Circular Motion 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.

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 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.

**Hypothesis**

If an object undergoes circular motion, then its circumferential energy (outermost rotation) is greater than its radial energy (at the center of rotation).

**Materials** 70 cm length of thin string Straw Meter Stick

 2 Washers Washer 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**

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Procedure #** | **Distance from straw to rubber stopper** | **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 |  |

Based on the arrows, which represent the centripetal force, centrifugal force, tangential (linear) speed in the diagram?

A

B

C

A.

B.

C.

**Conclusions and Questions**

1. What force kept the washer from escaping?

2. What force allowed the washer to move farther away from the straw when spinning?

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

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

5. Did the washer rotate or revolve around the straw?

6. Describe / distinguish the linear, tangential, and rotational speeds of the straw system.

7. Which diameter of circular orbit produced the greatest linear speed (20 cm, 40 cm, 60 cm)? Explain.

Answer Key

**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** |

Based on the arrows, which represent the centripetal force, centrifugal force, tangential (linear) speed in the diagram?

A

B

C

A. **centripetal force**

B. **tangential (linear) speed**

C. **centrifugal force**

**CONCLUSIONS AND QUESTIONS**

1. What force kept the washer from escaping? **centripetal force (towards the center)**

2. What force allowed the washer to move farther away from the straw when spinning?

**centrifugal force (away from center)**

3. 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 moving washer had to travel farther (assuming all washers traveled the same speed) … [*show the hub and rim of a wheel on a bike*]**

4. 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 moving washer travelled less distance (assuming all washers travelled the same speed)**

5. Did the washer rotate or revolve around the straw? What about your hand holding the straw?

**The washer revolved around the straw because it turned around an external axis (e.g. you riding a merry-go-round). The hand rotated around the axis of the straw because the straw represented the internal axis.**

6. Describe / distinguish the linear, tangential, and rotational speeds of the straw system.

**The linear speed relates to the distance an object moves over time. Linear speed is greatest on the outer edge of a rotating object.**

**Tangential speed relates to an object moving in a circular path. Objects always want to go in a straight line, but when a centripetal force is exerted, it causes the object to move in a circular path. Linear and tangential speeds are the same for circular motion.**

**Rotational speed (angular speed) relates to the number of rotations per unit time. Object in a system with a rigid axis that rotates (e.g. merry-go-round, turntable) have the same rotational speed anywhere in the system.**

7. Which diameter of circular orbit produced the greatest linear speed (20 cm, 40 cm, 60 cm)? Explain.

**The 60 cm circumference produced the greatest linear or tangential speed because it was the greatest distance from the central axis.**