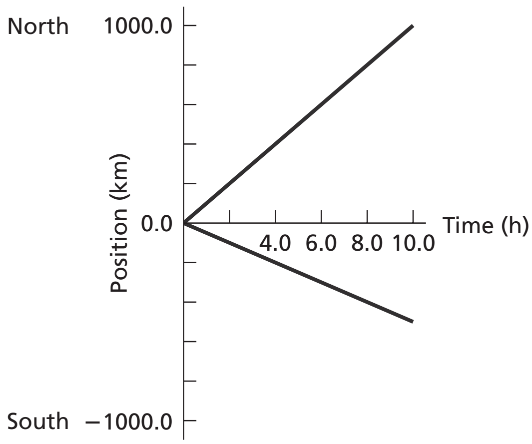
4. Two trains simultaneously leave the same train station at noon. One train travels north and the other travels south. The position-time graph for both trains is shown in the accompanying figure.



a. What is the position of the train traveling north at 6.0 h?

600.0 km

b. What is the position of the train traveling south at 6.0 h?

300.0 km

c. What is the distance between the trains at 6.0 h? What is the distance at 10.0 h?

900.0 km, 1500.0 km

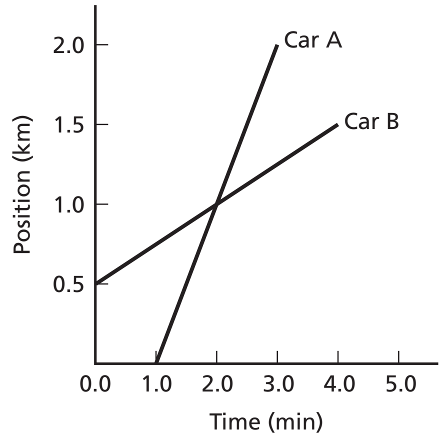
d. At what time are the trains 600.0 km apart?

4.0 h

e. Which train is moving more quickly?

northbound train

5. Two cars head out in the same direction. Car A starts 1.0 min before car B. The position-time graphs for both cars are shown in the accompanying figure.



a. How far apart are the two cars when car B starts out at $t = 1.0$ min?

0.75 km

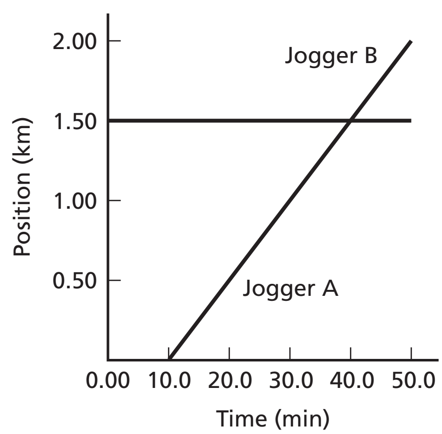
b. At what time do the cars meet?

2.0 min

c. How far apart are the cars at time $t = 3.0$ min?

0.75 km

6. The position-time graph for two joggers, A and B, is shown in the accompanying figure.



a. How far apart are the two runners at 10.0 min?

1.50 km

b. At what time are they 1.00 km apart?

20.0 min

c. How far apart are they at 50.0 min?

0.50 km

d. At what time do they meet?

40.0 min

e. What distance does jogger B cover between 30.0 min and 50.0 min?

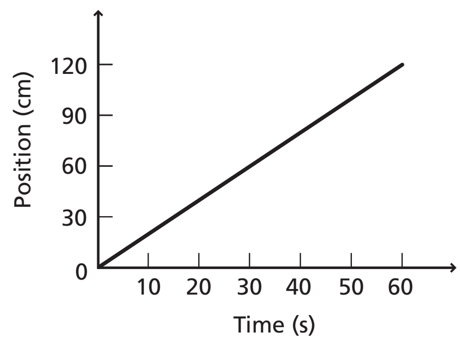
0.00 km

f. What distance does jogger A cover between 30.0 min and 50.0 min?

1.00 km

7. A child's toy train moves at a constant speed of 2.0 cm/s.

a. Draw the position-time graph showing the position of the toy for 1.0 min.

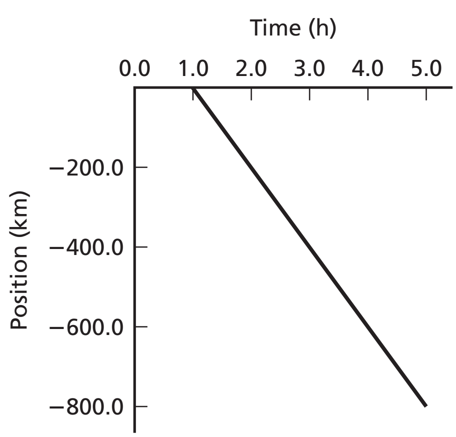


b. What is the slope of the line representing the motion of the toy?

$$\textbf{slope} = \frac{\textbf{rise}}{\textbf{run}} = \frac{\textbf{120 cm}}{\textbf{60 s}}$$

$$= \textbf{2.0 cm/s, the same as the train's speed}$$

8. The position of an airplane as a function of time is shown in the figure below.



a. What is the average velocity of the airplane?

velocity = slope of line

$$= \frac{-800.0\text{ km} - 0.0\text{ km}}{5.0\text{ h} - 1.0\text{ h}}$$

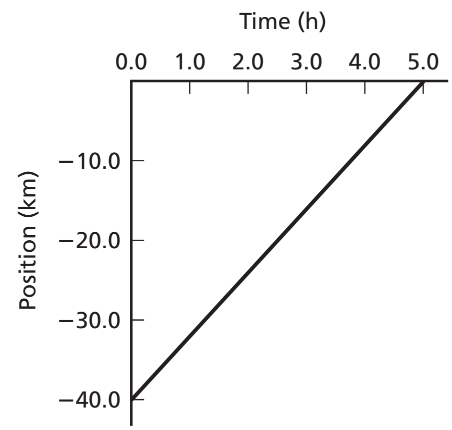
$$= -2.0\times10^{2}\text{ km/h}$$

b. What is the average speed of the airplane?

speed = absolute value of the velocity

$$= 2.0\times10^{2}\text{ km/h}$$

9. The position-time graph for a hot-air balloon that is in flight is shown in the accompanying figure.



a. What is the average velocity of the balloon?

velocity = slope

$$= \frac{0.00\text{ km} - (-40.0\text{ km})}{5.0\text{ h} - 0.0\text{ h}}$$

$$= 8.0\text{ km/h}$$

b. What is the average speed of the balloon?

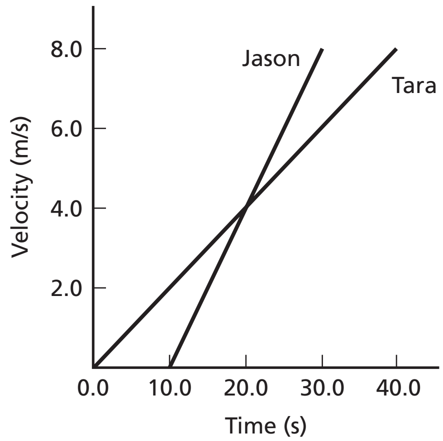
speed = absolute value of slope

$$= 8.0\text{ km/h}$$

Chapter 3

pages 861–862

1. Jason and his sister, Tara, are riding bicycles. Jason tries to catch up to Tara, who has a 10.0-s head start.



a. What is Jason's acceleration?

$$a_J = \frac{8.0\ \text{m/s} - 0.0\ \text{m/s}}{30.0\ \text{s} - 10.0\ \text{s}}$$

$$= 0.40\ \text{m/s}^2$$

b. What is Tara's acceleration?

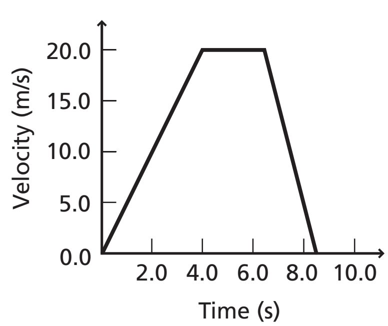
$$a_T = \frac{8.0\ \text{m/s} - 0.0\ \text{m/s}}{40.0\ \text{s} - 0.0\ \text{s}}$$

$$= 0.20\ \text{m/s}^2$$

c. At what time do they have the same velocity?

20.0 s

2. A dragster starts from rest and accelerates for 4.0 s at a rate of 5.0 m/s^2. It then travels at a constant speed for 2.5 s. A parachute opens, stopping the vehicle at a constant rate in 2.0 s. Plot the *v-t* graph representing the entire motion of the dragster.



3. A car traveling at 21 m/s misses the turnoff on the road and collides into the safety guard rail. The car comes to a complete stop in 0.55 s.

a. What is the average acceleration of the car?

$$\overline{a} = \frac{v_f - v_i}{t_f - t_i} = \frac{0.00\ \text{m/s} - 21\ \text{m/s}}{0.55\ \text{s}}$$

$$= -38\ \text{m/s}^2$$

b. If the safety rail consisted of a section of rigid rail, the car would stop in 0.15 s. What would be the acceleration in this case?

$$\overline{a} = \frac{v_f - v_i}{t_f - t_i} = \frac{0.00\ \text{m/s} - 21\ \text{m/s}}{0.15\ \text{s}}$$

$$= -1.4\times10^2\ \text{m/s}^2$$

4. On the way to school, Jamal realizes that he left his physics homework at home. His car was initially heading north at 24.0 m/s. It takes him 35.5 s to turn his car around and head south at 15.0 m/s. If north is designated to be the positive direction, what is the average acceleration of the car during this 35.5-s interval?

$$\overline{a} = \frac{v_f - v_i}{t_f - t_i} = \frac{-15.0\ \text{m/s} - 24.0\ \text{m/s}}{35.5\ \text{s}}$$

$$= 1.10\ \text{m/s}^2$$

5. A cheetah can reach a top speed of 27.8 m/s in 5.2 s. What is the cheetah's average acceleration?

$$\overline{a} = \frac{v_f - v_i}{t_f - t_i} = \frac{27.8\ \text{m/s} - 0.0\ \text{m/s}}{5.2\ \text{s}}$$

$$= 5.3\ \text{m/s}^2$$

6. After being launched, a rocket attains a speed of 122 m/s before the fuel in the motor is completely used. If you assume that the acceleration of the rocket is constant at 32.2 m/s^2, how much time does it take for the fuel to be completely consumed?

$$\overline{a} = \frac{\Delta v}{\Delta t}$$

$$\Delta t = \frac{\Delta v}{\overline{a}} = \frac{122\ \text{m/s} - 0.00\ \text{m/s}}{32.2\ \text{m/s}^2} = 3.79\ \text{s}$$

7. An object in free fall has an acceleration of 9.80 m/s^2 assuming that there is no air resistance. What is the speed of an object dropped from the top of a tall cliff 3.50 s after it has been released, if you assume the effect of air resistance against the object is negligible?

$$\bar{a} = \frac{\Delta v}{\Delta t}$$

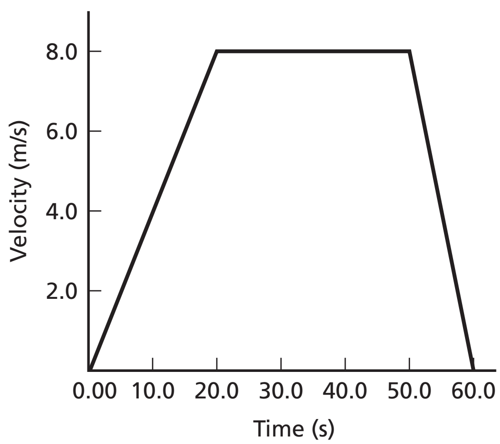
$$\Delta v = \bar{a}\Delta t = g\Delta t = (9.80 \text{ m/s}^2)(3.50 \text{ s})$$
$$= 34.3 \text{ m/s}$$

8. A train moving with a velocity of 51 m/s east undergoes an acceleration of −2.3 m/s^2 as it approaches a town. What is the velocity of the train 5.2 s after it has begun to decelerate?

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

$$v_f = \bar{a}\Delta t + v_i$$
$$= (-2.3 \text{ m/s}^2)(5.2 \text{ s}) + 51 \text{ m/s}$$
$$= 39 \text{ m/s}$$

9. The *v-t* graph of a runner is shown in the accompanying figure.



The displacement is the area under the graph.

a. What is the displacement of the runner between t = 0.00 s and t = 20.0 s?

$$\Delta d = \left(\frac{1}{2}\right)(8.0 \text{ m/s})(20.0 \text{ s})$$
$$= 8.0\times10^1 \text{ m}$$

b. What is the displacement of the runner between t = 20.0 s and t = 50.0 s?

$$\Delta d = (8.0 \text{ m/s})(50.0 \text{ s} - 20.0 \text{ s})$$
$$= 240 \text{ m}$$

c. What is the displacement of the runner between t = 50.0 s and t = 60.0 s?

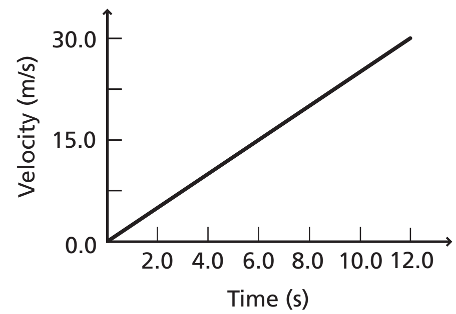
$$\Delta d = \left(\frac{1}{2}\right)(8.0 \text{ m/s})(60.0 \text{ s} - 50.0 \text{ s})$$
$$= 4.0\times10^1 \text{ m}$$

10. Draw the *v-t* graph of an automobile that accelerates uniformly from rest at t = 0.00 s and covers a distance of 180.0 m in 12.0 s.

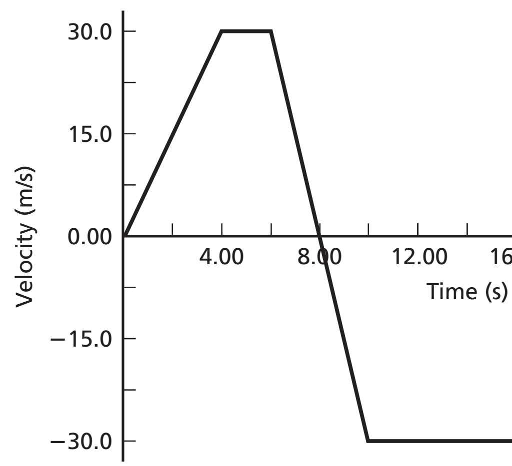
Since the car accelerates uniformly, the *v-t* graph is a straight line. Starting from the origin, the area is triangular.

Thus, $\Delta d = \frac{1}{2} v_{max}\Delta t$

$$v_{max} = \frac{2\Delta d}{\Delta t} = \frac{(2)(180.0 \text{ m})}{12.0 \text{ s}} = 30.0 \text{ m/s}$$



11. The *v-t* graph of a car is shown in the accompanying figure. What is the displacement of the car from t = 0.00 s to t = 15.0 s?



displacement = area under *v-t* graph

The total displacement is the sum of the displacements from 0.00 s to 4.00 s, 4.00 s to 6.00 s, 6.00 s to 8.00 s, 8.00 s to 10.0 s, and 10.0 s to 15.0 s:

$$\Delta d_{total} = \Delta d_1 + \Delta d_2 + \Delta d_3 + \Delta d_4 + \Delta d_5$$

$$= \left(\frac{1}{2}\right)(30.0 \text{ m/s})(4.00 \text{ s}) + (30.0 \text{ m/s})(2.00 \text{ s}) + \left(\frac{1}{2}\right)(30.0 \text{ m/s})(2.00 \text{ s}) + \left(\frac{1}{2}\right)(-30.0 \text{ m/s})(2.00 \text{ s}) + (-30.0 \text{ m/s})(5.00 \text{ s})$$

$$= -30.0 \text{ m}$$

12. Suppose a car rolls down a 52.0-m-long inclined parking lot and is stopped by a fence. If it took the car 11.25 s to roll down the hill, what was the acceleration of the car before striking the fence?

$$d_f = d_i + v_i t_f + \frac{1}{2} a t_f^2$$

v_i = 0.00 m/s since the car starts from rest

$$a = \frac{2(d_f - d_i)}{t_f^2} = \frac{(2)(52.0 \text{ m})}{(11.25 \text{ s})^2} = 0.823 \text{ m/s}^2$$

13. A sky diver in free fall reaches a speed of 65.2 m/s when she opens her parachute. The parachute quickly slows her down to 7.30 m/s at a constant rate of 29.4 m/s^2. During this period of acceleration, how far does she fall?

$$v_f^2 = v_i^2 + 2a(d_f - d_i)$$

$$d_f - d_i = \frac{v_f^2 - v_i^2}{2a}$$

$$= \frac{(-7.30 \text{ m/s})^2 - (-65.2 \text{ m/s})^2}{(2)(29.4 \text{ m/s}^2)}$$

$$= -71.4 \text{ m}$$

She has fallen 71.4 m during the acceleration period.

14. A child rolls a ball up a hill at 3.24 m/s. If the ball experiences an acceleration of 2.32 m/s^2, how long will it take for the ball to have a velocity of 1.23 m/s down the hill?

Let the positive direction be up the hill.

$$v_f = v_i + a t_f$$

$$t_f = \frac{v_f - v_i}{a} = \frac{-1.23 \text{ m/s} - 3.24 \text{ m/s}}{-2.32 \text{ m/s}^2}$$

$$= 1.93 \text{ s}$$

15. A cheetah can accelerate from rest to a speed of 27.8 m/s in 5.20 s. The cheetah can maintain this speed for 9.70 s before it quickly runs out of energy and stops. What distance does the cheetah cover during this 14.9-s run?

During the acceleration period:

$$v_f = v_i + a t_f$$

$$a = \frac{v_f - v_i}{t_f} = \frac{27.8 \text{ m/s} - 0.00 \text{ m/s}}{5.20 \text{ s}}$$

$$= 5.35 \text{ m/s}^2$$

With this acceleration the distance during acceleration can be determined.

$$v_f^2 = v_i^2 + 2a(d_f - d_i)$$

$$d_f - d_i = \frac{v_f^2 - v_i^2}{2a}$$

$$= \frac{(27.8 \text{ m/s})^2 - (0.00 \text{ m/s})^2}{(2)(5.35 \text{ m/s}^2)}$$

$$= 72.3 \text{ m}$$

During the constant speed period, a = 0.00 m/s^2.

$$d = vt = (27.8 \text{ m/s})(9.70 \text{ s})$$

$$= 2.70\times10^2 \text{ m}$$

The total distance is then the sum of the two.

$$\text{distance} = 2.70\times10^2 \text{ m} + 72.3 \text{ m}$$

$$= 342 \text{ m}$$

16. A cab driver in a hurry is sitting at a red light. When the light turns green she rapidly accelerates for 3.50 s at 6.80 m/s^2. The next light is still red. She then slams on the brakes, accelerating at a rate of −9.60 m/s^2 before coming to rest at the stop light. What was her total distance for this trip?

During the first part of the trip,

$$d_f = d_i + v_i t_f + \frac{1}{2} a t_f^2$$

$$d_f - d_i = \frac{1}{2} a t_f^2 = \left(\frac{1}{2}\right)(6.80 \text{ m/s}^2)(3.50 \text{ s})^2$$

$$= 41.6 \text{ m}$$