Exam Three Momentum Concept Questions

Isolated Systems

4. A car accelerates from rest. In doing so the absolute value of the car's momentum changes by a certain amount and that of the Earth changes by:

1. a larger amount.
2. the same amount .
3. a smaller amount.
4. The answer depends on the interaction between the two.

Answer: 2. Momentum is equal to the force times the time over which it acts. The forces exerted on the car by Earth and those exerted on Earth by the car are equal and opposite, and the times during which these forces are exerted are equal.

6. Suppose the entire population of the world gathers in one spot and, at the sounding of a prearranged signal, everyone jumps up. While all the people are in the air, does Earth gain momentum in the opposite direction?

1. No; the inertial mass of Earth is so large that the planet's change in motion is imperceptible.
2. Yes; because of its much larger inertial mass, however, the change in momentum of Earth is much less than that of all the jumping people.
3. Yes; Earth recoils, like a rifle firing a bullet, with a change in momentum equal to and opposite that of the people.
4. It depends.

Answer: 3. If we consider Earth to be an isolated system (during the short time interval that the people jump up, this approximation is appropriate), then momentum must be conserved. So the momentum of Earth must be equal to and opposite that of the jumping people. Because of Earth's large inertial mass, however, there is no perceptible motion.

7. Suppose the entire population of the world gathers in one spot and, at the sound of a prearranged signal, everyone jumps up. About a second later, 5 billion people land back on the ground. After the people have landed, Earth's momentum is

1. the same as what it was before the people jumped.

2. different from what it was before the people jumped.

Answer: 1. It's impossible to change the momentum of an isolated system from inside the system.

Collisions:

8. Suppose rain falls vertically into an open cart rolling along a straight horizontal track with negligible friction. As a result of the accumulating water, the momentum of the cart

1. momentum of the cart increases, and the kinetic energy of the cart increases.
2. momentum of the cart increases, and the kinetic energy of the cart does not change
3. momentum of the cart increases, and the kinetic energy of the cart does decreases
4. momentum of the cart does not change ,and the kinetic energy of the cart increases.
5. momentum of the cart does not change , and the kinetic energy of the cart does not change
6. momentum of the cart does not change , and the kinetic energy of the cart decreases
7. momentum of the cart decreases, and the kinetic energy of the cart increases.
8. momentum of the cart does decreases, and the kinetic energy of the cart does not change
9. momentum of the cart decreases, and the kinetic energy of the cart decreases

Answer: 6. The water, because it falls vertically, does not change the cart's horizontal momentum. The mass of the cart increases, however, and so its speed decreases. Therefore its kinetic energy decreases as well.

10. Consider these situations: (*i*) a ball moving at speed v is brought to rest; (*ii*) the same ball is projected from rest so that it moves at speed v; (*iii*) the same ball moving at speed v is brought to rest and then projected backward to its original speed. In which case(s) does the ball undergo the largest change in momentum?

1. (*i*)
2. (*i*) and (*ii*)
3. (*i*), (*ii*), and (*iii*)

4. (*ii*)
5. (*ii*) and (*iii*)
6. (*iii*)

Answer: 6. Let's say the ball has inertial mass m and velocity v. The decrease in momentum in case (*i*) is $0 - mv = -mv$ (final momentum minus initial momentum). In case (*ii*), we find $mv - 0 = +mv$. In case (*iii*), we have $m(-v) - mv = -2mv$ because the ball's velocity is now in the opposite direction. So the magnitude of the change is greatest in the third case.

11. Consider two carts, of masses m and $2m$, at rest on an air track. If you push first one cart for 3 s and then the other for the same length of time, exerting equal force on each, the momentum of the light cart is

1. four times
2. twice
3. equal to
4. one-half
5. one-quarter

the momentum of the heavy cart.
Answer: 3. Momentum is equal to force times time. Because the forces on the carts are equal, as are the times over which the forces act, the final momenta of the two carts are equal.

12. Consider two carts, of masses m and $2m$, at rest on an air track. If you push first one cart for 3 s and then the other for the same length of time, exerting equal force on each, the kinetic energy of the light cart is

1. larger than
2. equal to
3. smaller than

the kinetic energy of the heavy car.

Answer: 1. Because the momenta of the two carts are equal, the velocity of the light cart must be twice that of the heavy cart. Thus, the kinetic energy of the light cart is twice the kinetic energy of the heavy one.

13. Suppose a ping-pong ball and a bowling ball are rolling toward you. Both have the same momentum, and you exert the same force to stop each. How do the time intervals to stop them compare?

1. It takes less time to stop the ping-pong ball.
2. Both take the same time.
3. It takes more time to stop the ping-pong ball.

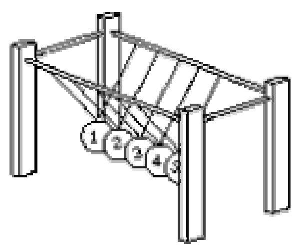
Answer: 2. Because force equals the time rate of change of momentum, the two balls lose momentum at the same rate. If both balls initially have the same momentum, it takes the same amount of time to stop them.

14. Suppose a ping-pong ball and a bowling ball are rolling toward you. Both have the same momentum, and you exert the same force to stop each. How do the distances needed to stop them compare?

1. It takes a shorter distance to stop the ping-pong ball.
2. Both take the same distance.
3. It takes a longer distance to stop the ping-pong ball.

Answer: 3. Because the momenta of the two balls are equal, the ball with the larger velocity has the larger kinetic energy. Being that the ping-pong ball has a smaller inertial mass, it must therefore have the larger kinetic energy. This means more work must be done on the ping-pong ball than on the bowling ball. Because work is the product of force and displacement, the distance to stop the ping-pong ball is greater.

15. If ball 1 in the arrangement shown here is pulled back and then let go, ball 5 bounces forward. If balls 1 and 2 are pulled back and released, balls 4 and 5 bounce forward, and so on. The number of balls bouncing on each side is equal because



1. of conservation of momentum.
2. the collisions are all elastic.
3. neither of the above

Answer: 2. There are many different final states that conserve momentum, but this is the only one that also conserves kinetic energy. Since conservation of kinetic energy is the same thing as saying "the collisions are elastic," choice 2 is correct.

16. A cart moving at speed *v* collides with an identical stationary cart on an air track, and the two stick together after the collision. What is their velocity after colliding?

1. *v*
2. 0.5 *v*
3. zero

4. -0.5 *v*
5. -*v*
6. need more information

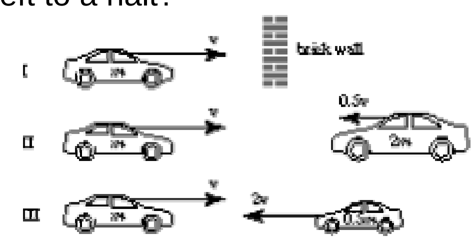
Answer: 2. Because total momentum must be conserved, we have $mv = 2mu$, which gives a final velocity $u = 0.5v$.

17. A person attempts to knock down a large wooden bowling pin by throwing a ball at it. The person has two balls of equal size and mass, one made of rubber and the other of putty. The rubber ball bounces back, while the ball of putty sticks to the pin. Which ball is most likely to topple the bowling pin?

1. the rubber ball
2. the ball of putty
3. makes no difference
4. need more information

Answer: 1. Because momentum is conserved in these interactions, more momentum is transferred to the bowling pin from the rubber ball than from the putty ball. Hence, the rubber ball is more likely to knock the pin over.

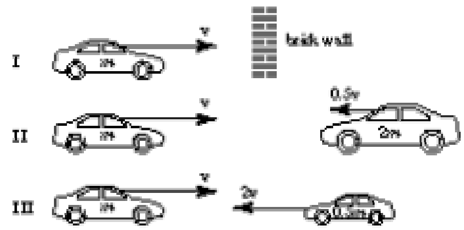
19. If all three collisions in the figure shown here are totally inelastic, which bring(s) the car on the left to a halt?



1. I
2. II
3. III
4. I, II
5. I, III
6. II, III
7. all three

Answer: 7. Momentum conservation tells us that all three collisions bring the left-hand car to a halt.

20. If all three collisions in the figure shown are totally inelastic, which cause(s) the most damage?



1. I
2. II
3. III
4. I, II
5. I, III
6. II, III
7. all three

Answer: 3. The right car in III loses more kinetic energy in the collision than the right car in II or the wall (which has zero kinetic energy) in I. Since any amount of kinetic energy lost goes into deforming the cars, the most damage occurs in III.

21. A golf ball is fired at a bowling ball initially at rest and bounces back elastically. Compared to the bowling ball, the golf ball after the collision has

1. more momentum but less kinetic energy.
2. more momentum and more kinetic energy.
3. less momentum and less kinetic energy.
4. less momentum but more kinetic energy.
5. none of the above

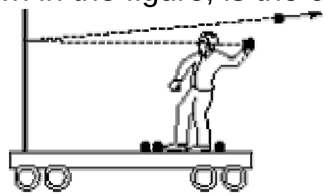
Answer: 4. The golf ball bounces back at nearly its incident speed, whereas the bowling ball hardly budges. Thus the change in momentum of the golf ball is nearly $-2mv$, and the bowling ball must gain momentum $+2mv$ to conserve momentum. However, since the mass of the bowling ball is much larger than that of the golf ball, the bowling ball's velocity and hence its kinetic energy are much smaller than those of the golf ball.

22. A golf ball is fired at a bowling ball initially at rest and sticks to it. Compared to the bowling ball, the golf ball after the collision has

1. more momentum but less kinetic energy.
2. more momentum and more kinetic energy.
3. less momentum and less kinetic energy.
4. less momentum but more kinetic energy.
5. none of the above

Answer: 3. Both balls move at the same speed after the collision. So the ball with the larger inertial mass has both the larger momentum and the larger kinetic energy.

23. Suppose you are on a cart, initially at rest on a track with very little friction. You throw balls at a partition that is rigidly mounted on the cart. If the balls bounce straight back as shown in the figure, is the cart put in motion?



1. Yes, it moves to the right.
2. Yes, it moves to the left.
3. No, it remains in place.

Answer: 2. Because all the balls bounce back to the right, then in order to conserve momentum, the cart must move forward.

24. A compact car and a large truck collide head on and stick together. Which undergoes the larger momentum change?

1. car
2. truck
3. The momentum change is the same for both vehicles.
4. Can't tell without knowing the final velocity of combined mass.

Answer: 3. Conservation of momentum tells us that the changes in momentum must add up to zero. So the change in the car's momentum must be equal to the change in the truck's momentum, and the two changes must be in the opposite directions.

25. A compact car and a large truck collide head on and stick together. Which vehicle undergoes the larger acceleration during the collision?

1. car
2. truck
3. Both experience the same acceleration.
4. Can't tell without knowing the final velocity of combined mass.

Answer: 1. Say the car has inertial mass m and the truck has inertial mass $M >> m$. Because the changes in momentum are equal (neglecting the fact that they are in opposite directions), we have $m\mathrm{d}v = M\mathrm{d}V$, where $\mathrm{d}v$ is the change in the car's speed and $\mathrm{d}V$ the change in the truck's speed. Because $m << M$, $\mathrm{d}v >> \mathrm{d}V$. The acceleration is proportional to the change in speed, and both changes in speed take place over the same time interval (the duration of the collision). Therefore the car undergoes a much larger acceleration than the truck.

26. Is it possible for a stationary object that is struck by a moving object to have a larger final momentum than the initial momentum of the incoming object?

1. Yes.
2. No because such an occurrence would violate the law of conservation of momentum.

Answer: 1. Think of a small ball bouncing back upon striking a much more massive object. If the ball bounces back at its incoming speed, its change in momentum is 2*mv*. Conservation of momentum then requires the more massive object to have a momentum 2*mv* in the opposite direction. This is larger than the initial momentum of the ball, which was *mv*.

27.
Consider the following two situations:

1. Cart A of inertia m collides with cart B of inertia M > > m, which, in turn, collides with cart C of inertia m.
2. Cart B is missing and cart A hits cart C directly.

The initial momentum of cart A is the same in both cases. In which case is more energy transferred to cart C?

1. case 1
2. case 2
3. both the same

Answer: 2.

28. Cart A is at rest. An identical cart B, moving to the right, collides with cart A. They stick together. After the collision, which of the following is true?

1. Carts A and B are both at rest.
2. Carts A and B move to the right with a speed greater than cart B's original speed.
3. Carts A and B move to the right with a speed less than cart B's original speed.
4. Cart B stops and cart A moves to the right with speed equal to the original speed of cart B.

Answer: 3. Choice 4 is not an option because the question states that the carts stick together. We can rule out choices 1 and 2 by conservation of momentum. Call the initial speed v and the mass of a cart m. Before the collision, total momentum is mv. After the collision, the momentum is 2mu, where u is the final speed of the two carts together. For momentum to be conserved, 2mu=mv, so u=v/2, which is obviously less than the original speed. More generally, remember that momentum is conserved, so if more mass is moving, it must all be moving (on average) at a slower speed.

29. Cart A is at rest. An identical cart B, moving to the right, collides elastically with cart A. They do not stick together. After the collision, which of the following is true?

1. Carts A and B are both at rest.
2. Cart B stops and cart A moves to the right with speed equal to the original speed of cart B.
3. Cart A remains at rest and cart B bounces back with speed equal to its original speed.
4. Cart A moves to the right with a speed slightly less than the original speed of cart B and cart B moves to the right with a very small speed.

Answer: 2. An elastic collision is one in which energy is conserved. So our equations for momentum conservation are:
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$, and
$m_1v_{1i}^2 + m_2v_{2i}^2 = m_1v_{1f}^2 + m_2v_{2f}^2$ (after multiplying both sides by 2)
Since $m_1 = m_2$ and $m_{2i} = 0$, we have
$mv_{1i} = m(v_{1f} + v_{2f})$, and
$mv_{1i}^2 = m(v_{1f}^2 + v_{2f}^2)$,
which implies that
$(v_{1f} + v_{2f})^2 = v_{1f}^2 + v_{2f}^2$, or
$(v_{1f})(v_{2f}) = 0$.
But the total final velocity must be in the same direction as the total initial velocity (the magnitude difference of the velocities is determined by the amount of mass moving before and after the collision), so v_{2f} 0 (because the second mass physically obstructs the first mass, $v_{1f} < v_{2f}$, so if $v_{2f} = 0$, v_{1f} would be directed opposite v_{1i} and momentum would not be conserved). Thus $v_{1f} = 0$. Choice 2 is the only one which satisfies this condition and conservation of momentum.

30. Two carts travel toward each other at the same speed. They collide and stick together. The inertias of the two carts are

1. the same
2. different
3. need more information to compare the carts' inertias

Answer: 3. Without knowing the final speed of the two-cart system, we cannot use conservation of momentum to determine the ratio of the inertias.

31. You throw a ball horizontally against a wall. Just after the ball bounces off the wall, how does the wall move?

1. horizontally toward you
2. horizontally away from you
3. it doesn't move
4. don't know

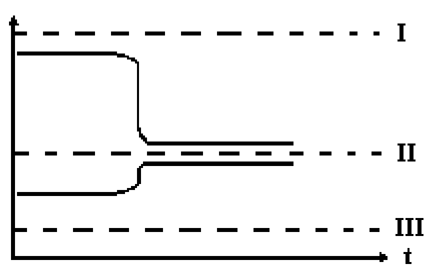
Answer: 2. The motion of the wall is very slight, however, so we do not ordinarily notice it.

32. You are in charge of hooking together the individual cars of a train. The engine is sitting at rest and two cars of equal mass are coming in to hook up to the engine. Car A is traveling twice as fast as car B. You cannot stop the cars before connecting them to the engine. In which order should you attach the cars to the engine so that the train has the smallest final speed?

1. car A first
2. car B first
3. the order doesn't matter
4. don't know

Answer: 3. Answer is (3), assuming that there is negligible friction between the cars + engine and the tracks. Conservation of momentum dictates that the total momentum of the two cars and the engine must be the same before and after connecting everything together; so the final speed of the coupled cars & engine is determined solely by the initial speeds.

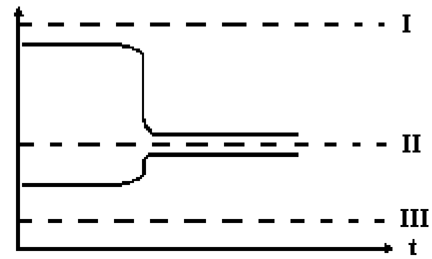
33. The graph below shows a property of two colliding objects as a function of time. The property shown is



1. momentum
2. velocity
3. could be either
4. neither

Answer: 1.

34. The graph below shows a property of two colliding objects as a function of time.

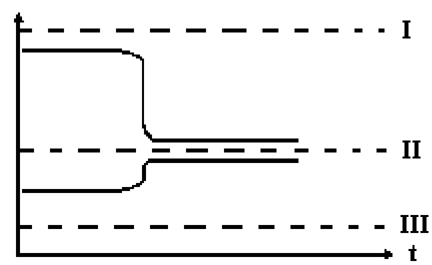


For the above pt graph is the p = 0 line

1. dashed line I
2. dashed line II
3. dashed line III
4.

Answer: 9.

35. The graph below shows a property of two colliding objects as a function of time.



For the above pt graph, where is the total

1. dashed line I
2. dashed line II
3. dashed line III
4.

Answer: 9.

36. Two pucks collide on a frictionless surface. Puck 1 has twice the inertia of Puck 2. Before the collision, Puck 1 is moving at 20 m/s. Following the collision, the momentum of Puck 2 is:

1. less than the initial momentum of Puck 1
2. greater than the initial momentum of Puck 1
3. equal to the initial momentum of Puck 1
4. could be any of the answers above
5. none of the above

Answer: 4. The outcome of the collision depends also on the initial velocity of Puck 2 and the elasticity of the collision.

37. Two pucks collide on a frictionless surface. Puck 1 has twice the inertia of Puck 2. Before the collision, Puck 1 is moving at 20 m/s. Following the collision, the speed of Puck 2 is:

1. less than the initial speed of Puck 1
2. greater than the initial speed of Puck 1
3. equal to the initial speed of Puck 1
4. could be any of the answers above
5. none of the above

Answer: 4. The outcome of the collision depends also on the initial velocity of Puck 2 and the elasticity of the collision.

38. Two objects with inertias m_1 and m_2 approach each other from opposite directions and collide head-on elastically. Object 1 leaves with a final speed greater than its initial speed. How do m_1 and m_2 compare?

1. $m_1 > m_2$
2. $m_1 = m_2$
3. $m_1 < m_2$
4. not enough information
5.

Answer: 9.

39. A basketball dropped (from rest) from a height of 1 meter strikes the earth and returns to a height of 1 meter. The collision between the basketball and the earth is:

1. elastic
2. inelastic
3. totally inelastic
4. explosive

5. not enough information

Answer: 1. The potential energy of the earth-basketball system is the same at the beginning and end so no energy is dissipated.

40. A fly splats on your windshield. The collision is:

1. elastic
2. inelastic
3. not enough information

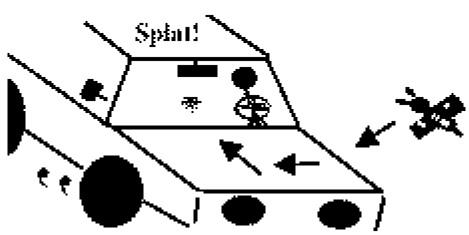
Answer: 2. The relative velocity of fly and windshield starts out as nonzero and ends as zero, so energy is lost and the collision is inelastic.

41. Two carts, one initially stationary, collide elastically. The moving cart has an initial speed of v. The cart that was initially moving continues after the collision with a speed of 0.5 v. Find the final speed of the cart that was initially stationary.

1. v
2. 0.75v
3. 0.5v
4. 0.25v
5. not enough information

Answer: 5. You need to know the relative inertias of carts 1 and 2 in order to determine the final speed of cart 2.

42. Choose all systems where momentum will be conserved for the following situation.



1. Bug
2. Bug + car
3. Bug + car + earth
4. Car
5. Car + earth

Estimate the change in velocity of the bug and of the car.
Answer: 3. There are horizontal interactions between all three.

43. Objects 1 and 2 move with constant speeds. Given their relative velocity, can you determine whether they will collide?

1. Always
2. Sometimes
3. Never

Given their relative speed, can you tell if they will collide?
Answer: 2. If the relative velocity is zero, you know they will not collisde. Otherwise you cannot tell. Given their relative speed, if it is zero, they will not collide; otherwise, you cannot tell.

44. Skater A of mass 75 kg and skater B of mass 50 kg are initially at rest some distance apart. Each skater holds tightly onto a rope of negligible mass. Skater A only pulls on the rope with constant force so that the skaters approach each other and meet. The ice is completely frictionless. Which statements must be TRUE?

1. Only skater B moves relative to the ice.
2. The magnitude of the acceleration of skater A is less than the magnitude of the acceleration of skater B.
3. Just before they meet, the speed of skater A is less than the speed of B.
4. The work done by the tension on skater A is equal to the work done by the tension on B.
5. While the skaters are moving, their momentum vectors have equal magnitudes.

Answer: 235. 1 is FALSE because both skaters move and meet at their center of mass since no external forces act on the two-skater system. 2 is TRUE; the same net force (tension) acts on each skater therefore the more massive skater will have the smaller acceleration. 3 is TRUE; the skaters have been moving for the same amount of time, but A has the smaller acceleration. 4 is FALSE because work is (in this case) force times distance; the force is the same but skater A being closer to the center of mass travels the shorter distance. 5 is TRUE because momentum is conserved; it is zero before the skaters move and must remain zero when they do move. Two vectors add up to zero only if they have equal magnitudes and opposite directions

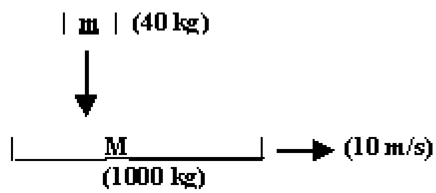
45. Two 1-kg carts are about to collide; one is initially at rest, the other comes in at a speed of 4 m/s. From the information given, you

1. can
2. cannot

determine the final velocities of the two carts.

Answer: 2. What information is given in this problem? Conservation of momentum gives us a relation between the momenta of the two carts before and after the collision (and thus a relation between the velocities of the carts before and after the collision). But we don't know anything else and we need to solve for two variables (the velocities of the carts after the collision) and we only have one equation. Mathematically we're stuck. This is insufficient information. We need to know if the collision was elastic or inelastic.

26. A railcar (mass of 1000 kg) moves horizontally at speed 10 m/s. Friction between the railcar and the track can be neglected. A 40-kg bale of hay falls vertically onto the railcar; the car continues to move horizontally.



How do the horizontal momentum and the kinetic energy of the railcar-hay system change, if at all, when the bale of hay falls into the car? (Assume that the vertical speed of the hay just before it lands in the cart is small enough to neglect its contribution to the system kinetic energy.) Choose all that are true.

1. horizontal momentum remains constant
2. horizontal momentum increases
3. horizontal momentum decreases
4. kinetic energy remains constant
5. kinetic energy increases
6. kinetic energy decreases

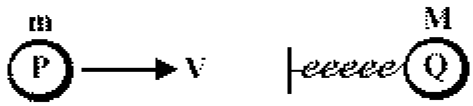
Answer: 1, 4. Neglecting the initial KE of the hay means that we can treat the collision as elastic. Horizontal momentum must remain constant because the system is isolated.

27. A Toyota (small car) strikes a Mack truck (large truck) head-on. They stick together after the collision. Defining the system as the car plus the truck, which of the following are conserved?

1. kinetic energy
2. total momentum
3. total energy

Answer: 2, 3. Assuming that the drivers do not apply the brakes and thus the system is isolated, both total momentum and total energy are conserved. Some kinetic energy is dissipated into the deformation of the car and truck so kinetic energy is not conserved.

28. An object P has an initial velocity **v**. It strikes an initially stationary object Q which is attached to a spring, as shown.

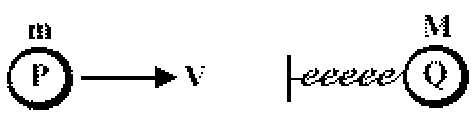


The compression of the spring is greatest at the instant when:

1. the velocity of P is exactly zero
2. P and Q move with the same velocity
3. Q begins to move
4. Q reaches the initial velocity of P
5. All the kinetic energy of P has been transferred to the spring

Answer: 2. This problem is just like an elastic collision with the spring providing the elasticity. Thus we know that the maximum amount of energy is stored in the spring at the moment when the kinetic energy is minimum - when the relative velocity of P and Q is zero. Maximum compression corresponds to maximum stored energy.

29. An object P has an initial velocity **v**. It strikes an initially stationary object Q which is attached to a spring, as shown.



Assume that P and Q have equal inertias ($m_P = m_Q$) and the inertia of the spring can be neglected. At the point of maximum compression, the energy stored in the spring is:

1. all of the initial KE of P
2. 3/4 of the initial KE of P
3. 1/2 of the initial KE of P
4. 1/4 of the initial KE of P
5. none of the above

Answer: 3. At the point of maximum compression, $\mathbf{v_P} = \mathbf{v_Q}$. To conserve momentum, $|\mathbf{v_P}| = |\mathbf{v_Q}| = \mathbf{v}/2$. Calculating the total KE gives half that of P before the collision.

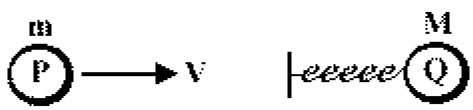
30. An object P has an initial velocity **v**. It strikes an initially stationary object Q which is attached to a spring, as shown.

Assume that the inertias of P and Q are equal. At the point of maximum compression of the spring, how does the momentum of Q compare to the initial momentum of P:

1. greater than the initial momentum of P
2. equal to the initial momentum of P
3. less than the initial momentum of P

Answer: 3. At the point of maximum compression, $\mathbf{v_P = v_Q}$. To conserve momentum,
$\mathbf{|v_P| = |v_Q| = v/2}$, so $P_a < P_{p,i}$

31. An object P has an initial velocity **v**. It strikes an initially stationary object Q which is attached to a spring, as shown.

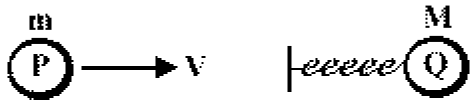


Suppose now that $m_P << m_Q$. How does the fraction of the total energy of the system of P and Q which is stored in the spring at the point of maximum compression compare to that fraction in the case of equal inertias?

1. greater for $m_P << m_Q$ than for $m_P = m_Q$
2. equal in both cases
3. less for $m_P << m_Q$ than for $m_P = m_Q$

Answer: 1. In the case of $m_P << m_Q$, we know that in an elastic collision, the lighter object basically just bounces back with the heavier object acquiring very little velocity. At the moment of zero relative velocity, the velocity of P and Q is quite small. (We can see this from momentum conservation;
if $m_P << m_Q$, then the velocity needed for P and Q together to have the same momentum as P alone moving at velocity **v** is much less than **v**.) Thus nearly all the energy gets stored in the spring at that moment, much more than if $m_P = m_Q$.

32. An object P has an initial velocity **v**. It strikes an initially stationary object Q which is attached to a spring, as shown.



Suppose now that $m_P >> m_Q$. How does the fraction of the total energy of the system of P and Q which is stored in the spring at the point of maximum compression compare to that fraction in the case of equal inertias?

1. greater for $m_P >> m_Q$ than for $m_P = m_Q$
2. equal in both cases
3. less for $m_P >> m_Q$ than for $m_P = m_Q$

Answer: 3. In this case, P is barely affected by Q - just slowed down a tiny bit - as can be seen from momentum conservation. Thus nearly all the kinetic energy of the system stays as kinetic energy and only a small amount is stored in the spring.

33. A puck moving across a horizontal surface experiences constant negative acceleration due to friction, and comes to rest after 12 seconds. How does the energy lost in the first 6 seconds compare to the energy lost in the last 6 seconds?

1. first half > second half
2. first half = second half
3. first half < second half
4. too little information

Answer: 1. The puck's speed decreases from v_i to 1/2 v_i in the first 6 seconds and from 1/2 v_i to 0 in the last 6. Thus the energy loss in the first 6 s is proportional to (v_i^2 - 1/2 v_i^2) and in the last 6 s is proportional to 1/2 v_i^2.

34. When two carts with inertias of *M* and 10*M* collide, which is larger?

1. the maximum internal energy, assuming the collision is elastic
2. the kinetic energy loss, assuming the collision is totally inelastic
3. both are the same

Answer: 3. A the instant at which the relative velocity of the two carts is zero, the internal energy is maximum in an elastic collision. This is the same amount of energy that must be dissipated in a totally inelastic collision, in which the **final** relative velocity of the carts remains zero.

35. A toy truck with low-friction bearings is rolling on a flat, horizontal surface when a pebble is gently dropped into its bed such that the pebble's horizontal velocity before landing in the truck is zero. Compared to the momentum of the truck before the pebble lands in the bed, the momentum of the truck and pebble after the pebble lands in the truck is

1. greater
2. less
3. the same
4.

Answer: 9.

36. A toy truck with low-friction bearings is rolling on a flat, horizontal surface when a pebble is gently dropped into its bed such that the pebble's horizontal velocity before landing in the truck is zero. Compared to the kinetic energy of the truck before the pebble lands in the bed, the kinetic energy of the pebble and truck afterwards is

1. greater
2. less
3. the same

Answer: 3. The system is isolated and so there is not change in its momentum, and there are no ways for the KE to be dissipated or converted to other forms.

37. An explosion splits an object initially at rest into two pieces of unequal mass. Which piece moves at greater speed?

1. The more massive piece.
2. The less massive piece.
3. They both move at the same speed.
4. There is not enough information to tell.

Answer: 2. Since the object is initially at rest, the total momentum of the two fragments must be zero. They must move in opposite directions and the more massive one must move more slowly.

38. An explosion splits an object initially at rest into two pieces of unequal mass. Which piece has greater kinetic energy?

1. The more massive piece.
2. The less massive piece.
3. They both have the same kinetic energy.
4. There is not enough information to tell.

Answer: 2. The momentum of the two pieces must be equal in magnitude and opposite in sign. $K = pv/2$, so the piece with greater speed - the less massive one - has greater K.

39. Two cars of equal inertia are travelling in opposite directions. Just before colliding, the speed of one is twice that of the other. They collide and lock together, moving off as one unit. Compared to the kinetic energy of the cars before the collision, their kinetic energy after the collision is

1. greater
2. less
3. the same

Answer: 2. This is an inelastic sollision - the relative veloctiy of the cars decreases - and so the kinetic energy decreases in the collision.

40. Compared to the amount of energy required to accelerate a car from rest to 10 miles per hour, the amount of energy required to accelerate the same car from 10 mph to 20 mph is

1. the same
2. twice as much
3. three times as much
4. four times as much

Answer: 3. The energy increase in going from zero speed to speed v is $1/2mv^2$. To go from v to 2v is $1/2m(2v)^2 - 1/2mv^2 = 3/2mv^2$.

41. A ball is thrown against a wall; it bounces off and returns with speed equal to its initial speed before striking the wall. Which of the following statements is true from before to after the collision between the ball and the wall?

1. The kinetic energy of the ball is the same.
2. The momentum of the ball is the same.
3. Both the kinetic energy and the momentum of the ball are the same.
4. Neither the kinetic energy nor the momentum of the ball are the same.
5. The collision is inelastic.
6. Two of the above.

Answer: 1. The kinetic energy of the ball is the same before and after since the speed is the same, and thus the collision is elastic. The momentum is not since the direction is different.

42. Two skaters of the same mass are moving directly toward each other across an iced-over pond. Assume the pond is very smooth and that there is no friction between the skaters and the ice, just like we assume for air track carts. Each skaters is initially traveling at a speed of 4 m/s. They collide, and separate with a relative velocity of 6 m/s. What is the coefficient of restitution for this collision?

1. 3/2
2. 3/4
3. 2/3

Answer: 2. The coefficient of restitution is the ratio of the final and initial relative speeds; the initial relative speed is 8 m/s so the ratio is 6/8 = 3/4.

43. Objects 1 and 2 move with constant speeds in the same direction taken to be positive where object 2 is in the lead. With $\mathbf{v}_{\text{rel}} = \mathbf{v}_1 - \mathbf{v}_2$, the two objects will collide if

1. $\mathbf{v}_{\text{rel}} > 0$
2. $\mathbf{v}_{\text{rel}} < 0$
3. $\mathbf{v}_{\text{rel}} = 0$

Answer: 1. For object 1 to overtake object 2 and thus collide, $|\mathbf{v}_1|$ must be greater than $|\mathbf{v}_2|$. This gives $\mathbf{v}_{\text{rel}} > 0$ since both $\mathbf{v}_1$ and $\mathbf{v}_2$ are positive.
Index: relative velocity, collisions