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Class	9th	Chapter	03
Subject	Physics	Board	Punjab

CHAPTER 03: DYNAMICS — SOLUTIONS

A. Multiple Choice Questions

- **3.1. When we kick a stone, we get hurt. This is due to:**
  - **Options:** (a) inertia | (b) velocity | (c) momentum | (d) **reaction** *(Correct Answer)*
  - *Explanation:* According to Newton's third law of motion, every action has an equal and opposite reaction. When you exert force on the stone, the stone exerts an equal and opposite force on your foot, causing pain.
- **3.2. An object will continue its motion with constant acceleration until:**
  - **Options:** (a) the resultant force on it begins to decrease. | (b) **the resultant force on it is zero.** *(Correct Answer)* | (c) the resultant force on it begins to increase. | (d) the resultant force is at right angle to its tangential velocity.
  - *Explanation:* By Newton's second law ($F = ma$), acceleration is directly proportional to the resultant force. Constant acceleration implies a constant resultant force acting on the object.
- **3.3. Which of the following is a non-contact force?**
  - **Options:** (a) Friction | (b) Air resistance | (c) **Electrostatic force** *(Correct Answer)* | (d) Tension in the string
  - *Explanation:* Electrostatic, gravitational, and magnetic forces act at a distance without physical contact.
- **3.4. A ball with initial momentum p hits a solid wall and bounces back with the same velocity. Its momentum p' after collision will be:**
  - **Options:** (a) $p' = p$ | (b) $p' = -p$ *(Correct Answer)* | (c) $p' = 2p$ | (d) $p' = -2p$
  - *Explanation:* Momentum is a vector quantity. When the ball bounces back in the opposite direction with the same speed, its momentum vector reverses sign, so $p' = -p$.
- **3.5. A particle of mass m moving with a velocity v collides with another particle of the same mass at rest. The velocity of the first particle after collision is:**

- **Options:** (a) v | (b) $-v$ | (c) 0 *(Correct Answer)* | (d) $-1/2$
- *Explanation:* In a perfectly elastic head-on collision between two equal masses where one is at rest, the moving particle transfers all its velocity and momentum to the stationary particle and comes to rest.

- **3.6. Conservation of linear momentum is equivalent to:**
  - **Options:** (a) Newton's first law of motion | (b) Newton's second law of motion | (c) **Newton's third law of motion** *(Correct Answer)* | (d) None of these
  - *Explanation:* The law of conservation of momentum is a direct consequence of Newton's third law of motion (action and reaction forces during collision are equal and opposite).

- **3.7. An object with a mass of 5 kg moves at constant velocity of 10 m s^{-1}. A constant force then acts for 5 seconds on the object and gives it a velocity of 2 m s^{-1} in the opposite direction. The force acting on the object is:**
  - **Options:** (a) 5 N | (b) -10 N | (c) -12 N *(Correct Answer)* | (d) -15 N
  - *Explanation:* Initial velocity $v_i = +10$ m/s, final velocity $v_f = -2$ m/s, mass $m = 5$ kg, time $t = 5$ s. Force $F = \frac{m(v_f - v_i)}{t} = \frac{5(-2-10)}{5} = -12$ N.

- **3.8. A large force acts on an object for a very short interval of time. In this case, it is easy to determine:**
  - **Options:** (a) magnitude of force | (b) time interval | (c) **product of force and time** *(Correct Answer)* | (d) none of these
  - *Explanation:* The product of force and time is impulse ($J = F \times \Delta t$), which is equal to the change in momentum and can be measured directly from the overall collision effect.

- **3.9. A lubricant is usually introduced between two surfaces to decrease friction. The lubricant:**
  - **Options:** (a) decreases temperature | (b) acts as ball bearings | (c) **prevents direct contact of the surfaces** *(Correct Answer)* | (d) provides rolling friction
  - *Explanation:* Lubricants form a thin fluid film between moving surfaces, separating them and replacing solid-solid friction with fluid friction.

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B. Short Answer Questions

- **3.1. What kind of changes in motion may be produced by a force?**
  - **Answer:** A force can cause an object at rest to move, speed up or slow down a moving object, change the direction of motion, or change the shape of an object.
- **3.2. Give 5 examples of contact forces.**
  - **Answer:**
    1. Frictional force
    2. Normal force
    3. Tension force
    4. Air resistance (drag)
    5. Applied pushing/pulling force
- **3.3. An object moves with constant velocity in free space. How long will the object continue to move with this velocity?**
  - **Answer:** According to Newton's first law of motion (inertia), the object will continue to move with constant velocity indefinitely unless acted upon by an external unbalanced force.
- **3.4. Define impulse of force.**
  - **Answer:** Impulse is the product of a large force acting on an object and the very short time interval for which it acts. It is mathematically equal to the change in momentum ($J = F \times \Delta t = \Delta p$).
- **3.5. Why has not Newton's first law been proved on the Earth?**
  - **Answer:** Newton's first law describes an ideal situation where no external forces act. On Earth, it is impossible to completely eliminate external opposing forces such as friction, air resistance, and gravity, so a moving body eventually slows down on its own.
- **3.6. When sitting in a car which suddenly accelerates from rest, you are pushed back into the seat, why?**
  - **Answer:** This is due to inertia (Newton's first law). Your body tends to remain at rest while the car moves forward, causing you to be pressed against the seat.
- **3.7. The force expressed in Newton's second law is a net force. Why is it so?**
  - **Answer:** Because acceleration is produced only by the resultant (net) unbalanced force acting on a body, taking into account all opposing forces like friction.
- **3.8. How can you show that rolling friction is lesser than the sliding friction?**
  - **Answer:** By pulling a heavy block or suitcase on wheels versus dragging it flat on the floor; the force required on wheels (rolling friction) is significantly smaller than sliding it.
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- **3.9. Define terminal velocity of an object.**
    - **Answer:** Terminal velocity is the constant maximum velocity reached by a falling object when the downward force of gravity equals the upward drag (air resistance) force, resulting in zero acceleration.
- **3.10. An astronaut walking in space wants to return to his spaceship by firing a hand rocket. In what direction does he fire the rocket?**
    - **Answer:** He fires the rocket in the opposite direction to where he wants to go. By Newton's third law, the gases expelled forward push him backward toward the spaceship.

C. Constructed Response Questions

- **3.1. Two ice skaters weighing 60 kg and 80 kg push off against each other on a frictionless ice track. The 60 kg skater gains a velocity of 4 m s^{-1}. Considering all the relevant calculations involved, explain how Newton's third law applies to this situation.**
    - **Answer:** According to Newton's third law, the force exerted by skater 1 on skater 2 is equal and opposite to the force exerted by skater 2 on skater 1 ($F_{12} = -F_{21}$). Since impulse ($F \times t$) and change in momentum are equal and opposite: $m_1 v_1 = -m_2 v_2$. For the 60 kg skater: $60 \times 4 = 240$ kg · m/s. For the 80 kg skater: $80 \times v_2 = -240 \Longrightarrow v_2 = \frac{-240}{80} = -3$ m/s. The 80 kg skater moves backward at 3 m/s.
- **3.2. Inflatable airbags are installed in the vehicles as safety equipment. In terms of momentum, what is the advantage of airbags over seatbelts?**
    - **Answer:** Airbags increase the impact time (Δt) during a collision. Since force $F = \frac{\Delta p}{\Delta t}$, extending the time interval significantly reduces the magnitude of the impact force experienced by the passenger, preventing severe injury.
- **3.3. A horse refuses to pull a cart. The horse argues, 'according to Newton's third law, whatever force I exert on the cart, the cart will exert an equal and opposite force on me. Since the net force will be zero, therefore, I have no chance of accelerating (pulling) the cart.' What is wrong with this reasoning?**
    - **Answer:** The horse considers action and reaction pairs acting on the same body (cart and horse combined). Action and reaction forces always act on two different bodies. The horse pulls the cart forward, and the cart pulls the horse backward. However, the horse also pushes backward against the ground with its feet, and the ground pushes the horse forward with a friction force greater than the cart's resistance, enabling forward acceleration.
- **3.4. When a cricket ball hits high, a fielder tries to catch it. While holding the ball he/she draws hands backward. Why?**

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- **Answer:** Drawing hands backward increases the time interval (Δt) over which the ball's momentum is brought to zero. By increasing time, the impact force ($F = \frac{\Delta p}{\Delta t}$) on the hands is reduced, preventing injury.

- **3.5. When someone jumps from a small boat onto the river bank, why does the jumper often fall into the water? Explain.**
  - **Answer:** When jumping forward, the person exerts a backward force on the boat. By Newton's third law, the boat moves backward away from the bank, reducing the landing distance and causing the person to fall short into the water.
- **3.6. Imagine that if friction vanishes suddenly from everything, then what could be the scenario of daily life activities?**
  - **Answer:** Without friction, we would not be able to walk or run (our feet would slip), cars could not accelerate, brake, or turn, nails would slip out of walls, knots would untie, and writing with a pencil on paper would be impossible.

D. Comprehensive Questions

- **3.1. Explain the concept of force by practical examples.**
  - **Answer:** A force is a push or pull that changes or tends to change the state of rest or uniform motion of a body or changes its direction/shape. Examples: pushing a cart, kicking a football, pulling a drawer.
- **3.2. Describe Newton's laws of motion.**
  - **Answer:**
    1. *First Law (Inertia):* Every body continues its state of rest or uniform motion in a straight line unless acted upon by an external unbalanced force.
    2. *Second Law:* The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass ($F = ma$).
    3. *Third Law:* To every action, there is always an equal and opposite reaction.
- **3.3. Define momentum and express Newton's 2nd law of motion in terms of change in momentum.**
  - **Answer:** Momentum (p) is the quantity of motion possessed by a body, defined as the product of mass and velocity ($p = mv$). Newton's second law states that the rate of change of momentum of a body is directly proportional to the applied net force ($F = \frac{\Delta p}{\Delta t}$).
- **3.4. State and explain the principle of conservation of momentum.**
  - **Answer:** The total linear momentum of an isolated system of two or more interacting bodies remains constant ($m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$).
- **3.5. Describe the motion of a block on a table taking into account the friction between the two surfaces. What is the static friction and kinetic friction?**

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- **Answer:** When a pulling force is applied, static friction opposes impending motion up to a maximum limit (limiting friction). Once motion starts, kinetic friction opposes sliding motion and is generally slightly less than static friction.

- **3.6. Explain the effect of friction on the motion of vehicles in context of tyre surface and braking force.**
  - **Answer:** Friction between tyres and road provides the necessary centripetal force for turning and traction for acceleration. Braking force creates friction that stops wheel rotation, bringing the vehicle to a halt.

E. Numerical Problems

- **3.1. A 10 kg block is placed on a smooth horizontal surface. A horizontal force of 5 N is applied to the block. Find: (a) the acceleration produced in the block. (b) the velocity of block after 5 seconds.**
  - **Answer:**
    - (a) Mass $m = 10$ kg, Force $F = 5$ N. Acceleration $a = \frac{F}{m} = \frac{5}{10} = \mathbf{0.5}$ m/s$^{\mathbf{2}}$.
    - (b) Initial velocity $v_i = 0$, time $t = 5$ s. Final velocity $v_f = v_i + at = 0 + (0.5 \times 5) = \mathbf{2.5}$ m/s.
- **3.2. The mass of a person is 80 kg. What will be his weight on the Earth? What will be his weight on the Moon? The value of acceleration due to gravity of Moon is 1.6 m s^{-2}.**
  - **Answer:**
    - Mass $m = 80$ kg
    - (a) Weight on Earth $W_{\text{earth}} = m \times g_{\text{earth}} = 80 \times 10 = \mathbf{800}$ N (using $g = 10$ m/s^2).
    - (b) Weight on Moon $W_{\text{moon}} = m \times g_{\text{moon}} = 80 \times 1.6 = \mathbf{128}$ N.
- **3.3. What force is required to increase the velocity of 800 kg car from 10 m s^{-1} to 30 m s^{-1} in 10 seconds?**
  - **Answer:**
    - Mass $m = 800$ kg, $v_i = 10$ m/s, $v_f = 30$ m/s, $t = 10$ s.
    - Force $F = \frac{m(v_f - v_i)}{t} = \frac{800 \times (30-10)}{10} = \frac{800 \times 20}{10} = \mathbf{1600}$ N.
- **3.4. A 5 g bullet is fired by a gun. The bullet moves with a velocity of 300 m s^{-1}. If the mass of the gun is 10 kg, find the recoil speed of the gun.**
  - **Answer:**
    - Mass of bullet $m_1 = 5$ g $= 0.005$ kg, velocity of bullet $v_1 = 300$ m/s.
    - Mass of gun $m_2 = 10$ kg, recoil speed $v_2 = ?$
    - By conservation of momentum: $m_1 v_1 + m_2 v_2 = 0 (0.005 \times 300) + (10 \times v_2) = 0 \Longrightarrow 1.5 + 10 v_2 = 0 \Longrightarrow v_2 = \frac{-1.5}{10} = -\mathbf{0.15}$ m/s.

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- **3.5. An astronaut weighs 70 kg. He throws a wrench of mass 300 g at a speed of 3.5 m s⁻¹. Determine: (a) the speed of astronaut as he recoils away from the wrench. (b) the distance covered by the astronaut in 30 minutes.**
    - **Answer:**
        - Mass of astronaut $m_1 = 70$ kg, mass of wrench $m_2 = 300$ g $= 0.3$ kg, velocity of wrench $v_2 = 3.5$ m/s.
        - (a) Recoil speed of astronaut $v_1 = -\frac{m_2 v_2}{m_1} = -\frac{0.3 \times 3.5}{70} = \frac{-1.05}{70} = -0.015$ m/s $= \mathbf{-1.5 \times 10^{-2}}$ m/s.
        - (b) Time $t = 30$ minutes $= 30 \times 60 = 1800$ s. Distance $S = v \times t = 0.015$ m/s $\times 1800$ s $= \mathbf{27}$ m.
- **3.6. A 6.5 × 10³ kg bogie of a goods train is moving with a velocity of 0.8 m s⁻¹. Another bogie of mass 9.2 × 10³ kg coming from behind with a velocity of 1.2 m s⁻¹ collides with the first one and couples to it. Find the common velocity of the two bogies after they become coupled.**
    - **Answer:**
        - $m_1 = 6.5 \times 10^3$ kg, $v_1 = 0.8$ m/s
        - $m_2 = 9.2 \times 10^3$ kg, $v_2 = 1.2$ m/s
        - By conservation of momentum: $m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f (6.5 \times 10^3 \times 0.8) + (9.2 \times 10^3 \times 1.2) = (6.5 \times 10^3 + 9.2 \times 10^3) v_f 5200 + 11040 = 15{,}700 v_f \Longrightarrow 16{,}240 = 15{,}700 v_f \Longrightarrow v_f = \frac{16{,}240}{15{,}700} \approx \mathbf{1.03}$ m/s.
- **3.7. A cyclist weighing 55 kg rides a bicycle of mass 5 kg. He starts from rest and applies a force of 90 N for 8 seconds. Then he continues at a constant speed for another 8 seconds. Calculate the total distance travelled by the cyclist.**
    - **Answer:**
        - Total mass $m = 55 + 5 = 60$ kg, Force $F = 90$ N.
        - Acceleration during first 8 s: $a = \frac{F}{m} = \frac{90}{60} = 1.5$ m/s^2.
        - Distance in first 8 s (S_1): $v_i = 0, t_1 = 8$ s. $S_1 = v_i t_1 + \frac{1}{2} a t_1^2 = 0 + \frac{1}{2}(1.5)(8)^2 = 0.75 \times 64 = 48$ m.
        - Final velocity at $t = 8$ s: $v_f = v_i + at = 0 + (1.5 \times 8) = 12$ m/s.
        - Distance in next 8 s (S_2) at constant speed $v = 12$ m/s: $S_2 = v \times t_2 = 12 \times 8 = 96$ m.
        - Total distance $= S_1 + S_2 = 48 + 96 = \mathbf{144}$ m.
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- **3.8. A ball of mass 0.4 kg is dropped on the floor from a height of 1.8 m. The ball rebounds straight upward to a height of 0.8 m. What is the magnitude and direction of the impulse applied to the ball by the floor?**
  - **Answer:**
    - Mass $m = 0.4$ kg, $h_1 = 1.8$ m, $h_2 = 0.8$ m.
    - Velocity just before hitting floor $v_1 = \sqrt{2gh_1} = \sqrt{2 \times 10 \times 1.8} = \sqrt{36} =$ 6 m/s (downward, take -6 m/s).
    - Velocity just after hitting floor $v_2 = \sqrt{2gh_2} = \sqrt{2 \times 10 \times 0.8} = \sqrt{16} =$ 4 m/s (upward, take $+4$ m/s).
    - Impulse $J = \Delta p = m(v_2 - v_1) = 0.4 \times [4 - (-6)] = 0.4 \times 10 =$ **4** N · s (upward).
- **3.9. Two balls of masses 0.2 kg and 0.4 kg are moving towards each other with velocities 20 m s⁻¹ and 5 m s⁻¹ respectively. After collision, the velocity of 0.2 kg ball becomes 6 m s⁻¹. What will be the velocity of 0.4 kg ball?**
  - **Answer:**
    - $m_1 = 0.2$ kg, $u_1 = +20$ m/s
    - $m_2 = 0.4$ kg, $u_2 = -5$ m/s (moving towards each other)
    - $v_1 = +6$ m/s (assuming it rebounds forward)
    - By conservation of momentum: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2(0.2 \times 20) + \big(0.4 \times (-5)\big) = (0.2 \times 6) + (0.4 \times v_2)4 - 2 = 1.2 + 0.4v_2 \implies 2 = 1.2 + 0.4v_20.4v_2 = 0.8 \implies v_2 = \frac{0.8}{0.4} =$ $+\mathbf{2}$ m/s (moving in opposite direction).

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