Question:

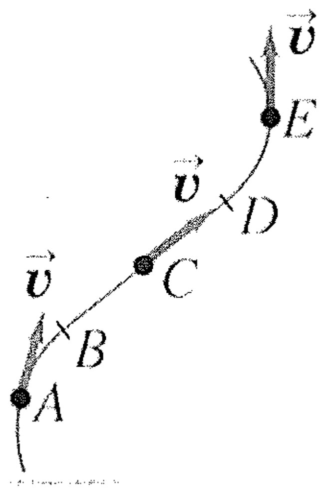
At this point, you can apply the kinematic principles to determine the position, displacement, velocity and acceleration of an object moving along a straight path. But how can these quantities be used to describe the motion of objects moving along a curved path in two or three dimensions?

Answer:

In order to describe two- or three- dimensional motion, the principles of kinematics and vectors are combined. As a result, the one-dimensional kinematic quantities take on two- and three-dimensional qualities which can be applied to a variety of situations exhibiting more involved and complex motion.

A3.3

The motion diagram shows an object moving along a curved path at constant speed. At which of the points *A*, *C*, and *E* does the object have *zero* acceleration?



A. point *A* only

✓ B. point *C* only

C. point *E* only

D. points *A* and *C* only

E. points *A*, *C*, and *E*

Question:

When an object moves in non-uniform circular motion:

a. There must exist a radial component of its velocity.
b. The radial component of its acceleration must vary with time.
c. The total acceleration vector must at all times be directed radially outward form the circle's center of rotation.
d. There must be at all times a component of the object's acceleration directed opposite to the velocity.
e. None of the above

Answer:

e.

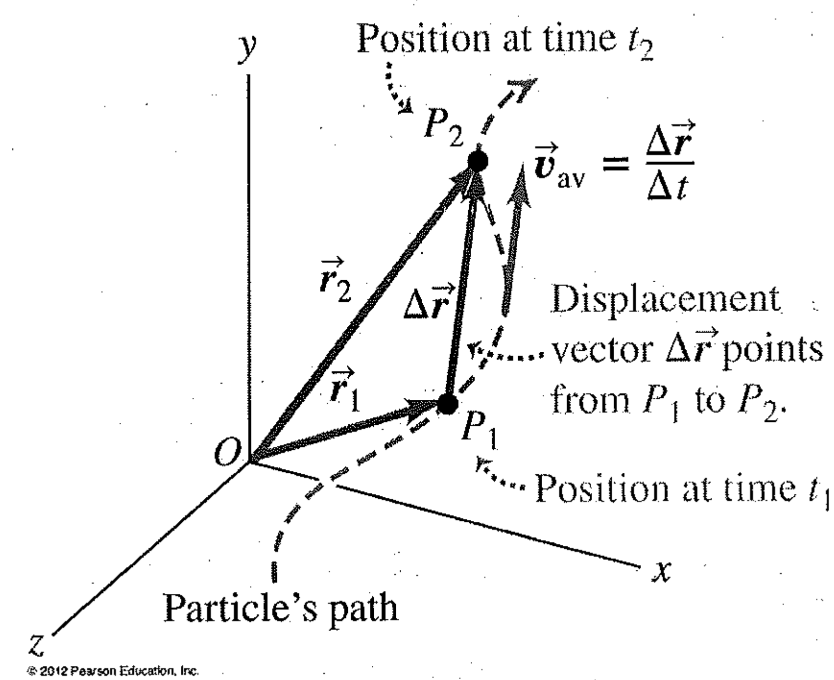
Question:

The average velocity for a particle moving along a curved path between points P_1 and P_2 has the same direction as

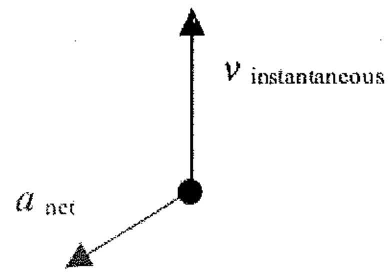
a. the change in position vector from P_2 to P_1.
b. the displacement vector from P_1 and P_2.
c. the displacement vector form the origin to P_1.
d. the displacement vector form the origin to P_2.
e. the instantaneous velocity at the midpoint of the path between points P_1 and P_2.

Answer:

b.



Question:

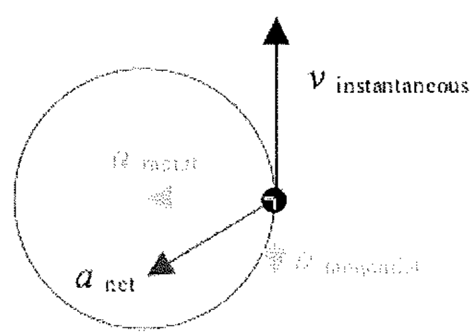


The instantaneous velocity and net acceleration for an object moving in a circular path are shown above. At this moment in time, the object is

a. speeding up in a clockwise circle
b. slowing down in a clockwise circle
c. speeding up in a counterclockwise circle
d. slowing down in a counterclockwise circle
e. traveling in a clockwise circle at constant speed

Answer:

The correct answer is *d.* The instantaneous velocity of the object is tangent to its circular path, and we know that there's a radial (centripetal) aspect of the net acceleration that points towards the center of the circular path. Thus, we can conclude that the object is traveling in a circular path that is located to its left, as shown here.



We can also see that the net acceleration must include a tangential component of acceleration that is in the opposite direction of the instantaneous velocity, implying that the object is slowing down as it travels along this circular path.

Question:

Which of the following statements concerning circular motion is correct?

- **I. An object's velocity is constantly changing as it moves in a circular path at constant speed.**
- **II. Any object moving in a circular path at constant speed is accelerating.**
- **III. Circular motion is not a natural state of motion.**

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

Answer:

e.

Question:

What is the direction of an object's acceleration as it moves in a circular path at constant speed?

a. Tangent to the path
b. Outward, away from the circle's center
c. Inward, toward the circle's center
d. Objects moving in circular paths are not accelerating
e. Can't answer unless the speed of the object is known

Answer:

c.

Question:

Which of the following statements concerning uniform circular motion is correct?

I. **An object moving in uniform circular motion follows a path governed by its inertia.**
II. **In order for an object to move in uniform circular motion it must have an acceleration which is tangent to the circular path of its motion.**
III. **The direction of an object moving in uniform circular motion is at every point tangent to the circular path of its motion.**

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

Answer:

c.

Question:

A child whirls a ball at the end of a rope, in a uniform circular motion. Which of the following statements is **NOT** true?

(A) The speed of the ball is constant
(B) The velocity of the ball is constant
(C) The radius is constant
(D) The magnitude of the ball's acceleration is constant
(E) The acceleration of the ball is directed radially inwards towards the center

Answer:

B. Any object moving in a curved path, like a circle, has a constant change in direction. Velocity is a vector comprising both magnitude and direction. By definition, since the ball's direction is constantly changing, the velocity must also be changing.

Question

A pendulum swings back and forth, reaching a maximum angle of 45° from the vertical. Which arrow shows the direction of the pendulum bob's acceleration at *P* (the far left point of the motion)?

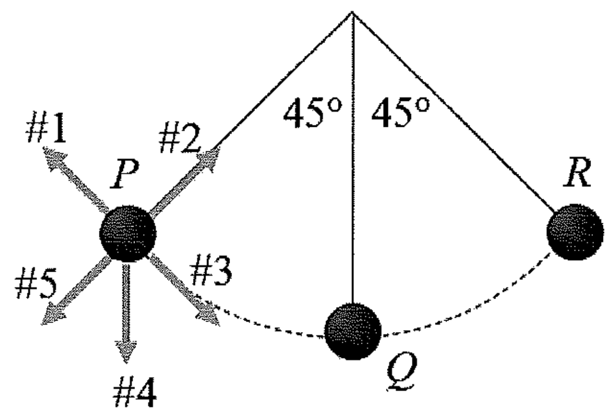
A. #1 (up and to the left)

B. #2 (up and to the right)

✓ C. #3 (down and to the right)

D. #4 (straight down)

E. #5 (down and to the left)



Question

A pendulum swings back and forth, reaching a maximum angle of 45° from the vertical. Which arrow shows the direction of the pendulum bob's acceleration as it moves from left to right through point Q (the low point of the motion)?

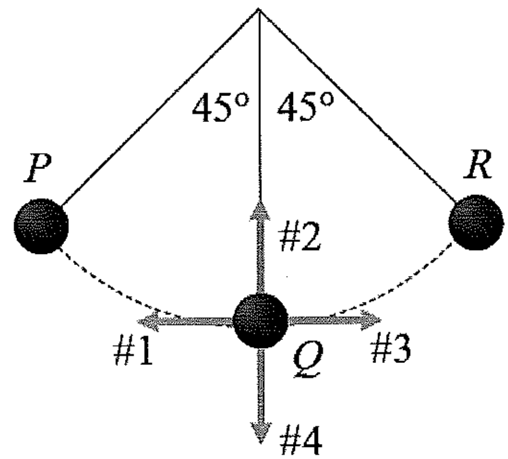
A. #1 (to the left)

✓ B. #2 (straight up)

C. #3 (to the right)

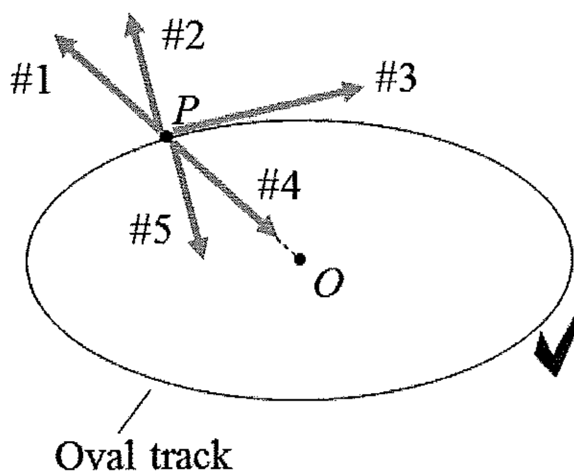
D. #4 (straight down)

E. misleading question—the acceleration is zero at Q



Question

An object moves at a constant speed in a clockwise direction around an oval track. The geometrical center of the track is at point *O*. When the object is at point *P*, which arrow shows the direction of the object's acceleration vector?



A. #1 (directly away from *O*)

B. #2 (perpendicular to the track)

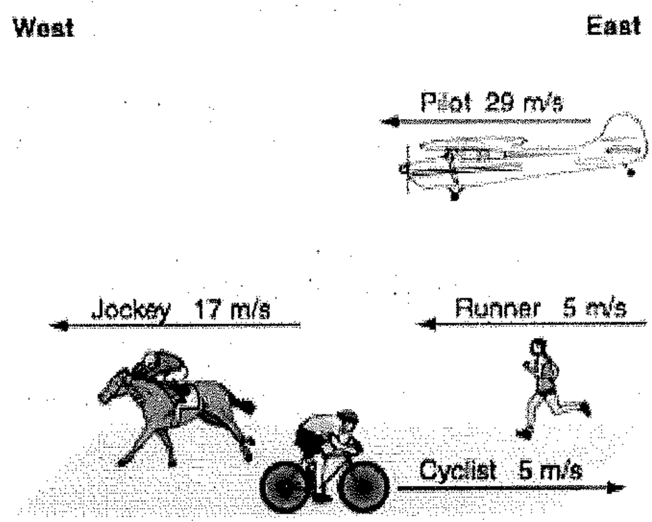
C. #3 (in the direction of motion)

D. #4 (directly toward *O*)

E. #5 (perpendicular to the track)

Question:

Consider the velocities of the objects shown in the figure below. The velocities given are those relative to the Earth.



Determine:

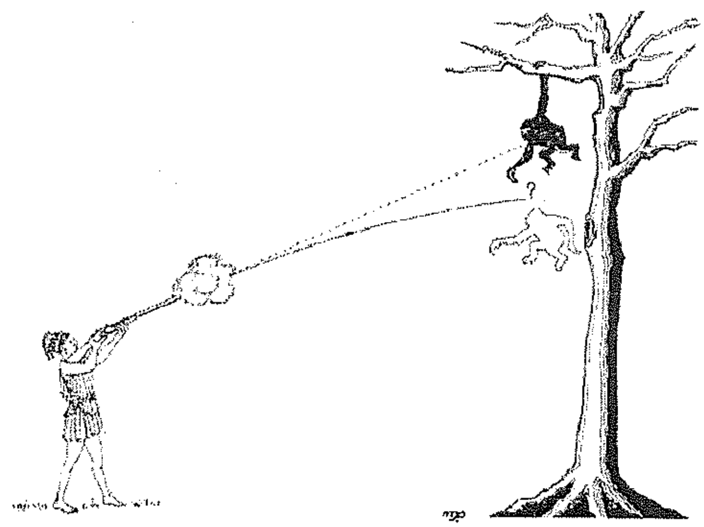
1. **the Jockey's velocity relative to the Pilot.**
2. **the Runner's velocity relative to the Jockey.**
3. **the Jockey's velocity relative to the Cyclist.**

Answer:

1. **12 m/s East**
2. **12 m/s East**
3. **22 m/s West**

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.

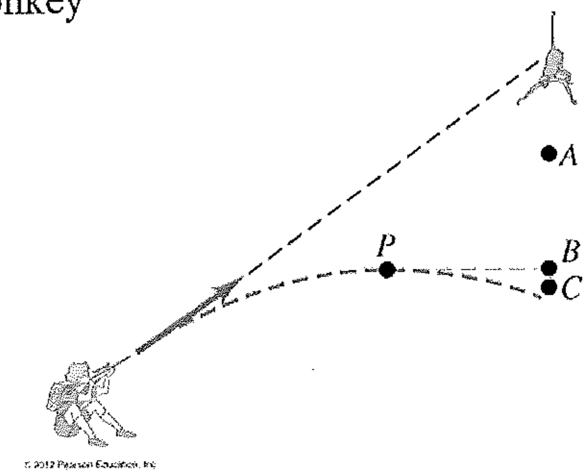
When the dart is at *P*, the monkey

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

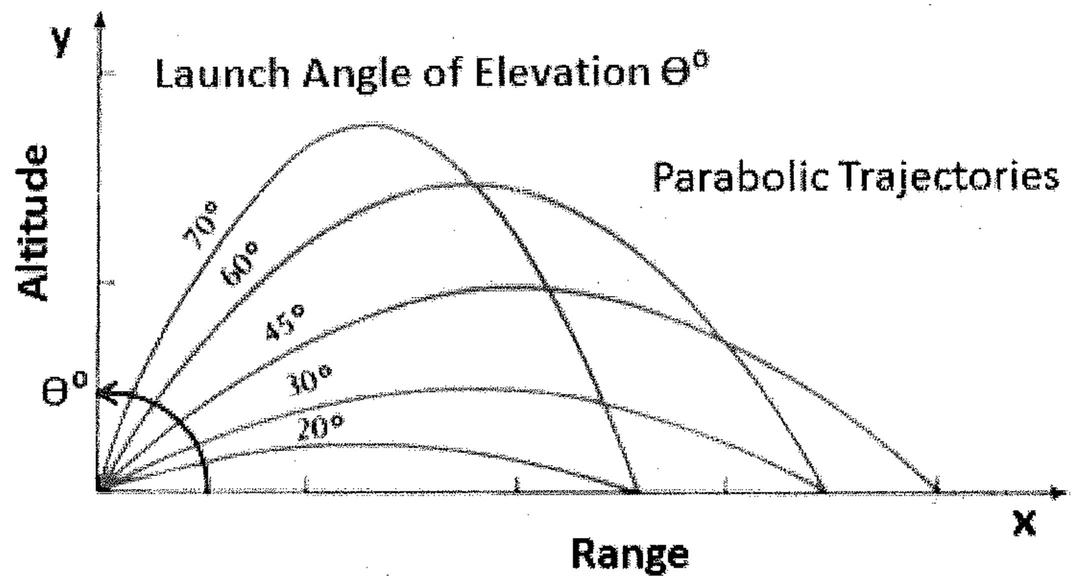


Answer:

A.

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 $a_y = -g$.

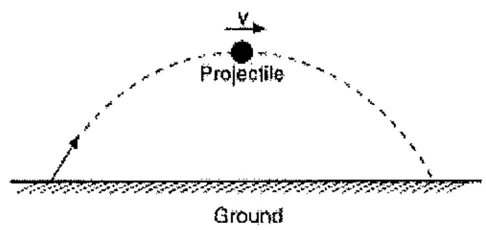
a. I only
b. II only
c. I and II
d. II and III
e. I, II and III

Answer:

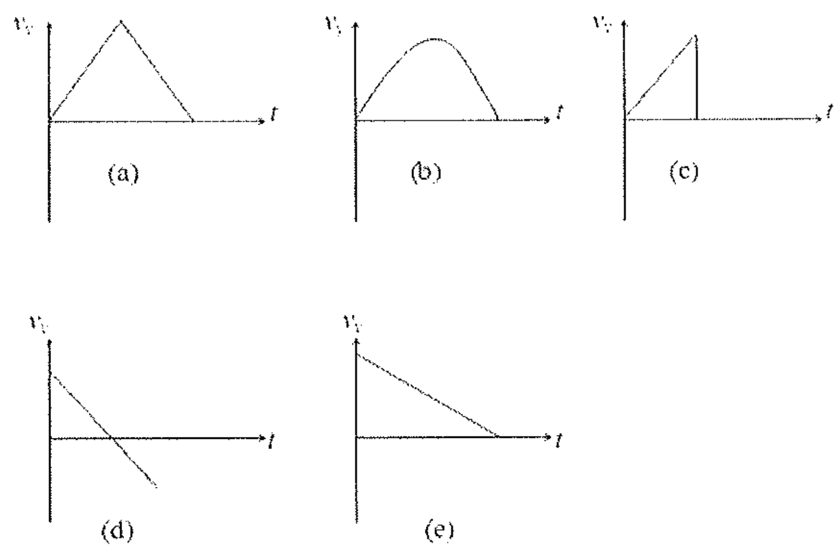
e.

Question:

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



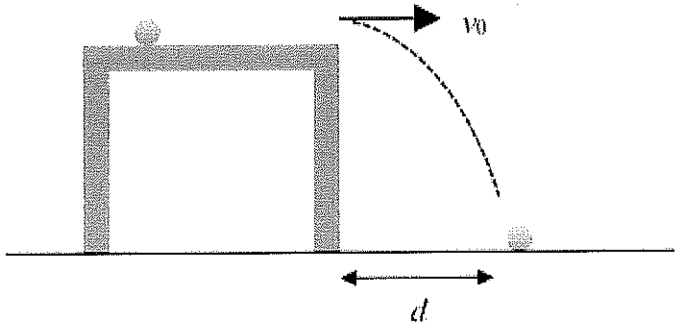
Which graph below shows the vertical velocity of the projectile as a function of time?



Answer:

d

Question:



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:

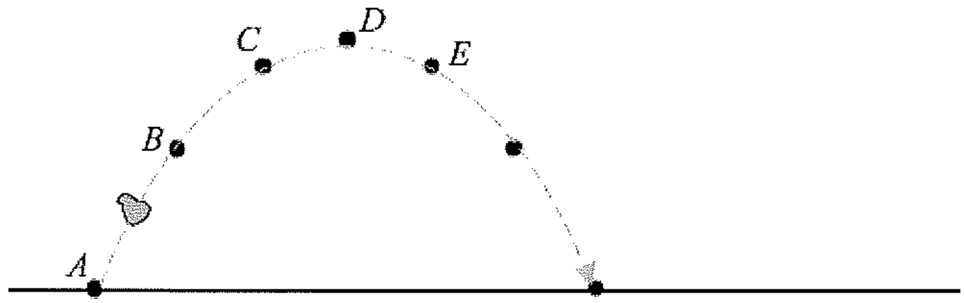
A projectile is launched at a 30° angle above the horizontal. Ignoring air resistance, the projectile's acceleration is

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:

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

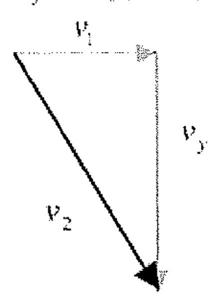
Answer:

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

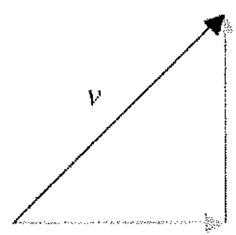
b. $\frac{y}{2}$

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:



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

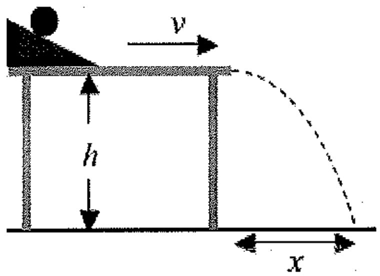
$$y = \frac{0 - v_i^2}{-2g} = \frac{v_i^2}{2g}$$

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:



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:

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

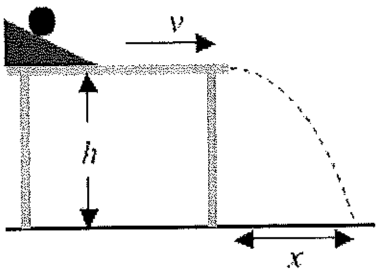
$$t = \sqrt{\frac{2\Delta y}{-g}} = \sqrt{\frac{2h}{g}}$$

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

$$\Delta x = vt$$

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

Question:



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

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

e. none of these

Answer:

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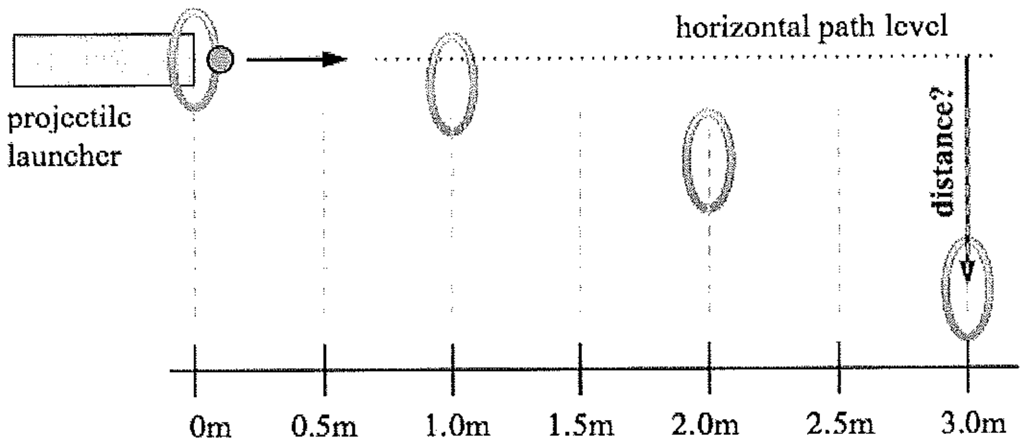
Question:



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:

$$\Delta x = v_x t$$

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

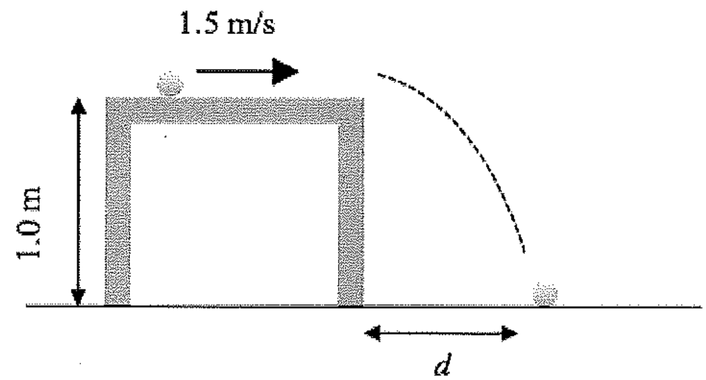
During that time, the vertical distance that the ball falls can be determined:

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

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

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 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.

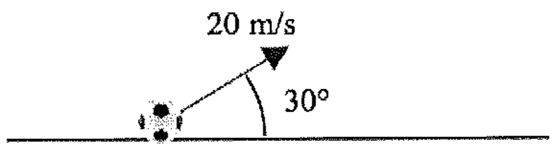
$v = 1.5m/s$

$t = 0.45s$ (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:

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 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:

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

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

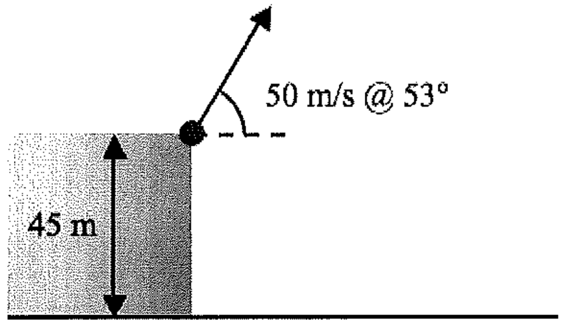
$t = \sqrt{4} = 2\ s$

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

$\Delta x = v_x t$

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

Question:



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:

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

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

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:

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

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:

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:

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 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 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):

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

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

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:

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:

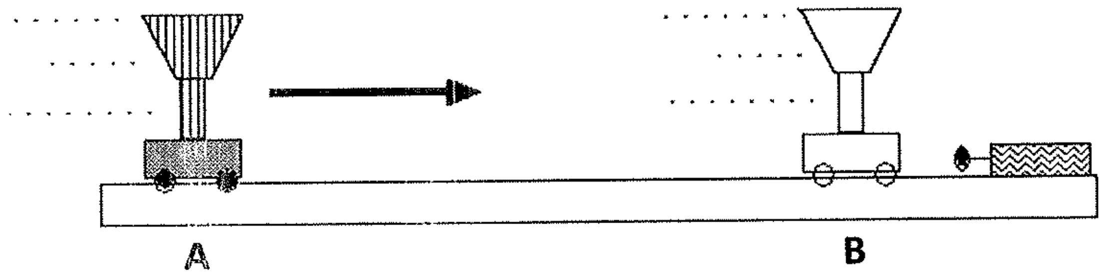
a. Upwards at 9.8 m/s^2
b. Upwards at 4.9 m/s^2
c. Downwards at 9.8 m/s^2
d. 0 m/s^2
e. None of these

Answer:

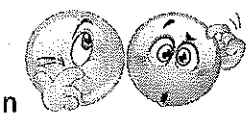
The correct answer is *c*. The ball, even as it moves upwards and sideways through the air, experiences a force of gravity acting on it, which causes it to accelerate downwards at **g**.

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?



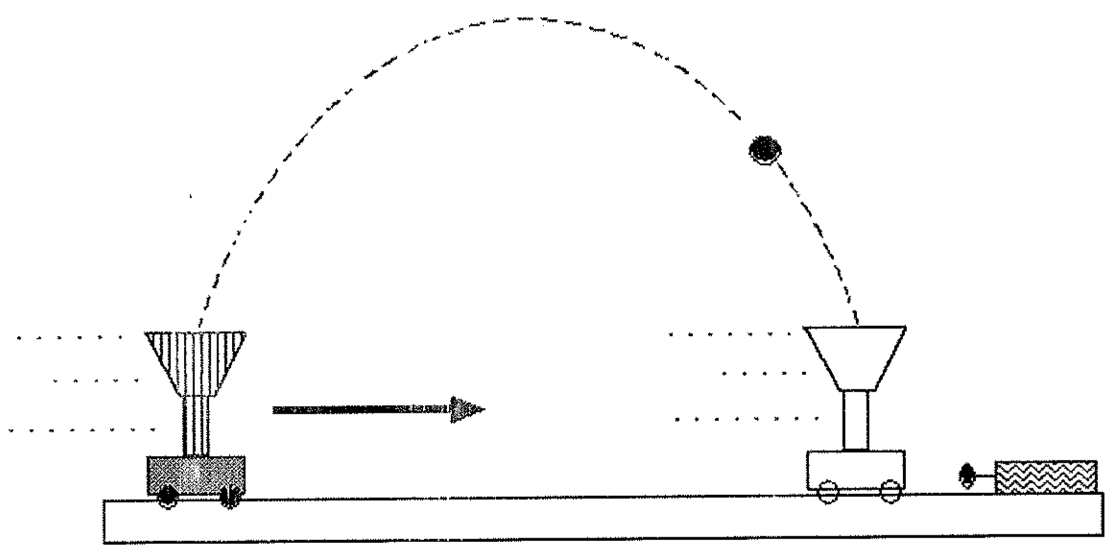
a. The ball will land in the cup when the cart reaches Point **B**.
b. The ball will be fired at a forward angle and land at a position on the track ahead of the cup when the cart reaches Point **B**.
c. The ball will go straight up and land on the track at Point **A**.
d. The ball will be fired at a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



e. Something else will happen

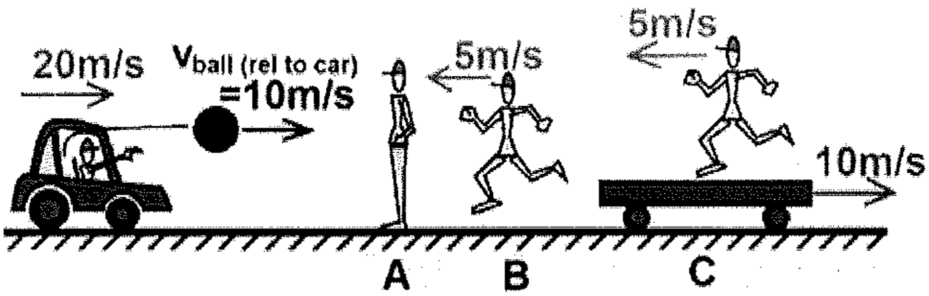
Answer:

a



Question:

In the figure below, the relative motion of several objects and their relative velocities are shown. Applying the correct concepts and principles, determine the velocity of the ball relative to persons **A**, **B** and **C**.



$V_{\text{ball (relative to A)}} = ?$

$V_{\text{ball (relative to B)}} = ?$

$V_{\text{ball (relative to C)}} = ?$

Answer:

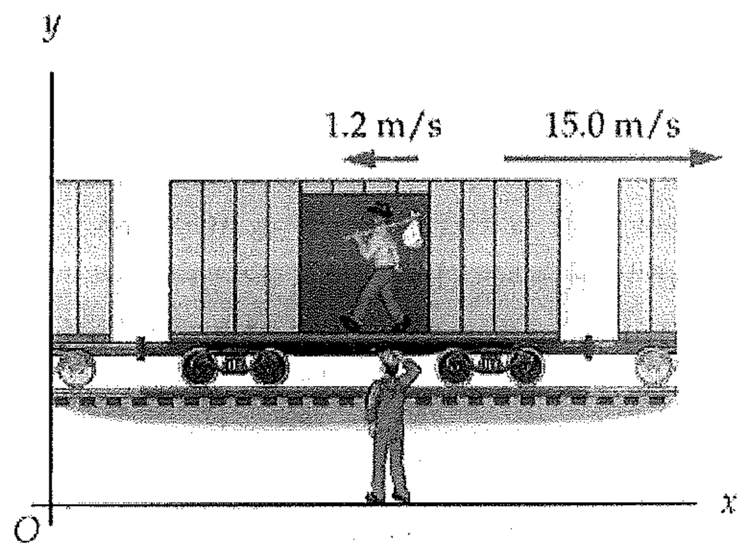
$V_{\text{ball (relative to A)}} = +30\ \text{m/s}$

$V_{\text{ball (relative to B)}} = +35\ \text{m/s}$

$V_{\text{ball (relative to C)}} = +25\ \text{m/s}$

Question:

A hobo is walking in a train car at 1.2 m/s to the left relative to the car while the train moves at a velocity of 15.0 m/s to the right relative to the Earth. What is the velocity of a railroad worker relative to the hobo if the worker is stationary on the Earth?

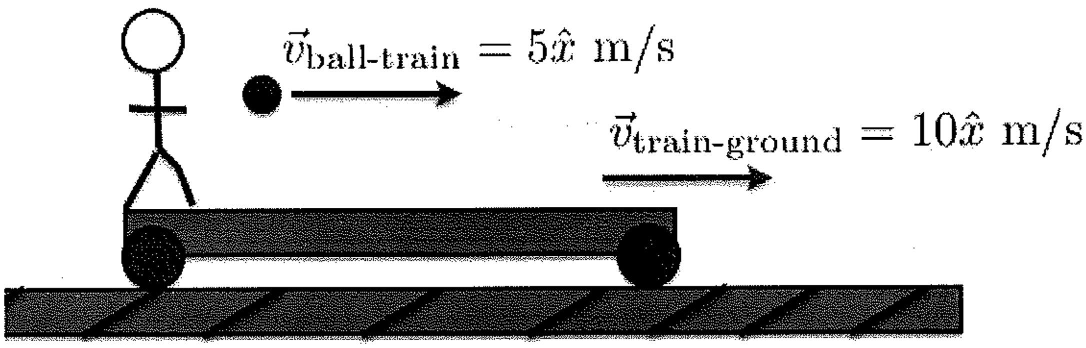


Answer:

13.8 m/s Left

Question:

Consider the one-dimensional motion situation shown in the figure below. A railroad worker stationary on a flatbed train throws a ball to the right as the train moves along the tracks to the right. A second worker, not shown, is standing on the ground observing the motions.



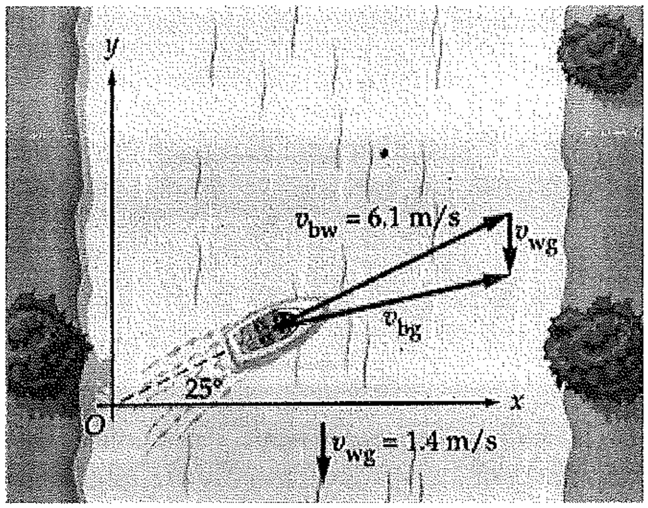
1. **What is the velocity of the ball relative to the second worker who is walking to the right at 7 m/s?**
2. **What would be the velocity of the ball relative to the second worker if the second worker is walking to the left at 6 m/s?**
3. **What would the second worker's velocity have to be in order for the ball to appear at rest relative to him?**

Answer:

1. **8 m/s Right**
2. **21 m/s Right**
3. **15 m/s Right**

Question:

The pilot of a work boat points his boat at an angle of 25^0 in an attempt to cross a river to its eastern side as shown below. The river is flowing south at 1.4 m/s and the boat can move at a velocity of 6.1 m/s in still water.



a. What is the velocity of the boat relative to the shore?
b. How long will it take for the boat to reach the other side if the river is 126 m wide?

Solution:

First break the boat velocity into component vectors:

$$v_x = 6.1 \cos 25^\circ = 5.53 \, m/s$$
$$v_y = 6.1 \sin 25^\circ = 2.58 \, m/s$$

Then add the vectors in the vertical and horizontal directions:

$$v_y = 2.58 \, m/s - 1.4 \, m/s = 1.18 \, m/s$$

Then use the pythagorean theorem to find the resultant:

$$\vec{v}_{bg} = \sqrt{(5.53)^2 + (1.18)^2} = 5.65 \, m/s$$

$$\theta = \tan^{-1} \frac{1.18}{5.53} = 12^\circ$$

Question:

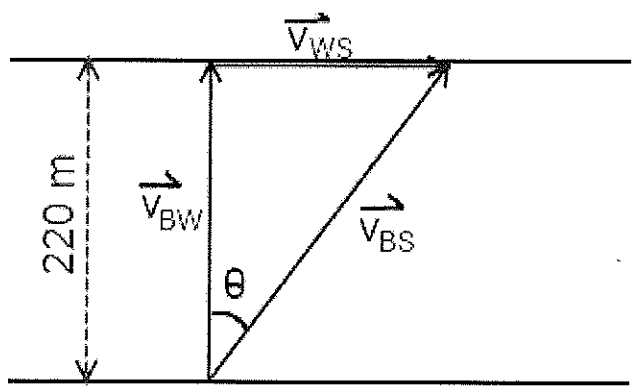
Consider the following situation: A person in a boat leaves the shore of a river to travel to the opposite shore 220 m away. They head the boat directly across the river and row at a speed of 1.2 m/s, but since the river is moving at a speed of 3.4 m/s parallel to the shore they end up at a position down the river from their destination point.

Answer the following:

a) **Draw a vector diagram of the situation.**
b) **Determine the velocity of the boat relative to the shore?**
c) **What is the boat's actual displacement?**
d) **How long did it take the boat to cross the river?**

Answer:

a)



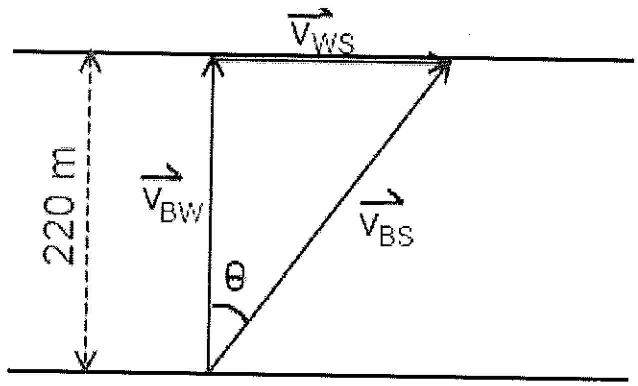
b) $V_{B/S}$ = 3.6 m/s θ = 70.6^0

c) 661 m

d) 184 s = 3.06 min

Solution:

a)



b)

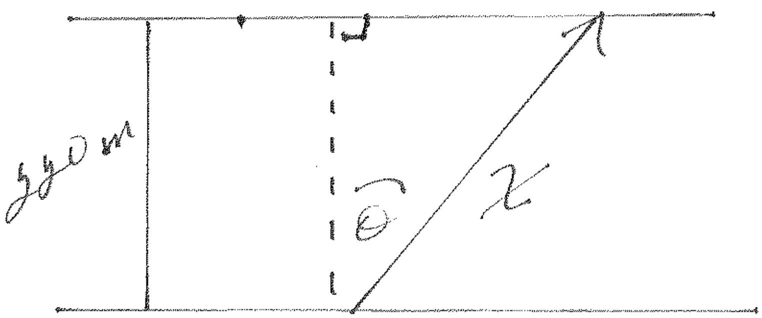
$$V_{B/S} = \sqrt{V_{B/W}^2 + V_{W/S}^2}$$

$$V_{B/S} = 3.6 \ \frac{m}{s}$$

$$\theta = \tan^{-1} \frac{V_{W/S}}{V_{B/W}}$$

$$\theta = 70.6^\circ$$

c)



$$\cos\theta = \frac{adj}{hyp} = \frac{220\,m}{x}$$

$$x = \frac{220\,m}{\cos\theta} = \frac{220\,m}{\cos 70.6^\circ}$$

$$x = 661\,m$$

d)

$$x = V_{B/S}\, t$$

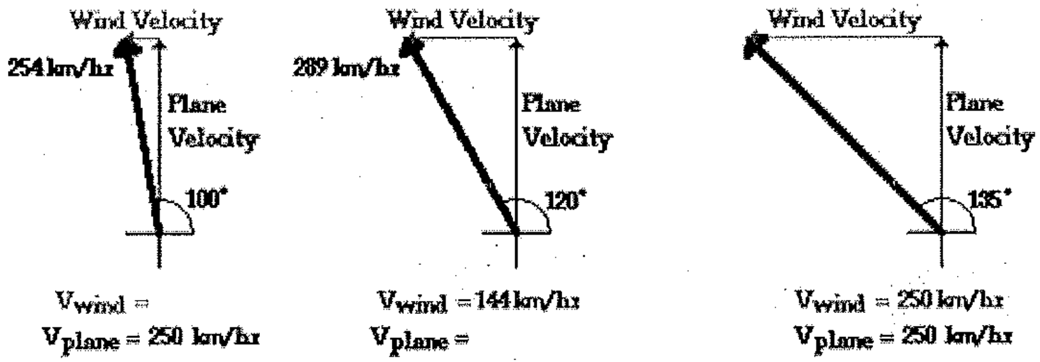
$$t = \frac{x}{V_{B/S}}$$

$$= \frac{661\,m}{3.6\,\frac{m}{s}}$$

$$t = 184\,s \approx 3.06\,min$$

Question:

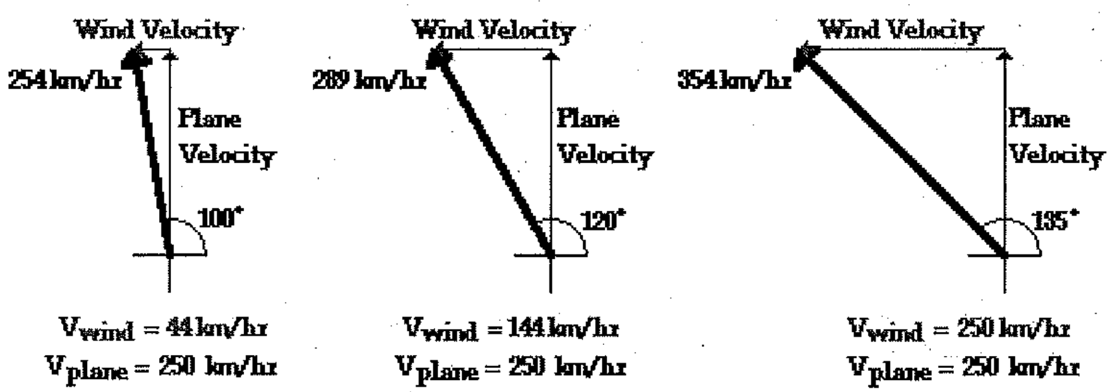
In each of the three examples shown below a plane heads North on a flight to its destination, but the wind blows it off course. In each case, one of the relative velocity vectors is missing. Applying the correct concepts and principles, calculate the missing relative velocity vectors.



The resulting motion of a plane in the presence of a wind is dependent upon the velocity of the crosswind. An alteration of the wind velocity affects the resulting motion but does NOT affect the velocity at which the plane flies northward. Perpendicular components of motion are independent of each other.

Answer:

Apply the Pythagorean theorem or the trigonometric functions to calculate each of the unknown values. The correct values are shown below.



The resulting motion of a plane in the presence of a wind is dependent upon the velocity of the crosswind. An alteration of the wind velocity affects the resulting motion but does NOT affect the velocity at which the plane flies northward. Perpendicular components of motion are independent of each other.