Question:

Assuming that the quantities of motion have been established and understood, what is the first step in analyzing or describing the rectilinear motion of an object?

a. Determine if the object is moving.
b. Measure the object's distance or displacement.
c. Measure the object's speed or velocity.
d. Determine the object's acceleration.
e. None of the above

Answer:

e. The first step is to establish a frame of reference and to define the origin and the +/- direction of motion in that frame.

Question:

Which statement concerning the description of motion in rectilinear kinematics is correct?

I. **In kinematics, absolute rest and absolute motion are the underlying foundations of describing motion.**
II. **In kinematics, the first thing to establish when defining motion is whether an object is moving.**
III. **In kinematics, a frame of reference is the environment or perspective used to judge or describe the motion of objects.**

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

Answer:

c.

Question:

Consider the following steps of physics problem solving:

A. **Substitute Known Quantities**
B. **Identify the Unknown Quantities**
C. **Read – Re-Read – Interpret /Classify**
D. **Box and Evaluate**
E. **Solve Defining Equation Algebraically**
F. **Identify the Defining Equation**
G. **Calculate**
H. **State Important Relationships**
I. **Sketch/Diagram the Physical Situation**

Without using your problem solving guide, list these steps in the correct sequential order.

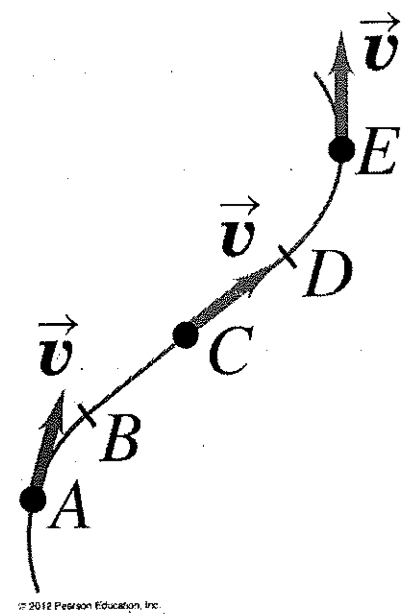
Answer:

C – I – B – H – F – E – A – G – D

Question:

The motion diagram below 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*



Answer:

b.

Question:
A car travels at an average speed of 50 kilometers per hour for 2 hours. What distance did it travel during this time?

a. 25 km
b. 100 km
c. 2500 km
d. 200 km
e. 0.40 km

Answer:
The correct answer is *b*. The car travels 50 kilometers during the first hour, and another 50 kilometers during the second hour, for a total of 100 km for the two hours.

We can analyze this more quantitatively using the speed formula– $speed = \frac{distance}{time}$ –and rearranging it to solve for distance.

$$s = \frac{d}{t}$$

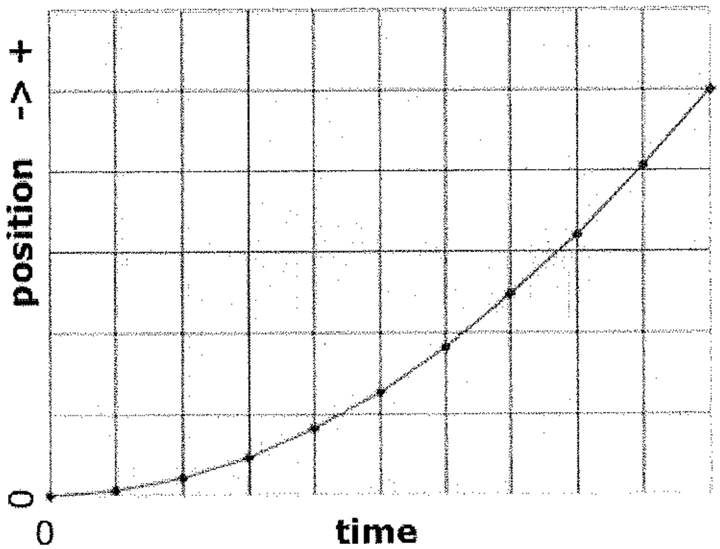
Rearrange to get :

$$d = st$$

$$d = \left(50\frac{km}{hr}\right)(2hr) = 100km$$

Notice that it's useful to include units in our calculations, so that we can see them cancel and ensure that we've set up our calculation correctly.

Question:



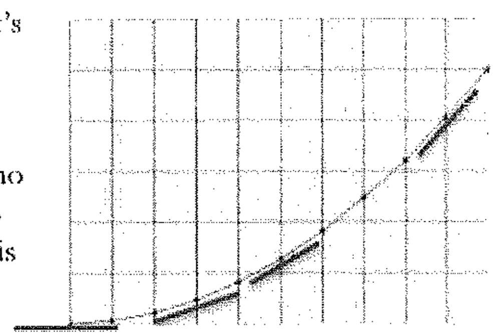
A student walks along a straight line according to the displacement-time graph shown here. Based on the graph, we can tell that the student

a. began at rest, then began to move faster and faster with acceleration in the positive direction
b. began at rest, then began to move in the positive direction with a negative acceleration
c. began with a positive velocity that increased over time
d. began with a positive velocity that decreased over time
e. moved with a constant positive speed the entire time

Answer:

The correct answer is ***a***. We can determine the student's velocity at any point in time by looking at the slope of the graph at that point in time.

At the beginning, the slope of the line is 0, indicating no velocity. As time passes, the slope of the line begins to increase, revealing an increasing velocity. The student is covering greater and greater distances as each second passes. This is the very definition of acceleration, with an increasing velocity in the direction of motion.



Green lines indicate increasing slope with time.

Question:

A marble rolling across a carpet in the $-x$ direction (to the left), slows from an initial speed of 55 cm/s to a final speed of 11 cm/s, 4.0 seconds later? What is the acceleration of the marble during this time period?

a. 11 cm/s to the left
b. 11 cm/s to the right
c. 11 cm/s^2 to the left
d. 11 cm/s^2 to the right
e. none of these

Answer:

The correct answer is ***d***. We can see that in the 4.0 second time period in this problem, the marble slows down from 55 cm/s to 44, then 33, then 22, then 11 cm/s. In other words, it is slowing down by 11 cm/s, *per second*, or 11 cm/s^2.

The direction of an acceleration is in the same direction as the motion if the object is speeding up, and in the opposite direction of the motion if the object is slowing down. Here, the marble is traveling in the negative-x direction (to the left) and is slowing down, so its acceleration must be in the opposite direction, to the right.

This is all neatly determined by using the acceleration equation:

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{(-11cm/s) - (-55cm/s)}{4.0s} = +11cm/s^2$$

Question:

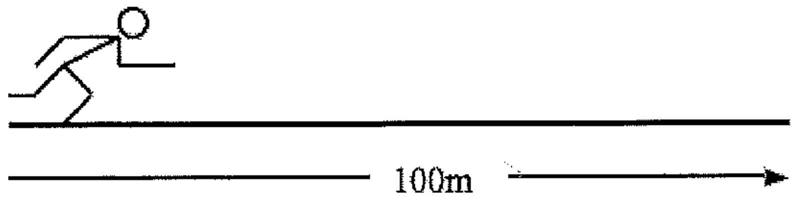
Displacement is a vector that indicates change in position. *Velocity* is a vector that indicates how quickly the change in position occurs. An object has *acceleration* if

a. its direction of motion is changing.
b. its speed is changing.
c. its velocity is changing.
d. its speed *and* direction are changing.
e. all of the above.

Answer:

The correct answer is *e*. Acceleration is, by definition, a vector quantity that indicates how quickly an object's velocity is changing. Because the velocity vector includes both direction of travel and speed, a changing velocity occurs in each situation *a* – *d* listed above.

Question:



A runner travels straight along a 100 meter track to the East as shown above, in 10.0 seconds. The runner has:

a. An average speed of 10.0 m/s, and an average velocity of 10.0 m/s.
b. An average speed of 10.0 m/s, and an average velocity of 10.0 m/s East.
c. An average speed of 10.0 m/s East, and an average velocity of 10.0 m/s.
d. An average speed of 10.0 m/s East, and an average velocity of 10.0m/s East.
e. An average speed of 10.0 m/s, and an average velocity of 10.0 m/s West.

Answer:

The correct answer is *b*. Speed is a measure of distance traveled per time:

$$speed = \frac{distance}{time} \qquad s = \frac{d}{t}$$

In this case:

$$s = \frac{d}{t} = \frac{100m}{10.0s} = 10.0m/s$$

Because speed is a *scalar* quantity, it only has a magnitude for its value–no direction is required.

Velocity, on the other hand, is a *vector* quantity, which means that a magnitude and a direction are both necessary. The magnitude is calculated according to the *displacement* divided by *time*:

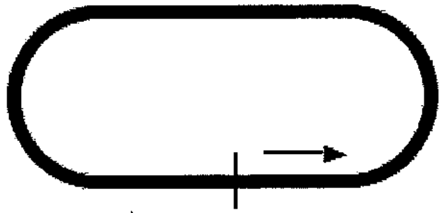
$$velocity = \frac{displacement}{time} \qquad \mathbf{v} = \frac{\Delta \mathbf{x}}{t} = \frac{x_f - x_i}{t}$$

In this case, the velocity is:

$$\mathbf{v} = \frac{x_f - x_i}{t} = \frac{+100m - 0m}{10.0s} = +10.0m/s, \text{ or } 10.0\text{m/s, East}$$

One can indicate the direction of the velocity as "East," or "in the positive-*x* direction." When solving vector problems in physics, we sometimes get a little sloppy–the direction of motion might be obvious from the problem statement, and so we might just indicate the magnitude of the velocity, and leave off the direction. It's important to remember, however, that *vector quantities* are always represented both by a *magnitude* and a *direction*, and if you're being careful, you'll want to specify both.

Question:



A runner takes off from the starting line and runs 400 meters around a track to return to her original starting position. The runner:

a. ran a distance of 400 m, but had a displacement of 0.
b. ran a distance of 0 m, but had a displacement of 400m.
c. ran a distance of 400m and had a displacement of 400m.
d. ran a distance of 0m and had a displacement of 0 m.
e. ran a distance of 400m, but her displacement is undefined.

Answer:
The correct answer is *a*. The runner travelled 400 meters around the track, and *distance* is defined as the length of the path travelled. *Displacement* is a vector quantity, typically with a magnitude and a direction, that is calculated based on the initial and final positions of an object that has moved:

$$\text{displacement} \quad \Delta x = x_{final} - x_{initial}$$

In this problem, because the runner starts and ends at the same location, the displacement is 0.

Question:
A car at one moment in time is traveling at 30 kilometers per hour. Five seconds later, the car is traveling at 40 kilometers per hour. The car's acceleration is

a. 10 km/hr
b. 5 km/hr
c. 2 km/hr
d. 10 km/hr/s
e. 2 km/hr/s

Answer:
The correct answer is *e*. The car sped up 10 km/hr over the course of 5 seconds, so it must have been speeding up at 2 km/hr each second, or 2 km/hr/s.

That may make some intuitive sense, and in study of conceptual physics, we'll try to emphasize the logical nature these kinds of things. As you continue your study of physics, however, you'll also want to be able to use a formula to help determine the answer to problems that may not have nice round numbers given to you. The formula that helps us calculate the acceleration here is

$$acceleration = \frac{change\ in\ velocity}{time\ period}$$

$$a = \frac{v_{final} - v_{initial}}{t}$$

$$a = \frac{40km/hr - (30km/hr)}{5s}$$

$$a = \frac{10km/hr}{5s} = \frac{2km/hr}{s} = 2km/hr/s$$

Question:
A rocket accelerates upwards with an average velocity of 100 m/s for a time period of 10.0 seconds has passed. What is the displacement of the rocket during this time?

a. 2000 m
b. 2000 m, upwards
c. 1000 m
d. 1000 m, upwards
e. The problem can't be solved without more information

Answer:
The correct answer is *d*. The rocket's displacement upwards can be calculated by using its average velocity and the time it was in motion:

$$\Delta x = v_{avg} \Delta t$$

$$\Delta x = (+100 m/s)(10.0 s)$$

$$\Delta x = +1000 m$$

Notice that this answers is expressed with a plus-sign (+) in front, indicating that we know that the displacement is in the positive-*y* direction, or upwards. It would also be correct to simply say Δx = "1000 m, upwards."

Question:

A car leaves the Los Angeles area and arrives at Las Vegas 5.0 hours later. If the displacement of the car from start to finish is 400 km northeast, which statement must be true?

a. The car traveled a distance of 400 km.
b. The car had an average speed of 80 km/hr.
c. The car had an average velocity of 80 km/hr, northeast.
d. The car had the same velocity during the 5 hour period.
e. The car had the same speed during the 5 hour period.

Answer:

The correct answer is *c*. Average velocity is a measure of a car's displacement over time, i.e. "where did the car end up relative to where it started" divided by "how long the motion took."

$$v = \frac{displacement}{time} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t}$$

Recall that "displacement" is a *vector* quantity, and has a direction associated with it. If we take the car's starting point at Los Angeles to be 0 km, and the ending point to be 400 km to the northeast, we have

$$v = \frac{400km,\ northeast}{5.0\ \ hrs} = 80\ \ km/hr,\ northeast$$

Keep in mind that in normal conversation, the terms "speed" and "velocity" tend to be used interchangeably, but in physics, those two terms have different meanings, and the quantities are calculated in different ways.

The other answers listed in the problem statement *may* have been true, but not necessarily. A car traveling with an average velocity of 80 km/hr, northeast almost certainly doesn't travel with that velocity the entire time. Likewise, the distance that the car traveled along its path was almost certainly more than the "change in position"—*displacement*—of 400 km.

Question:

An object is dropped from the top of a high cliff, and it free-falls with negligible air friction. The average velocity of the object during its fall was 32 m/s downwards. What was the final velocity of the object just before it hits the ground?

a. 0 m/s
b. 32 m/s
c. 9.8 m/s
d. 64 m/s
e. 9.8 m/s^2

Answer:

The correct answer is ***d***. The object accelerated as it fall, speeding up in the downward direction from 0 m/s when it's first released, to some final velocity v_f.

The average velocity can be calculated the same way any average of two numbers is calculated: add them together and divide by 2. In this case, we don't need to calculate average velocity based on initial and final–we need to get final velocity based on initial and average.

$$v_{average} = \frac{v_{initial} + v_{final}}{2}$$

Rearrange equation to solve for desired variable:

$$2v_{average} = v_{initial} + v_{final}$$

$$v_{final} = 2v_{average} - v_{initial}$$

$$v_{final} = 2(-32m/s) - 0 = -64m/s$$

Notice that I've chosen to indicate the direction using a negative sign for "downward"; one could also simply state "65 m/s, down" for the answer.

Question:
An object is dropped from a cliff, and falls straight downward with an average velocity of 30.0 m/s for 6.0 seconds. Which statement is true?

a. The ball had a displacement of 180 meters, down.
b. The ball had a constant velocity of 30.0 m/s as it fell.
c. The ball had an upwards velocity as it fell.
d. The ball had an upwards acceleration as it fell.
e. The ball's final velocity at time $t = 6.0$ seconds is 30.0 m/s .

Answer:
The correct answer is *a*. The ball's displacement—its final position relative to its initial position—can be determined by finding out how far the ball fell.

In this problem the ball fell straight down, so we can either calculate the *distance* it traveled:

$$distance = speed \times time$$

$$d = st$$

$$d = (30.0m/s)(6.0s) = 180m$$

... and make sure to indicate that the displacement has a direction "down," or we can calculate the *displacement* using velocity:

$$displacement = velocity \times time$$

$$\Delta x = vt$$

$$\Delta x = (30.0m/s,\ down)(6.0s) = 180m,\ down$$

In physics, vertical vectors are often considered to be positive if they're in the upward direction, and negative in the downward direction. Another way of solving this problem, using negative to indicate the downward direction, would be this:

$$\Delta x = vt$$

$$\Delta x = (-30.0m/s)(6.0s) = -180m$$

As a physics student, you would be expected to understand that the negative sign here indicates a displacement in the downward direction.

Question:
An object is thrown straight up into the air (in the positive-y direction), and reaches a maximum height of 20.0 meters in 2.0 seconds. What is the average speed of the object as it is traveling up into the air?

a. 10 m/s
b. 20 m/s
c. 0 m/s
d. 15 m/s
e. The object has an average velocity, but not an average speed.

Answer:
The correct answer is ***a***. Average speed is calculated according to ***distance traveled*** per ***time of travel***:

$$s = \frac{d}{t}$$

$$s = \frac{20.0m}{2.0s} = 10m/s$$

Note that this average speed is a scalar quantity, and doesn't require that a direction be given to it (even though we clearly know that the object is traveling upwards). Note, also, that we know that the object isn't traveling with the same speed the entire time: it was traveling pretty fast at the beginning, and slows down as it travels upwards. Still, our ***average speed*** calculation for its motion over the 2.0 seconds is correct: it's an ***average*** of the varying speeds.

Question:

A rocket accelerates upwards with an average velocity of 100 m/s for a time period of 10.0 seconds has passed. What is the displacement of the rocket during this time?

a. 2000 m
b. 2000 m, upwards
c. 1000 m
d. 1000 m, upwards
e. The problem can't be solved without more information

Answer:

The correct answer is ***d***. The rocket's displacement upwards can be calculated by using its average velocity and the time it was in motion:

$$\Delta x = v_{avg}\Delta t$$

$$\Delta x = (+100m/s)(10.0s)$$

$$\Delta x = +1000m$$

Notice that this answers is expressed with a plus-sign (+) in front, indicating that we know that the displacement is in the positive-*y* direction, or upwards. It would also be correct to simply say Δx = "1000 m, upwards."

Question:

A toy car has an average velocity of 25 centimeters per second as it rolls 250.0 centimeters across a long table. How much time does it take for the car to travel this distance?

a. 6250 seconds
b. 100 seconds
c. 10 seconds
d. 1.0 second
e. 0.10 seconds

Answer:

The correct answer is *c*. It probably makes some sense that a car traveling at 25 cm/s, and going 10 times 25 cm would take 10 time 1second–10 seconds–to travel that distance. We can also justify this reasoning by using the speed formula, rearranged to solve for distance.

$$s = \frac{d}{t}$$

Rearrange to get:

$$t = \frac{d}{s}$$

$$t = \frac{250\cancel{cm}}{25\cancel{cm}/s} = 10s$$

Notice how that calculation–dividing the numerator by a unit 1/seconds–results in the *seconds* unit appearing in the numerator of the answer.

Question:
An object is dropped from the top of a high cliff, and it free-falls with negligible air friction. The average velocity of the object during its fall was 32 m/s downwards. What was the final velocity of the object just before it hits the ground?

a. 0 m/s
b. 32 m/s
c. 9.8 m/s
d. 64 m/s
e. 9.8 m/s^2

Answer:
The correct answer is *d*. The object accelerated as it fall, speeding up in the downward direction from 0 m/s when it's first released, to some final velocity v_f.

The average velocity can be calculated the same way any average of two numbers is calculated: add them together and divide by 2. In this case, we don't need to calculate average velocity based on initial and final–we need to get final velocity based on initial and average.

$$v_{average} = \frac{v_{initial} + v_{final}}{2}$$

Rearrange equation to solve for desired variable:

$$2v_{average} = v_{initial} + v_{final}$$

$$v_{final} = 2v_{average} - v_{initial}$$

$$v_{final} = 2(-32m/s) - 0 = -64m/s$$

Notice that I've chosen to indicate the direction using a negative sign for "downward"; one could also simply state "65 m/s, down" for the answer.

Question:

A race car, starting from rest, accelerates at 30 feet/s^2 for 7 seconds. How far does the car travel during this time?

a. 735 feet
b. 105 feet
c. 6300 feet
d. 1470 feet
e. 210 feet

Answer:

The correct answer is *a*. One can arrive at this answer in a number of ways.

One solution involves carefully considering various aspects of the car's motion. It started at rest, and accelerated at 30 feet/s^2 for 7 seconds, so its final velocity must be 210 feet/s. Knowing this, we can determine that its average velocity is half that value, or 105 feet/s. And finally, knowing that the car traveled at that average velocity for 7 seconds:

$$d = v_{avg}t$$

$$d = (105 ft/s)(7s) = 735 ft$$

Another solution simply requires using a formula that is built upon this same thought process:

$$d = \frac{1}{2}at^2$$

$$d = \frac{1}{2}(30 ft/s^2)(7s)^2 = 735 ft$$

While using the formula is more convenient and probably a faster way to get the answer, make sure that your understanding of physics goes beyond simply plugging numbers into an equation!

Note that some Conceptual Physics courses use a more complete version of the distance-acceleration formula. This version takes into account the initial velocity of the object, if it's moving: $d = v_i t + \frac{1}{2}at^2$

Question:

An car begins accelerating from rest, and reaches a final velocity of 30.0 m/s in the positive x-direction 5.0 seconds later. The average velocity of the car was

a. +30 m/s
b. -30 m/s
c. +6.0 m/s
d. -6.0 m/s
e. +15 m/s

Answer:

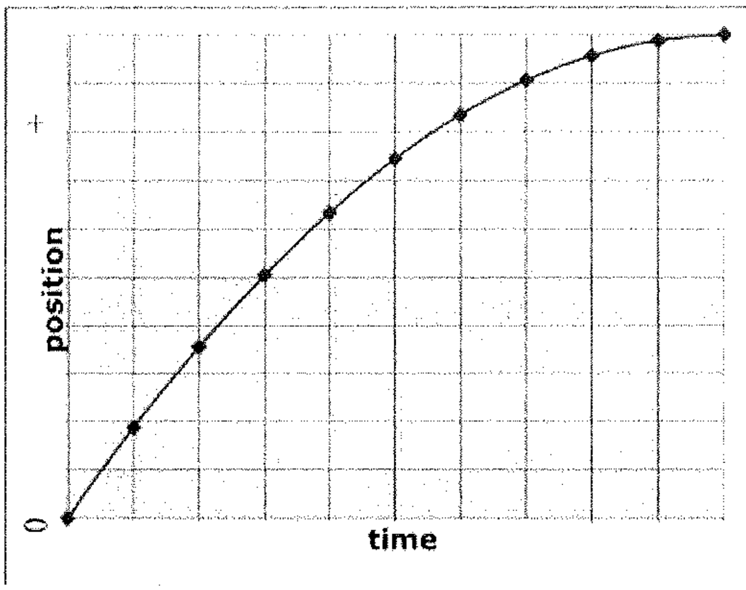
The correct answer is *e*. The average velocity of the car can be calculated in a number of different ways. In this case, based on knowing the initial velocity of the car–it was at rest at the beginning of the problem, so we can write $v_{initial} = 0$–and the final velocity of $v_{final} =$ +30.0 m/s, the average velocity is just the sum of those two velocities, divided by 2.

$$v_{average} = \frac{v_i + v_f}{2}$$

$$v_{average} = \frac{0 + 30 m/s}{2} = +15 m/s$$

Note that we've been careful to indicate direction with the plus-sign in our answer, because it's appropriate to indicate direction for velocities.

Question:



A student walks along a straight line according to the displacement-time graph shown here. Based on the graph, we can tell that the student must have been

a. Walking faster and faster, accelerating in the direction of travel
b. Walking with constant speed, and moving in the positive direction
c. Walking faster and faster, and moving in the negative direction
d. Walking slower and slower, accelerating in the direction of travel
e. Walking slower and slower, accelerating in the opposite direction of travel

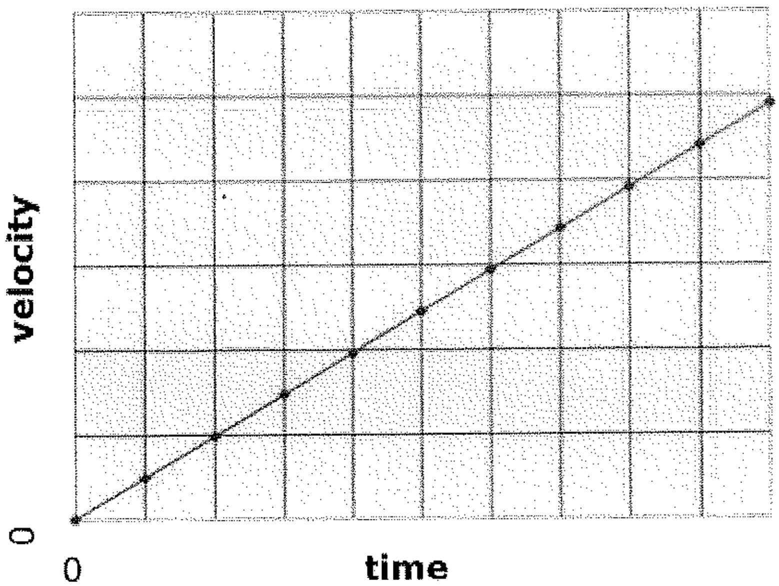
Answer:
The correct answer is e. From the graph of the student's motion, we can see that her position is changing by a smaller amount as each unit of time goes by. Therefore she is slowing down, and has an acceleration that is in the opposite direction of her travel.

We can also think about her motion in terms of the changing slope of the graph. Slope of a graph is defined as "rise over run," or "change in *y* over change in *x*." Here, the *y*-axis represents position, and the *x*-axis represents time, so "slope" of this graph is really "change in position over time," which is velocity.

$$slope\ m = \frac{\Delta y}{\Delta x} = \frac{\Delta\, position}{\Delta\, time} = velocity$$

We can see from the graph that the slope of the student's motion is changing over time: it starts out pretty steep (a positive velocity), and gets less and less steep over time (decreasing velocity). This represents a positive velocity that is changing (accelerating) in the negative direction.

Question:

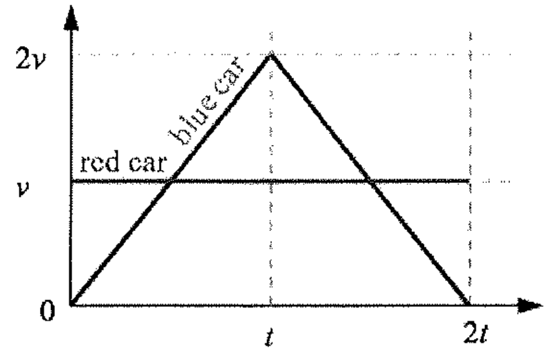


A car moves in a straight line with a motion described by the velocity-time graph shown here. Based on the graph, we can tell that the car

a. is traveling at a constant speed.
b. is traveling at a constant velocity.
c. is speeding up as it moves.
d. is slowing down as it moves.
a. none of the above.

Answer:
The correct answer is *c*. As time passes, the velocity of the car on the *y*-axis is getting higher and higher. For a car traveling in a straight line, this means that the car is speeding up.

Question:



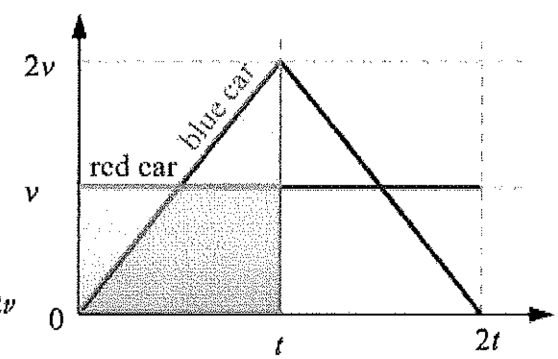
At time $t = 0$, a red car and a blue car are both located at $x = 0$, with the red car travelling at a constant speed v along the positive x-axis and the blue car at rest and just beginning to accelerate along a path parallel to the red car. The velocity of both cars from time 0 to $2t$ is graphed above. At time t:

a. the blue car has traveled farther, and both cars have the same velocity
b. both cars have traveled the same distance, and the blue car has a greater velocity
c. the red car has traveled farther, and both cars have the same velocity
d. both cars have traveled the same distance, and both cars have the same velocity
e. the blue car has traveled farther, and the blue car has a greater velocity

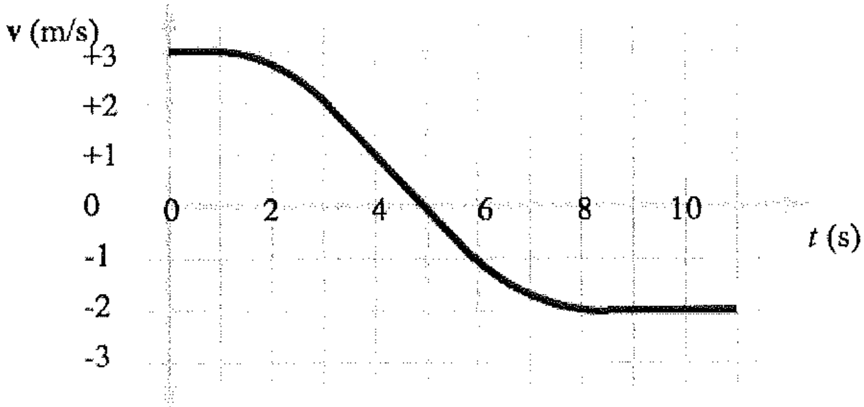
Answer:

The correct answer is *b*. The displacement of the cars can be determined by looking at the area under the curve of the velocity-time graph. The area under curve for the red car at time t is vt, while the area under the curve for the blue car is $\frac{1}{2}(2v)(t) = vt$, so both cars have the same displacement.

At time t, the blue car has the greater velocity—$2v$ compared with the red car's v.



Question:



A billiard ball rolling across a table in the +**x** direction at 3 m/s hits the edge of the table at a perpendicular angle, and bounces back in the -**x** direction, now traveling at 2 m/s in the opposite direction. The greatest magnitude of acceleration for the billiard ball was at time

a. $t = 1$ s
b. $t = 2$ s
c. $t = 5$ s
d. $t = 7$ s
e. $t = 9$ s

Answer:

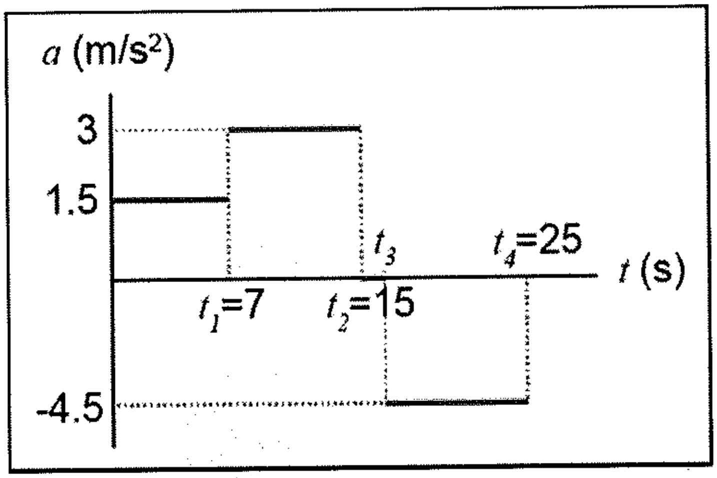
The correct answer is *c*. Acceleration is defined as the change in velocity over time:

$$a = \frac{\Delta v}{\Delta t} = \frac{v_{final} - v_{initial}}{t_{final} - t_{initial}}$$

Because *v* here is plotted on the *y*-axis and *t* is on the *x*-axis, $\frac{\Delta v}{\Delta t} = \frac{rise}{run} = m$, the slope of the graph. The slope of a velocity-time graph represents the acceleration of the object, so the greatest acceleration occured where the slope was greatest. Here, that would be at any time between $t = 3$ and $t = 6$ seconds.

Question:

Below is an acceleration-time graph showing four distinct time interval sections for an object moving in rectilinear motion. Examine the graph and use it along with the graphing techniques you have learned to answer the questions that follow.



1) _____ How many sections show the object moving with uniform velocity?
2) _____ If the object is moving in the negative direction, how many sections show the object slowing down?
3) _____ How many sections show the object moving with uniform acceleration?
4) _____ How many sections correspond to the object moving according to the law of squares?
5) _____ For which time interval section does the object undergo its greatest velocity change?

a) 1st b) 2nd c) 3rd d) 4th e) All sections show an equal velocity change

Answers

1) **1: Between t_2 and t_3**
2) **2: The two positive sections. Recall that when *v* and *a* are opposite, speed decreases.**
3) **3: The three sections which indicate non-zero constant acceleration.**
4) **3: The three sections which indicate non-zero uniform acceleration.**
5) **d: Recall that velocity change is taken from the area on a *a* vs t graph.**

Question:
A marble rolling across a carpet in the –*x* direction (to the left), slows from an initial speed of 55 cm/s to a final speed of 11 cm/s, 4.0 seconds later? What is the acceleration of the marble during this time period?

a. 11 cm/s to the left
b. 11 cm/s to the right
c. 11 cm/s^2 to the left
d. 11 cm/s^2 to the right
e. none of these

Answer:
The correct answer is *d*. We can see that in the 4.0 second time period in this problem, the marble slows down from 55 cm/s to 44, then 33, then 22, then 11 cm/s. In other words, it is slowing down by 11 cm/s, *per second*, or 11 cm/s^2.

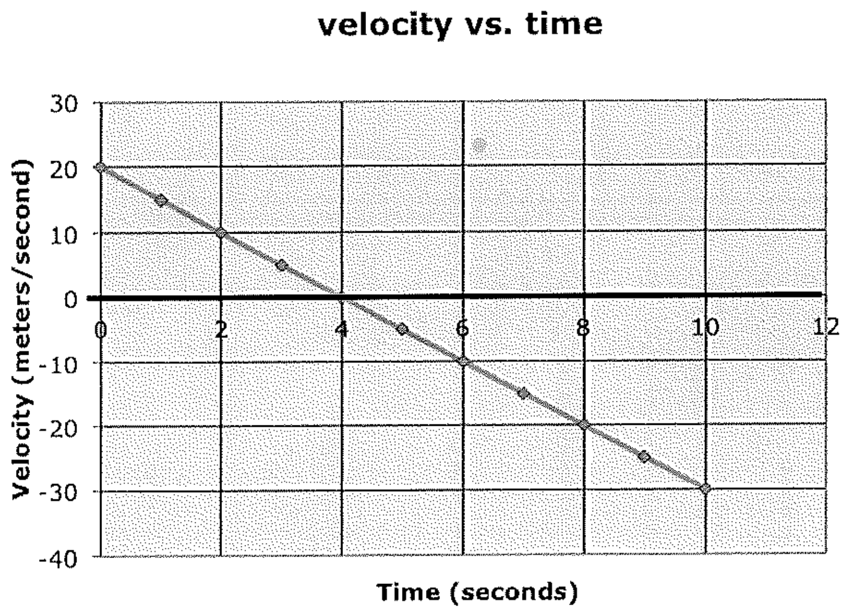
The direction of an acceleration is in the same direction as the motion if the object is speeding up, and in the opposite direction of the motion if the object is slowing down. Here, the marble is traveling in the negative-*x* direction (to the left) and is slowing down, so its acceleration must be in the opposite direction, to the right.

This is all neatly determined by using the acceleration equation:

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{(-11cm/s)-(-55cm/s)}{4.0s} = +11cm/s^2$$

Question:



The motion of an object traveling horizontally has been graphed as shown above, with *positive* velocity values indicating a *forward* direction. Which of the following statements is true about this object in motion?

a. The slope of the graph is constant, indicating a constant velocity for the object.
b. The slope of the graph is negative, indicating an object that is traveling *backwards*.
c. At time $t = 0$, the object is not moving.
d. This object has an acceleration of $-10\ m/s^2$.
e. This object moves *forwards* and *backwards* during the course of its motion.

Answer:
The correct answer is *e*. The initial velocity of the object is +20 m/s, and the slope of its velocity-time graph is calculated using its rise-over-run:

$$m = \frac{\Delta y}{\Delta x} = \frac{0 - 20m/s}{4m/s - 0} = -5m/s^2$$

This suggests that the object, initially moving forward, is slowing down over time, until it reaches an instantaneous velocity of 0 at time $t = 4$ s. After that point, the object begins moving faster and faster in the negative direction, going backwards. The only answer consistent with this analysis is choice *e*.

Question:

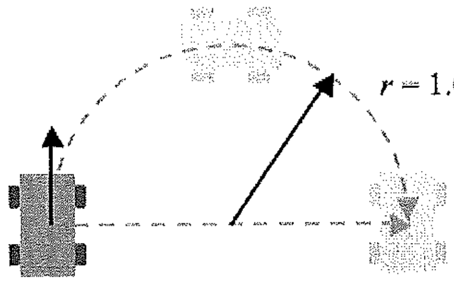
Displacement is a vector that indicates change in position. *Velocity* is a vector that indicates how quickly the change in position occurs. An object has *acceleration* if

a. its direction of motion is changing.
b. its speed is changing.
c. its velocity is changing.
d. its speed *and* direction are changing.
e. all of the above.

Answer:

The correct answer is *e*. Acceleration is, by definition, a vector quantity that indicates how quickly an object's velocity is changing. Because the velocity vector includes both direction of travel and speed, a changing velocity occurs in each situation *a* – *d* listed above.

Question:

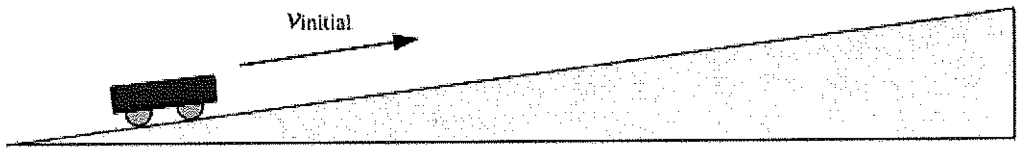


A toy car travels in a semi-circular path from its starting point to a final position 2.00 meters away in the positive-x direction. The car's motion along the path of travel is 3.14 meters. Therefore:

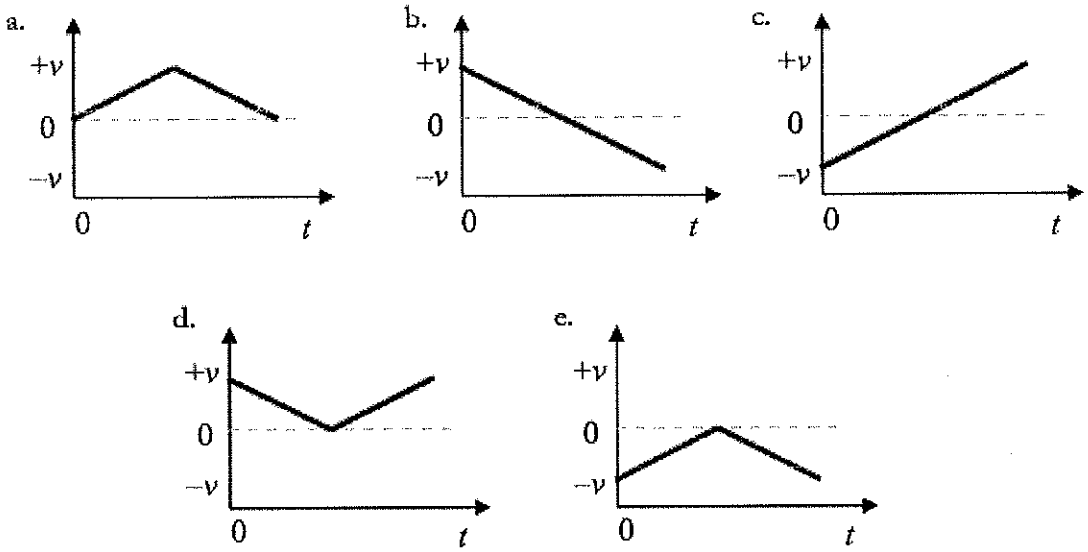
a. the car's displacement was 3.14 meters.
b. the car's distance traveled was 2.00 meters.
c. the car's distance traveled was 2.00 meters in the positive-x direction.
d. the car's displacement was 2.00 meters in the positive-x direction.
e. none of the above statements are true.

Answer:
The correct answer is *d*. While the car travels a *distance* (along its path) of 3.14 meters, its *displacement*—its final position relative to its initial position—is 2.00 meters in the positive-x direction.

Question:



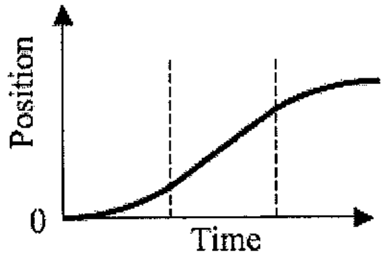
A "frictionless cart," with wheels that turn with negligible friction, is given an initial velocity up an inclined ramp as shown. The cart reaches a maximum height on the ramp before coming to a stop and then rolling back down the ramp. If the positive direction is considered "up the ramp," which motion graph correctly describes the motion of the cart on the ramp?



Answer:
The correct answer is *b*. The cart has an initial positive velocity up the ramp, and this velocity decreases to zero as the cart reaches its high point. As the cart begins to roll back down the ramp, its velocity is negative, and increases in the negative direction as it speeds up down the ramp.

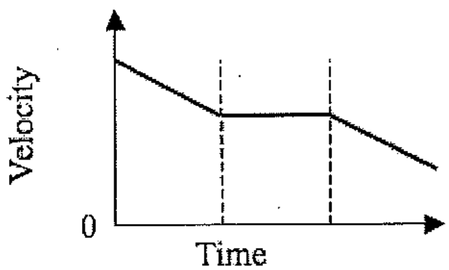
If asked, we could identify the acceleration of the cart by examining the slope of this *velocity-time* graph, where the slope is the "rise over the run" of the graph. With velocity on the *y*-axis and time on the *x*-axis, $m = \frac{rise}{run} = \frac{\Delta v}{\Delta t} = a$ (acceleration).

Question:

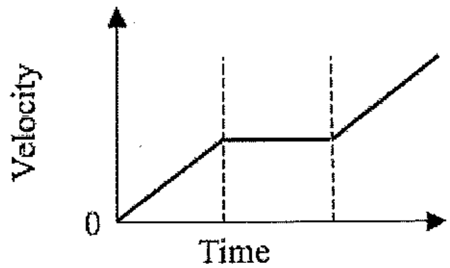


The graph given here shows the *position* vs. *time* for an object traveling along the *x*-axis. Which graph below shows the *velocity* vs. *time* for this same object during the same time period?

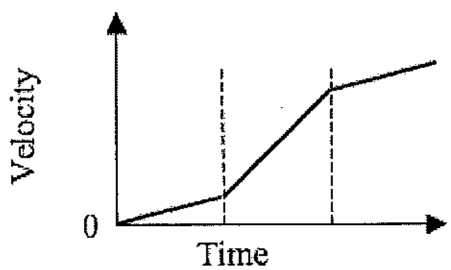
a.



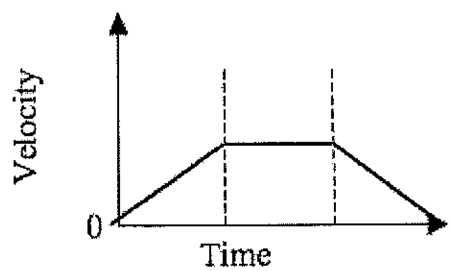
b.



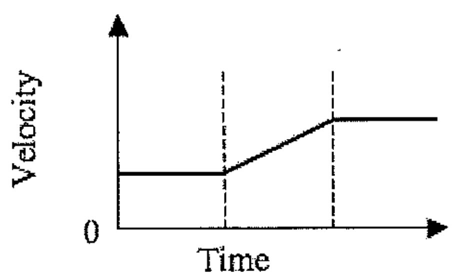
c.



d.



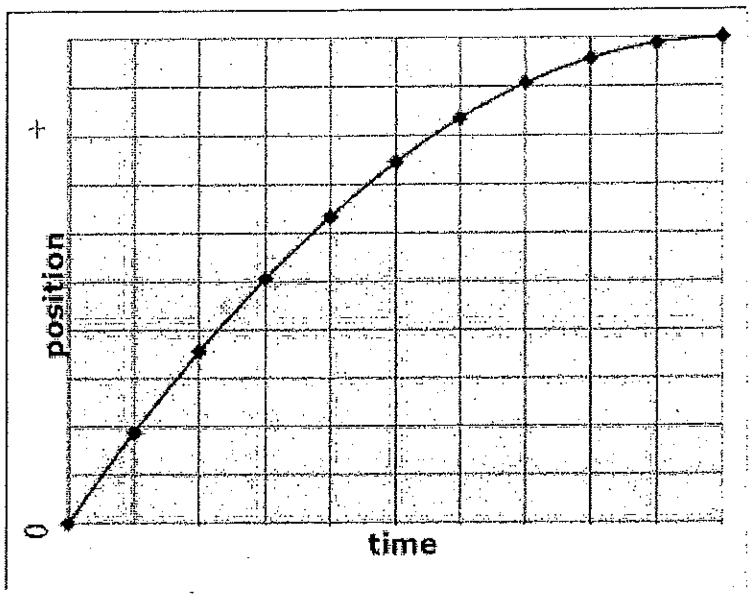
e.



Answer:

The correct answer is *d*. Recall that velocity (=Δposition/Δtime) represents the slope of a *position-time* graph. A constant slope (straight line) on the position-time graph represents a flat line on the *velocity-time* graph, and a changing slope on the *position-time* graph will represent a changing velocity: increasing velocity for a concave upwards *position-time* curve, and decreasing velocity for a concave-down *position-time* curve.

Question:



A student walks along a straight line according to the displacement-time graph shown here. Based on the graph, we can tell that the student must have been

a. Walking faster and faster, accelerating in the direction of travel
b. Walking with constant speed, and moving in the positive direction
c. Walking faster and faster, and moving in the negative direction
d. Walking slower and slower, accelerating in the direction of travel
e. Walking slower and slower, accelerating in the opposite direction of travel

Answer:
The correct answer is *e*. From the graph of the student's motion, we can see that her position is changing by a smaller amount as each unit of time goes by. Therefore she is slowing down, and has an acceleration that is in the opposite direction of her travel.

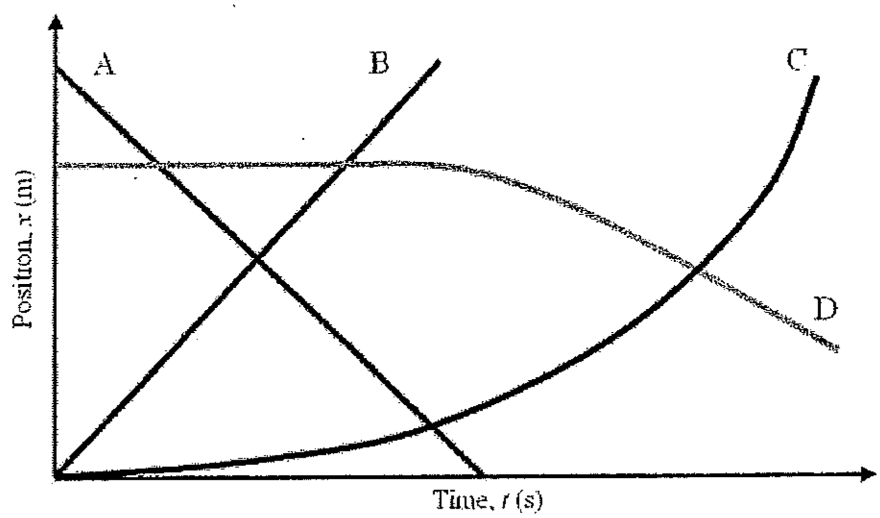
We can also think about her motion in terms of the changing slope of the graph. Slope of a graph is defined as "rise over run," or "change in *y* over change in *x*." Here, the *y*-axis represents position, and the *x*-axis represents time, so "slope" of this graph is really "change in position over time," which is velocity.

$$slope\ m = \frac{\Delta y}{\Delta x} = \frac{\Delta\, position}{\Delta\, time} = velocity$$

We can see from the graph that the slope of the student's motion is changing over time: it starts out pretty steep (a positive velocity), and gets less and less steep over time (decreasing velocity). This represents a positive velocity that is changing (accelerating) in the negative direction.

Question:

Which statement concerning the *position-time* graph below is correct?



I. **Curve A corresponds to an object slowing down.**

II. **Curve D describes and an object first at rest, then accelerating with negative velocity and increasing speed.**

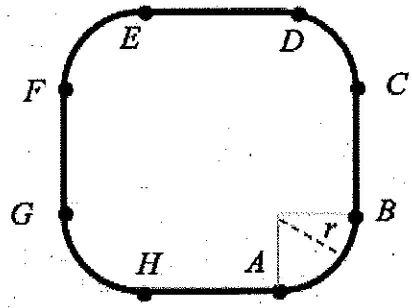
III. **Curve C represents an object that has a positive, increasing velocity and a positive acceleration.**

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

Answer:

d.

Question:



A race car drives at constant speed on a horizontal track, starting at point A and proceeding in order to points B, C, etc. until returning to point A, on the race track shown above. The race track consists of rounded, circular corners, each equal in length to the straight-line segments that connect them. Which graph best represents the magnitude of the acceleration of the car as it moves around the track?

a. 

b. 

c. 

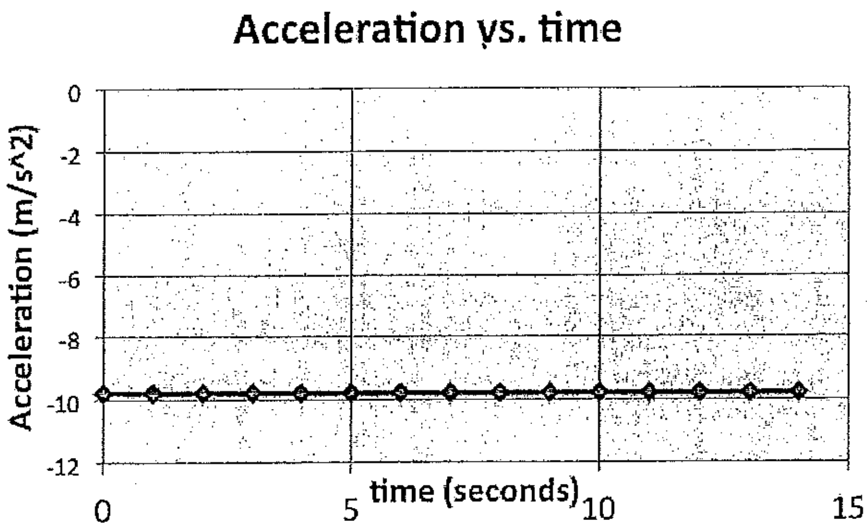
d. 

e. 

Answer:

The correct answer is *e*. The car is traveling at constant speed, so the only acceleration it will experience during its trip around the track is centripetal acceleration, when it is moving in a circular fashion at the corners. Thus, it as accelerating during line segments AB, CD, EF, and GH, but has no acceleration when it is traveling the straight-line segments that connect those circular corners.

Question:



The motion of an object has been graphed above, with *positive* values on the *y*-axis indicating an *upward* direction. Which of the following statements is true about this object in motion?

a. The graph is flat, indicating that the object is not moving.
b. The graph is flat, indicating that the object has a constant velocity in the negative direction.
c. The graph is flat, indicating that the object is not accelerating.
d. The graph is flat, and indicates a constant downward acceleration.
e. None of the statements above are true.

Answer:

The correct answer is *d*. The graph indicates a constant acceleration of 9.8 m/s^2 in the negative, or *downward* direction.

This is the acceleration for any object that is experiencing freefall, where the effect of air friction is negligible. Note that the acceleration for an object that has been thrown into the air with a positive velocity is also -9.8 m/s^2. The object traveling upwards slows down due to the negative acceleration, and after it reaches its maximum height, it speeds up as it falls, due to this save negative acceleration. Just looking at the graph above, however, there's no way to know whether the object is traveling upwards or downwards. All we can say is that it has a negative acceleration.

Question:

Acceleration is defined as...

a. how quickly a moving object's speed changes.
b. how quickly a moving object's velocity changes.
c. the change in an object's position over time.
d. the change in an object's displacement over time.
e. a scalar quantity.

Answer:

The correct answer is *b*. By definition, an object's acceleration is determine by the rate at which its velocity changes. You may see this formula written in several different ways:

$$acceleration = \frac{change\ \ in\ \ velocity}{time\ \ period}$$

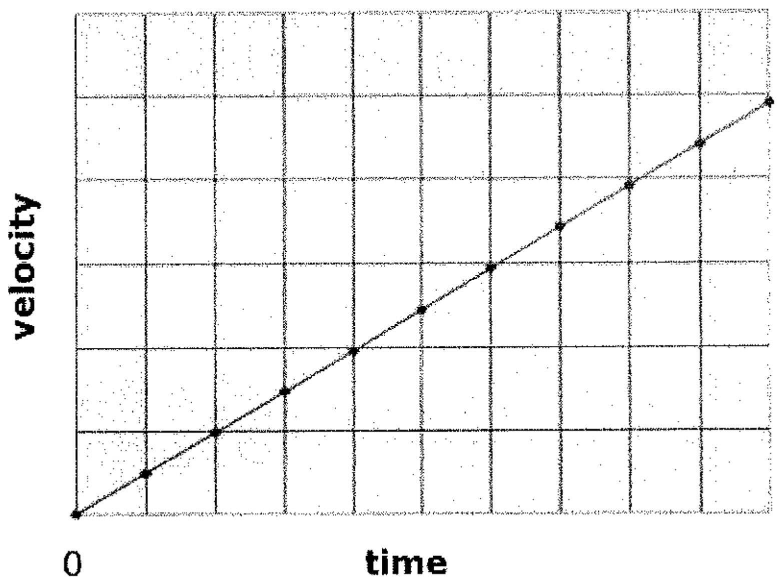
$$a = \frac{\Delta v}{\Delta t}$$

$$a = \frac{v_{final} - v_{initial}}{t_{final} - t_{initial}}$$

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{v - v_0}{t}$$

Question:



The velocity-time graph above describes the motion of a truck traveling in a straight line. What does the *slope* of the line indicate for the time period indicated?

a. the speed of the truck
b. the distance the truck has traveled
c. the velocity of the truck
d. the time that the truck has traveled for
e. the acceleration of the truck

Answer:
The correct answer is ***e***. The slope of a graph *m* is determined by looking at the "rise over the run":

$$m = \frac{rise}{run} = \frac{\Delta y}{\Delta x}$$

In this case, the value changing on the *y*-axis is the velocity, and the value changing on the *x*-axis is time. Therefore,

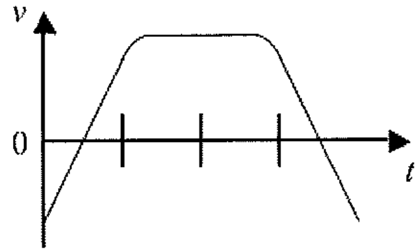
$$m = \frac{\Delta y}{\Delta x} = \frac{\Delta velocity}{time}$$

We recognize the formula for acceleration, where $a = \frac{\Delta v}{t}$.

We might also think about the units for velocity and time, and look at the unit that results when we do a division. Those units, m/s^2, are the units for acceleration:

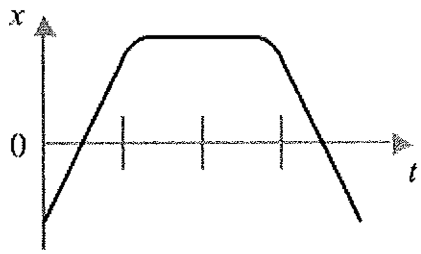
$$a = \frac{\Delta velocity}{time} = \frac{meters/second}{second} = \frac{m}{s^2}$$

Question:

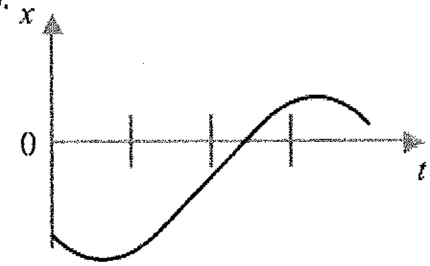


The graph above describes the velocity *v* of an object moving along the *x*-axis as a function of time *t*. Which graph below is a possible position vs. time graph for this object?

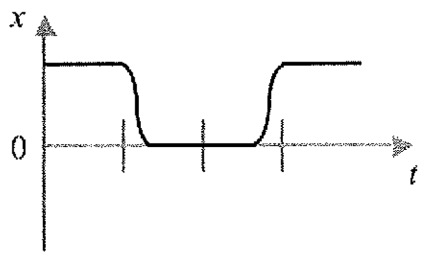
a.



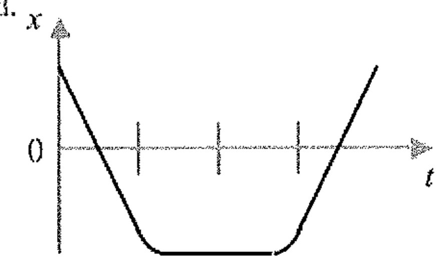
b.



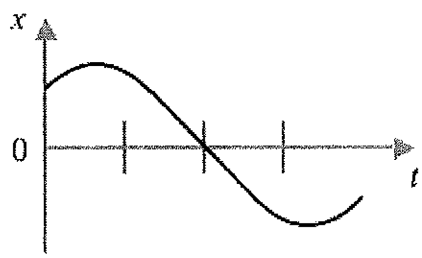
c.



d.



e.



Answer:
The correct answer is *b*. Velocity is the time-derivative of position, so the velocity graph can be thought of as a graph of the slopes of the position graph we're looking for. In this case, the velocity-time graph has values that go from increase constantly from a negative value through zero to a positive value, remains at that positive value for a time, and then decreases back through zero to the original negative value. Thus, we're looking for a graph that has slopes that are decreasingly negative, 0, increasingly positive, constantly positive, then decreasingly positive, and increasingly negative.