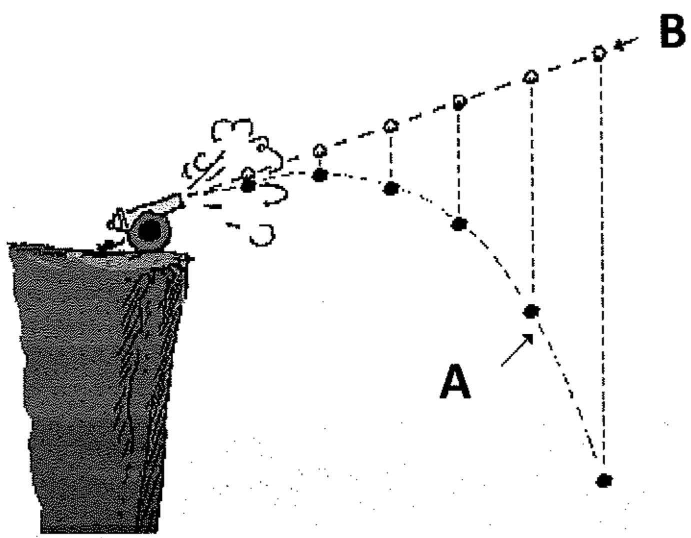
Question:

In the figure below, two possible paths of a fired cannonball projectile are shown. Which statement regarding the paths is correct?



A) Path **A** is the projectile's parabolic inertial trajectory.
B) Path **B** represents the projectile's linear gravitational trajectory.
C) Path **A** corresponds to the projectile's linear gravitational trajectory.
D) Path **B** shows the projectile's parabolic inertial trajectory.
E) None of the above statements are correct

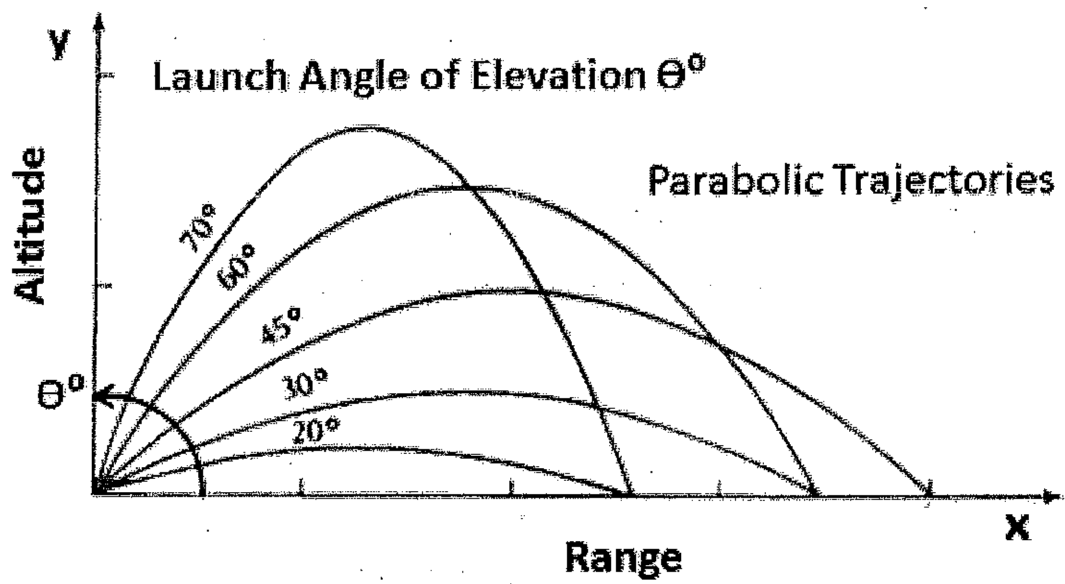
Provide an explanation which justifies your answer!

Answer:

E > Path A shows the projectile's parabolic gravitational trajectory while path B corresponds to the projectile's linear inertial trajectory under the absence of a gravitational force.

Carefully examine the following projectile motion diagram:

Range R vs Launch Angle Θ for a Given Initial Velocity V_0



What do you notice?

List three (3) relationships that stand out.

Answer:

1. **Complimentary angles (angles that add to 90 degrees) yield the same horizontal range for a given initial velocity.**
2. **For a given initial velocity. 45 degrees yields the greatest range.**
3. **For a given initial velocity, the greater the launch angle, the greater vertical height.**

Question:

If air resistance is neglected, which statement concerning projectiles and projectile motion is correct?

I. **The shape of a projectile's trajectory is a parabola.**
II. **For an object to be a projectile it must be in free-fall and have an initial x component of velocity.**
III. **A projectile is characterized by $a_x = 0$ and $a_y = -g$.**

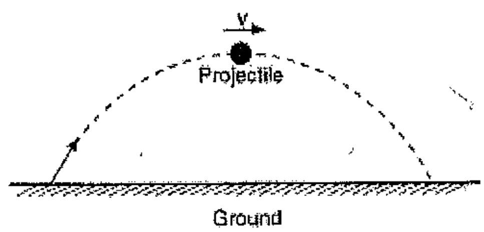
a. I only
b. II only
c. I and II
d. II and III
e. I, II and III

Answer:

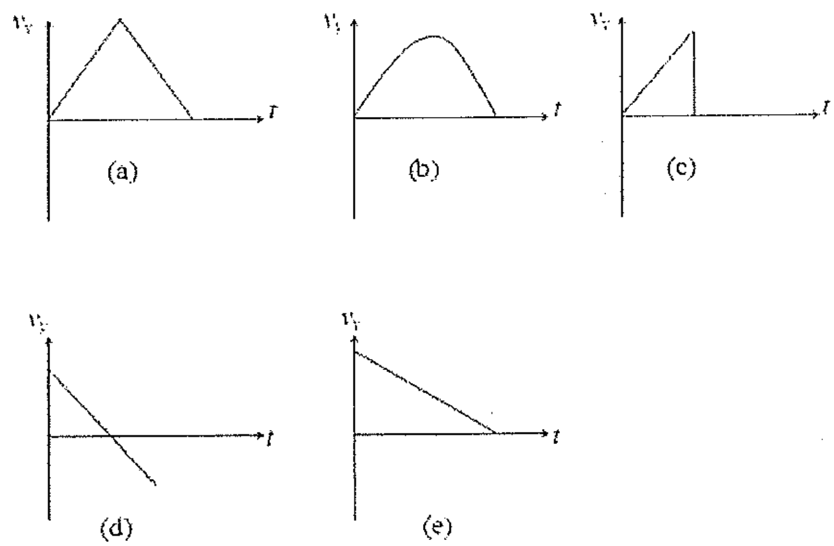
e.

Question:

A projectile is fired in the absence of air resistance and its path is shown below.



Which graph below shows the vertical velocity of the projectile as a function of time?



Answer:

d

Question:

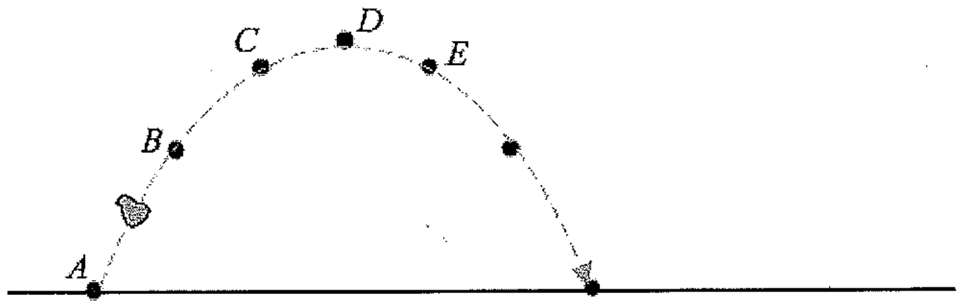
A projectile is launched at a 30° angle above the horizontal. Ignoring air resistance, the projectile's acceleration is

a. greatest at a point between the launch point and the high point of the trajectory.
b. greatest at the high point of the trajectory.
c. greatest at a point between the high point of the trajectory and where it hits the ground.
d. the same (but nonzero) at all points along the trajectory.
e. zero at all points along the trajectory.

Answer:

d.

Question:



A rock is thrown into the air at an angle relative to the vertical, and follows the path shown here. Consider air friction to be negligible. At which position is the vertical velocity of the ball zero?

a. *A*
b. *B*
c. *C*
d. *D*
e. the vertical velocity of the rock is never zero.

Answer:
The correct answer is *d*. The rock has a horizontal velocity throughout its entire path of travel, but its instantaneous vertical velocity is zero at the very top of its trajectory.

Question:

Consider a ball thrown up from the surface of the earth into the air at an angle of 30° above the horizontal. Air friction is negligible. Just *after* the ball is released, its acceleration is:

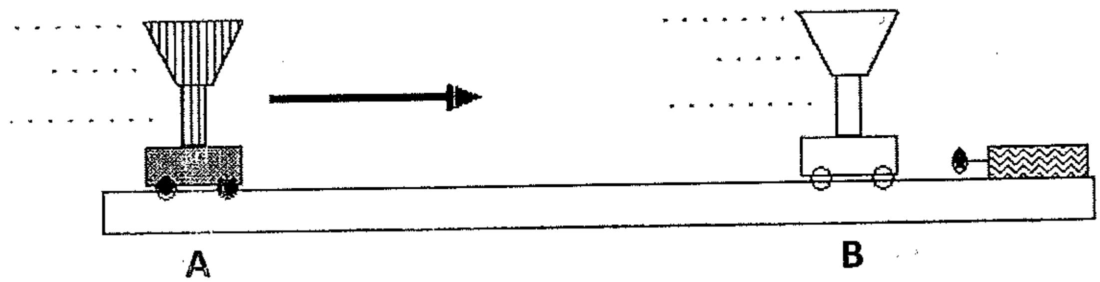
a. Upwards at 9.8 m/s^2
b. Upwards at 4.9 m/s^2
c. Downwards at 9.8 m/s^2
d. 0 m/s^2
e. None of these

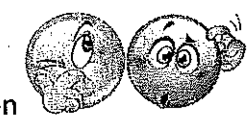
Answer:

The correct answer is *c*. The ball, even as it moves upwards and sideways through the air, experiences a force of gravity acting on it, which causes it to accelerate downwards at g.

Question:

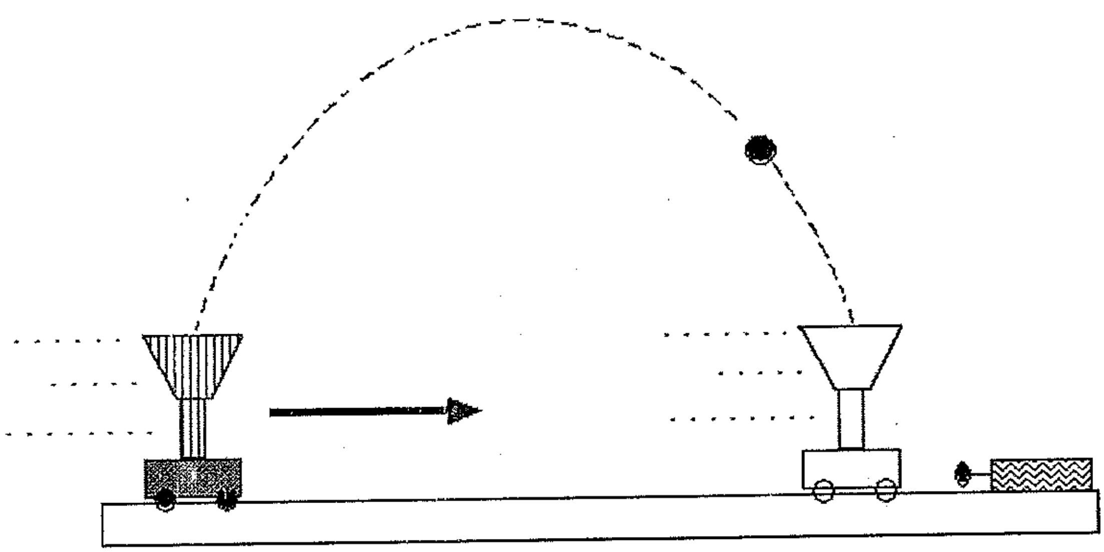
A small ball is placed in a spring-loaded cup attached to a cart that moves along a straight track. The ball is fired straight up when the cart reaches Point **A**. If the cart continues at a constant speed along the track, what will be the position of the ball relative to the cup when it returns to the same height from which it was fired?



- **a.** The ball will land in the cup when the cart reaches Point **B.**
- **b.** The ball will be fired at a forward angle and land at a position on the track ahead of the cup when the cart reaches Point **B.**
- **c.** The ball will go straight up and land on the track at Point **A.**
- **d.** The ball will be fired at a backward angle and land at a position on the track behind Point **A.**
- **e.** Something else will happen 

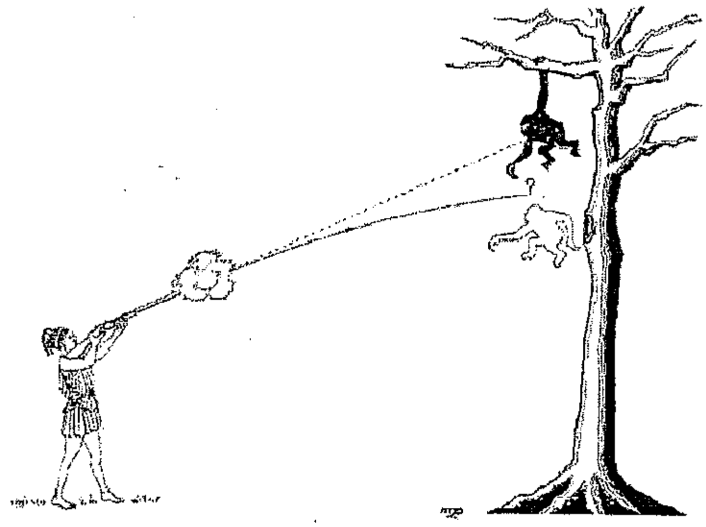
Answer:

a



Question:

Where should the vet aim to hit the monkey with a tranquilizer dart?



a. Aim just above the monkey
b. Aim directly at the monkey
c. Aim just below the monkey
d. Aim the gun horizontally
e. Can't be determined without knowing the speed of the dart

Answer:

b.

Question:

A zookeeper fires a tranquilizer dart directly at a monkey. The monkey lets go at the same instant that the dart leaves the gun barrel. The dart reaches a maximum height P before striking the monkey. Ignore air resistance.

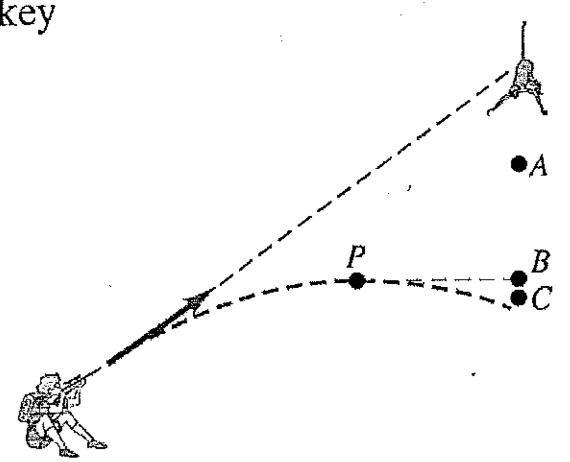
When the dart is at P, the monkey

A. is at A (higher than P).

B. is at B (at the same height as P).

C. is at C (lower than P).

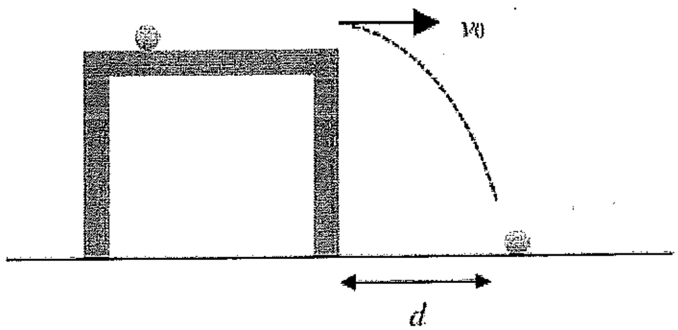
D. not enough information given to decide



Answer:

A.

Question:



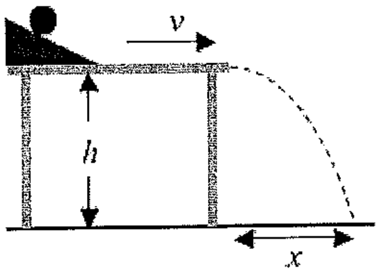
In a physics problem that ignores air friction, a ball rolls across a table, leaves the edge of the table with a horizontal velocity v_0, and is predicted to land on the floor a distance *d* away from the bottom edge of the table. If the ball still leaves the table with a velocity v_0, but air friction is now considered, which of the following statements is true?

a. The ball will land in the same location it landed before.
b. Air friction will slow the ball's vertical travel so it takes longer to fall, and will land at a distance greater than *d*.
c. Air friction acts on both the horizontal and vertical motion of the ball as it falls, and it lands at a distance less than *d*.
d. Air friction acts on both the horizontal and vertical motion of the ball as it falls, but more on the vertical motion.
e. The ball is a projectile—as it falls through the air, its horizontal velocity remains constant.

Answer:
The correct answer is *c*. The air friction force acts according to the velocity of the ball in both horizontal and vertical frames—a greater velocity produces a greater force of air friction. Here, because the horizontal velocity is greater at the beginning of the fall, the air friction horizontally is greater at that moment. We don't have enough information about the relative velocities horizontally and vertically, so we can't really describe the relative strength of the forces throughout the entire time of the fall. But it does act in both directions, reducing the distance that the ball is able to travel.

Another way to consider this is to think of the problem in terms of energy. The initial kinetic and gravitational potential energies of the ball are converted to kinetic energy, with some energy converted to heat during the fall. This has the effect of reducing the final velocity of the ball (along both *x* and *y* axes), compared with the frictionless situation.

Question:



In a lab experiment, a ball is rolled down a ramp so that it leaves the edge of the table with a horizontal velocity v. If the table has a height h above the ground, how far away from the edge of the table, a distance x, does the ball land? You may neglect air friction in this problem.

a. $\frac{2v^2}{g}$

b. $v\sqrt{\frac{2h}{g}}$

c. $\frac{2vh}{g}$

d. $\frac{2h}{g}$

e. none of these

Answer:

The correct answer is *b*. The ball takes a time t to fall from the table, as determined here:

$$\Delta y = v_0 t + \tfrac{1}{2}at^2$$

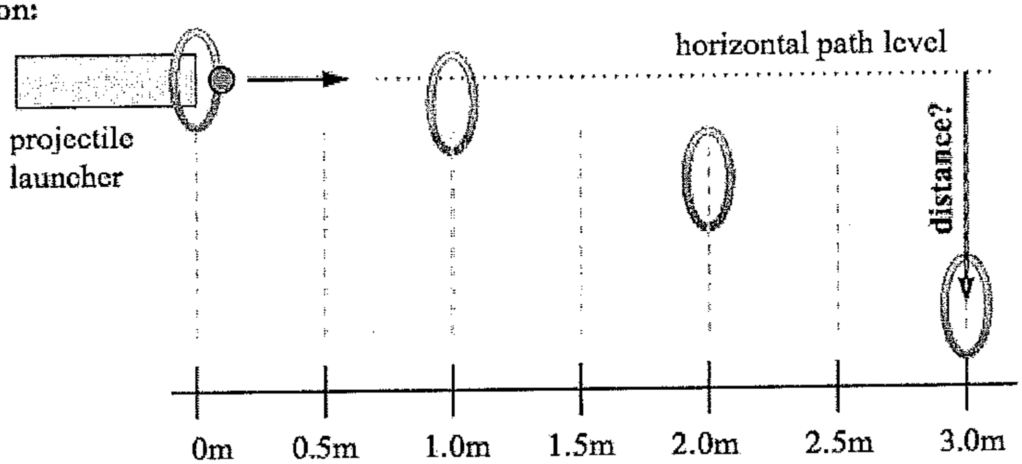
$$t = \sqrt{\frac{2\Delta y}{-g}} = \sqrt{\frac{2h}{g}}$$

Horizontally, during that time the ball travels at constant velocity:

$$\Delta x = vt$$

$$x = v\sqrt{\frac{2h}{g}}$$

Question:



A physics teacher wants to prepare a demonstration on projectile motion for her students. A launcher, placed at the top of a building, will fire a ball horizontally, and the ball will pass through a series of elevated rings that have been set up as shown above. The ball is fired with an initial horizontal velocity of 2.0 m/s; air friction is negligible. At what distance below the horizontal path level should the fourth ring be placed if the ball is to pass through it?

a. 1.5 m
b. 3.0 m
c. 4.5 m
d. 6.0 m
e. 11 m

Answer:

The correct answer is *e*. A horizontal analysis of the ball reveals that it will reach ring 4 in 1.5 seconds:

$$\Delta x = v_x t$$

$$t = \frac{\Delta x}{v_x} = \frac{3.0m}{2.0m/s} = 1.5s$$

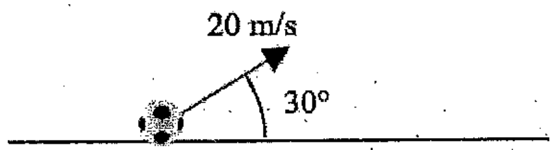
During that time, the vertical distance that the ball falls can be determined:

$$\Delta y = v_i t + \frac{1}{2}at^2$$

$$\Delta y = 0t + \frac{1}{2}(-10m/s^2)(1.5s)^2 = 5 \bullet 2.25 = -11.0m$$

You can also estimate the distance that the ball has traveled during the 1.5 seconds by using average velocity: the accelerating ball has an average velocity of 5m/s during its first second of travel. After one second of falling the ball will have dropped 5.0 meters. In the additional half-second of travel the ball will be moving even faster, making the 11 meter answer the logical result.

Question:



A soccer ball is kicked to give it an initial velocity of 20 m/s at 30° relative to the ground, as shown. The maximum height reached by the ball will be about

a. 10 m
b. 1.0 m
c. 5.0 m
d. 20 m
e. 15 m

Answer:
The correct answer is *c*. To determine the vertical height reached by the ball, we focus only on the vertical aspects of the ball's motion.

The ball has an initial vertical velocity of 20 sin 30, or 10 m/s. The ball's final vertical velocity at the top of its path is 0 m/s. Using kinematics, the maximum height of the ball *y* can be determined:

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$\Delta y = \frac{v_f^2 - v_i^2}{2a} = \frac{0^2 - (10m/s)^2}{2(-10m/s^2)} = 5m$$

The ball has a horizontal aspect to its motion as well, of course—a horizontal velocity of 20 cos 30 = 17.3 m/s, and no acceleration—but these qualities are independent of the ball's vertical motion.

Question:

A rock is thrown straight up into the air with an initial velocity of +50 m/s. How much time does the rock take to reach its maximum height? How much time does it take to fall back down?

	Time up	Time down
a.	5.0 s	5.0 s
b.	10.0 s	10.0 s
c.	5.0 s	10.0 s
d.	10.0 s	5.0 s
e.	2.5 s	2.5 s

Answer:

The correct answer is ***a***. One way of solving this problem is to figure out how long it takes the rock to slow down to a speed of 0 m/s--that's the point at which it will reach its maximum height.

We can sketch a quick table of the rock's speed as it slows down ("*accelerates*") at -10 m/s^2:

Time *t*	Speed *s*
0.0 s	+50.0 m/s
1.0 s	+40.0 m/s
2.0 s	+30.0 m/s
3.0 s	+20.0 m/s
4.0 s	+10.0 m/s
5.0 s	+0.0 m/s

Thus, we can see that it takes about 5.0 seconds to reach that maximum height.

The principle of *symmetry* allows us to predict that the rock is going to take the same amount of time to return to the point from which it was thrown. That may seem true intuitively, but we can also show that that's the case mathematically by calculating the maximum height that it rises to (about 125 meters), and then calculating how long it takes to fall back down:

$$d_{falling} = \frac{1}{2}at^2$$

$$-125m = \frac{1}{2}(-10m/s^2)t^2$$

$$t^2 = \frac{125}{5} = 25;\ t = 5.0s$$

The total time that the rock is in the air is 5.0s + 5.0s = 10.0 s.

Question:

A particle begins from rest at a point +10 meters from the origin at time $t = 0$, and begins accelerating at a constant 2 m/s^2 in the negative direction. At time $t = 4$ seconds, the particle has reached a certain speed; it stops accelerating, and continues traveling with that same speed until $t = 7$ seconds. What is its position relative to the origin at $t = 7$ seconds?

a. -6 meters
b. -30 meters
c. -8 meters
d. -40 meters
e. -59 meters

Answer:

The correct answer is *b*. We can determine the displacement of the particle relative to the origin by examining its motion in two separate steps.

From $t = 0$ to 4 seconds (particle accelerating):

$$x_f = x_i + v_i t + \tfrac{1}{2}at^2$$

$$x_f = +10m + 0 + \tfrac{1}{2}(-2m/s^2)(4s)^2 = -6m$$

To get the displacement for the next part, we need to know how fast the particle is traveling after the 4 seconds have passed:

$$v_f = v_i + at$$

$$v_f = 0 + (-2m/s^2)(4s) = -8m/s$$

From $t = 4$ to 7 seconds (particle at constant velocity:

$$\Delta x = vt$$

$$x_f = x_i + vt$$

$$x_f = -6m + (-8m/s)(3s)$$

$$x_f = -30m$$

Question:

A 2.00 kg mass is dropped from the top of an 80.0 m high vertical cliff at the same time that a 1.00 kg mass is launched horizontally from the top of the cliff with an initial velocity of 8.00 m/s. If air resistance is negligible:

a. the 2 kg mass lands first, with the 1 kg mass landing about 32 m from the base of the cliff
b. the 1 kg mass lands first, about 24 m from the base of the cliff
c. the two masses land at the same time, the 1 kg mass landing about 80 m from the base of the cliff
d. the 2 kg mass lands first, with the 1 kg mass landing about 80 m from the base of the cliff
e. none of the above

Answer:

The correct answer is *e*. Because air resistance is negligible, both masses are going to accelerate at approximately 10 m/s^2 down. It takes about 4 seconds for both masses to reach the ground:

$$\Delta y = v_i t + \frac{1}{2}at^2$$

$$-80 = 0t + \frac{1}{2}(-10)t^2$$

$$t = 4s$$

During that time, the 1 kg projectile has been traveling at a constant 8 m/s horizontally, so it lands 32 m from the base of the cliff.

$$\Delta x = vt$$

$$\Delta x = (8m/s)(4s)$$

$$\Delta x = 32m$$

Question:

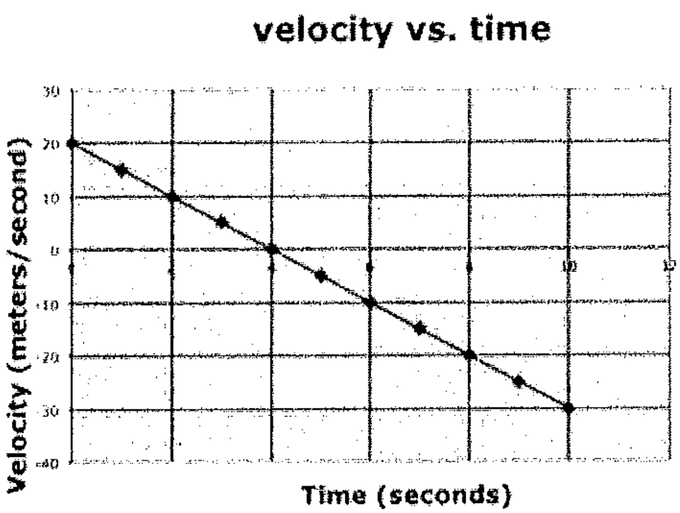
A baseball is tossed straight up into the air so that it rises up a vertical distance and then falls back down where it is caught again. Which of the following statements is true?

a. The ball, while it's traveling upwards, has an upward acceleration.
b. The ball, while it's falling back down, has an upward acceleration.
c. The ball, while it's traveling upwards, has a downward velocity.
d. The ball, at the top of its path, has a downward velocity.
e. The ball, at the top of its path, has a downward acceleration.

Answer:

The correct answer is *e*. The acceleration of the ball throughout its motion in the air is downward, at 9.8 m/s^2 toward the earth.

You may wonder how it could be that an object that is not moving for a moment could nevertheless have an acceleration. The key is that the ball's velocity is in the process of changing, as we can see from this graph of a hypothetical ball's velocity over time.

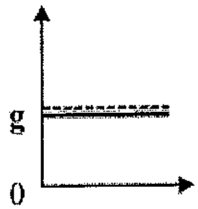


The ball's velocity is constantly changing, from an initial velocity of +20 m/s in this case, to +10 m/s, to +5 m/s, to 0 m/s, and then on down to -5 m/s, -10 m/s, etc. This line crosses the x-axis at 4.0s, at which point the ball's velocity is 0, but the ball's velocity is still in the process of *changing*, and that's why it has an acceleration.

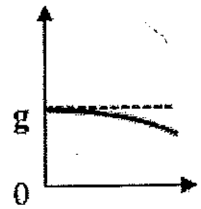
Question:

An object is dropped and accelerates downwards. As it falls it is affected by air friction, but never reaches terminal velocity during the course of its fall. The graph that could indicate the magnitude of the object's acceleration as a function of time is

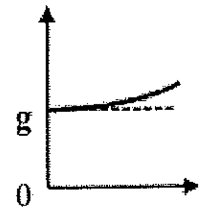
a.



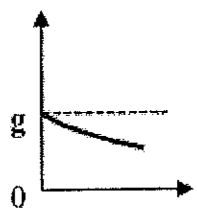
b.



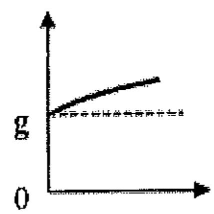
c.



d.



e.



Answer:

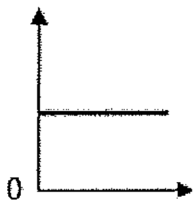
The correct answer is ***d***. The falling object, when released from rest, has an initial acceleration of 9.8 m/s^2 (if near the surface of the earth). As its velocity increases, it collides with air molecules at an increasing rate, thus reducing the rate at which it accelerates. (The acceleration is usually modeled as a function of v or v^2, depending on a number of factors.) The acceleration continues to decrease until the acceleration of the object is 0, at which point the velocity of the falling object remains constant.

The only graph consistent with this analysis is *d*, where the acceleration curve can be seen to be approaching zero asymptotically.

Question:

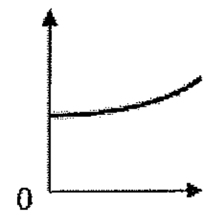
An object is dropped and accelerates downwards. As it falls it is affected by air friction, but never reaches terminal velocity during the course of its fall. The graph that could indicate the magnitude of the object's velocity as a function of time is

a.

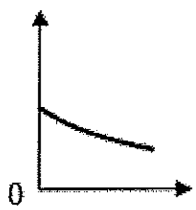


b.

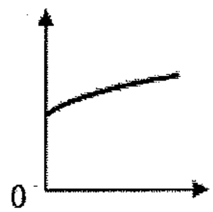
c.



d.



e.



Answer:

The correct answer is *e*. As the falling object accelerates, its velocity continues to increase until its velocity reaches a constant, terminal, velocity, at which point the velocity function will be a straight, flat line. The only curve that shows an increase in velocity, approaching a slope of zero, is answer *e*.

Question:

Consider a ball thrown up from the surface of the earth into the air at an angle of 30° above the horizontal. Air friction is negligible. Just *after* the ball is released, its acceleration is:

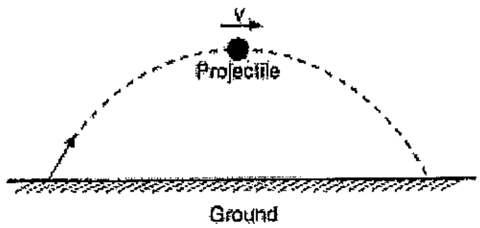
a. Upwards at 9.8 m/s^2
b. Upwards at 4.9 m/s^2
c. Downwards at 9.8 m/s^2
d. 0 m/s^2
e. None of these

Answer:

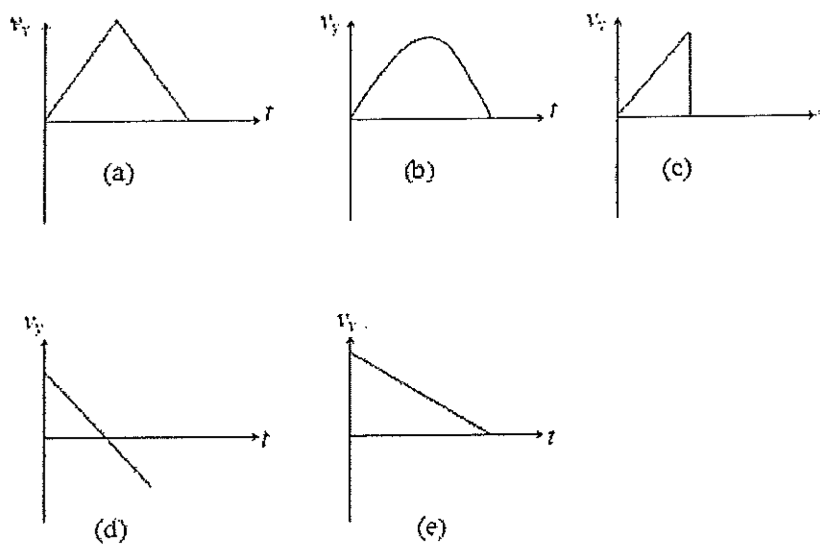
The correct answer is *c*. The ball, even as it moves upwards and sideways through the air, experiences a force of gravity acting on it, which causes it to accelerate downwards at g.

Question:

A projectile is fired in the absence of air resistance and its path is shown below.



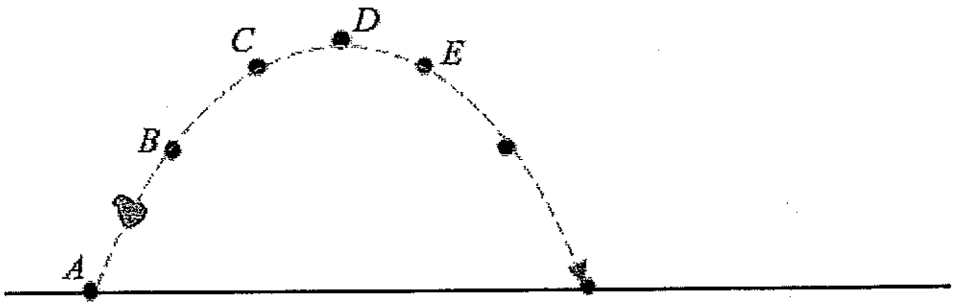
Which graph below shows the vertical velocity of the projectile as a function of time?



Answer:

d

Question:



A rock is thrown into the air at an angle relative to the vertical, and follows the path shown here. Consider air friction to be negligible. At which position is the vertical velocity of the ball zero?

a. *A*
b. *B*
c. *C*
d. *D*
e. the vertical velocity of the rock is never zero.

Answer:
The correct answer is ***d***. The rock has a horizontal velocity throughout its entire path of travel, but its instantaneous vertical velocity is zero at the very top of its trajectory.

Question:

If air resistance is neglected, which statement concerning projectiles and projectile motion is correct?

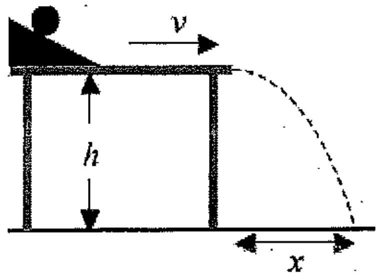
I. **The shape of a projectile's trajectory is a parabola.**
II. **For an object to be a projectile it must be in free-fall and have an initial x component of velocity.**
III. **A projectile is characterized by $a_x = 0$ and $a_y = -g$.**

a. I only
b. II only
c. I and II
d. II and III
e. I, II and III

Answer:

e.

Question:



In a lab experiment, a ball is rolled down a ramp so that it leaves the edge of the table with a horizontal velocity v. If the table has a height h above the ground, how far away from the edge of the table, a distance x, does the ball land? You may neglect air friction in this problem.

a. $\frac{2v^2}{g}$

b. $v\sqrt{\frac{2h}{g}}$

c. $\frac{2vh}{g}$

d. $\frac{2h}{g}$

e. none of these

Answer:

The correct answer is *b*. The ball takes a time t to fall from the table, as determined here:

$$\Delta y = v_0 t + \tfrac{1}{2}at^2$$

$$t = \sqrt{\frac{2\Delta y}{-g}} = \sqrt{\frac{2h}{g}}$$

Horizontally, during that time the ball travels at constant velocity:

$$\Delta x = vt$$

$$x = v\sqrt{\frac{2h}{g}}$$

Question:

A ball rolling across a flat, horizontal table has a velocity of v_1. After it leaves the edge of the table, the ball continues to travel with a constant horizontal velocity as it begins to fall. Just before the ball hits the ground, it has a net velocity of v_2. What is the ball's vertical speed at this moment?

a. v_2

b. $v_1 + v_2$

c. $v_2 - v_1$

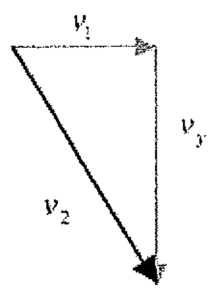
d. $\sqrt{v_1^2 + v_2^2}$

e. $\sqrt{v_2^2 - v_1^2}$

Answer:

The correct answer is *e*. This is a projectile problem in which the ball has a constant horizontal velocity v_1 and an unknown vertical velocity. The given *net* velocity v_2 can be used to find the unknown vertical velocity v_y by applying the Pythagorean theorem:

$$v_1^2 + v_y^2 = v_2^2$$
$$v_y^2 = v_2^2 - v_1^2$$
$$v_y = \sqrt{v_2^2 - v_1^2}$$



Question:
A circus cannon fires an acrobat into the air at an angle of 45° above the horizontal, and the acrobat reaches a maximum height y above her original launch height. The cannon is now aimed so that it fires straight up into the air at an angle of 90° to the horizontal. What is the maximum height reached by the same acrobat now?

a. y

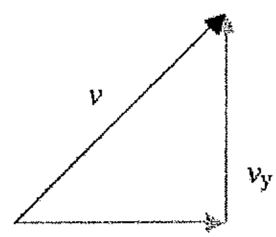
b. $\frac{y}{2}$

c. $2y$

d. $y\sqrt{2}$

e. $\frac{2y}{\sqrt{2}}$

Answer:
The correct answer is *c*. The acrobat reaches her height in the first instance based on the initial vertical component of velocity, v_y:



$$v_f^2 = v_i^2 - 2ay$$

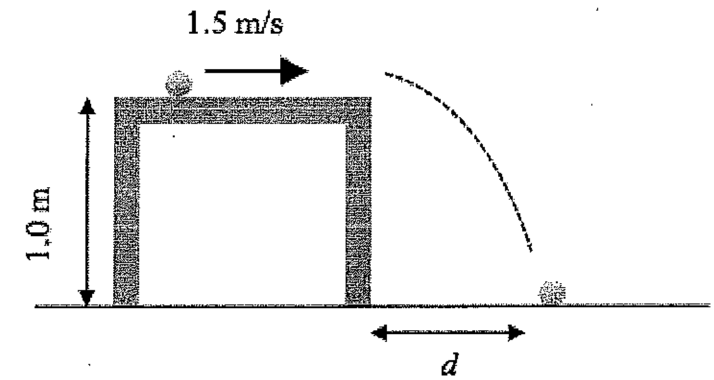
$$y = \frac{0 - v_i^2}{-2g} = \frac{v_i^2}{2g}$$

For the second situation, the vertical velocity v is greater than v_y from before, by a factor of $\sqrt{2}$. Using this information:

$$y' = \frac{(v_i')^2}{2g}$$

$$y' = \frac{(v\sqrt{2})^2}{2g} = \frac{2v^2}{2g} = 2y$$

Question:



A marble rolls along the top of a smooth, flat table with a velocity of 1.5 m/s. When the marble rolls off the edge of the 1.0-meter high table, how far away from the bottom edge of the table will it land?

a. 0.50 m
b. 0.68 m
c. 0.45 m
d. 1.5 m
e. 0.15 m

Answer:

The correct answer is *b*. The first step is to figure out how long it takes the ball to fall to the floor, which is a *vertical* problem: we'll only be using vertical quantities for this analysis.

$v_i = 0$

$a = -9.8m/s^2$

$\Delta y = -1.0m$ (or you might use $d = 1.0m$)

$t = ?$

$\Delta y = v_i t + \frac{1}{2}at^2 \rightarrow t = \sqrt{\frac{2\Delta y}{a}}$ (or you might use $d = \frac{1}{2}at^2$)

$t = \sqrt{\frac{2(1.0m)}{9.8m/s^2}} = 0.45s$

Note that there are slightly different versions of the formula that you might use, depending on how you want to analyze the problem (or what your teacher uses).

Now, the time that the ball takes to fall *vertically* is the same amount of time that the ball is in motion *horizontally*, so let's see how far it travels horizontally during that time.

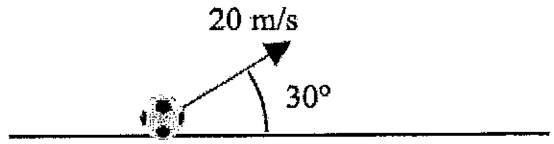
$v = 1.5m/s$

$t = 0.45s$ (from above)

$d = ?$

$d = st = (1.5m/s)(0.45s) = 0.68m$

Question:



A soccer ball is kicked to give it an initial velocity of 20 m/s at 30° relative to the ground, as shown. The maximum height reached by the ball will be about

a. 10 m
b. 1.0 m
c. 5.0 m
d. 20 m
e. 15 m

Answer:
The correct answer is *c*. To determine the vertical height reached by the ball, we focus only on the vertical aspects of the ball's motion.

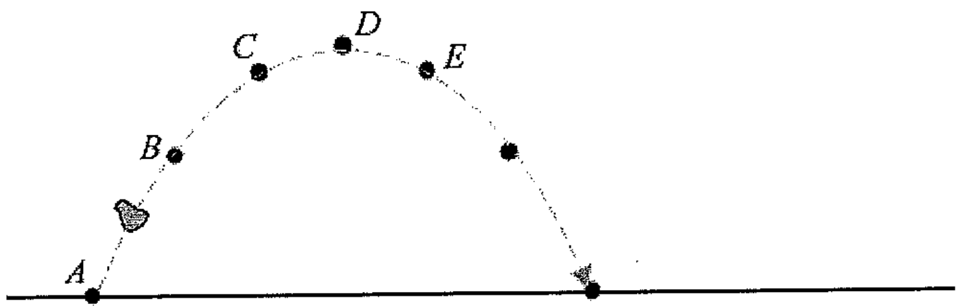
The ball has an initial vertical velocity of 20 sin 30, or 10 m/s. The ball's final vertical velocity at the top of its path is 0 m/s. Using kinematics, the maximum height of the ball *y* can be determined:

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$\Delta y = \frac{v_f^2 - v_i^2}{2a} = \frac{0^2 - (10m/s)^2}{2(-10m/s^2)} = 5m$$

The ball has a horizontal aspect to its motion as well, of course—a horizontal velocity of 20 cos 30 = 17.3 m/s, and no acceleration—but these qualities are independent of the ball's vertical motion.

Question:



A rock is thrown into the air at an angle relative to the vertical, and follows the path shown here. Consider air friction to be negligible. What is the direction of the net acceleration of the rock at point *D*?

a. to the left
b. to the right
c. straight up
d. straight down
e. there is no net acceleration at point *D*

Answer:
The correct answer is ***d***. The rock has constant horizontal velocity, and therefore no horizontal acceleration. Vertically, the rock's velocity is constantly changing, slowing down as it ascends, and speeding up as it falls. Its net acceleration, or change in velocity per unit time, is always in the downward direction.

Question:

A projectile is fired horizontally from a height of 20 meters above the ground, with an initial velocity of 7.0 m/s. How far does the projectile travel horizontally before it reaches the ground?

a. 7m
b. 14m
c. 140m
d. 3.5m
e. 20m

Answer:

The correct answer is *b*. We begin by finding how much time it takes the object to fall the 20m:

$$\Delta y = v_i t + \tfrac{1}{2}at^2$$

$$-20m = 0t + \tfrac{1}{2}(-10)t^2$$

$$t = \sqrt{4} = 2\ s$$

Then, determine how far the ball travels horizontally during that time:

$$\Delta x = v_x t$$

$$\Delta x = (7m/s)(2s) = 14m$$

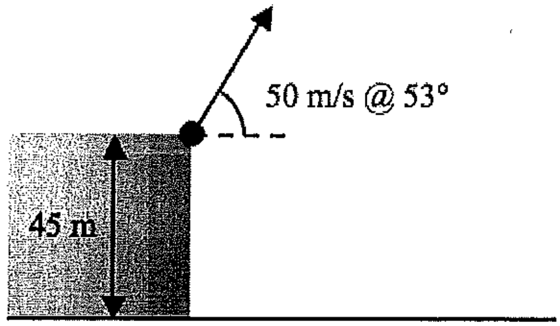
Question:

Imagine that you're a passenger in the back seat of a car moving at constant speed along a straight road. You toss a ball straight up.

1. **What direction does the ball seem to move**
   a) **as seen from your viewpoint riding in the car?**
   b) **to an observer at rest on the sidewalk?**

For each of the cases above, explain your reasoning and draw a diagram that supports your analysis.

Question:



A projectile is launched at 50 m/s, at an angle of 53 degrees above the horizontal, from the top of a 45 meter high vertical cliff. If air resistance is negligible, the projectile lands:

a. about 120 m from the base of the cliff
b. about 90 m from the base of the cliff
c. about 135 m from the base of the cliff
d. about 450 m from the base of the cliff
e. about 270 m from the base of the cliff

Answer:

The correct answer is *e*. The projectile begins its motion at an angle of 53° above the horizontal, which indicates that its components are part of a 3-4-5 triangle:

$$v_x = v\cos\theta = 50\cos 53° = 50(3/5) = 30 m/s$$

$$v_y = v\sin\theta = 50\sin 53° = 50(4/5) = 40 m/s$$

Kinematics can be applied to the vertical motion to determine the time that the projectile is in the air:

$$\Delta y = v_i t + \frac{1}{2}at^2$$

$$-45 = 40t + \frac{1}{2}(-10)t^2$$

$$-9 = 8t - t^2$$

$$t^2 - 8t - 9 = 0$$

$$(t-9)(t+1) = 0$$

$$t = \{9, -1\}$$

The particle is in the air for 9 seconds, so we can determine how far it travels horizontally in that time:

$$\Delta x = vt = (30 m/s)(9 s) = 270 m$$

Question:

If air resistance is neglected, the range of a projectile is dependent on

I. ***g***, **the acceleration due to gravity.**

II. **the *horizontal* component of its initial velocity.**

III. **the *vertical* component of its initial velocity.**

a. I only
b. II only
c. I and II
d. II and III
e. I, II and III

Answer:

e.

Question:

From the top of a tall cliff of height *y*, one soccer ball is released from rest so that it falls straight down, and another is kicked horizontally so that it leaves the cliff at the same time with a horizontal velocity *v*. Assuming air friction is negligible:

a. the ball falling straight down will reach the ground first

b. the kicked ball will reach the ground first

c. both balls will reach the ground at time $t = \frac{2y}{g}$

d. both balls will reach the ground at time $t = \sqrt{\frac{2y}{g}}$

e. both balls will reach the ground at time $t = \frac{-v \pm \sqrt{v^2 + 2g}}{a}$

Answer:

The correct answer is *d*. The vertical acceleration of both soccer balls is **g** in the downward direction, and the time that it takes each ball to reach the ground may be determined using kinematics:

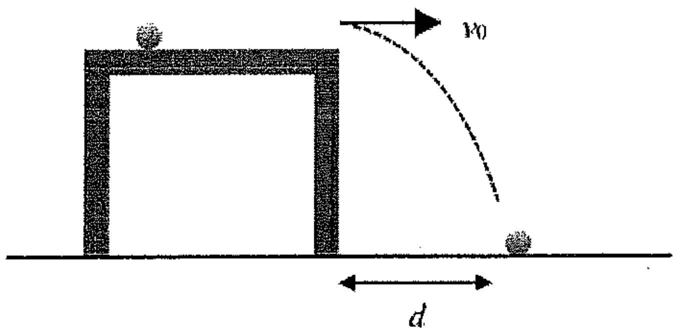
$$\Delta y = v_i t + \frac{1}{2}at^2$$

$$y = 0t + \frac{g}{2}t^2$$

$$t = \sqrt{\frac{2y}{g}}$$

Although the kicked ball does have an initial horizontal velocity, this fact doesn't affect its vertical motion, so both balls reach the ground at the same time.

Question:



In a physics problem that ignores air friction, a ball rolls across a table, leaves the edge of the table with a horizontal velocity v_0, and is predicted to land on the floor a distance *d* away from the bottom edge of the table. If the ball still leaves the table with a velocity v_0, but air friction is now considered, which of the following statements is true?

a. The ball will land in the same location it landed before.
b. Air friction will slow the ball's vertical travel so it takes longer to fall, and will land at a distance greater than *d*.
c. Air friction acts on both the horizontal and vertical motion of the ball as it falls, and it lands at a distance less than *d*.
d. Air friction acts on both the horizontal and vertical motion of the ball as it falls, but more on the vertical motion.
e. The ball is a projectile—as it falls through the air, its horizontal velocity remains constant.

Answer:
The correct answer is *c*. The air friction force acts according to the velocity of the ball in both horizontal and vertical frames—a greater velocity produces a greater force of air friction. Here, because the horizontal velocity is greater at the beginning of the fall, the air friction horizontally is greater at that moment. We don't have enough information about the relative velocities horizontally and vertically, so we can't really describe the relative strength of the forces throughout the entire time of the fall. But it does act in both directions, reducing the distance that the ball is able to travel.

Another way to consider this is to think of the problem in terms of energy. The initial kinetic and gravitational potential energies of the ball are converted to kinetic energy, with some energy converted to heat during the fall. This has the effect of reducing the final velocity of the ball (along both *x* and *y* axes), compared with the frictionless situation.