**Free Fall and Projectiles**

**Questions from a Conceptual Course**

**Category 1: Free Fall and Projectile Motion Concepts**

**Question 1:**

aa. Which statement best describes a free-falling object?

a. It is an object that is under the sole influence of gravity.

b. It is an object that is falling with a terminal velocity.

c. It is any object that is having a skydiving-like experience.

d. It is a person that is excused from paying their gravity bill.

**Question 2:**

aa. One can be certain that an object is undergoing free fall if they observe that \_\_\_\_\_.

a. it is falling

b. it is falling fast

c. it is falling from a high position

d. it is falling with an acceleration of 9.8 m/s/s

**Question 3:**

**A B C D**

aa. Consider the *dot diagrams* at the right. Which diagram is consistent with the motion of a free-falling object?

**Question 4:**

aa. What does the acceleration of gravity refer to?

a. The acceleration of gravity is the force of gravity that acts upon an object.

b. The acceleration of gravity refers to the speed with which an object falls.

c. The acceleration of gravity refers to the acceleration of a free falling object.

d. The acceleration of gravity refers to the time that it takes an object to fall.

**Question 5:**

aa. Which one of the following objects would free fall to the ground with the greatest acceleration?

a. A 2-kg brick

b. A 5 kg bowling ball

c. A 50-kg student

d. Nonsense! They all free fall with the same acceleration.

**Question 6:**

aa. Which one of the following objects would free fall to the ground with the smallest acceleration?

a. A 2-kg brick

b. A 5 kg bowling ball

c. A 50-kg student

d. Nonsense! They all free fall with the same acceleration.

**Question 7:**

aa. Which one of the following variables would affect the acceleration of a free falling object?

a. The mass of the object.

b. Whether the object is dropped from rest or projected.

c. The direction that the object is initially projected – upward, downward or horizontally.

d. Nonsense! None of these variables would affect the free fall acceleration of an object.

**Question 8:**

aa. Which one of the following variables would affect the acceleration of a free falling object?

a. The speed with which the object is initially projected.

b. The time that the object has been free falling.

c. The mass of the object.

d. Nonsense! None of these variables would affect the free fall acceleration of an object.

**Question 9:**

aa. Which one of these objects would experience the greatest acceleration as it free falls to the ground?

a. A 500-gram basketball dropped from rest.

b. A 500-gram basketball thrown upward with an initial speed of 20 m/s.

c. A 500-gram basketball thrown horizontally with an initial speed of 20 m/s.

d. Nonsense! Each of these objects accelerates at the same rate.

**Question 10:**

aa. Which one of these objects would experience the smallest acceleration as it free falls to the ground?

a. A 500-gram basketball dropped from rest.

b. A 500-gram basketball thrown upward with an initial speed of 20 m/s.

c. A 500-gram basketball thrown horizontally with an initial speed of 20 m/s.

d. Nonsense! Each of these objects accelerate at the same rate.

**Question 11:**

aa. How does the free fall acceleration of a ball dropped from rest compare to the free fall acceleration of a ball that is thrown downward?

a. The ball dropped from rest will have the smaller free fall acceleration.

b. The two balls will have the same free fall acceleration.

c. The ball dropped from rest will have the greater free fall acceleration.

**Question 12:**

aa. How does the free fall acceleration of a ball dropped from rest compare to the free fall acceleration of a ball that is thrown downward?

a. The ball that is thrown downward will have the smaller free fall acceleration.

b. The two balls will have the same free fall acceleration.

c. The ball that is thrown downward will have the greater free fall acceleration.

**Question 13:**

aa. How does the free fall acceleration of a ball dropped from rest compare to the free fall acceleration of a ball that is thrown upward?

a. The ball dropped from rest will have the smaller free fall acceleration.

b. The two balls will have the same free fall acceleration.

c. The ball dropped from rest will have the greater free fall acceleration.

**Question 14:**

aa. How does the free fall acceleration of a ball dropped from rest compare to the free fall acceleration of a ball that is thrown upward?

a. The ball that is thrown upward will have the smaller free fall acceleration.

b. The two balls will have the same free fall acceleration.

c. The ball that is thrown upward will have the greater free fall acceleration.

**Question 15:**

aa. A ball is dropped from the ceiling and free falls to the floor. Which one of the following statements regarding the ball’s motion is incorrect?

a. The ball speeds up as it falls to the ground.

b. The velocity of the ball is downward (in the negative direction).

c. The velocity of the ball has a constant value of 9.8 m/s.

**Question 16:**

aa. A ball is dropped from the ceiling and free falls to the floor. Which one of the following statements regarding the ball’s motion is incorrect?

a. The ball accelerates in the downward (negative) direction.

b. The acceleration of the ball is a constant value.

c. The acceleration of the ball increases as it falls to the ground.

**Question 17:**

aa. A ball is dropped from the ceiling and free falls to the floor. Which one of the following statements regarding the ball’s motion is incorrect?

a. The velocity of the ball changes by the same amount each second that it falls.

b. The position of the ball changes by the same amount each second that it falls.

c. The longer that the ball has been falling, the faster that it moves.

**Question 18:**

aa. A ball is dropped from the ceiling and free falls to the floor. Which one of the following statements regarding the ball’s motion is incorrect?

a. The distance the ball falls is proportional to the time that it falls.

b. The position change of the ball during any second is greater than it was during the previous second.

c. The position change during each second becomes less and less as it approaches the ground.

**Question 19:**

aa. A ball is dropped from the ceiling and free falls to the floor. Which one of the following statements regarding the ball’s motion is correct?

a. The ball speeds up as it falls to the ground.

b. The velocity of the ball is downward; its value remains constant.

c. The velocity of the ball has a constant value of 9.8 m/s.

**Question 20:**

aa. A ball is dropped from the ceiling and free falls to the floor. Which one of the following statements regarding the ball’s motion is correct?

a. The ball accelerates with a constant velocity value.

b. The acceleration of the ball is a constant value.

c. The acceleration of the ball increases as it falls to the ground.

**Question 21:**

aa. A ball is dropped from the ceiling and free falls to the floor. Which one of the following statements regarding the ball’s motion is correct?

a. The velocity of the ball changes by the same amount each second that it falls.

b. The position of the ball changes by the same amount each second that it falls.

c. The longer that the ball has been falling, the greater that the acceleration is.

**Question 22:**

aa. A ball is dropped from the ceiling and free falls to the floor. Which one of the following statements regarding the ball’s motion is correct?

a. The ball changes its position by the same amount each second that it falls.

b. The position change of the ball during any second is greater than it was during the previous second.

c. The position change during each second becomes less and less as it approaches the ground.

**Question 23:**

aa. Which statement describes how the velocity of an object changes as it free falls through air?

a. The velocity remains constant.

b. The velocity changes by a varying amount each consecutive second.

c. The velocity changes by the same amount each consecutive second.

**Question 24:**

aa. As we have learned, the quantity that we call **velocity** is a vector; it has a magnitude and a direction. Which statement describes the velocity of an object that is dropped from the ceiling and free falls to the ground?

a. The velocity is a constant value; its direction is changing.

b. The velocity has a changing value; its direction is constant.

c. The velocity has a changing value and a changing direction.

d. The velocity has both a constant value and a constant direction.

**Question 25:**

aa. As we have learned, the quantity that we call **acceleration** is a vector; it has a magnitude and a direction. Which statement describes the acceleration of a free falling object?

a. The acceleration is a constant value; its direction is changing.

b. The acceleration has a changing value; its direction is constant.

c. The acceleration has a changing value and a changing direction.

d. The acceleration has both a constant value and a constant direction.

**Question 26:**

aa. A ball is thrown upward with a speed of approximately 30 m/s. Which of the following sets of numbers are good estimates of the ball’s velocity 1 second, 2 seconds and 3 seconds later?

a. -10 m/s, -10 m/s, -10 m/s b. 30 m/s, 30 m/s, 30 m/s

c. 40 m/s, 50 m/s, 60 m/s d. 20 m/s, 10 m/s, 0 m/s

**Question 27:**

aa. A ball is thrown upward with a speed of approximately 20 m/s. Which of the following sets of numbers are good estimates of the ball’s velocity 1 second, 2 seconds and 3 seconds later?

a. -10 m/s, -10 m/s, -10 m/s b. 20 m/s, 20 m/s, 20 m/s

c. 30 m/s, 40 m/s, 50 m/s d. 10 m/s, 0 m/s, -10 m/s

**Question 28:**

aa. A ball is thrown upward with a speed of approximately 40 m/s. Which of the following sets of numbers are good estimates of the ball’s velocity 1 second, 2 seconds and 3 seconds later?

a. -10 m/s, -10 m/s, -10 m/s b. 40 m/s, 40 m/s, 40 m/s

c. 50 m/s, 60 m/s, 70 m/s d. 30 m/s, 20 m/s, 10 m/s

**Question 29:**

aa. A ball is thrown upward with a speed of approximately 10 m/s. Which of the following sets of numbers are good estimates of the ball’s velocity 1 second, 2 seconds and 3 seconds later?

a. -10 m/s, -10 m/s, -10 m/s b. 10 m/s, 10 m/s, 10 m/s

c. 20 m/s, 30 m/s, 40 m/s d. 0 m/s, -10 m/s, -20 m/s

**Question 30:**

aa. A ball is thrown upward with a speed of approximately 50 m/s. Which of the following sets of numbers are good estimates of the ball’s velocity 1 second, 2 seconds and 3 seconds later?

a. -10 m/s, -10 m/s, -10 m/s b. 50 m/s, 50 m/s, 50 m/s

c. 60 m/s, 70 m/s, 80 m/s d. 40 m/s, 30 m/s, 20 m/s

**Question 31:**

aa. A ball is thrown upward from the ground with a speed of 20 m/s. Approximately how much time does it take for the ball to reach its highest point?

a. 1 second b. 2 seconds

c. 4 seconds d. It depends on the ball’s mass.

**Question 32:**

aa. A ball is thrown upward from the ground with a speed of 20 m/s. Approximately how much time will the ball be in the air before it finally lands back on the ground?

a. 1 second b. 2 seconds

c. 4 seconds d. It depends on the ball’s mass.

**Question 33:**

aa. A ball is thrown upward from the ground with a speed of 30 m/s. Approximately how much time does it take for the ball to reach its highest point?

a. 1.5 seconds b. 3 seconds

c. 6 seconds d. It depends on the ball’s mass.

**Question 34:**

aa. A ball is thrown upward from the ground with a speed of 30 m/s. Approximately how much time will the ball be in the air before it finally lands back on the ground?

a. 1.5 seconds b. 3 seconds

c. 6 seconds d. It depends on the ball’s mass.

**Question 35:**

aa. A ball is thrown upward from the ground with a speed of 40 m/s. Approximately how much time does it take for the ball to reach its highest point?

a. 2 seconds b. 4 seconds

c. 8 seconds d. It depends on the ball’s mass.

**Question 36:**

aa. A ball is thrown upward from the ground with a speed of 40 m/s. Approximately how much time will the ball be in the air before it finally lands back on the ground?

a. 2 seconds b. 4 seconds

c. 8 seconds d. It depends on the ball’s mass.

**Question 37:**

aa. A ball is thrown upward from the ground with a speed of 50 m/s. Approximately how much time does it take for the ball to reach its highest point?

a. 2.5 seconds b. 5 seconds

c. 10 seconds d. It depends on the ball’s mass.

**Question 38:**

aa. A ball is thrown upward from the ground with a speed of 50 m/s. Approximately how much time will the ball be in the air before it finally lands back on the ground?

a. 2.5 seconds b. 5 seconds

c. 10 seconds d. It depends on the ball’s mass.

**Question 39:**

aa. A ball is thrown upward from the ground with a speed of 60 m/s. Approximately how much time does it take for the ball to reach its highest point?

a. 3 seconds b. 6 seconds

c. 12 seconds d. It depends on the ball’s mass.

**Question 40:**

aa. A ball is thrown upward from the ground with a speed of 60 m/s. Approximately how much time will the ball be in the air before it finally lands back on the ground?

a. 3 seconds b. 6 seconds

c. 12 seconds d. It depends on the ball’s mass.

**Question 41:**

aa. A ball is thrown upward from the ground with a speed of 10 m/s. Approximately how much time does it take for the ball to reach its highest point?

a. 0.5 seconds b. 1 second

c. 2 seconds d. It depends on the ball’s mass.

**Question 42:**

aa. A ball is thrown upward from the ground with a speed of 10 m/s. Approximately how much time will the ball be in the air before it finally lands back on the ground?

a. 0.5 seconds b. 1 second

c. 2 seconds d. It depends on the ball’s mass.

**Question 43:**

aa. A ball is thrown upward from the ground with a speed of 20 m/s. What will be its speed when it reaches its highest point?

a. 0 m/s b. 9.8 m/s

c. 20 m/s d. There's no way to predict such a value.

**Question 44:**

aa. A ball is thrown upward from the ground with a speed of 30 m/s. What will be its speed when it reaches its highest point?

a. 0 m/s b. 9.8 m/s

c. 30 m/s d. There's no way to predict such a value.

**Question 45:**

aa. A ball is thrown upward from the ground with a speed of 40 m/s. What will be its speed when it reaches its highest point?

a. 0 m/s b. 9.8 m/s

c. 40 m/s d. There's no way to predict such a value.

**Question 46:**

aa. A ball is thrown upward from the ground and rises to its highest point before finally falling to the ground. What will be its speed when it reaches its highest point?

a. 0 m/s

b. 9.8 m/s

c. The same as its initial speed.

d. There's no way to predict such a value.

**Question 47:**

aa. A ball is thrown upward with a speed of 50 m/s. It rises to its highest position (its *peak*) before falling back down to the ground. What is the ball's speed 2 seconds before reaching its peak?

a. Exactly 0 m/s. b. Approximately 10 m/s.

c. Approximately 20 m/s. d. Exactly 50 m/s.

**Question 48:**

aa. A ball is thrown upward with a speed of 40 m/s. It rises to its highest position (its *peak*) before falling back down to the ground. What is the ball's speed 2 seconds before reaching its peak?

a. Exactly 0 m/s. b. Approximately 10 m/s.

c. Approximately 20 m/s. d. Exactly 40 m/s.

**Question 49:**

aa. A ball is thrown upward with a speed of 30 m/s. It rises to its highest position (its *peak*) before falling back down to the ground. What is the ball's speed 2 seconds before reaching its peak?

a. Exactly 0 m/s. b. Approximately 10 m/s.

c. Approximately 20 m/s. d. Exactly 30 m/s.

**Question 50:**

aa. A ball is thrown upward with a speed of 50 m/s. It rises to its highest position (its *peak*) before falling back down to the ground. What is the ball's speed 2 seconds after reaching its peak?

a. Exactly 0 m/s. b. Approximately 10 m/s.

c. Approximately 20 m/s. d. Exactly 50 m/s.

**Question 51:**

aa. A ball is thrown upward with a speed of 40 m/s. It rises to its highest position (its *peak*) before falling back down to the ground. What is the ball's speed 2 seconds after reaching its peak?

a. Exactly 0 m/s. b. Approximately 10 m/s.

c. Approximately 20 m/s. d. Exactly 40 m/s.

**Question 52:**

aa. A ball is thrown upward with a speed of 30 m/s. It rises to its highest position (its *peak*) before falling back down to the ground. What is the ball's speed 2 seconds after reaching its peak?

a. Exactly 0 m/s. b. Approximately 10 m/s.

c. Approximately 20 m/s. d. Exactly 30 m/s.

**Question 53:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. How does its initial speed (when launched from the ground) compare to its final speed (when it lands on the ground)? Assume a free fall motion.

a. Its initial speed is less than its final speed.

b. Its initial speed is equal to its final speed.

c. Its initial speed is greater than its final speed.

**Question 54:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. Which of the following quantities will be constant over the course of this up and down motion?

a. The ball's position. b. The ball's speed.

c. The ball's acceleration. d. Nonsense! None of these are constant.

**Question 55:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. Which one of the following vector quantities is always directed in the same direction as the ball travels along this up and down path?

a. The ball's velocity.

b. The ball's acceleration.

c. None of these.

d. Both of these.

**Question 56:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. In which direction is the **velocity vector** directed as the ball is rising towards its peak?

a. In the upward direction.

b. In the downward direction.

c. Nonsense! Its direction is not predicable.

**Question 57:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. In which direction is the **velocity vector** directed as the ball is falling from its peak?

a. In the upward direction.

b. In the downward direction.

c. Nonsense! Its direction is not predicable.

**Question 58:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. In which direction is the **acceleration vector** directed as the ball is rising towards its peak?

a. In the upward direction.

b. In the downward direction.

c. Nonsense! Its direction is not predicable.

**Question 59:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. In which direction is the **acceleration vector** directed as the ball is falling from its peak?

a. In the upward direction.

b. In the downward direction.

c. Nonsense! Its direction is not predicable.

**Question 60:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. Which one of the following statements comparing its initial velocity (when launched from the ground) compare to its final velocity (when it lands on the ground) is correct? Assume a free fall motion.

a. Its initial velocity has the same magnitude as the final velocity.

b. Its initial velocity has the same direction as the final velocity.

c. Its initial velocity has a much greater magnitude than its final velocity.

d. Its final velocity has a much greater magnitude than its initial velocity.

**Question 61:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. Which one of the following statements comparing its initial acceleration (immediately after being launched from the ground) to its final acceleration (just before landing on the ground) is correct? Assume a free fall motion.

a. Its initial acceleration is upward and its final acceleration is downward.

b. The initial acceleration is much greater than the final acceleration.

c. The initial acceleration has the same magnitude and direction as the final acceleration.

d. The initial acceleration has the same magnitude and the opposite direction as the final acceleration.

**Question 62:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. Which one of the following statements is true about the ball’s motion?

a. The acceleration of the ball is 0 m/s/s at the highest point.

b. The acceleration vector is directed upward as it rises and downward as it falls.

c. The magnitude and direction of the acceleration vector never changes.

d. The initial acceleration is equal in magnitude and opposite in direction as the final acceleration.

**Question 63:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point and fall back to the ground. Which one of the following statements about the ball’s motion is **FALSE**?

a. The velocity of the ball is 0 m/s/s at the highest point.

b. The velocity vector is directed upward as it rises and downward as it falls.

c. The magnitude and direction of the velocity vector never changes.

d. The initial velocity is equal in magnitude and opposite in direction as the final velocity.

**Question 64:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point (the *peak*) and fall back to the ground. How does the time to rise to its highest point compare to the time to fall from its highest point? Assume a free fall motion.

a. It takes more time to rise to the peak as it does to fall from the peak.

b. It takes less time to rise to the peak as it does to fall from the peak.

a. It takes the same amount of time to rise to the peak as it does to fall from the peak.

**Question 65:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point (the *peak*) and fall back to the ground. It takes 3.0 seconds for the ball to reach its highest point. How much time does it take the ball to fall from its *peak* to the ground? Assume a free fall motion.

a. 1.5 seconds b. 3.0 seconds

c. 6.0 seconds d. 9.8 seconds

**Question 66:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point (the *peak*) and fall back to the ground. It takes 4.0 seconds for the ball to reach its highest point. How much time does it take the ball to fall from its *peak* to the ground? Assume a free fall motion.

a. 2.0 seconds b. 4.0 seconds

c. 8.0 seconds d. 9.8 seconds

**Question 67:**

aa. A ball that is thrown upwards from the ground will eventually reach its highest point (the *peak*) and fall back to the ground. It takes 6.0 seconds for the ball to reach its highest point. How much time does it take the ball to fall from its *peak* to the ground? Assume a free fall motion.

a. 3.0 seconds b. 6.0 seconds

c. 9.8 seconds d. 12.0 seconds

**Question 68:**

aa. Suppose that a freely falling object were somehow equipped with an odometer. Would the readings of distance fallen each second indicate equal or unequal distances of fall for successive seconds?

a. equal b. unequal

**Question 69:**

aa. When a ball player throws a ball straight up with a speed of 30 m/s, by how much does the speed of the ball decrease each second while it is rising towards its peak?

a. 0 m/s b. 10 m/s

c. 15 m/s d. 30 m/s

**Question 70:**

aa. When a ball player throws a ball straight up with a speed of 40 m/s, by how much does the speed of the ball decrease each second while it is rising towards its peak?

a. 0 m/s b. 10 m/s

c. 20 m/s d. 40 m/s

**Question 71:**

aa. For a freely falling object dropped from rest, what is the acceleration at the end of the 3rd second of fall?

a. 0 m/s/s b. -9.8 m/s/s

c. -29.4 m/s/s c. -44.1 m/s/s

**Question 72:**

aa. For a freely falling object dropped from rest, what is the acceleration at the end of the 4th second of fall?

a. 0 m/s/s b. -9.8 m/s/s

c. -39.2 m/s/s c. -78.4 m/s/s

**Question 73:**

aa. For a freely falling object dropped from rest, what is the acceleration at the end of the 5th second of fall?

a. 0 m/s/s b. -9.8 m/s/s

c. -49.0 m/s/s c. -122.5 m/s/s

a

**Question 74:**

a. An object falls under the sole influence of gravity. Which of these observations could be made of the object?

a. Its velocity increases.

b. Its acceleration increases.

c. Both its velocity and acceleration increases.

d. Neither its velocity or acceleration increases.

**Question 75:**

aa. Which one of the following describes the amount of speed gained by a free falling object during one second of fall?

a. 0 m/s. Its speed is constant.

b. It gains 10 m/s of speed each second.

c. The amount of speed change depends up on its initial speed.

d. Impossible. It’s not the same change during the first second as the last second of fall.

**Question 76:**

aa. A ball is thrown straight upwards and travels to its highest point (i.e., its *peak*) before falling. Which statement describes its velocity and acceleration at its peak?

a. Its velocity is 0 m/s and its acceleration is 0 m/s/s.

b. Its velocity is 10 m/s and its acceleration is 10 m/s/s.

c. Its velocity is 10 m/s and its acceleration is 0 m/s/s.

d. Its velocity is 0 m/s and its acceleration is 10 m/s/s.

**Question 77:**

aa. A bullet is dropped from the top of the John Hancock building while another bullet is fired downward from the same location. Once they begin their free fall motion, how does their acceleration values compare?

a. Both bullets have the same acceleration.

b. The fired bullet has the greater acceleration.

c. The dropped bullet has the greater acceleration.

**Question 78:**

aa. A bullet is dropped from the top of the John Hancock building while another bullet is fired upward from the same location. Once they begin their free fall motion, how does their acceleration values compare?

a. Both bullets have the same acceleration.

b. The fired bullet has the greater acceleration.

c. The dropped bullet has the greater acceleration.

**Question 79:**

aa. A bullet is dropped from the top of the John Hancock building while another bullet is fired horizontally from the same location. Once they begin their free fall motion, how does their acceleration values compare?

a. Both bullets have the same acceleration.

b. The fired bullet has the greater acceleration.

c. The dropped bullet has the greater acceleration.

**Question 80:**

aa. A ball is projected horizontally from the top of a cliff. At the same moment, a second identical ball is dropped from rest from the same location. Which ball lands on the ground first? Assume free fall motion.

a. The horizontally projected ball lands on the ground first.

b. The ball dropped from rest lands on the ground first.

c. Both balls land on the ground at the same time.

**Question 81:**

aa. A ball is projected horizontally from the top of a cliff. At the same moment, a second identical ball is dropped from rest from the same location. Which one of the following quantities is NOT the same for the two balls? Assume free fall motion.

a. The velocity with which the two balls hit the ground.

b. The time it takes the two balls to hit the ground.

c. The acceleration of the two balls as they fall to the ground.

**Question 82:**

aa. A ball is projected horizontally from the top of a cliff and free falls to the ground. Which one of the following statements accurately describes the ball’s motion?

a. The ball moves horizontally with a constant velocity but accelerates downward.

b. The ball’s horizontal position changes by a different amount every second.

c. The ball has a horizontal acceleration of 9.8 m/s/s.

**Question 83:**

aa. A ball is projected horizontally from the top of a cliff and free falls to the ground. Which one of the following statements regarding the ball’s motion is incorrect?

a. The force of gravity does not affect the horizontal motion of the ball.

b. The ball is moving horizontally with a constant speed throughout its motion.

c. The ball accelerates horizontally, changing its horizontal speed by 9.8 m/s each second.

**Question 84:**

aa. A ball is projected horizontally from the top of a cliff and free falls to the ground. Which one of the following statements regarding the ball’s motion is incorrect?

a. The ball does not accelerate in the horizontal direction.

b. The ball changes its horizontal position by 9.8 m each second.

c. The ball hits the ground with the same horizontal speed as it had when projected.

**Question 85:**

aa. A ball is projected horizontally from the top of a cliff and free falls to the ground. Which one of the following statements regarding the ball’s motion is correct?

a. The ball speeds up in both the horizontal and the vertical direction.

b. The ball speed up in the vertical direction but slows down in the horizontal direction.

c. The ball speeds up in the vertical direction but its horizontal speed remains the same.

**Question 86:**

aa. A ball is projected horizontally from the top of a cliff and free falls to the ground. Which one of the following statements regarding the ball’s motion is incorrect?

a. The vertical speed of the ball increases.

b. The vertical acceleration of the ball increases.

c. The horizontal speed of the ball remains constant.

**Question 87:**

aa. A ball is projected horizontally from the top of a cliff and free falls to the ground. Which one of the following statements regarding the ball’s motion is correct?

a. The ball accelerates vertically with a constant acceleration.

b. The ball accelerates horizontally with a constant acceleration.

c. The vertical acceleration changes by 9.8 m/s/s each second.

**Question 88:**

aa. A ball is projected horizontally from the top of a cliff and free falls to the ground. Which one of the following statements regarding the ball’s motion is incorrect?

a. The ball maintains a constant horizontal velocity.

b. The vertical velocity of the ball increases by 9.8 m/s each second.

c. The vertical acceleration is decreasing as it falls to the ground.

**Question 89:**

aa. A ball is projected horizontally from the top of a cliff and free falls to the ground. Which one of the following statements regarding the ball’s motion is correct?

a. The horizontal acceleration is a constant value of 9.8 m/s/s.

b. The vertical acceleration decreases as the ball falls to the ground.

c. The change in vertical position each second is increasing as it falls.

**Question 90:**

aa. A ball rolls off the table and free falls to the ground. Which statement accurately describes its speed as it falls?

a. It falls with a constant speed.

b. Its speed increases as it falls.

c. Its speed decreases as it falls.

**Question 91:**

aa. A ball rolls off the table and free falls to the ground. Which statement accurately describes its acceleration as it falls?

a. It falls with a constant acceleration.

b. Its acceleration increases as it falls.

c. Its acceleration decreases as it falls.

**Question 92:**

aa. Two balls roll off the table at the same time and free fall to the ground. Ball A is moving at 1 m/s when it rolls off the table. Ball B is moving at 2 m/s when it rolls off the table. Which ball hits the ground first?

a. Ball A. b. Ball B.

c. The two balls land at the same time.

**Question 93:**

aa. Two balls roll off the table at the same time and free fall to the ground. Ball A is moving at 1 m/s when it rolls off the table. Ball B is moving at 2 m/s when it rolls off the table. Which ball has the greatest acceleration as it falls to the ground?

a. Ball A. b. Ball B.

c. The two balls have the same acceleration.

**Question 94:**

aa. A ball rolls off the table and free falls to the ground. Which statement accurately describes the horizontal part of its velocity (vx) during its falling motion?

a. Its horizontal velocity is constant.

b. Its horizontal velocity is increasing.

c. Its horizontal velocity is decreasing.

**Question 95:**

aa. A ball rolls off the table and free falls to the ground. Which statement accurately describes the vertical part of its velocity (vy) during its falling motion?

a. Its vertical velocity is constant.

b. Its vertical velocity is increasing.

c. Its vertical velocity is decreasing.

**Question 96:**

aa. A ball rolls off the table and free falls to the ground. Which statement accurately describes its motion as it falls to the ground?

a. Its horizontal and its vertical speed increase.

b. Its horizontal and its vertical speed do not change.

c. Its horizontal speed increases but its vertical speed does not change.

d. Its horizontal speed does not change but its vertical speed increases.

**Question 97:**

aa. A ball rolls off the table and free falls to the ground. Which statement accurately describes its acceleration?

a. Its acceleration is downward and is increasing in value as it falls.

b. Its acceleration is downward but remains a constant value as it falls.

c. It has both a horizontal and vertical acceleration; both are constant in value.

d. It has both a horizontal and vertical acceleration; the vertical value increases.

**Question 98:**

aa. The **vector diagram** at the right represents the path of a horizontally launched projectile. The horizontal and vertical velocity vectors are shown for **position X**. Which diagram below accurately represents the magnitude and direction of these velocity vectors for **position Y**?

**Y**

**A B C**

**Question 99:**

aa. The **vector diagram** at the right represents the path of a horizontally launched projectile. The horizontal and vertical velocity vectors are shown for **position X**. Which diagram below accurately represents the magnitude and direction of these velocity vectors for **position Y**?

**Y**

**X**

**A B C**

**Question 100:**

aa. The **vector diagram** at the right represents the path of a horizontally launched projectile. The horizontal and vertical velocity vectors are shown for **position X**. Which diagram below accurately represents the magnitude and direction of these velocity vectors for **position Y**?

**Y**

**X**

**A B C**

**Y**

**X**

**Question 101:**

aa. The **vector diagram** at the right represents the path of a horizontally launched projectile. The horizontal and vertical velocity vectors are shown for **position X**. Which diagram below accurately represents the magnitude and direction of these velocity vectors for **position Y**?

**A B C**

**vx = 16 m/s**

**F**

**Question 102:**

aa. The diagram below shows *the start of a* **vector diagram** for a horizontally launched projectile. The position of the ball at 1.0-second intervals is shown. The initial horizontal velocity is 16 m/s as shown. What are approximate values of the horizontal and vertical velocities at point F?

a. vx = 16 m/s, vy = 20 m/s

b. vx = 36 m/s, vy = 20 m/s

c. vx = 16 m/s, vy = 10 m/s

d. vx = 16 m/s, vy = 16 m/s

e. vx = 36 m/s, vy = 10 m/s

**Question 103:**

aa. The diagram below shows *the start of a* **vector diagram** for a horizontally launched projectile. The position of the ball at 1.0-second intervals is shown. The initial horizontal velocity is 16 m/s. What are approximate values of the horizontal and vertical velocities at point F?

**vx = 16 m/s**

**F**

a. vx = 16 m/s, vy = 10 m/s

b. vx = 16 m/s, vy = 30 m/s

c. vx = 30 m/s, vy = 10 m/s

d. vx = 46 m/s, vy = 10 m/s

e. vx = 46 m/s, vy = 30 m/s

**Question 104:**

aa. The diagram below shows *the start of a* **vector diagram** for a horizontally launched projectile. The position of the ball at 1.0-second intervals is shown. The initial horizontal velocity is 16 m/s. What are approximate values of the horizontal and vertical velocities at point F?

**vx = 16 m/s**

**F**

a. vx = 16 m/s, vy = 10 m/s

b. vx = 56 m/s, vy = 10 m/s

c. vx = 40 m/s, vy = 40 m/s

d. vx = 16 m/s, vy = 40 m/s

e. vx = 16 m/s, vy = 0 m/s

**Question 105:**

aa. The diagram below shows *the start of a* **vector diagram** for a horizontally launched projectile. The position of the ball at 1.0-second intervals is shown. The initial horizontal velocity is 16 m/s. What are approximate values of the horizontal and vertical velocities at point F?

**vx = 16 m/s**

**F**

a. vx = 50 m/s, vy = 10 m/s

b. vx = 66 m/s, vy = 50 m/s

c. vx = 16 m/s, vy = 10 m/s

d. vx = 16 m/s, vy = 50 m/s

e. vx = 66 m/s, vy = 50 m/s

**Category 2: Graph Analysis, Information Analysis, and Experimental Design**

**Questions 106-109:**

The velocity-time graph below represents the motion of a ball that is thrown upward from the ground and remains in the air for 7.0 seconds. Use the graph to answer the following questions:

aa. What is the initial velocity value of the ball?

a. Exactly 0.0 m/s b. Approximately 7 m/s

c. Approximately 35 m/s d. Approximately 40 m/s

aa. What is the final velocity value of the ball?

a. Approximately 7 m/s b. Approximately 8 m/s

c. Approximately -35 m/s d. Approximately -40 m/s

aa. At what time is the ball at its highest point of its path (i.e., the peak)?

a. Exactly 0.0 seconds b. Approximately 3.5 seconds

c. Approximately 7.0 seconds d. Approximately 35 seconds

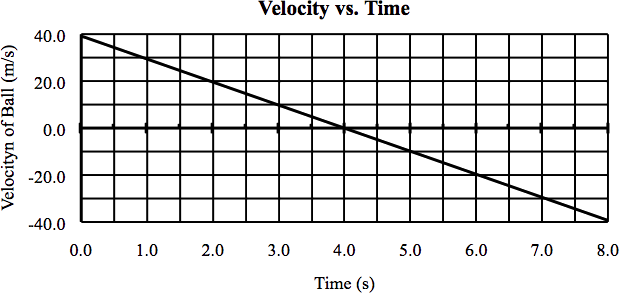
aa. At what time does the ball change its direction of motion?

a. Exactly 0.0 seconds b. Approximately 3.5 seconds

c. Approximately 7.0 seconds d. Approximately 35 seconds

**Questions 110-115:**

The velocity-time graph below represents the motion of a ball that is thrown upward from the ground and remains in the air for 8.0 seconds. Use the graph to answer the following questions:



aa. With what velocity was the ball initially thrown upward?

a. At approximately 40 m/s. b. At approximately 50 m/s

c. At approximately 80 m/s d. It’s impossible to tell from this graph.

aa. For how much time was the ball in the air?

a. 4.0 seconds b. 5.0 seconds

c. 8.0 seconds d. 10.0 seconds

aa. At what time does the ball turn around and change its direction?

a. At 4.0 seconds b. At 5.0 seconds

c. At 8.0 seconds d. At 10.0 seconds

e. Nonsense! The ball never changes its direction.

aa. With what speed is the ball moving at 6.0 seconds?

a. 0 m/s b. 10 m/s

c. 20 m/s d. 60 m/s

aa. Use the graph to determine the velocity of the ball at 3.0 seconds. How many seconds later will the ball be moving with this same speed?

a. 2.0 seconds later b. 4.0 seconds later

c. 5.0 seconds later d. 10.0 seconds later

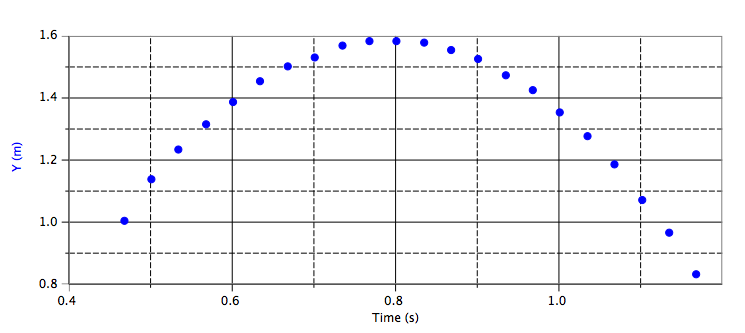
aa. Estimate the velocity of the ball at 6.5 seconds.

a. Approximately -10 m/s. b. Approximately -25 m/s.

c. Approximately 40 m/s. d. Approximately 65 m/s.

**Questions 116-119:**

An experimenter tosses a ball vertically into the air. The ball rises to its peak and falls back onto a table 0.80 meters above the ground. A video of the motion is inserted into Logger Pro and analyzed. The graph below represents the vertical position (y) as a function of time. Use the graph to answer the next AAA questions.



aa. To what height (in meters) above the ground does the ball rise before falling?

a. 0.8 b. 1.0

c. Between 1.1 and 1.2 d. 1.6

aa. Approximately how much time does it take the ball to fall from its peak to the table below?

a. Approximately 0.38 seconds b. Approximately 0.80 seconds

c. Approximately 1.4 seconds d. Approximately 1.6 seconds

aa. How high above the ground is the ball at a time of 0.95 seconds?

a. Approximately 0.65 meters. b. Approximately 1.13 meters.

c. Approximately 1.45 meters. d. Approximately 1.52 meters.

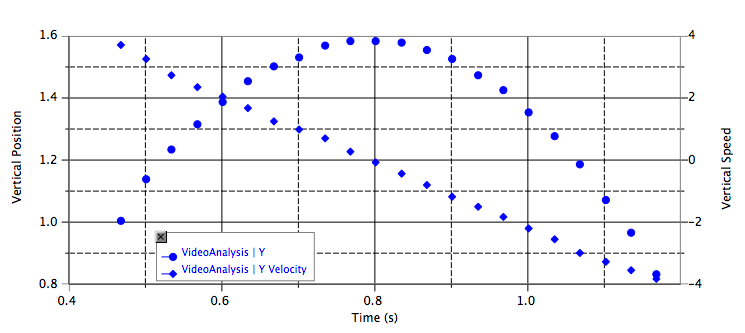
aa. How high above the ground is the ball at a time of 0.85 seconds?

a. Approximately 0.45 meters. b. Approximately 0.75 meters.

c. Approximately 1.15 meters. d. Approximately 1.56 meters.

**Questions 120-126:**

An experimenter tosses a ball vertically into the air. The ball rises to its peak and falls back onto a table 0.80 meters above the ground. A video of the motion is inserted into Logger Pro and analyzed. The graph below represents the vertical position (Y) and vertical velocity (Y Velocity) as a function of time. Use the graph to answer the next AAA questions.



aa. At which one of the listed times is the object moving with a vertical speed of 1.0 m/s?

a. At approximately 1.02 seconds b. At approximately 1.44 seconds

c. At approximately 1.50 seconds d. At approximately 2.40 seconds

aa. To what height (in meters) above the ground does the ball rise before falling?

a. 0.8 b. 1.0

c. Between 1.1 and 1.2 d. 1.6

aa. Approximately how much time does it take the ball to fall from its peak to the table below?

a. Approximately 0.38 seconds b. Approximately 0.80 seconds

c. Approximately 1.4 seconds d. Approximately 1.6 seconds

aa. With what speed is the ball moving when it hits the ground?

a. Exactly 0 m/s b. Approximately 0.8 m/s

c. Between 1.0 and 1.1 m/s d. Approximately 4 m/s

aa. The ball is released from the experimenter’s hands at a height (vertical position) of 1.0 m. How many seconds later is the ball at the peak of its upward path?

a. Approximately 0.34 seconds b. Approximately 0.60 seconds

c. Approximately 0.70 seconds d. Approximately 0.80 seconds

aa. At which one of the following times is the ball positioned 1.3 meters above the ground?

a. At exactly 0.50 seconds b. At approximately 0.57 seconds

c. At exactly 1.0 seconds d. At approximately 1.02 seconds

aa. At which of the following vertical heights above the ground is the ball moving downward with a vertical speed of 2.0 m/s?

a. At exactly 1.0 meters b. Between 1.0 and 1.1 meters

c. Between 1.1 and 1.2 meters d. Approximately 1.4 meters