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.

EXAMPLES (Numerical problems) OF CHAPTER

Give the solution of the following numerical questions.

EXAMPLE

The velocity-time graph of a car moving on a straight road is shown in Fig. Describe the motion of the car and find the distance covered.

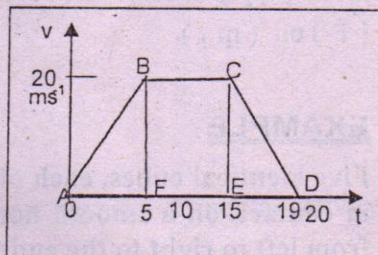

Fig. Velocity time graph of a car.

SOLUTION

(i). The graph tells us that the car starts from rest at A, and its velocity increases uniformly to 20 ms^{-1} in 5 seconds. During this interval of time, its acceleration is constant and is equal to the slope of the line AB. So,

$$a = \frac{\Delta v}{\Delta t} = \frac{20\, ms^{-1}}{5s} = 4\, ms^{-2}$$

(ii) The graph further tells us that the velocity of the car remains constant from 5^{th} to 15^{th} second and the acceleration is zero.

(iii) The velocity of the car decreases uniformly to zero from 15^{th} to 19^{th} seconds. The deceleration during the last 4 seconds is

$$a = \frac{\Delta v}{\Delta t} = \frac{-20\, ms^{-1}}{4s} = -5\, ms^{-2}$$

(iv)The distance covered by the car is equal to the area between the velocity-time graph and the time axis. Thus

The distance covered s = Area Δ ABF + Area of rectangle BCEF + Area ΔCDE

$$= \frac{1}{2} \times 20\, ms^{-1} \times 5\, s + 20\, ms^{-1} \times 10\, s + \frac{1}{2} \times 20\, ms^{-1} \times 4\, s$$

$$= 50\ m + 200\ m + 40\ m = 290\ m$$

EXAMPLE

Five identical cubes, each of mass (m), lie in a straight line, with adjacent faces in contact, on a smooth horizontal surface, Fig. . A constant force F is applied from left to right to the end face of (A).

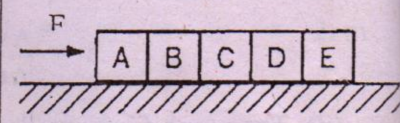

Fig.

(a) What is the acceleration of the system ?

(b) Resultant force on each cube

(c) What force does cube (C) exert on cube (D) ?

SOLUTION

The external force F applied through A is, in fact, applied to the entire system of mass (5m). The acceleration produced in the entire system is given by:

$$F = (5\,m)\,a$$

(a) $\Rightarrow a = \dfrac{F}{5\,m}$

(b) Since the masses move together, each mass has the same acceleration: $a = \dfrac{F}{5\,m}$.

The resultant force on each cube is $F_R = ma = m \times \dfrac{F}{5\,m} = \dfrac{F}{5}$

(c) The combined mass of blocks C and D, $m_{CD} = m + m = 2m$

The acceleration of combined mass of the blocks = $a = \dfrac{F}{5\,m}$

The force exerted by C on D block = $F_{CD} = m_{CD} \times a = 2m \times \dfrac{F}{5m} = \dfrac{2F}{5}$

EXAMPLE

A constant force F changes the velocity of a 80 kg sprinter from 3 m s $^{-1}$ to 4 m s $^{-1}$ in 0.5s. Calculate the acceleration of the sprinter.

SOLUTION

Mass of the sprinter: $m = 80$ kg

Initial velocity, $v_i = 3\ ms^{-1}$

Final velocity, $v_f = 4\ ms^{-1}$

Time elapsed, $\Delta t = 0.5$ s

Aeverage acceleration, $a_{av} = \dfrac{v_f - v_i}{\Delta t} = \dfrac{4-3}{0.5}\ ms^{-2} = 2\ ms^{-2}$