Last names	Section	Date	Score
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Phys 20.01 Group homework 3

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2025 W45

Instructions: For comprehension and conceptual questions, choose the best answer. For problem-solving questions, choose the best answer and show your solution and reasoning. Comprehension is 1 pt each, conceptual is 2 pt each, and problem-solving is 3 pt each.

1. Comprehension

1. What is an isolated system?
   a. A system in which net internal force is zero
   b. A system in which net external force is zero
   c. A system in which net internal force is a nonzero constant
   d. A system in which net external force is a nonzero constant

2. In which equation of Newton's second law is mass assumed to be constant?
   a. $\vec{F} = m\vec{a}$
   b. $\vec{F} = \Delta\vec{p}/\Delta t$
   c. $\vec{F} = \Delta\vec{p}\Delta t$
   d. $\vec{F} = \Delta m/\Delta\vec{a}$

3. What is an inelastic collision?
   a. when objects stick together after impact, and their internal energy is not conserved
   b. when objects stick together after impact, and their internal energy is conserved
   c. when objects stick together after impact, and always come to rest instantaneously after collision
   d. when objects stick together after impact, and their internal energy increases

4. Which type of simple machine is a knife?
   a. A ramp
   b. A wedge
   c. A pulley
   d. A screw

5. Why does it hurt less when you fall on a softer surface?
   a. It increases duration of impact, reducing the force
   b. It decreases duration of impact, reducing the force
   c. It increases duration of impact, increasing force
   d. It decreases duration of impact, increasing force

6. How is net force related to momentum of the object?
   a. Net force acting on the object is equal to its momentum
   b. Net force acting on the object is equal to the change in its momentum
   c. Net force acting on the object is equal to the product of the momentum and the time interval momentum
   d. Net force acting on the object is equal to the rate of change of the momentum

7. Two objects having equal masses and velocities collide with each other and come to a rest. What type of a collision is this and why?
   a. Elastic, as internal kinetic energy is conserved
   b. Inelastic, as internal kinetic energy is not conserved
   c. Elastic, as internal kinetic energy is not conserved
   d. Inelastic, as internal kinetic energy is conserved

8. The potential energy of a spring is
   a. proportional to half of the amount the spring is stretched
   b. proportional to the square of half of the amount the spring is stretched
   c. proportional to the amount the spring is stretched
   d. proportional to the square of the amount the spring is stretched

9. Suppose you know the potential energy function corresponding to a force. Is it always possible to calculate the force?
   a. yes
   b. yes, if the force is nonconservative
   c. yes, but only its magnitude not its direction
   d. not at all

10. Which is true? Conservation of the total momentum of a system
    a. holds only when mechanical energy is conserved
    b. holds for any system
    c. follows from Newton's second law
    d. is equivalent to Newton's third law

11. A rocket is propelled forward by ejecting gas at high speed. The forward motion is a consequence of
    a. conservation of energy
    b. conservation of momentum
    c. both of the above
    d. neither of the above

12. The gravitational potential energy of an object at a height z above Earth's surface
    a. depends on the height z
    b. depends on path taken to bring the object to z
    c. both of the above

13. A man pushes a very heavy load across a horizontal floor. The work done by gravity on the load
    a. depends on the weight of the load
    b. cannot be calculated without more information
    c. is equal to zero

14. The impulse delivered to a body by a force is
    a. defined only for interactions of short duration
    b. equal to the change in momentum of the body
    c. equal to the area under an F vs. x graph
    d. defined only for elastic collisions

15. In an elastic collision
    a. energy is conserved
    b. momentum is conserved
    c. the magnitude of the relative velocity is conserved
    d. all of the above

16. In an inelastic collision
    a. both energy and momentum are conserved
    b. energy is conserved
    c. momentum is conserved
    d. neither is conserved

17. In a collision between two billiard balls,
    a. energy is not conserved if the collision is perfectly elastic
    b. energy is not conserved if the collision is perfectly inelastic
    c. momentum is not conserved if the collision is elastic
    d. momentum is not conserved if the collision is inelastic

18. In two-dimensional elastic collisions, conservation laws
    a. allow us to determine the final motion
    b. place restrictions on possible final motions
    c. do not allow us to say anything about final motion
    d. none of the above

2. Conceptual

1. At the beginning of a roller coaster ride, the roller coaster car has an initial energy mostly in the form of potential energy. Why is the car fastest at the lowest point in the ride?
    a. At bottom, kinetic energy is at its maximum and potential energy is at its minimum
    b. At bottom, potential energy is at its maximum and kinetic energy is at its minimum
    c. At bottom, both kinetic and potential energies reach their maximum values
    d. At bottom, both kinetic and potential energies reach their minimum values

2. A coin falling through a vacuum loses no energy to friction, and yet, after it hits the ground, it has lost all its potential and kinetic energy. Why is the law of conservation of energy still valid in this case?
    a. When coin hits the ground, the ground gains potential energy that quickly changes to thermal energy
    b. When coin hits the ground, the ground gains kinetic energy that quickly changes to thermal energy
    c. When coin hits the ground, the ground gains thermal energy that quickly changes to kinetic energy
    d. When coin hits the ground, the ground gains thermal energy that quickly changes to potential energy

3. A stone is launched upward into the air. In addition to the force of gravity, the stone is subject to a frictional force due to air resistance. The time the stone takes to reach the top of its flight path is … the time it takes to return from the top to its original position.
    a. is larger than
    b. is equal to
    c. is smaller than
    d. cannot be determined relative to

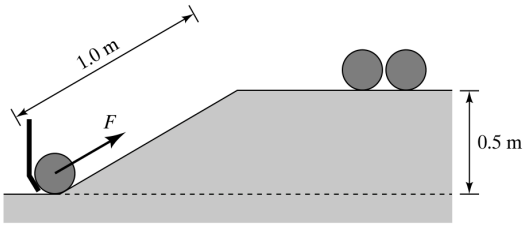
4. Which activity requires a person to exert force on an object that causes the object to move but does not change the kinetic or potential energy of the object?
    a. Moving an object higher with acceleration
    b. Moving an object higher without acceleration
    c. Carrying an object with acceleration at same height
    d. Carrying an object without acceleration at same height

5. Two people, who have the same mass, throw two different objects at the same velocity. If the first object is heavier than the second, compare the velocities gained by the two people due to recoil.
    a. The first person gains more velocity due to recoil
    b. The second person gains more velocity due to recoil
    c. Both people gain the same velocity due to recoil
    d. The velocity of both people is zero due to recoil

6. The starting line of a cross country foot race is at the bottom of a hill. Which form/s of mechanical energy of the runners will change when the starting gun is fired?
    a. Kinetic energy only
    b. Potential energy only
    c. Both kinetic and potential energy
    d. Neither kinetic nor potential energy

7. Work can be negative or positive because an object can do work on its surroundings or have work done on it. Which describe a situation in which an object can do work on its surroundings by decreasing its altitude?
    a. A construction worker lowers a heavy steel beam using a crane
    b. Falling water turns a turbine to generate electricity
    c. Rising steam turns a turbine to generate electricity
    d. A parachute captures air to slow a skydiver's fall

8. At the bowling alley, the ball-feeder mechanism must exert a force to push the bowling balls up a 1.0-m long ramp. The ramp leads the balls to a chute 0.5 m above the base of the ramp. Approximately how much force must be exerted on a 5.0-kg bowling ball?
    a. 200 N
    b. 50 N
    c. 25 N
    d. 5.0 N
    e. impossible to determine



9. Suppose you want to ride your mountain bike up a steep hill. Two paths lead from the base to the top, one twice as long as the other. Compared to the average force you would exert if you took the short path, the average force you exert along the longer path is
   a. four times as small
   b. three times as small
   c. half as small
   d. the same
   e. undetermined—it depends on the time taken

10. A car accelerates from rest. It gains a certain amount of kinetic energy and Earth
   a. gains more kinetic energy
   b. gains the same amount of kinetic energy
   c. gains less kinetic energy
   d. loses kinetic energy as the car gains it

11. A compact car and a large truck collide head on and stick together. Which vehicle undergoes the larger acceleration during the collision?
   a. car
   b. truck
   c. Both experience the same acceleration
   d. Can't tell without knowing the final velocity of combined mass

12. You are given two carts, A and B. They look identical and you are told that they are made of the same material. You place A at rest on an air track and give B a constant velocity directed to the right so that it collides with A. After the collision, both carts move to the right, the velocity of B being smaller than what it was before the collision. What do you conclude?
   a. Cart A is hollow
   b. The two carts are identical
   c. Cart B is hollow
   d. Need more information

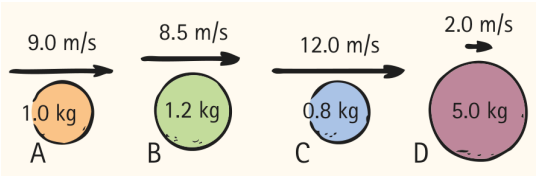
13. Two carts are put back-to-back on a track. Cart A has a spring-loaded piston. Cart B, which has twice the inertial mass of cart A, is entirely passive. When the piston is released, it pushes against cart B, and the carts move apart. How do the magnitudes of the final momenta and kinetic energies compare?
   a. $p_A > p_B$, $K_A > K_B$
   b. $p_A > p_B$, $K_A = K_B$
   c. $p_A > p_B$, $K_A < K_B$
   d. $p_A = p_B$, $K_A > K_B$
   e. $p_A = p_B$, $K_A = K_B$
   f. $p_A = p_B$, $K_A < K_B$
   g. $p_A < p_B$, $K_A > K_B$
   h. $p_A < p_B$, $K_A = K_B$
   i. $p_A < p_B$, $K_A < K_B$

14. Two cars, one twice as heavy as the other, are at rest on a horizontal track. A person pushes each car for 5 s. Igrnoring friction and assuming equal force exerted on both cars, the momentum of the light car after the push … the momentum of the heavy car.
   a. is smaller than
   b. is equal to
   c. is larger than
   d. cannot be determined relative to

15. **Animal propulsion.** Squids and octopuses propel themselves by expelling water. They do this by keeping water in a cavity and then suddenly contracting the cavity to force out the water through an opening. A 6.50 kg squid (including the water in the cavity) at rest suddenly sees a dangerous predator. If the squid has 1.75 kg of water in its cavity, at what speed must it expel this water suddenly to achieve a speed of 2.50 m/s to escape the predator? Ignore any drag effects of the surrounding water.
   a. 0.92 m/s
   b. 6.79 m/s
   c. 9.29 m/s
   d. 11.79 m/s

16. How much kinetic energy does the squid create by this maneuver?
   a. 14.8 J
   b. 40.3 J
   c. 55.1 J
   d. 60.6 J

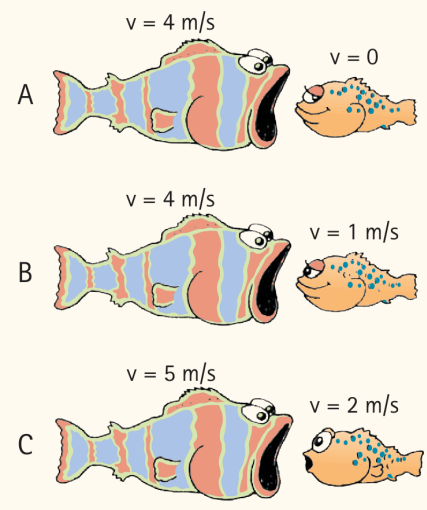
17. The balls shown have different masses and speeds. For each ball, rank the momenta from greatest to least.
   a. A, C, D, B
   b. B, C, D, A
   c. B, D, C, A
   d. C, A, B, D
   e. D, B, A, C



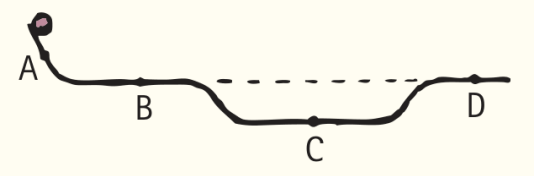
18. Rank the impulses needed to stop the balls.
   a. A, C, D, B
   b. B, C, D, A
   c. B, D, C, A
   d. C, A, B, D
   e. D, B, A, C

19. A hungry fish is about to have lunch at the speeds shown. Assume the hungry fish has a mass five times the mass of the small fish. Immediately after lunch, rank from greatest to least the speeds of the formerly hungry fish.
   a. A, B, C
   b. C, A, B

c. B, C, A
d. C, B, A



20. A ball is released from rest at the left of the metal track shown here. Assume it has only enough friction to roll, but not to lessen its speed. Rank the momenta from greatest to least at each point.
    a. A, B, C, D
    b. C, D, B, A
    c. C, B = D, A
    d. A, B = D, C
    e. B = D, C, A
    f. A, C, B = D



21. Rank the potential energies.
    a. A, B, C, D
    b. C, D, B, A
    c. C, B = D, A
    d. A, B = D, C
    e. B = D, C, A
    f. A, C, B = D

3. Problem solving

Momentum and the archerfish. Archerfish are tropical fish that hunt by shooting drops of water from their mouths at insects above the water's surface to knock them into the water, where the fish can eat them. A 65 g fish at rest just at the surface of the water can expel a 0.30 g drop of water in a short burst of 5.0 ms. High-speed measurements show that the water has a speed of 2.5 m/s just after the archerfish expels it.

1. What is the momentum of one drop of water immediately after it leaves the fish's mouth?
    a. 7.5×10^{-4} kg m/s
    b. 1.5×10^{-4} kg m/s
    c. 7.5×10^{-3} kg m/s
    d. 1.5×10^{-3} kg m/s.

$$p = (3 \times 10^{-4}\ \text{kg})(2.5\ \text{m/s}) = 7.5 \times 10^{-4}\ \text{kg m/s}$$

2. What is the speed of the archerfish immediately after it expels the drop of water?
    a. 0.0025 m/s
    b. 0.012 m/s
    c. 0.75 m/s
    d. 2.5 m/s.

We use the conservation of momentum. The initial momentum of the system is $P_1 = 0$ because both the fish f and water w are initially at rest. The final momentum is

$$P_2 = m_f v_f + m_w v_w$$

As per conservation of momentum, $P_1 = P_2$ (as in initial equals final momentum), so

$$\begin{aligned} 0 &= m_f v_f + m_w v_w \\ m_f v_f &= -m_w v_w \\ v_f &= -\frac{m_w}{m_f} v_w \end{aligned}$$

which after calculation gives us

$$\begin{aligned} v_f &= -\frac{3 \times 10^{-4}\ \text{kg}}{0.065\ \text{kg}}(2.5\ \text{m/s}) \\ &= -0.012\ \text{m/s} \end{aligned}$$

The negative velocity makes sense since the fish should move at the opposite direction relative to the drop of water that has been ejected.

Bowl-a-bowl. You are to knock over a gigantic bowling pin at a fair by throwing a ball at it.

1. You have a choice between two balls, one that collides elastically and another that collides inelastically. Which do you choose and why? Write down your reasoning.
    a. elastical collision
    b. inelastical collision
    c. perfectly inelastical collision
    d. it doesn't matter

To knock over the pin, you need to transfer maximum momentum to it. In an elastic collision, the ball bounces back, meaning its change in momentum is effectively twice its initial momentum (from forward to backward motion). This larger change in momentum from the ball is transferred as a greater impulse to the pin, making it more likely to fall. An inelastic ball, by not bouncing back or sticking, transfers less momentum to the pin.