# Chapter 4: MOTION IN TWO AND THREE DIMENSIONS

1. Velocity is defined as:
   - A. rate of change of position with time
   - B. position divided by time
   - C. rate of change of acceleration with time
   - D. a speeding up or slowing down
   - E. change of position

   ans: A

2. Acceleration is defined as:
   - A. rate of change of position with time
   - B. speed divided by time
   - C. rate of change of velocity with time
   - D. a speeding up or slowing down
   - E. change of velocity

   ans: C

3. Which of the following is a scalar quantity?
   - A. Speed
   - B. Velocity
   - C. Displacement
   - D. Acceleration
   - E. None of these

   ans: A

4. Which of the following is a vector quantity?
   - A. Mass
   - B. Density
   - C. Speed
   - D. Temperature
   - E. None of these

   ans: E

5. Which of the following is NOT an example of accelerated motion?
   - A. Vertical component of projectile motion
   - B. Circular motion at constant speed
   - C. A swinging pendulum
   - D. Earth's motion about sun
   - E. Horizontal component of projectile motion

   ans: E

6. A particle goes from $x = -2\,\mathrm{m}$, $y = 3\,\mathrm{m}$, $z = 1\,\mathrm{m}$ to $x = 3\,\mathrm{m}$, $y = -1\,\mathrm{m}$, $z = 4\,\mathrm{m}$. Its displacement is:
   A. $(1\,\mathrm{m})\,\hat{\imath} + (2\,\mathrm{m})\,\hat{\jmath} + (5\,\mathrm{m})\,\hat{k}$
   B. $(5\,\mathrm{m})\,\hat{\imath} - (4\,\mathrm{m})\,\hat{\jmath} + (3\,\mathrm{m})\,\hat{k}$
   C. $-(5\,\mathrm{m})\,\hat{\imath} + (4\,\mathrm{m})\,\hat{\jmath} - (3\,\mathrm{m})\,\hat{k}$
   D. $-(1\,\mathrm{m})\,\hat{\imath} - (2\,\mathrm{m})\,\hat{\jmath} - (5\,\mathrm{m})\,\hat{k}$
   E. $-(5\,\mathrm{m})\,\hat{\imath} - (2\,\mathrm{m})\,\hat{\jmath} + (3\,\mathrm{m})\,\hat{k}$
   
   ans: B

7. A jet plane in straight horizontal flight passes over your head. When it is directly above you, the sound seems to come from a point behind the plane in a direction $30°$ from the vertical. The speed of the plane is:
   A. the same as the speed of sound
   B. half the speed of sound
   C. three-fifths the speed of sound
   D. 0.866 times the speed of sound
   E. twice the speed of sound
   
   ans: B

8. A plane traveling north at $200\,\mathrm{m/s}$ turns and then travels south at $200\,\mathrm{m/s}$. The change in its velocity is:
   A. zero
   B. $200\,\mathrm{m/s}$ north
   C. $200\,\mathrm{m/s}$ south
   D. $400\,\mathrm{m/s}$ north
   E. $400\,\mathrm{m/s}$ south
   
   ans: E

9. Two bodies are falling with negligible air resistance, side by side, above a horizontal plane. If one of the bodies is given an additional horizontal acceleration during its descent, it:
   A. strikes the plane at the same time as the other body
   B. strikes the plane earlier than the other body
   C. has the vertical component of its velocity altered
   D. has the vertical component of its acceleration altered
   E. follows a straight line path along the resultant acceleration vector
   
   ans: A

10. The velocity of a projectile equals its initial velocity added to:
    A. a constant horizontal velocity
    B. a constant vertical velocity
    C. a constantly increasing horizontal velocity
    D. a constantly increasing downward velocity
    E. a constant velocity directed at the target
    
    ans: D

11. A stone thrown from the top of a tall building follows a path that is:
    A. circular
    B. made of two straight line segments
    C. hyperbolic
    D. parabolic
    E. a straight line
        ans: D

12. Identical guns fire identical bullets horizontally at the same speed from the same height above level planes, one on the Earth and one on the Moon. Which of the following three statements is/are true?
        I.   The horizontal distance traveled by the bullet is greater for the Moon.
        II.  The flight time is less for the bullet on the Earth.
        III. The velocity of the bullets at impact are the same.
    A. III only
    B. I and II only
    C. I and III only
    D. II and III only
    E. I, II, III
        ans: B

13. A stone is thrown horizontally and follows the path XYZ shown. The direction of the acceleration of the stone at point Y is:
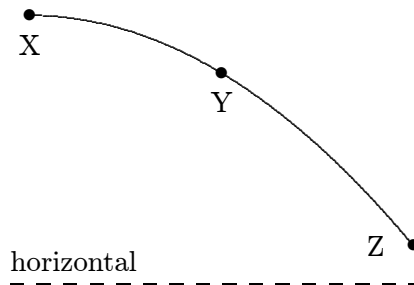


    A. ↓
    B. →
    C. ↘
    D. ↙
    E. ↗
        ans: A

14. A bullet shot horizontally from a gun:
    A. strikes the ground much later than one dropped vertically from the same point at the same instant
    B. never strikes the ground
    C. strikes the ground at approximately the same time as one dropped vertically from the same point at the same instant
    D. travels in a straight line
    E. strikes the ground much sooner than one dropped from the same point at the same instant

    ans: C

15. A bomber flying in level flight with constant velocity releases a bomb before it is over the target. Neglecting air resistance, which one of the following is NOT true?
    A. The bomber is over the target when the bomb strikes
    B. The acceleration of the bomb is constant
    C. The horizontal velocity of the plane equals the vertical velocity of the bomb when it hits the target
    D. The bomb travels in a curved path
    E. The time of flight of the bomb is independent of the horizontal speed of the plane

    ans: C

16. The airplane shown is in level flight at an altitude of 0.50 km and a speed of 150 km/h. At what distance d should it release a heavy bomb to hit the target X? Take $g = 10\,\text{m/s}^2$.
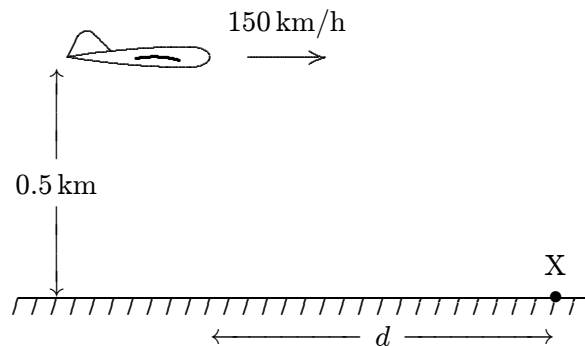


    A. 150 m
    B. 295 m
    C. 420 m
    D. 2550 m
    E. 15,000 m

    ans: C

17. An object is shot from the back of a railroad flatcar moving at 40 km/h on a straight horizontal road. The launcher is aimed upward, perpendicular to the bed of the flatcar. The object falls:
    A. in front of the flatcar
    B. behind the flatcar
    C. on the flatcar
    D. either behind or in front of the flatcar, depending on the initial speed of the object
    E. to the side of the flatcar

    ans: C

18. A ball is thrown horizontally from the top of a 20-m high hill. It strikes the ground at an angle of 45°. With what speed was it thrown?
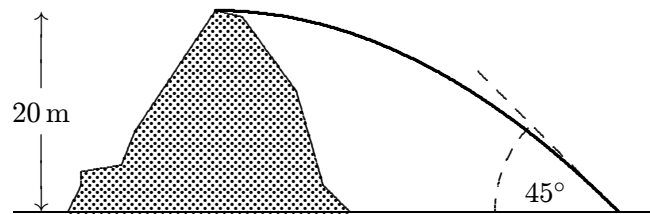


    A. 14 m/s
    B. 20 m/s
    C. 28 m/s
    D. 32 m/s
    E. 40 m/s

    ans: B

19. A stone is thrown outward from the top of a 59.4-m high cliff with an upward velocity component of 19.5 m/s. How long is stone in the air?
    A. 4.00 s
    B. 5.00 s
    C. 6.00 s
    D. 7.00 s
    E. 8.00 s

    ans: C

20. A large cannon is fired from ground level over level ground at an angle of 30° above the horizontal. The muzzle speed is 980 m/s. Neglecting air resistance, the projectile will travel what horizontal distance before striking the ground?
    A. 4.3 km
    B. 8.5 km
    C. 43 km
    D. 85 km
    E. 170 km

    ans: D

21. A boy on the edge of a vertical cliff 20 m high throws a stone horizontally outward with a speed of 20 m/s. It strikes the ground at what horizontal distance from the foot of the cliff? Use $g = 10\,\text{m/s}^2$.

    A. 10 m
    B. 40 m
    C. 50 m
    D. $50\sqrt{5}$ m
    E. none of these

      ans: B

22. Which of the curves on the graph below best represents the vertical component $v_y$ of the velocity versus the time $t$ for a projectile fired at an angle of 45° above the horizontal?
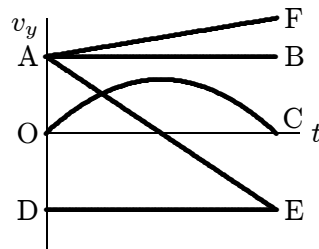


    A. OC
    B. DE
    C. AB
    D. AE
    E. AF

      ans: D

23. A cannon fires a projectile as shown. The dashed line shows the trajectory in the absence of gravity; points MNOP correspond to the position of the projectile at one second intervals. If $g = 10\,\mathrm{m/s}^2$, the lengths X,Y,Z are:
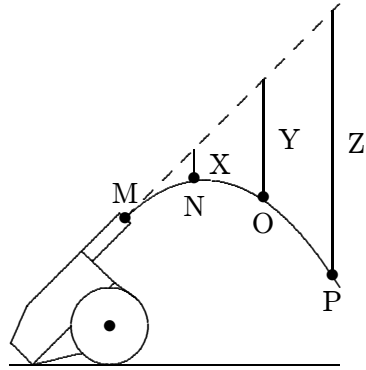


A. 5 m, 10 m, 15 m
B. 5 m, 20 m, 45 m
C. 10 m, 40 m, 90 m
D. 10 m, 20 m, 30 m
E. 0.2 m, 0.8 m, 1.8 m

   ans: B

24. A dart is thrown horizontally toward X at $20\,\mathrm{m/s}$ as shown. It hits Y 0.1 s later. The distance XY is:
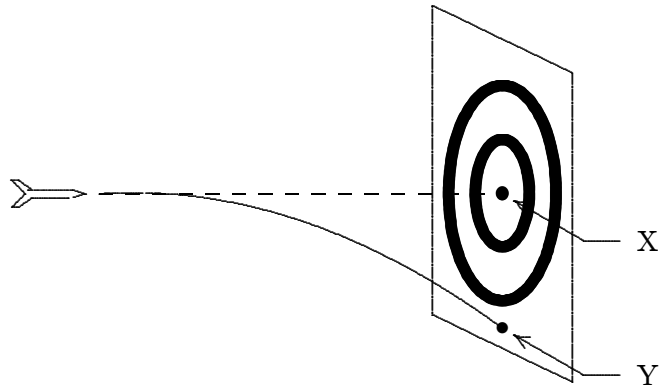


A. 2 m
B. 1 m
C. 0.5 m
D. 0.1 m
E. 0.05 m

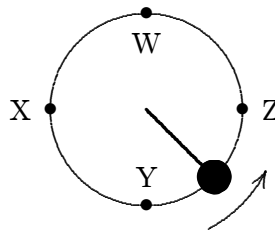   ans: E

25. A projectile is fired from ground level over level ground with an initial velocity that has a vertical component of $20\,\mathrm{m/s}$ and a horizontal component of $30\,\mathrm{m/s}$. Using $g = 10\,\mathrm{m/s^2}$, the distance from launching to landing points is:

   A. $40\,\mathrm{m}$
   B. $60\,\mathrm{m}$
   C. $80\,\mathrm{m}$
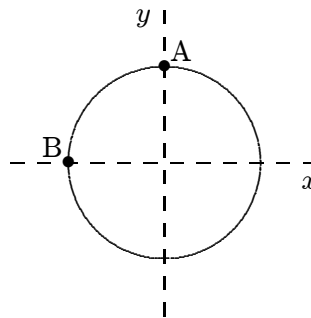   D. $120\,\mathrm{m}$
   E. $180\,\mathrm{m}$

   ans: D

26. An object, tied to a string, moves in a circle at constant speed on a horizontal surface as shown. The direction of the displacement of this object, as it travels from W to X is:



   A. ←
   B. ↓
   C. ↑
   D. ↗
   E. ↙

   ans: E

27. A toy racing car moves with constant speed around the circle shown below. When it is at point A its coordinates are $x = 0$, $y = 3\,\mathrm{m}$ and its velocity is $(6\,\mathrm{m/s})\hat{\imath}$. When it is at point B its velocity and acceleration are:



   A. $-(6\,\mathrm{m/s})\hat{\jmath}$ and $(12\,\mathrm{m/s^2})\hat{\imath}$, respectively
   B. $(6\,\mathrm{m/s})\hat{\imath}$ and $-(12\,\mathrm{m/s^2})\hat{\imath}$, respectively
   C. $(6\,\mathrm{m/s})\hat{\jmath}$ and $(12\,\mathrm{m/s^2})\hat{\imath}$, respectively
   D. $(6\,\mathrm{m/s})\hat{\imath}$ and $(2\,\mathrm{m/s^2})\hat{\jmath}$, respectively
   E. $(6\,\mathrm{m/s})\hat{\jmath}$ and 0, respectively

   ans: C

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28. An airplane makes a gradual 90° turn while flying at a constant speed of 200 m/s. The process takes 20.0 seconds to complete. For this turn the magnitude of the average acceleration of the plane is:

A.   zero
B.   $40 \, \text{m/s}^2$
C.   $20 \, \text{m/s}^2$
D.   $14 \, \text{m/s}^2$
E.   $10 \, \text{m/s}^2$

ans: D

29. An airplane is flying north at 500 km/h. It makes a gradual 180° turn at constant speed, changing its direction of travel from north through east to south. The process takes 40 s. The average acceleration of the plane for this turn (in km/h·s) is:

A.   $12.5 \, \text{km/h} \cdot \text{s}$, north
B.   $12.5 \, \text{km/h} \cdot \text{s}$, east
C.   $12.5 \, \text{km/h} \cdot \text{s}$, south
D.   $25 \, \text{km/h} \cdot \text{s}$, north
E.   $25 \, \text{km/h} \cdot \text{s}$, south

ans: E

30. An object is moving on a circular path of radius $\pi$ meters at a constant speed of 4.0 m/s. The time required for one revolution is:

A.   $2/\pi^2 \, \text{s}$
B.   $\pi^2/2 \, \text{s}$
C.   $\pi/2 \, \text{s}$
D.   $\pi^2/4$
E.   $2/\pi \, \text{s}$

ans: B

31. A particle moves at constant speed in a circular path. The instantaneous velocity and instantaneous acceleration vectors are:

A.   both tangent to the circular path
B.   both perpendicular to the circular path
C.   perpendicular to each other
D.   opposite to each other
E.   none of the above

ans: C

32. A stone is tied to a string and whirled at constant speed in a horizontal circle. The speed is then doubled without changing the length of the string. Afterward the magnitude of the acceleration of the stone is:

A.   the same
B.   twice as great
C.   four times as great
D.   half as great
E.   one-fourth as great

ans: C

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33. Two objects are traveling around different circular orbits with constant speed. They both have the same acceleration but object A is traveling twice as fast as object B. The orbit radius for object A is _____ the orbit radius for object B.
    A. one-fourth
    B. one-half
    C. the same as
    D. twice
    E. four times
        ans: E

34. A stone is tied to a 0.50-m string and whirled at a constant speed of $4.0\,\mathrm{m/s}$ in a vertical circle. Its acceleration at the top of the circle is:
    A. $9.8\,\mathrm{m/s}^2$, up
    B. $9.8\,\mathrm{m/s}^2$, down
    C. $8.0\,\mathrm{m/s}^2$, down
    D. $32\,\mathrm{m/s}^2$, up
    E. $32\,\mathrm{m/s}^2$, down
        ans: E

35. A stone is tied to a 0.50-m string and whirled at a constant speed of $4.0\,\mathrm{m/s}$ in a vertical circle. Its acceleration at the bottom of the circle is:
    A. $9.8\,\mathrm{m/s}^2$, up
    B. $9.8\,\mathrm{m/s}^2$, down
    C. $8.0\,\mathrm{m/s}^2$, up
    D. $32\,\mathrm{m/s}^2$, up
    E. $32\,\mathrm{m/s}^2$, down
        ans: D

36. A car rounds a 20-m radius curve at $10\,\mathrm{m/s}$. The magnitude of its acceleration is:
    A. 0
    B. $0.20\,\mathrm{m/s}^2$
    C. $5.0\,\mathrm{m/s}^2$
    D. $40\,\mathrm{m/s}^2$
    E. $400\,\mathrm{m/s}^2$
        ans: C

37. For a biological sample in a 1.0-m radius centrifuge to have a centripetal acceleration of $25g$ its speed must be:
    A. $11\,\mathrm{m/s}$
    B. $16\,\mathrm{m/s}$
    C. $50\,\mathrm{m/s}$
    D. $122\,\mathrm{m/s}$
    E. $245\,\mathrm{m/s}$
        ans: B

38. A girl jogs around a horizontal circle with a constant speed. She travels one fourth of a revolution, a distance of $25\,\mathrm{m}$ along the circumference of the circle, in $5.0\,\mathrm{s}$. The magnitude of her acceleration is:

    A. $0.31\,\mathrm{m/s^2}$
    B. $1.3\,\mathrm{m/s^2}$
    C. $1.6\,\mathrm{m/s^2}$
    D. $3.9\,\mathrm{m/s^2}$
    E. $6.3\,\mathrm{m/s^2}$

    ans: C

39. A stone is tied to the end of a string and is swung with constant speed around a horizontal circle with a radius of $1.5\,\mathrm{m}$. If it makes two complete revolutions each second, the magnitude of its acceleration is:

    A. $0.24\,\mathrm{m/s^2}$
    B. $2.4\,\mathrm{m/s^2}$
    C. $24\,\mathrm{m/s^2}$
    D. $240\,\mathrm{m/s^2}$
    E. $2400\,\mathrm{m/s^2}$

    ans: D

40. A Ferris wheel with a radius of $8.0\,\mathrm{m}$ makes 1 revolution every $10\,\mathrm{s}$. When a passenger is at the top, essentially a diameter above the ground, he releases a ball. How far from the point on the ground directly under the release point does the ball land?

    A. 0
    B. $1.0\,\mathrm{m}$
    C. $8.0\,\mathrm{m}$
    D. $9.1\,\mathrm{m}$
    E. $16\,\mathrm{m}$

    ans: D

41. A boat is able to move through still water at $20\,\mathrm{m/s}$. It makes a round trip to a town 3.0 km upstream. If the river flows at $5\,\mathrm{m/s}$, the time required for this round trip is:

    A. $120\,\mathrm{s}$
    B. $150\,\mathrm{s}$
    C. $200\,\mathrm{s}$
    D. $300\,\mathrm{s}$
    E. $320\,\mathrm{s}$

    ans: E

42. A boat is traveling upstream at $14\,\mathrm{km/h}$ with respect to a river that is flowing at $6\,\mathrm{km/h}$ (with respect to the ground). A man runs directly across the boat, from one side to the other, at $6\,\mathrm{km/h}$ (with respect to the boat). The speed of the man with respect to the ground is:

    A.  $10\,\mathrm{km/h}$
    B.  $14\,\mathrm{km/h}$
    C.  $18.5\,\mathrm{km/h}$
    D.  $21\,\mathrm{km/h}$
    E.  $26\,\mathrm{km/h}$

    ans: A

43. A ferry boat is sailing at $12\,\mathrm{km/h}$ $30°$ W of N with respect to a river that is flowing at $6.0\,\mathrm{km/h}$ E. As observed from the shore, the ferry boat is sailing:

    A.  $30°$ E of N
    B.  due N
    C.  $30°$ W of N
    D.  $45°$ E of N
    E.  none of these

    ans: B

44. A boy wishes to row across a river in the shortest possible time. He can row at $2\,\mathrm{m/s}$ in still water and the river is flowing at $1\,\mathrm{m/s}$. At what angle $\theta$ should he point the bow (front) of his boat?
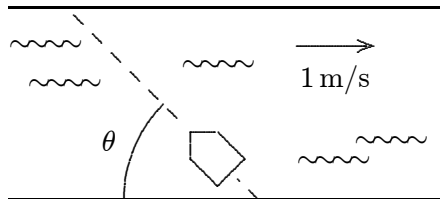


    A.  $30°$
    B.  $45°$
    C.  $60°$
    D.  $63°$
    E.  $90°$

    ans: E

45. A girl wishes to swim across a river to a point directly opposite as shown. She can swim at $2\,\mathrm{m/s}$ in still water and the river is flowing at $1\,\mathrm{m/s}$. At what angle $\theta$ with respect to the line joining the starting and finishing points should she swim?
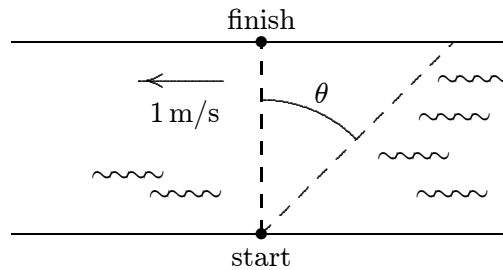


A. 30°
B. 45°
C. 60°
D. 63°
E. 90°

ans: A

46. A motor boat can travel at 10 km/h in still water. A river flows at 5 km/h west. A boater wishes to cross from the south bank to a point directly opposite on the north bank. At what angle must the boat be headed?

A. 27° E of N
B. 30° E of N
C. 45° E of N
D. 60° E of N
E. depends on the width of the river

ans: B

47. Two projectiles are in flight at the same time. The acceleration of one relative to the other:

A. is always $9.8\,\mathrm{m/s}^2$
B. can be as large as $19.8\,\mathrm{m/s}^2$
C. can be horizontal
D. is zero
E. none of these

ans: D