Chapter 9. Force And Law Of Motion

Force : Force is push or pull which change or it has tendency to change the position of body.
In other words; Applied pushing, hitting and pulling on an object is known as force.

The S.I unit of force is neuton (N) or kgm^{-2}. It is a vector quantity. It has both magnitude and direction. Force is caused motion in an object.

Type of forces:

1. Friction force: This is a force which acts opposite to the direction of motion. It acting between to surfaces. Example: (i) When we walk the force acting between our slipper and the earth.

(ii) When a car runs on the road force acting between tires and the road.

Reducing the friction force: For reducing or minimising the frictional force we use

(i) Smooth marble (ii) Smooth plane (iii) Providing a lubricant on top of the planes

2. Centripital force:
3. Magnetic force:
4. Gravitational force:

Acording to its severity there are two kinds of force is known;

(i) Balanced force : If the resultant of several force acting on a body is zero then force are said to be balanced force.

(ii) Unbalanaced force : If the resultant of several force acting on a body is not zero then force are said to be balanced force.

- If an unbalanced force is applied on the object, there will be a change either in its speed or in the direction of its motion.
- An unbalanced force is required to accelerate the motion of an object.
- The change in the speed (or in the direction of motion) of object would continue as long as this unbalanced force is applied.

Newton further studied Galileo's ideas on force and motion and presented three fundamental laws that govern the motion of objects. These three laws are known as **Newton's laws of motion**.

(1) The First Law of Motion
(2) The Second Law of Motion
(3) The Third Law of Motion

(1) The First Law of Motion:

The first law of motion states;"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."

In other words: all objects resist a change in their state of motion.

- The first law of motion tells us that the motion of an object due to applying unbalanced force. When an unbalanced force is applied to any object it moves due to force.

- The first law of motion indicates that when an unbalanced external force acts on an object, its velocity changes, that is, the object
  gets an acceleration.

Inertia: 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.

- Inertia is a property or tendency of every object.
- Inertia is measured by mass of an object.
- The heavier object has the greater inertia than the light object.

Law of inertia: The tendency of undisturbed objects to stay at rest or to keep moving with the same velocity is called inertia.

Types of inertia : (i) Inertia of Rest
(ii) Inertia of motion
(iii) Inertia of direction

Examples of inertia:

(I) Travelling in a car: While travelling in a motorcar can be explained on the basis of the law of inertia. We tend to remain at rest with respect to the seat until the drives applies a braking force to stop the motorcar. With the application of brakes, the car slows down but our body tends to continue in the same state of motion because of its inertia. A sudden application of brakes may thus cause injury to us by impact or collision with the panels in front. Safety belts are worn to prevent such accidents. Safety belts exert a force on our body to make the forward motion slower.

(ii) Standing in bus: When we are standing in a bus and the bus begins to move suddenly. Now we tend to fall backwards. This is because the sudden start of the bus brings motion to the bus as well as to our feet in contact with the floor of the bus. But the rest of our body opposes this motion because of its inertia.

(iii) Sharp turning at high speed of a car: When a motorcar makes a sharp turn at a high speed, we tend to get thrown to one side. This can again be explained on the basis of the law of inertia. We tend to continue in our straight-line motion. 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.

- A body will remain at rest unless acted upon by an unbalanced force.

(iv) Hitting aarom coins by a stricker: When we attempt a sharp horizontal hit at the botton of the pile using another carom coins or stricker. If the hits is strong enough. the bottom coin moves out quickly and removed and due to inertia of the other coins makes them fall vertically on the table.

This is why, **the first law of motion** is also known as **the law of inertia**.

Mass: The quantity of material present in a object is called its mass.

The mass of an object is a measure of its inertia.

Differences between Inertia and Mass:

Inertia	Mass
1. Inertia is a property of an object.	1. Mass is a amount of material of an object.
2. Intertia of a object is measured by its mass.	2. Mass is a measurable quantity itself.

(2) The Second Law of Motion:

- The acceleration of an object depends on the force applied to it and how we measure a force.
- The second law of motion give the formulla to measure the applied force on an object.
- If an object is to be accelerated, we know that a greater force is required to give a greater velocity.
- The effects produced by an object is depended on the mass and the velocity of the object.

Momentum: The momentum is an another type of quantity which is represented by Neuton.

Momentum is defined by the product of mass and velocity of an object. (P=mv)

Defintion: "Momentum is the product of mass and velocity of an object."

It is denoted by the letter "p". It is a vector quantity. As it has both magnitude and direction. It has same direction as velocity of an object.

S.I unit of momentum is kilogram-meter/second ($kgms^{-1}$)

As we know that the change in velocity is made using applying the unbalanced force on the object, so force can change the momentum of an object.

Two factors which can change the momentum of an object:

(i) Change in mass of an object
(ii) Change in velocity of an object

- the force necessary to change the momentum of an object depends on the time rate at which the momentum is changed.

The second law of motion states, **"the rate of change of momentum of an object is proportional to the applied unbalanced force in the direction of force."**

- The Second law of motion gives a method to measure the force applied on an object.

Mathematically find the force from the second la w of motion:

Suppose an object moves with initial velocity = u ms^{-1}

And its final velocity = v ms^{-1}

And taken time = t

Having mass = m

According to second law of motion we have;

Initial momentum $p_1 = mu$ $kgms^{-1}$

Final momentum $p_2 = mv$ $kgms^{-1}$

$$\text{Change in momentum} \propto p_2 - p_1$$
$$\propto mv - mu$$
$$\propto m(v-u)$$

$$\text{Rate of change in momentum} \propto \frac{m(v-u)}{t}$$
$$\propto \frac{m \times (v-u)}{t}$$
$$\propto ma \qquad \left[\because a = \frac{(v-u)}{t}\right]$$

ma gives force,

$\therefore F = k\,ma\ kgms^{-2}$

The quantity, k is a constant of proportionality.

Uses of the second law of motion in daily life:

(i) A cricket player pulls his hand backward while catching ball:

While catching a fast moving cricket ball, a fielder in the ground gradually pulls his hands backwards with the moving ball. This is why, The fast moving ball has a large amount of momemtum, due to its high velocity. This ball carries greater force, that may cause hand injury. Therefore the fielder pulls his hand backward to increase the time, Due to incerase in time the rate of change in momentum decreases to zero.

(ii) Using a cushioned bed or on a sand bed in high jump:

In a high jump athletic event, the athletes are made to fall either on a cushioned bed or on a sand bed. This is to increase the time of the athlete's fall to stop after making the jump. This decreases the rate of change of momentum and hence the force.

The Third law of motion

(3) The Third law of motion:

The third law of motion states that when one object exerts a force on another object, the second object instantaneously exerts a force back on the first.