Name Date

Section
9.2
Summary

Calculating Acceleration

Textbook pages 392–405

Before You Read

How do you think a velocity-time graph might differ from the position-time graph you learned about in the previous chapter? Write your answer on the lines below.

___

___

Draw a Graph

Draw a velocity-time graph for an object experiencing positive, zero, and negative acceleration.

Reading Check

1. Write the equation for acceleration.

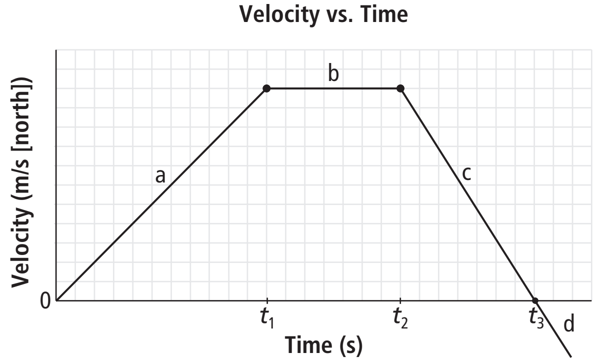
___

How is acceleration determined on a velocity-time graph?

A **velocity-time graph** represents the motion of an object with changing velocity. The slope of a velocity-time graph gives the object's acceleration, which is measured in m/s^2. When a best-fit line passes through all data points, the object's velocity is changing at a constant rate and it experiences **constant acceleration**. However, since not all the velocities may be directly on the best-fit line, the slope is referred to as **average acceleration** ($\vec{a}$).

If north is considered positive, for lines above the *x*-axis:

- a positive slope (a) represents the average acceleration of an object that increases speed at a constant rate while travelling north. Acceleration is constant and positive.
- zero slope (b) represents an object travelling north at a constant speed. It is not accelerating.
- a negative slope (c) represents an object that decreases speed at a constant rate while travelling north. Acceleration is constant and negative. Velocity is positive.



A line below the *x*-axis (d) represents increasing speed at a constant rate toward the south. Acceleration is constant and negative. Velocity is negative.

How is acceleration calculated without using a velocity-time graph?

Recall that average acceleration is the slope of a velocity-time graph:

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

This textbook only considers situations where acceleration is constant. This means average acceleration is actually the same as acceleration at any instant.

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$$ ✔

This equation can be rearranged to calculate velocity or time.

For velocity:

$$\Delta\vec{v} = \vec{a}\Delta t$$

For time:

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

What is the relationship between gravity and acceleration?

When an object falls near Earth's surface, the force of **gravity** pulls it downward. Consider a ball being thrown straight up into the air, where "up" is positive.

- On the way up, the ball's velocity is decreasing. The ball is slowing down, so its acceleration is negative.
- At its maximum height, the ball's velocity is zero for an instant since the direction of the ball is changing. (Because the ball's velocity is still changing, the ball is accelerating although its velocity is zero for an instant.)
- When the ball starts to come down, its speed increases. However, its velocity is negative because the ball is heading "down." The ball's acceleration is negative.

How does air resistance influence acceleration due to gravity?

Objects fall at different rates because of **air resistance**, a friction-like force. In the absence of air resistance, all objects, regardless of their weight, fall with the same constant acceleration of 9.8 m/s^2 downward. This is **acceleration due to gravity** (g). In many situations, the air resistance acting on a falling object is so small that we can assume the object has a constant acceleration of $-9.8\ m/s^2$, where up is positive. ✔

✔ *Reading Check*

2. What is the value of acceleration due to gravity on Earth?

____

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Use with textbook pages 396–400.

Calculating acceleration

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

(a) acceleration ________ (b) change in velocity ________ (c) time interval ________

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

Change in Velocity	Time	Acceleration	Formula Used and Calculation Shown
140 m/s	8 s	17.5 m/s²	$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{140}{8} = 17.5$ m/s
–60 km/h	4 h		
120 km/h		48 km/h²	
	15 s	–3.5 m/s²	
12 m/s	2.5 s		
–25 m/s		–12.5 m/s²	
	9.6 h	5 km/h²	

3. Solve each problem using the appropriate motion formula. Show all your work and use the correct units.

a) A car moving north goes from 5.56 m/s to 63.9 m/s in 7.5 s. What is the acceleration?

____

b) If a sprinter starts a race and has an acceleration of 2.4 m/s^2 in 2.5 s, what is his final velocity, assuming the initial velocity is 0 m/s^2?

____

c) A rock accelerates at –9.8 m/s^2 when falling. How long does it take to change its velocity from –4.5 m/s to –19.4 m/s?

____

d) A satellite released from a stationary space shuttle accelerates to +68 m/s^2 in 25 s. What is its change in velocity?

____

Use with textbook pages 394–396.

Analyzing velocity-time graphs

1. What is the meaning of each of the following features of a velocity-time graph?

(a) the slope of the line ______________________________

(b) a line above the *x*-axis ______________________________

(c) a line below the *x*-axis ______________________________

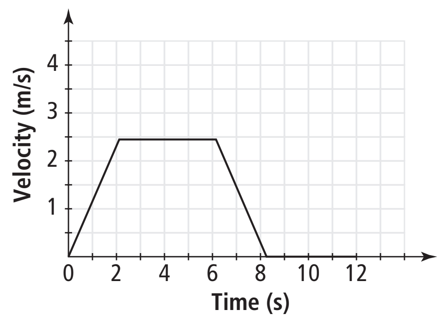
(d) a line with a positive slope ______________________________

(e) a line with a negative slope ______________________________

(f) a horizontal section of the graph ______________________________

(g) a point where the line crosses the *x*-axis ______________________________

Use the following velocity-time graph representing the motion of a ball moving to the right on a table to answer questions 2 and 3.



2. Complete the following table. Describe the slope, acceleration, and velocity of the ball (e.g. positive, negative, or zero).

MOTION OF A BALL			
Time Interval	**Slope**	**Acceleration**	**Velocity**
0 s – 2 s			
2 s – 6 s			
6 s – 8 s			
8 s – 12 s			

3. Describe the motion of the ball at each time interval.

(a) 0 s – 2 s ______________________________

(b) 2 s – 6 s ______________________________

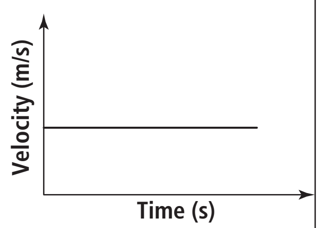
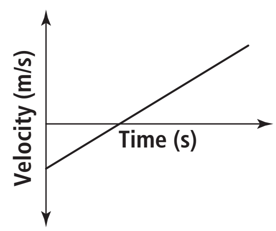
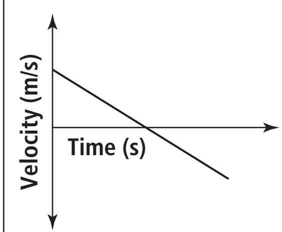
(c) 6 s – 8 s ______________________________

(d) 8 s – 12 s ______________________________

Use with textbook pages 395–396.

Sketching and interpreting velocity-time graphs

1. Complete the following table. What is the slope (e.g. positive, negative, or zero) of each velocity-time graph? State whether the graph shows positive acceleration, negative acceleration, or zero acceleration.

	Graph A	Graph B	Graph C
			
Slope			
Acceleration			

2. Sketch a velocity-time graph for each scenario given below.

	Positive Acceleration	Negative Acceleration
Positive Velocity		
Negative Velocity		

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Illustrating Concepts

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3. (a) Sketch a velocity-time graph of a field trip to the science museum, showing all the stages (i to v) listed below.

i. the bus is stationary (has an initial velocity of zero) as the students board the bus at school

ii. the bus has constant acceleration as it leaves the school

iii. the bus is travelling at the speed limit with uniform motion on the highway

iv. the bus slows down as it approaches some traffic

v. the bus comes to a complete stop at the science museum

(b) Identify the sections of the velocity-time graph with positive, negative, and zero slope.

i: ______________________

ii: ______________________

iii: ______________________

iv: ______________________

v: ______________________

(c) Identify the stages of the field trip with positive, negative, and zero acceleration.

i: ______________________

ii: ______________________

iii: ______________________

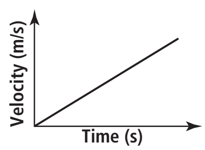
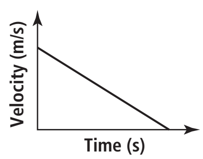
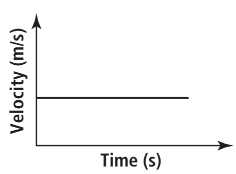
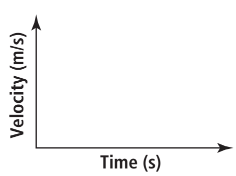
iv: ______________________

v: ______________________

Use with textbook pages 392–400.

Calculating acceleration

Match the Descriptor on the left with the best Velocity-Time Graph on the right. The Velocity-Time Graphs represent the motion of a car heading north. Each Velocity-Time Graph may be used only once.

Descriptor	Velocity-Time Graph
1. ______ The car is stopped. **2.** ______ The car is accelerating. **3.** ______ The car is slowing down. **4.** ______ The car is travelling at constant velocity.	**A.**  **B.**  **C.**  **D.** 

5. Acceleration is represented by the slope of a

A. velocity-time graph

B. position-time graph

C. distance-time graph

D. acceleration-time graph

6. A meteor goes from +1.0 km/s to +2.2 km/s in 0.04 s. What is its acceleration?

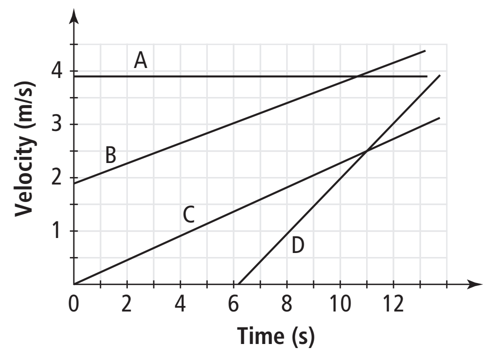
A. 0.03 km/s^2

B. 30 km/s^2

C. 55 km/s^2

D. 80 km/s^2

Use the following velocity-time graph to answer question 7.



7. Which line represents an object with the greatest acceleration?

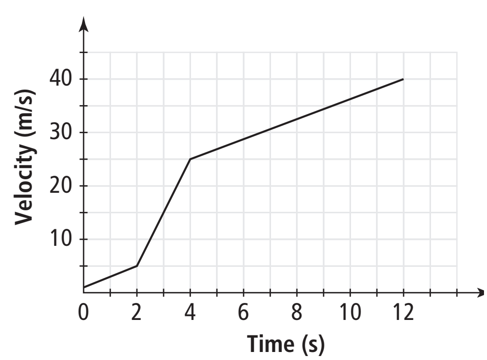
A. A

B. B

C. C

D. D

Use the following velocity-time graph to answer question 8.



8. What is the object's acceleration between the time interval 2 s and 4 s?

A. +1 m/s^2

B. +10 m/s^2

C. +20 m/s^2

D. +40 m/s^2