Q1W3-Qs. Bank-Ch.3- Two-D Motion and Vectors

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 1. Which of the following is a physical quantity that has a magnitude but no direction?
a. vector
b. scalar
c. resultant
d. frame of reference

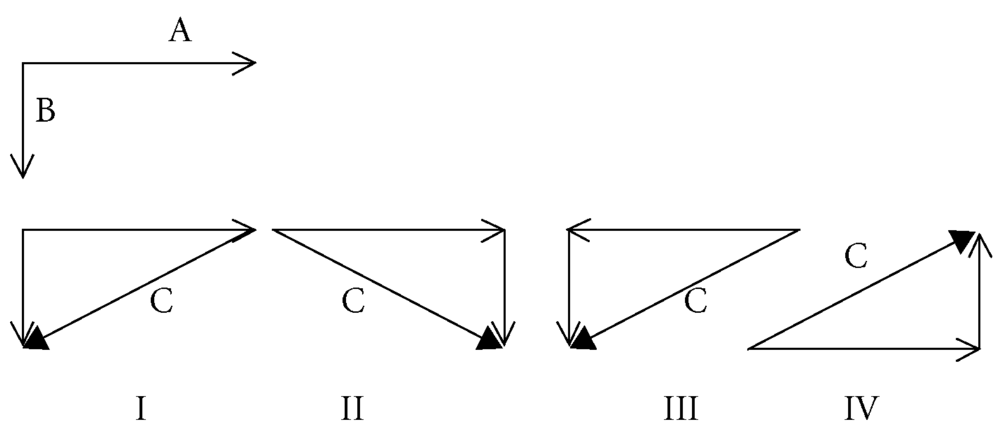
____ 2. Which of the following is a physical quantity that has both magnitude and direction?
a. vector
b. scalar
c. resultant
d. frame of reference

____ 3. Which of the following is an example of a vector quantity?
a. velocity
b. temperature
c. volume
d. mass

____ 4. The written abbreviation, $\vec{a}$, represents a quantity that has which of the following abbreviations in the text?
a. a
b. *a*
c. **a**
d. ***a***

____ 5. Identify the following quantities as scalar or vector: the mass of an object, the number of leaves on a tree, wind velocity.
a. vector, scalar, scalar
b. scalar, scalar, vector
c. scalar, vector, scalar
d. vector, scalar, vector

____ 6. Identify the following quantities as scalar or vector: the speed of a snail, the time it takes to run a mile, the free-fall acceleration.
a. vector, scalar, scalar
b. scalar, scalar, vector
c. vector, scalar, vector
d. scalar, vector, vector



____ 7. In the figure above, which diagram represents the vector addition **C** = **A** + **B**?
a. I
b. II
c. III
d. IV

____ 8. In the figure above, which diagram represents the vector subtraction **C** = **A**–**B**?
a. I
b. II
c. III
d. IV

____ 9. For the winter, a duck flies 10.0 m/s due south against a gust of wind with a speed of 2.5 m/s. What is the resultant velocity of the duck?

a. 12.5 m/s south
b. –12.5 m/s south
c. 7.5 m/s south
d. –7.5 m/s south

____ 10. Multiplying or dividing vectors by scalars results in
a. vectors.
b. scalars.
c. vectors if multiplied or scalars if divided.
d. scalars if multiplied or vectors if divided.

____ 11. A car travels down a road at a certain velocity, $\mathbf{v}_{car}$. The driver slows down so that the car is traveling only half as fast as before. Which of the following is the correct expression for the resulting velocity?
a. $2\mathbf{v}_{car}$
b. $\frac{1}{2}\mathbf{v}_{car}$
c. $-\frac{1}{2}\mathbf{v}_{car}$
d. $-2\mathbf{v}_{car}$

____ 12. A football player runs in one direction to catch a pass, then turns and runs twice as fast in the opposite direction toward the goal line. Which of the following is a correct expression for the original velocity and the resulting velocity?
a. $-\mathbf{v}_{player}$, $-2\mathbf{v}_{player}$
b. $\mathbf{v}_{player}$, $2\mathbf{v}_{player}$
c. $\mathbf{v}_{player}$, $-2\mathbf{v}_{player}$
d. $2\mathbf{v}_{player}$, $-\mathbf{v}_{player}$

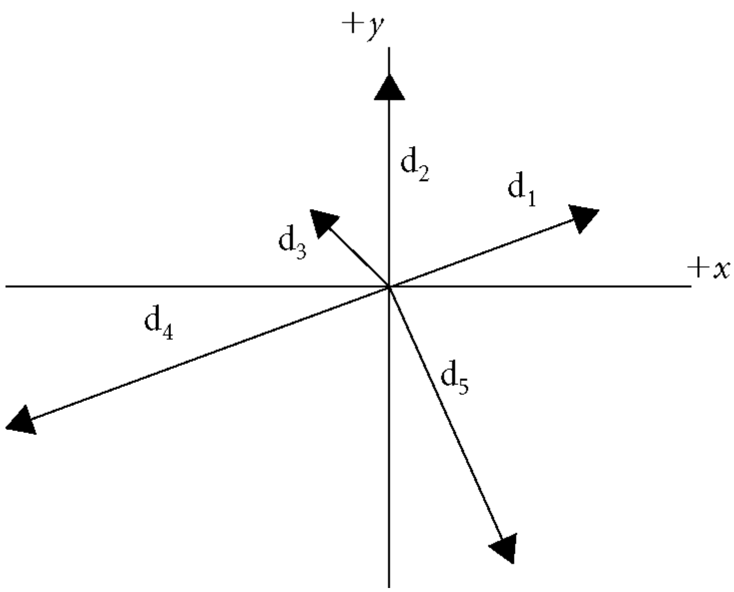
____ 13. A student walks from the door of the house to the end of the driveway and realizes that he missed the bus. The student runs back to the house, traveling three times as fast. Which of the following is the correct expression for the return velocity if the initial velocity is $\mathbf{v}_{student}$?
a. $3\mathbf{v}_{student}$
b. $\frac{1}{3}\mathbf{v}_{student}$
c. $\frac{1}{3}\mathbf{v}_{student}$
d. $-3\mathbf{v}_{student}$

____ 14. Which of the following is the best coordinate system to analyze a painter climbing a ladder at an angle of 60° to the ground?
a. *x*-axis: horizontal along the ground; *y*-axis: along the ladder
b. *x*-axis: along the ladder; *y*-axis: horizontal along the ground
c. *x*-axis: horizontal along the ground; *y*-axis: up and down
d. *x*-axis: along the ladder; *y*-axis: up and down

____ 15. An ant on a picnic table travels 3.0×10^1 cm eastward, then 25 cm northward, and finally 15 cm westward. What is the magnitude of the ant's displacement relative to its original position?
a. 70 cm
b. 57 cm
c. 52 cm
d. 29 cm

____ 16. In a coordinate system, a vector is oriented at angle θ with respect to the *x*-axis. The *x* component of the vector equals the vector's magnitude multiplied by which trigonometric function?
a. cos θ
b. cot θ
c. sin θ
d. tan θ

____ 17. In a coordinate system, a vector is oriented at angle θ with respect to the *x*-axis. The *y* component of the vector equals the vector's magnitude multiplied by which trigonometric function?
a. cos θ
b. cot θ
c. sin θ
d. tan θ



____ 18. How many displacement vectors shown in the figure above have horizontal components?
a. 2
b. 3
c. 4
d. 5

____ 19. How many displacement vectors shown in the figure above have components that lie along the *y*-axis and are pointed in the –*y* direction?
a. 0
b. 2
c. 3
d. 5

____ 20. Which displacement vectors shown in the figure above have vertical components that are equal?
a. $\mathbf{d_1}$ and $\mathbf{d_2}$
b. $\mathbf{d_1}$ and $\mathbf{d_3}$
c. $\mathbf{d_2}$ and $\mathbf{d_5}$
d. $\mathbf{d_4}$ and $\mathbf{d_5}$

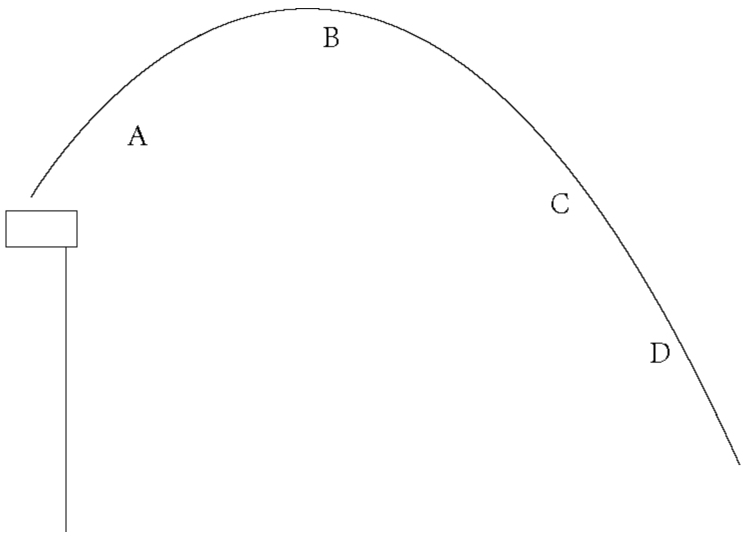
____ 21. In a coordinate system, the magnitude of the *x* component of a vector and θ, the angle between the vector and *x*-axis, are known. The magnitude of the vector equals the *x* component
a. divided by the cosine of θ.
b. divided by the sine of θ.
c. multiplied by the cosine of θ.
d. multiplied by the sine of θ.

____ 22. Find the resultant of these two vectors: 2.00×10^2 units due east and 4.00×10^2 units 30.0° north of west.
a. 300 units, 29.8° north of west
b. 581 units, 20.1° north of east
c. 546 units, 59.3° north of west
d. 248 units, 53.9° north of west

____ 23. Which of the following is *not* an example of projectile motion?
a. a volleyball served over a net
b. a baseball hit by a bat
c. a hot-air balloon drifting toward Earth
d. a long jumper in action

____ 24. What is the path of a projectile (in the absence of friction)?
a. a wavy line
b. a parabola
c. a hyperbola
d. Projectiles do not follow a predictable path.

____ 25. Which of the following does *not* exhibit parabolic motion?
a. a frog jumping from land into water
b. a basketball thrown to a hoop
c. a flat piece of paper released from a window
d. a baseball thrown to home plate



The figure above shows the path of a ball tossed from a building. Air resistance is ignored.

____ 26. At what point of the ball's path shown in the figure above is the vertical component of the ball's velocity zero?
a. A
b. B
c. C
d. D

____ 27. In the figure above, the magnitude of the ball's velocity is least at location
a. A.
b. B.
c. C.
d. D.

____ 28. In the figure above, the magnitude of the ball's velocity is greatest at location
a. A.
b. B.
c. C.
d. D.

____ 29. In the figure above, the horizontal component of the ball's velocity at A is
a. zero.
b. equal to the vertical component of the ball's velocity at C.
c. equal in magnitude but opposite in direction to the horizontal component of the ball's velocity at D.
d. equal to the horizontal component of its initial velocity.

____ 30. In the figure above, at which point is the ball's speed about equal to the speed at which it was tossed?
a. A
b. B
c. C
d. D

____ 31. A track star in the long jump goes into the jump at 12 m/s and launches herself at 20.0° above the horizontal. What is the magnitude of her horizontal displacement? (Assume no air resistance and that $a_y = -g = -9.81$ m/s^2.)
a. 4.6 m
b. 9.2 m
c. 13 m
d. 15 m

____ 32. Which of the following is a coordinate system for specifying the precise location of objects in space?
a. *x*-axis
b. *y*-axis
c. frame of reference
d. diagram

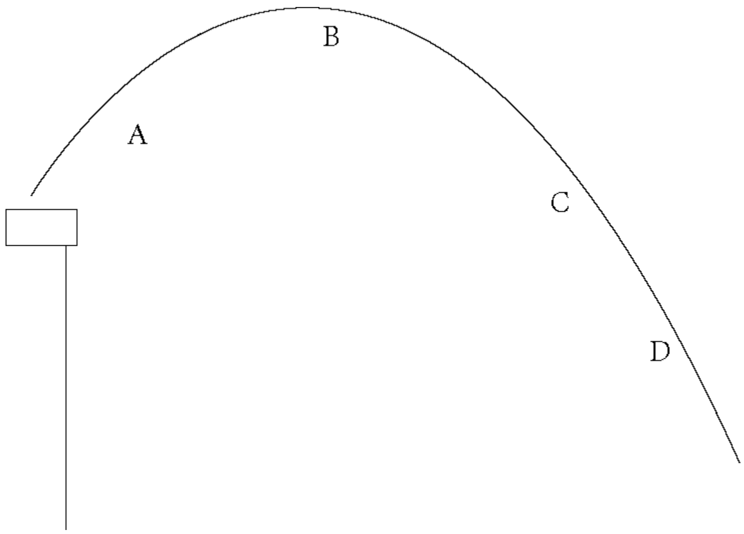
____ 33. A passenger on a bus moving east sees a man standing on a curb. From the passenger's perspective, the man appears to
a. stand still.
b. move west at a speed that is less than the bus's speed.
c. move west at a speed that is equal to the bus's speed.
d. move east at a speed that is equal to the bus's speed.

____ 34. A piece of chalk is dropped by a teacher walking at a speed of 1.5 m/s. From the teacher's perspective, the chalk appears to fall
a. straight down.
b. straight down and backward.
c. straight down and forward.
d. straight backward.

____ 35. A jet moving at 500.0 km/h due east is in a region where the wind is moving at 120.0 km/h in a direction 30.00° north of east. What is the speed of the aircraft relative to the ground?
a. 620.2 km/h
b. 606.9 km/h
c. 588.7 km/h
d. 511.3 km/h

Short Answer

1. Which is a scalar quantity, instantaneous velocity or average speed?
2. What is a vector quantity?
3. The length of a vector arrow in a diagram is proportional to what property of the vector?
4. The displacement, –2.0 m north, represents a positive displacement in which direction?
5. Briefly explain the triangle (or polygon) method of addition.
6. Is the quantity $\mathbf{v_i}\Delta t$ a scalar quantity or vector quantity?
7. Is the quantity $\frac{\Delta \mathbf{v}}{\Delta t}$ a scalar quantity or vector quantity?
8. The equation $d = \sqrt{\Delta x^2 + \Delta y^2}$ is valid only if Δx and Δy are magnitudes of vectors that have what orientation with respect to each other?
9. A baby toddles 3 m west and 2 m south. If $\theta = \tan^{-1}\left(\frac{2}{3}\right)$, the baby's resultant displacement will be oriented counterclockwise at angle θ from which axis? Assume east and north lie along the $+x$-axis and $+y$-axis, respectively.
10. Breaking a vector into two components is given what term?
11. The component A_x of a vector **A** lies along what axis?
12. If the magnitude of a vector component equals the magnitude of the vector, then what is the magnitude of the other vector component?
13. If the magnitude of a vector component is the magnitude of the vector, what is the orientation of the vector with respect to that axis?
14. If the magnitude of a vector component is zero, what is the orientation of the vector with respect to that axis?
15. How can you use the Pythagorean theorem to add two vectors that are not perpendicular?



The figure above shows the path of a ball tossed from a building. Air resistance is ignored.

16. In the figure above, what would happen to the width of the ball's path if it were launched with a greater velocity?

17. Describe the graph of the vertical component of velocity versus time for the motion of the ball shown in the figure above. Identify any constants that would appear in the graph.

18. Briefly explain why the true path of a projectile traveling through Earth's atmosphere is not a parabola.

A crew member is walking on a tugboat that is pulling a barge. The tugboat is moving at a constant speed upstream in a river that has a constant downstream current.

19. In the situation above, a dockhand measures the magnitude and direction of the velocity of the tugboat's crew member as $+\mathbf{v_c}$ relative to the dockhand. In terms of $\mathbf{v_c}$, what is the magnitude and direction of the velocity of the dockhand relative to the crew member?

20. An observer accurately measures the constant velocity of a car from her frame of reference. Another observer measures the constant velocity of the car from his frame of reference. If the two frames of reference are at rest with respect to each other, how will the velocity measurements compare?

Problem

1. A lightning bug flies at a velocity of 0.15 m/s due east toward another lightning bug seen off in the distance. A light easterly breeze blows on the bug at a velocity of 0.15 m/s. What is the resultant velocity of the lightning bug?

2. A jogger runs 7.0 blocks due east, 9.0 blocks due south, and another 5.0 blocks due east. Assume all blocks are of equal size. Use the graphical method to find the magnitude of the jogger's net displacement.

3. An airplane flying at 180 km/h due west moves into a region where the wind is blowing at 60 km/h due east. If the plane's original vector velocity is $\mathbf{v_{plane}}$, what is the expression for the plane's resulting velocity in terms of $\mathbf{v_{plane}}$?

4. A dog walks 17 steps north and then walks 51 steps west to bury a bone. If the dog walks back to the starting point in a straight line, how many steps will the dog take? Use the graphical method to find the magnitude of the net displacement.

5. A duck waddles 2.3 m east and 7.0 m north. What are the magnitude and direction of the duck's displacement with respect to its original position?

6. A plane flies from city A to city B. City B is 1650 km west and 1170 km south of city A. What is the total displacement of the plane?

7. While following directions on a treasure map, a person walks 66.0 m south, then turns and walks 7.60 m east. Which single straight-line displacement could the person have walked to reach the same spot?

8. A string attached to an airborne kite was maintained at an angle of 65.0° with the ground. If 170 m of string was reeled in to return the kite back to the ground, what was the horizontal displacement of the kite? (Assume the kite string did not sag.)

9. A skateboarder rolls 41.0 m down a hill that descends at an angle of 12.0° with the horizontal. Find the horizontal and vertical components of the skateboarder's displacement.

10. Vector **A** is 4.8 m in length and points along the positive *y*-axis. Vector **B** is 4.9 m in length and points along a direction 205° counterclockwise from the positive *x*-axis. What is the magnitude of the resultant when vectors **A** and **B** are added?

11. What is the magnitude of the resultant displacement of a dog looking for its bone in the yard if the dog first heads 57.0° north of west for 10.3 m and then turns and heads west for 4.00 m?

12. A hiker walks 3.3 km at an angle of 45.0° north of west. Then the hiker walks 3.4 km south. What is the magnitude of the hiker's total displacement?

13. A cow ambles through a break in the barnyard fence and wanders 34 m at 60.1° north of east, and then 21 m east. If the cow's wanderings last 3.4 minutes, what is the cow's average velocity?

14. A stone is thrown at an angle of 30.0° above the horizontal from the top edge of a cliff with an initial speed of 15 m/s. A stopwatch measures the stone's trajectory time from the top of the cliff to the bottom at 6.30 s. What is the height of the cliff? (Assume no air resistance and that $a_y = -g = -9.81\ m/s^2$.)

15. A model rocket flies horizontally off the edge of a cliff at a velocity of 70.0 m/s. If the canyon below is 110.0 m deep, how far from the edge of the cliff does the model rocket land? ($a_y = -g = -9.81\ m/s^2$)

16. A fox sees a piece of carrion being thrown from a hawk's nest and rushes to snatch it. The nest is 14.0 m high, and the carrion is thrown with a horizontal velocity of 1.3 m/s. The fox is 8.0 m from the base of the tree. What is the magnitude of the fox's average velocity if it grabs the carrion in its mouth just as it touches the ground? (Assume no air resistance and that $a_y = -g = -9.81\ m/s^2$.)

17. A pebble falls vertically from the edge of a cliff 29 m high. After falling 1.1 s, the pebble glances off a small rock protruding from the face of the cliff. The impact with the ledge has negligible effect on the pebble's vertical motion. However, the pebble is deflected perpendicular to the face of the cliff with a horizontal velocity of 5 cm/s. How far from the base of the cliff does the pebble land? (Assume there is no air resistance and that $a_y = -g = -9.81\ m/s^2$.)

18. A cat pushes a ball from a 20.00 m high window, giving it a horizontal velocity of 0.15 m/s. As it falls, the ball is deflected from the edge of a 5.00 m high downspout. The impact with the downspout has little effect on the ball's vertical motion. However, the ball's horizontal velocity increases by 0.040 m/s. How far from the base of the building does the ball land? (Assume no air resistance and that $a_y = -g = -9.81$ m/s^2.)

19. Experiencing a constant horizontal 1.10 m/s wind, a hot-air balloon ascends from the launch site at a constant vertical speed of 2.70 m/s. At a height of 202 m, the balloonist maintains constant altitude for 10.3 s before releasing a small sandbag. How far from the launch site does the sandbag land?

20. A juggler is strolling along a moving walkway while tossing a ball vertically upward to a height of 3.60 m. The juggler strolls at a constant velocity of +1.20 m/s with respect to the walkway, which moves at a constant velocity of +0.50 m/s with respect to the ground. An observer on the ground passes the juggler and notices that the path of the ball is a parabola with a maximum width of +1.80 m. What is the velocity of the observer with respect to the ground? (Assume no air resistance and that $a_y = -g = -9.81$ m/s^2.)

Q1W3-Qs. Bank-Ch.3- Two-D Motion and Vectors
Answer Section

MULTIPLE CHOICE

1. ANS: B PTS: 1 DIF: I OBJ: 3-1.1
2. ANS: A PTS: 1 DIF: I OBJ: 3-1.1
3. ANS: A PTS: 1 DIF: I OBJ: 3-1.1
4. ANS: C PTS: 1 DIF: I OBJ: 3-1.1
5. ANS: B PTS: 1 DIF: II OBJ: 3-1.1
6. ANS: B PTS: 1 DIF: II OBJ: 3-1.1
7. ANS: B PTS: 1 DIF: I OBJ: 3-1.2
8. ANS: D PTS: 1 DIF: I OBJ: 3-1.2
9. ANS: C

   Given
   $\mathbf{v}_1$ = 10.0 m/s south
   $\mathbf{v}_2$ = 2.5 m/s north

   Solution
   $v_R = v_1 - v_2 = 10.0 \text{ m/s} - 2.5 \text{ m/s} = 7.5 \text{ m/s}$
   $\mathbf{v}_\mathbf{R}$ = 7.5 m/s south

   PTS: 1 DIF: IIIA OBJ: 3-1.2
10. ANS: A PTS: 1 DIF: I OBJ: 3-1.3
11. ANS: B PTS: 1 DIF: II OBJ: 3-1.3
12. ANS: C PTS: 1 DIF: II OBJ: 3-1.3
13. ANS: D PTS: 1 DIF: II OBJ: 3-1.3
14. ANS: C PTS: 1 DIF: I OBJ: 3-2.1
15. ANS: D

   Given
   $\Delta x_1 = 3.0 \times 10^1$ cm
   Δy_1 = 25 cm
   Δx_2 = –15 cm

   Solution
   $$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = (3.0 \times 10^1 \text{ cm}) + (-15 \text{ cm}) = 15 \text{ cm}$$
   $$\Delta y_{tot} = \Delta y_1 = 25 \text{ cm}$$
   $$d^2 = (\Delta x_{tot})^2 + (\Delta y_{tot})^2$$
   $$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(15 \text{ cm})^2 + (25 \text{ cm})^2}$$
   $$d = 29 \text{ cm}$$

   PTS: 1 DIF: IIIA OBJ: 3-2.2

16.	ANS: A	PTS: 1	DIF: I	OBJ: 3-2.3
17.	ANS: C	PTS: 1	DIF: I	OBJ: 3-2.3
18.	ANS: C	PTS: 1	DIF: I	OBJ: 3-2.3
19.	ANS: B	PTS: 1	DIF: I	OBJ: 3-2.3
20.	ANS: B	PTS: 1	DIF: I	OBJ: 3-2.3
21.	ANS: A	PTS: 1	DIF: II	OBJ: 3-2.3

22. ANS: D

Given

$\mathbf{d_1}$ = 2.00 × 10^2 units east

$\mathbf{d_2}$ = 4.00 × 10^2 units 30.0° north of west

Solution

Measuring direction with respect to *x* = (east),

$$\Delta x_1 = 2.00 \times 10^2 \text{ units}$$

$$\Delta y_1 = 0$$

$$\Delta x_2 = d_2 \cos\theta = (4.00 \times 10^2 \text{ units})(\cos 150.0°) = -3.46 \times 10^2 \text{ units}$$

$$\Delta y_2 = d_2 \sin\theta = (4.00 \times 10^2 \text{ units})(\sin 150.0°) = 2.00 \times 10^2 \text{ units}$$

$$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = (2.00 \times 10^2 \text{ units}) + (-3.46 \times 10^2 \text{ units}) = -1.46 \times 10^2 \text{ units}$$

$$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 0 + (2.00 \times 10^2 \text{ units}) = 2.00 \times 10^2 \text{ units}$$

$$d^2 = (\Delta x_{tot})^2 + (\Delta y_{tot})^2$$

$$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(-1.46 \times 10^2 \text{ units})^2 + (2.00 \times 10^2 \text{ units})^2}$$

$$d = 2.48 \times 10^2 \text{ units}$$

$$\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right) = \tan^{-1}\left(\frac{2.00 \times 10^2 \text{ units}}{-1.46 \times 10^2 \text{units}}\right) = -53.9°$$

$\mathbf{d} = 2.48 \times 10^2$ units, 53.9°north of west

	PTS: 1	DIF: IIIB	OBJ: 3-2.4	
23.	ANS: C	PTS: 1	DIF: I	OBJ: 3-3.1
24.	ANS: B	PTS: 1	DIF: I	OBJ: 3-3.2
25.	ANS: C	PTS: 1	DIF: I	OBJ: 3-3.2
26.	ANS: B	PTS: 1	DIF: I	OBJ: 3-3.2
27.	ANS: B	PTS: 1	DIF: II	OBJ: 3-3.2
28.	ANS: D	PTS: 1	DIF: II	OBJ: 3-3.2
29.	ANS: D	PTS: 1	DIF: II	OBJ: 3-3.2
30.	ANS: C	PTS: 1	DIF: II	OBJ: 3-3.2

31. ANS: B

Given

$\mathbf{v_i}$ = 12 m/s at 20.0° above the horizontal

Solution

$$v_x = v_{i,x} = v_i \cos\theta = (12\text{ m/s})(\cos 20.0°) = 11\text{ m/s}$$

$$v_{i,y} = v_i \sin\theta = (12\text{ m/s})(\sin 20.0°) = 4.1\text{ m/s}$$

$$\Delta y = 0 = v_{i,y}\Delta t + \tfrac{1}{2}a_y(\Delta t)^2$$

$$\Delta t = \frac{-2v_{i,y}}{a_y} = \frac{-2(4.1\text{ m/s})}{-9.81\text{ m/s}^2} = 0.84\text{ s}$$

$$\Delta x = v_x\Delta t = (11\text{ m/s})(0.84\text{ s}) = 9.2\text{ m}$$

PTS: 1 DIF: IIIC OBJ: 3-3.3

32. ANS: C PTS: 1 DIF: I OBJ: 3-4.1
33. ANS: C PTS: 1 DIF: I OBJ: 3-4.1
34. ANS: A PTS: 1 DIF: I OBJ: 3-4.1
35. ANS: B

Given
$\mathbf{v}_{pa}$ = velocity of plane relative to the air = 500.0 km/h east
$\mathbf{v}_{ag}$ = velocity of air relative to the ground = 120.0 km/h 30.00° north of east

Solution

$$v_{ag,x} = v_{ag}\cos\theta = (120.0\text{ km/h})(\cos 30.00°) = 103.9\text{ km/h}$$

$$v_{ag,y} = v_{ag}\sin\theta = (120.0\text{ km/h})(\sin 30.00°) = 60.00\text{ km/h}$$

$$v_{pg,x} = v_{pa} + v_{ag,x} = 500.0\text{ km/h} + 103.9\text{ km/h} = 603.9\text{ km/h}$$

$$v_{pg,y} = 60.00\text{ km/h}$$

$$v_{pg} = \sqrt{(v_{pg,x})^2 + (v_{pg,y})^2} = \sqrt{(603.9\text{ km/h})^2 + (60.00\text{ km/h})^2} = 606.9\text{ km/h}$$

PTS: 1 DIF: IIIB OBJ: 3-4.2

SHORT ANSWER

1. ANS:
Average speed is a scalar quantity.

PTS: 1 DIF: I OBJ: 3-1.1

2. ANS:
A vector quantity is a quantity that has magnitude and direction.

PTS: 1 DIF: I OBJ: 3-1.1

3. ANS:
The length of the vector arrow is proportional to the magnitude of the vector.

PTS: 1 DIF: I OBJ: 3-1.1

4. ANS:
The direction of the positive displacement is south.

PTS: 1 DIF: I OBJ: 3-1.2

5. ANS:
The triangle method of adding vectors requires that you align the vectors, tail to tip, by moving them parallel to their original orientations. The resultant vector is an arrow drawn from the tail of the first vector to the tip of the last vector.

PTS: 1 DIF: II OBJ: 3-1.2

6. ANS:
The quantity is a vector quantity.

PTS: 1 DIF: II OBJ: 3-1.3

7. ANS:
The quantity is a vector quantity.

PTS: 1 DIF: II OBJ: 3-1.3

8. ANS:
The vectors must be perpendicular to each other.

PTS: 1 DIF: I OBJ: 3-2.2

9. ANS:
The baby's resultant displacement will be oriented counterclockwise at angle θ from the $-x$-axis, which is west.

PTS: 1 DIF: II OBJ: 3-2.2

10. ANS:
resolving the vector

PTS: 1 DIF: I OBJ: 3-2.3

11. ANS:
the x-axis

PTS: 1 DIF: I OBJ: 3-2.3

12. ANS:
zero

PTS: 1 DIF: II OBJ: 3-2.3

13. ANS:
The vector is parallel to that axis.

PTS: 1 DIF: II OBJ: 3-2.3

14. ANS:
The vector is perpendicular to that axis.

PTS: 1 DIF: II OBJ: 3-2.3

15. ANS:
Resolve each vector into perpendicular components and add the components that lie along the same axis. The resultant vectors can be added by using the Pythagorean theorem because they are perpendicular.

PTS: 1 DIF: II OBJ: 3-2.4

16. ANS:
The width of the ball's path would increase.

PTS: 1 DIF: I OBJ: 3-3.2

17. ANS:
The graph of the vertical component of the velocity versus time is a straight line with a negative slope. The slope of the line is $-9.81\ m/s^2$, which is $-g$.

PTS: 1 DIF: II OBJ: 3-3.2

18. ANS:
With air resistance, a projectile slows down as it collides with air particles. Therefore, the true path of a projectile would not be a parabola.

PTS: 1 DIF: II OBJ: 3-3.2

19. ANS:
The magnitude and direction of the velocity of the dockhand relative to the crew member is $-\mathbf{v_c}$.

PTS: 1 DIF: I OBJ: 3-4.1

20. ANS:
The velocity measurements will be the same.

PTS: 1 DIF: I OBJ: 3-4.1

PROBLEM

1. ANS:
0.00 m/s

Given
$\mathbf{v}_1$ = 0.15 m/s east
$\mathbf{v}_2$ = 0.15 m/s west

Solution
$v_R = v_1 - v_2 = 0.15\ m/s - 0.15\ m/s = 0.00\ m/s$

PTS: 1 DIF: IIIA OBJ: 3-1.2

2. ANS:
15.0 blocks

Solution
Students should use graphical techniques. Their answers can be checked using the techniques presented in Section 2.

$$d = \sqrt{(12.0\ blocks)^2 + (9.0\ blocks)^2} = 15.0\ blocks$$

PTS: 1 DIF: IIIA OBJ: 3-1.2

3. ANS:

$\frac{2}{3}\mathbf{v_{plane}}$

Given
$\mathbf{v_{plane}}$ = 180 km/h west = –180 km/h
$\mathbf{v_{wind}}$ = 60 km/h east = +60 km/h

Solution
$v_R = v_{plane} + v_{wind} = -180\ \text{km/h} + (60\ \text{km/h}) = -120\ \text{km/h}$

$\frac{v_R}{v_{plane}} = \frac{-120\ \text{km/h}}{-180\ \text{km/h}} = \frac{2}{3}$

$\mathbf{v_R} = \frac{2}{3}\mathbf{v_{plane}}$

PTS: 1 DIF: IIIA OBJ: 3-1.3

4. ANS:
54 steps

Solution
Students should use graphical techniques. Their answers can be checked using the techniques presented in Section 2.

$d = \sqrt{(17\ \text{steps})^2 + (51\ \text{steps})^2}$

$d = \sqrt{290\ \text{steps}^2 + 2600\ \text{steps}^2}$

$d = \sqrt{2900\ \text{steps}^2}$

$d = 54\ \text{steps}$

PTS: 1 DIF: IIIA OBJ: 3-2.2

5. ANS:
7.3 m at 72° north of east

Given
$\mathbf{d_1}$ = 2.3 m east = +2.3 m
$\mathbf{d_2}$ = 7.0 m north = +7.0 m

Solution

$\Delta x = d_1 = 2.3 \text{ m}$

$\Delta y = d_2 = 7.0 \text{ m}$

$d^2 = \Delta x^2 + \Delta y^2$

$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(2.3 \text{ m})^2 + (7.0 \text{ m})^2}$

$d = \sqrt{5.3 \text{ m}^2 + 49 \text{ m}^2}$

$d = \sqrt{54 \text{ m}^2}$

$d = 7.3 \text{ m}$

$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{7.0 \text{ m}}{2.3 \text{ m}}\right) = 72°$

d = 7.3 m at 72° north of east

PTS: 1 DIF: IIIB OBJ: 3-2.2

6. ANS:
2020 km, 35.3° south of west

Given
$\mathbf{d_1}$ = 1650 km west = –1650 km
$\mathbf{d_2}$ = 1170 km south = –1170 km

Solution
$\Delta x = d_1 = -1650 \text{ km}$

$\Delta y = d_2 = -1170 \text{ km}$

$d^2 = \Delta x^2 + \Delta y^2$

$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(-1.65 \times 10^3 \text{ km})^2 + (-1.17 \times 10^3 \text{ km})^2}$

$d = \sqrt{2.72 \times 10^6 \text{ km}^2 + 1.37 \times 10^6 \text{ km}^2}$

$d = 2.02 \times 10^3 \text{ km} = 2020 \text{ km}$

$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{-1170 \text{ km}}{-1650 \text{ km}}\right) = 35.3°$

d = 2020 km at 35.3° south of west

PTS: 1 DIF: IIIB OBJ: 3-2.2

7. ANS:
66.5 m at 83.4° south of east

Given
$\mathbf{d_1}$ = 66.0 m south = –66.0 m
$\mathbf{d_2}$ = 7.60 m east = +7.60 m

Solution

$\Delta x = d_2 = 7.60 \text{ m}$

$\Delta y = d_1 = -66.0 \text{ m}$

$d^2 = \Delta x^2 + \Delta y^2$

$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(7.60 \text{ m})^2 + (-66.0 \text{ m})^2}$

$d = \sqrt{57.8 \text{ m}^2 + 4360 \text{ m}^2}$

$d = \sqrt{4420 \text{ m}^2}$

$d = 66.5 \text{ m}$

$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{-66.0 \text{ m}}{7.60 \text{ m}}\right) = -83.4°$

d = 66.5 m at 83.4° south of east

PTS: 1 DIF: IIIB OBJ: 3-2.2

8. ANS:
72 m

Given
$d = 170$ m, $\theta = 65.0°$

Solution

$d_x = d \cos \theta = (170 \text{ m})(\cos 65.0°)$

$d_x = (170 \text{ m})(0.423)$

$d_x = 72 \text{ m}$

PTS: 1 DIF: IIIA OBJ: 3-2.3

9. ANS:
$d_x = 40.1$ m, $d_y = -8.53$ m

Given
$d = 41.0$ m, $\theta = -12.0°$

Solution

$d_x = d\cos\theta = (41.0\text{ m})(\cos(-12.0°))$

$d_x = (41.0\text{ m})(0.978)$

$d_x = 40.1\text{ m}$

$d_y = d\sin\theta = (41.0\text{ m})(\sin(-12.0°))$

$d_y = (41.0\text{ m})(-0.208)$

$d_y = -8.53\text{ m}$

PTS: 1 DIF: IIIB OBJ: 3-2.3

10. ANS:
5.1 m

Given
$\mathbf{d_1}$ = 4.8 m along +*y*-axis
$\mathbf{d_2}$ = 4.9 m at 205° counterclockwise from +*x*-axis

$d_1 = 4.8\text{ m}$ $\theta_1 = 0.0°$
$d_2 = 4.9\text{ m}$ $\theta_2 = 205°$

Solution
$\Delta x_1 = 0.0\text{ m}$

$\Delta y_1 = 4.8\text{ m}$

$\Delta x_2 = d_2\cos\theta_2 = (4.9\text{ m})(\cos 205°)$

$\Delta x_2 = (4.9\text{ m})(-0.906\text{ m}) = -4.4\text{ m}$

$\Delta y_2 = d_2\sin\theta_2 = (4.9\text{ m})(\sin 205°)$

$\Delta y_2 = (4.9\text{ m})(-0.423\text{ m}) = -2.1\text{ m}$

$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = (0\text{ m}) + (-4.4\text{ m}) = -4.4\text{ m}$

$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = (4.8\text{ m}) + (-2.1\text{ m}) = 2.7\text{ m}$

$d^2 = (\Delta x_{tot})^2 + (\Delta y_{tot})^2$

$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2}$

$d = \sqrt{(-4.4\text{ m})^2 + (2.7\text{ m})^2}$

$d = \sqrt{19\text{ m}^2 + 7.3\text{ m}^2}$

$d = 5.1\text{ m}$

PTS: 1 DIF: IIIB OBJ: 3-2.4

11. ANS:
12.92 m

Given
d_1 = 10.3 m at 57.0° north of west
d_2 = 4.00 m west

$d_1 = 10.3$ m $\theta_1 = 57.0°$
$d_2 = 4.00$ m $\theta_2 = 0.0°$

Solution
$$\Delta x_1 = d_1 \cos\theta_1 = (10.3\text{ m})(\cos 57.0°)$$
$$\Delta x_1 = (10.3\text{ m})(0.545)$$
$$\Delta x_1 = 5.61\text{ m}$$
$$\Delta y_1 = d_1 \sin\theta_1 = (10.0\text{ m})(\sin 57.0°)$$
$$\Delta y_1 = (10.3\text{ m})(0.839)$$
$$\Delta y_1 = 8.64\text{ m}$$
$$\Delta x_2 = 4.00\text{ m}$$
$$\Delta y_2 = 0.00\text{ m}$$
$$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = -5.61\text{ m} + 4.00\text{ m} = 9.61\text{ m}$$
$$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 8.64\text{ m} + 0.00\text{ m} = 8.64\text{ m}$$
$$d^2 = (\Delta x_{tot})^2 + (\Delta y_{tot})^2$$
$$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(9.61\text{ m})^2 + (8.64\text{ m})^2}$$
$$d = \sqrt{92.4\text{ m}^2 + 74.6\text{ m}^2}$$
$$d = \sqrt{167\text{ m}^2}$$
$$d = 12.92\text{ m}$$

PTS: 1 DIF: IIIB OBJ: 3-2.4

12. ANS:
2.5 km

Given
$\mathbf{d_1}$ = 3.3 km at 45.0° north of west = 3.3 km at (180.0° – 45.0°) north of east
= 3.3 km at 135.0° north of east
$\mathbf{d_2}$ = 3.4 km south = –3.4 km

Solution

$\Delta x_1 = d_1 \cos\theta = (3.3\ \text{km})(\cos\ 135.0°)$

$\Delta x_1 = (3.3\ \text{km})(-0.707)$

$\Delta x_1 = -2.3\ \text{km}$

$\Delta y_1 = d_1 \sin\theta = (3.3\ \text{km})(\sin 135.0°)$

$\Delta y_1 = (3.3\ \text{km})(0.707)$

$\Delta y_1 = 2.3\ \text{km}$

$\Delta x_2 = 0.0\ \text{km}$

$\Delta y_2 = -3.4\ \text{km}$

$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = -2.3\ \text{km} + 0.0\ \text{km} = -2.3\ \text{km}$

$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 2.3\ \text{km} + (-3.4\ \text{km}) = -1.1\ \text{km}$

$d^2 = (\Delta x_{tot})^2 + (\Delta y_{tot})^2$

$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(-2.3\ \text{km})^2 + (-1.1\ \text{km})^2}$

$d = \sqrt{5.3\ \text{km}^2 + 1.2\ \text{km}^2}$

$d = 2.5\ \text{km}$

PTS: 1 DIF: IIIB OBJ: 3-2.4

13. ANS:
0.23 m/s, 37° north of east

Given

$d_1 = 34$ m $\theta_1 = 60.1°$ north of east

$d_2 = 21$ m $\theta_2 = 0.0°$ east

$\Delta t = (3.4\ \text{min})(60.0\ \text{s/min}) = 204\ \text{s}$

Solution

$\Delta x_1 = d_1 \cos \theta_1 = (34 \text{ m})(\cos 60.1°)$

$\Delta x_1 = (34 \text{ m})(0.498)$

$\Delta x_1 = 17 \text{ m}$

$\Delta y_1 = d_1 \sin \theta_1 = (34 \text{ m})(\sin 60.1°)$

$\Delta y_1 = (34 \text{ m})(0.867)$

$\Delta y_1 = 29 \text{ m}$

$\Delta x_2 = 21 \text{ m}$

$\Delta y_2 = 0 \text{ m}$

$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = 17 \text{ m} + 21 \text{ m} = 38 \text{ m}$

$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = 29 \text{ m} + 0 \text{ m} = 29 \text{ m}$

$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(38 \text{ m})^2 + (29 \text{ m})^2}$

$d = \sqrt{1400 \text{ m}^2 + 841 \text{ m}^2}$

$d = \sqrt{2240 \text{ m}^2}$

$d = 47.3 \text{ m}$

$\theta = \tan^{-1} \frac{\Delta y_{tot}}{\Delta x_{tot}} = \tan^{-1}\left(\frac{29 \text{ m}}{38 \text{ m}}\right) = 37°$

d = 47.3 m, 37° north of east

$v_{avg} = \frac{d}{\Delta t} = \frac{47.3 \text{ m}}{204 \text{ s}} = 0.23 \text{ m/s}$

$\mathbf{v}_{\mathbf{avg}}$ = 0.23 m/s, 37° north of east

PTS: 1 DIF: IIIC OBJ: 3-2.4

14. ANS:
148 m

Given
$\mathbf{v}_\mathbf{i}$ = 15 m/s at 30.0° above the horizontal
Δt = 6.30 s
g = 9.81 m/s^2

Solution

$v_{i,y} = v_i \sin\theta = (15 \text{ m/s})(\sin 30.0°) = 7.5 \text{ m/s}$

$\Delta y = v_{i,y}\Delta t + \frac{1}{2}a_y(\Delta t)^2 = (7.5 \text{ m/s})(6.30 \text{ s}) + \frac{1}{2}(-9.81 \text{ m/s}^2)(6.30 \text{ s})^2$

$\Delta y = 47 \text{ m} - 195 \text{ m} = -148 \text{ m}$

$h = 148 \text{ m}$

PTS: 1 DIF: IIIB OBJ: 3-3.3

15. ANS:
3.31×10^2 m

Given
v = 70.0 m/s horizontally
Δy = −110.0 m

Solution
$v_{i,x} = v_x = 70.0 \text{ m/s}$

$v_{i,y} = 0$

$\Delta y = \frac{1}{2}a_y(\Delta t)^2$

$(\Delta t)^2 = \frac{2\Delta y}{a_y}$

$\Delta t = \sqrt{\frac{2\Delta y}{a_y}} = \sqrt{\frac{2(-110.0 \text{ m})}{(-9.81 \text{ m/s}^2)}} = \sqrt{22.4 \text{ s}^2} = 4.73 \text{ s}$

$\Delta x = v_x\Delta t = (70.0 \text{ m/s})(4.73 \text{ s}) = 3.31 \times 10^2 \text{ m}$

PTS: 1 DIF: IIIB OBJ: 3-3.3

16. ANS:
3.4 m/s

Given
$v_{carrion} = v_c$ = 1.3 m/s horizontally
Δy = −14.0 m
d = 8.0 m

Solution

$\Delta x_{fox} = d - \Delta x_c$

$\Delta x_{fox} = v_{fox}\Delta t$

$\Delta x_c = v_c\Delta t$

$v_{fox}\Delta t = d - v_c\Delta t$

$v_{fox} = \frac{d}{\Delta t} - v_c$

$\Delta y_c = \frac{1}{2}a_y(\Delta t)^2$

$(\Delta t)^2 = \frac{2\Delta y_c}{a_y}$

$\Delta t = \sqrt{\frac{2\Delta y_c}{a_y}} = \sqrt{\frac{2(-14.0\ \text{m})}{(-9.81\ \text{m/s}^2)}} = \sqrt{2.85\ \text{s}^2} = 1.69\ \text{s}$

$v_{fox} = \frac{d}{\Delta t} - v_c = \frac{8.0\ \text{m}}{1.69\ \text{s}} - 1.3\ \text{m/s} = 4.7\ \text{m/s} - 1.3\ \text{m/s} = 3.4\ \text{m/s}$

PTS: 1 DIF: IIIC OBJ: 3-3.3

17. ANS:
7 cm

Given
$\Delta y = -29$ m
$v_x = 5$ cm/s
$\Delta t = 1.1$ s

Solution
$\Delta x = v_x\Delta t_2$

$\Delta t_2 = \Delta t_1 - \Delta t$

$\Delta y = \frac{1}{2}a_y(\Delta t_1)^2$

$\Delta t_1 = \sqrt{\frac{2\Delta y}{a_y}} = \sqrt{\frac{2(-29\ \text{m})}{(-9.81\ \text{m/s}^2)}} = \sqrt{5.9\ \text{s}^2} = 2.4\ \text{s}$

$\Delta t_2 = 2.4\ \text{s} - 1.1\ \text{s} = 1.3\ \text{s}$

$\Delta x = v_x\Delta t_2 = (5\ \text{cm/s})(1.3\ \text{s}) = 7\ \text{cm}$

PTS: 1 DIF: IIIC OBJ: 3-3.3

18. ANS:
0.31 m

Given

$\Delta y_1 = -20.00$ m
$v_x = 0.15$ m/s
$\Delta y_2 = -5.00$m
$\Delta v_x = 0.040$ m/s

Solution
$\Delta x = v_x \Delta t_1 + \Delta v_x \Delta t$

$\Delta t = \Delta t_1 - \Delta t_{1-2}$

$\Delta y_1 = \frac{1}{2} a_y (\Delta t_1)^2$

$$\Delta t_1 = \sqrt{\frac{2\Delta y}{a_y}} = \sqrt{\frac{2(-20.00\text{ m})}{(-9.81\text{ m/s}^2)}} = \sqrt{4.08\text{ s}^2} = 2.02\text{ s}$$

$(\Delta y_1 - \Delta y_2) = \frac{1}{2} a_y (\Delta t_{1-2})^2$

$$\Delta t_{1-2} = \sqrt{\frac{2(\Delta y_1 - \Delta y_2)}{a_y}} = \sqrt{\frac{2[(-20.00\text{ m}) - (-5.00\text{ m})]}{(-9.81\text{ m/s}^2)}} = \sqrt{3.06\text{ s}^2} = 1.75\text{ s}$$

$\Delta t = \Delta t_1 - \Delta t_{1-2} = 2.02\text{ s} - 1.75\text{ s} = 0.27\text{ s}$

$\Delta x = v_x \Delta t_1 + \Delta v_x \Delta t = (0.15\text{ m/s})(2.02\text{ s}) + (0.040\text{ m/s})(0.27\text{ s})$

$\Delta x = 0.30\text{ m} + 0.011\text{ m}$

$\Delta x = 0.31\text{ m}$

PTS: 1 DIF: IIIC OBJ: 3-3.3

19. ANS:
1.01×10^2m

Given
$v_x = 1.10$ m/s
$v_y = 2.70$ m/s
$\Delta y_1 = 202$ m
$\Delta y_3 = -202$ m
$\Delta t_2 = 10.3$ s

Solution

$\Delta x = v_x \Delta t$

$\Delta t = \Delta t_1 + \Delta t_2 + \Delta t_3$

$\Delta t_1 = \frac{\Delta y_1}{v_y} = \frac{202 \text{ m}}{2.70 \text{ m/s}} = 74.8 \text{ s}$

$\Delta t_3 = \sqrt{\frac{2\Delta y_3}{a_y}} = \sqrt{\frac{2(-202 \text{ m})}{(-9.81 \text{ m/s}^2)}} = \sqrt{41.2 \text{ s}^2} = 6.42 \text{ s}$

$\Delta t = \Delta t_1 + \Delta t_2 + \Delta t_3 = 74.8 \text{ s} + 10.3 \text{ s} + 6.42 \text{ s} = 91.5 \text{ s}$

$\Delta x = v_x \Delta t = (1.10 \text{ m/s})(91.5 \text{ s}) = 1.01 \times 10^2 \text{ m}$

PTS: 1 DIF: IIIC OBJ: 3-3.3

20. ANS:
0.649 m/s opposite the direction of the moving sidewalk

Given
$\mathbf{v_{bj}}$ = horizontal velocity of ball relative to the juggler's hand = 0.0 m/s
$\mathbf{v_{jw}}$ = velocity of juggler's hand relative to the walkway = +1.20 m/s
$\mathbf{v_{wg}}$ = velocity of walkway relative to the ground = +0.50 m/s
Δy = distance that ball falls from top of path = –3.60 m
Δx_{bO} = width of parabola noticed by observer = +1.80 m

Solution
$\mathbf{v_{bg}} = \mathbf{v_{bj}} + \mathbf{v_{jw}} + \mathbf{v_{wg}}$
$\Delta x_{bg} = v_{bg} \Delta t$

$v_{bg} = (0.0 \text{ m/s}) + (1.20 \text{ m/s}) + (0.50 \text{ m/s}) = 1.70 \text{ m/s}$

$\Delta t = 2\Delta t_1 = 2\sqrt{\frac{2\Delta y}{a_y}} = 2\sqrt{\frac{2(-3.60 \text{ m})}{(-9.81 \text{ m/s}^2)}} = 2\sqrt{0.734 \text{ s}^2} = 1.71 \text{ s}$

$\Delta x_{bg} = v_{bg} \Delta t = (1.70 \text{ m/s})(1.71 \text{ s}) = 2.91 \text{ m}$

Δx_{bO} = horizontal displacement of ball to observer = $\Delta x_{bg} + \Delta x_{Og}$

$\Delta x_{Og} = \Delta x_{bO} - \Delta x_{bg} = 1.80 \text{ m} - 2.91 \text{ m} = -1.11 \text{ m}$

$v_{Og} = \frac{\Delta x_{Og}}{\Delta t} = \frac{-1.11 \text{ m}}{1.71 \text{ s}} = -0.649 \text{ m/s}$

v_{Og} = 0.649 m/s opposite the direction of the moving sidewalk

PTS: 1 DIF: IIIC OBJ: 3-4.2