Board – CBSE	Class – 9th	Topic – Force and Lows of Motion

Q.1 Why are car seat belts designed to stretch somewhat in a collision?

Ans: Car seatbelts are somewhat stretchable to increase the time taken by the passengers to fall forward. Due to this, passengers' rate of change of momentum is reduced, and hence a less stopping force acts on them. So the passengers do not get hurt.

Q.2 Why would an aircraft be unable to fly on the moon?

Ans: An aircraft needs air because air moving under the wings of the aircraft is strong enough to hold it up, and the air is also required to burn the fuel in aircraft engines. Since there is no air on the moon, an aircraft cannot fly on the moon.

Q.3 A boy of mass $50\ kg$ running at $5\ m/s$ jumps onto a $20\ kg$ trolley travelling in the same direction at $1.5\ m/s$. What is their common velocity?

Ans: Mass of the boy, $m_1 = 50\ kg$

Speed of boy, $u_1 = 5\ m/s$

Mass of trolley $m_2 = 20\ kg$

Speed of trolley $u_2 = 1.5\ m/s$

The combined mass of boy and trolley, $m = 20 + 50 = 70\ kg$

Combined velocity v

Acc. to the law of conservation of momentum

$m_1u_1 + m_2u_2 = mv$

$50\times5 + 20\times1.5 = 70\times v$

$v = \frac{250+30}{70} = 4\ m/s$

Q.4 A girl of mass $50\ kg$ jumps out of a rowing boat of $300\ kg$ onto the bank, with a horizontal velocity of $3\ m/s$. With what velocity does the boat begin to move backwards?

Ans: Mass of the boat $m_b = 300\ kg$

Velocity of boat v_b

Mass of girl $m_g = 50\ kg$

Velocity of girl $v_g = 3\ m/s$

Acc. to the law of conservation of momentum

$m_b v_b = m_{g v_g}$

$300 \times v_b = 50 \times 3$

$v_b = \frac{50 \times 3}{300} = 0.5\ m/s$

Q.5 Explain why it is possible for a small animal to fall from a considerable height without any injury being caused when it reaches the ground.

Ans: A small animal can fall from a considerable height without being injured because a small animal has a small mass, so the momentum produced is less. When the small animal falls to the ground with less momentum, the less opposing force of ground acts on it and hence no injury is caused to it

Q.6 A truck of mass $500\ kg$ moving at $4\ m/s$ collides with another truck of mass $1500\ kg$ moving in the same direction at $2\ m/s$. What is their common velocity just after the collision if they move off together?

Ans: Mass of the first truck, $m_1 = 500\ kg$

Speed of first truck, $u_1 = \frac{4\ m}{s}$

Mass of second truck, $m_2 = 1500\ kg$

Speed of second truck, $u_2 = \frac{2\ m}{s}$

The combined mass of both trucks, $m = 1500 + 500 = 2000\ kg$

Combined velocity v

Acc. to the law of conservation of momentum

$m_1 u_1 + m_2 u_2 = mv$

$500 \times 4 + 1500 \times 2 = 2000 \times vv = \frac{2000+3000}{2000} = 2.5\ m/s$

Q.7 A ball X of mass $1\ kg$ travelling at $2\ m/s$ has a head-on collision with an identical ball Y at rest. X stops, and Y moves off. Calculate the velocity of Y after the collision.

Ans: Mass of the ball x, $m_1 = 1\ kg$

Speed of ball x, $u_1 = \frac{2\ m}{s}$

Mass of ball y, $m_2 = 1\ kg$

Speed of ball y, $u_2 = 0\ m/s$ (at rest)

The velocity of ball x after the collision, $v_1 = \frac{0\ m}{s}$

The velocity of ball y after the collision, v_2

Acc. to the law of conservation of momentum

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$1\times2 + 1\times0 = 1\times0 + 1\times v_2$

$v_2 = \frac{1\times2}{1} = 2\ m/s$

Q.8 The troops (soldiers) equipped to be dropped by parachutes from an aircraft are called paratroopers. Why do paratroopers roll on landing?

Ans: The paratroopers roll on landing to increase the time taken to reduce the momentum of their bodies. Thus, the rate of momentum change is reduced, and hence less force is exerted on their legs, and they do not get hurt.

Q.9 A heavy car A of mass 2000 kg travelling at $10\ m/s$ has a head-on collision with a sports car B of mass $500\ kg$. If both cars stop dead on colliding, what was the velocity of car B?

Ans: Mass of car A, $m_1 = 2000\ kg$

Speed of car A, $v_1 = \frac{10\ m}{s}$

Mass of car B, $m_2 = 500\ kg$

Speed of car B, v_2

Acc to the law of conservation of momentum

$m_1v_1 = m_2v_2$

$2000\times10 = 500\times v_2$

$v = \frac{2000\times10}{500} = 40\ m/s$

Q.10 Explain why is it difficult for a fireman to hold a hose, which ejects a large amount of water at a high velocity.

Ans: The water ejected from the hose in the forward direction comes out with large momentum. An equal amount of momentum is developed in the hose in the opposite direction; hence, the hose is pushed backwards. It becomes difficult for a fireman to hold a hose that experiences this large momentum.

Q.11 A man wearing a bullet-proof vest stands still on roller skates. The total mass is 80 kg. A bullet of mass 20 grams is fired at 400 m/s. It is stopped by the vest and falls to the ground. What is then the velocity of the man?

Ans: Mass of the man, $m_1 = 80\ kg$

Speed of man, v_1

Mass of bullet $m_2 = 20\ g = 0.02\ kg$

Speed of bullet $v_2 = \frac{400\ m}{s}$

Acc. to the law of conservation of momentum

$m_1v_1 = m_2v_2 80\times v_1 = 0.02\times400$

$v_2 = \frac{400\times0.02}{80} = 0.1\ m/s$

Q.12 A 60 g bullet fired from a 5 kg gun leaves with a speed of 500 m/s. Find the speed (velocity) with which the gun recoils (jerks backwards).

Ans: Mass of bullet, $m_1 = 60\ g = 0.06\ kg$

Velocity of bullet $v_1 = \frac{500\ m}{s}$

Mass of gun $m_2 = 5\ kg$

Recoil velocity v_2

According to the law of conservation of momentum

$m_1 \times v_1 = m_2 \times v_2$

$0.06 \times 500 = 5 \times v_2$

$v_2 = \frac{0.06 \times 500}{5} = 6\ m/s$

Q.13 A 10 g bullet travelling at $200 m/s$ strikes and remains embedded in a 2 kg target which is originally at rest but free to move. At what speed does the target move off?

Ans: Mass of bullet, $m_1 = 10\ g = 0.01\ kg$

Velocity of bullet $v_1 = \frac{200\ m}{s}$

Mass of block with the bullet as bullet gets embedded in it, $m_2 = 2 + 0.01 = 2.01\ kg$

Recoil velocity v_2

According to the law of conservation of momentum $m_1 \times v_1 = m_2 \times v_2$

$0.01 \times 200 = 2.01 \times v_2$

$v_2 = \frac{0.01 \times 200}{2.01} = 0.99\ m/s$

Q.14 How much momentum will a dumbbell of mass 10 kg transfer to the floor if it falls from a height of 80 cm? Take its downward acceleration to be 10 ms^{-2},

Ans: Mass of dumb-bell $= 10\ kg$

Height, $h = 80\ cm = 0.8\ m$

$a = 10\ m/s^2$

$u = 0$

$v^2 - u^2 = 2as$

$v^2 - (0)^2 = 2 \times 10 \times 0.8$

$v^2 = 16$

$v = 4\ m/s$

Momentum $p = mv$

$= 10 \times 4$

$= 40 kgm/s$

Q.15 A body of mass 2 kg is at rest. What should be the magnitude of force which will make the body move with a speed of 30 m/s at the end of 1 s?

Ans: Mass of the body $= 2\ kg$

Initial velocity $u = 0$

Final velocity $v = \frac{30\ m}{s}$

Time $t = 1\ s$

Acceleration $a = \frac{v-u}{t} = \frac{30.0}{1} = \frac{30\ m}{s^2}$

Force $= m \times a = 2 \times 30 = 60\ N$

Q.16 A body of mass 5 kg is moving with a velocity of 10 m/s. A force is applied to it so that in 25 seconds, it attains a velocity of 35 m/s. Calculate the value of the force applied.

Ans: Mass of the body $= 5\ kg$

Initial velocity $u = \frac{10\ m}{s}$

Final velocity $v = \frac{35\ m}{s}$

Time $t = 25\ s$

Acceleration $a = \frac{v-u}{t} = \frac{35-10}{25} = \frac{1\ m}{s^2}$

Force $= m \times a = 5 \times 1 = 5\ N$

Q.17 For how long should a force of 100 N act on a body of 20 kg so that it acquires a velocity of 100 m/s?

Ans: Mass of the body $= 20\ kg$

Initial velocity $u = \frac{0\ m}{s}$

Final velocity $v = \frac{100\ m}{s}$

Force $F = 100\ N$

Acceleration $a = \frac{F}{m} = \frac{100}{20} = \frac{5\ m}{s^2}$

Time $t = \frac{v-u}{a} = \frac{100-0}{5} = 20\ s$

Q.18 How long will it take a force of $10\ N$ to stop a mass of $2.5\ kg$, which is moving at $20\ m/s$?

Ans: Mass of the body $= 2.5\ kg$

Initial velocity $u = \frac{20\ m}{s}$

Final velocity $v = \frac{0\ m}{s}$

Force $F = 10\ N$

Acceleration $a = \frac{F}{m} = \frac{10}{2.5} = \frac{4\ m}{s^2}$

Since $v < u$, so acceleration will have a negative sign $a = -\frac{4\ m}{s^2}$

Time $t = \frac{v-u}{a} = \frac{100-0}{5} = 20\ s$

Q.19 The velocity of a body of mass $10\ kg$ increases from $4\ m/s$ to $8\ m/s$ when a force acts on it for $2\ s$.

(a) What is the momentum before the force acts?

(b) What is the momentum after the force acts?

(c) What is the gain in momentum per second?

(d) What is the value of the force?

Ans: Mass of the body $= 10\ kg$

Initial velocity $u = \frac{4\ m}{s}$

Final velocity $v = \frac{8\ m}{s}$

Time $t = 2\ s$

(a) Momentum before force acts $p_1 = m \times u = 10 \times 4 = 40\ kg.\frac{m}{s}$

(b) Momentum after force acts $p_2 = m \times v = 10 \times 8 = 80\ kg \cdot \frac{m}{s}$

(c) The gain in momentum for $2\ s = p_2 - p_1 = 40\ kg \cdot \frac{m}{s}$

The gain in momentum per second $= \frac{40}{2} = 20\ kg \cdot \frac{m}{s}$

(d) Acceleration

$a = \frac{v-u}{t} = \frac{8-4}{2} = 2\ m/s^2$

$Force = m \times a = 10 \times 2 = 20\ N$

Q.20 A gun of mass 3 kg fires a bullet of mass 30 g. The bullet takes 0.003 s to move through the gun barrel and acquires a velocity of 100 m/s. Calculate:

(i) the velocity with which the gun recoils.

(ii) the force exerted on gunman due to recoil of the gun

Ans: Mass of the gun $m_1 = 3\ kg$

Mass of bullet $m_2 = 30\ g = 0.03\ kg$

Velocity of bullet $v_2 = \frac{100\ m}{s}$

(i) According to the law of conservation of momentum

$m_1 \times v_1 = m_2 \times v_2$

$3 \times v_1 = 0.03 \times 100$

Recoil velocity $v_1 = \frac{100 \times 0.03}{3} = \frac{1\ m}{s}$

(ii) Initial velocity of the gun $u = \frac{0\ m}{s}$

The final velocity of the gun $v = \frac{1\ m}{s}$

Time $t = 0.003\ s$

$a = \frac{v-u}{t} = \frac{1-0}{0.003} = \frac{1000}{3}\ m/s^2$

Force $= m \times a = 3 \times \frac{1000}{3} = 1000\ N$

Q.21 Name the laws involved in the following situations:

(a) The sum of products of masses and velocities of two moving bodies before and after their collision remains the same.

(b) a body of mass 5 kg can be accelerated more easily by force than another body of mass 50 kg under similar conditions

(c) When person A standing on roller skates pushes another person B (also standing on roller skates) and makes him move to the right side, person A himself gets moved to the left side by an equal distance.

(d) If there were no friction and no air resistance, then a moving bicycle would go on moving forever.

Ans: (a) Law of conservation of momentum

(b) Newton's second law of motion

(c) Newton's third law of motion

(d) Newton's first law of motion