

## Concepts of Physics

# Lab 3: Centripetal Force

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### Centripetal force

When an object of mass  $M$  travels in a circle of radius  $R$  at constant speed  $v$ , there must be a force causing the continual change in direction. That force is called the centripetal force, and is directed toward the center of the circle. The magnitude of the centripetal force,  $F_c$ , is equal to  $Mv^2/R$ . In this part of the lab, you will find  $F_c$  by measuring  $M$ ,  $R$ , and  $v$ .

You will find  $v$  by measuring the distance traveled, and the time to travel it. Since you can measure the time for many revolutions more precisely than the time for one revolution, that is what you will do. If  $t_n$  is the time to make  $n$  revolutions, then:

$$v = \frac{\text{(distance traveled)}}{t_n} = \frac{n2\pi R}{t_n}. \quad (1)$$

Therefore:

$$F_c = \frac{M \left( \frac{n2\pi R}{t_n} \right)^2}{R} = \frac{Mn^2 4\pi^2 R}{t_n^2}. \quad (2)$$

You will measure  $M$ ,  $n$ ,  $R$  and  $t_n$  directly.

For this rotating object, the centripetal force will be caused by a stretched spring. You can measure this force by hanging masses from a string attached to the spring, and finding out how much mass it takes to stretch it to the appropriate length. If the hanging mass needed is  $m$ , then the force exerted by the spring at that length,  $F_s$ , must be  $mg$ . Here,  $g$  is the acceleration due to gravity—assume  $g = 9.80 \text{ m/s}^2$ .

## Activity 1: Rotating, counting and timing

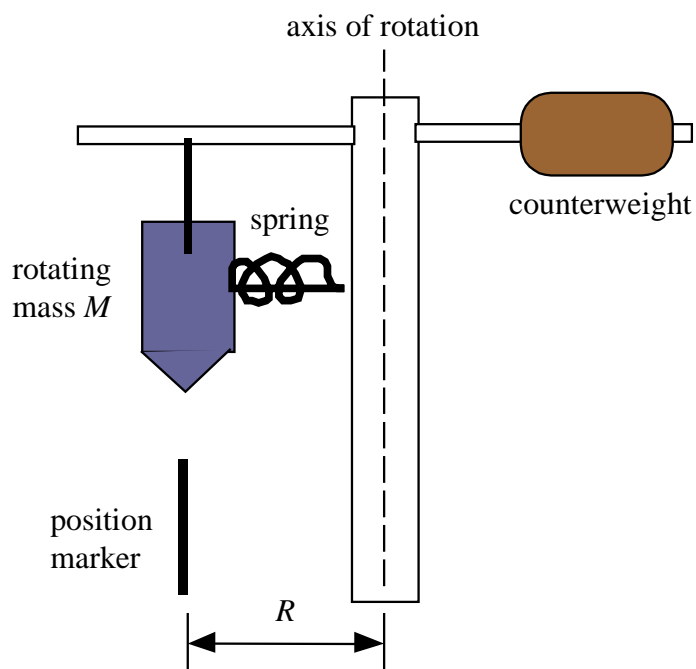


Figure 1: Experimental setup

Set up the apparatus as shown in Figure 1. When the mass  $M$  is directly over the position marker, the spring should be stretched and horizontal.

Now practice spinning the apparatus so that it stays just above the position marker—that is how you keep  $R$  constant. When spinning, the mass should be hanging vertically, and the spring should be horizontal—make adjustments if necessary. Practice timing how long it takes for the mass to go around  $n$  times (where  $n$  is at least 50). The person rotating the axle should count the rotations out as another person times the  $n$  rotations.

### To hand in for activity 1

*Nothing.*

## Activity 2: Finding $F_c$

Measure  $R$ ,  $M$ ,  $n$ , and (as outlined in activity 1)  $t_n$ ; and calculate  $F_c$ .

### To hand in for activity 2

- Values for  $R$ ,  $M$ ,  $n$ , and  $t_n$ ,
- Equation used for  $F_c$ ,
- Final value for  $F_c$ .

## Activity 3: Finding $F_s$

Attach a string to the outer edge of the mass  $M$ , run it over the pulley, and hang various masses from it until the mass  $M$  hangs just over the position marker. Measure  $m$ , and calculate  $F_s$ .

You have now measured a force—the force exerted by a spring stretched a certain amount—two different ways. You have no accepted value for this force, so it will not be possible to calculate a percent error. It would, however, make sense to calculate the percent difference between your two results. The percent difference between results  $r_1$  and  $r_2$  is:

$$\% \text{ difference} = \frac{|r_1 - r_2|}{(r_1 + r_2)/2} \times 100\%$$

### To hand in for activity 3

- Values for  $g$  and  $m$ ,
- Equation used for  $F_s$ ,
- Final value for  $F_s$ ,
- Percent difference between  $F_c$  and  $F_s$ .