Force and Laws of Motion - Notes

Notes Important Questions

Force and Laws of Motion - Notes

Force:- A push or pull on an object is called force.

A force can change-

- the state of motion of an object i.e, motion to rest or, rest to motion.
- the speed of the object
- the direction of motion
- the shape of the object

Contact Force:- The force exerted by one object on another object due to the physical contact between them is called contact force.

Ex:- muscular force, frictional force etc.

Non-contact Force:- The force exerted by one object on another object without any physical contact between them is called non-contact force.

Ex:- Magnetic force, electrostatic force, gravitational force etc.

Balanced Forces:- If the net force acting on an object is zero, then the forces acting on the object are said to be balanced.

Unbalanced Forces:- If the net force acting on an object is not zero, then the forces acting on the object are said to be unbalanced.

Newton's First Law of Motion (Law of Inertia):- An object remains in a state of rest or of uniform motion in a straight line unless or until an unbalanced force is applied.

***Or*,** All objects resist a change in their state of motion.

Inertia:-The natural tendency of an object to resist a change in its state of motion or of rest is called inertia.

Inertia is classified as:-

- **Inertia of rest:** Ex - A person seating in a car leans backward when the car starts all of a sudden
- **Inertia of motion:** Ex - A person seating in a moving car leans forward when the car stops all of a sudden
- **Inertia of direction:** Ex - Whenever a bus takes a sharp turn, the passengers experience a force acting away from the centre of the curve

Note:-

- Mass of an object is a measure of its inertia.
- Inertia ? Mass

Momentum:- The momentum of an object is defined as the product of its mass and velocity.

- **p = mv**
- S.I. unit:- kg m/s

Newton's Second Law Of Motion:- The force applied on an object is directly proportional to the rate of change of momentum in the direction of force.

Mathematical Formulation Of Second Law Of Motion:-

Consider an object of mass 'm' moving in a straight line with initial velocity 'u'. It is uniformly accelerated to final velocity 'v' in time 't'.

So, initial momentum = p_1 = mu and final momentum = p_2 =mv

A/c to second law of motion,

Force applied ? Change in momentum/time

or, F ? (p_2 - p_1)/t

or, F ? (mv - mu)/t

or, F ? m(v-u)/t

or, F ? ma **[**since, **a = (v-u)/t]**

or, F = k m a where, k is constant of proportionality

Here, k = 1 So, **F = ma**

- S.I. unit of force:- **kg m/s^2**
- **1 Newton of force**:- The amount of force is said to be 1 newton that produces an acceleration of 1 m/s^2 in an object of 1 kg mass.

Proof Of First Law Of Motion Using Second Law Of Motion:-

From second law of motion,

F = ma

or, F = m(v-u)/t

or, Ft/m = v-u

when, **F = 0**

then, v-u = 0

or, **v = u**

Here, we see that when external applied force is 0, then there is no change in its state of motion or of rest which is the first law of motion.

Newton's Third Law Of Motion:- It states that every action has equal and opposite reaction.

Ex:- A forward force on the bullet and recoil of the gun.

Law Of Conservation Of Momentum:- 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.

Mathematical Proof Of Law Of Conservation Of Momentum:-

Consider two objects having masses m_1 and m_2 moving with initial velocities u_1 and u_2 respectively in the same direction such that $u_1 > u_2$. After collision, let their final velocities be v_1 and v_2 respectively.

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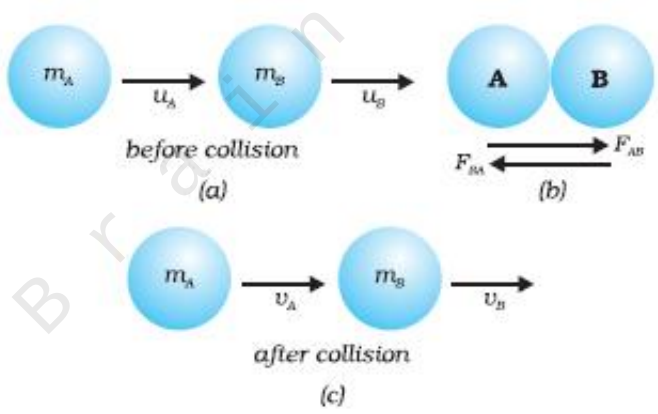

Conservation of momentum in collision of two balls.

From 2nd law of motion,

Force exerted by A on B = $F_{AB} = m_A(v_A-u_A)/t$

Force exerted by B on A = $F_{BA} = m_B(v_B-u_B)/t$

From 3rd law of motion,

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

or, $m_A(v_A-u_A)/t = -m_B(v_B-u_B)/t$

or, $m_Av_A - m_Au_A = -m_Bv_B + m_Bu_B$

or, $\mathbf{m_Au_A + m_Bu_B = m_Av_A + m_Bv_B}$