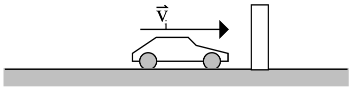
Chapter 4 Problem 15 [†]



Given
$\vec{v}_i = 110\hat{\imath}\ km/h$
$v_f = 0\ km/h$
$\Delta t = 0.14\ s$
$m = 60\ kg$

Solution
Find the average force on the passenger.

From Newton's 2nd law,

$$\Sigma\vec{F} = m\vec{a}$$

During the collision the car as well as the passenger are decelerating. From the change in velocity and the change in time, the average acceleration can be calculated. First convert the velocity into m/s.

$$v_i = \frac{100\ km}{h}\left(\frac{1000\ m}{1\ km}\right)\left(\frac{1\ h}{3600\ s}\right) = 30.6\ m/s$$

Although it is not necessary to use vector notation on this problem, I will use it so you can get used to it. Average acceleration is then,

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t} = \frac{0 - \vec{v}_i}{t} = \frac{-\vec{v}_i}{t}$$

The force provided by the seatbelt is that which provides the deceleration to the 60 kg passenger.

$$\vec{F} = m\vec{a} = m\frac{(-\vec{v}_i)}{t} = -(60\ kg)\frac{30.6\hat{\imath}\ m/s}{0.14\ s} = -13,100\hat{\imath}\ N$$

The force is 13.1 kN in a direction opposite of the initial velocity.

[†]Problem from Essential University Physics, Wolfson