Unit :- I Laws of motion.

Newton first law of motion :-

Every body in this universe continues to be in its state of rest or uniform motion in a straight line, unless its compelled to change that state by forces impressed on it.

According to Aristole → Constant force
→ Constant velocity.

Galileo → No force → uniform velocity.

First Law gives the definition of force. Force is defined as the external agency that changes or tends to change that state of rest or of uniform motion of a body in a straight line.

The first Law of motion is also called "Law of inertia" is the inability of a material body to change by itself its state of rest or of uniform motion in a straight line.

Newton's second Laws of motion :-

Definition :-

The rate of change of momentum of a body is directly proportional to the impressed force and takes place in the direction of the force.

Explanation :-

A body posseses mass. If a body of mass "m" is moving with a velocity v its posseses momentum.

$$P = mv$$

p - Momentum, m - Mass, v - velocity.

The direction of momentum is the same as the direction of velocity.

According to newton's second law of motion the rate of change of momentum is,

$$\frac{dp}{dt} = \frac{d}{dt}(mv)$$

$$= m\frac{dv}{dt} + v\frac{dm}{dt}$$

$\frac{dm}{dt} = 0$ m = Constant.

$\frac{dp}{dt} = ma$ But $F \propto \frac{dp}{dt}$.

$F \propto ma$

$F = kma$ k - Proportinality constant

Suppose $m = a = F = k = 1 \Rightarrow F = 1 \times 1 \times 1 = 1$

∴ Unit force is defined as the force which can Produce an acceleration of 1 unit on mass of one unit.

Newton's third law of motion :-

To every action there is always can equal and Opposite reaction.

Explanation:

Consider two particles in an isolated System. Their masses one m_1 and m_2 their velocities are v_1 and v_2

Consider that the two bodies are moving along the same line and they interact.

Due to interaction, their velocities change consequently there will be change in their momenta in time Δt.

Change in momentum of the first particle = ΔP_1

" " of the second particle = ΔP_2

From the law of conservation of linear momentum in an isolated System having external force zero.

$$\Delta P_1 + \Delta P_2 = 0$$

$$\Delta P_2 = -\Delta P_1$$

$\div$ by Δt $\quad \frac{\Delta P_2}{\Delta t} = \frac{-\Delta P_1}{\Delta t}$

When $\Delta t \Rightarrow 0$. $\quad \frac{dP_2}{dt} = -\frac{dP_1}{dt}$

$$F_2 = -F_1$$

Force acting on m_2 = - force action on m_1,

Action = - Reaction.

Example :-

1. When a men jum from a boat due to reaction the boat moves away from him.

2. The moon in attracting the earth with a certain force (action). The earth also attracts the moon with an equal and opposite force (reaction)

3. When a bullet is fired from a rifle with a certain force (action), there is an equal and opposite force exerted on the rifle in the backward direction (reaction)

Impulse of a force :-

The change in momentum of a body is called Impulse.

From definition of force.

Force is defined as that external agency that changes or tends to change the state of rest or of uniform motion of a body in a straight line.

$$F = \frac{dP}{dt} \quad \text{(momentum)}$$

$$dP = F\,dt$$

$$\int_{P_1}^{P_2} dP = \int_0^t F \cdot dt.$$

Impulse $P_2 - P_1 = \int_0^t F \cdot dt.$

Impulse is denoted by J

$$J = \int_0^t F \cdot dt.$$

If a constant force F acts on a body for a time t, the impulse

$$J = F \cdot t$$

Example :-

1. A person falling on a cemented floor gets injured more. Where as a person falling on a sand floor or mattress does not get hurt. Also for the same reason in wrestling, pole vault and high jump, soft ground is provided.

2. It is easier to catch a tennis ball as compared to a cricket ball moving with the same velocity. The mass of a cricket ball is more than that of a tennis ball. The change in momentum is more in the case of a cricket ball. Consequently less force is to be applied in the case of a tennis ball.