Chapter 27.2 - Law of Equal Areas (Kepler's 2nd Law)

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Orbital Speed Demonstration Kit

Introduction

How do the radius of an orbit and gravitational forces affect orbital speed? In this demonstration, a simple apparatus will be assembled and used to demonstrate orbital speed and centripetal force.

Concepts

- Orbits
- Kepler's Law
- Orbital speed
- Centripetal force

Materials (for each demonstration)

Calculator
Handle tube*
Meter stick
Paper clips, 2*
Rubber stopper, two-hole*
String, 1.5 m*
Stopwatch or clock with second hand
Washers, 18*

**Materials included in kit.*

Safety Precautions

The very nature of the motion in this activity makes it potentially dangerous. Use caution when twirling the rubber stopper. This demonstration is best conducted in a large open area. Wear safety glasses. Please follow all laboratory safety guidelines.

Procedures

Part I. Orbital Speed and Radius

1. Obtain a two-hole rubber stopper, the handle tube, string and a meter stick.
2. Thread the string through one hole in the rubber stopper and then back through the other hole. Tie the stopper securely to the end of the string. Tie a few knots to make sure the stopper is secure.
3. Thread the free end of the string through the handle tube. Leave about 1 meter of string between the top of the handle and the rubber stopper. See Figure 1 for the basic setup.
4. Hold the bottom of the free end of the string firmly in one hand and the handle tube in the other hand (see Figure 1). *Caution:* Be sure you are in an open area clear of people and any breakable items.
5. Twirl the rubber stopper *slowly* in a horizontal circle over your head and gradually increase the speed of the rubber stopper until it just stays in a horizontal orbit. Be sure to hold on tight to the bottom of the string.
6. Spin the stopper at a constant rate for 20 seconds. Have students count and record the number of revolutions the stopper makes in a 20-second period when the orbit radius is one meter in the Orbital Speed Worksheet.

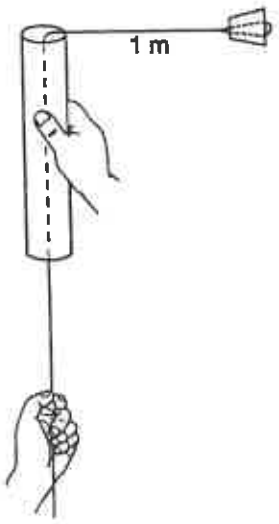

Figure 1.

7. Shorten the length of the string above the handle to approximately 0.5 meters and repeat steps 4 though 6 for an orbi radius of 0.5 meters.

Name: _____

Orbital Speed Worksheet

Part I — Orbital Speed and Radius

String Radius (meters)	Number of Revolutions in 20 Seconds	Period (Number of Revolutions Per Second)
1.0		
0.5		

Use the following equation to calculate orbital speed (velocity, v)

$$\text{Orbital speed} = \frac{2\pi r}{T}$$

v is the velocity (m/s)
r is the radius of the orbit (m)
T is the period—time for one revolution (s)

Orbital speed of stopper at:

1.0 meter _____ m/s

0.5 meter _____ m/s

Part II — Orbital Speed and Force of Gravity

Number of Washers	Number of Revolutions in 20 Seconds	Period (Number of Revolutions Per Second)
6		
18		

Use the orbital speed equation above to calculate the orbital speed of the stopper using:

6 washers _____ m/s

18 washers _____ m/s

Questions

1. Using the results from Part I, describe the relationship between orbital radius and orbital speed.

2. Using the results from Part II, describe the relationship between gravitational force and orbital speed.

3. Predict what would happen to the stopper if the string were suddenly cut during the demonstration.

4. How is this demonstration similar to the orbits of the planets? How is it different? What does the stopper represent? the tube handle?

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