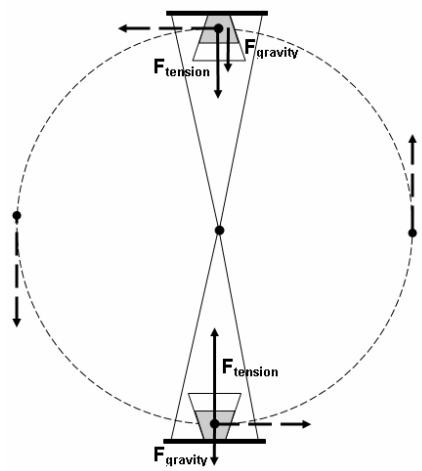
Name _____ Date _____ Period _____

# Lab: Circular Motion and Force

COORDINATED SCIENCE 1

**Background:** Suppose that you were driving a car with the steering wheel turned in such a manner that your car followed the path of a perfect circle with a constant radius. And suppose that as you drove, your speedometer maintained a constant reading of 10 mi/hr. In such a situation as this, the motion of your car would be described to be experiencing uniform circular motion. ***Uniform circular motion*** is the motion of an object in a circle with a constant or uniform speed.

**Uniform circular motion** - circular motion at a constant speed - is one of many forms of circular motion. An object moving in uniform circular motion would cover the same linear distance in each second of time. When moving in a circle, an object traverses a distance around the perimeter of the circle. So if your car were to move in a circle with a constant speed of 5 m/s, then the car would travel 5 meters along the perimeter of the circle in each second of time. The distance of one complete cycle around the perimeter of a circle is known as the **circumference**. At a uniform speed of 5 m/s, if the circle had a circumference of 5 meters, then it would take the car 1 second to make a complete cycle around the circle. At this uniform speed of 5 m/s, each cycle around the 5-m circumference circle would require 1 second. At 5 m/s, a circle with a circumference of 20 meters could be made in 4 seconds; and at this uniform speed, every cycle around the 20-m circumference of the circle would take the same time period of 4 seconds. This relationship between the circumference of a circle, the time to complete one cycle around the circle, and the speed of the object is merely an extension of the average speed equation.




$$\text{Average Speed} = \frac{\text{distance}}{\text{time}} = \frac{\text{circumference}}{\text{time}}$$

The circumference of any circle can be computed using from the radius according to the equation

$$Circumference = 2 \cdot \Pi \cdot radius$$

Combining these two equations above will lead to a new equation relating the speed of an object moving in uniform circular motion to the radius of the circle and the time to make one cycle around the circle (***period***).

$$\bar{v} = \frac{2 \cdot \Pi \cdot r}{T}$$

**Procedure:**

1. Form groups of 3-4 students.
2. Obtain materials for "whirling-cup" experiment (cup, plate w/ string) *One set-up per group.*
3. Fill up your plastic cup approximately **2/3rds full**. Weigh the cup on the triple-beam scale and record below. (Make sure you change from **g** to **kg**) Record in Table # 1.
4. Walk outside with your group and find a spot away from the other students where you can swing the cup in a vertical circle without hitting anyone else.
5. Using a meter stick, measure the **radius** (**r**) of the motion. Put into table #1 (express in meters)

6. Your job will be to try and calculate the minimum ***period*** (***T***) of the swinging cup that maintains the water in the cup. You may want to start swinging it faster and then slow down until it almost looks like the cup will "fall out" of the tray. Have one of your group time **10** complete revolutions and calculate the period (**T**) *Note: Take the time (in seconds) for 10 revolutions and divide by 10. Put into Table # 1.*

7. Now that you know the time it takes for one revolution (the period), calculate the ***rotational speed*** in ***RPM*** (revolutions per minute) *Note: Divide 60 by the period you calculated above to calculate the rotational speed in RPM.* Put into table #1

8. Using the information in Table 1 below, calculate the minimum ***average velocity (tangential speed)*** that was required to keep the cup full of water and swinging in a circle. (See equation on page 1). Put into Table # 1.

9. When you have completed Table # 1, answer the questions below.

| **Table # 1** | | |
|---|---|---|
| Mass of cup (**m**) | (g) | (kg) |
| Weight of cup ($F_g = mg$) | | (N) |
| Length of string (**r**) in meters | | (m) |
| Period of rotation (**T**) in seconds | | (s) |
| Rotational speed (**RPM**) | | (RPM) |
| Minimum Average velocity = | | (m/s) |

## Conclusion Questions

1. What is the definition of **period** (**T**)?

3. What happens to your cup of water when you velocity fell below the minimum you calculated?

3. What is the name of the force that keeps the cup moving in uniform circular motion?

4. What do you think would happen if the mass of the object you were swinging in a circle was much greater?

5. What is the force that is keeping the object in uniform circular motion?