Chapter 3: Describing Motion: Velocity

Practice Problems

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1. A high school athlete runs 1.00×10^2 m in 12.20 s. What is the velocity in m/s and km/h?

$$\bar{v} = \frac{\Delta d}{\Delta t} = (1.00 \times 10^2 \text{ m})(12.20 \text{ s})$$

$$= 8.20 \text{ m/s};$$

$$(8.20 \text{ m/s})(1 \text{ km}/1000 \text{ m})(3600 \text{ s}/1 \text{ h})$$

$$= 29.5 \text{ km/h}$$

or

$$(8.20 \text{ m/s})(3600 \text{ s/h})(1000 \text{ m/km})$$

$$= 29.5 \text{ km/h}$$

2. A person walks 13 km in 2.0 h. What is the person's average velocity in km/h and m/s?

$$\bar{v} = \frac{\Delta d}{\Delta t} = (13 \text{ km})/(2.0 \text{h})$$

$$= 6.5 \text{ km/h};$$

$$(6.5 \text{ km/h})(1 \text{ h}/3600 \text{ s})(1000 \text{ m}/1 \text{ km})$$

$$= 1.8 \text{ m/s}$$

or

$$(6.5 \text{ km/h})(1000 \text{ m/km})/(3600 \text{ s/h})$$

$$= 1.8 \text{ m/s}$$

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3. Using the data in Table 3–1, during what one–second–long time interval is the car moving slowest? The fastest?

Slowest between 0.0 and 1.0 s (0 m/s). Fastest between 3.0 and 4.0 s (15 m/s).

4. Using the data in Table 3–1, find the average velocity of the car in the time interval between 0.0 and 2.0 seconds.

Practice Problems

$$\bar{v} = (d_2 - d_1)/(t_2 - t_1)$$
$$= (35 \text{ m} - 30 \text{ m})/(2.05 - 0.05)$$
$$= 2.5 \text{ m/s}$$

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5. Suppose a car travels at a constant 10 m/s. How far would it move in 1 hour? In 1 minute? In 1 second? In 1 millisecond? In 1 microsecond? In 1 nanosecond?

Using $d = vt$ with $v = 10$ m/s:

t	d
1 h = 3600 s	3.6×10^4 m
1 min = 60 s	6.0×10^2 m
1 s	10 m
1 ms = 10^{-3} s	10×10^{-3} m = 10 mm
1 μs = 10^{-6} s	10×10^{-6} m = 10 μm
1 ns = 10^{-9} s	10×10^{-9} m = 10 nm

6. A train leaves the station at the 0.0–m marker traveling with a constant velocity of 36.0 m/s.

a. How many seconds later will the train pass the 1620.0 m marker?

$$v = \frac{d}{t} \text{ so } t = \frac{d}{v} = \frac{(1620.0 \text{ m})}{(36.0 \text{ m/s})} = 45.0 \text{ s}$$

b. What is the velocity of the train in km/h?

$$v = (36.0 \text{ m/s})(1 \text{ km}/1000 \text{ m})(3600 \text{ s}/1 \text{ h})$$

$$= 130 \text{ km/h}$$

7. At 1:00 p.m. a car, traveling at a constant velocity of 94 km/h toward the west, is 17 km to the west of your school. Where will it be at 3:30 p.m.?

$$\bar{v} = \frac{(d_2 - d_1)}{(t_2 - t_1)} \text{ with } t_2 - t_1 = 2.5 \text{ h}.$$

$$d_2 = d_1 + \bar{v}(t_2 - t_1)$$

$$= 17 \text{ km} + (94 \text{ km/h})(2.5 \text{ h})$$

$$= 252 \text{ km west of school.}$$

Practice Problems

8. Suppose the car in Problem 7 started 17 km east of your school at the same time, moving in the same direction at the same velocity.

   a. Where would it be at 3:30 pm?

   Same displacement, but position is –17 km +235 km = 218 km west of school.

   b. When would it be at your school?

$$\Delta t = \frac{\Delta d}{\bar{v}} = \frac{(17\ \text{km})}{(94\ \text{km/h})} = 11\ \text{min},$$

   so t = 1:11 pm.

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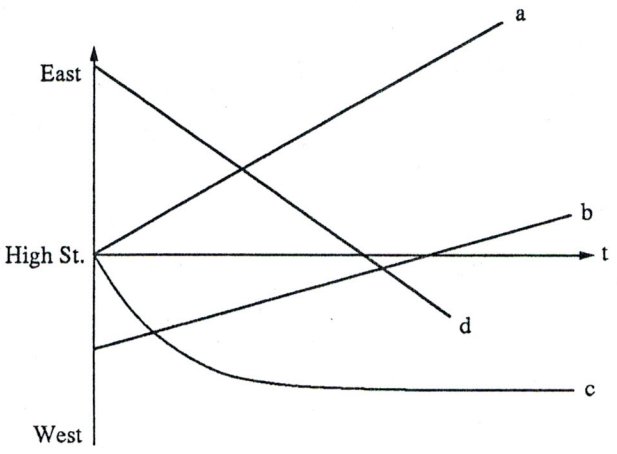
9. Describe in your own words the motion of the four walkers shown in the four curves in Figure 3–10. Assume the positive direction is east and the reference point is the corner of High Street.

   a. Starts at High St., walking east at constant velocity.
   b. Starts west of High St., walking east at slower constant velocity.
   c. Walks west from High St., first fast, but slowing to a stop.
   d. Starts east of High St., walking west at constant velocity.



Practice Problems

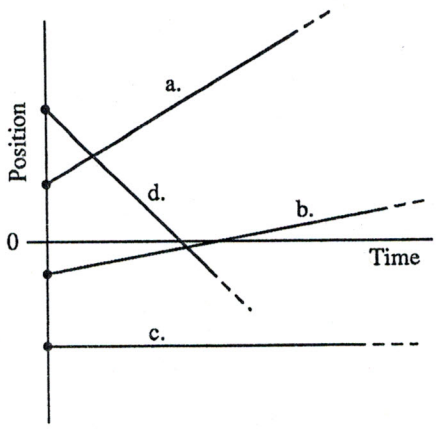
10. Sketch position–time graphs for these four motions:

   a. starting at a positive position with a positive velocity

   b. starting at a negative position with a smaller positive velocity

   c. remaining at a negative position

   d. starting at a positive position with a negative velocity.



11. Find the average velocities shown in Figure 3–11.

   a. between t = 10 and 12 s.

$$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{+5\ \text{m}}{2\ \text{s}} = 2.5\ \text{m/s}$$

   b. between t = 14 and 18 s.

$$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{0\ \text{m}}{4\ \text{s}} = 0\ \text{m/s}$$

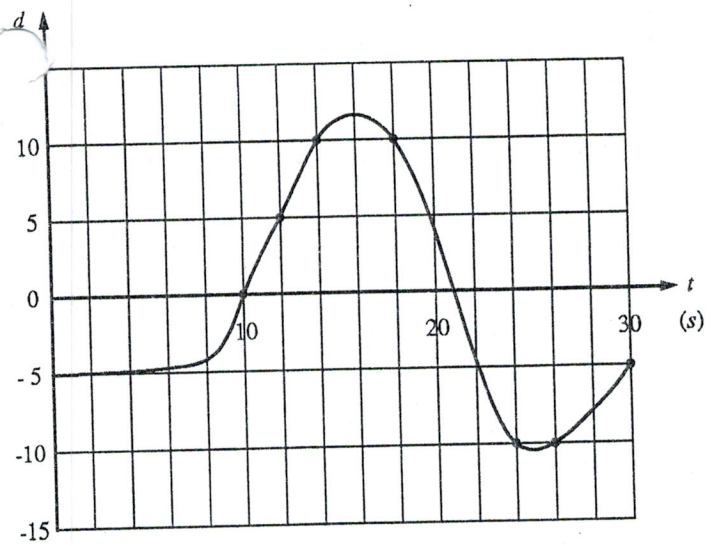
   c. between t = 20 and 24 s.

$$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{-15\ \text{m}}{4\ \text{s}} = -3.75\ \text{m/s}$$

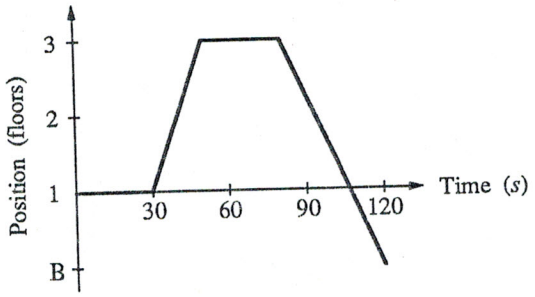
   d. between t = 26 and 20 s.

$$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{+5\ \text{m}}{4\ \text{s}} = 1.25\ \text{m/s}$$

Practice Problems



12. Draw a position–time graph of a moving elevator. Use the first floor as reference point and up as positive. The elevator waits on the first floor for 30 s, rises to the third floor in 20 s, where it stops for 30 s, before going to the basement, which it reaches in 40 s.



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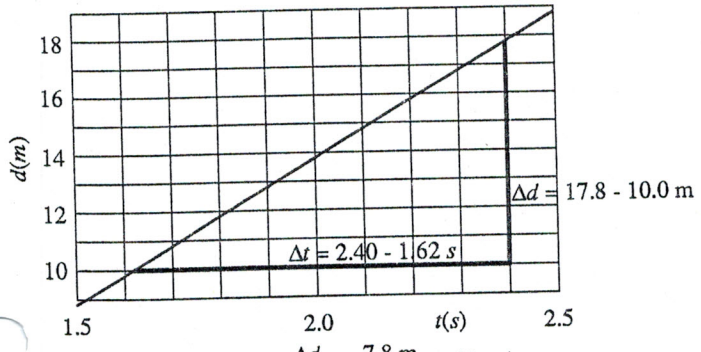
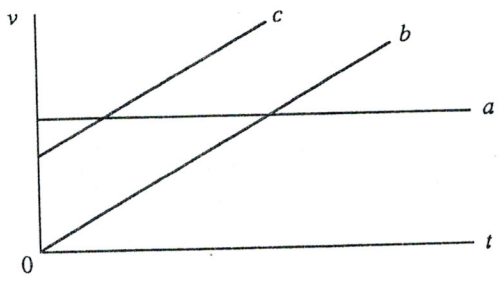
13. Using Figure 3–15c, find the sprinter's velocity at 2.0 seconds.



$$v = \frac{\Delta d}{\Delta t} = \frac{7.8\text{ m}}{0.78\text{ s}} = 10\text{ m/s}$$

Practice Problems

14. Use your hand on your desk to model the motion shown by the curves in Figure 3–16a below. Describe in words the motions.



a. Moves to right at constant speed.

b. Moves to right from rest at constantly increasing speed.

c. Has an initial non–zero velocity to the right and continues to move to right at constantly increasing speed.

15.

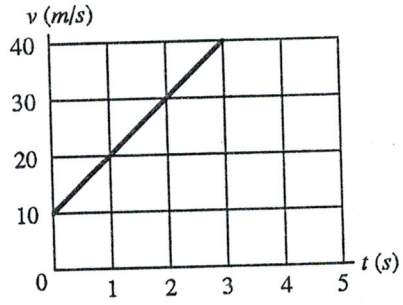


Figure 3–16b is the velocity–time graph of an object. What is its velocity at

a. 0 seconds?

10 m/s

b. 1 second?

20 m/s

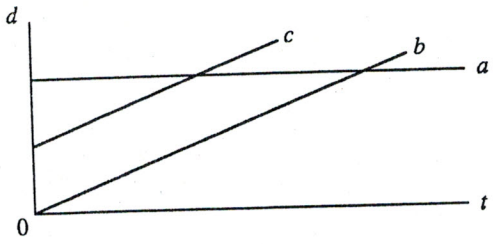
c. 2 seconds?

30 m/s

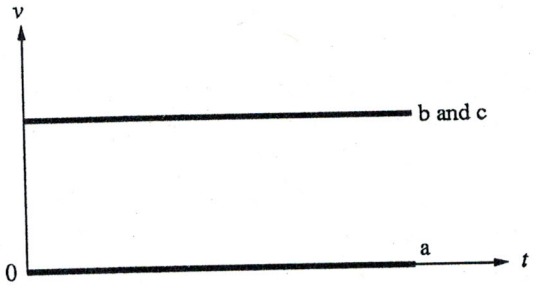
Practice Problems

16. Using the graph in Figure 3–16b describe how the instantaneous velocity changes with time.

    Each second it increases 10 m/s.

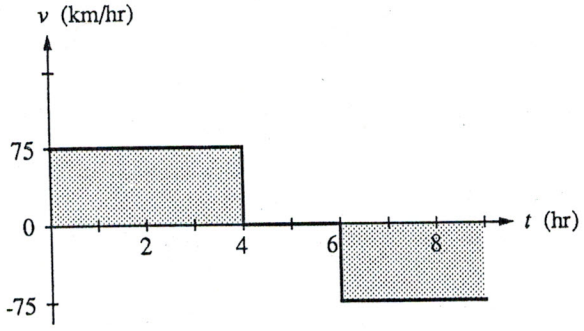
17. 

    Sketch velocity–time graphs for the position–time graphs in Figure 3–16c.



18. A car moves along a straight road at a constant velocity of +75 km/h for 4.0 hours, stops for 2.0 hours, and then drives in the reverse direction at the original speed for 3.0 hours.

    a. Plot a velocity–time graph for the car.



Practice Problems

b. Find the area under curve for the first four hours. What does this represent?

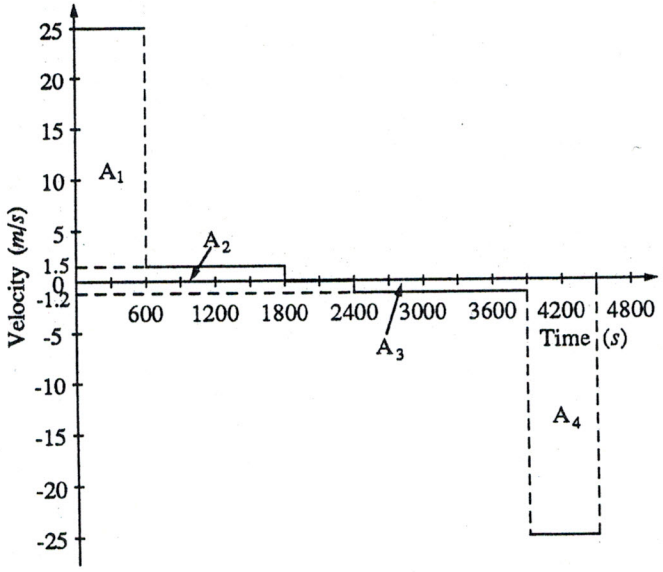
Area is (75 km/h)(4 h) = 300 km, the distance travelled in that time.

c. Explain how to use the graph to find the distance the car is from its starting point at the end of 9.0 hours.

Find total area under curve for all three segments of trip, which is
300 km + 0 km + (–225 km) = 75 km.

19. A person drives a car at a constant +25 m/s for 10.0 minutes. The car runs out of gas, so the driver, carrying an empty gasoline can, walks at +1.5 m/s for 20.0 minutes to the nearest gas station. After the 10.0 minutes needed to fill the can, the driver walks back to the car at a slower –1.2 m/s. The car is then driven back home at –25 m/s.

    a. Draw a velocity–time graph for the driver, using seconds as your time unit. You will have to calculate the distance the driver walked to the station in order to find the time needed to walk back to the car.

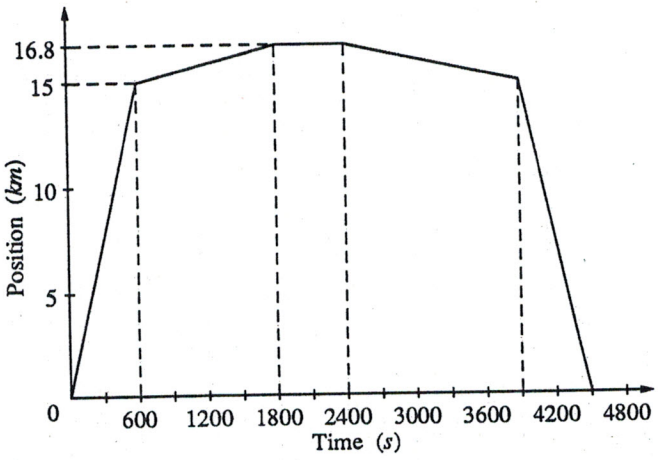


Practice Problems

Distance walked to station
= (1.5 m/s)(20.0 min)(60 s/min)
= 1800 m.

Time for walk back to car
$= \frac{(1800\ \text{m})}{(1.2\ \text{m/s})}$
= 1500 s.

b. Draw a position–time graph for the problem from the areas under the curves of the velocity–time graph.



From the graph in part a, the changes in position are:

$\Delta d_1 = A_1$ = (25 m/s)(600 s)
= 15 000 m = 15 km

$\Delta d_2 = A_2$ = (1.5 m/s)(1200 s)
= 1800 m = 1.8 km

$\Delta d_3 = A_3$ = (–1.2 m/s)(1500 s)
= –1800 m = –1.8 km

$\Delta d_4 = A_4$ = (–25 m/s)(600 s)
= –15 000 m = –15 km

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20. From the reference frame of a stationary observer, a car, traveling at a constant speed of 92 km/h, is passed by a truck moving at 105 km/h.

Practice Problems

a. From the point of view of the car, what is the truck's speed?

If $V_B = V_A + V_{BA}$, where V_A, V_B are velocities relative to Earth and V_{BA} is the velocity of B relative to A, then $V_{BA} = V_B - V_A$.

$V_{tc} = V_t - V_c$ = 105 km/h – 92 km/h
= 13 km/h

b. From the point of view of the truck, what is the car's speed?

$V_{ct} = V_c - V_t$ = 92 km/h – 105 km/h
= –13 km

21. As you travel at a constant 95 km/h, a car that you know to be 3.5 m long, passes you in 1.8 s. How fast is it going relative to Earth?

The relative speed is $\frac{(3.5\ \text{m})}{(1.8\ \text{s})}$ = 1.9 m/s = 7.0 km/h, so its speed is 102 km/h.

Chapter Review Problems

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1. While John is traveling along an interstate highway he noticed a mile marker read 160 as he passed through town. Later John passed another mile marker, 115.

a. What is the distance between town and John's current location?

45 miles

b. What is John's current position?

+115

2. While John is traveling along a straight interstate highway he noticed that the mile marker reads 260. John traveled until he reached the 150 mile marker and then retraced his path to the 175 mile marker. What is the magnitude of John's resultant displacement from the 260 mile marker?

$\Delta d = d_2 - d_1$ = 175 mi – 260 mi = –85 mi

3. A physics book is moved once around the perimeter of a table of dimensions 1.0 m by 2.0 m.

   a. If the book ends up at its initial position, what is its displacement?

   Any time a book ends up where it started its displacement is zero.

   b. What is the distance traveled?

   The distance is equal to the perimeter of the table, 6.0 m.

4. Light from the sun reaches Earth in 8.3 min. The velocity of light is 3.00×10^8 m/s. How far is Earth from the sun?

   Time = 8.3 min = 498 = 5.0×10^2 s

   $$\bar{v} = \frac{\Delta d}{\Delta t},$$

   so $\Delta d = \bar{v}\Delta t = (3.00 \times 10^8 \text{ m/s})(5.0 \times 10^2 \text{ s})$
   $= 1.5 \times 10^{11}$ m

5. You and a friend each drive 50 km. You travel at 90 km/h, your friend at 95 km/h. How long will your friend wait for you at the end of the trip?

   It takes your friend $\frac{(50 \text{ km})}{(95 \text{ km/h})} = 31.6$ minutes, and takes you $\frac{(50 \text{ km})}{(90 \text{ km/h})} = 33.3$ minutes, so your friend waits 1.8 minutes.

6. From the list of winning times from the 1988 Summer Olympics, in Table 3–2, calculate the average speeds for each race. Assume the length of each event is known to the nearest 0.1 m.

Chapter Review Problems

Length of event (m)	Time (min:sec)	
	Men	Women
100	9.92	10.54
200	19.75	21.34
400	43.87	48.65
800	1:44.06	1:56.10
1 500	3:35.96	3:53.96
3 000		8:26.53
5 000	13:11.70	
10 000	27:21.46	31:05.21

Length of event (m)	Velocity (m/s)	
	Men	Women
10.1	10.1	9.488
200	10.13	9.372
400	9.118	8.222
800	7.688	6.891
1 500	6.9457	6.411
3 000		5.9227
5 000	6.3155	
10 000	6.09214	5.36133

7. Construct a table similar to Table 3–2 listing average speeds for track events in your school, district, or state.

   Students answers will vary.

8. Construct an average speed table similar to Problem 6 for swimming events at your school, district, or state. Compare times for swimming to those for running. Explain.

Student answers will vary.
Students can run faster than they can swim.

9. Two cars approach each other; both cars are moving westward, one at 78 km/h, the other at 64 km/h.

a. What is the velocity of the first relative to (in the frame of reference of) the second?

Let east be the positive direction.

Initially car 1 is going –78 km/h and car 2 is going –64 km/h. To use car 2 as our reference point add the opposite of its current velocity, +64 km/h, to give it a zero speed. Add +64 km/h to car 1's velocity also; –78 km/h + (+64 km/h) = –14 km/h or 14 km/h, west.

b. After they pass, will their relative velocity change?

No

10. Ann is driving down a street in a car at 55 km/h. Suddenly a child runs into the street. If it takes Ann 0.75 s to react and apply the brakes, how many meters will she have moved before she begins to slow down?

$$\bar{v} = \frac{\Delta d}{\Delta t}, \text{ so}$$

$$\Delta d = \bar{v}\Delta t = \frac{(55 \text{ km/h})(0.75 \text{ s})(1000 \text{ m/km})}{(3600 \text{ s/h})}$$

$$= 11 \text{ m}$$

11. You plan a trip on which you want to average 90 km/h. You cover the first half of the distance at an average speed of only 48 km/h.

a. What must your average speed be in the second half of the trip to meet your goal? Note that velocities are based on half the distance, not half the time.

$$\bar{v} = \frac{\Delta d}{\Delta t}, \text{ so } \Delta t = \frac{\Delta d}{\bar{v}}$$

Let $d = \frac{1}{2}d + \frac{1}{2}d$ and $t_{total} = t_1 + t_2$,

$$\text{so } \frac{d}{v} = \frac{\frac{1}{2}d}{v_1} + \frac{\frac{1}{2}d}{v_2} \text{ multiply by } 2d$$

$$\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2},$$

$$\text{so } \frac{1}{v_2} = \frac{2}{v} - \frac{1}{v_1}$$

$$= \frac{2}{90 \text{ km/h}} - \frac{1}{48 \text{ km/h}}$$

so $v_2 = 720$ km/h

b. Is this a reasonable speed?

No

12. You drive a car 2.0 hours at 40 km/h, then 2.0 hours at 60 km/h.

a. What is your average velocity?

Total distance: 80 km + 120 km = 200 km. Total time 4.0 hours, so,

$$v = \frac{\Delta d}{\Delta t} = \frac{200 \text{ km}}{4.0 \text{ h}} = 50 \text{ km/h}.$$

b. Do you get the same answer if you drive 100 km at each of the two speeds above?

No. Total distance still 20 km, but total

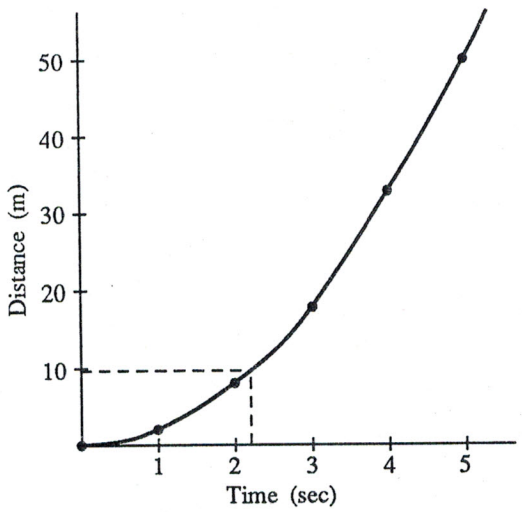
$$\text{time } \frac{(100 \text{ km})}{(40 \text{ km/h})} + \frac{(100 \text{ km})}{(60 \text{ km/h})}$$

$$= 2.5 \text{ h} + 1.7 \text{ h} = 4.2 \text{ h}.$$

$$\text{So } v = \frac{\Delta d}{\Delta v} = \frac{200 \text{ km}}{4.2 \text{ h}} = 48 \text{ km/h}.$$

13. The total distance a steel ball rolls down an incline at the end of each second of travel is given in Table 3–3.

a. Draw a position–time graph of the motion of the ball. When setting up the axes use five divisions for each 10 m of travel on the d–axis. Use five divisions for each second of time on the t–axis.



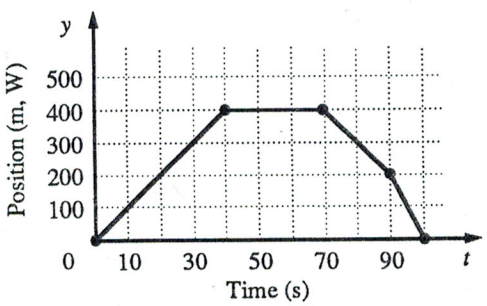
b. What type of curve is the line of the graph?

The curve is a parabola.

c. What distance has the ball rolled at the end of 2.2 s?

After 2.2 seconds the ball has rolled approximately 10 m.

14. Use the position–time graph in Figure 3–24 to find



Chapter Review Problems

a. How far the object travels between $t = 0$ s and $t = 40$ s.

$\Delta d = d_{40} - d_0 = 400 \text{ m} - 0 \text{ m} = 400 \text{ m}$

b. How far it travels between $t = 40$ s and $t = 70$ s.

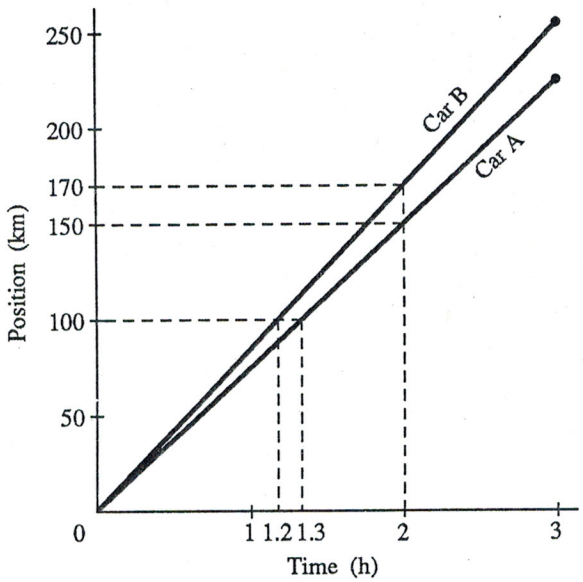
$\Delta d = d_{70} - d_{40} = 400 \text{ m} - 400 \text{ m} = 0$

c. How far it travels between $t = 90$ s and $t = 100$ s.

$\Delta d = d_{100} - d_{90} = 0 - 200 \text{ m} = -200 \text{ m}$

15. Both car A and car B leave school when a clock reads zero. Car A travels at a constant 75 km/h, while car B keeps its velocity 85 km/h.

a. Draw a position–time graph showing the motion of both cars.



b. How far are the two cars from school when the clock reads 2.0 hours? Calculate the distances using the equation of motion and show them on your graph.

$d_A = v_A t = (75 \text{ km/h})(2.0 \text{ h}) = 150 \text{ km}$

$d_B = v_B t = (85 \text{ km/h})(2.0 \text{ h}) = 170 \text{ km}$

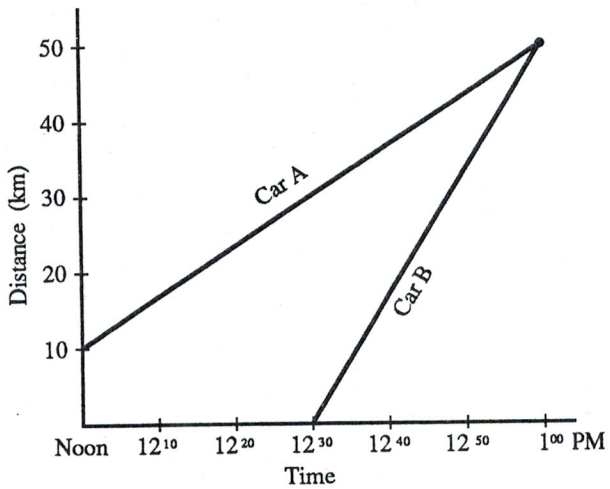
c. Both cars passed a gas station 100 km from the school. When did each car pass the station? Calculate the times and show them on your graph.

$d = vt$, so $t = \frac{d}{v}$

$$t_A = \frac{d}{v_A} = \frac{100\ \text{km}}{75\ \text{km/h}} = 1.3\ \text{h}$$

$$t_B = \frac{d}{v_B} = \frac{100\ \text{km}}{85\ \text{km/h}} = 1.2\ \text{h}$$

16. Draw a position–time graph for two cars driving to the beach, 50 km from school. Car A leaves a store 10 km from school closer to the beach at noon, and drives at 40 km/h. Car B starts from school at 12:30 pm and drives at 100 km/h. At what time does each get to the beach?



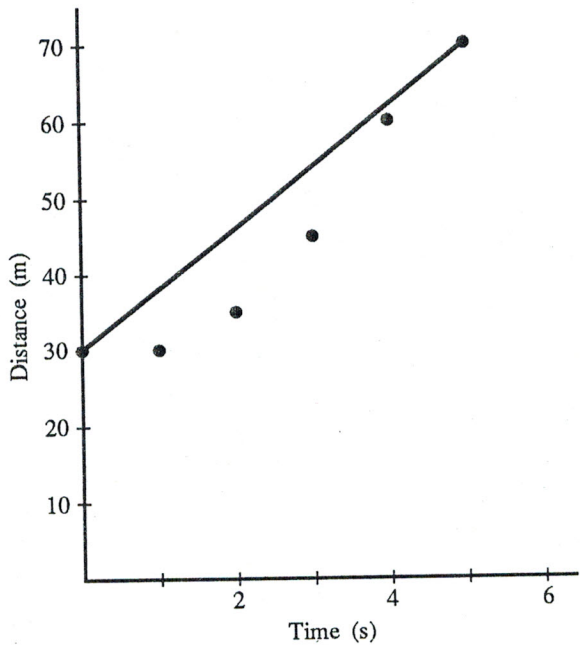
Both cars arrive at the beach at 1:00.

17. Plot the data in Table 3–1 on a position–time graph. Find the average velocity in the time interval between 0.0 and 5.0 seconds.

Table 3–1

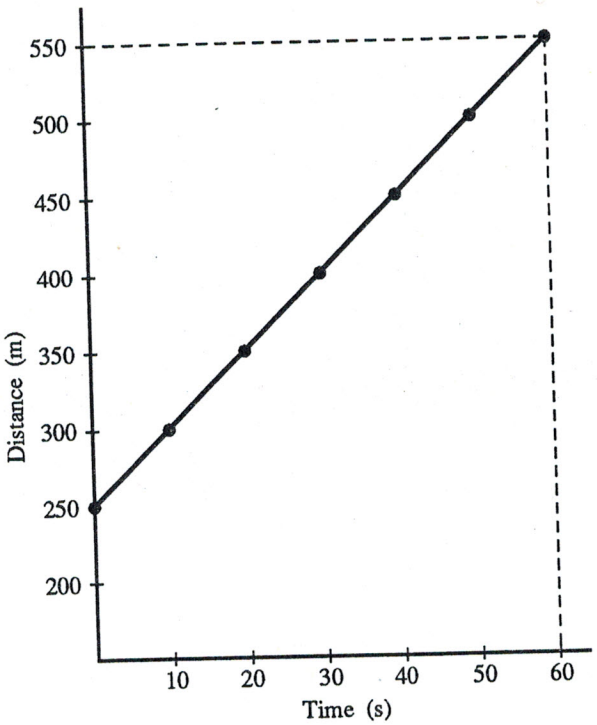
Clock Readings, t	Positions, d,
in s	in m
0.0	30
1.0	30
2.0	35
3.0	45
4.0	60
5.0	70

$$\text{slope} = \frac{\Delta d}{\Delta t} = \frac{70\ \text{m} - 30\ \text{m}}{5.0\ \text{s} - 0.0\ \text{s}} = 8.0\ \text{m/s}$$



18. A cyclist maintains a constant velocity of +5.0 m/s. At time $t = 0$, the cyclist is +250 m from point *A*.

a. Plot a position–time graph of the cyclist's location from point *A* at 10.0 second intervals for 60.0 s.



b. What is the position from point *A* at 60.0 s?

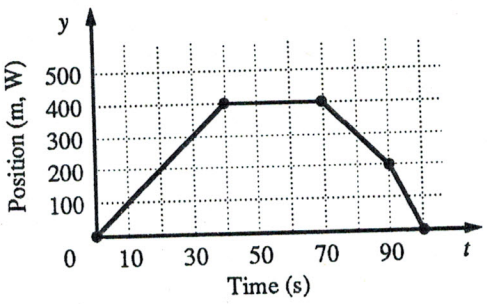
550 m

c. What is the displacement from the starting position at 60.0 s?

550 m – 250 m = 300 m

Chapter Review Problems

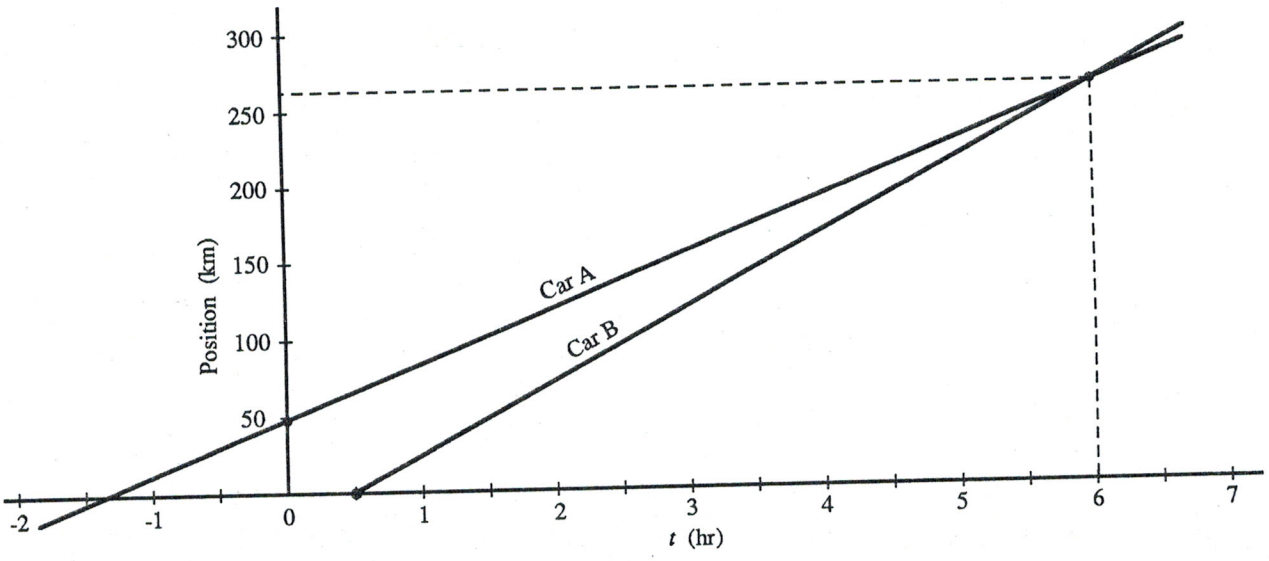
19. From the position–time graph, Figure 3–24, construct a table showing the average velocity of the object during each 10–s interval over the entire 100 s.



Time interval (s)	Average Velocity (m/s)
0–10	10
10–20	10
20–30	10
30–40	10
40–50	0
50–60	0
60–70	0
70–80	–10
80–90	–10
90–100	–20

20. Two cars travel along the same straight road. When a stopwatch reads $t = 0.0$ hr car A is at $d_A = 48.0$ km moving at a constant 36.0 km/h. Later, when the watch reads $t = 0.50$ hr car B is at $d_B = 0.00$ km moving at 48.0 km/h. Solve the following questions first graphically by creating a postion–time graph, second algebraically by writing down equations for the positions d_A and d_B as a function of the stopwatch time t.

a. What will the watch read when car B passes car A?



6.00 h

Cars pass when the distances are equal, $d_A = d_B$.
$d_A = 48.0 \text{ km} + (36.0 \text{ km/h})t$ and $d_B = 0 + (48.0 \text{ km/h})(t - 0.50 \text{ h})$, so

$$48.0 \text{ km} + (36.0 \text{ km/h})t = (48.0 \text{ km/h})(t - 0.50 \text{ h})$$
$$48.0 \text{ km} + (36.0 \text{ km/h})t = (48.0 \text{ km/h})t - 24 \text{ km}$$
$$72 \text{ km} = (12.0 \text{ km/h})t$$
$$t = 6.0 \text{ h}$$

b. At what position will the passing occur?

$d_A = 48.0 \text{ km} + (36.0 \text{ km/h})(6.0 \text{ h}) = 2.6 \times 10^2 \text{ km}$

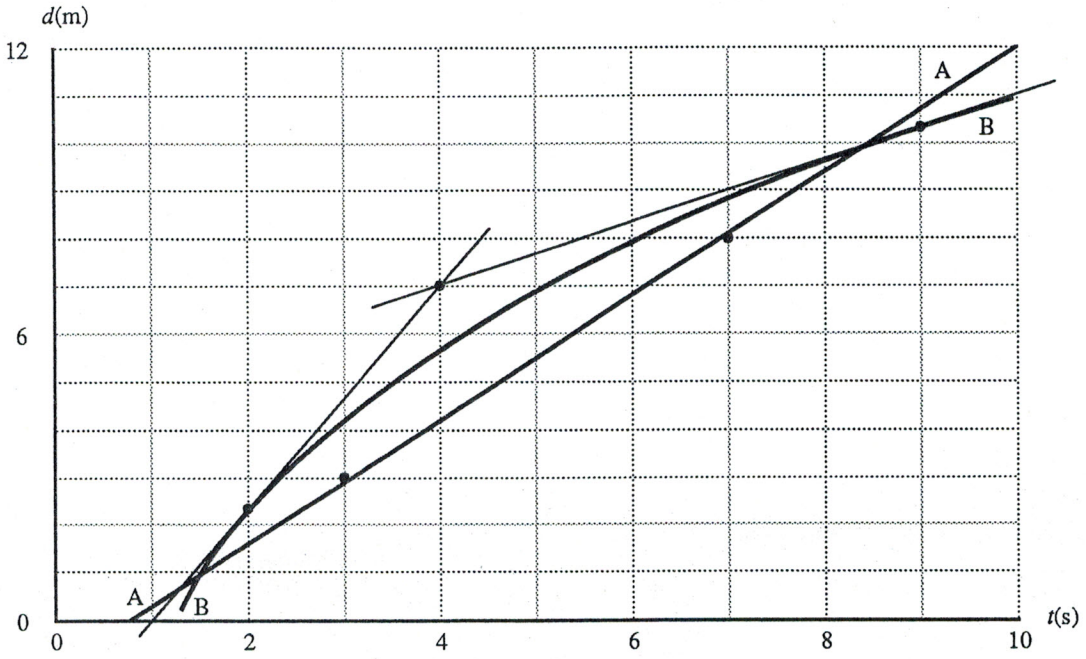
c. When the cars pass, how long will it have been since car A was at the reference point?

$d = vt$, so $t \frac{d}{v} = \frac{-48.0 \text{ km}}{36.0 \text{ km/h}} = -1.33 \text{ h}$

Car A started 1.33 h before the clock started.

$t = 6.0 \text{ h} + 1.3 \text{ h} = 7.3 \text{ h}$

21.



Refer to Figure 3–22 to find the instantaneous speed for

a. car B at 2.0 s

$$\text{slope} = \frac{\Delta d}{\Delta t} = \frac{7\text{ m} - 0\text{ m}}{4\text{ s} - 1\text{ s}} = 2.3\text{ m/s}$$

b. car B at 9.0 s

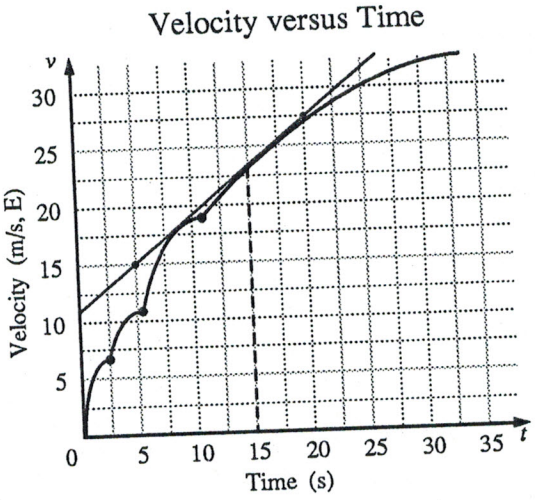
$$\text{slope} = \frac{\Delta d}{\Delta t} = \frac{11\text{ m} - 7\text{ m}}{10\text{ s} - 4\text{ s}} = 0.67\text{ m/s}$$

c. car A at 2.0 s

$$\text{slope} = \frac{\Delta d}{\Delta t} = \frac{8\text{ m} - 3\text{m}}{7\text{ s} - 3\text{ s}} = 1.25\text{ m/s}$$

Student answers will vary.

22. Find the instantaneous speed of the car at 15 s from Figure 3–19.

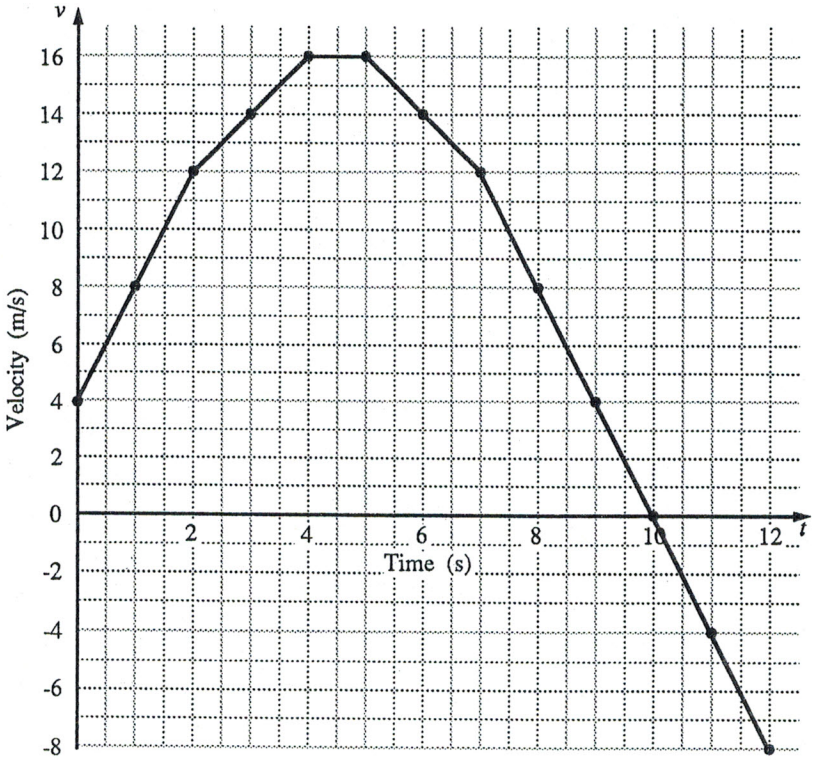


Student answer will vary.

$$\text{slope} = \frac{\Delta v}{\Delta t} = \frac{27.5 \text{ m/s} - 15 \text{ m/s}}{20 \text{ s} - 5 \text{ s}} = 0.83 \text{ m/s}^2$$

23. Plot a velocity–time graph using the information in Table 3–4.

Time (s)	Velocity (m/s)	Time (s)	Velocity (m/s)
0.0	4.0	7.0	12.0
1.0	8.0	8.0	8.0
2.0	12.0	9.0	4.0
3.0	14.0	10.0	0.0
4.0	16.0	11.0	–4.0
5.0	16.0	12.0	–8.0
6.0	14.0		



24. Refer to Figure 3–25 to find the distance the moving object travels

a. between $t = 0$ s and $t = 5$ s.

$$\text{Area I} = \frac{1}{2}bh = \frac{1}{2}(5\text{s})(30\text{ m/s}) = 75\text{ m}$$

b. between $t = 5$ s and $t = 10$ s.

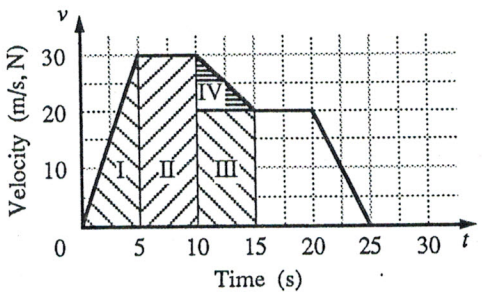
$$\text{Area II} = bh = (10\text{ s} - 5\text{ s})(30\text{ m/s}) = 150\text{ m}$$

c. between $t = 10$ s and $t = 15$ s.

$$\text{Area III} + \text{Area IV} = bh + \frac{1}{2}bh = (15\text{ s} - 10\text{ s})(20\text{ m/s}) + \frac{1}{2}(15\text{ s} - 10\text{ s})(10\text{ m/s})$$
$$= 100\text{ m} + 25\text{ m} = 125\text{ m}$$

d. between $t = 0$ s and $t = 25$ s.

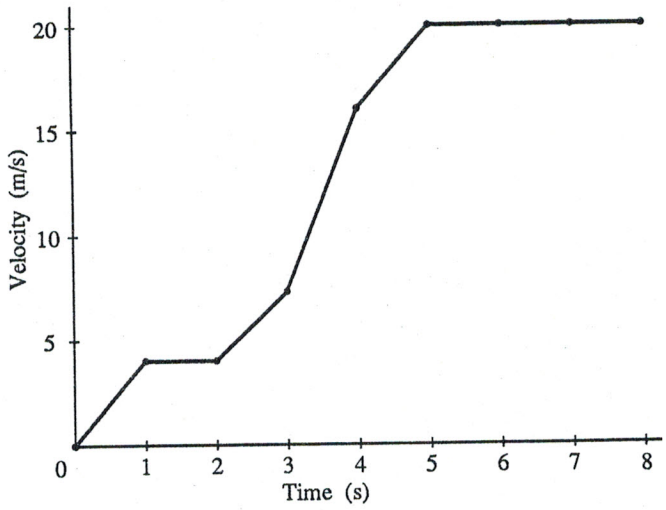
$$75\text{ m} + 150\text{ m} + 125\text{ m} + 100\text{ m} + 50\text{ m} = 500\text{ m}$$



25. The velocity of an automobile changes over an 8.0–s time period as shown in Table 3–5.

Time (s)	Velocity (m/s)	Time (s)	Velocity (m/s)
0.0	0.0	5.0	20.0
1.0	4.0	6.0	20.0
2.0	4.0	7.0	20.0
3.0	8.0	8.0	20.0
4.0	16.0		

a. Plot the velocity–time graph of the motion.



b. Determine the distance the car travels during the first 2.0 s.

$$\Delta d = \frac{1}{2}(1.0\text{ s})(4.0\text{ m/s}) + (1.0\text{ s})(4.0\text{ m/s}) = 6.0\text{ m}$$

c. What distance does the car travel during the first 4.0 s?

$$\Delta d = 6.0\text{ m} + \frac{1}{2}(1.0\text{ s})(8.0\text{ m/s} - 4.0\text{ m/s}) + (1.0\text{ s})(4.0\text{ m/s}) + \frac{1}{2}(1.0\text{ s})(16.0\text{ m/s} - 8.0\text{ m/s}) + (1.0\text{ s})(8.0\text{ m/s}) = 24\text{ m}$$

d. What distance does the car travel during the entire 8.0 s?

$$\Delta d = 24\text{ m} + (1.0\text{ s})(16.0\text{ m/s}) + \frac{1}{2}(1.0\text{ s})(20.0\text{ m/s} - 16.0\text{ m/s}) + (3.0\text{ s})(20.0\text{ m/s}) = 102\text{ m}$$

Supplemental Problems (Appendix B)

1. Bob walks 80 m and then he walks 125 m.

   a. What is Bob's displacement if he walks east both times?

   205 m

   b. What is Bob's displacement if he walks east then west?

   –45 m

   c. What distance does Bob walk in each case?

   205 m

2. A cross country runner runs 5.0 km east along the course, then turns around and runs 5.0 km west along the same path. She returns to the starting point in 40 min. What is her average speed? Her average velocity?

   average speed
   = (distance traveled during time interval)(time)

   $$= \frac{(5.0\text{ km} + 5.0\text{ km})}{(40\text{ min})}$$

   = (0.25 km/min)(60 min/h)
   = 15 km/h, average velocity

   $$= \frac{(\text{displacement during time interval})}{(\text{time})}$$

   $$= \frac{(+5.0\text{ km} - 5.0\text{ km})}{(40\text{ min})} = 0$$

3. 0.30 s after seeing a puff of smoke rise from the starter's pistol, the sound of the firing of the pistol is heard by the track timer 100 m away. What is the velocity of sound?

   $$v = \frac{d}{t} = \frac{100}{0.30} = 330\text{ m/s}$$

4. The radius of the tires on a particular vehicle is 0.62 m. If the tires are rotating 5 times per second, what is the velocity of the vehicle?

   $$C = 2\pi R = 2\pi(0.62) = 3.9\text{ m}$$

   $$V = \left[\frac{3.9\text{ m}}{\text{Rotation}}\right]\left[\frac{5\text{ Rotations}}{\text{s}}\right] = 20\text{ m/s}$$

Supplemental Problems

5. A bullet is fired with a speed of 720.0 m/s.

   a. What time is required for the bullet to strike a target at a position +324 m?

   $$t = \frac{d}{v} = \frac{(324\text{ m})}{(720.0\text{ m/s})} = 0.450\text{ s}$$

   b. What is the velocity in km/h?

   $$v = \frac{(720.0\text{ m/s})(3600\text{ s/h})}{(1000\text{ m/km})} = 2592\text{ km/h}$$

6. Light travels at 3.0×10^8 m/s. How many seconds go by from the moment the starter's pistol is shot until the smoke is seen by the track timer 100 m away?

   $$t = \frac{d}{v} = \frac{100}{3.0 \times 10^8} = 3.3 \times 10^{-7}\text{ s}$$

7. You drive your car from home at an average velocity of 80 km/h for 3 hours. Being halfway to your destination you develop some engine problems, and for 5 hours you nurse the car the rest of the way. What is your average velocity for the entire trip?

   $$d = \bar{v}t = (80)(3) = 240\text{ km}$$

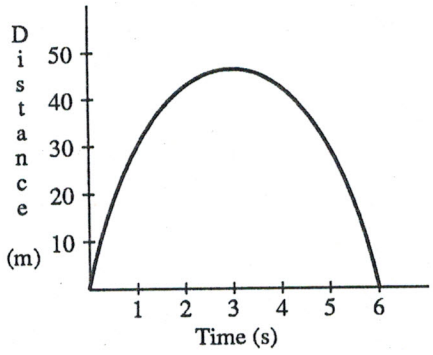
   Total distance traveled is 480 km.
   Total time is 8 hours.

   $$\bar{v} = \frac{d}{t} = \frac{480}{8} = 60\text{ km/h}$$

8. The total distance a ball is off the ground when thrown vertically is given for each second of flight by the following table:

Time (s)	Distance (m)
0.0	0.0
1.0	24.5
2.0	39.2
3.0	44.1
4.0	39.2
5.0	24.5
6.0	0.0

a. Draw a position–time graph of the motion of the ball.

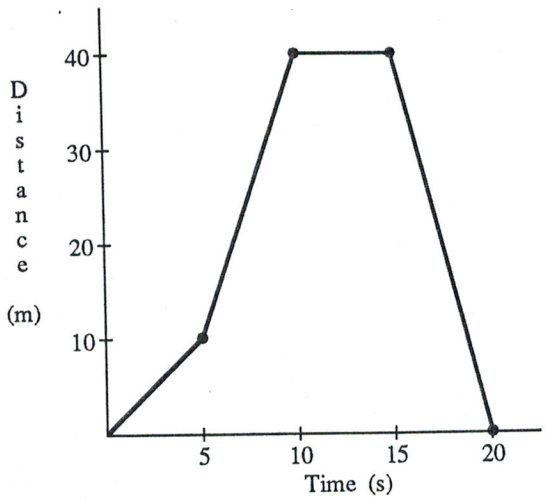


b. How far off the ground is the ball at the end of 0.5 s? When would the ball again be this distance from the ground?

13.5 m, 5.5 s

Supplemental Problems

9. Use the following position–time graph to find how far the object travels:



a. between $t = 0$ s to $t = 5$ s

10 m

b. between $t = 0$ s to $t = 10$ s

30 m

c. between $t = 10$ s to $t = 15$ s

0 m

d. between $t = 15$ s to $t = 20$ s

–40 m

e. between $t = 0$ s to $t = 20$ s

80 m of distance, but 0 displacement

10. Use the position–time graph from problem 9 to find the object's velocity:

a. between $t = 0$ s to $t = 5$ s

$$v = \frac{\Delta y}{\Delta x} = \frac{10}{5} = 2 \text{ m/s}$$

b. between $t = 5$ s to $t = 10$ s

$$v = \frac{30}{5} = 6 \text{ m/s}$$

c. between $t = 10$ s to $t = 15$ s

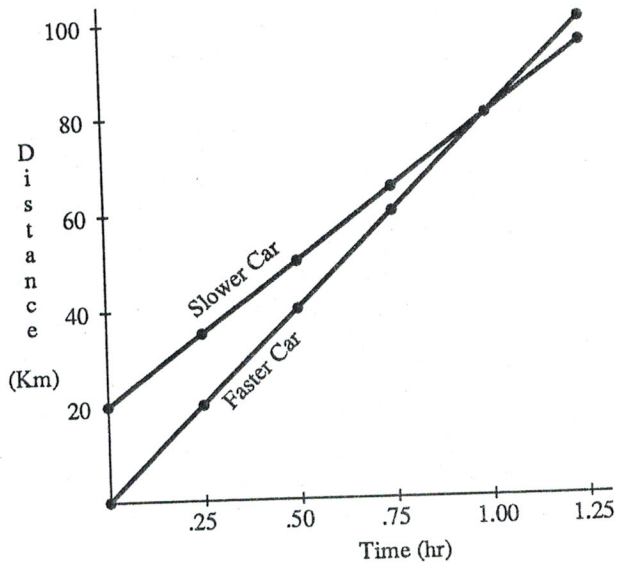
$$v = \frac{0}{5} = 0 \text{ m/s}$$

d. between $t = 15$ s to $t = 20$ s

$$v = \frac{-40}{5} = -8 \text{ m/s}$$

11. Two cars are headed in the same direction; one traveling 60 km/h is 20 km ahead of the other traveling 80 km/h.

a. Draw a position–time graph showing the motion of the cars.



b. Using your graph show the time when the faster car overtakes the slower one.

1 hr

12. Use the graph from Problem 8 to calculate the ball's instantaneous velocity at:

a. $t = 2$ s

≈ 10 m/s

b. $t = 3$ s

0 m/s

c. $t = 4$ s

≈ -10 m/s

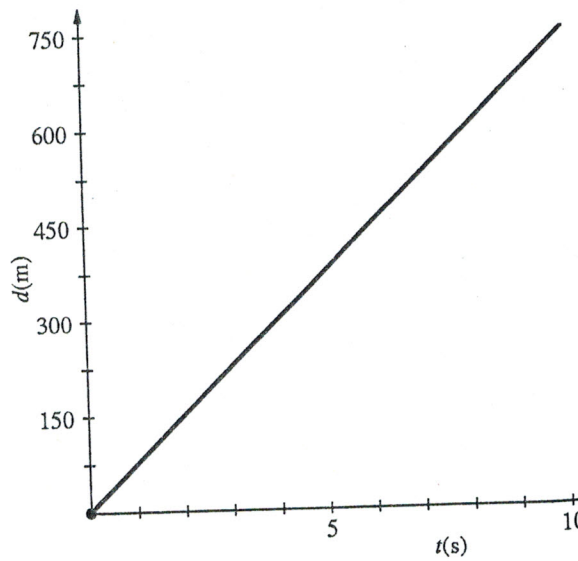
Supplemental Problems

13. A plane flies in a straight line at a constant speed of +75 m/s. Assume that it is at the reference point when the clock reads $t = 0$.

a. Construct a table showing the position or displacement of the plane at the end of each second for a 10 s period.

Clock Reading t, in s	Position, d, in m
0	0
1	75
2	150
3	225
4	300
5	375
6	450
7	525
8	600
9	675
10	750

b. Use the data from the table to plot a position–time graph.



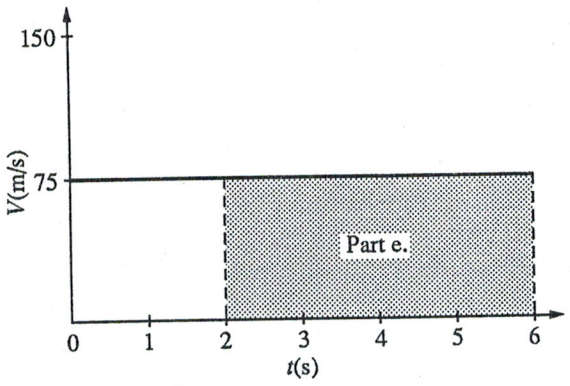
c. Show that the slope of the line is the velocity of the plane. Use at least two different sets of points along the line.

From d–t graph:

$$\text{slope } 1 = \frac{(450 \text{ m})}{(6 \text{ s} - 0 \text{ s})} = 75 \text{ m/s},$$

$$\text{slope } 2 = \frac{(600 \text{ m} - 200 \text{ m})}{(8 \text{ s} - 2.67 \text{ s})} = 75 \text{ m/s}$$

d. Plot a velocity–time graph of the plane's motion for the first 6 s of the 10–s interval.



e. From the velocity–time graph, find the displacement of the plane between the second and sixth seconds.

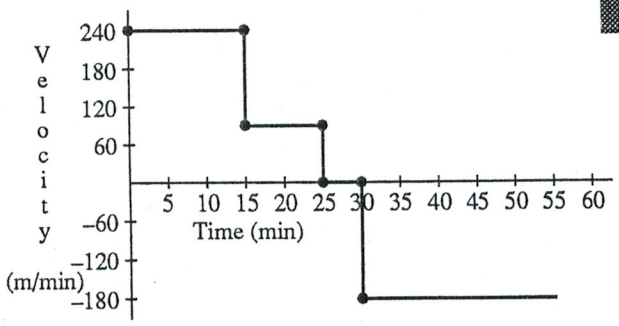
Shaded area under v – t graph = d

= (75 m/s)(4 s) = 300 m

14. Mary jogs for 15 minutes at 240 m/min, walks the next 10 minutes at 90 m/min, rests for 5 minutes, and jogs back to where she started at –180 m/min.

Supplemental Problems

a. Plot a velocity–time graph for Mary's exercise run.



b. Find the area under the curve for the first 15 minutes. What does this represent?

Area = 240(15) = 3600 m
The distance jogged.

c. What is the total distance traveled by Mary?

3600 + 900 + 4500 = 9000 m

d. What is Mary's displacement from start to finish?

4500 – 4500 = 0 m

15. Car A is traveling at 85 km/h while car B is at 60 km/h. What is the relative velocity of car A to Car B:

a. If they both are traveling in the same direction?

85 – 60 = 25 km/h

b. If they are headed towards each other?

85 + 60 = 145 km/h