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Class 9 Science

C9: Force and Laws of Motion



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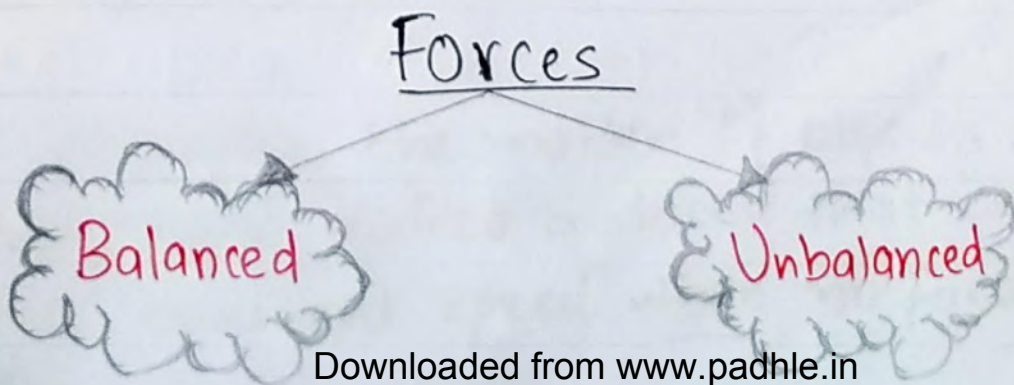
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FORCE AND LAWS OF MOTION ¹

- What is force?
- Whenever we push or pull an object a force acts upon them and makes them move from one place to another.
- It can change the speed, direction and shape of a body.
- The trolley moves along the direction we push it.
- The drawer is pulled.



- Under Balanced force :

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- If two individual forces are of equal magnitude and opposite direction, then the forces are said to be balanced.

- Under Unbalanced force :

- If one of the forces is greater, the body will accelerate in the direction of the greater one force.

1) Thus, only an unbalanced force can change the motion of a body.

2) The acceleration resulting from an unbalanced force becomes zero as soon as the unbalanced force is removed.

- First Law of Motion :

- By observing the motion of objects on an inclined plane Galileo deduced that objects move with a constant speed when no force acts on them.

- He observed that when a marble rolls down an inclined plane, its velocity increases.

- frictional force :

- The force that always opposes the motion of objects is called a force of friction.

- What all did Galileo said?

1) When a marble is rolled down from the left - it will go up on the opposite side up to the same height at which it is dropped down.

2) If the inclination of plane is equal - The marble would travel equal distances while climbing up as travelled while rolling down.

3) If we decrease the angle of inclination of the right plane - The marble would travel further until it reaches its original height.

- If the right side plane is made flat - Marble would travel forever to achieve the same height.

- What does the first law of Motion state?
- 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, this is also called Law of inertia.
- When we are in a bus and it starts moving, we suddenly tend to fall backwards as it opposes the motion of the vehicle.
- Inertia And Mass :
- Quantitatively, the inertia of an object is measured by its mass.
- We may thus relate inertia and mass as follows:
- 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 :

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- It states that the rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts.
- A small mass, such as a bullet may kill a person when fired from a gun.
- These observations suggest that the impact produced by the objects depends on their mass and velocity.
- Similarly, if an object is to be accelerated, we know that a greater force is required to give a greater velocity.
- In other words, there appears to exist some quantity of importance that combines the object's mass and its velocity.
- One such property called momentum was introduced by Newton.

- Mathematical formulation of Second Law of Motion:

- The change in momentum $\propto p_2 - p_1$
 $\propto mv - mu$
 $\propto m \times (v - u)$

The rate of change of momentum $\propto \frac{m(v-u)}{t}$
Or, the applied force,

$$F \propto \frac{m(v-u)}{t}$$

$$F = \frac{km(v-u)}{t} \quad (9.2)$$

$$= kma \quad (9.3)$$

SI unit - 1 unit of force = $k \times (1\text{kg}) \times (1\text{m s}^{-2})$.

Thus, the value of 'k' becomes '1'. From equation (9.3)

$$F = ma$$

Example: Cricketer when catches a ball pulls his hands in the backward direction to give some time to decrease the velocity of the ball.

- As the acceleration of the ball decreases the force exerted on catching the moving ball also decreases.

- If the cricketer would try to stop a moving ball suddenly he would have to apply larger force.
- The third Law of Motion :
- Action and Reaction forces :
- Two forces acting from opposite directions are called Action and Reaction forces.
- for example : a ball when hits the ground (action) bounces back with a certain force (reaction).
- What does the third law of motion say?
- When an object exerts a force on another object, the second object instantly exerts a force back onto the first object.
- These forces are always equal in magnitude but opposite in direction.
- These forces act on two different objects always.

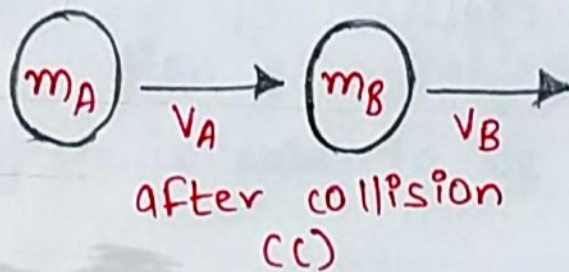
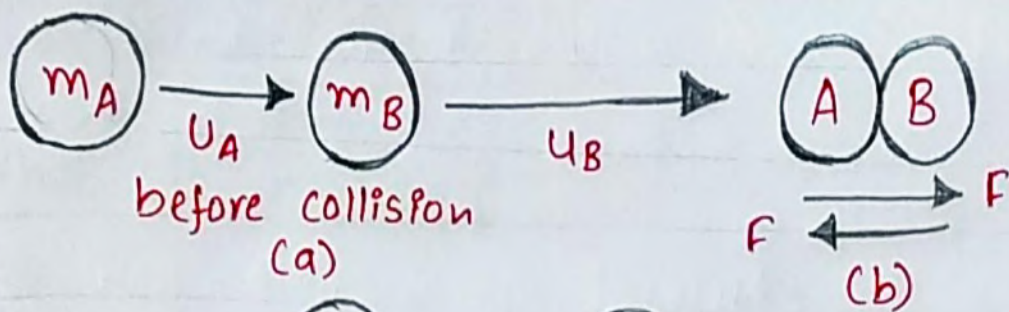
- The third law of motion can also be illustrated when a sailor jumps out of a rowing boat.

- As the sailor jumps forward, the force on the boat moves it backwards.



- Conservation of Momentum :

- If the external force on a system is zero, the momentum of the system remains constant.
i.e. In an isolated system, the total momentum remains conserved.



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