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Chapter 4 Linear Motion

Summary

THE BIG IDEA **You can describe the motion of an object by its position, speed, direction, and acceleration.**

4.1 Motion Is Relative

An object is moving if its position relative to a fixed point is changing.

- When we describe the motion of one object with respect to another, we say that the object is moving **relative** to the other object.
- Unless stated otherwise, when we discuss the speeds of things in our environment, we mean speed with respect to the surface of Earth.

4.2 Speed

You can calculate the speed of an object by dividing the distance covered by time.

- Galileo is credited as being the first to measure *speed* by considering the distance covered and the time it takes.
- **Speed** is how fast an object is moving.
- Any combination of units for distance and time that are useful and convenient are legitimate for describing speed.
- Some units that describe speed are miles per hour (mi/h) and kilometers per hour. The slash symbol (/) is read as "per."
- The speed of an object at any instant is called the **instantaneous speed.**
- The **average speed** of an object is the total distance covered divided by the time.
- Average speed does not indicate variations in the speed that may take place during the trip.
- A simple rearrangement of the definition of average speed gives the total distance covered:

  total distance covered = average speed × travel time

4.3 Velocity

Speed is a description of how fast an object moves; velocity is how fast and in what direction it moves.

- **Velocity** is speed in a given direction.
- A quantity such as velocity, which specifies direction as well as magnitude, is called a vector quantity.
- Quantities that require only magnitude for a description are scalar quantities.
- Constant speed means steady speed.
- Constant velocity means both constant speed *and* constant direction, which is in a straight line.
- If *either* an object's speed *or* its direction (or both) is changing, then the object's velocity is changing.

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4.4 Acceleration

You can calculate the acceleration of an object by dividing the change in its velocity by time.

- **Acceleration** is the rate at which the velocity is changing.
- In physics, the term *acceleration* applies to decreases as well as increases in speed.
- Acceleration also applies to changes in *direction.*
- Acceleration is defined as the rate of change in *velocity,* rather than *speed.*
- Acceleration, like velocity, is a vector quantity because it is directional.
- If an object's speed, direction, or both, changes, the object changes velocity and accelerates.
- When the direction is not changing, acceleration may be expressed as the rate at which *speed* changes.
- Since acceleration is the change in velocity or speed per time interval, its units are those of speed per time.

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Exercises

4.1 Motion Is Relative (page 47)

1. Is the following sentence true or false? When we describe the motion of one object with respect to another, we say that the object is moving relative to the other object. _____
2. An object is _____ if its position relative to a fixed point is _____.
3. A driver is going 20 kilometers per hour down the street. What is the driver's speed relative to?

   _____

4.2 Speed (pages 48–49)

4. Define speed. _____
5. Complete the following equation: speed = distance/_____.
6. How is the slash symbol read in *km/h*? _____
7. Circle the letters of the sentences that are true of instantaneous speed.
   a. Instantaneous speed is the total distance covered divided by time.
   b. Instantaneous speed is the speed at any instant.
   c. The speedometer on a car shows the instantaneous speed.
   d. If you traveled 30 kilometers in 1 hour, your instantaneous speed would be 30 km/h.
8. How is average speed calculated?

   _____

9. If you traveled 80 kilometers in 2 hours, what was your average speed?

   _____

10. If your average speed is 30 kilometers per hour and your trip took 1 hour, what was the total distance covered?

    _____

4.3 Velocity (page 50)

Determine if each of the following statements is true or false. Write the correct word on the line provided.

_____ 11. Speed is velocity in a given direction.

_____ 12. The speed of a plane can be described as 300 mi/h.

_____ 13. The velocity of a car can be described as 60 km/h to the north.

_____ 14. Speed is a vector quantity.

_____ 15. Velocity is a vector quantity.

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16. If either the _____ or the _____ is changing (or both are), then the velocity is changing.

4.4 Acceleration (pages 51–52)

17. What is acceleration?

_____

18. How is acceleration calculated?

_____

19. In physics, the term *acceleration* applies to both _____ and _____ in speed.

20. Acceleration is a change in speed, a change in _____, or both.

21. Is the following sentence true or false? Acceleration is a vector quantity.

_____

22. If a car is traveling around a curve on a highway at a constant speed, is the car accelerating? Explain your answer.

_____

23. Circle the letter of the value and units that represent acceleration.

a. 5 km
b. 15 km/s
c. 25 s/km
d. 55 km/s^2