Projectile Review 1

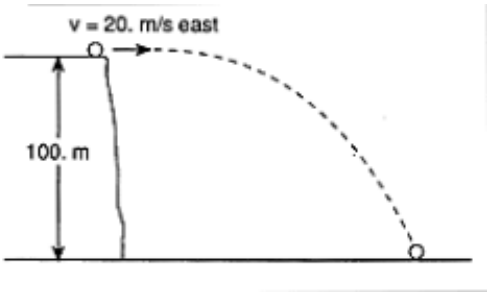
TEACHER ANSWER KEY
December 10, 2004

4
1. A baseball player throws a ball horizontally. Which statement best describes the ball's motion after it is thrown? [Neglect the effect of friction.]

1. Its vertical speed remains the same, and its horizontal speed increases.
2. Its vertical speed remains the same, and its horizontal speed remains the same.
3. Its vertical speed increases, and its horizontal speed increases.
4. Its vertical speed increases, and its horizontal speed remains the same.

4 A projectile launched horizontally has an initial vertical velocity of zero. After release, the projectile begins to fall and accelerate due to the force of gravity, and thus its vertical speed increases. Since no forces act in the horizontal direction, horizontal speed remains the same.

1
2. Base your answer on the diagram which shows a ball projected horizontally with an initial velocity of 20. meters per second east, off a cliff 100. meters high. [Neglect air resistance.]During the flight of the ball, what is the direction of its acceleration?



1. downward
2. upward
3. westward
4. eastward

No Explanation Available.

3
3. A projectile is fired at an angle of 53' to the horizontal with a speed of 80. meters per second.What is the vertical component of the projectile's initial velocity?

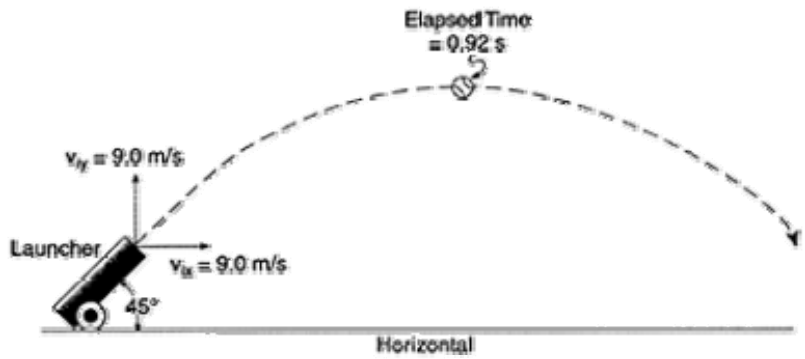
1. 130 m/s
2. 100 m/s
3. 64 m/s
4. 48 m/s

No Explanation Available.

3

4. A machine launches a tennis ball at an angle of 45° with the horizontal, as shown. The ball has an initial vertical velocity of 9.0 meters per second and an initial horizontal velocity of 9.0 meters per second. The ball reaches its maximum height 0.92 second after its launch. [Neglect air resistance and assume the ball lands at the same height above the ground from which it was launched.]

The speed of the tennis ball as it leaves the launcher is approximately



1. 4.5 m/s
2. 8.3 m/s
3. 13 m/s
4. 18 m/s

3 Write out the problem.

Given: $v_{i_y} = 9.0$ m/s Find: $v_i = ?$

$v_{i_x} = 9.0$ m/s

$\theta = 45°$ to the ground

Δt at $\Delta s_{max} = 0.92$ s

Refer to the *Motion in a Plane* section in the *Reference Tables* to find an equation(s) that relates velocity with its vertical and horizontal components, a launch angle, and time.

Solution 1:

$$v_{i_y} = v_i \sin\theta$$

$$v_i = \frac{v_{i_y}}{\sin\theta}$$

$$= \frac{9.0 \text{ m/s}}{\sin 45°}$$

$$= 13 \text{ m/s}$$

or Solution 2:

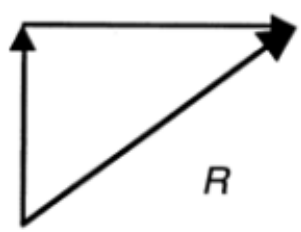
$$v_{i_x} = v_i \cos\theta$$

$$v_i = \frac{v_{i_x}}{\cos\theta}$$

$$= \frac{9.0 \text{ m/s}}{\cos 45°}$$

$$= 13 \text{ m/s}$$

or Solution 3: To find the resultant vector, simply sketch the vectors to scale, place the vectors head to tail, and draw the resultant vector from the tail of the first vector to the head of the last vector.



By using the Pythagorean theorem:

$$a^2 + b^2 = c^2$$

$$(9.0 \text{ m/s})^2 + (9.0 \text{ m/s})^2 = c^2$$

$$\sqrt{162 \text{m}^2/\text{s}^2} = c$$

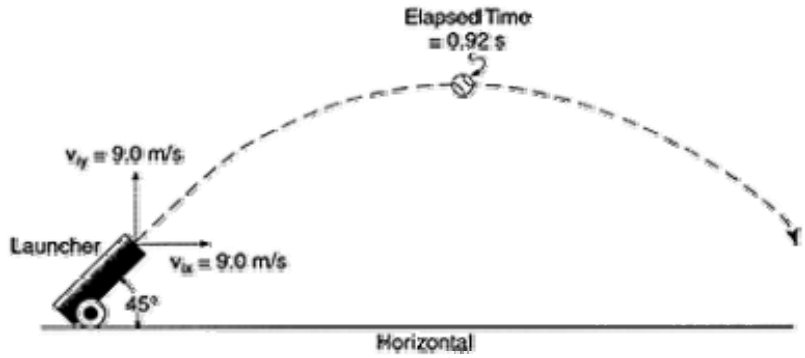
$$13 \text{ m/s} = c$$

(Note that time is not needed for these calculations.)

2

5. A machine launches a tennis ball at an angle of 45° with the horizontal, as shown. The ball has an initial vertical velocity of 9.0 meters per second and an initial horizontal velocity of 9.0 meters per second. The ball reaches its maximum height 0.92 second after its launch. [Neglect air resistance and assume the ball lands at the same height above the ground from which it was launched.]

The total horizontal distance traveled by the tennis ball during the entire time it is in the air is approximately



1. 23 m
2. 17 m
3. 8.3 m
4. 4.1 m

2 Since no net force acts in the horizontal direction, no acceleration occurs horizontally. Therefore, velocity in the horizontal direction is constant for the flight of a projectile. Time of flight is the time required for an object to fall to the ground. All objects regardless of their mass will fall with the same acceleration due to gravity. Therefore, the time needed for the tennis ball to reach its maximum height equals the time needed for it to fall back down to the ground. Write out the problem.

Given: $\bar{v}_x = 9.0$ m/s, $\Delta t = 1.84$ s Find: $\Delta s_x = ?$

Refer to the *Mechanics* section in the *Reference Tables* to find an equation(s) that relates displacement with velocity and time.

Solution: $\bar{v}_x = \dfrac{\Delta s_x}{\Delta t}$

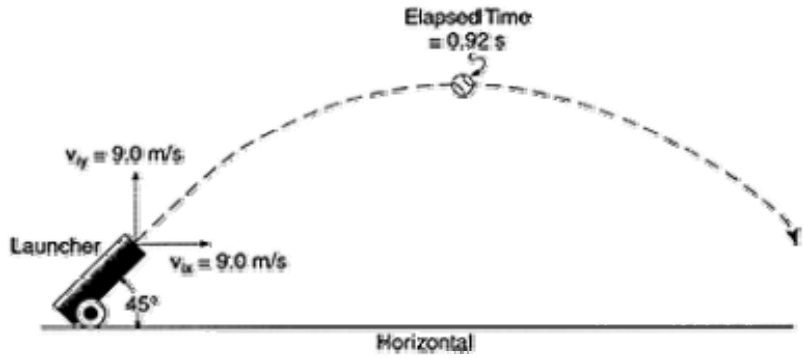
$$\Delta s_x = \bar{v}_x \, \Delta t$$
$$= (9.0 \text{ m/s})(1.84 \text{ s})$$
$$= 17 \text{ m}$$

1

6. A machine launches a tennis ball at an angle of 45° with the horizontal, as shown. The ball has an initial vertical velocity of 9.0 meters per second and an initial horizontal velocity of 9.0 meters per second. The ball reaches its maximum height 0.92 second after its launch. [Neglect air resistance and assume the ball lands at the same height above the ground from which it was launched.]

The speed at which the launcher fires tennis balls is constant, but the angle between the launcher

and the horizontal can be varied. As the angle is decreased from 45° to 30.°, the range of the tennis balls



1. decreases
2. increases
3. remains the same

1 If the angle of the launcher decreases, the magnitude of the initial velocity in the y direction will decrease. Refer to the *Motion in a Plane* section in the *Reference Tables*

$$v_{i_y} = v_i \sin \theta$$

If the magnitude of the initial velocity in the y direction decreases, the time of flight will decrease. Refer to the *Mechanics* section in the *Reference Tables* to find an equation(s) that relates velocity with time and acceleration.

$$\bar{a} = \frac{\Delta v}{\Delta t}$$

If time of flight decreases, the range would also decrease. Refer to the *Mechanics* section in the *Reference Tables* to find an equation(s) that relates displacement with velocity and time.

$$\bar{v}_x = \frac{\Delta s_x}{\Delta t}$$

$$\Delta s_x = \bar{v}_x \Delta t$$

4

7. A 2-kilogram block is dropped from the roof of a tall building at the same time a 6-kilogram ball is thrown horizontally from the same height. Which statement best describes the motion of the block and the motion of the ball? [Neglect air resistance.]

1. The 2-kg block hits the ground first because it has no horizontal velocity.

2. The 6-kg ball hits the ground first because it has more mass.

3. The 6-kg ball hits the ground first because it is round.

4. The block and the ball hit the ground at the same time because they have the same vertical acceleration.

4 Time of flight is the time needed for an object to fall to the ground. All objects regardless of their mass will fall with the same acceleration due to gravity. The 2-kilogram block is dropped so its initial velocity in the y direction is 0. Since the 6-kilogram ball is thrown horizontally, its initial velocity in the y direction is also 0. Both objects are dropped from the same height. Refer to the *Mechanics* section in the *Reference Tables* to find an equation(s) that relates time with acceleration, velocity, and displacement.

Solution: $\Delta s_y = v_{i_y} \Delta t + \frac{1}{2} a(\Delta t)^2$

$$\Delta t = \sqrt{\frac{2\Delta s_y}{a}}$$

Since height and acceleration are equal for both objects, the time of flight for both must also be equal.

2

8. A ball is thrown horizontally at a speed of 20. meters per second from the top of a cliff. How long does the ball take to fall 19.6 meters to the ground?

1. 1.0 s
2. 2.0 s
3. 9.8 s
4. 4.0 s

No Explanation Available.

1

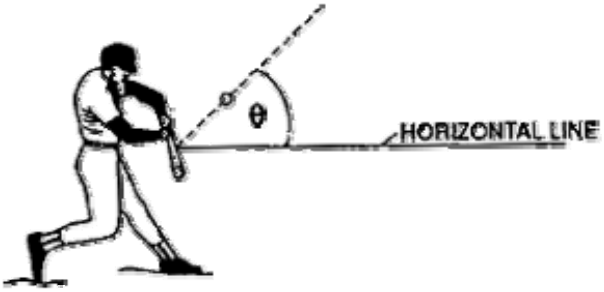
9. A book is pushed with an initial horizontal velocity of 5.0 meters per second off the top of a desk. What is the initial vertical velocity of the book?

1. 0 m/s
2. 2.5 m/s
3. 5.0 m/s
4. 10. m/s

No Explanation Available.

2

10. The diagram shows a baseball being hit with a bat. Angle "theda" represents the angle between the horizontal and the ball's initial direction of motion. Which value of "theda" would result in the ball traveling the longest horizontal distance? [Neglect air resistance.]

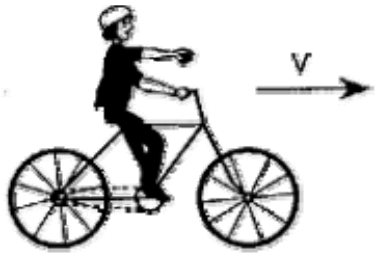


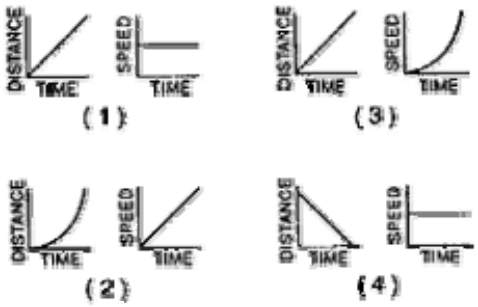
1. 25'
2. 45'
3. 60'
4. 90'

No Explanation Available.

1

11. The diagram represents a bicycle and rider traveling to the right at a constant speed. A ball is dropped from the hand of the cyclist. Which set of graphs best represents the horizontal motion of the ball relative to the ground? [Neglect air resistance.]





No Explanation Available.

1

12. The path of a projectile fired at a 30° angle to the horizontal is best described as

1. parabolic
2. linear
3. circular
4. hyperbolic

1 Projectiles move simultaneously in the horizontal and vertical directions independently of each other. With air resistance neglected, they move at a constant speed in the horizontal direction and experience a downward force in the vertical direction due to gravity. The best description of the path they follow is parabolic.

2

13. A projectile is launched with an initial velocity of 200 meters per second at an angle of 30° above the horizontal. What is the magnitude of the vertical component of the projectile's initial velocity?

1. 200 m/s X cos 30°
2. 200 m/s X sin 30°
3. 200 m/s / sin 30°
4. 200 m/s / cos 30°

2 Write out the problem.

Given: $v_i = 200$ m/s
$\theta = 30°$ to the horizontal

Find: $v_{i_y} = ?$

Refer to the *Motion in a Plane* section in the *Reference Tables* to find an equation(s) that relates velocity with its vertical component at an angle.

Solution: $v_{i_y} = v_i \sin \theta$
$= 200 \text{ m/s} \times \sin 30°$

2

14. A football player kicks a ball with an initial velocity of 25 meters per second at an angle of 53° above the horizontal. The vertical component of the initial velocity of the ball is

1. 25 m/s
3. 15 m/s

2. 20. m/s

4. 10. m/s

2 Write out the problem.

Given: $v_i = 25$ m/s, $\theta = 53°$ Find: $v_{i_y} = ?$

Refer to the *Motion in a Plane* section in the *Reference Tables* to find an equation(s) that relates initial velocity in the y direction with initial velocity and angle.

Solution:
$$\begin{aligned} v_{i_y} &= v_i \sin\theta \\ &= (25 \text{ m/s})\sin 53° \\ &= 20. \text{ m/s} \end{aligned}$$

4

15. A student throws a stone upward at an angle of 45°. Which statement best describes the stone at the highest point that it reaches?

1. Its acceleration is zero.
2. Its acceleration is at a maximum.
3. Its potential energy is at a minimum.
4. Its kinetic energy is at a minimum.

4 A projectile launched at an angle has the same upward motion as if it had been thrown straight up. Its speed decreases as it rises because of the acceleration due to gravity. This continues until its velocity equals zero. At that point, it has reached its maximum height. It now begins to fall and its speed increases again in the downward direction because of the acceleration due to gravity. Refer to the *Energy* section in the *Reference Tables* to find an equation for kinetic energy.

$$KE = \frac{1}{2}mv^2$$

Kinetic energy is directly proportional to the velocity squared. Therefore, when a projectile is at its maximum height and has a velocity of zero, kinetic energy will be at a minimum.

1

16. A red ball and a green ball are simultaneously thrown horizontally from the same height. The red ball has an initial speed of 40. meters per second and the green ball has an initial speed of 20. meters per second. Compared to the time it takes the red ball to reach the ground, the time it takes the green ball to reach the ground will be

1. the same
2. twice as much
3. half as much
4. four times as much

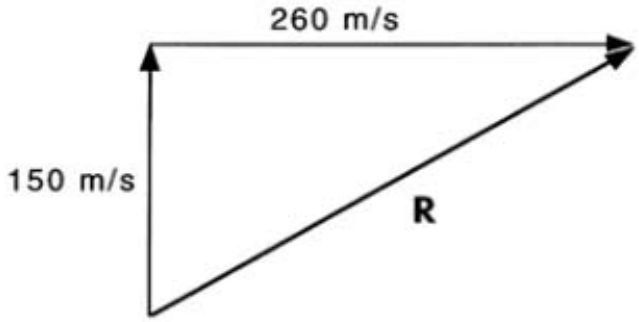
1 In projectile motion, horizontal and vertical motions occur simultaneously but independently of each other. The time a projectile needs to reach the ground is determined by motion in the vertical direction only and thus depends solely on the height of the drop, initial velocity in the vertical direction, and the acceleration due to gravity. Both the red and green balls start from the same height, have an initial speed of zero in the vertical direction, and are subject to the same vertical acceleration due to gravity. Therefore, both balls will take the same amount of time to reach the ground. Their initial horizontal velocities will affect only how far they travel from the launch point horizontally.

3

17. An artillery shell is fired at an angle to the horizontal. Its initial velocity has a vertical component of 150 meters per second and a horizontal component of 260 meters per second. What is the magnitude of the initial velocity of the shell?

1. 9.0×10^4 m/s
2. 4.1×10^2 m/s
3. 3.0×10^2 m/s
4. 1.1×10^2 m/s

3 Velocity is a vector quantity, and therefore arrows can be used to represent the horizontal and vertical velocities. To find a *resultant vector*, place the given vectors head to tail, and draw the resultant vector from the tail of the first vector to the head of the second vector.



Since the result is a right triangle, use the Pythagorean theorem

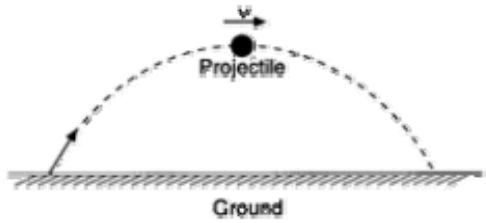
$$a^2 + b^2 = c^2$$

to determine the magnitude of the resultant.

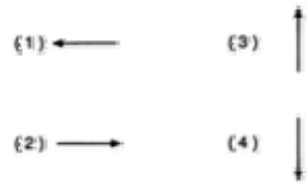
$$\begin{aligned} R^2 &= (150\ \text{m/s})^2 + (260\ \text{m/s})^2 \\ &= 22{,}500\ \text{m}^2/\text{s}^2 + 67{,}600\ \text{m}^2/\text{s}^2 \\ &= 90{,}100\ \text{m}^2/\text{s}^2 \\ R &= 300\ \text{m/s} \\ &= 3.0 \times 10^2\ \text{m/s} \end{aligned}$$

4

18. The diagram shows a projectile moving with speed *v* at the top of its trajectory.



Which vector best represents the acceleration of the projectile in the position shown?

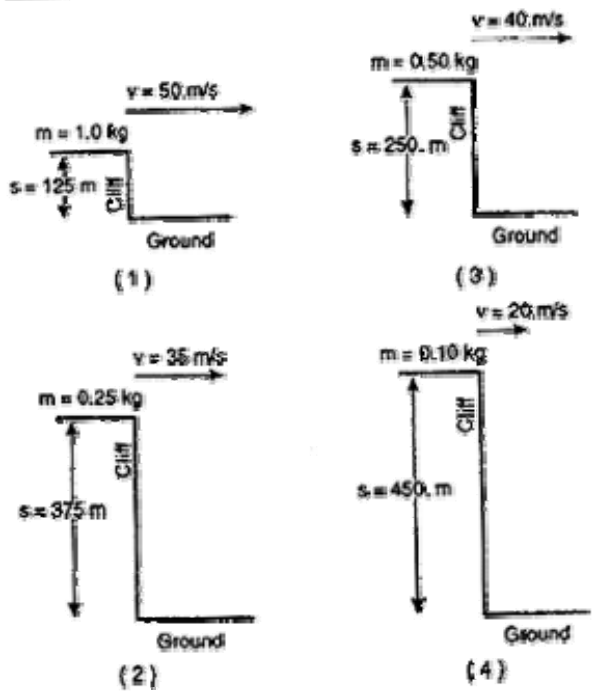


4 The only acceleration that the projectile is experiencing is acceleration due to Earth's gravity. This acceleration always points downward, toward the ground.

Vector (4) best represents the acceleration of the projectile in the position shown.

1

19. Four different balls are thrown horizontally off the top of four cliffs. In which diagram does the ball have the shortest time of flight?

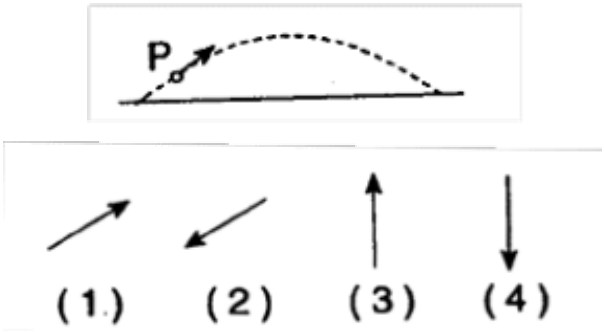


1. 1
2. 2
3. 3
4. 4

No Explanation Available.

2

20. A soccer ball travels the path shown in the diagram at the right. Which vector best represents the direction of the force of air friction on the ball at point P?



No Explanation Available.

4

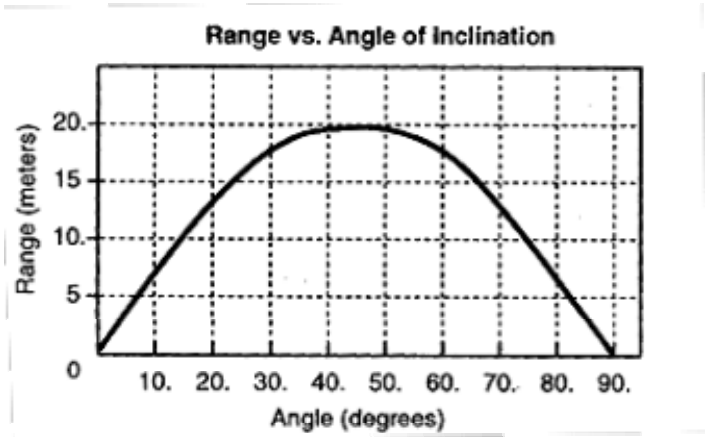
21. A baseball player throws a baseball at a speed of 40.0 m/s at an angle of 30' to the ground. The horizontal component of the baseball's speed is approximately

1. 15 m/s
2. 20 m/s
3. 30 m/s
4. 35 m/s

No Explanation Available.

3

22. Projectiles are fired from different angles with the same initial speed of 14 m/second. The graph shows the range of projectiles as a function of the original angle of inclination to the ground, neglecting air resistance. The graph shows that the range of the projectiles is



1. the same for all angles
3. greatest for an angle of 45'

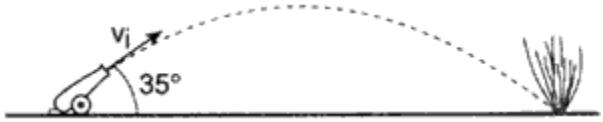
2. the same for angles of 20' and 80'

4. greatest for an angle of 90'

No Explanation Available.

1

23. Base your answer on the information and diagram. A cannon elevated at an angle of 35' to the horizontal fires a cannonball, which travels the path shown in the diagram. [Neglect air resistance and assume the ball lands at the same height above the ground from which it was launched.] If the ball lands 7.0 x 10^2 meters from the cannon 10. seconds after it was fired, what is the horizontal component of its initial velocity?



1. 70. m/s

2. 49 m/s

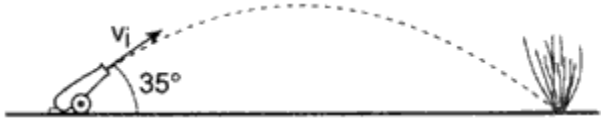
3. 35 m/s

4. 7.0 m/s

No Explanation Available.

2

24. Base your answer on the information and diagram. A cannon elevated at an angle of 35' to the horizontal fires a cannonball, which travels the path shown in the diagram. [Neglect air resistance and assume the ball lands at the same height above the ground from which it was launched.] I the ball's time of flight is 10. seconds, what is the vertical component of its initial velocity?



1. 9.8 m/s

2. 49 m/s

3. 70. m/s

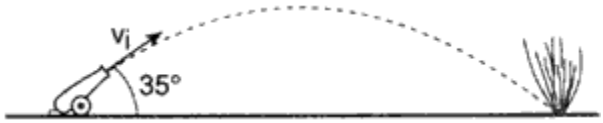
4. 98 m/s

No Explanation Available.

2

25. Base your answer on the information and diagram. A cannon elevated at an angle of 35' to the horizontal fires a cannonball, which travels the path shown in the diagram. [Neglect air resistance and assume the ball lands at the same height above the ground from which it was launched.] If the angle of elevation of the cannon is decreased from 35' to 30', the vertical component of the ball's

initial velocity will

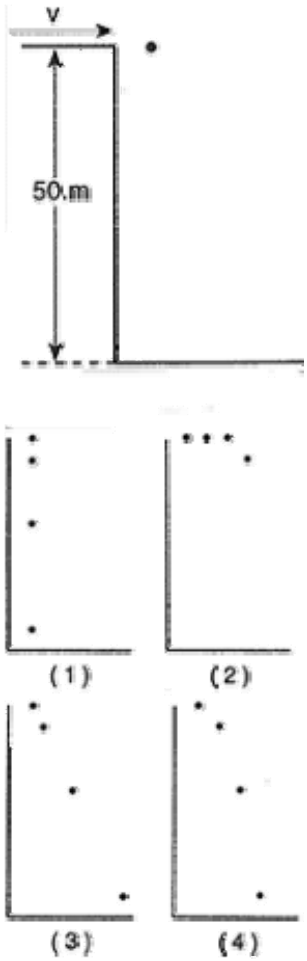


1. decrease and its horizontal component will decrease
2. decrease and its horizontal component will increase
3. increase and its horizontal component will decrease
4. increase and its horizontal component will increase

No Explanation Available.

4

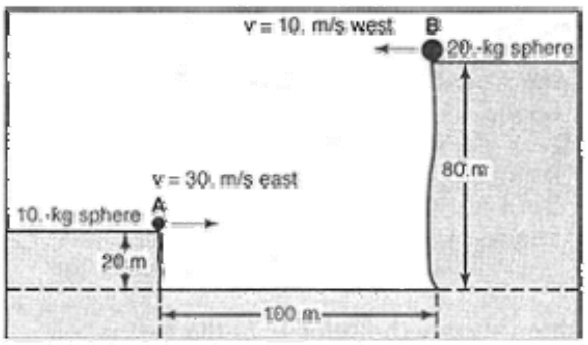
26. A ball is projected horizontally to the right from a height of 50. meters, as shown in the diagram. Which diagram best represents the position of the ball at 1.0-second intervals? [Neglect air resistance.]



No Explanation Available.

3

27. In the diagram, a 10 kilogram sphere, A, is projected horizontally with a velocity of 30 meters/second due east from a height of 20 meters above level ground. At the same instant, a 20 kilogram sphere, B, is projected horizonatlly with a velocity of 10 meters/second due west from a height of 80 meters above sea ground. [Neglect air friction]Initally, the spheres are separated by a horizontal distance of 100 meters. What is the horizontal separation of the spheres at the end of 1.5 seconds?

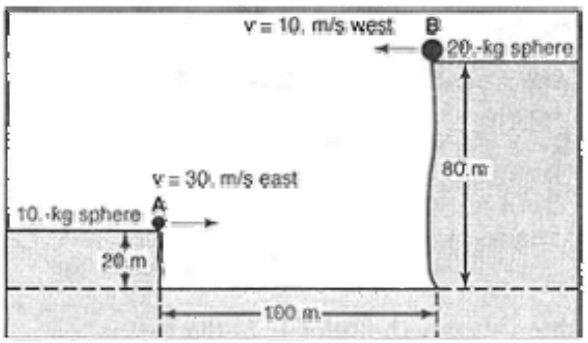


1. 15 m
2. 30 m
3. 40 m
4. 45 m

No Explanation Available.

1

28. In the diagram, a 10 kilogram sphere, A, is projected horizontally with a velocity of 30 meters/second due east from a height of 20 meters above level ground. At the same instant, a 20 kilogram sphere, B, is projected horizonatlly with a velocity of 10 meters/second due west from a height of 80 meters above sea ground. [Neglect air friction] The magnitude of the horizontal acceleration of sphere A, is

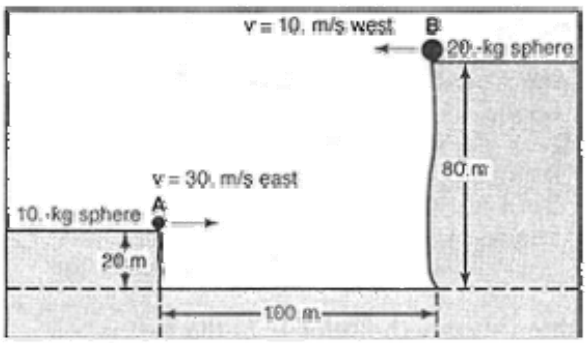


1. 0.0 m/second^2
2. 2.0 m/second^2
3. 9.8 m/second^2
4. 15 m/second^2

No Explanation Available.

1

29. In the diagram, a 10 kilogram sphere, A, is projected horizontally with a velocity of 30 meters/second due east from a height of 20 meters above level ground. At the same instant, a 20 kilogram sphere, B, is projected horizonatlly with a velocity of 10 meters/second due west from a height of 80 meters above sea ground. [Neglect air friction] Compared to the vertical acceleration of sphere A, the vertical acceleration of sphere b is



1. the same
2. twice as great
3. one-half as great
4. four times as great

No Explanation Available.

2

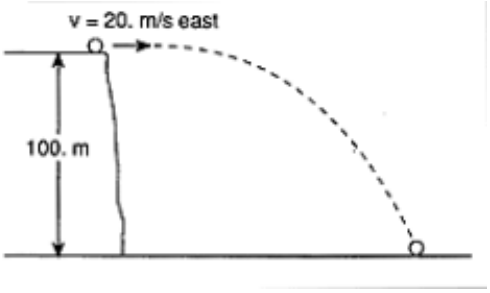
30. A cannon with a muzzle velocity of 500 meters/second fire a cannonball at an angle of 30 degrees above the horizontal. What is the vertical component of the cannonball's velocity as it leaves the cannon?

1. 0.0 m/s
2. 250 m/s
3. 433 m/s
4. 500 m/s

No Explanation Available.

1

31. Base your answer on the diagram which shows a ball projected horizontally with an initial velocity of 20. meters per second east, off a cliff 100. meters high. {Neglect air resistance.]How many seconds does the ball take to reach the ground?

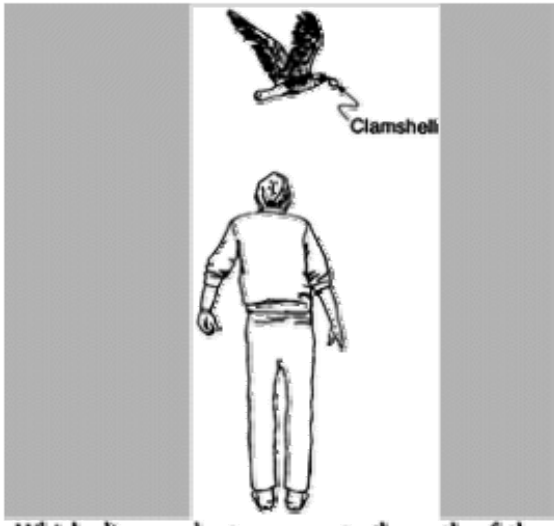


1. 4.5 s
2. 20. s
3. 9.8 s
4. 2.0 s

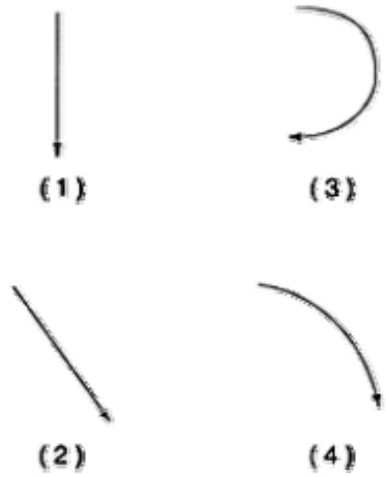
No Explanation Available.

4

32. In the diagram , a stationary observer on the ground watches as a seagull flying horizontally to the right drops a clamshell.



Which diagram best represents the path of the falling clamshell as seen by the observer? [Neglect air resistance.]

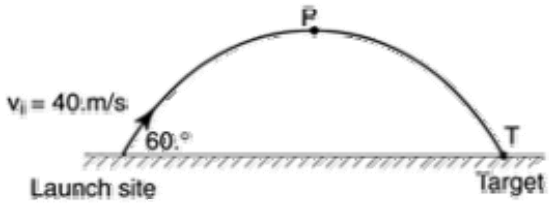


4 The clamshell's descent is an example of projectile motion. The clamshell has an initial horizontal velocity equal to the velocity of flight of the seagull and an initial vertical velocity of 0. Objects in projectile motion, because of the independent horizontal and vertical motions, follow a parabolic pathway best represented in diagram (4).

1

33. A projectile is launched at an angle of 60.° above the horizontal at an initial speed of 40. meters per second, as shown in the diagram . The projectile reaches its highest altitude at point *P* and strikes a target at point *T*. [Neglect air resistance.]

What is the magnitude of the vertical component of the projectile's initial speed?



1. 35 m/s
2. 20. m/s
3. 9.8 m/s
4. 4.3 m/s

1 Write out the problem.

Given: $v_i = 4.0$ m/s
$\theta = 60°$ to the ground

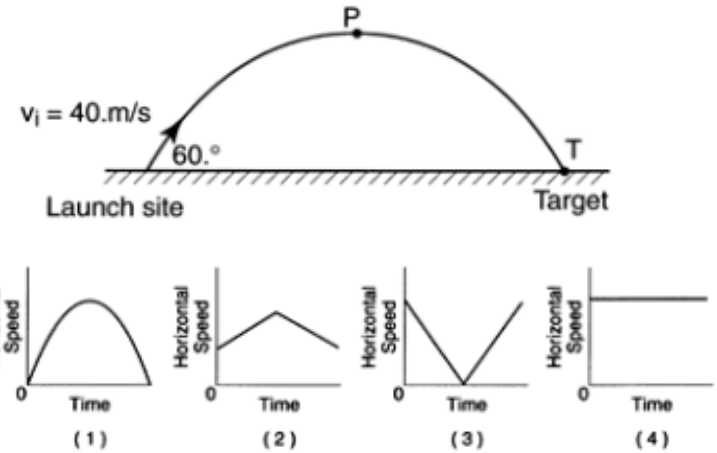
Find: $v_{i_y} = ?$

Refer to the *Motion in a Plane* section in the *Reference Tables* to find an equation(s) that relates the vertical component of initial velocity with an initial velocity and an angle.

Solution: $v_{i_y} = v_i \sin \theta$
$= (40.\ \text{m/s})(\sin 60°)$
$= 35$ m/s

4

34. A projectile is launched at an angle of 60.° above the horizontal at an initial speed of 40. meters per second, as shown in the diagram . The projectile reaches its highest altitude at point *P* and strikes a target at point *T*. [Neglect air resistance.]
Which graph best represents the horizontal speed of the projectile as a function of time? [Neglect air resistance.]



4 As there is no net force acting in the horizontal direction, there is no acceleration. Therefore, velocity in the horizontal direction (40 m/s) is constant for the flight of the projectile. Graph (4) accurately represents constant horizontal speed as a function of time.

Wrong Choices Explained:

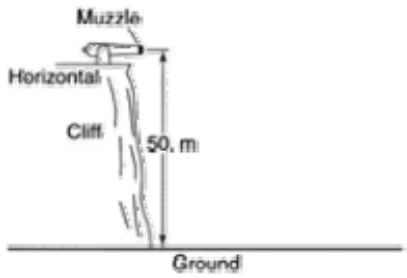
(1) This graph shows continually changing acceleration over time.

(2) This graph indicates a constant positive acceleration, followed by a constant negative acceleration, over time.

(3) This graph indicates a constant negative acceleration, followed by a constant positive acceleration, over time.

3

35. The diagram shows the muzzle of a cannon located 50. meters above the ground. When the cannon is fired, a ball leaves the muzzle with an initial horizontal speed of 250. meters per second. [Neglect air resistance.]



Which action would most likely increase the time of flight of a ball fired by the cannon?

1. pointing the muzzle of the cannon toward the ground
2. moving the cannon closer to the edge of the cliff
3. positioning the cannon higher above the ground
4. giving the ball a greater initial horizontal velocity

3 Time of flight is the time an object takes to fall to the ground. All objects, regardless of their masses, will fall with the same acceleration due to gravity. Since the cannon fires the balls horizontally, their initial velocities in the y directions will all be 0. The only difference between them is the distance of their fall.

$$\Delta s_y = v_{i_y}\Delta t + \frac{1}{2}a_y(\Delta t)^2$$

$$\Delta t = \sqrt{\frac{2\Delta s_y}{a_y}}$$

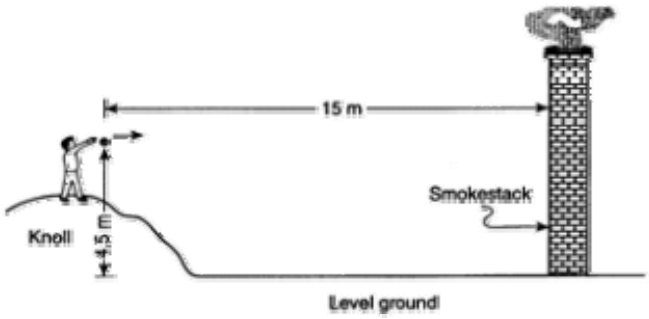
Since the greater the value of Δs, the longer the time of flight, positioning the cannon higher above the ground would be the action most likely to increase the ball's time of flight.

3

36. Base your answer to the following question on the information and diagram.

A student standing on a knoll throws a snowball horizontally 4.5 meters above the level ground toward a smokestack 15 meters away. The snowball hits the smokestack 0.65 second after being released. [Neglect air resistance.]

Approximately how far above the level ground does the snowball hit the smokestack?



1. 0.0 m
2. 0.4 m
3. 2.4 m
4. 4.5 m

3 To know how far above the level ground the snowball hits the smokestack, you need to calculate how far it falls in the 0.65 s before it hits. Motions in the horizontal and vertical directions are independent of each other. Since it is the vertical direction you are interested in, you must consider that an object falling freely near the surface of Earth is subject to a constant acceleration due to Earth's gravity (refer to the *List of Physical Constants* in the *Reference Tables*) and that initially this object has no velocity in the vertical direction.

Given: $\Delta s_{yi} = 4.5$ m Find: height above level ground = ?

$v_{iy} = 0$ m/s

$\Delta t = 0.65$ s

$a_y = 9.8$ m/s^2

Refer to the *Mechanics* section in the *Reference Tables* to find an equation(s) that relates displacement with acceleration and time.

Solution:

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

$$= (0 \text{ m/s})(0.65 \text{ s}) + \frac{1}{2}(9.8 \text{ m/s}^2)(0.65 \text{ s})^2$$

$$= 2.1 \text{ m}$$

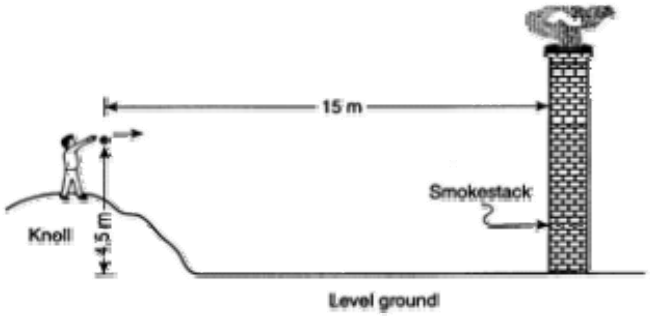
Subtract the 2.1 m that the snowball fell from the initial 4.5 m above the ground at which it started to find that the snowball hits the smokestack 2.4 m above the level ground

4

37. Base your answer to the following question on the information and diagram.

A student standing on a knoll throws a snowball horizontally 4.5 meters above the level ground toward a smokestack 15 meters away. The snowball hits the smokestack 0.65 second after being released. [Neglect air resistance.]

At the instant the snowball is released, the horizontal component of its velocity is approximately



1. 6.9 m/s
2. 9.8 m/s
3. 17 m/s
4. 23 m/s

4 Motions in the horizontal and vertical directions are independent of each other. In this case, no external forces are acting in the horizontal direction, and therefore velocity is constant.

Given: $\Delta s_x = 15\text{ m}$ Find: $v_x = ?$
$\Delta t = 0.65\text{ s}$

Refer to the *Mechanics* section in the *Reference Tables* to find an equation(s) that relates velocity with displacement and time.

Solution:

$$\bar{v}_x = \frac{\Delta s_x}{\Delta t}$$
$$= \frac{15\text{ m}}{0.65\text{ s}}$$
$$= 23\text{ m/s}$$