Chapter – 09 FORCE AND LAWS OF MOTION

Force :- A force is anything that can cause a change in objects. Forces can –

1. Change the shape of an object.
2. Move or stop an object.
3. Change the direction of a moving object.

A force can be classified as –

1. **Contact force :-** A contact force must touch or keep contact with an object to cause a change. Ex. – Friction, force of windmill.
2. **Non-contact force :-** A non-contat force does not have to touch an object to cause a change. Ex. Gravitational force, magnetic force.

Balanced and Unbalanced Forces :-
Balanced Forces :-The net force is when two or more forces are applied on the same object and at the same time. The applied forces combined are called the net force.

Unbalanced Forces :- A force is applied in one direction and either another smaller or larger force is applied in the opposite direction or no force is applied at all in the opposite direction.

Newton's laws of motion :- Newton presented three fundamental laws that govern the motion of objects. These three laws are known as Newton's laws of motion.

First Law of Motion :- The first law of motion is stated as - **An object remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by an applied force.**

All objects resist a change in their *state of motion*. The tendency of objects to stay at rest or to keep moving with the same velocity is called inertia. This is why, the first law of motion is also known as the law of inertia.

Ex. - When a motorcar makes a sharp turn at a high speed, we tend to get thrown to one side. When an unbalanced force is applied by the engine to

change the direction of motion of the motorcar, we slip to one side of the seat due to the inertia of our body.

Inertia and Mass :- There is a resistance offered by an object to change its state of motion. If it is at rest it tends to remain at rest; if it is moving it tends to keep moving. This property of an object is called its inertia.

The inertia of an object is measured by its mass. Inertia is the natural tendency of an object to resist a change in its state of motion or of rest. The mass of an object is a measure of its inertia.

Second Law of Motion :- The second law of motion is stated as - **The rate of change of momentum of an object is proportional to the applied unbalanced force in the direction of the force.**

$$\text{Force} = \frac{\text{Momentum}}{\text{Time}}$$

$$F = \frac{P}{t}$$

Third Law of Motion :- The third law of motion is stated as - **To every action, there is an equal and opposite reaction and they act on two different bodies.**
Ex. –

1. When a gun is fired, it exerts a forward force on the bullet. The bullet exerts an equal and opposite reaction force on the gun. This results in the recoil of the gun. Since the gun has a much greater mass than the bullet, the acceleration of the gun is much less than the acceleration of the bullet.

2. When a sailor jumps out of a rowing boat. As the sailor jumps forward, the force on the boat moves it backwards

Conservation of Momentum :- Suppose two objects (two balls A and B, say) of masses m_A and m_B are travelling in the same direction along a straight line at different velocities u_A and u_B, respectively. And there are no other external unbalanced forces acting on them. Let $u_A > u_B$ and the two balls collide with each other. During collision which lasts for a time t, the ball A exerts a force F_{AB} on ball B and the ball B exerts a force F_{BA} on ball A. Suppose v_A and v_B are the velocities of the two balls A and B after the collision respectively the momenta of ball A before and after the collision are $m_A u_A$ and $m_A v_A$, respectively. The rate of change of its momentum (or F_{AB}, action) during the collision will be –

$$m_A \frac{(v_A - u_A)}{t}$$

Similarly, the rate of change of momentum of ball B (= F_{BA} or reaction) during the collision will be

$$m_B \frac{(v_B - u_B)}{t}$$

According to the third law of motion, the force F_{AB} exerted by ball A on ball B (action) and the force F_{BA} exerted by the ball B on ball A (reaction) must be equal and opposite to each other. Therefore,

$$F_{AB} = -F_{BA}$$

$$m_A \frac{(v_A - u_A)}{t} = - m_B \frac{(v_B - u_B)}{t}$$

This gives,

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$

Since $(m_A u_A + m_B u_B)$ is the total momentum of the two balls A and B before the collision and $(m_A v_A + m_B v_B)$ is their total momentum after the collision. The total momentum of the two balls remains unchanged or conserved provided no other external force acts.

As a result of this ideal collision experiment, we say that the sum of momenta of the two objects before collision is equal to the sum of momenta after the collision provided there is no external unbalanced force acting on them. This is known as the law of conservation of momentum. This statement can alternatively be given as the total momentum of the two objects is unchanged or conserved by the collision.