attached
to a spring. As shown in the diagram, the apparatus is adjusted so the forces
on the mass are only vertical or horizontal as it undergoes circular motion.
No trigonometry will be needed to break forces into components. We are
interested in the horizontal circular motion of the object with mass M.
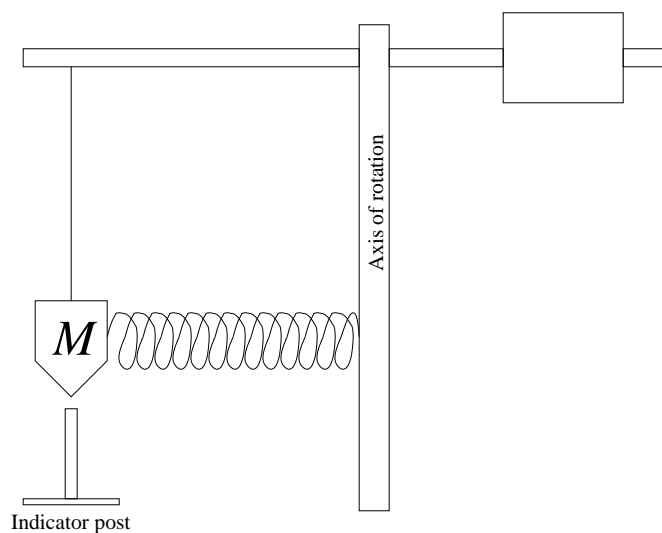
1   Measurements with a large radius

The indicator post is the long, thin, vertical stick of metal that slides back and forth at the base of the rotating arm apparatus. The distance between the indicator post and the axis of rotation defines the radius of the circular motion that we will produce. Choose a large radius by sliding the indicator post so that it is as far away from the axis of rotation as possible. Record this radius below. (Later, we will repeat the experiment with a small radius.)

Radius for circular motion	

Unhook the spring from the mass M so that it hangs freely. Adjust the apparatus so that the hanging mass hangs just above the indicator post. Connect the spring to the hanging mass. Now, it won't be hanging straight down.

1.1   Dynamic measurement of spring force

One person will spin the central rod with her/his hand, trying to maintain a speed that keeps the hanging mass just over the indicator post. This first person needs to carefully watch the mass as it passes above the indicator post, and gently adjust the amount of rotation that is applied to the central axle to keep the mass just above the indicator post as it rotates. A second person will time how long it takes for the hanging mass to complete 25 revolutions.

Time for 25 revolutions	

Calculate the speed of the hanging mass. Show your work.

If you know that the mass M is in uniform circular motion, what can you say about its acceleration?

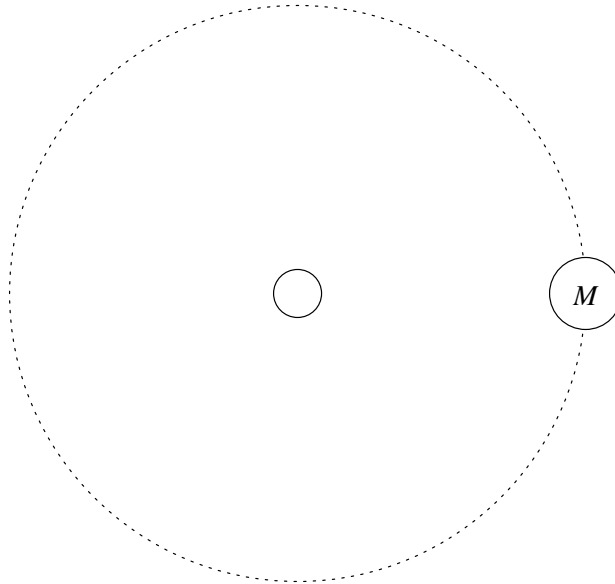Measure the mass M of the hanging object.

Mass M of object moving in a circle	

Explain how you can use the measurements that you have taken and the quantities that you have computed to find the net force on the mass M.

Draw a free-body diagram that includes all of the forces that act on mass M. Give names to each of the forces on the free-body diagram.

Explain how you will find the force that the spring exerts on the hanging object, and find that force.

The figure below is a simplified top view of the apparatus. Draw vectors on the picture for the velocity of the mass M and the acceleration of the mass M.

1.2 Static measurement of spring force

In this part, we do not rotate the hanging object. Instead, we apply a force to the hanging object by attaching a string to the side opposite the spring, we run the string over a pulley, and we hang some weight. Use an amount of weight so that the hanging object sits just above the indicator post. Record

the mass that you hung below.

Mass to stretch spring	

Draw a free-body diagram for the object with mass M in this situation.

What can you say about the net force on the object with mass M in this situation? Explain.

Explain how you can find the force that the spring exerts on the object with mass M (in the static situation), and find that force.

How does the static spring force compare to the spring force from before, when the object was in circular motion?

2   Measurements with a small radius

Choose a small radius at which to place the hanging object, and record this radius below.

Radius for circular motion	

Adjust the apparatus so that your hanging mass hangs at the radius you chose (do not connect the spring to the mass M yet), and so the indicator post sticking up is right under the tip of the hanging mass. It should be hanging straight down.

Connect the spring to the hanging mass. Now, it won't be hanging straight down.

2.1   Dynamic measurement of spring force

One person will spin the central rod with her/his hand, trying to maintain a speed that keeps the hanging mass just over the indicator post. A second person will time how long it takes for the hanging mass to complete 25 revolutions.

Time for 25 revolutions	

Calculate the speed of the hanging mass.

Find the force that the spring exerts on the hanging object. Show your work.

2.2   Static measurement of spring force

In this part, we do not rotate the hanging object. Instead, we apply a force to the hanging object by attaching a string to the side opposite the spring, we run the string over a pulley, and we hang some weight. Use an amount of weight so that the hanging object sits just above the indicator post. Record the mass that you hung below.

Mass to stretch spring	

Find the force that the spring exerts on the object with mass M (in the static situation). Show your work.

How does the static spring force compare to the spring force from before, when the object was in circular motion?