Question:

Physics problems sometimes instruct the student to consider a "freely falling" object. Which of the following statements about a dropped object in freefall near the surface of the earth is *false?*

a. The object falls a greater distance during each second that it falls.
b. The object's speed increases by a constant amount each second that it falls.
c. Air friction is considered to be negligible.
d. The acceleration of the object depends on its weight.
e. Freefall acceleration is indicated by the symbol **g**.

Answer:

The correct answer is ***d***. The acceleration of the object does ***not*** depend on its weight.

Near the surface of the earth, an object is considered to be in freefall if earth's gravity is the only force acting on the object. Under these conditions, the acceleration of the object will be close to 9.8 m/s^2 downwards, although in we will often round that number to 10 m/s^2 for the purposes of making quick calculations easier.

FOLLOW-UP QUESTION: Is an object thrown up into the air considered "freely-falling?"

FOLLOW-UP ANSWER: Even though the object is not actually "falling" as it's traveling upwards, because gravity is the only force acting on it, and because it is accelerating at 9.8 m/s^2 downwards, the object *is* considered to be in free-fall.

Question:

A rock is released from rest so that it falls from the top of a very high cliff. Air friction is negligible. The rock's speed, after falling a distance of 7 m, is about

a. 10 m/s
b. 15 m/s
c. 12 m/s
d. 7 m/s
e. 49 m/s

Answer:

The correct answer is *c*. We can calculate the speed of the rock using kinematics, with an acceleration of ~10 m/s^2.

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

$$v_f^2 = 0 + 2(-10m/s^2)(-7m)$$

$$v_f = \sqrt{140m^2/s^2} \approx 12m/s$$

It's also possible to estimate the approximate speed of the rock by remember some of the common displacement and velocity values for an object in free-fall. One second after being released from rest, a rock is traveling at 10 m/s down, and has fallen 5 meters, and two seconds after being released, the rock is traveling at 20 m/s and has fallen 15 meters. In this problem the rock has fallen 7 meters, not much farther than the 5 meter/10 m/s state. We can estimate, then, that the rock is traveling a little faster than 10 m/s, which leads us to the 12 m/s answer.

Question:

Which statement regarding *free-fall* motion is correct?

Neglect the effect of air.

I. When objects fall upward, they accelerate downward.
II. The rate of change of position for falling objects is constant.
III. The acceleration of an object falling vertically downward is zero.

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

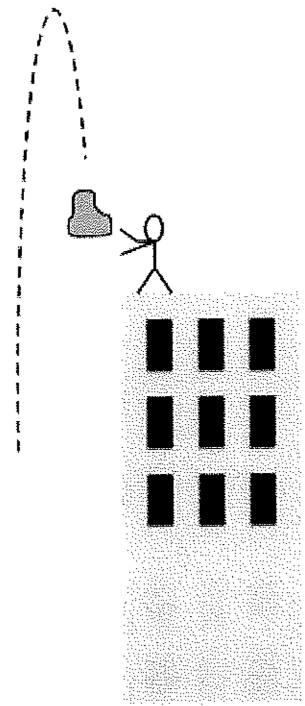
Answer:

a.

Question:

A rock is thrown into the air vertically by a student standing at the edge of the top of a tall building. If the rock has an initial velocity of 20 m/s, where is the ball located after 5.0 seconds have passed?

a. 10 meters above the top of the building
b. 25 meters above the top of the building
c. 5 meters below the top of the building
d. 25 meters below the top of the building
e. 225 meters below the top of the building



Answer:

The correct answer is ***d***. There are a several ways to solve this problem.

If you're familiar with the equation $d = v_i t + \frac{1}{2}at^2$, *d* refers to the ***displacement*** of the rock–its position relative to where it was released from. Using the initial velocity given in the problem, and the acceleration due to gravity in the downward (negative) direction, we can calculate

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

$$d = (+20m/s)(5s) + \frac{1}{2}(-10m/s^2)(5s)^2 = -25m$$

In a slightly more roundabout way, we can determine the initial and final velocities of the rock–+20m/s at the beginning, and -30m/s at the end–and use the average velocity with the time of 5s to determine the displacement:

$$d = v_{avg}t = \left(\frac{+20 + -30}{2}\right)5s = -25m$$

One could also split the problem into two parts: an "up" part and a "down" part. Find out how far the rock moved upwards (this is what we'd do if we'd been asked to find the rock's maximum height), and then figure out how far the rock fell during the downwards part of its motion.

Question:

Which of the following statements concerning *free-fall* motion are correct?

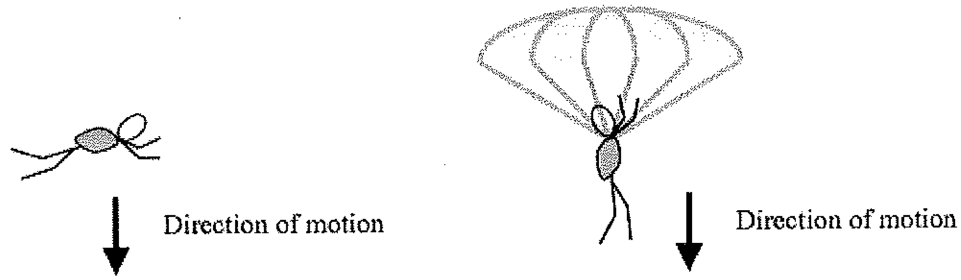
I. **The rate of change of *position* is constant during free-fall.**
II. **The rate of change of *velocity* is constant during free-fall.**
III. **The rate of change of *acceleration* is zero during free-fall.**

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

Answer:

e.

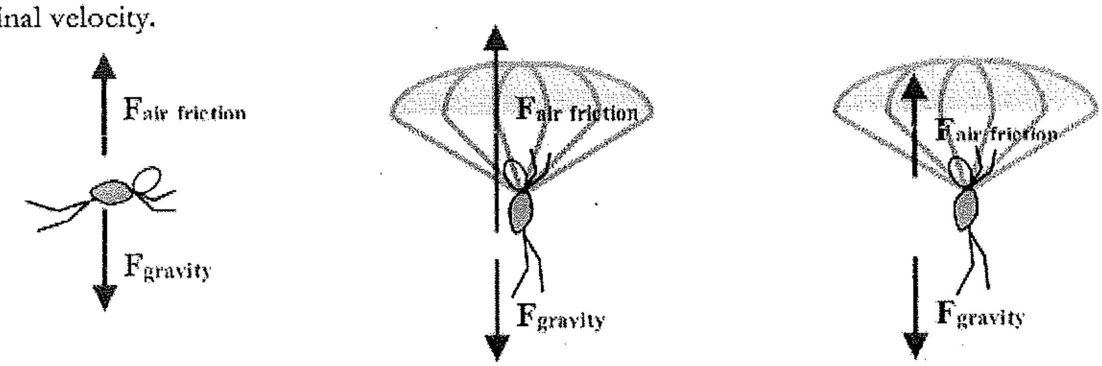
Question:



A skydiver with an unopened parachute is falling at his *terminal velocity*. When he opens the parachute, which statement is true?

a. As the parachute opens, the net force on the skydiver is still in the downward direction.
b. As the parachute opens, there is an increased force of air friction, but it's less than the force of gravity.
c. As the parachute opens, the skydiver will begin to move upwards.
d. After the skydiver reaches a new terminal velocity, the net force on him is downward.
e. none of the above statements are true.

Answer:
The correct answer is *e*. The opening of the parachute momentarily increases the force of air friction upwards, causing the skydiver to *decelerate* (accelerate in the upward direction) even as he continues to travel downwards–thus, the skydiver is slowing down to a new, smaller, terminal velocity.



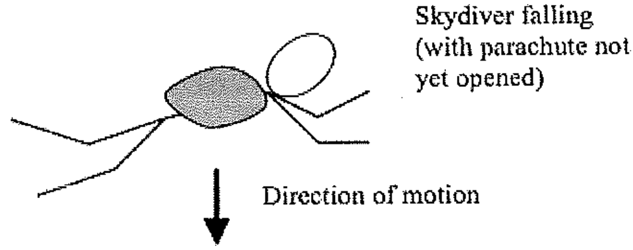
At terminal velocity, the net Force is zero.

As parachute opens at high terminal velocity, Force of air friction is momentarily greater than Force of gravity.

Once skydiver as decelerated, Force of air friction and Force of gravity are again the same.

At these terminal velocities, the net Force is always zero, so the object isn't accelerating downwards–it's *moving* downwards at constant velocity.

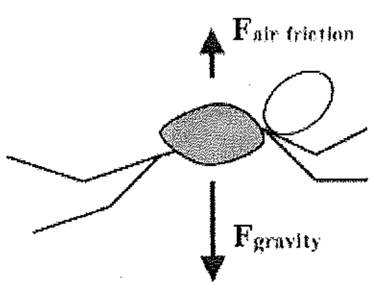
Question:



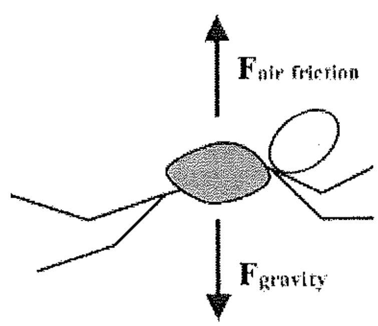
A skydiver who drops from a plane will accelerate downwards for awhile, and then reach a final *terminal velocity*. Which statement is true?

a. At terminal velocity, the skydiver continues to accelerate at 9.8 m/s^2 downwards.
b. At terminal velocity, the skydiver continues to accelerate, but at less than 9.8 m/s^2, due to air friction.
c. At terminal velocity, air friction is no longer a factor in the skydiver's fall.
d. At terminal velocity, the velocity of the skydiver is 0.
e. At terminal velocity, the force of gravity is balanced by the force of air friction.

Answer:
The correct answer is *e*. The skydiver will fall with an initial acceleration of 9.8 m/s^2, but that acceleration will decrease as the force of air friction increases, causing a decreasing net acceleration.



Before terminal velocity
(net Force down, so
accelerating down)



At terminal velocity
(net Force of zero, so no
further acceleration)

Air friction increases as velocity increases, due to an increased number of interactions with the molecules in the air. At *terminal velocity*, the forces of gravity and air friction are balanced, so there is no longer any net force on the skydiver, and thus no net acceleration. The skydiver continues to fall, of course--she just isn't *accelerating*.

Question:

A skydiver jumps from a plane at a great height above the ground. Which of the following statements concerning the free-fall of the skydiver in air is correct?

I. **The skydiver's velocity is always downward as they fall.**
II. **The skydiver's acceleration remains constant and equal to *g* as they fall.**
III. **The skydiver will reach *terminal velocity* when the force of air drag equals the force of gravity acting on them.**

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

Answer:

c.

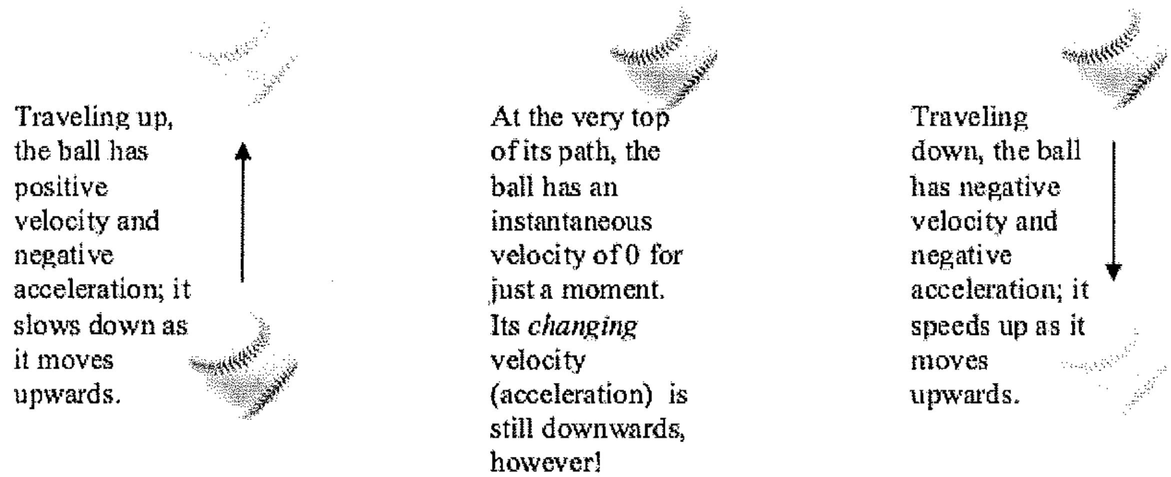
Question:

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 *false*?

a. The ball, at its maximum height, has an acceleration of -9.8 m/s^2.
b. The ball, as its traveling upwards, has a downwards acceleration.
c. The ball, at its maximum height, has a velocity of 0.
d. The ball, as it's traveling downwards, has an upwards acceleration.
e. The ball takes the same amount of time to go up as it does to fall back down.

Answer:

The correct answer is ***d***. The ball, as it's traveling downwards, has a ***downwards*** acceleration of 9.8 m/s^2. This is the same acceleration that the ball has the entire time that it is in the air.



For choice *e*, the problem is assuming that the ball is caught at the same height that it is thrown from, in which case the problem is *symmetrical*: the upwards and downwards motions are similar. The time the ball takes to go up is the same that it takes to fall back down. The distance the ball travels upwards is the same as the distance that it falls back down. The speed that the ball was thrown up at is the same as the speed the ball has just before it is caught again.

Question:

An object is released from rest from a certain height above the ground. If the effects of air resistance are neglected, which of the following statements is true?

a. The object travels 9.8 m during each second
b. The object's speed changes by 9.8 m/s during each second
c. The object's acceleration changes by 9.8 m/s^2 during each second
d. The object travels 9.8 m only during the first second
e. None of the above

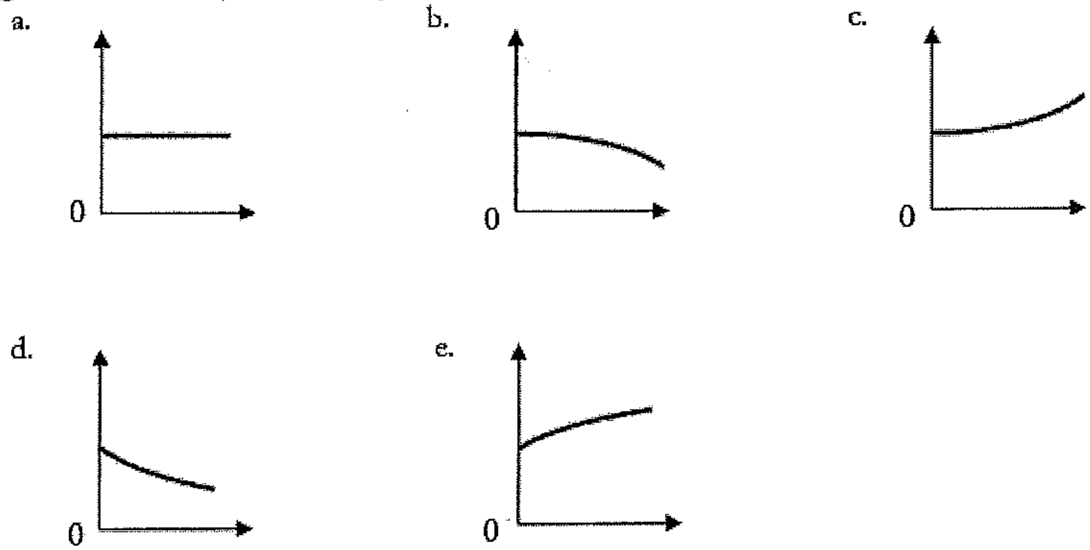
Answer:

b. The acceleration *g* in free-fall is constant. This causes the speed to change by a constant amount.

Question:

Which of the following statements concerning the *SI System* are correct?

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

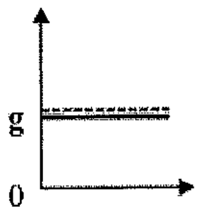


Answer:
The correct answer is *e*. As the falling object accelerates, its velocity continues to increase until its velocity reaches a constant, terminal, velocity, at which point the velocity function will be a straight, flat line. The only curve that shows an increase in velocity, approaching a slope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

Question:

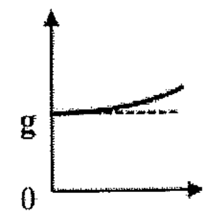
An object is dropped and accelerates downwards. As it falls it is affected by air friction, but never reaches terminal velocity during the course of its fall. The graph that could indicate the magnitude of the object's acceleration as a function of time is

a.

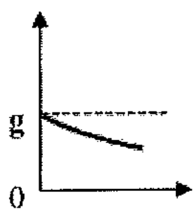


b.

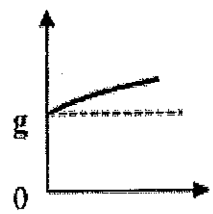
c.



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 astronaut standing on the moon holds a large, heavy brick and a small, light rock, and then releases them from the same height at the same time. Which object reaches the moon's surface first?

a. The brick, because it's heavier and accelerates faster..
b. The brick, because it has a greater force of gravity acting on it.
c. The rock, because there is less air friction acting on it.
d. They reach the surface at the same time because their accelerations are equal.
e. Both the rock and brick will just float there when released–there is no gravity on the moon.

Answer:

The correct answer is ***d***. The two objects experience the same acceleration when they are released–about 1/6 of the earth's acceleration of **g** = 9.8 m/s^2–and so they reach the surface at the same time.

Note that choice ***b*** states that the rock has a greater force of gravity acting on it, and this part of that answer is true: The force of gravity acting on something, also called its ***weight***, is calculated using $W = mg$. But the same ***mass*** that makes the rock weigh more also makes it harder to ***move*** that rock; it has more ***inertia***.

Question:

An object thrown straight up into the air, in the absence of air friction, accelerates at 9.8 m/s^2, downward. Which of the following statements is true?

a. The object speeds up at 9.8 m/s as it travels upward.
b. The object travels 9.8 m during every second of its motion.
c. The object travels 9.8 m during the first second of its motion.
d. The object's velocity changes by 9.8 m/s every second of its motion.
e. The integral of its acceleration as a function of time is 9.8 m/s.

Answer:

The correct answer is ***d***. By definition, an object accelerating at 9.8m/s, *per second*, has a velocity that changes by that amount.

While choice *e* is correct in identifying a velocity as the integral (with respect to time) of acceleration, the actual value of that integral will vary depending on the conditions (initial velocity, etc) of the problem.

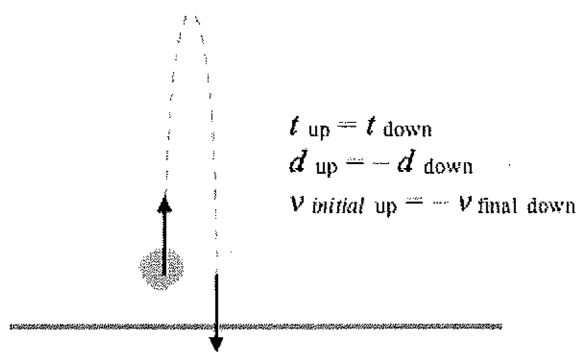
Question:

A rock is thrown straight up into the air with an initial velocity of +40 m/s, and eventually falls straight back down. What is the velocity of the rock just before it lands?

a. 40.0 m/s
b. 20.0 m/s
c. 0 m/s
d. -20 m/s
e. -40 m/s

Answer:

The correct answer is *e*. The rock's final velocity can be identified by using the principal of symmetry: for certain free-fall problems, the object will take the travel the same distance up as is falls back down, obviously. The object will take the same amount of time to travel upwards as it will take to fall back down. And it will have the same initial speed and final speed, although at the end of this problem, the velocity is obviously in the negative (downward) direction.



Knowing about symmetry is important because it allows you to quickly determine answers to problems that might otherwise require more lengthy calculations.

Question:

Physics problems sometimes instruct the student to consider a "freely falling" object. Which of the following statements about a dropped object in freefall near the surface of the earth is *false?*

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b. The object's speed increases by a constant amount each second that it falls.
c. Air friction is considered to be negligible.
d. The acceleration of the object depends on its weight.
e. Freefall acceleration is indicated by the symbol **g**.

Answer:

The correct answer is ***d***. The acceleration of the object does ***not*** depend on its weight.

Near the surface of the earth, an object is considered to be in freefall if earth's gravity is the only force acting on the object. Under these conditions, the acceleration of the object will be close to 9.8 m/s^2 downwards, although in we will often round that number to 10 m/s^2 for the purposes of making quick calculations easier.

FOLLOW-UP QUESTION: Is an object thrown up into the air considered "freely-falling?"

FOLLOW-UP ANSWER: Even though the object is not actually "falling" as it's traveling upwards, because gravity is the only force acting on it, and because it is accelerating at 9.8 m/s^2 downwards, the object *is* considered to be in free-fall.

Question:

Galileo drops a stone from a height of 55.0 meters on the Leaning Tower of Pisa. About how long does it take for the stone to reach the ground?

a. 5.6 s
b. 2.4 s
c. 3.3 s
d. 10.9 s
e. 4.8 s

Answer:

The correct answer is *c*. We can solve this problem by clearly stating the knowns and unknowns, and looking for an equation that will help us identify the unknown value in terms of the knowns.

Knowns and unknowns:

$$v_{initial} = 0$$

$$height = 55.0m;\ or\ \Delta y = -55.0m$$

$$a = g = -9.8m/s^2$$

$$t = ?$$

Solution:

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

$$t = \sqrt{\frac{2d}{a}}$$

$$t = \sqrt{\frac{2 \bullet 55m}{9.8m/s^2}} = 3.3s$$

or

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

$$-55m = 0t + \frac{1}{2}(-9.8m/s^2)t^2$$

$$t = \sqrt{\frac{-55m}{-4.9m/s^2}} = 3.3s$$

Note that in the analysis on the left, we simply stated that the stone was traveling in a certain direction (down), and that the acceleration was in that same direction, without use of any negative numbers to indicate direction. In the analysis on the right, we clearly indicated that down was negative, both for the *displacement* vector and the *acceleration* vector. Both solutions allow one to arrive at the correct answer.

Note also that there is no record that Galileo actually dropped any objects off the Tower of Pisa. He was born in the city of Pisa, however, so it's nice to imagine that he *might* have performed this experiment!

Question:

A baseball is tossed straight up into the air in the $+y$ direction. Which of the following statements is true at the point where the baseball reaches its greatest height?

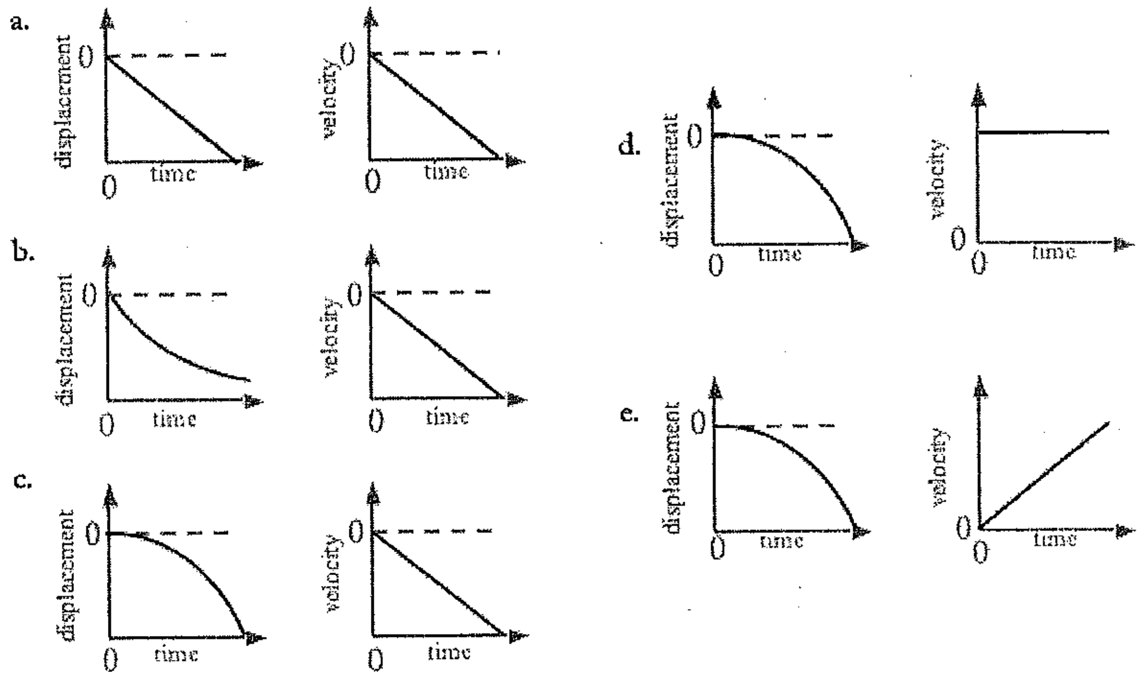
a. The velocity of the ball is 0 and the acceleration of the ball is negative.
b. The velocity of the ball is 0 and the acceleration is 0.
c. The velocity of the ball is positive and the acceleration of the ball is negative
d. The velocity of the ball is positive and the acceleration of the ball is 0.
e. The velocity of the ball is negative and the acceleration of the ball is negative.

Answer:

The correct answer is *a*. Although the ball's instantaneous velocity at this point in its path is 0, its acceleration remains a constant 9.80 m/s^2 in the downward (negative) direction.

Question:

A mass is dropped from a height *h* above the ground, and freely falls under the influence of gravity. Which graphs here correctly describe the displacement and velocity of the object during the time the object is falling? Consider the "up" direction to be positive.

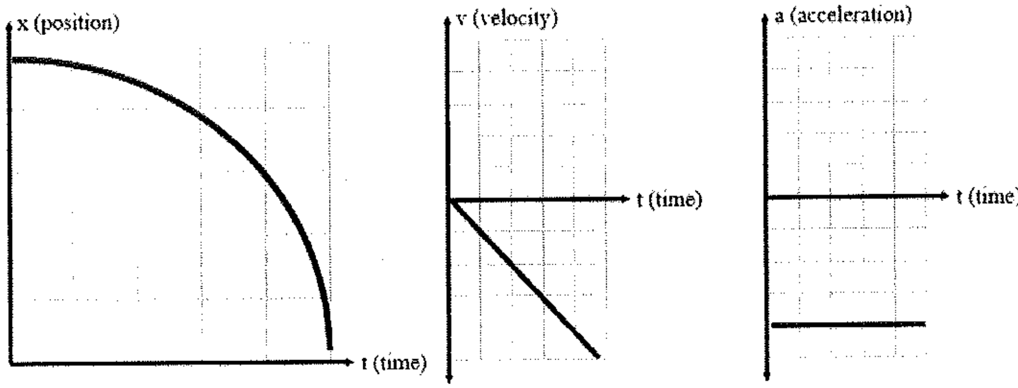


Answer:

The correct answer is *c*. The object begins to fall from a height *h* in the negative direction, accelerating as it falls, so it's covering a greater and greater distance per unit time. This is consistent with the displacement graphs a, c, d, and e. The object's speed increases with time, but its velocity is in the downward, or negative direction, as indicated in the velocity-time graph for answer *c*.

Question:

The graphs below could correspond to which motion?



I. An object falling upward.
II. An object falling downward.
III. An object with uniform acceleration moving along a horizontal path with increasing speed.

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

Answer:

d.