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. 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 an example of a vector quantity?
   a. velocity  
   b. temperature  
   c. volume  
   d. mass

3. In the figure above, which diagram represents the vector addition, \( C = A + B \)?
   a. I  
   b. II  
   c. III  
   d. IV

4. In the figure above, which diagram represents vector subtraction, \( C = A - B \)?
   a. I  
   b. II  
   c. III  
   d. IV

5. 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.

6. In a coordinate system, a vector is oriented at angle \( \theta \) with respect to the \( x \)-axis. The \( x \) component of the vector equals the vector’s magnitude multiplied by which trigonometric function?
   a. \( \cos \theta \)  
   b. \( \cot \theta \)  
   c. \( \sin \theta \)  
   d. \( \tan \theta \)
7. How many displacement vectors shown in the figure above have horizontal components?
   a. 2  c. 4
   b. 3  d. 5

8. Which displacement vectors shown in the figure above have vertical components that are equal?
   a. \(d_1\) and \(d_2\)  c. \(d_2\) and \(d_5\)
   b. \(d_1\) and \(d_3\)  d. \(d_4\) and \(d_5\)

9. A hiker undergoes a displacement of \(d_5\) as shown in the figure above. A single displacement that would return the hiker to his starting point would have which of the following sets of components?
   a. \(+d_5, x; +d_5, y\)  c. \(-d_5, x; +d_5, y\)
   b. \(+d_5, x; -d_5, y\)  d. \(-d_5, x; -d_5, y\)

10. Which of the following is an example of projectile motion?
    a. a jet lifting off a runway
    b. a baseball being thrown
    c. dropping an aluminum can into the recycling bin
    d. a space shuttle orbiting Earth

11. What is the path of a projectile?
    a. a wavy line
    b. a parabola
    c. a hyperbola
    d. Projectiles do not follow a predictable path.

12. Which of the following exhibits parabolic motion?
    a. a stone thrown into a lake
    b. a space shuttle orbiting Earth
    c. a leaf falling from a tree
    d. a train moving along a flat track
13. 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

14. 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

15. 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.

16. 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.

SHORT ANSWER

17. Is distance or displacement a vector quantity?

   ____________________________
18. The equation $D = \sqrt{\Delta x^2 + \Delta y^2}$ is valid only if $\Delta x$ and $\Delta y$ are magnitudes of vectors that have what orientation with respect to each other?

PROBLEM

19. 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 12 m/s. A stopwatch measures the stone's trajectory time from the top of the cliff to the bottom at 5.6 s. What is the height of the cliff? (Assume no air resistance and that $a_y = -g = -9.81 \text{ m/s}^2$.)

20. A small airplane flies at a velocity of 145 km/h toward the south as observed by a person on the ground. The airplane pilot measures an air velocity of 172 km/h south. What is the velocity of the wind that affects the plane?
13. The displacement is negative because a change of position in the direction opposite of increasing positive position is negative displacement.

14. The dog's initial position and its final position are the same position.

15. Since the usual choice of coordinates uses positive as the direction away from Earth, the direction of free-fall acceleration is negative because the object accelerates toward Earth.

16. \(1.7 \times 10^{-2}\) h

Given

\[ v_{avg} = 1.8 \text{ km/h} \]
\[ \Delta x = 0.30 \text{ km} \]

Solution

\[ v_{avg} = \frac{\Delta x}{\Delta t} \]
\[ \Delta t = \frac{\Delta x}{v_{avg}} = \frac{0.30 \text{ km}}{18 \text{ km/h}} = 1.7 \times 10^{-2} \text{ h} \]

17. 1.2 km, north

Given

\[ v_{avg,1} = -0.75 \text{ km/h} \]
\[ \Delta t_1 = 1.5 \text{ h} \]
\[ v_{avg,2} = 0.90 \text{ km/h} \]
\[ \Delta t_2 = 2.5 \text{ h} \]

Solution

\[ \Delta x = v_{avg,1} \Delta t_1 + v_{avg,2} \Delta t_2 \]
\[ \Delta x = (0.90 \text{ km/h})(2.5 \text{ h}) + (-0.75 \text{ km/h})(1.5 \text{ h}) = 1.2 \text{ km, north} \]

18. 1.0 m/s

Given

\[ v_i = 1.8 \text{ m/s} \]
\[ a = -3.00 \text{ m/s}^2 \]
\[ \Delta x = 0.37 \text{ m} \]

Solution

\[ v_f^2 = v_i^2 + 2a\Delta x \]
\[ v_f = \sqrt{v_i^2 + 2a\Delta x} = \sqrt{(1.8 \text{ m/s})^2 + 2(-3.00 \text{ m/s}^2)(0.37 \text{ m})} \]
\[ v_f = 1.0 \text{ m/s} \]

19. at least 0.20 m

Given

\[ a = -g = -9.81 \text{ m/s}^2 \]
\[ \Delta t = 0.20 \text{ s} \]
\[ v_i = 0.0 \text{ m/s} \]

Solution

\[ \Delta x = v_i \Delta t + \frac{1}{2}a(\Delta t)^2 = v_i \Delta t + \frac{1}{2}(-g)(\Delta t)^2 \]
\[ \Delta x = (0 \text{ m/s})(0.20 \text{ s}) + \frac{1}{2}(-9.81 \text{ m/s}^2)(0.20 \text{ s})^2 = 0.20 \text{ m} \]

20. 30.5 m

Given

\[ a = -g = -9.81 \text{ m/s}^2 \]
\[ v_{i,1} = 0.0 \text{ m/s} \]
\[ \Delta x = -32.0 \text{ m} \]
\[ v_{i,2} = 0.0 \text{ m/s} \]
\[ \Delta t_{1,2} = 2.0 \text{ s} \]

Solution

\[ \Delta x_1 = v_{i,1} \Delta t_1 + \frac{1}{2}a(\Delta t_1)^2 = v_{i,1} \Delta t_1 + \frac{1}{2}(a)(\Delta t_1)^2 \]
\[ \Delta t_1 = \sqrt{\frac{2\Delta x_1}{a}} = \sqrt{\frac{2\Delta x_1}{-9.81 \text{ m/s}^2}} = 2.56 \text{ s} \]
\[ \Delta t_2 = \Delta t_1 - \Delta t_{1,2} = 2.56 \text{ s} - 2.00 \text{ s} = 0.56 \text{ s} \]
\[ \Delta x_2 = v_{i,2} \Delta t_2 + \frac{1}{2}a(\Delta t_2)^2 = v_{i,2} \Delta t_2 + \frac{1}{2}(-9.81 \text{ m/s}^2)(\Delta t_2)^2 \]
\[ \Delta x_2 = (0 \text{ m/s})(0.56 \text{ s}) + \frac{1}{2}(-9.81 \text{ m/s}^2)(0.56 \text{ s})^2 = -1.5 \text{ m} \]
\[ h = 32.0 \text{ m} - 1.5 \text{ m} = 30.5 \text{ m} \]

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CHAPTER TEST A (GENERAL)

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

17. Displacement is a vector quantity.
18. The vectors must be perpendicular to each other.
19. 120 m

Given

\[ v_i = 12 \text{ m/s at 30.0° above the horizontal} \]
\[ \Delta t = 5.6 \text{ s} \]
\[ q = 9.81 \text{ m/s}^2 \]
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CHAPTER TEST B (ADVANCED)

1. b
2. d
3. d
4. a
5. d
6. b
7. d
8. b
9. c
10. b

Solution

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

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

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

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

\[ \Delta y = -120 \text{ m} \]

\[ h = \frac{120 \text{ m}}{2} \]

20. 27 km/h north

Given

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

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

Solution

\( v_{pg} = v_{pa} + v_{ag} \)

\( v_{ag} = v_{pg} - v_{pa} \)

\( v_{ag} = 145 \text{ km/h} - 172 \text{ km/h} = -27 \text{ km/h} \)

\( v_{ag} = 27 \text{ km/h north} \)