CHAPTER 7
Laboratory Exercise

OBJECTIVES

- Examine the relationship between the force that maintains circular motion, the radius, and the tangential speed of a whirling object.

MATERIALS LIST

- ✔ 1.5 m nylon cord
- ✔ 2-hole rubber stopper
- ✔ masking tape
- ✔ meterstick
- ✔ PVC tube, about 15 cm long and 1 cm in diameter
- ✔ set of masses
- ✔ stopwatch

CIRCULAR MOTION

In this experiment, you will construct a device for measuring the tangential speed of an object undergoing circular motion, and you will determine how the force and the radius affect the tangential speed of the object.

SAFETY

- **Tie back long hair, secure loose clothing, and remove loose jewelry to prevent their getting caught in moving or rotating parts.**
- **Wear eye protection and perform this experiment in a clear area. Swinging or dropped masses can cause serious injury.**

PREPARATION

1. Read the entire lab, and plan what measurements you will take.
2. Prepare a data table in your lab notebook with five columns and fifteen rows. In the first row, label the columns *Trial, Hanging mass (kg), Mass of stopper (kg), Total time (s), Radius (m).* In the first column, label the second through fifteenth rows *1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,* and *14.*

PROCEDURE

Constant radius with varying force

3. Measure the mass of the rubber stopper, and record it in your data table. Fasten one end of the nylon cord securely to the rubber stopper. Pass the other end of the cord through the PVC tube and securely fasten a 100 g mass to the other end, as shown in **Figure 7-21.** Leave approximately 0.75 m of cord between the top of the tube and the rubber stopper. Attach a piece of masking tape to the cord just below the bottom of the tube.
4. Make sure the area is clear of obstacles, and warn other students that you are beginning your experiment. Support the 100 g mass with one hand and hold the PVC tube in the other. Make the stopper at the end of the cord circle around the top of the tube by moving the tube in a circular motion.
5. Slowly release the 100 g mass, and adjust the speed of the stopper so that the masking tape stays just below the bottom of the tube. Make several practice runs before recording any data.

6. When you can keep the velocity of the stopper and the position of the masking tape relatively constant, measure the time required for 20 revolutions of the stopper. Record the time interval in your data table in the row labeled *Trial 1*. Repeat this trial and record the time interval in your data table as *Trial 2*.

7. Place the apparatus on the lab table. Extend the cord so that it is taut and the masking tape is in the same position it was in during the experiment. Measure the cord from the center of the top of the PVC tube to the center of the rubber stopper. Record this distance in the data table as *Radius* for *Trials 1* and *2*.

8. Repeat the procedure with three different masses for *Trials 3–8*. Keep the radius the same as in the first trial and use the same rubber stopper, but increase the mass at the end of the cord each time. Do not exceed 500 g. Attach all masses securely. Perform each trial two times, and record all data in your data table.

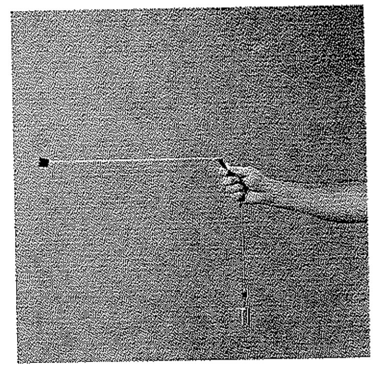

Figure 7-21
Step 3: To attach masses, make a loop in the cord, place the mass inside the loop, and secure the mass with masking tape.
Step 4: You will need a clear area larger than two times the radius.
Step 5: Spin the stopper so that the cord makes a 90 degree angle with the PVC tube. Release the mass slowly without changing the speed.
Step7: Make sure the cord is held straight when you make your measurements.

Constant force with varying radius

9. For *Trials 9–14*, use the same stopper and the 100 g mass and try three different values for the radius in the range 0.50 m to 1.00 m. Make sure that you have a clear area of at least 2.5 m in diameter to work in. Record all data in your data table.

ANALYSIS AND INTERPRETATION

Calculations and data analysis

1. **Organizing data** Calculate the weight of the hanging mass for each trial. This is the force that maintains circular motion, F_c.

2. **Organizing data** For each trial, find the time necessary for one revolution of the stopper by dividing the total time required for 20 revolutions by 20.

3. **Organizing data** Find the tangential speed for each trial.
   a. Use the equation $v_t = \frac{2\pi r}{\Delta t}$.
   b. Use the equation $v_t = \sqrt{\frac{F_c r}{m}}$, where r is the radius of revolution and m is the mass of the stopper.

4. **Graphing data** Plot the following graphs:
   a. Use the data from *Trials 1–8* to plot a graph of force versus tangential speed.
   b. Use the data from *Trials 9–14* to plot a graph of tangential speed versus radius.