

8 Force and Laws of Motion

Fastrack Revision

- **Force:** It is a push or hit or pull on a body. Force cannot be seen, tasted or felt but we can see or feel the effect of a force. It is a vector quantity.

Effects of Force

- A force can change the magnitude of velocity of an object.
- A force can change the direction of motion of an object.
- A force can change the shape or size of objects.

Types of Force: Forces are of two types:

- **Balanced Forces:** These are the forces which do not change the state of rest or motion of an object. Also, the forces are balanced if the resultant of applied forces is equal to zero.
- **Unbalanced Forces:** If the resultant of applied forces is non-zero, the forces are unbalanced. In this case, the object would move in the direction of the greater force. An object in rest can be moved because of applying unbalanced forces.
- **Newton's Laws of Motion:** Newton has given three laws to define the motion of bodies. These laws are called Newton's laws of motion.
- **Newton's First Law of Motion:** An object continues to be in a state of rest or of uniform motion along a straight line unless acted upon by an unbalanced force.
- **Inertia:** The natural tendency of objects to resist a change in their state of rest or of uniform motion is called inertia.

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Inertia is the inherent property of all bodies and Newton's first law of motion is also known as the law of inertia.

Types of Inertia

- **Inertia of Rest:** It is the tendency of a body to oppose any change in its state of rest.
- **Inertia of Motion:** It is the tendency of a body to oppose any change in its state of uniform motion.
- **Inertia of Direction:** It is the tendency of a body to oppose any change in its direction of motion.
- **Mass:** It is a measure of inertia of an object. Its SI unit is **kilogram (kg)**. Inertia increases with increase in mass and decreases with decrease in mass.

- **Friction:** Force of friction always opposes motion of objects. It arises between two surfaces in contact. It acts opposite to the direction of motion.

- **Momentum:** It measures the quantity of motion possessed by a body and is defined as the product of mass and velocity of the body. It is a vector quantity and its SI unit is Newton-second (N-s) or $\text{kg}\cdot\text{m}\cdot\text{s}^{-1}$.

$$\text{Momentum } (p) = \text{mass } (m) \times \text{velocity } (v)$$

$$\text{or } p = mv$$

Its direction is the same as that of velocity v .

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If the body is at rest, its velocity, $v = 0$ and so momentum, $p = 0$.

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

$$\therefore \text{Force} = \frac{\text{Change in momentum}}{\text{Time taken}} = \frac{mv - mu}{t}$$

$$\text{or } F = m \times a \quad \left(\because a = \frac{v - u}{t} \right)$$

Thus, force is also defined as the product of mass and acceleration. Its SI unit is Newton or $\text{kg}\cdot\text{m}\cdot\text{s}^{-2}$ and is represented by the symbol N.

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

- A force of one Newton produces an acceleration of $1 \text{ m}\cdot\text{s}^{-2}$ on an object of mass 1 kg.
- **Newton's Third Law of Motion:** When one object exerts a force on another object, then the second object instantaneously exerts an equal and opposite force on the first object. These forces are known as action and reaction forces which are always equal in magnitude but opposite in direction.

This law can also be stated as to every action, there is an equal and opposite reaction and they act on two different bodies.