Chapter 2 Review Answers

Student Textbook pages 85–87

Knowledge and Understanding

1. (a) Kinematics is the study of the description of motion without regard to its causes.
   (b) Dynamics is the study of the causes (forces or other agents) of motion.
   (c) Mechanics is the study of motion and includes both kinematics and dynamics.
   (d) Velocity is the rate of change of displacement.
   (e) Acceleration is the rate of change of velocity.
   (f) The frame of reference is the location or position with which the motion of an object is compared. The selected coordinate system is at rest in the frame of reference.
   (g) The centre of mass is the point on an object where all of the mass appears to be concentrated when analyzing the motion of the object.
   (h) A vector is a quantity that contains a magnitude, unit, and direction, such as position and acceleration.
   (i) A scalar is a quantity that contains a magnitude and unit only, such as speed and distance.
2. Movies, videos, and cartoons are actually still frames in which the positions of objects change a small amount from frame to frame. The frame rate is so fast that our eyes perceive that the objects are moving.
3. (a) The average velocity is equal to the slope of the straight line joining two points on a position-time graph. The instantaneous velocity is the value approached by the average velocity as the time interval approaches zero. It is obtained by finding the slope of the tangent at a moment in time on a position-time graph.
   (b) Average acceleration for an interval of time is equal to the slope of the line joining the two points on a velocity-time graph. Instantaneous acceleration is the value approached by the average acceleration as the time interval approaches zero. It is obtained by finding the slope of the tangent at a moment in time on a velocity-time graph.
4. The application of a changing force on an object could produce a non-uniform acceleration. A constant force such as gravity would cause a uniform acceleration.
5. The area under a curve requires that you make narrow time interval columns, otherwise it will not be accurate. Refer to Figure 2.27 on page 76 in the student textbook. The areas of each individual column are then added, to obtain the total area under the curve.
6. Position is the location of an object relative to the origin of the selected coordinate system. Displacement is the change in position of an object.
7. When an object is accelerating, the velocity is changing every second. For example, if an object is accelerating at 5 m/s^2, the velocity is changing, increasing by 5 m/s every second.
8. Some applications of acceleration are the accelerometer, a device used to measure acceleration; the design of runways, where planes speed up or slow down; spacecraft and all vehicles undergoing rapid velocity changes; parachutes and braking systems designed to slow down objects, anti-gravity suits, etc.
9. A negative area under a velocity-time graph means the object is moving in the negative direction. For example, if east is defined as the positive direction, the object would be moving west.

24. The acceleration of the car is $-2.8\ \text{m/s}^2$.

$$a = \frac{v_f - v_i}{\Delta t}$$
$$= \frac{0 - 14\ \frac{\text{m}}{\text{s}}}{5.0\ \text{s}}$$
$$= -2.8\ \frac{\text{m}}{\text{s}^2}$$

25. The initial velocity of the runner was 3 m/s.

$$v_f = v_i + a\Delta t$$

Solve for v_i

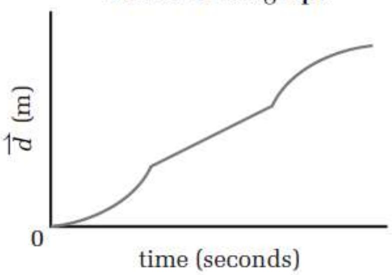
$$v_f = v_i + a\Delta t$$
$$= 6.4\ \frac{\text{m}}{\text{s}} - (0.3\ \frac{\text{m}}{\text{s}^{\cancel{2}}})(12\ \cancel{\text{s}})$$
$$= 2.8\ \frac{\text{m}}{\text{s}}$$
$$= 3\ \frac{\text{m}}{\text{s}}$$

26. The baseball would have a velocity of 1.9 m/s[down] after 4.0 s.

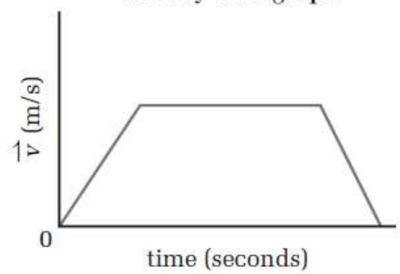
$$v_f = v_i + a\Delta t$$
$$v_f = 4.5\ \frac{\text{m}}{\text{s}} + (-1.6\ \frac{\text{m}}{\text{s}^{\cancel{2}}})(4.0\ \cancel{\text{s}})$$
$$= 4.5\ \frac{\text{m}}{\text{s}} - 6.4\ \frac{\text{m}}{\text{s}}$$
$$= -1.9\ \frac{\text{m}}{\text{s}}$$

27. Refer to the graphs below.

Position-time graph



Velocity-time graph



28. (a) The final velocity of the car is 17 m/s.

$\Delta d = (\frac{v_i + v_f}{2})\Delta t$

$50 \text{ m} = (\frac{0 + v_f}{2})(6.0 \text{ s})$

$50 \text{ m} = (v_f)3.0 \text{ s}$

$v_f = 16.7 \frac{\text{m}}{\text{s}}$

(b) The acceleration of the car is 2.8 m/s^2.

$a = \frac{v_f - v_i}{\Delta t}$

$= \frac{16.7 \frac{\text{m}}{\text{s}} - 0}{6.0 \text{ s}}$

$= 2.8 \frac{\text{m}}{\text{s}^2}$

29. (a) The cyclist travels 27 m during the 4.0 s interval.

$\Delta d = v_i\Delta t + \frac{1}{2}a\Delta t^2$

$= (5.6 \frac{\text{m}}{\text{s}})(4.0 \text{ s}) + \frac{1}{2}(0.6 \frac{\text{m}}{\text{s}})(4.0 \text{ s})^2$

$= 22.4 \text{ m} + 4.8 \text{ m}$

$= 27.2 \text{ m}$

(b) The cyclist attains a velocity of 8.0 m/s.

$v_f = v_i + a\Delta t$

$= 5.6 \frac{\text{m}}{\text{s}} + 0.6 \frac{\text{m}}{\text{s}^2}(4.0 \text{ s})$

$= 5.6 \frac{\text{m}}{\text{s}} + 2.4 \frac{\text{m}}{\text{s}}$

$= 8.1 \frac{\text{m}}{\text{s}}$

30. (a) The acceleration of the truck is $a = -1.2 \text{ m/s}^2$.

To derive an equation that relates initial and final velocities and distance to acceleration, start with the following.

$a = \frac{v_f - v_i}{\Delta t}$

Solve for Δt and substitute it into the following.

$v_f = v_i + a\Delta t$

Rearrange the resulting equation to obtain the following (see Think It Through on page 77 of the textbook).

$v_f^2 = v_i^2 + 2ad$

$\left(14 \frac{\text{m}}{\text{s}}\right)^2 = \left(22 \frac{\text{m}}{\text{s}}\right)^2 + 2a(125 \text{ m})$

$196 \frac{\text{m}^2}{\text{s}^2} = 484 \frac{\text{m}^2}{\text{s}^2} + a(250 \text{ m})$

$a = \frac{(196 - 484)\frac{\text{m}^2}{\text{s}^2}}{250 \text{ m}}$

$a = -1.152 \frac{\text{m}}{\text{s}^2}$

(b) It took 6.9 s for the truck driver to change his speed.
Solve for Δt in the following.

$$a = \frac{v_f - v_i}{\Delta t}$$

$$\Delta t = \frac{v_f - v_i}{a}$$

$$\Delta t = \frac{14\ \frac{m}{s} - 22\ \frac{m}{s}}{-1.152\ \frac{m}{s^2}}$$

$$= 6.94\ s$$

31. Find the initial velocity.

$$v_f = v_i + a\Delta t$$

$$v_i = v_f - a\Delta t$$

$$v_i = (-30\ \tfrac{m}{s}) - (-3.2\ \tfrac{m}{s^{\cancel{2}}})8.0\ \cancel{s}$$

$$v_i = (-30\ \tfrac{m}{s}) + 25.6\ \tfrac{m}{s}$$

$$v_i = -4.4\ \tfrac{m}{s}$$

Find the displacement.

$$\Delta d = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

$$= \Delta d(-4.4\ \tfrac{m}{\cancel{s}})8.0\ \cancel{s} + \tfrac{1}{2}(-3.2\ \tfrac{m}{\cancel{s^2}})(8.0\ \cancel{s})^2$$

$$= \Delta d(-4.4\ m) - 102.4\ m$$

$$= \Delta d = -106.8\ m$$

The sky diver's displacement was -1.1×10^2 m or 1.1×10^2 m[down].

32. When the police car catches up with the speeder, both vehicles will have travelled the same distance during the same time interval.

(a) It will take the police car 23 s to catch up to the speeder.

$$\Delta d_{speeder} = \Delta d_{police}$$

$$v\Delta t = \frac{1}{2}a\Delta t^2$$

$$24\ \tfrac{m}{s^2}\Delta t = \tfrac{1}{2}\left(2.1\ \tfrac{m}{s^2}\right)\Delta t^2$$

$$\tfrac{1}{2}\left(2.1\ \tfrac{m}{s^2}\right)\Delta t^2 - 24\ \tfrac{m}{s}\Delta t = 0$$

$$1.05\ \tfrac{m}{s^2}\Delta t^2 - 24\ \tfrac{m}{s}\Delta t = 0$$

$$\left(1.05\ \tfrac{m}{s^2}\Delta t - 24\ \tfrac{m}{s}\right)\Delta t = 0$$

$$\Delta t = 0 \text{ or } 1.05\ \tfrac{m}{s^2}\Delta t - 24\ \tfrac{m}{s} = 0$$

$$1.05\ \tfrac{m}{s^2}\Delta t = 24\ \tfrac{m}{s}$$

$$\Delta t = 22.86\ s$$

Note that the solution, $\Delta t = 0$, represents the fact that the time at which the speeder passed the police car the first time. $\Delta t = 23$ s is the second time that the speeder and the police car were at the same position, that is, when the police car caught up with the speeder.

(b) Each vehicle will travel 5.50×10^2 m. Use either formula $\Delta d = v\Delta t$ for the speeder or $\Delta d = \frac{1}{2}a\Delta t^2$ for the police car to obtain the distance.

$$\Delta d = v\Delta t$$

$$\Delta d = 24\ \tfrac{m}{s}(22.86\ s)$$

$$= 548.57\ m$$

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$$\Delta d = v\Delta t$$

$$\Delta d = 24\ \tfrac{\text{m}}{\text{s}}(22.86\ \text{s})$$

$$= 548.57\ \text{m}$$