Name Date

Section
8.2
Summary

Average Velocity

Textbook pages 362–375

Before You Read

Based on your current knowledge, how do you think speed differs from velocity? Write your answer in the lines below.

____

____

State the Main Ideas

Use your own words to express the main ideas covered in this section.

What is the difference between velocity and speed?

Velocity ($\vec{v}$) is a vector that describes how quickly an object's position changes, as well as the direction of this change.

Speed (v) is a scalar that measures the magnitude of velocity.

Both speed and velocity are measured in metres per second (m/s).

Objects travelling at the same speed can have different velocities. Imagine two escalators travelling at the same speed, one going up, and the other down. Because they are travelling in opposite directions, one of the directions has a negative sign. Thus, they have different velocities. ✔

Reading Check

What is velocity?

____

____

____

How is velocity determined on a position-time graph?

Velocity can be determined from the slope of a position-time graph. Where the graph shows a straight line, the velocity is constant. The slope is calculated as follows:

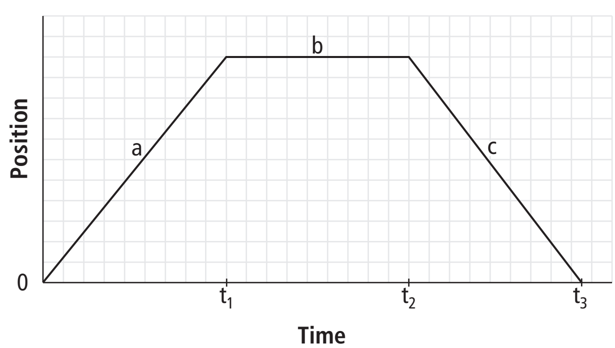
$$\text{Slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta \vec{d}}{\Delta t}$$

The slope shows, on average, how far an object has moved in a certain time interval. In other words, the slope shows the object's average velocity. **Average velocity** ($\vec{v}_{av}$) is the rate of change in position over a time interval. It is almost impossible for an object to move at a perfectly uniform rate. Many factors, such as wind or an uneven surface, may cause the object to slightly speed up or slow down. Average velocity "smoothes out" these changes. It is a vector and includes direction. The slope of a position-time graph can be positive, zero, or negative (see figure on next page).

If moving away from the origin is considered positive:

- a positive slope (a) represents the average velocity of the object moving away from the origin.
- a horizontal line, which has zero slope (b), represents an object at rest.
- a negative slope (c) represents the average velocity of the object moving back toward the origin.

Position vs. Time



How is average velocity calculated without using a position-time graph?

Since average velocity is the slope of a position-time graph, it can be written as follows:

$$\vec{v}_{av} = \frac{\Delta\vec{d}}{\Delta t}$$

By using this relationship, you can calculate the average velocity without analyzing a position-time graph.

Example: A sprinter takes 8.2 s to run forward 75.0 m. What is the sprinter's average velocity?

$$\Delta\vec{d} = +75.0 \text{ m}, \Delta t = 8.2\ s$$

$$\begin{aligned}\vec{v}_{av} &= \frac{\Delta\vec{d}}{\Delta t} \\ &= \frac{+75.0 \text{ m}}{8.2 \text{ s}} \\ &= +9.1 \text{ m/s}\end{aligned}$$

Thus, the sprinter ran 9.1 m/s forward.
This equation can also be rearranged to calculate displacement or time.

For displacement:

$$\Delta\vec{d} = (\vec{v}_{av})(\Delta t)$$

For time

$$\Delta t = \frac{\Delta\vec{d}}{\vec{v}_{av}}$$

Reading Check

Give the equation for average velocity.

Use with textbook pages 362–366.

Calculating average velocity

1. What is the formula for each of the following quantities?

a) average velocity ___________ **b)** displacement ___________ **c)** time ___________

2. Complete the following table. Use the motion formula to calculate the missing quantities. Show all your work and use the correct units.

Displacement	Time	Average Velocity	Formula Used and Calculation Shown
15.6 m	3 s	5.2 m/s	$\vec{v}_{av} = \frac{\Delta\vec{d}}{\Delta t} = \frac{15.6}{3} = 5.2$ m/s
357.5 km	6.5 h		
22.6 m		5.65 m/s	
	3.25 h	75 km/h	
12.6 m	3.15 s		
24 km		32 km/h	
	8 s	60 m/s	

3. Complete the following table. Show all your work and use the correct units.

Question	Formula Used and Calculation Shown	Answer
a) A woman wants to paddle 420 m across a lake in her kayak. If she paddles across the lake at an average velocity of 2.8 m/s, how long does it take her to cross?		
b) If a cyclist rides west at 14 m/s, how long would it take her to travel 980 m?		
c) A cheetah runs at a velocity of 30 m/s [E]. If it runs for 8.5 s, what is its displacement?		
d) The Australian dragonfly can fly at 16 m/s. How long does it take to fly 224 m?		
e) The Skyride gondola at Grouse Mountain in North Vancouver takes 8 min to go up the 3 km mountain. What is the average velocity of the gondola?		
f) Due to plate tectonics, the North American and European continents are drifting apart at an average speed of about 3 cm per year. At this speed, how long (in years) will it take for them to drift apart by another 2400 m?		
g) A dragster heading north, reaches a velocity of 628 km/h from rest in 3.72 s. How far did it travel in that time?		

Use with textbook pages 364–367.

Slopes of position-time graphs

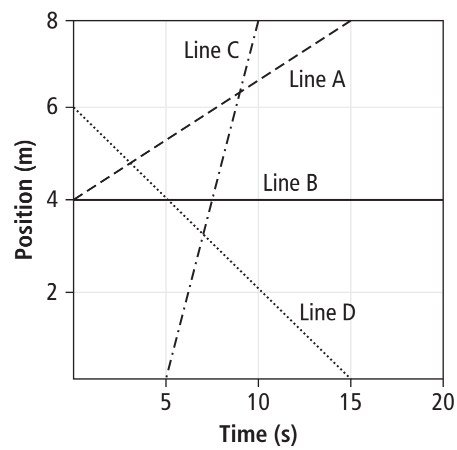
1. What does the slope of a line on a position-time graph represent?
____

2. What does a straight line on a position-time graph represent? _______________

3. Define slope. _______________

4. What is the formula used to calculate the slope of a straight line?
____

5. Using the position-time graph, determine the slope of each line segment by completing the following table.

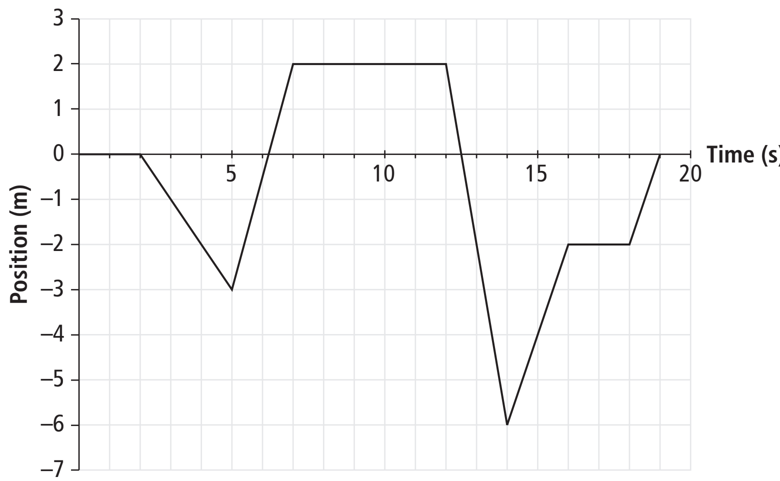


Line	Rise	Run	Slope Calculation	Slope
A				
B				
C				
D				

Use with textbook pages 364–367.

Analyzing position-time graphs

1. Use the following position versus time graph showing a girl's movement up and down the aisle of a store to answer the questions below. The origin is at one end of the aisle.



a) Complete the following table. Determine how far the girl travelled during each time interval and calculate the average velocity for each section of the graph.

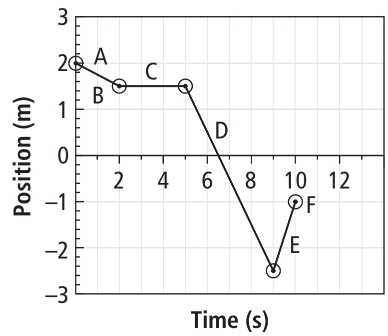
Time Interval	Displacement	Average Velocity
0 s–2 s		
2 s–5 s		
5 s–7s		
7 s–12 s		
12 s–14 s		
14 s–16 s		
16 s–18 s		
18 s–19 s		
19 s–20 s		

b) When does the girl have a position of –6 m? ____________________

c) What is the girl's total displacement after 20 seconds? ____________________

Name Date

2. Use the following position-time graph, showing the motion of a gymnast on a balance beam, to Match each **Descriptor** below with the corresponding part of the **Graph** shown above. Each part of the Graph may be used as often as necessary. Assume the centre of the balance beam is the reference point (origin).



_____ **a)** She stands still for 3 s.

_____ **b)** She moves even faster to the right for 1 s.

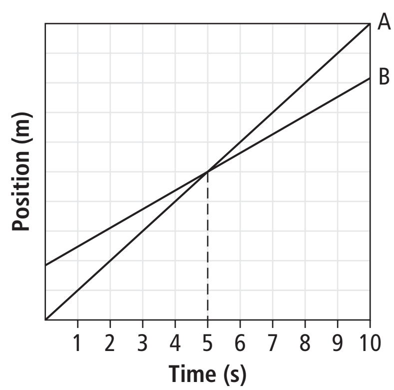
_____ **c)** She moves very slowly to the left for 2 s.

_____ **d)** She moves more quickly to the left for 4 s.

_____ **e)** She ends up 1 m left of the centre of the balance beam.

_____ **f)** She starts 2 m to the right of the centre of the balance beam.

3. Use the following position-time graph, showing the motion of two runners, to answer the questions below.



a) What does the *y*-intercept represent? ____________________

b) Do the runners start at the same place? ____________________

c) At about 2 s, which runner is running faster? How can you tell?

____

d) What occurs at 5 s? ____________________

e) At 10 s, which runner is ahead? ____________________

Name Date

Extension Activity

Section 8.2

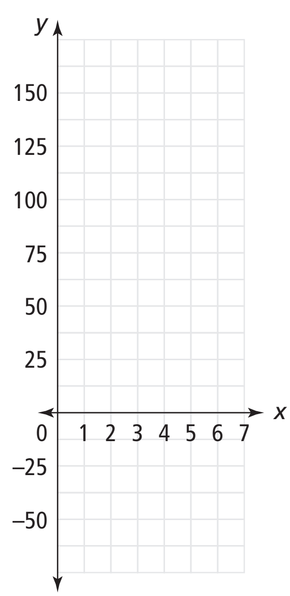
Use with textbook pages 366–367

Constructing and interpreting position-time graphs

1. Use the following data table, showing a car's recorded positions over 7 seconds, to answer the questions below. Assume 0 m is the reference point.

Time (s)	Position (m)
0	125
1	100
2	75
3	50
4	25
5	0
6	–25
7	–50

a) Label the x-axis with Time (s) and the y-axis with Position (m). Use the grid to plot the data points from the data table. Draw a best-fit line through the points.



b) When was the car 50 m [E] of the reference point? ____________________

c) What was the car's position at 1 s? ____________________

d) Where was the car at 5.5 s? ____________________

e) What was the car's average velocity between 0 s and 7 s? ____________________

f) Describe the motion of the car during the time interval 2 s – 4 s.

____

2. Sketch a position-time graph for each of the following scenarios. If specific time, positions, and velocities are given, label them on the graph. Assume all motion is uniform and in a straight line.

a) A car is travelling north at a velocity of 50 km/h. It slows down to 30 km/h when it enters a school zone.

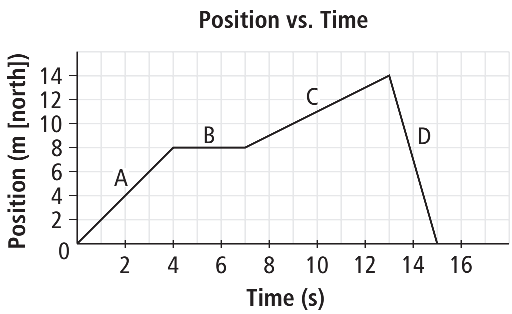
b) A boy walks away from the kitchen table, 4 m to the right with a velocity of 2 m/s. He spends 6 s getting a bowl of fruit salad out of the refrigerator, and then walks back to the table at a velocity of 1 m/s.

c) At soccer practice, the coach makes the players run back and forth between two lines four times.

Use with textbook pages 362–370.

Average velocity

Use the following position-time graph to answer questions 1 to 4.



Match each Descriptor below with the corresponding part of the Graph shown above.
1. ______ has an average velocity of 0 m/s
2. ______ has an average velocity of 1 m/s [N]
3. ______ has an average velocity of 2 m/s [N]
4. ______ has an average velocity of 7 m/s [S]

5. Which two terms represent a vector quantity and the scalar quantity of the vector's magnitude, respectively?

A. velocity and speed

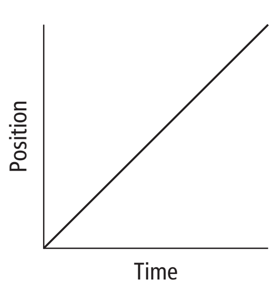
B. time and time interval

C. acceleration and velocity

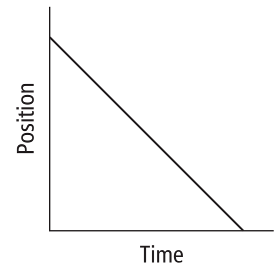
D. position and displacement

6. Which of the following graphs represent the motion of an object with a constant velocity?

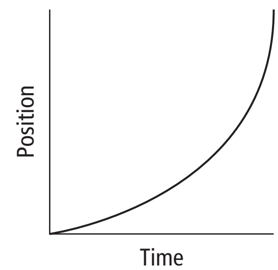
I



II



III



A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

7. How long would a meteor, with a velocity of 45 km/s, take to travel 120 km through Earth's atmosphere to Earth's surface? Assume no atmospheric friction.

A. 0.375 s

B. 2.66 s

C. 45 s

D. 5400 s

8. It took 0.45 s for a fastball to reach the batter. If the pitcher is 18 m away from the batter, how fast was the fastball pitch?

A. 0.025 m/s

B. 8.1 m/s

C. 18 m/s

D. 40 m/s

9. The average velocity of a plane was 600 km/h [N]. How long did it take the plane to travel 120 km?

A. 0.2 min

B. 5 min

C. 12 min

D. 5.0 h

10. A Canada goose flew 860 km from Washington to British Columbia with an average velocity of 30.5 m/s [N]. Approximately how long did it take the goose to make its journey?

A. 0.04 h

B. 7.8 h

C. 28.2 h

D. 469.9 h

11. An odometer in a car has a reading of 50 km at the beginning of a trip and a reading of 125 km half an hour later. What is the average speed of the car?

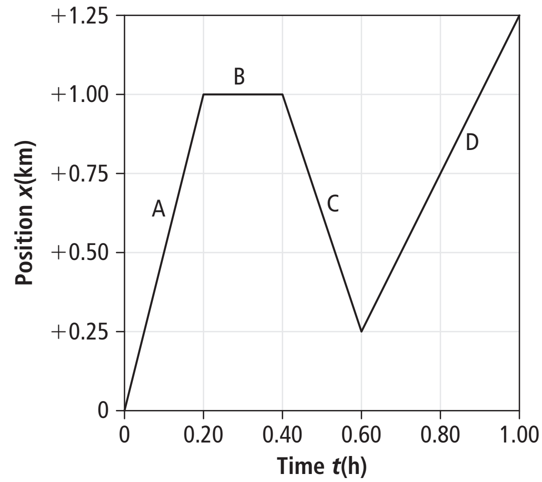
A. 3.75 km/h

B. 62.5 km/h

C. 150 km/h

D. 250 km/h

Use the following position-time graph of the motion of an object to answer questions 12 to 14.



12. During which time interval is the object moving towards the origin?

A. interval A

B. interval B

C. interval C

D. interval D

13. What is the average velocity between 0.6 h and 1 h?

A. +0.4 km/h

B. +1.25 km/h

C. +1.66 km/h

D. +2.5 km/h

14. What is the object's displacement between 0.4 h and 0.6 h?

A. –0.75 km

B. +0.25 km

C. +0.75 km

D. +1.0 km