

# Centripetal Acceleration

## Spin a Penny on a Hanger

### Introduction

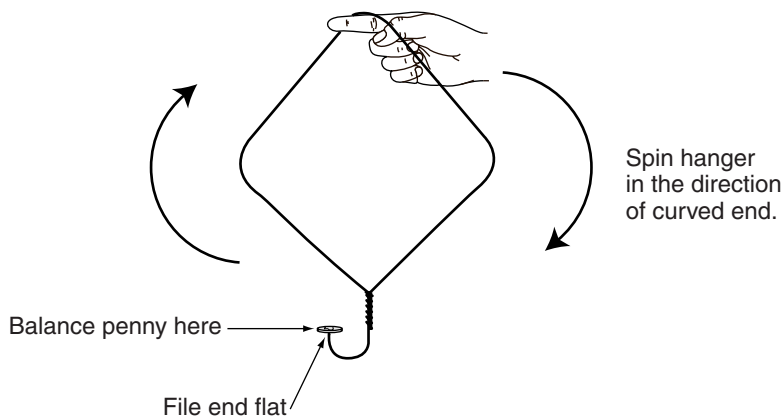
Take your students on an amusement park ride—for just a penny! Discuss how an object can be accelerating yet moving at constant speed. Investigate how a change in direction (at constant speed) is acceleration; that is, centripetal acceleration!

### Physical Science Concepts

- Centripetal acceleration
- Velocity
- Vectors

### Materials (for each demonstration)

Hanger, metal  
File  
Penny



### Safety Precautions

*Both the demonstrator and all observers should wear protective eyewear. Use caution when performing this activity. Have all observers stand away as the demonstrator rotates the hanger and penny—the penny may fly off.*

### Preparation

1. Bend a metal hanger so that it forms a diamond shape, as shown in the diagram.
2. File the end of the looped portion of the hanger so it is flat and so that a penny may be easily balanced without falling off. The loop may need to be bent slightly.
3. Practice the demonstration before class.

### Procedure

1. Using one index finger pointed straight out, hold the hanger at the top of the diamond, so that the loop hangs downward.
2. Using the other hand, balance the penny (heads-up) on the flat, filed end of the hanger (see *Tips* section).
3. Once the penny is balanced, gently and carefully rotate the hanger in a full circular motion at a constant speed. Start rotating slowly and without jerking the hanger or the penny will drop.
4. Observe the penny as it follows the loop of the hanger—it remains in place on the hanger. Discuss this observation with your class.

## NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

### Disciplinary Core Ideas: Middle School

MS-PS2 Motion and Stability: Forces and Interactions  
 PS2.A: Forces and Motion  
 PS2.B: Types of Interactions

### Disciplinary Core Ideas: High School

HS-PS2 Motion and Stability: Forces and Interactions  
 PS2.A: Forces and Motion  
 PS2.B: Types of Interactions

### Science and Engineering Practices

Developing and using models  
 Constructing explanations and designing solutions

### Crosscutting Concepts

Cause and effect  
 Structure and function

## Tips

- Balancing the penny on the flat, filed end of the hanger is not easy and may take some practice. The easiest way to balance the penny is to hold the penny flat on your middle and index fingers. With those two fingers slightly spread, lower the penny onto the flat, filed end of the hanger. It has also been found that raising the hanger to meet the penny works well.
- Allow students to practice and then have them demonstrate this activity in front of the class. This can be a motivational, attention-getting activity at the beginning of the motion unit, or an activity to break up the period when students are doing math calculations on velocity and acceleration.

## Discussion

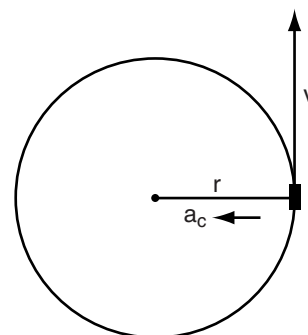
*Velocity* is the rate of motion in a specified direction and *acceleration* is a change in an object's velocity. Both velocity and acceleration are vector quantities in that they are based on a magnitude AND a specified direction (i.e., the car is traveling north at 55 mph). *Speed*, on the other hand, is an object's rate of motion. Speed is a scalar quantity and is based only on a magnitude

(i.e., the car is traveling at 55 mph). Whenever there is a force, there is acceleration according to Newton's second law of motion ( $F = ma$ ). A force is required to change an object's speed, and a force is required to change an object's direction. Since velocity is a quantity of speed and direction, a change in an object's speed OR a change in its direction, or both cause the object to accelerate. The force can change the speed of the object without affecting its direction (linear acceleration), or the force can change the direction of the object with or without affecting its speed (centripetal acceleration).

Acceleration toward the center of a curved or circular path is called *centripetal acceleration* ( $a_c$ ). The word centripetal means "toward the center." If an object is spinning in a circle at a constant speed, the object is accelerating. This is because there is a continuous change in direction (and velocity includes both speed *and* direction).

As an object moves in a circle, the change in its direction of motion is always toward the center of the circle, while the direction of its motion is always perpendicular to the radius of the circle. The force acting on the object in a direction toward the center of the curve is termed the *centripetal force*. This force is based on the perpendicular speed of the object and its distance from the center as measured by  $v^2/r$ , where  $v$  is the object's velocity and  $r$  is the circle's radius.

Another common term associated with circular motion is *centrifugal acceleration*. Centrifugal acceleration is a fictitious outward force (a pseudoforce) that balances centripetal acceleration. It is a term commonly used to describe the "force" of inertia that wants to keep an object traveling in a straight line.



## Materials for *Centripetal Acceleration* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP8975	File, Triangular, 101/29
AP8826	File, Triangular, Handle

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.