Summary

THE BIG IDEA **Centripetal force keeps an object in circular motion.**

10.1 Rotation and Revolution

Two types of circular motion are rotation and revolution.

- An **axis** is the straight line around which rotation takes place.
- When an object turns about an *internal* axis—that is, an axis located within the body of the object—the motion is called **rotation,** or spin. A Ferris wheel rotates about an axis.
- When an object turns about an *external* axis, the motion is called **revolution.** Riders *revolve* about the axis of a Ferris wheel.
- Earth undergoes both types of circular motion. It revolves around the sun once every 365 1/4 days, and it rotates around an axis passing through its geographical poles once every 24 hours.

10.2 Rotational Speed

Tangential speed depends on rotational speed and the distance from the axis of rotation.

- **Linear speed** is the distance traveled per unit of time. The linear speed is greater on the outer edge of a rotating object, such as a merry-go-round, than it is closer to the axis.
- **Tangential speed** is the speed of something moving along a circular path. For circular motion, the terms *linear speed* and *tangential speed* are interchangeable.
- **Rotational speed,** which is sometimes called angular speed, is the number of rotations per unit of time. All parts of a merry-go-round have the same rotational speed.
- Tangential speed and rotational speed are related.

$$\text{Tangential speed} \sim \text{radial distance} \times \text{rotational speed}$$

$$v \sim r\omega$$

- As you move away from the axis of a rotating platform, your tangential speed increases while your rotational speed stays the same.
- Wheels of a train stay on the track because their rims are slightly tapered. So when a train rounds a curve, wheels on the outer track ride on the wider part of the tapered rims (and cover a greater distance in the same time) while opposite wheels ride on their narrow parts (covering a smaller distance in the same time).

10.3 Centripetal Force

The centripetal force on an object depends on the object's tangential speed, its mass, and the radius of its circular path.

- Any object moving in a circle undergoes an acceleration that is directed to the center of the circle. This is centripetal acceleration. *Centripetal* means "toward the center."
- The force directed toward a fixed center that causes an object to follow a circular path is called **centripetal force.**
- Centripetal forces can be exerted in a variety of ways. Anything that moves in a circular path is acted on by a centripetal force.
- Centripetal force can be calculated using the following equation:

$$\text{Centripetal force} = \frac{\text{mass} \times \text{speed}^2}{\text{radius of curvature}} \quad \text{or}$$

$$F_c = \frac{mv^2}{r}$$

- Centripetal force F_c is measured in newtons when mass m is expressed in kilograms, speed v in meters/second, and radius of curvature r in meters.
- The centripetal force acting on a circularly moving object is the net force that acts exactly along the radial direction—toward the center of the circular path.

10.4 Centripetal and Centrifugal Forces

The "centrifugal-force effect" is attributed not to any real force but to inertia—the tendency of the moving body to follow a straight-line path.

- The apparent outward force on a rotating or revolving body is called **centrifugal force.** *Centrifugal* means "center-fleeing," or "away from the center."
- If you are in a car that rounds a sharp corner to the left, you tend to pitch outward against the right door. This happens not because of some outward or centrifugal force, but because there is no centripetal force holding you in circular motion.
- Likewise, the only force exerted on a whirling can at the end of a string is a centripetal force. No outward force acts on the can.

10.5 Centrifugal Force in a Rotating Reference Frame

Centrifugal force is an effect of rotation. It is not part of an interaction and therefore it cannot be a true force.

- Because centrifugal force is merely an effect of rotation, it is not a true force like gravitational, electromagnetic, and nuclear forces.
- Physicists refer to centrifugal force as a "fictitious force."
- To observers in a rotating system, however, centrifugal force is very real.