M.6.2 Impulse

To change a body's momentum a force must be applied. Usually this force will be in the form of a collision, of fairly short duration and its size may vary. This type of force is called an impulsive force. The average impulsive force is defined as the rate of change of momentum.

i.e. $\quad F_{ave} = \dfrac{p_f - p_i}{\Delta t}$

or $\quad F_{ave} = \dfrac{\Delta p}{\Delta t}$

Impulse $= \Delta$ Momentum

$\quad I = \Delta P$

or $\quad I = F\Delta t \qquad\qquad$ Unit, Newton second (N S)

Example:
When served, a tennis ball leaves the racquet with a speed of 45 ms^{-1}. The impact time between the racquet and the ball is 5 x 10^{-3} s. The mass of the ball is 0.06 Kg. Find the average impulsive force which acts on the ball. The speed of the ball before being hit is zero.
$v_f = 45 \quad v_i = 0 \quad m = 0.06 \quad t = 5 \times 10^{-3}$

$\quad p_f = 0.06 \times 45 = 2.7$

$\quad p_i = 0.06 \times 0 = 0$

$\quad \Delta p = p_f - p_i = 2.7 - 0 = 2.7$

$\quad F_{ave} = \dfrac{\Delta p}{\Delta t}$

$\qquad = \dfrac{2.7}{5 \times 10^{-3}}$

$\qquad = 540 \text{ N}$

M.6.1   *Force-time Graphs*

In real life the force applied is often in the form of a hit and varies in size throughout. In this case we can use a force-time graph to determine the impulse.

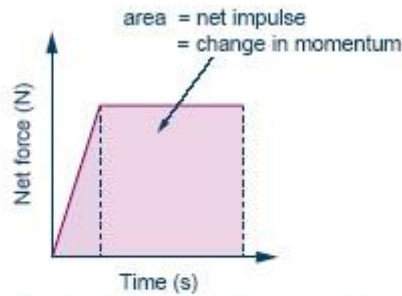Impulse is the area under a force–time graph

Figure 2.4   The area under a force–time graph gives the impulse produced by the force or the momentum change experienced by the object.

Air bags and other collision protection use this force time connection. A small force over a long time can produce the same impulse as a large force acting for a short time.
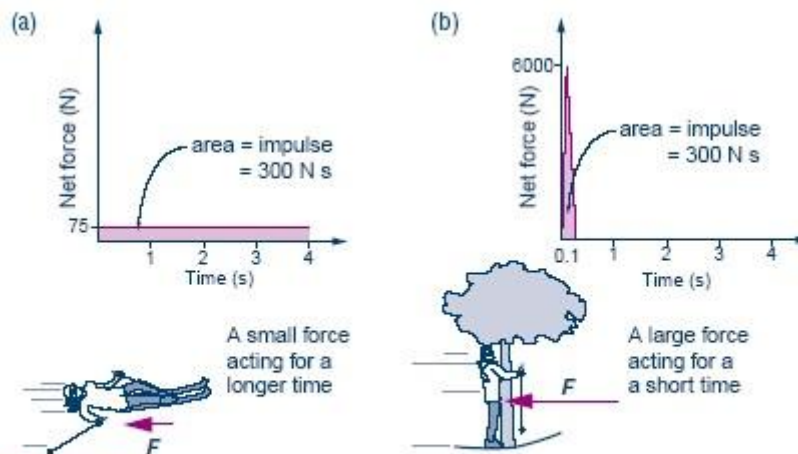

Figure 2.5   These graphs show the force that acts to stop this skier when (a) she slides to rest in the snow and (b) she crashes into a tree. The impulse (and momentum change) that the skier has experienced is the same in both cases.

Air bags increase the time and thus the force we experience in the collision is reduced.

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