Answer on Question #70915, Physics / Mechanics | Relativity

A resultant force of 50 Newton acts on a mass of 2.5 kg starting from rest. Calculate;

a) the acceleration produced

b) the final velocity

c) the change in momentum

SOLUTION

The second Newton's law states: If a net external force acts on a body, the body accelerates. The direction of acceleration is the same as the direction of the net force. The mass of the body times the acceleration of the body equals the net force vector. In symbols,

$$\sum \vec{F} = m\vec{a}. \text{ (1)}$$

Thus, the acceleration of a body is equal to the net force divided by the body's mass:

$$\vec{a} = \frac{\sum \vec{F}}{m}. \text{ (2)}$$

In our case, the resultant force in absolute value is $\left|\sum \vec{F}\right| = 50\ N$. Therefore

$$|\vec{a}| = \frac{\left|\sum \vec{F}\right|}{m} = \frac{50\ N}{2.5\ kg} = 20\frac{m}{s^2}.$$

The problem of final velocity is something unclear in the current conditions. Due to motion with constant acceleration, which is here, we can express velocity as

$$\vec{v} = \overrightarrow{v_0} + \vec{a}t, \text{ (3)}$$

Where t is time passed from initial moment, v_0 is body's velocity at the moment t=0 (in our case v_0=0 because body was in rest). It simplifies (3) to

$$\vec{v} = \vec{a}t. \text{ (4)}$$

This gives us a result that the final speed may be infinitely big in value although we do not observe it in real life because either accounting relativistic effect or stop applying force. Anyway, after time t the result speed will be $|\vec{v}| = 20\frac{m}{s^2} \cdot t$.

Momentum is a multiplication of mass over velocity. Newton's second law in term of momentum claims:

$$\sum \vec{F} = \frac{d\vec{p}}{dt}. \text{ (5)}$$

In other words, the resultant force acting on a body equals the time rate of change of momentum of the particle. Thus the change in momentum during time t is

$$\Delta p = \left|\sum \vec{F}\right| t = 50\ N \cdot t. \text{ (6)}$$

We can get the same result by multiplying the both parts of equation (4) by m.

ANSWER: (in answers beneath t is the elapsed time since initial moment)

a) $|\vec{a}| = 20\frac{m}{s^2}$.

b) $|\vec{v}| = 20\frac{m}{s^2} \cdot t$.

c) $\Delta p = 50\ N \cdot t$.