Impulse and Momentum

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Q1: What happens to the force on a ball during the collision with a bat?

A) It remains constant throughout the collision.

B) It is zero just before contact and increases to a maximum during contact.

C) It decreases to zero after the collision begins.

D) It is maximum just before contact and decreases during contact.

Q2: According to Newton's second law in the form $F = dp/dt$, what does the force on an object cause?

A) A change in the object's mass.

B) A change in the object's velocity only.

C) A change in the object's momentum only.

D) A change in the object's velocity and momentum.

Q3: How can the total change in momentum of an object during a collision be calculated?

A) By multiplying the force by the distance.

B) By integrating the force over the time interval of the collision.

C) By multiplying the mass by the velocity.

D) By summing the initial and final velocities.

Q4: What does the impulse J represent in the context of a collision?

A) The product of mass and velocity. The product of mass and velocity.

B) The change in velocity.

C) The product of force and time interval.

D) The average force applied during the collision.

Q5: If the force-time graph for a collision is provided, how can the impulse be determined?

A) By finding the area under the force-time curve.

B) By finding the slope of the force-time curve.

C) By finding the maximum force value.

D) By finding the average force value.

Q6: A ball of mass 0.40 kg is thrown left towards a wall at 30 m/s and rebounds at 20 m/s. What is the change in momentum of the ball? (Take motion to the left as negative)

A) 10 kg·m/s

B) 20 kg·m/s

C) 8 kg·m/s

D) 12 kg·m/s

Q7: Using the previous example, if the collision lasts 0.02 s, what is the average force exerted by the wall on the ball?

A) 200 N

B) 2000 N

C) 1000 N

D) 2500 N

Q8: What does the direction of the impulse vector indicate?

A) The direction of the applied force.

B) The direction of the initial velocity.

C) The direction of the change in momentum.

D) The direction of the final velocity.

Q9: In a real-life scenario, which ball would be easier to catch: a 0.50 kg ball moving at 20 m/s or a 2.50 kg ball moving at 4 m/s?

A) The 0.5 kg ball.

B) The 2.50 kg ball.

C) Both are equally easy to catch.

D) Neither can be caught.

Q10: When comparing change in momentum and change in kinetic energy, which statement is true?

A) Change in momentum depends on the distance over which the force acts.

B) Change in kinetic energy depends on the time over which the force acts.

C) Change in momentum depends on time, while the change in kinetic energy depends on distance.

D) Both depend on time and distance.

1. B) It is zero just before contact and increases to a maximum during contact.

Explanation: The force on the ball varies during the collision; it starts at zero just before contact, reaches a maximum when the ball and bat are in complete contact, and then decreases as the ball moves away from the bat. This variation is due to the dynamics of the collision process.

2. D) A change in the object's velocity and momentum.

Explanation: Newton's second law in this form states that the force applied to an object is equal to the rate of change of its momentum. This indicates that the force causes the object's momentum to change over time. Momentum being a derivative of velocity ($p = mv$) implies velocity changes as well

3. B) By integrating the force over the time interval of the collision.

Explanation: The total change in momentum can be found by integrating the force over the time during which the force acts. This integral accounts for the variations in force over the collision duration. This is also then equivalent to area under a force time graph which is nothing but impulse ($\Delta p = \int F \, dt$)

4. C) The product of force and time interval.

Explanation: Impulse is defined as the product of the average force applied during the collision and the time interval over which it acts. It represents the total effect of the force on the object's momentum. (also read answer to Q3)

5. A) By finding the area under the force-time curve.

Explanation: The impulse is given by the area under the force-time curve. This area represents the integral of force over time, which equals the impulse.

6. B) 20 kg·m/s

Explanation: The initial momentum is $p_1 = 0.40 \, (-30) = -12$ kg·m/s and the final momentum is $p_2 = 0.40 \, (20) = 8$ kg·m/s. The change in momentum is $\Delta p = p_2 - p_1 = 8 - (-12) = 20$ kg·m/s.

7. C) 1000 N

Explanation: The impulse is 20 N·s. Using the equation $F_{avg} = J / \Delta t$, we get $F_{avg} = 20 / 0.02 = 1000$ N. Observe that the sign of force as well as the impulse in the previous question is the same that is positive. Remember, the direction of change of momentum or the impulse is the same as the direction of force on the object

8. C) The direction of the change in momentum.

Explanation: The impulse vector points in the direction of the change in momentum. Since impulse and change in momentum are directly related, they share the same direction.

9. B) The 2.50 kg ball.

Explanation: Both balls have the same momentum, but the smaller ball has a higher kinetic energy, requiring more work to stop it ($W = K_2 - K_1$). Therefore, the larger, slower ball is easier to catch as it has lower kinetic energy.

10. C) Change in momentum depends on time, while change in kinetic energy depends on distance.

Explanation: Change in momentum depends on the time duration of the force application ($dp = F\, dt$), while kinetic energy change depends on the distance over which the force acts ($K_2 - K_1 = W = F\, d$). This difference highlights how momentum and kinetic energy are affected by force differently.