DYNAMICS

NEWTON’S LAWS OF MOTION

Following are the three laws of motion, which were enunciated by Newton, who is regarded as father of the Science.

1. Newton’s First Law of Motion states, “Everybody continues in its state of rest or of uniform motion, in a straight line, unless it is acted upon by some external force.”

2. Newton’s Second Law of Motion states, “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.”

3. Newton’s Third Law of Motion states, “To every action, there is always an equal and opposite reaction.

D’ALEMBERT’S PRINCIPLE

It states, “If a rigid body is acted upon by a system of forces, this system may be reduced to a single resultant force whose magnitude, direction and the line of action may be found out by the methods of graphic statics.”

We have already discussed, that force acting on a body. $P = ma$ ...(i)

where m = mass of the body, and a = Acceleration of the body. The equation (i) may also be written as : $P - ma = 0$ ...(ii)

It may be noted that equation (i) is the equation of dynamics whereas the equation (ii) is the equation of statics. The equation (ii) is also known as the equation of dynamic equilibrium under the action of the real force P. This principle is known as D' Alembert’s principle.

KINETIC ENERGY

It is the energy, possessed by a body, for doing work by virtue of its mass and velocity of motion. Now consider a body, which has been brought to rest by a uniform retardation due to the applied force.

Let m = Mass of the body u = Initial velocity of the body P = Force applied on the body to bring it to rest, a = Constant retardation, and s = Distance travelled by the body before coming to rest.

Since the body is brought to rest, therefore its final velocity, $v = 0$ and

Work done, $W = \text{Force} \times \text{Distance} = P \times s$ ...(i)

POTENTIAL ENERGY

It is the energy possessed by a body, for doing work, by virtue of its position. e.g.,

1. A body, raised to some height above the ground level, possesses some potential energy, because it can do some work by falling on the earth’s surface.

2. Compressed air also possesses potential energy, because it can do some work in expanding, to the volume it would occupy at atmospheric pressure.

3. A compressed spring also possesses potential energy, because it can do some work in recovering to its original shape.

Now consider a body of mass (m) raised through a height (h) above the datum level.

We know that work done in raising the body = Weight × Distance = $(mg)\,h = mgh$

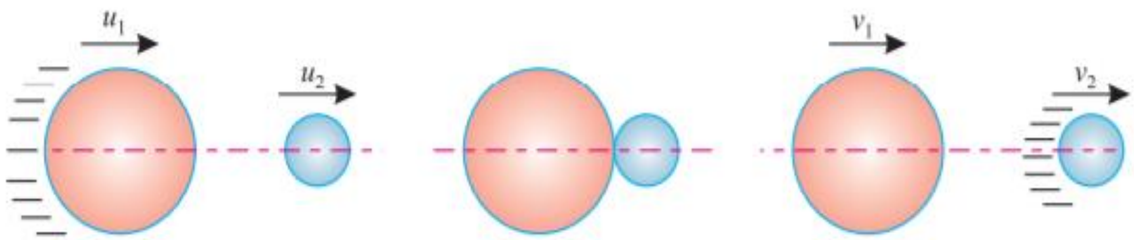
LAW OF CONSERVATION OF ENERGY

It states " The energy can neither be created nor destroyed, though it can be transformed from one form into any of the forms, in which the energy can exist."

Linear momentum

It is the vector quantity and **defined** as the product of the mass of an object, m, and its velocity, v. The letter 'p' is applied to express it and used as **momentum** for short.

27.5. COEFFICIENT OF RESTITUTION



(*a*) Before impact (*b*) During impact (*c*) After impact

Fig. 27.1.

Consider two bodies *A* and *B* having a direct impact as shown in Fig. 27.1 (*a*).

Let u_1 = Initial velocity of the first body,

v_1 = Final velocity of the first body, and

u_2, v_2 = Corresponding values for the second body.

A little consideration will show, that the impact will take place only if u_1 is greater than u_2. Therefore, the velocity of approach will be equal to $(u_1 - u_2)$. After impact, the separation of the two bodies will take place, only if v_2 is greater than v_1. Therefore the velocity of separation will be equal to $(v_2 - v_1)$. Now as per Newton's Law of Collision of Elastic Bodies :

$$\text{Velocity of separation} = e \times \text{Velocity of approach}$$

$$(v_2 - v_1) = e\,(u_1 - u_2)$$

where e is a constant of proportionality, and is called the *coefficient of restitution.* Its value lies between 0 and 1. It may be noted that if $e = 0$, the two bodies are inelastic. But if $e = 1$, the two bodies are perfectly elastic.