

Session 32

Mass: It is the matter contained in a body. The unit of mass is kg.

Weight: It is the force, by which the body is attracted towards the centre of the earth. The unit of weight is same as that of force i.e. N.

Momentum: It is the quantity of motion possessed by a body. It is expressed mathematically as

$$\text{Momentum} = \text{Mass} \times \text{Velocity}$$

The unit of momentum depends upon the units of mass and velocity. In S.I. units, the mass is measured in kg, and velocity in m/s, therefore the unit of momentum will be kg-m/s or N-s.

Force: It is a very important factor in the field of dynamics and may be defined as any cause which produces or tends to produce, stops or tends to stop motion. The unit of force, like that of weight, is N.

Inertia: It is an inherent property of a body, which offers resistance to the change of its state of rest or uniform motion.

Basic Laws of Dynamics

1. Newton's second law of motion
2. D'Alembert's principle
3. Work-energy principle
4. Impulse-momentum principle
5. Law of conservation of momentum
6. Law of conservation of energy

1. Newton's Second Law of Motion

It states that the rate of change of momentum is directly proportional to the impressed force and takes place, in the same direction in which the force acts. This law enables us to measure a force and establishes the fundamental equation of dynamics.

According to Newton's second law of motion,

$$\text{Net force} = \text{mass} \times \text{acceleration}$$

$$F = ma$$

The above law consists of the following two parts:

- A body can possess acceleration only when some force is applied on it. Or in other words, if no force is applied on the body, then there will be no acceleration, and the body will continue to move with the existing uniform velocity.
- The force applied on a body is proportional to the product of the mass of the body and the acceleration produced in it.

Note: This law is very suitable to apply in a numerical problem where the acceleration is either given or asked in the problem.

2. D'Alembert's principle

- This law is an important principle by application of which a dynamic problem is converted into an equivalent static problem by adding an imaginary force to the existing system of real forces. This imaginary force is known as inertia force.
- Once the problem becomes static, all equations of static equilibrium can be used to the body. This state of the body is known as dynamic equilibrium.

According to Newton's second law of motion,

Net force = mass x acceleration

$$F = ma$$

$$F - ma = 0$$

$$F + (-ma) = 0$$

$$F + F_I = 0$$

where $F_I = -ma$ is known as inertia force.

Its magnitude is given by $m.a$

Its direction is given by opposite to acceleration.

It acts at the centre of gravity of the body.

Note: This law is highly appreciated in a numerical problem where the acceleration is either given or asked in the problem.

3. Work-Energy Principle

It states that the work done by a body for any displacement is equal to the change in kinetic energy during that displacement.

Mathematically, Work done = change in kinetic energy

$$F \times s = \frac{1}{2}m(v^2 - u^2)$$

Graphically, the area under the force-displacement diagram for any displacement is equal to the work done during that displacement.

Note: This law is highly appreciated in a numerical problem where the displacement is either given or asked in the problem.

4. Impulse-momentum principle

It states that the impulse produced by a body for any time interval is equal to the change in momentum during that interval.

Mathematically, Impulse = change in momentum

$$F \times t = m(v - u)$$

Graphically, the area under the force-time diagram for any time interval is equal to the impulse produced during that interval.

Note: This law is highly appreciated in a numerical problem where the time interval is either given or asked in the problem.