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Assessment

Chapter Test B

Two-Dimensional Motion and Vectors

MULTIPLE CHOICE

In the space provided, write the letter of the term or phrase that best completes each statement or best answers each question.

_____ **1.** 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

_____ **2.** 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 $\mathbf{v}_{\mathbf{student}}$?

a. $3\mathbf{v}_{\mathbf{student}}$
b. $\frac{1}{3}\mathbf{v}_{\mathbf{student}}$
c. $\frac{1}{3}\mathbf{v}_{\mathbf{student}}$
d. $-3\mathbf{v}_{\mathbf{student}}$

_____ **3.** 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

_____ **4.** 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.

_____ **5.** 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

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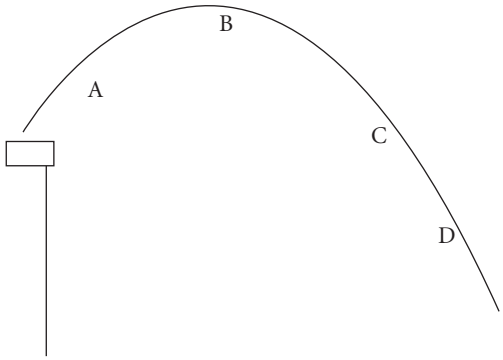
Chapter Test B *continued*

_____ **6.** In the figure at right, the magnitude of the ball's velocity is least at location

a. A.
b. B.
c. C.
d. D.



_____ **7.** In the figure at right, 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.

_____ **8.** 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 $a_y = -g = -9.81\ \text{m/s}^2$.)

a. 4.6 m
b. 9.2 m
c. 13 m
d. 15 m

_____ **9.** A boat travels directly across a river that has a downstream current, **v.** What is true about the perpendicular components of the boat's velocity?

a. One component equals **v;** the other component equals zero.
b. One component is perpendicular to **v;** the other component equals **v.**
c. One component is perpendicular to **v;** the other component equals **−v.**
d. One component is perpendicular to **v;** the other component equals zero.

_____ **10.** 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

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SHORT ANSWER

11. Briefly explain the triangle (or polygon) method of addition.

_____

_____

_____

12. If the magnitude of a component vector equals the magnitude of the vector, then what is the magnitude of the other component vector?

_____

_____

13. How can you use the Pythagorean theorem to add two vectors that are not perpendicular?

_____

_____

_____

_____

14. Briefly explain why a basketball being thrown toward a hoop is considered projectile motion.

_____

_____

PROBLEM

15. A cave explorer travels 3.0 m eastward, then 2.5 m northward, and finally 15.0 m westward. Use the graphical method to find the magnitude of the net displacement.

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16. A dog walks 28 steps north and then walks 55 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.

17. A quarterback takes the ball from the line of scrimmage and runs backward for 1.0×10^1 m then sideways parallel to the line of scrimmage for 15 m. The ball is thrown forward 5.0×10^1 m perpendicular to the line of scrimmage. The receiver is tackled immediately. How far is the football displaced from its original position?

18. Vector **A** is 3.2 m in length and points along the positive y-axis. Vector **B** is 4.6 m in length and points along a direction 195° counterclockwise from the positive x-axis. What is the magnitude of the resultant when vectors **A** and **B** are added?

19. A model rocket flies horizontally off the edge of a cliff at a velocity of 50.0 m/s. If the canyon below is 100.0 m deep, how far from the edge of the cliff does the model rocket land? ($a_y = -g = -9.81$ m/s^2)

20. A boat moves at 10.0 m/s relative to the water. If the boat is in a river where the current is 2.00 m/s, how long does it take the boat to make a complete round trip of 1000.0 m upstream followed by 1000.0 m downstream?

Solution

$v_{i,y} = v_i \sin\theta = (12\text{ m/s})(\sin 30.0°) = 6.0\text{ m/s}$

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

$\frac{1}{2}(-g)(\Delta t)^2 + v_{i,y}\Delta t =$

$\frac{1}{2}(-9.81\text{ m/s}^2)(5.6\text{ s})^2 +$

$(6.0\text{ m/s})(5.6\text{ s})$

$\Delta y = -120\text{ m}$

$h = \boxed{120\text{ m}}$

20. 27 km/h north

Given

$\boldsymbol{v_{pg}}$ = velocity of plane to ground = 145 km/h south

$\boldsymbol{v_{pa}}$ = velocity of plane to air = 170.0 km/h south

Solution

$\boldsymbol{v_{pg}} = \boldsymbol{v_{pa}} + \boldsymbol{v_{ag}}$

$\boldsymbol{v_{ag}} = \boldsymbol{v_{pg}} - \boldsymbol{v_{pa}}$

$\boldsymbol{v_{ag}} = 145\text{ km/h} - 172\text{ km/h} = -27\text{ km/h}$

$\boldsymbol{v_{ag}} = \boxed{27\text{ km/h north}}$

Two-Dimensional Motion and Vectors

CHAPTER TEST B (ADVANCED)

1. b

2. d

3. d

Given

$\mathbf{\Delta x_1} = 3.0 \times 10^1$ cm east

$\mathbf{\Delta y_1} = 25$ cm north

$\mathbf{\Delta x_2} = 15$ cm west

Solution

$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = (3.0 \times 10^1\text{ cm}) + (-15\text{ cm}) = 15\text{ cm}$

$\Delta y_{tot} = \Delta y_2 = 25\text{ cm}$

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

$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(15\text{ cm})^2 + (25\text{ cm})^2}$

$d = \boxed{29\text{ cm}}$

4. a

5. d

Solution

$\Delta x_1 = 2.00 \times 10^2$ units

$\Delta y_1 = 0$

$\Delta x_2 = d_2 \cos\theta = (4.00 \times 10^2\text{ units})(\cos 30.0°) = 3.46 \times 10^2$ units

$\Delta y_2 = d_2 \sin\theta = (4.00 \times 10^2\text{ units})(\sin 30.0°) = 2.00 \times 10^2$ units

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

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

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

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

$d = 2.48 \times 10^2$ units

$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta y}\right) =$

$\tan^{-1}\frac{2.00 \times 10^2\text{ units}}{1.46 \times 10^2\text{ units}} = 53.9°$

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

6. b

7. d

8. b

Solution

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

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

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

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

$= 0.84\text{ s}$

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

9. c

10. 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

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

$v_{ag,y} = v_{ag} \sin \theta = (120.0 \text{ km/h})(\sin 30.00°) = 60.0 \text{ km/h}$

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

$v_{pg,y} = 60.0 \text{ km/h}$

$v_{pg} = \sqrt{(v_{pg,x})^2 + (v_{pg,y})^2} = \sqrt{(603.9 \text{ km/h})^2 + (60.0 \text{ km/h})^2} = \boxed{606.9 \text{ km/h}}$

11. The triangle method of adding vectors requires that you align the vectors, one after the other, tail to nose, by moving them parallel and perpendicular 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.

12. The magnitude of the other component vector is zero.

13. 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.

14. Objects sent into the air and subject to gravity exhibit projectile motion.

15. 12.2 m

Solution

$d = \sqrt{(12.0 \text{ m})^2 + (2.5 \text{ m})^2} = \boxed{12.2 \text{ m}}$

16. 62 steps

Solution

$d = \sqrt{(28 \text{ steps})^2 + (55 \text{ steps})^2} = \boxed{62 \text{ steps}}$

17. 43 m

Given

$\Delta \mathbf{x_1} = -1.0 \times 10^1 \text{ m}$

$\Delta \mathbf{y_1} = 15 \text{ m}$

$\Delta \mathbf{x_2} = +5.0 \times 10^1 \text{ m}$

Solution

$\Delta x_{tot} = \Delta x_1 + \Delta x_2 = (-1.0 \times 10^1 \text{ m}) + (5.0 \times 10^1 \text{ m}) = 4.0 \times 10^1 \text{ m}$

$\Delta y_{tot} = \Delta y_1 = -15 \text{ m}$

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

$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(4.0 \times 10^1 \text{ m})^2 + (1.5 \times 10^1 \text{ m})^2} = \boxed{4.3 \times 10^1 \text{ m}}$

18. 4.9 m

Given

$\mathbf{d_1} = 3.2 \text{ m along } +y\text{-axis}$

$\mathbf{d_2} = 4.6 \text{ m at } 195° \text{ counterclockwise from } +x\text{-axis}$

$d_1 = 3.2 \text{ m} \qquad \theta_1 = 0.0°$

$d_2 = 4.6 \text{ m} \qquad \theta_2 = 195°$

Solution

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

$\Delta y_1 = 3.2 \text{ m}$

$\Delta x_2 = d_2 \cos \theta = (4.6 \text{ m})(\cos 195°) = -4.4 \text{ m}$

$\Delta y_2 = d_2 \sin \theta = (4.6 \text{ m})(\sin 195°) = -1.2 \text{ m}$

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

$\Delta y_{tot} = \Delta y_1 + \Delta y_2 = (3.2 \text{ m}) + (-1.2 \text{ m}) = 2.0 \text{ m}$

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

$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2} = \sqrt{(-4.4 \text{ m})^2 + (2.0 \text{ m})^2} = \boxed{4.9 \text{ m}}$

19. 226 m

Given

$\mathbf{v} = 50.0 \text{ m/s horizontally}$

$\Delta y = -100.0 \text{ m}$

Solution

$\mathbf{v_{i,x}} = \mathbf{v_x} = 50.0 \text{ m/s horizontally}$

$\mathbf{v_{i,y}} = 0$

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

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

$\Delta t = \sqrt{\dfrac{2\Delta y}{a_y}} = \sqrt{\dfrac{2\Delta y}{(-g)}} = \sqrt{\dfrac{2(-100.0 \text{ m})}{-9.81 \text{ m/s}^2}} = 4.52 \text{ s}$

$\Delta x = v_x \Delta t = (50.0 \text{ m/s})(4.52 \text{ s}) = \boxed{226 \text{ m}}$

20. 208 s

Given

$\mathbf{v_{rg}}$ = velocity of river to ground = 2.00 m/s downstream

$\mathbf{v_{br}}$ = velocity of boat to river = 10.00 m/s

$\mathbf{x_1} = 1000.0 \text{ m downstream}$

$\mathbf{x_2} = -1000.0 \text{ m downstream}$

$\mathbf{v_{bg}}$ = velocity of boat

Solution
downstream
$\mathbf{v_{bg}} = \mathbf{v_{br}} + \mathbf{v_{rg}}$
$v_{bg} = 10.00 \text{ m/s} + 2.00 \text{ m/s} = 12.00 \text{ m/s}$
$\Delta t_1 = \Delta x_1/v_{bg} = 1000.0 \text{ m}/12.00 \text{ m/s} = 83.33 \text{ s}$
upstream
$\mathbf{v_{bg}} = \mathbf{v_{br}} + \mathbf{v_{rg}}$
$v_{bg} = -10.00 \text{ m/s} + 2.00 \text{ m/s} = -8.00 \text{ m/s}$

$$\Delta t_2 = \Delta x_2 \backslash v_{bg} = \frac{-1000.0 \text{ m}}{-8.00 \text{ m/s}} = 125 \text{ s}$$

$\Delta t = \Delta t_1 + \Delta t_2 = 83.33 \text{ s} + 125 \text{ s} = \boxed{208 \text{ s}}$

Forces and the Laws of Motion

CHAPTER TEST A (GENERAL)

1. c
2. d
3. d
4. c
5. c
6. c
7. c
8. b
9. d
10. d
11. c
12. a
13. d
14. d
15. b
16. d
17. c
18. d

19. Forces exerted by the object do not change its motion.

20. An object at rest remains at rest and an object in motion continues in motion with constant velocity unless it experiences a net external force.

21. $\Sigma\mathbf{F}$ is the vector sum of the external forces acting on the object.

22. In most cases, air resistance increases with increasing speed.

23. 27 N, to the right

Given
$\mathbf{F_1} = 102$ N, to the right
$\mathbf{F_2} = 75$ N, to the left

Solution
$\mathbf{F_{net}} = \mathbf{F_1} + \mathbf{F_2}$
$F_{net} = F_1 - F_2 = 102 \text{ N} - 75 \text{ N} = 27 \text{ N}$
$\mathbf{F_{net}} = \boxed{27 \text{ N, to the right}}$

24. 16 N

Given
$m = 33$ kg
$a = 0.50 \text{ m/s}^2$

Solution
$F_{net,\,x} = \Sigma F_x = ma_x =$
$(32 \text{ kg})(0.50 \text{ m/s}^2) = \boxed{16 \text{ N}}$

25. 10.4 N

Given
$m = 1.10$ kg
$\alpha = 15.0°$
$g = 9.81 \text{ m/s}^2$

Solution
$F_{net,\,y} = \Sigma F_y = F_n - F_y = 0$
$\theta = 180° - 90° - 15.0° = 75.0°$
$F_n = F_y = F_g \sin\theta = mg \sin\theta$
$F_n = (1.10 \text{ kg})(9.81 \text{ m/s}^2)(\sin 75.0°)$
$= \boxed{10.4 \text{ N}}$

Forces and the Laws of Motion

CHAPTER TEST B (ADVANCED)

1. d
2. a
3. c
4. b

Given
$F_y = 60.0$ N
$\theta = 30.0°$

Solution

$$\cos\theta = \frac{F_y}{F}$$

$$F = \frac{F_y}{\cos\theta} = \frac{60.6 \text{ N}}{\cos 30.0°} = \boxed{70.0 \text{ N}}$$

5. c
6. d
7. d
8. a
9. c
10. a
11. b
12. a

Given
$F_g = 1.0 \times 10^2$ N
$\theta = 20.0°$

Solution
$\Sigma F_y = F_n - F_{g,y} = 0$
$F_n = F_{g,\,y} = F_g \cos\theta =$
$(1.0 \times 10^2 \text{ N})(\cos 20.0°) = \boxed{94 \text{ N}}$

13. b

Given
$F_{g,\,book} = 5$ N
$\mu_s = 0.2$