PHYSICS

تجميعت هيكل فيزياء

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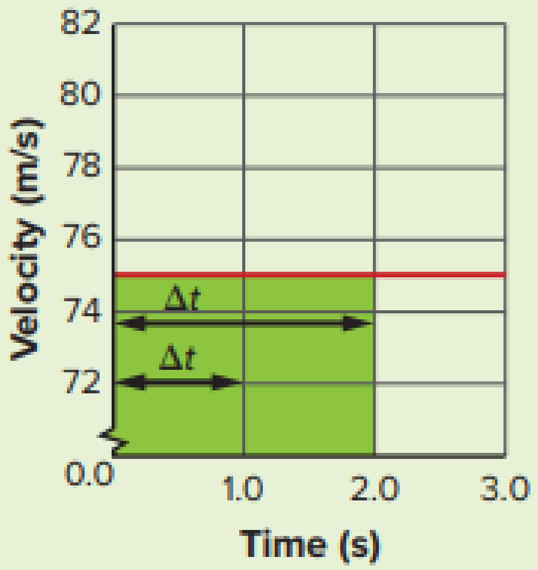
1	Relate the slope of a velocity time graph to the average acceleration of the object in motion	example 3	70

EXAMPLE Problem 3

FINDING DISPLACEMENT FROM A VELOCITY-TIME GRAPH The velocity-time graph at the right shows the motion of an airplane. Find the displacement of the airplane for $\Delta t = 1.0$ s and for $\Delta t = 2.0$ s. Let the positive direction be forward.



1 ANALYZE AND SKETCH THE PROBLEM

- The displacement is the area under the *v-t* graph.
- The time intervals begin at $t = 0.0$ s.

KNOWN	UNKNOWN
$v = +75$ m/s	$\Delta x = ?$
$\Delta t = 1.0$ s	
$\Delta t = 2.0$ s	

2 SOLVE FOR THE UNKNOWN

Use the relationship among displacement, velocity, and time interval to find Δx during $\Delta t = 1.0$ s.

$\Delta x = v\Delta t$

$= (+75 \text{ m/s})(1.0 \text{ s})$ Substitute $v = +75$ m/s, $\Delta t = 1.0$ s.

$= +75$ m

Use the same relationship to find Δx during $\Delta t = 2.0$ s.

$\Delta x = v\Delta t$

$= (+75 \text{ m/s})(2.0 \text{ s})$ Substitute $v = +75$ m/s, $\Delta t = 2.0$ s.

$= +150$ m

3 EVALUATE THE ANSWER

- **Are the units correct?** Displacement is measured in meters.
- **Do the signs make sense?** The positive sign agrees with the graph.
- **Is the magnitude realistic?** Moving a distance of about one football field per second is reasonable for an airplane.

2	Apply the equation of motion relating the final velocity of an object to its initial velocity, uniform acceleration, and time ($v_f = v_i + at$)	problems 5,6	67

5. A race car's forward velocity increases from 4.0 m/s to 36 m/s over a 4.0-s time interval. What is its average acceleration?

$$(a) = (v_f - v_i) / (\Delta t)$$

$$(a) = (36 m/s - 4.0 m/s) / (4.0 s)$$

Now, calculate the acceleration:

$$(a) = (32 m/s) / (3 s)$$

$$(a) = 8\ m/s^2$$

6. The race car in the previous problem slows from 36 m/s to 15 m/s over 3.0 s. What is its average acceleration?

$$(a) = (v_f - v_i) / (\Delta t)$$

$$(a) = (15 m\ s - 36 ms) / (3.0 s)$$

Now, calculate the acceleration:

$$(a) = (-21 m\ s) / (3 s)$$

$$(a) = -7\ m/s^2$$

3	Use appropriate significant figures to record answers from a mathematical operation, with the correct number of digits	problem 12	13

8. **Significant Figures** Solve the following problems, using the correct number of signif cant figures each time.

a. 10.8 g – 8.264 g

b. 4.75 m – 0.4168 m

c. 139 cm × 2.3 cm

d. 13.78 g / 11.3 mL

e. 1.6 km + 1.62 m + 1200 cm

a. 10.8g - 8.264g

10.8 g
- 8.264 g
2.536 g
=2.5 g after rounding

Because it is subtraction, the answer must contain one significant digit after the comma.

b. 4.75m - 0.4168m

4.75 m
-0.4168 m
4.3332 m
= 4.33 m after rounding

Because it is subtraction, the answer must contain two significant figures after the comma

c. 139cm x 2.3cm

139 cm x 2.3 cm
320 cm^2 or 3.2×10^2 cm^2

Because it is a multiplication operation, the entire answer must contain two significant figures.

d. 13.78 g / 11.3 mL

13.78 g / 11.3 mL
= 1.219469027 g/ml
1.22 g/ml after rounding

Because it is a division process, the complete answer must contain three significant figures.

e. 6.201cm + 7.4cm + 0.68m + 12cm

0.68m = 68 cm
6.201cm + 7.4cm + 68cm + 12cm
=93.601cm
= 93.6cm after rounding

Here the answer must contain one significant figure after the comma.

f. 1.6km + 1.62m + 1200cm

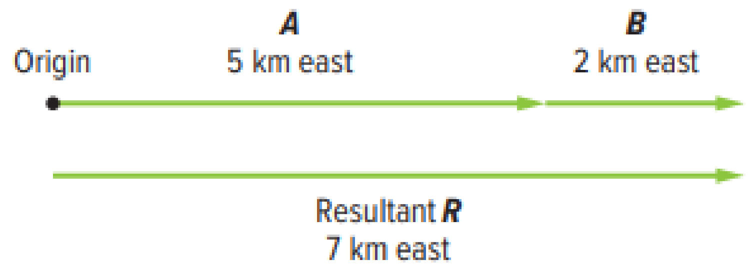
1.6 km = 1600 m
1.62 m = 1.62 m
1200 cm= + 12 m
=1613.62 m
= 1600 m or 1.6×10^3 m after rounding

4	Differentiate between distance travelled and displacement	figure 10	40

Figure 10 You can use a diagram or an equation to combine vectors.
Analyze *What is the sum of a vector 12 m north and a vector 8 m north?*

COLOR CONVENTION
Displacement (x) — green

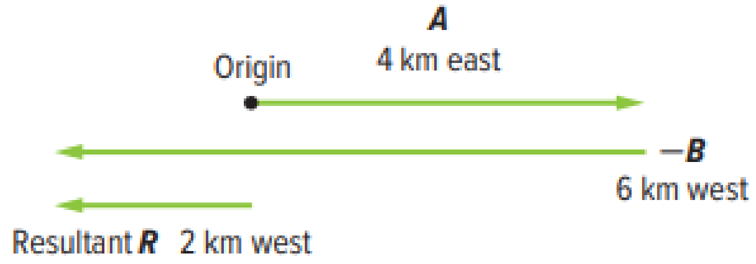
Example of Vector Addition



$R = A + B$
$= 5\text{ km} + 2\text{ km}$
$= 7\text{ km}$

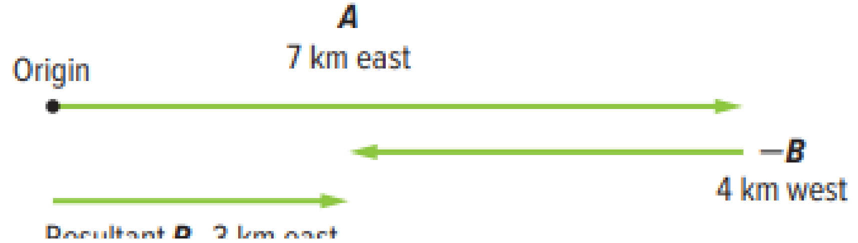
$\mathbf{R} = \mathbf{A} + \mathbf{B}$
$= 7\text{ km east}$

Examples of Vector Subtraction



$R = A - B$
$= 4\text{ km} - 6\text{ km}$
$= -2\text{ km}$

$\mathbf{R} = \mathbf{A} - \mathbf{B}$
$= \mathbf{A} + (-\mathbf{B})$
$= 2\text{ km west}$



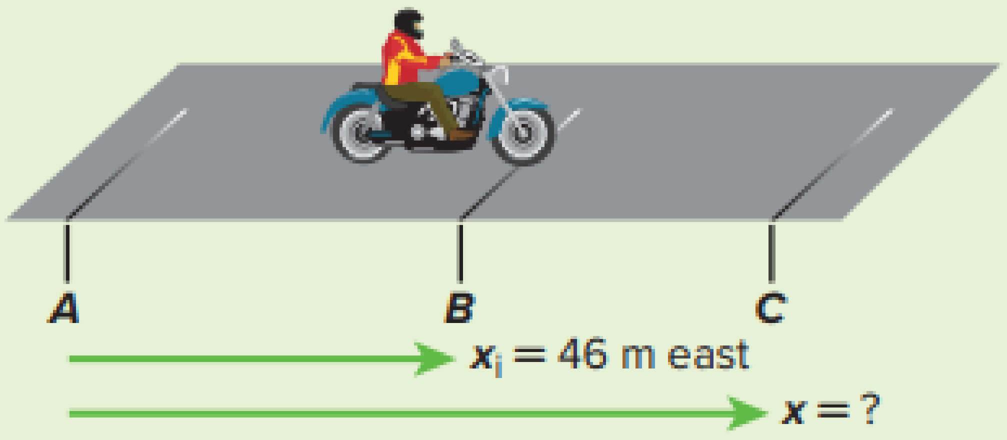
$R = A - B$
$= 7\text{ km} - 4\text{ km}$
$= 3\text{ km}$

$\mathbf{R} = \mathbf{A} - \mathbf{B}$
$= \mathbf{A} + (-\mathbf{B})$
$= 3\text{ km east}$

5	Apply the equation of motion, (xf = vavgt + xi) or (xf - xi = vavgt), in numerical problems to calculate the position or other physical quantities	exmple 4	50

EXAMPLE Problem 4

POSITION The figure shows a motorcyclist traveling east along a straight road. After passing point ***B***, the cyclist continues to travel at an average velocity of 12 m/s east and arrives at point ***C*** 3.0 s later. What is the position of point ***C***?



1 ANALYZE THE PROBLEM

Choose a coordinate system with the origin at ***A***.

KNOWN	UNKNOWN
$\bar{\mathbf{v}}$ = 12 m/s east	$\mathbf{x}$ = ?
$\mathbf{x}_i$ = 46 m east	
t = 3.0 s	

2 SOLVE FOR THE UNKNOWN

$x = \bar{v}t + x_i$ — Use magnitudes for the calculations.

$= (12\text{ m/s})(3.0\text{ s}) + 46\text{ m}$ — Substitute $\bar{v}$ = 12 m/s, t = 3.0 s, and x_i = 46 m.

$= 82\text{ m}$

$\mathbf{x}$ = 82 m east

3 EVALUATE THE ANSWER

Are the units correct? Position is measured in meters.

Does the direction make sense? The motorcyclist is traveling east the entire time.

6	Classify physical quantities into vector and scalar quantities (distance, mass, displacement, speed, velocity, acceleration, force, work, energy, pressure)	as mentioned in the book	38

Scalar	vector
Distance	Displacement
Mass	Velocity
speed	Acceleration
Pressure	Force
Work-energy	

تعليم

7	Apply the alternative equation of motion relating an object's final velocity to its initial velocity, its constant aceleration, and its initial and final positions ($v2f = v2i + 2a(xf - xi)$)	problem 16	69

A)

$vf = vi + at$

$vf = 2.0 + (- 0.50) \times 2.0 =$

$vf = 1.0 m/s$

$vi = 2.0\ m/s$

$a = - 0.50\ m/s^2$

$t = 2.0\ s$

$vf = ?$

16. A golf ball rolls up a hill toward a miniature-golf hole. Assume the direction toward the hole is positive.

a. If the golf ball starts with a speed of 2.0 m/s and slows at a constant rate of 0.50 m/s², what is its velocity after 2.0 s?

b. What is the golf ball's velocity if the constant acceleration continues for 6.0 s?

c. Describe the motion of the golf ball in words and with a motion diagram.

6.0 s?

B)

$vf = vi + at$

$vf = 2.0 + (- 0.50) \times 6.0 =$

$vf = -1.0 m/s$

$vi = 2.0\ m/s$

$a = - 0.50\ m/s^2$

$t = 6.0\ s$

$vf = ?$

C)

Low velocity of the ball in the first case.

In the second case, the speed of the ball decreased until it stopped and then began to move down the inclined surface.

8	Define a coordinate system and identify the origin, position, and distance in a coordinate system	figure 9	39

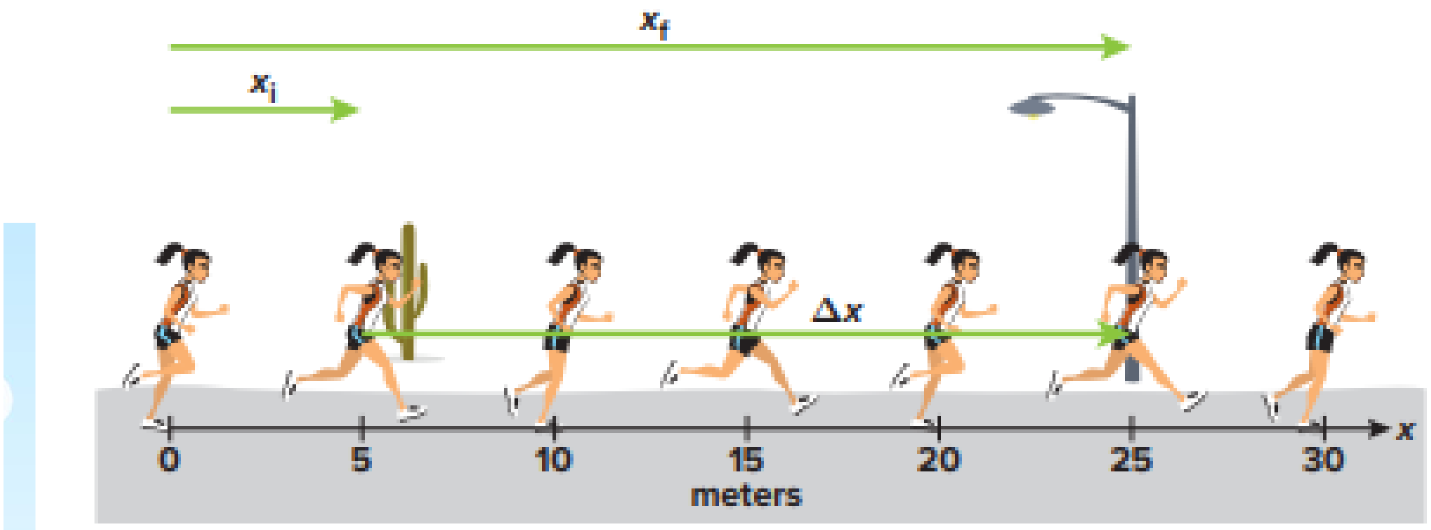


Figure 9 The vectors x_i and x_f represent positions. The vector Δx represents displacement from x_i to x_f.

Describe *the displacement from the lamppost to the cactus.*

Figure 9 shows the position of the runner at both the cactus and the lamppost. Notice that you can draw an arrow from the origin to the location of the runner in each case. These arrows have magnitude and direction. In common speech, a position refers to a certain place, but in physics, the definition of a position is more precise. A position is a vector with the arrow's tail at the origin of a coordinate system and the arrow's tip at the place.

You can use the symbol x to represent position vectors mathematically. In **Figure 9**, the symbol x_i represents the position at the cactus, and the symbol x_f represents the position at the lamppost. The symbol Δx represents the change in position from the cactus to the lamppost. Because a change in position is described and analyzed so often in physics, it has a special name. In physics, a change in position is called a **displacement.** Because displacement has both magnitude and direction, it is a vector.

What was the runner's displacement when she ran from the cactus to the lamppost? By looking at **Figure 9**, you can see that this displacement is 20 m to the right. Notice also, that the displacement from the cactus to the lamppost (Δx) equals the position at the lamppost (x_f) minus the position at the cactus (x_i). This is true in general; displacement equals final position minus initial position.

9	Describe the motion of an object if its velocity and acceleration are either in the same directions or opposite directions, hence state if an object is slowing down or speeding up	as mentioned in the book	61

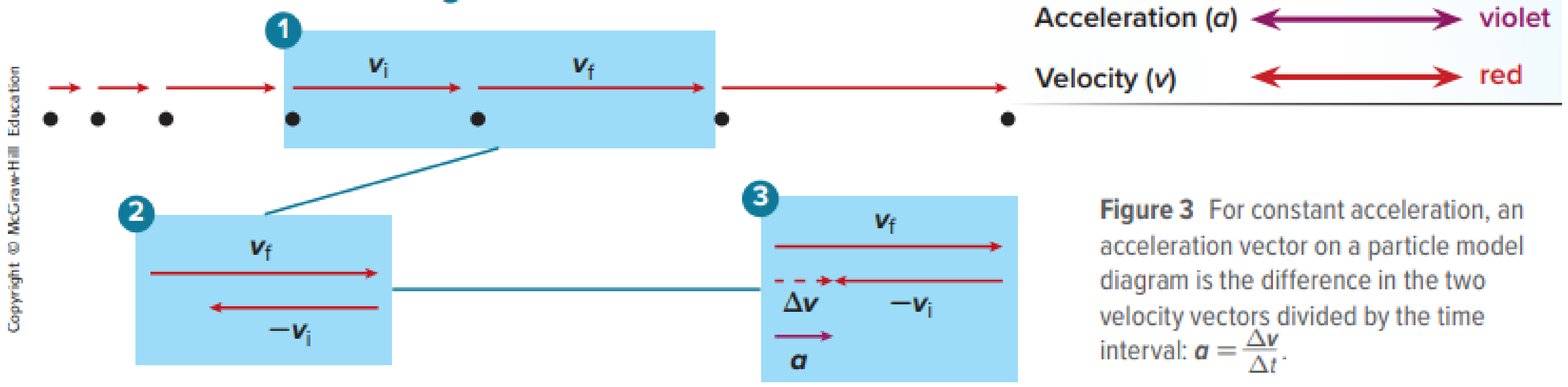
Displaying acceleration on a motion diagram For a motion diagram to give a full picture of an object's movement, it should contain information about the rate at which the object's velocity is changing. The rate at which an object's velocity changes is called the **acceleration** of the object. By including acceleration vectors on a motion diagram, you can indicate the rate of change for the velocity.

Figure 2 The change in length of the velocity vectors on these motion diagrams indicates whether the jogger is speeding up or slowing down.

Figure 3 shows a particle motion diagram for an object with increasing velocity. Notice that the lengths of the red velocity vectors get longer from left to right along the diagram. The figure also describes how to use the diagram to draw an acceleration vector for the motion. The acceleration vector that describes the increasing velocity is shown in violet on the diagram.

Notice in the figure that if the object's acceleration is constant, you can determine the length and direction of an acceleration vector by subtracting two consecutive velocity vectors and dividing by the time interval. That is, first find the change in velocity, $\Delta v = v_f - v_i = v_f + (-v_i)$, where v_i and v_f refer to the velocities at the beginning and the end of the chosen time interval. Then divide by the time interval (Δt). The time interval between each dot in **Figure 3** is 1 s. You can draw the acceleration vector from the tail of the final velocity vector to the tip of the initial velocity vector.

Finding Acceleration Vectors



First, draw $\mathbf{v}_f$. Below that, draw $\mathbf{v}_i$ with its tail aligned with the tip of $\mathbf{v}_f$.

Next, draw the vector $\Delta\mathbf{v}$ from the tail of $\mathbf{v}_f$ to the tip of $\mathbf{v}_i$. The acceleration vector $\mathbf{a}$ is the same as $\Delta\mathbf{v}$ divided by the time interval.

Figure 3 For constant acceleration, an acceleration vector on a particle model diagram is the difference in the two velocity vectors divided by the time interval: $\mathbf{a} = \frac{\Delta \mathbf{v}}{\Delta t}$.

Analyze *Can you draw an acceleration vector for two successive velocity vectors that are the same length and direction? Explain.*

10	Define and calculate the average acceleration	problem 12	67

12. **Position-Time and Velocity-Time Graphs** Two joggers run at a constant velocity of 7.5 m/s east. **Figure 10** shows the positions of both joggers at time $t = 0$.

a. What would be the difference(s) in the position-time graphs of their motion?

b. What would be the difference(s) in their velocity-time graphs?

Figure 10

a. What would be the difference(s) in the position-time graphs oftheir motion?

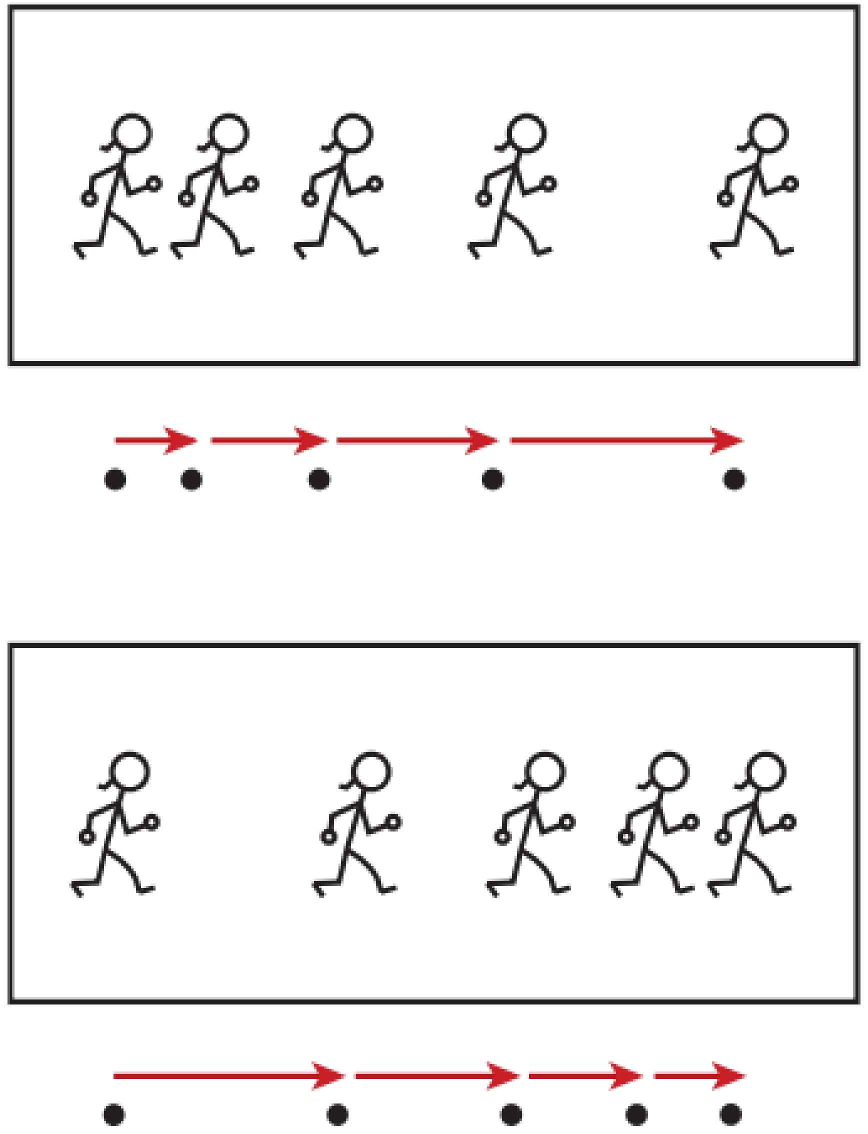
The difference(s) is that there are in different positions

b. What would be the difference(s) in their velocity-time graphs?

They started at the same time.

11	Recognize uniform or non-uniform motion from a motion diagram or a particle model	figure 11	15

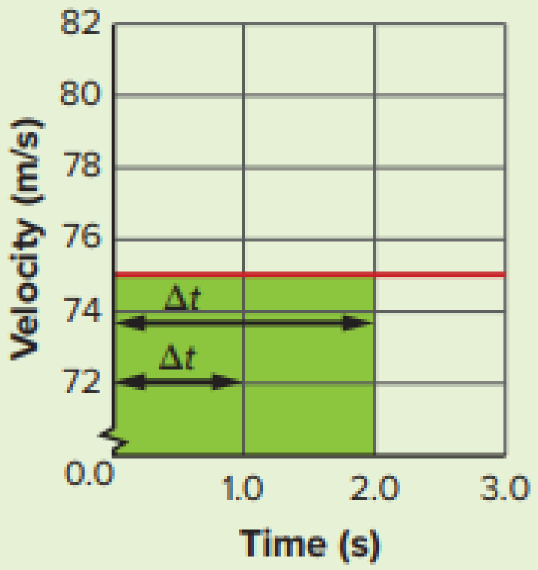
Particle model diagram What does a particle model motion diagram look like for an object with changing velocity? **Figure 2** shows particle model motion diagrams below the motion diagrams of the jogger when she is speeding up and slowing down. There are two major indicators of the change in velocity in this form of the motion diagram. The change in the spacing of the dots and the differences in the lengths of the velocity vectors indicate the changes in velocity. If an object speeds up, each subsequent velocity vector is longer, and the spacing between dots increases. If the object slows down, each vector is shorter than the previous one, and the spacing between dots decreases. Both types of motion diagrams indicate how an object's velocity is changing.



12	Calculate the displacement as the area under the curve of a velocity-time graph	problem 3	70

EXAMPLE Problem 3

FINDING DISPLACEMENT FROM A VELOCITY-TIME GRAPH The velocity-time graph at the right shows the motion of an airplane. Find the displacement of the airplane for $\Delta t = 1.0$ s and for $\Delta t = 2.0$ s. Let the positive direction be forward.



1 ANALYZE AND SKETCH THE PROBLEM

- The displacement is the area under the *v-t* graph.
- The time intervals begin at $t = 0.0$ s.

KNOWN	UNKNOWN
$v = +75$ m/s	$\Delta x = ?$
$\Delta t = 1.0$ s	
$\Delta t = 2.0$ s	

2 SOLVE FOR THE UNKNOWN

Use the relationship among displacement, velocity, and time interval to find Δx during $\Delta t = 1.0$ s.

$\Delta x = v\Delta t$

$= (+75 \text{ m/s})(1.0 \text{ s})$ — Substitute $v = +75$ m/s, $\Delta t = 1.0$ s.

$= +75$ m

Use the same relationship to find Δx during $\Delta t = 2.0$ s.

$\Delta x = v\Delta t$

$= (+75 \text{ m/s})(2.0 \text{ s})$ — Substitute $v = +75$ m/s, $\Delta t = 2.0$ s.

$= +150$ m

3 EVALUATE THE ANSWER

- **Are the units correct?** Displacement is measured in meters.
- **Do the signs make sense?** The positive sign agrees with the graph.
- **Is the magnitude realistic?** Moving a distance of about one football field per second is reasonable for an airplane.

13	Classify physical quantities into vector and scalar quantities (distance, mass, displacement, speed, velocity, acceleration, force, work, energy, pressure)	as mentioned in the book	38

Scalar	vector
Distance	Displacement
Mass	Velocity
speed	Acceleration
Pressure	Force
Work-energy	

14	Interpret the velocity-time graph for a single or multiple objects in motion	figure 6	63

Get It?

Identify What can you conclude about the acceleration of an object if the graph of its motion is a straight line on a velocity-time graph?

The graph shows that the slope is 5.00 (m/s)/s, which is often written as 5.00 m/s^2. Consider the time interval between 4.00 s and 5.00 s. At 4.00 s, the car's velocity was 20.0 m/s in the positive direction. At 5.00 s, the car was traveling at 25.0 m/s in the same direction. Thus, in 1.00 s, the car's velocity increased by 5.0 m/s in the positive direction. When the velocity of an object changes at a constant rate, it has a constant acceleration.

Reading velocity-time graphs The motions of five runners are shown in **Figure 6.** Assume that the positive direction is east. The slopes of Graphs A and E are zero. Thus, the accelerations are zero. Both graphs show motion at a constant velocity—Graph A to the east and Graph E to the west. Graph B shows motion with a positive velocity eastward. Its slope indicates a constant, positive acceleration. You can infer that the speed increases because velocity and acceleration are positive. Graph C has a negative slope. It shows motion that begins with a positive velocity, slows down, and then stops. This means the acceleration and the velocity are in opposite directions. The point at which Graphs C and B cross shows that the runners' velocities are equal at that time. It does not, however, identify their positions.

using any two points on the line.

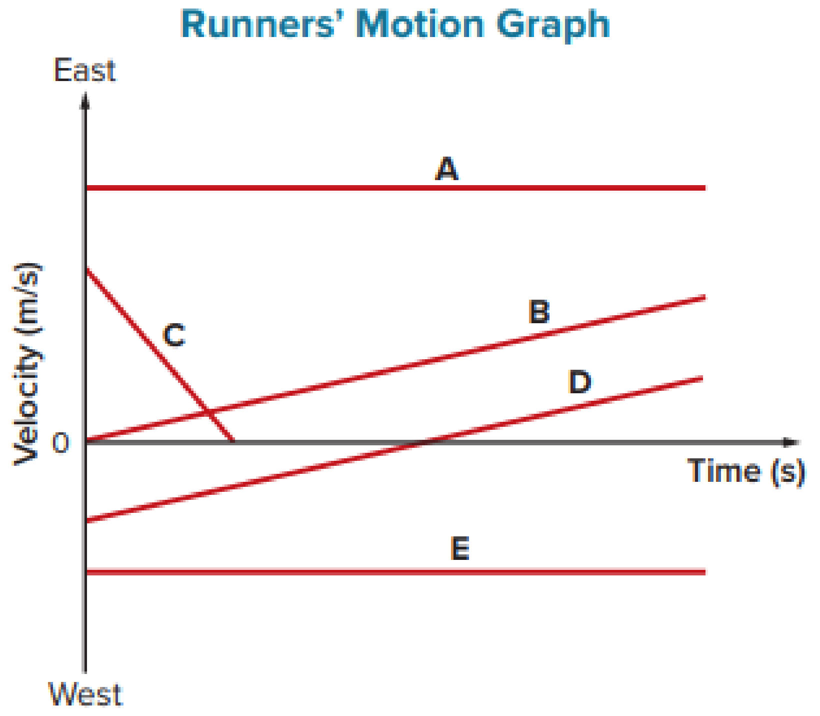


Figure 6 Because east is chosen as the positive direction on the graph, velocity is positive if the line is above the horizontal axis and negative if the line is below it. Acceleration is positive if the line is slanted upward on the graph. Acceleration is negative if the line is slanted downward on the graph. A horizontal line indicates constant velocity and zero acceleration.

تعليم

15	Define displacement as the change in an object's position Define average velocity and average acceleration	as mentioned in the book	37 47, 64

You can use the symbol x to represent position vectors mathematically. In **Figure 9**, the symbol x_i represents the position at the cactus, and the symbol x_f represents the position at the lamppost. The symbol Δx represents the change in position from the cactus to the lamppost. Because a change in position is described and analyzed so often in physics, it has a special name. In physics, a change in position is called a **displacement.** Because displacement has both magnitude and direction, it is a vector.

red and blue joggers. **Average velocity** is the ratio of an object's change in position to the time interval during which the change occurred. If the object is in uniform motion, so that its speed does not change, then its average velocity is the slope of its position-time graph.

The **average acceleration** of an object is its change in velocity during some measurable time interval divided by that time interval. Average acceleration is measured in meters per second per

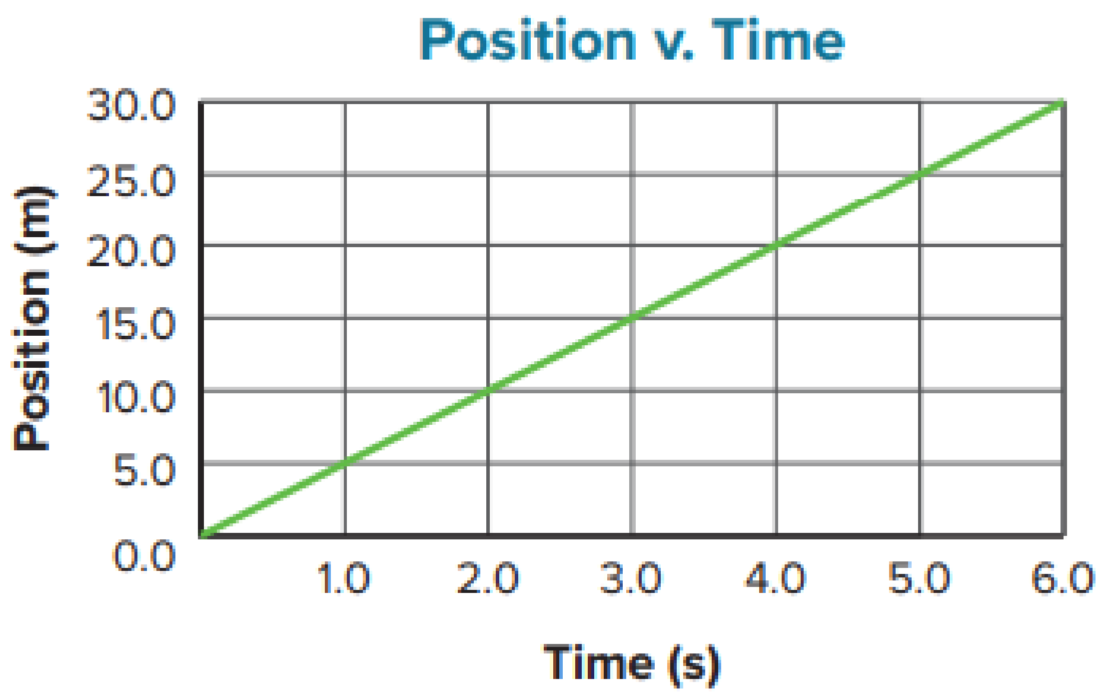
16	Plot a position-time graph given position-time values.	table 1 and figure 11	41

Estimating time and position Notice that the graph is not a picture of the runner's path—the graphed line is sloped, but the runner's path was horizontal. Instead, the line represents the most likely positions of the runner at the times between the recorded data points. Even though there is no data point exactly when the runner was 12.0 m beyond her starting point or where she was at t = 4.5 s, you can use the graph to estimate the time or her position. The example problem on the next page shows how.

Instantaneous position How long did the runner spend at any location? Each position has been linked to a time, but how long did that time last? You could say "an instant," but how long is that? If an instant lasts for any finite amount of time, then the runner would have stayed at the same position during that time, and she would not have been moving. An instant is not a finite period of time, however. It lasts zero seconds. The symbol x represents the runner's **instantaneous position**—the position at a particular instant. Instantaneous position is usually simply called position.

Table 1 Position v. Time

Time (s)	Position (m)
0.0	0.0
1.0	5.0
2.0	10.0
3.0	15.0
4.0	20.0
5.0	25.0



17	Represent data in graphical form, draw the best fit line, and identify from the shape of the graph if the relationship between the variables is linear, quadratic or inverse Find the slope from the graph of a linear relationship	as mentioned in the book	20-22

Linear Relationship Between Two Variables

$$y = mx + b$$

Quadratic Relationship Between Two Variables

$$y = ax^2 + bx + c$$

Slope

The slope of a line is equal to the rise divided by the run, which also can be expressed as the vertical change divided by the horizontal change.

$$m = \frac{rise}{run} = \frac{\Delta y}{\Delta x}$$

In **Figure 16:** $m = \frac{(16.0\ \text{cm} - 14.1\ \text{cm})}{(30\ \text{g} - 5\ \text{g})} = 0.08\ \text{cm/g}$

Δy

Inverse Relationship Between Two Variables

$$y = \frac{a}{x}$$

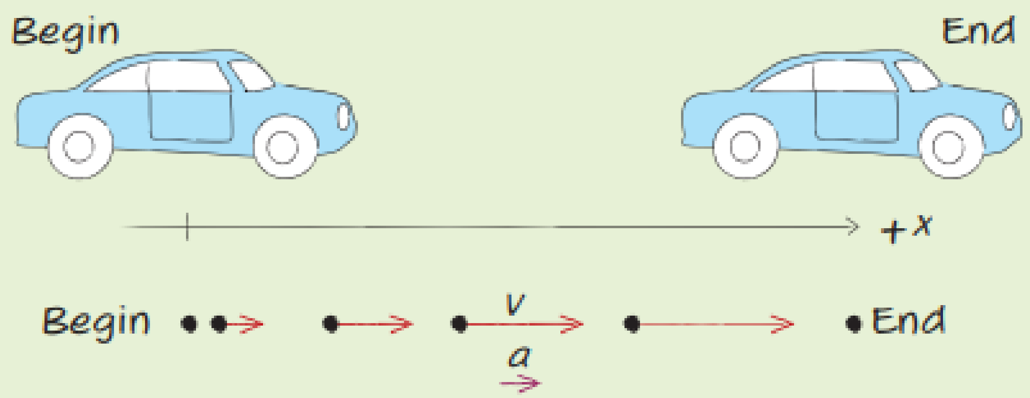
18	A. Apply the equation of motion relating the final position of an object to its initial position, initial velocity, uniform acceleration, and time	example 4	72

EXAMPLE Problem 4

DISPLACEMENT An automobile starts at rest and accelerates at 3.5 m/s² after a traffic light turns green. How far will it have gone when it is traveling at 25 m/s?

1 ANALYZE AND SKETCH THE PROBLEM

- Sketch the situation.
- Establish coordinate axes. Let the positive direction be to the right.
- Draw a motion diagram.



KNOWN	UNKNOWN
$x_i = 0.00$ m	$x_f = ?$
$v_i = 0.00$ m/s	
$v_f = +25$ m/s	
$\bar{a} = a = +3.5$ m/s²	

2 SOLVE FOR THE UNKNOWN

Use the relationship among velocity, acceleration, and displacement to find x_f.

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

$$x_f = x_i + \frac{v_f^2 - v_i^2}{2a}$$

$$= 0.00\text{ m} + \frac{(+25\text{ m/s})^2 - (0.00\text{ m/s})^2}{2(+3.5\text{ m/s}^2)}$$

Substitute $x_i = 0.00$ m, $v_f = +25$ m/s, $v_i = 0.00$ m/s, $a = +3.5$ m/s².

$$= +89\text{ m}$$

3 EVALUATE THE ANSWER

- **Are the units correct?** Position is measured in meters.
- **Do the signs make sense?** The positive sign agrees with both the pictorial and physical models.
- **Is the magnitude realistic?** The displacement is almost the length of a football field. The result is reasonable because 25 m/s (about 55 mph) is fast.

تعليم

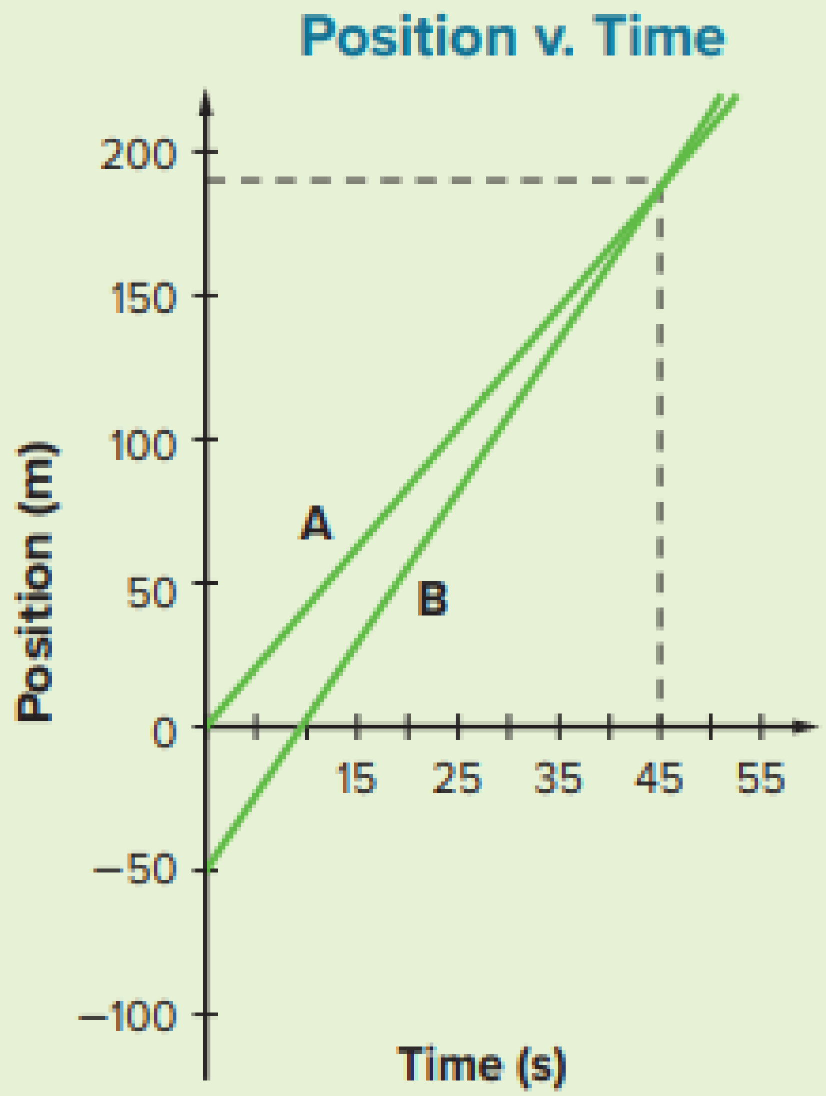
19	Define and identify independent and dependent variables for a given data set	as mentioned in the book	18

Independent and dependent variables A variable is any factor that might affect the behavior of an experimental setup. The factor that is manipulated during an investigation is the **independent variable.** In the experiment that gave the data in **Table 3,** the mass was the independent variable. The factor that depends on the independent variable is the **dependent variable.** In this investigation, the amount the spring stretched depended on the mass, so the amount of stretch was the dependent variable.

20	Interpret a position-time graph that represents the motion of a single object Interpret a position-time graph that represents the motion of multiple objects	example problem 2	44

EXAMPLE Problem 2

INTERPRETING A GRAPH The graph to the right describes the motion of two runners moving along a straight path. The lines representing their motion are labeled A and B. When and where does runner B pass runner A?



1 ANALYZE THE PROBLEM

Restate the questions.

Question 1: At what time are runner A and runner B at the same position?

Question 2: What is the position of runner A and runner B at this time?

2 SOLVE FOR THE UNKNOWN

Question 1

Examine the graph to find the intersection of the line representing the motion of runner A with the line representing the motion of runner B. These lines intersect at time 45 s.

Question 2

Examine the graph to determine the position when the lines representing the motion of the runners intersect. The position of both runners is about 190 m from the origin.

Runner B passes runner A about 190 m beyond the origin, 45 s after A has passed the origin.