CHAPTER OUTLINE

Section 1 Measuring Motion

Key Idea questions

> How is a frame of reference used to describe motion?
> What is the difference between speed and velocity?
> What do you need to know to find the speed of an object?
> How can you study speed by using graphs?

Observing Motion

> How is a frame of reference used to describe motion?

> When an object changes position with respect to a frame of reference, the object is in motion.

- motion: an object's change in position relative to a reference point
- frame of reference: a system for specifying the precise location of objects in space and time
- Distance measures the path taken.
- Displacement is the change of an object's position.
  - displacement: the change in position of an object
  - always includes direction

Speed and Velocity

> What is the difference between speed and velocity?

> Speed tells us how fast an object moves, and velocity tells us both the speed and the direction that the object moves.

- speed: the distance traveled divided by the time interval during which the motion occurred
- velocity: the speed of an object in a particular direction
- Velocity is described relative to a reference point.

  - Direction is described as positive or negative along the line of motion.
  - By convention, up and right are usually positive, and left and down are negative.
- Combined velocities determine the resultant velocity.

Calculating Speed

> What do you need to know to find the speed of an object?

> To calculate speed, you must measure two quantities: the distance traveled and the time it took to travel that distance.

- Average speed is calculated as distance divided by time.

$$\text{speed} = \frac{\text{distance}}{\text{time}}, \text{ or } v = \frac{d}{t}$$

- SI unit for speed: meters per second (m/s)
- Constant speed: equal distances in equal amounts of time
- Instantaneous speed: the speed at a given time

Graphing Motion

> How can you study speed by using graphs?

> You can plot a graph showing distance on the vertical axis and time on the horizontal axis.

- Motion can be studied using a distance vs. time graph.
  - time (*x*-axis) = independent variable
  - distance (*y*-axis) = dependent variable
- The slope of a distance vs. time graph equals speed.

Section 2 Acceleration

Key Idea questions

> What changes when an object accelerates?
> How do you calculate the acceleration of an object moving in a straight line?
> How can a graph be used to find acceleration?

Acceleration and Motion

> What changes when an object accelerates?

> When an object undergoes acceleration, its velocity changes.

- acceleration: the rate at which velocity changes over time; an object accelerates if its speed, direction, or both change
- Acceleration can be a change in speed.
  - An increase or decrease in speed is an acceleration.
- Acceleration can also be a change in direction.
  - A motorcyclist who rides around the inside of a large barrel is constantly accelerating.
  - A person riding a Ferris wheel at an amusement park is accelerating.
- The acceleration that occurs in circular motion is known as *centripetal acceleration.*

Calculating Acceleration

> How do you calculate the acceleration of an object moving in a straight line?

> The average acceleration over a given time interval can be calculated by dividing the change in the object's velocity by the time over which the change occurs.

- Acceleration is the rate at which velocity changes.

- In this book, for straight-line motion, a positive acceleration means that the object's velocity is increasing—the object is speeding up.

- Negative acceleration means that the object's velocity is decreasing—the object is slowing down.

- SI units of acceleration = meters per second per second (m/s/s), or m/s^2

Graphing Accelerated Motion

> How can a graph be used to find acceleration?

> The slope of a straight line on a speed vs. time graph is equal to the acceleration.

- Acceleration can also be seen on a distance vs. time graph.

  - The distance vs. time graph is not a straight line when the velocity is not constant.

  - This curved line indicates that the object is under acceleration.

Section 3 Motion and Force

Key Idea questions

> What do scientists identify as the fundamental forces of nature?
> What happens when there is a net force acting on an object?
> What force always opposes motion?
> Why is friction sometimes necessary?

Fundamental Forces

> What do scientists identify as the fundamental forces of nature?

> These forces are the force of gravity, the electromagnetic force, the strong nuclear force, and the weak nuclear force.

  – The strong and weak nuclear forces act only over a short distance.

  – The force of gravity is a force that you feel every day.

  – Other everyday forces, such as friction, are a result of the electromagnetic force.

- Fundamental forces vary in strength.

  – The fundamental forces vary widely in strength and the distance over which they act.

- Forces can act through contact or at a distance.

  – Pushes and pulls are examples of *contact forces.*

  – *Field forces* (like the force of gravity) do not require that the objects touch each other.

  – Both contact and field forces can cause an object to move or to stop moving.

Balanced and Unbalanced Forces

> What happens when there is a net force acting on an object?

> Whenever there is a net force acting on an object, the object accelerates in the direction of the net force.

- *net force:* the combination of all forces acting on an object
- Balanced forces do not change motion.
  - Forces are balanced when the net force is zero.
  - Example: For a light hanging from the ceiling (at rest), the upward force due to tension in the cord balances the downward force of gravity.
- Unbalanced forces do not cancel completely.
  - Forces are unbalanced when the net force is greater than zero.
  - The object will accelerate in the direction of the net force.
  - Example: If you push a box to the east and your friend pushes the box to the north, the box will accelerate in a northeasterly direction.

The Force of Friction

> What force always opposes motion?

> The force of friction always opposes the motion.

- friction: a force that opposes motion between two surfaces that are in contact
- Static friction is greater than kinetic friction.
  - static friction: the force that resists the initiation of sliding motion between two surfaces that are in contact and at rest
  - kinetic friction: the force that opposes the movement of two surfaces that are in contact and are moving over each other
- Not all kinetic friction is the same.
  - *sliding friction:* when objects slide past each other
  - *rolling friction:* when a rounded object rolls over a flat surface

– in general, rolling friction < sliding friction

Friction and Motion

> Why is friction sometimes necessary?

> Friction is necessary for many everyday tasks to work correctly.

- Unwanted friction can be lowered.
  - using low-friction materials, such as nonstick coatings on cooking pans
  - using *lubricants,* such as motor oil, wax, and grease
- Helpful friction can be increased.
  - scattering sand on icy roads to keep cars from skidding
  - wearing textured batting gloves when playing baseball to make it easier to grip the bat
- Cars could not move without friction.
  - Without friction between the tires and the road, the tires would not be able to push against the road and the car would not move forward.
  - The force pushing the car forward must be greater than the force of friction that opposes the car's motion**.**
  - Because of friction, a constant force must be applied to a car just to keep it moving at the same speed.