Newton’s Third Law Lab

**Introduction**

**Purpose** To investigate circular / orbital motion related to force & Newton’s Law.

**Discussion**

Circular motion is a movement of an object along the circumference of a circle or rotation along a circular path. It can be uniform, with constant angular rate of rotation and constant speed, or non-uniform with a changing rate of rotation.

Uniform circular motion can be described as the motion of an object in a circle at a constant speed. As an object moves in a circle, it is constantly changing its direction. At all instances, the object is moving tangent to the circle. Since the direction of the velocity vector is the same as the direction of the object's motion, the velocity vector is directed tangent to the circle as well. The animation at the right depicts this by means of a vector arrow.

An object moving in a circle is accelerating. Accelerating objects are objects which are changing their velocity - either the speed (i.e., magnitude of the velocity vector) or the direction. An object undergoing uniform circular motion is moving with a constant speed. Nonetheless, it is accelerating due to its change in direction. The direction of the acceleration is inwards. The animation at the right depicts this by means of a vector arrow.

The final motion characteristic for an object undergoing uniform circular motion is the net force. The net force acting upon such an object is directed towards the center of the circle. The net force is said to be an inward or centripetal force. Without such an inward force, an object would continue in a straight line, never deviating from its direction. Yet, with the inward net force directed perpendicular to the velocity vector, the object is always changing its direction and undergoing an inward acceleration.

Tangential velocity is the linear speed of any object moving along a circular path. A point on the outside edge of a turntable moves a greater distance in one complete rotation than a point near to the center.

**MATERIALS**: 70 cm length of thin string Straw Meter Stick

2 Washers Metric Ruler

straw

20 cm

washer

marks

Washer

20 cm

**PROCEDURES**:

1. Measure out a 70 cm length of string. Thread the string through the straw.
2. Tie one end of the string to the center of one of the washers. Tie the opposite end of the string to a washer and use it for gripping the string. Your distances are shown above.
3. Hold the straw vertically above your head with one hand and hold the lower washer by your other hand.
4. Adjust your string so that the non-held washer is 20 cm from the straw. In other words, pull the string out until the mark you made is right at the straw.
5. Twirl the straw so that the washer makes a circular orbit with a radius of 20 cm (making a **diameter** of **40 cm**). Continue to twirl the straw for 5-10 seconds while a partner measures the diameter of the circular orbit without touching the straw. It should be close to 40 cm.
6. Notice the string does not move from the original marks. Record “0 cm” in the Calculations and Data table for the “Distance string was moved to or from the Straw”.
7. While twirling the washer by the straw, pull slowly on the string with your left hand until the washer makes a circular orbit of **20 cm** in **diameter**. Continue to spin for 5-10 seconds at that diameter.
8. Keep the string at that exact position, but stop twirling. Measure the distance from the straw to the stopper and the distance the opposite end of the string moved from the straw. *Record these measurements on the Calculation and Data sheet*.
9. Pick up the straw/washer apparatus again and twirl the washer to give the original distances (20 cm on each end of the straw).
10. Slowly allow the string to go through the straw until you make a circular orbit with a **diameter** of **60 cm**. Hold that orbit for 5-10 seconds.
11. Keep the string at that exact position, but stop twirling. Measure the distance from the straw to the moving washer AND the distance the opposite end of the string moved towards the straw. *Record these measurements on the Calculation and Data sheet*.

**Calculations and Data Sheet**

Complete the chart below based on your observations and measurements. BE SURE TO INCLUDE UNITS for all your measurements.

|  |  |  |  |
| --- | --- | --- | --- |
| **Procedure #** | **Distance from straw to washer** | **Diameter of orbit produced** | **Distance string was moved to or from the Straw** |
| 5-6 | 20 cm | 40 cm |  |
| 7-8 | 10 cm | 20 cm |  |
| 10-11 | 30 cm | 60 cm |  |

**CONCLUSIONS AND QUESTIONS**

1. What kind of forces were acting on the string and the washer when the circular orbit was constant diameter?

2. What kind of force was needed to change the diameter of the circular orbit (either to make it smaller or larger)?

3. How did the measurements you observed prove Newton’s Third Law of motion? Consider the measurements you made for the length of string on each side of the straw when you changed the circular orbit?

1. Which diameter of circular orbit required the MOST energy to maintain (20 cm, 40 cm, 60 cm)? Explain.
2. Which diameter of circular orbit required the LEAST energy to maintain (20 cm, 40 cm, 60 cm)? Explain.
3. Which of Newton’s Laws would best explain your observation from #4 and why?

Answer Key

**Part II Orbital or Circular Motion** *(String, Rubber Stopper, Straw)*

Complete the chart below based on your observations and measurements. BE SURE TO INCLUDE UNITS for all your measurements.

|  |  |  |  |
| --- | --- | --- | --- |
| **Procedure #** | **Distance from straw to stopper** | **Diameter of orbit produced** | **Distance from Straw to mark or knots** |
| 7 | -**10 cm** | **20 cm** | **+10 cm** |
| 8-9 | 20 cm | **40 cm** | **0 cm** |
| 10-11 | **+10 cm** | 60 cm | **-10 cm** |

**CONCLUSIONS AND QUESTIONS**

1. What kind of forces were acting on the string and the washer when the circular orbit was constant diameter?

**Opposite & balanced forces (centripetal force)**

2. What kind of force was needed to change the diameter of the circular orbit (either to make it smaller or larger)?

**Unbalanced force**

3. How did the measurements you observed prove Newton’s Third Law of motion? Consider the measurements you made for the length of string on each side of the straw when you changed the circular orbit?

**For every centimeter change in one direction, there was an equal and opposite change in the other direction (+10 cm vs. –10 cm)**

4. Which diameter of circular orbit required the MOST energy to maintain (20 cm, 40 cm, 60 cm)? Explain.

**The largest diameter circular orbit required the most energy because the washer had to travel farther (assuming all stoppers traveled the same speed) … [*show the hub and rim of a wheel on a bike*]**

5. Which diameter of circular orbit required the LEAST energy to maintain (20 cm, 40 cm, 60 cm)? Explain.

**The smallest diameter circular orbit required the least energy because the washer travelled less distance (assuming all stoppers travelled the same speed)**

6. Which of Newton’s Laws would best explain your observation from #4 and why?

**Newton’s Third Law (Action/Reaction …. Equal & opposite reactions). Force is directly related to motion: the more force, the more motion. When the washer traveled farther, it required more force.**