Q.3 – 2. State and explain Newton's force laws of motion. Illustrate each law by examples.

Answer :

NEWTON FORCE LAWS OF MOTION

Sir Isaac Newton (1642 – 1727) has given three laws to describe the motion of objects or bodies. These laws are known as Newton's force laws of motion or Newton's laws of motion. These laws express the relationship among force, mass and the motion of an object. They form the basis of mechanics.

NEWTON'S FIRST LAW OF MOTION

(Newton's Law of Inertia)

STATEMENT

This law states that every object continues in its state of rest or uniform motion in a straight line unless it is acted upon by an external force (net force) which changes its state of rest or of uniform motion.

Mathematically , If

$$F = 0 , \quad \text{then } v = \text{constant} \quad a = 0$$

The first law of motion has two parts. The first part of the law is for the bodies at rest while the second part is for the bodies in motion.

First part of Newton's first law of motion :

The first part of the law sates that a body at rest will remain at rest if NO NET FORCE acts on it.

For example a chair or table lying in a room will remain stationary and will not change their states by themselves unless some one moves them by applying a force.

A book lying on a table cannot change its position by itself unless a force is applied to change its position.

Second part of Newton's first law of motion :

The second part of the law sates that a body in motion will continue to move in a straight line with uniform speed if NO NET FORCE acts on it. However our daily observation is against this.

- For example a moving ball comes to rest after some time. Because there exist forces between the moving ball and its environment which oppose the motion of the ball. These are forces of friction between the ball and the ground, gravitation and air resistance.

- If we stop pedaling a bicycle , which is moving at a uniform speed , the bicycle does not go on moving forever , it comes to rest after some time. The moving bicycle gas not been compelled to change its state of uniform motion by the external force of air resistance and friction. It there were no air resistance and no friction to oppose the motion of the bicycle , then according to Newton first law of motion , a moving bicycle would go on moving or ever. It would not stop by itself. This means that object would continue to move in a straight line for ever, with uniform speed if the forces opposing the motion of the object be completely removed.

INERTIA

The property of matter to maintain its state of rest or uniform motion and requiring a net force to change its state is inertia.

Also the resistance to change in velocity is called inertia. Newton's first law is, therefore, often called the law of inertia. The inertia of a body is directly proportional to the mass of the body. If a body has more mass it has more inertia and if a body has a less mass it has less inertia. We say that mass of an object is a measure of its inertia.

Greater the inertia of a body , greater will be the force required to bring a change in its state of rest or of uniform motion.

EXAMPLE

For example a stone has greater inertia than football. If we kick a stone , it will not move because of its high inertia but if we kick a football , it will move a long way. Thus a stone resist a change in its state better than a football. So , a stone has more inertia than football.

From this discussion we conclude that to overcome the inertia and make the boy move from rest , we must apply external force (net force).

EXAMPLES OF NEWTON'S LAW OF INERTIA

The following examples illustrate Newton's law of inertia.

- A fast moving child falls forward when his toe stumbles against a stone.
- When a car suddenly starts moving, a person sitting in it would fall backward.
- When the bus turns a corner sharply , we tend to fall sideways because of our inertia or tendency to continue moving in a straight line.
- A small coin placed on the card over a glass drops in to the glass when the card is flicked.

NEWTON'S SECOND LAW OF MOTION

(Force and Acceleration)

STATEMENT

Whenever a net force (unbalanced force) acts on a body, it produces acceleration in the direction of the net force. The acceleration is directly proportional to the net force and inversely proportional to the mass of the body.

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NEWTON'S THIRD LAW OF MOTION (Reacting forces)

STATEMENT

To every action there is always an equal and opposite reaction.

EXPLANATION

According to Newton's third law of motion : Whenever one exerts a force on another body , the second body exerts an equal and opposite force on the first body. The force exerted by the first body on the second body is called action force and the force exerted by the second body on the first body is called reaction force. Action force and reaction force act on two different bodies , but they act simultaneously.

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$$a \propto F \quad (\text{for constant mass } m)$$

$$a \propto \frac{1}{m} \quad (\text{for a constant force } F)$$

Combining the above proportions, we have

$$a \propto \frac{F}{m}$$

Replacing the proportionality sign by equality sign , we get

$$a = (\text{constant}) \frac{F}{m}$$

$$a = k \frac{F}{m}$$

where (k) is a constant of proportionality. In SI units , (k) has the value one. i.e k = 1

Thus , $$a = (1) \frac{F}{m}$$

$$m\,a = F$$

$$F = m\,a$$

$$\boxed{F = m\,a}$$

This is the mathematical form of Newton's second law of motion. It is the principal equation of dynamics.

EXAMPLES OF NEWTON'S SECOND LAW OF MOTION

- Greater the force applied to a given body, greater acceleration is produced. Doubling the force will produce double the acceleration.
- If the same amount of force is applied to different bodies, it will produce different accelerations. A heavier body will acquire lesser acceleration than a lighter body.

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