Ch 5. Laws of Motion

Fundamentals of Physics

For revision for competitive examinations

Ch 5. Newton’s First Law of Motion

If a body is in a state of rest, it will remain in the state of rest,

And, if it is in the state of motion, it will remain moving, in the same direction, with the same speed,

unless an external force is applied to it.

Two States of motion evolve from this law , namely state of Inertia and state of Rest.

Three concepts involved in this first law are (a) Inertia, (b) Mass (c) Force

Inertia

- The property of an object by virtue of which it neither changes its state nor it tends to change its state , is called inertia.
- An object cannot change its state by itself.

Mass

- Mass is the measure of inertia.
- The greater the mass, the greater is the inertia of the body.
- A lighter body has less inertia than a heavier body.

Force

- Force is that external cause which tends to change the state of rest or the state of motion
- Force is a vector quantity. The sum of two opposite and equal forces is zero. A body acted upon by several forces can also have the resultant force on it, equal to zero.
- This is the qualitative definition of Force.

Kinds of Inertia

1) Inertia of Rest: If a body is at rest , it will remain at rest unless an external force is applied to change the state of its inertia.

- This is called the property of inertia of rest.

2) Inertia of motion: A body is in a state of motion continued to be in the state of motion with the same speed, in the same direction in a straight line, unless an external force is applied on it to change its state.

Linear Momentum and Newton’s Second Law of Motion

(1) Linear momentum of a body is the product of its mass and velocity

Linear Momentum

pressure = mass x velocity

(2) Force needed to stop a moving body , in a definite time , depends both on the mass of the body and its velocity

When force is applied on a moving body , its velocity changes.

Change in momentum m . v can be either due to change in mass or change in velocity, or change in both m and v.

Rate of change of momentum = m a = mass x acceleration

Newton's Second and Third Laws of Motion

2nd Law: The rate of change of momentum of a body is directly proportional to the force applied on it and the change in momentum takes place in the direction in which the force is applied.

- This is the fundamental law of motion as the first law is included in the second law.

One newton is the force which when acts on a body of mass 1 kg, produces an acceleration of 1 cm s^{-2}. 1 newton = 1 kg x 1 cm s^{-2}. Symbol of newton is N, and the unit of force is dyne. 1 newton =10^5 dyne. Force = Rate of change of momentum.

- From the 2nd law Force = mass x acceleration. A given change in momentum of a body can be brought about by applying a large force for a small duration. Example: Hitting of a cricket ball by a bat.

3rd Law : To every action, there is always an equal and opposite reaction

- A boatman pushes the water backwards with the oars while rowing a boat. While catching a ball, the ball exerts a force on the hand, and the cricketer exerts an equal and opposite force on the ball to stop its momentum.

Gravitation

Mass of a body is the quantity
Of matter it contains
Weight of a body is the force with which the earth attracts it.
Weight = mass x acceleration due to gravity or W= mg

(1) Each mass particle attracts the other mass particle . Gravitational force is always attractive, and the Gravitational constant G is the universal constant. It is significant between heavenly bodies but is insignificant between individuals due to the small magnitude of G.

(2) The force of attraction is (a) directly proportional to the product of their masses , (b) inversely proportional to the square of distance between them. The earth attracts a mass of 1 kg by a G force of 9.8 N.

(3) The rate at which the velocity of a freely falling body increases, is called acceleration due to gravity. The acceleration of a freely falling body does not depend on its mass , or size or shape .

Free fall is a one dimensional motion, of a freely falling body thrown vertically upwards from surface of the earth .

(4) The value of acceleration due to gravity 'g' does not remain constant. It varies from place to place on the surface of the Earth. On Equator it is slightly less than at the Poles. At altitudes above the earth's surface or at depth below the earth's surface , the value of g decreases.

On the moon, the value of g is nearly one-sixth the value of g on earth's surface.

(5) The acceleration due to gravity g = GM / R square. The value of g on a satellite or a planet depends on mass and radius of that satellite or planet.