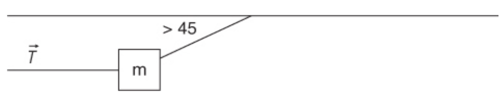
Diagnostic Test

AP Physics 1

SECTION I: MULTIPLE-CHOICE

DIRECTIONS: Select the best answer (or two best answers when indicated) on each of the following 26 multiple-choice questions as well as the 2 free-response questions. The detailed answer explanations will direct you to a specific chapter for further review on the specific subject matter in that question. You may use a calculator and make use of the formula sheet provided in the appendix.



1. A mass is suspended from the ceiling by one rope at an angle as indicated. The mass is held in place by a second, horizontal rope. Without knowing the exact angle from the ceiling, except that it is greater than 45 degrees, which statement best represents the possible value for tension in the horizontal line?

(A) $T > mg$
(B) $T = mg$
(C) $T < mg$
(D) cannot be determined without knowing the angle

2. Pushing on a mass of 15 kg with a sideways force of 120 N is not enough to get the mass to start sliding across the floor. Which of the following best describes the coefficient of static friction between the floor and the mass?

(A) $\mu = 0.8$
(B) $\mu > 0.8$
(C) $\mu < 0.8$
(D) $\mu = 1.25$

3. While standing on an elevator and experiencing a downward acceleration of 4.9 m/s^2, what is the force between the floor and your feet? The variable m is your mass.

(A) mg
(B) $0.5mg$
(C) $1.5mg$
(D) $4.9mg$

4. After throwing a ball at an upward angle, the reason the ball continues to go horizontally while falling due to gravity is that

(A) the ball's inertia keeps it going
(B) the force of the throw keeps it going
(C) the energy from gravitational potential keeps replenishing the lost energy
(D) air pressure keeps the ball from falling too quickly

5. Consider the situation in which your hand is pushing a book across a rough desktop with lots of friction. Of the many forces involved, consider only these two individual forces: the force on your hand from the book and the force the book is experiencing from your hand. While the book is accelerating from rest to its final velocity, which statement best compares the force experienced by your hand compared with that experienced by the book?

(A) Force on book > force on hand
(B) Force on hand > force on book
(C) Force on hand = force on book
(D) The relationship between these two forces depends on the frictional force.

6. A puck comes to a stop on a level floor in 20 meters after an initial speed of 10 m/s. What is the coefficient of kinetic friction between the puck and the floor?

(A) The mass is required to calculate this answer.
(B) 0.25
(C) 0.5
(D) 0.025

7. A rock is dropped from an extremely high cliff and experiences free-fall conditions. Which of the following statements is NOT true about the rock's velocity, acceleration, or displacement between the 3rd and 4th seconds of falling?

(A) The rock will fall an additional 4.9 meters.
(B) The rock will speed up by 9.8 m/s.
(C) The rock's acceleration will remain 9.8 m/s^2.
(D) The rock's displacement, velocity, and acceleration vectors are all directed downward.

8. When using the kinematics equation $x = x_0 + \upsilon_{x0}\, t + ½\, a_x\, t^2$, which of the following is always assumed to be true?

(A) a_x = zero
(B) $x > x_0$
(C) V_{x0} is positive.
(D) a_x is constant.

9. Consider a projectile launched at 30 degrees above a flat surface. The projectile experiences no air resistance and lands at the same height from which it was launched. Compare the initial and final conditions of the following vector components:

$$V_x \quad V_y \quad a_x \quad a_y$$

(A) They are all the same at both instances.
(B) They are all different from their initial values.
(C) V_x and V_y have changed, but a_x *and* a_y are constant.
(D) They are all the same except for V_y.

10. A physics teacher is swirling a bucket around in a vertical circle. If the bucket slips out of his hand when it is directly overhead, the bucket will

(A) fly upward initially
(B) drop straight down
(C) fly out horizontally initially
(D) fly out up and at an angle initially

11. If the Moon was twice as far from the center of Earth as it is currently, how would its orbital period change?

(A) The Moon's orbital period would double.
(B) The Moon's orbital period would increase by a factor of 4.
(C) The Moon's orbital period would increase by a factor of $2\sqrt{2}$.
(D) The Moon's orbital period would decrease by a factor of 2.

12. If you went to another planet, which of the following would be true?

(A) Your mass would be the same, but your weight would change.
(B) Your mass would change, but your weight would be the same.
(C) Your mass would be the same, and your weight would be the same.
(D) Your mass would change, and your weight would change.

13. You lift a heavy suitcase twice. Each time you lift it to the same height, but the second time you do it in half the time. Compare the work done to and power delivered to the suitcase.

(A) Same work, same power
(B) Twice the work, twice the power
(C) Twice the work, same power
(D) Same work, twice the power

14. A constant horizontal force of 12 N is applied for 5 meters to move an initially stationary mass of 5 kg. The friction between the floor and the mass does a total of −40 joules of work to the mass. The final speed (in m/s) of the object is

(A) $2(6)^{½}$
(B) $2(2)^{½}$
(C) $2(10)^{½}$
(D) 4

15. A skier begins a downhill run at a height of 9 meters and a speed of 2 m/s. If you ignore friction, what will be her speed when she is 3 meters from the bottom of the slope?

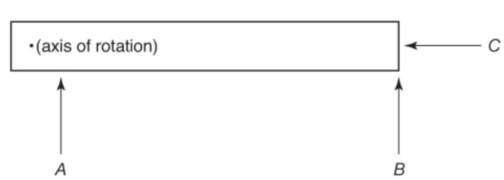
(A) 6.0 m/s
(B) 12.8 m/s
(C) 11.1 m/s
(D) 7.7 m/s

16. A rubber ball (m = 0.250 kg) strikes a wall horizontally at 3.50 m/s and rebounds elastically. What is the magnitude of impulse delivered to the wall in N · s?

(A) 0.875
(B) 1.75
(C) 2.50
(D) 8.75

17. A running back (m = 85 kg) running at 1.5 m/s is tackled from the side by another player (m = 75 kg) running perpendicularly to the running back's original heading at 1.75 m/s. What is the resulting speed of the two entangled players just after the tackle?

(A) 2.2 m/s
(B) 0.25 m/s
(C) 1.6 m/s
(D) 1.1 m/s



18. Which of the following ranks the torques applied by the three equal forces *A, B,* and *C* to the long thin rod about its fixed axis as indicated?

(A) $\tau_C > \tau_B > \tau_A$

(B) $\tau_A = \tau_B > \tau_C$

(C) $\tau_B = \tau_C > \tau_A$

(D) $\tau_B > \tau_A > \tau_C$

19. A large spherical cloud of dust in deep space that is spinning slowly collapses under its own gravitational force into a spherical cloud 10 times smaller in diameter. How does its rotational speed change?

(A) The rotational speed does not change.

(B) The rotational speed increases by a factor of 10.

(C) The rotational speed decreases by a factor of 10.

(D) The rotational speed increases by a factor of 100.

20. A single resistor attached to a constant voltage source has an additional, identical resistor inserted between one end of the resistor and the voltage supply. Which of these is the correct description of what will happen to the voltage drop across (V) and the current running through the original resistor (I) as a result?

(A) I and V will remain unchanged.

(B) I and V will both be halved.

(C) I will be halved; V will remain unchanged.

(D) V will be halved; I will remain unchanged.

21. A single resistor attached to a constant voltage source has an additional, identical resistor inserted beside it, forming its own connection across the voltage supply. Which of these is the correct description of what will happen to the voltage drop across (V) and the current running through the original resistor (I) as a result?

(A) I and V will remain unchanged.

(B) I and V will both be halved.

(C) I will be halved; V will remain unchanged.

(D) V will be halved; I will remain unchanged.

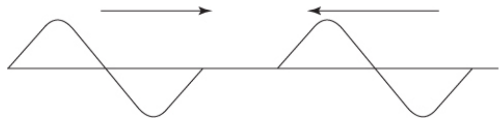
22. A simple circuit consisting of a battery, a switch, and a lightbulb in series is constructed. Which is the best explanation of what happens when the switch is closed for the first time?

(A) The lightbulb goes out immediately.

(B) Electrons are allowed to flow through the switch from the battery. When they reach the bulb, it lights.

(C) Electrons are allowed to flow through the switch. When those electrons already within the bulb move, the lightbulb lights.

(D) Electrons on the negative side of the switch are allowed to first flow. When they reach the bulb, it lights.

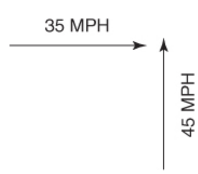


23. As two sine waves run into each other on a single rope under tension, as shown above, what is the resulting sequence of events?

(A) Initial constructive interference followed by unchanged waves emerging on opposite sides
(B) Initial constructive interference followed by waves bouncing backward
(C) Initial partial destructive interference followed by constructive interference followed by unchanged waves emerging on opposite sides
(D) Initial partial destructive interference followed by constructive interference followed by waves bouncing backward

24. As you stand on the side of the road, an ambulance approaches your position at high speed. Which option best describes the sound of the siren as observed by you as compared with the driver's perception?

	Frequency	Wavelength	Wave Speed
(A)	Higher	Lower	Same
(B)	Higher	Same	Same
(C)	Higher	Same	Higher
(D)	Lower	Higher	Higher



25. Two cars approach an intersection at right angles, as pictured above. What is their relative speed to each other?

(A) 10 mph
(B) 45 mph
(C) 57 mph
(D) 80 mph

26. Which of the following statements are true regarding collisions? Select two answers.

(A) An elastic collision conserves both net momentum and net kinetic energy.

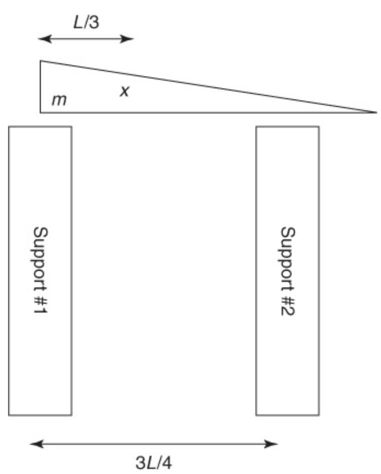
(B) An inelastic collision conserves mechanical energy but not net momentum.

(C) An elastic collision between two objects has equal but opposite impulses delivered.

(D) An inelastic collision between two objects is one in which both objects come to rest during the collision.

SECTION II: FREE-RESPONSE

1. A static, nonuniform wedge-shaped mass, *m* (with center of mass *x* as indicated), with a base length of *L* (shown below) is supported at two points. The first support point is at the bottom left corner of the wedge. The second support point is located at a point ¾ of the length of the wedge away from that corner.



(a) Using as givens *m, L,* and *g* (the gravitational field strength), solve for the two unknown contact forces at the points of support (F_1 and F_2).

(b) Support #2 is removed. The wedge begins to fall by rotating around support #1 with an angular acceleration of 2 rad/s^2. If the mass of the wedge is 3.8 kg and $L = 75$ cm, determine the moment of inertia of the nonuniform wedge about the top of support #1.

(c) As the wedge continues to rotate clockwise but remains in contact with support #1:

(i) Does the angular acceleration increase, decrease, or remain the same? Justify your response.

(ii) Does the moment of inertia of the wedge increase, decrease, or remain the same? Justify your response.

2. An object of unknown mass is fired at an unknown angle with an initial speed of 25 m/s. Ignore frictional effects. If only 45 percent of its initial kinetic energy is still present as kinetic energy at the projectile's highest point, determine the time in flight for the projectile.

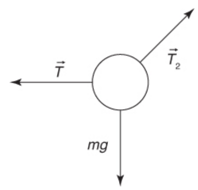
ANSWER KEY	Topic and Chapter to Reference
1. **(C)**	Statics problem, Chapter 3

2. **(B)**	Frictional dynamics, Chapter 3
3. **(B)**	Elevator problem, Chapter 3
4. **(A)**	Newton's first law, Chapter 3
5. **(C)**	Newton's third law, Chapter 3
6. **(B)**	Friction, Chapters 2 and 3
7. **(A)**	Friction, Chapters 2 and 3
8. **(D)**	Kinematics, Chapter 2
9. **(D)**	Projectile motion, Chapter 2
10. **(C)**	Circular motion, Chapter 3
11. **(C)**	Gravity, Chapter 5
12. **(A)**	Mass vs. weight, Chapter 3
13. **(D)**	Work and power, Chapter 4
14. **(B)**	Net work = ΔKE, Chapter 4
15. **(C)**	Net work = ΔKE, Chapter 4
16. **(B)**	Impulse and momentum, Chapter 6
17. **(D)**	Conservation of momentum, Chapter 6
18. **(D)**	Torque, Chapter 7
19. **(D)**	Conservation of angular momentum, Chapter 7
20. **(B)**	Series circuits, Chapter 9
21. **(A)**	Parallel circuits, Chapter 9
22. **(C)**	Open/closed circuit, Chapter 9
23. **(C)**	Open/closed circuit, Chapter 9
24. **(A)**	Sound waves, Chapter 10
25. **(C)**	Relative velocity, Chapter 2
26. **(A)** and **(C)**	Conservation of linear momentum, Chapter 6

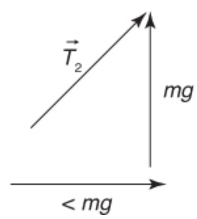
ANSWERS EXPLAINED

Section I: Multiple-Choice

1. **(C)** $T < mg$. Since the mass is stationary, we conclude that the net force is zero. The upward tension of the angled rope must be mg in order to cancel out gravity. The free-body diagram on the hanging mass is:



Since the angle θ is greater than 45 degrees, the vertical component of tension T_2 must be bigger than the horizontal component. (To see this quickly, draw an extreme case, such as 85 degrees.) Therefore, the horizontal component of tension must be less than mg. The horizontal rope T must cancel this horizontal component of T_2.

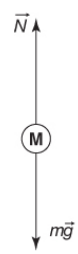


2. **(B)** $\mu > 0.8$. The normal force between the mass and the floor is 150 N. The needed sideways push to overcome static friction is **greater than** 120 N. Dividing these two forces would give us:

$$\mu_s = 120/150 = 0.8$$

Since a greater force is needed, the coefficient of static friction must be agreater than this value.

3. **(B)** $0.5mg$. The free-body diagram consists of only two forces.



Newton's second law gives us $+N - mg = ma$. Let $a = -0.5g$, which is half the value of g and downward:

$$N - mg = -0.5mg$$
$$N = 0.5mg$$

4. **(A)** The ball's inertia keeps it going. Newton's first law says that a body's inertia maintains its current motion once in motion. After the force of the throw, the only force on the ball is the

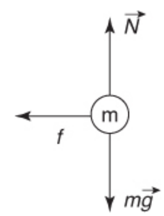
vertical force of gravity. This causes the ball to accelerate in the vertical direction while the ball's sideways velocity is maintained due to its inertia.

5. **(C)** Force on hand = force on book. Newton's third law of action-reaction states that the force pair of interaction between two objects is always equal and opposite. The acceleration of either object has no role in the third law. The acceleration comes about from the net force on a single object.

6. **(B)** 0.25. To find force, we must first find acceleration:

$$v_f^2 = v_i^2 + 2ad$$
$$(0)^2 = (10 \text{ m/s})^2 + (2a)(20 \text{ m})$$
$$a = -2.5 \text{ m/s}^2$$

The net force horizontally is the friction. There are no other horizontal forces:



Newton's second law gives us:

$$f = ma = -m(2.5)$$

Our model for friction gives us:

$$f = -\mu N$$

This value is negative since it is to the left. Since the vertical forces cancel out, $N = mg$. Substituting for friction from above and mg for N:

$$-m(2.5) = -\mu mg$$

Note that mass cancels:

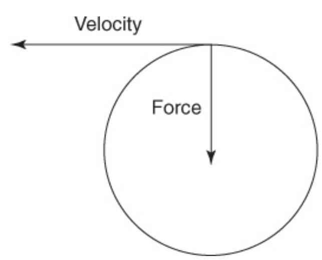
$$\mu = (2.5/g) = 0.25$$

7. **(A)** The rock will fall an additional 4.9 meters is NOT true. An object in free fall will accelerate by a constant 9.8 m/s^2. Since the rock is already moving downward, this leads to an increase in speed of 9.8 m/s in that 1-second interval. However, the rock will fall much farther than 4.9 m as it is already moving close to 30 m/s downward by the start of the 3rd second. It will fall an additional 35 meters in that 4th second. The rock does indeed fall 4.9 meters in the 1st second of the drop but falls an increasingly greater distance each second thereafter.

8. **(D)** a_x is constant. All the equations of motion are predicated on the assumption of constant acceleration. Any permutation of signs or values will work in any of the equations of motion. If the acceleration is not constant, one must use graphical methods or approximate the acceleration as constant over a narrow interval of time.

9. **(D)** They are all the same except for V_y. Projectile motion involves a constant vertical acceleration of $-g$ and no horizontal acceleration at all. Therefore, a_x and a_y are both constant throughout the flight. Since a_x is zero, there is no change in V_x. So V_x is also constant. V_y, however, is always changing. For a symmetric problem such as this one, the projectile lands with the same vertical speed as it had initially but in the opposite direction so that $V_{yf} = -V_{yi}$.

10. **(C)** The bucket will fly out horizontally initially. Objects executing circular motion have velocity vectors tangent to their motion while experiencing an inward acceleration. If the inward force is released, Newton's first law dictates that the object follow its velocity vector. Note that gravity will cause the object to fall after it is released, but the initial motion is horizontal.



11. **(C)** The Moon's orbital period would increase by a factor of $2\sqrt{2}$. Kepler's third law of orbital bodies states that their orbital periods squared are proportional to their orbital radius cubed:

$$T_{old}^2/R_{old}^3 = T_{new}^2/R_{new}^3$$

Substituting $R_{new} = 2R_{old}$:

$$T_{old}^2/R_{old}^3 = T_{new}^2/(2R_{old})^3$$

Cancel R and solve for T_{new}:

$$T_{new} = 8^{1/2}T_{old} = 2\sqrt{2}T_{old}$$

Note that you can also obtain this result by examining the equation for orbital speed from Newton ($v = (Gm/r)^{1/2}$). This shows that the orbital speed of the Moon must decrease by the square root of 2. Coupling this with the knowledge that the new orbit is now twice as large, it will take $2(2^{1/2})$ or $2\sqrt{2}$ times as long to orbit once around Earth as it used to.

12. **(A)** Your mass would be the same, but your weight would change. Mass is a property of an object and measures the object's inertia regardless of location. Weight is a force due to gravity and depends both on the object's mass and on the planetary gravity the object is currently experiencing.

13. **(D)** Same work, twice the power.

$$\text{Work} = \text{force} \times \text{distance}$$

For lifting operations, the force is assumed to be equal to the weight of the object for most of the lift. (Briefly, at the beginning of the lift, the lifting force must be greater than the weight in order to get the object moving. This brief force must be different in the second case in order to get the suitcase moving faster. However, this initial force is generally ignored in these calculations as it does not happen over an appreciable distance, just as the decrease in lifting force at the end of the lift is likewise ignored.) The same force over the same distance yields the same work. If the details of the forces contributing to the work are troublesome, you may prefer to think about the energy gained by the suitcase ($W = \Delta E$). Since the suitcase has gained the same amount of energy in both cases by being lifted, the work done must likewise be the same:

$$\text{Power} = \text{work/time}$$

If the same work is done in half the time, twice the power must be supplied.

14. **(B)** $2(2)^{½}$ m/s. From the work-energy theorem:

$$W_{\text{net}} = \Delta KE$$

$$\text{Work done by the horizontal force} = (12\text{ N})(5\text{ m}) = 60\text{ J}$$

$$\text{Work done by friction} = -40\text{ J}$$

$$W_{\text{net}} = +60 - 40 = 20\text{ J}$$

So the kinetic energy of the mass has gone up by 20 J. Initially, it had no KE since it was stationary. Therefore:

$$\frac{1}{2} m\nu\, f^2 = 20$$

$$\nu f^2 = 40/5 = 8$$

$$\nu f = 2\left(2^{1/2}\right)$$

15. **(C)** 11.1 m/s. Mechanical energy is conserved since there are no nonconservative forces involved:

$$ME_i = ME_f$$

$$KE_i + PE_i = KE_f + PE_f$$

$$\frac{1}{2} m(2\text{ m/s})^2 + mg\,(9\text{ m}) = \frac{1}{2} m\nu f^2 + mg\,(3\text{ m})$$

Canceling mass in every term and solving for v_f yields:

$$v_f^2 = 2^2 + 2\times(9g - 3g) = 4 + 12\,g = 124$$
$$v_f = 11.1 \text{ m/s}$$

16. **(B)** 1.75

$$\begin{aligned}\text{Impulse} &= \Delta\text{momentum} \\ &= m\overrightarrow{v_f} - m\overrightarrow{v_i}\end{aligned}$$

Since the collision is elastic, no kinetic energy is lost. Assuming the wall remains stationary, the rubber ball must rebound with the same speed but in the opposite direction:

$$\overrightarrow{v_f} = -\overrightarrow{v_i}$$

Substituting for v_f above:

$$\text{Impulse} = m\left(-\overrightarrow{v}_i\right) - m\overrightarrow{v}_i = -2m\overrightarrow{v}_i = -2\,(0.25\text{ kg})(3.5\text{ m/s}) = -1.75\text{ kg}\cdot\text{m/s}$$

Here the negative sign indicates that the impulse delivered to the ball is in the opposite direction from the ball's initial velocity. Note the ball and the wall receive equal and opposite impulses (from Newton's third law) and the problem asks for magnitude (absolute value).

Since $F\Delta t$ is also an impulse, units of N · s must be the same as kg · m/s and is quickly shown:

$$\text{N} \cdot \text{s} = (\text{kg}\cdot\text{m/s}^2)\text{s} = \text{kg}\cdot\text{m/s}$$

17. **(D)** 1.1 m/s. Total momentum must be conserved through the collision. So we need to find only the magnitude of the initial momentum of the system. Each player is originally running perpendicularly to the other. Thus, their individual momentums are different components. Imagine one as an *x*-component and the other as a *y*-component. Therefore, the resulting magnitude is found using the Pythagorean theorem. Dividing by total mass yields the speed of the combined players after impact:

$$p_{1x} = 85(1.5) = 127.5 \text{ kg}\cdot\text{m/s}$$
$$p_{2y} = 75(1.75) = 131.25 \text{ kg}\cdot\text{m/s}$$
$$\text{Magnitude} = 183 \text{ kg}\cdot\text{m/s}$$
$$\text{Net mass} = 160 \text{ kg}\cdot\text{m/s}$$
$$\text{Speed} = \text{magnitude/mass} = 1.14 \text{ m/s}$$

18. **(D)** $\tau_B > \tau_A > \tau_C$

$$\text{Torque} = (\text{force})\ (\text{distance from axis of rotation})\ \sin\theta$$

Force C is applied along the lever arm. So force C has an angle of 180°, resulting in no torque.

Force A has a much shorter lever arm than force B. Therefore, the torque supplied by A is much less than the torque supplied by B.

19. **(D)** The rotational speed increases by a factor of 100. The moment of inertia (I) for a sphere is proportional to R^2. Because the shape of the cloud is not changing, we can determine that the moment of inertia has decreased by a factor of 10^2. Since angular momentum is conserved:

$$I_1\omega_1 = I_2\omega_2$$

The new angular velocity (ω_2) must be 100 times bigger:

$$I_1\omega_1 = I_2\omega_2 = (I_1/100)(100\omega_1)$$

20. **(B)** I and V will both be halved. The effective resistance of the entire circuit is doubled, meaning the voltage supply will send out only half the current:

$$V = IR$$
$$V_{\text{same}}/R_{\text{doubled}} = I$$

The voltage used for the entire circuit must be shared between the two resistors. Since the two resistors are identical, the split will be 50/50.

21. **(A)** I and V will remain unchanged. The new resistor forms its own parallel path and therefore does not affect the voltage for the original path. Since the original resistor has the same voltage and resistance, it will draw the same current. Note, however, that the voltage supply must now furnish twice the current with the second resistor in place.

22. **(C)** Electrons are allowed to flow through the switch. When those electrons already within the bulb move, the lightbulb lights. Closing a switch completes the path, allowing electrons to move around the circuit. All components within the circuit have electrons that respond to the voltage difference and begin to flow. This resulting movement of electrons already within the bulb causes the lightbulb to glow. Recall that the drift velocities of electrons in simple circuits that make up the current are only about 0.03 cm/s.

23. **(C)** Initial partial destructive interference followed by constructive interference followed by unchanged waves emerging on opposite sides. After the waves superpose, they emerge as they were before as if they had never met. As they begin to overlap, the leading trough of the wave on the left will superpose with the leading peak of the wave on the right to interfere

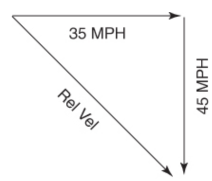
destructively. However, since the other halves of the waves are unaffected, this is only partial destruction. When the waves are completely superposed, trough will be on trough and peak on peak, leading to a constructive interference.

24. **(A)** Higher frequency, lower wavelength, same wave speed. Wave speed is determined by the medium, which is the air. So wave speed will not be observed to be different by either observer. Wavelength will appear to be shorter to the stationary observer as the crests are compressed by the ambulance moving toward you between peaks:

$$\text{Wavelength} \times \text{frequency} = \text{wave speed}$$

Since wavelength is shorter, the frequency must be higher in order to give the same speed. This higher frequency is the directly observable higher pitch that is known as the Doppler shift.

25. **(C)** 57 mph. Relative velocity is the difference in the velocity vectors. When the vectors are subtracted, the resultant is the hypotenuse of a right triangle:

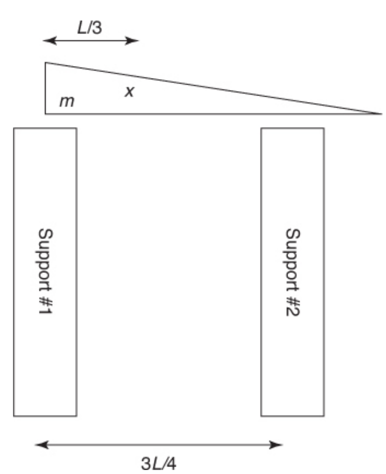


$\text{Relative velocity} = (35^2 + 45^2)^{1/2}$

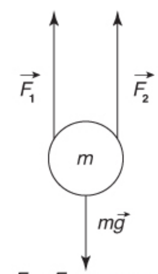
26. **(A)** and **(C)** An elastic collision conserves both net momentum and net kinetic energy. An elastic collision between two objects has equal but opposite impulses delivered. All collisions conserve net momentum. Elastic collisions also conserve kinetic energy. All collisions involve equal but opposite exchanges of momentums. Inelastic collisions simply indicate that kinetic energy is not conserved.

Section II: Free-Response

1. This is a statics problem (see Chapters 3 and 7 for more information).



(a) Both net force and net torque must add up to zero. Make a free-body diagram:



$$F_{net} = F_1 + F_2 - mg = ma = 0$$

$$F_1 + F_2 = mg$$

We now have two unknowns but only one equation! For torque, we are free to choose any axis of rotation we want since the wedge is not actually moving. We should place the axis of rotation at either contact point in order to eliminate one variable. If we place our axis of rotation at the F_1 contact point and use minus for clockwise rotations and plus for counterclockwise rotations:

$$\text{Net torque} = F_1(0) - mg(L/3) + F_2(3L/4) = I\alpha = 0$$

$$F_2(3L/4) = mg(L/3)$$

$$F_2 = 4mg/9$$

Combine this equation with the one found above.

$$F_1 = mg - 4mg/9 = 5mg/9$$

$$\text{Torque} = I\alpha$$

(b)

Since F_2 is gone, the torque is supplied only by the mass of the object:

$$\text{Torque} = FR \sin\theta$$

$$\text{Torque} = mg(L/3)(1)$$

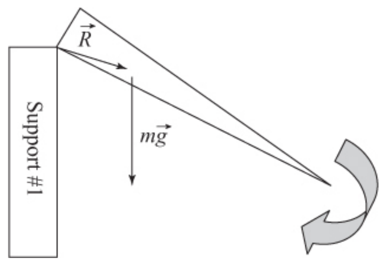
Substituting into the above equation:

$$mgL/3 = I\alpha = I(2)$$

$$I = mgL/6 = (3.8)(9.8)(0.75)/6 = 4.7 \text{ kg·m}^2$$

Note that $I = mr^2$ cannot be used, as the object has mass spread out over many different r values.

(c) (i) As the object rotates, neither the lever arm nor the force (*mg*) changes. However, the angle between the lever arm and force goes from 90° initially toward 0° at the lowest point of the downward swing. Since torque is proportional to sin θ, the torque (and thus the angular acceleration) will decrease.



(ii) Since neither the distribution of mass nor the axis of rotation changes during the swing, the object's moment of inertia remains constant.

2. This is a projectile motion (Chapter 2) and energy conservation (Chapter 4) problem. Energy conservation tells us that the other 55 percent of the initial energy is in gravitational potential energy.

$$\text{GPE at top} = 55\% \text{ of initial } KE = 0.55\left(\tfrac{1}{2}m\left(25^2\right)\right)$$
$$mgh = 0.55\left(\tfrac{1}{2}m\left(25^2\right)\right)$$

Solve for height and note that mass cancels:

$$h = 17.5m$$

Determine the time to fall from that height. Remember there is no vertical velocity at the highest point!

$$D_y = \tfrac{1}{2}at^2$$
$$17.5 = 4.9t^2$$
$$t = 1.89 \text{ s}$$

Double this value to obtain time in flight: 3.8 seconds.