Solutions to demo problems solved in class.. 8, 10, 13, 24.

8. ***Professional Application*** *A car moving at 10.0 m/s crashes into a tree and stops in 0.26 s. Calculate the force the seat belt exerts on a passenger in the car to bring him to a halt. The mass of the passenger is 70.0 kg.*

Solution

$$\text{net } F = \frac{\Delta p}{\Delta t} = \frac{(10\text{ m/s})(70\text{ kg})}{0.26\text{ s}} = \underline{2690\text{ N}}$$

10. ***Professional Application*** *A professional boxer hits his opponent with a 1000-N horizontal blow that lasts for 0.150 s. (a) Calculate the impulse imparted by this blow. (b) What is the opponent's final velocity, if his mass is 105 kg and he is motionless in midair when struck near his center of mass? (c) Calculate the recoil velocity of the opponent's 10.0-kg head if hit in this manner, assuming the head does not initially transfer significant momentum to the boxer's body. (d) Discuss the implications of your answers for parts (b) and (c).*

Solution

(a) $\Delta p = \text{net } F \times \Delta t = 1000\text{ N} \times 0.150\text{ s} = \underline{150\text{ kg.m/s}}$

(b) $\Delta p = m\Delta v \Rightarrow \Delta v = \frac{\Delta p}{m} = v_f - v_i$, so that $v_f = \frac{\Delta p}{m} + v_i = \frac{150\text{ kg.m/s}}{105\text{ kg}} + 0\text{ m/s} = \underline{1.43\text{ m/s}}$

(c) Assuming the mass of the head is 10.0 kg:

$$v_f = \frac{\Delta p}{m} + v_i = \frac{150\text{ kg.m/s}}{10.0\text{ kg}} + 0\text{ m/s} = \underline{15.0\text{ m/s}}$$

(d) The boxer's head recoils much faster than the body, since its mass is smaller. To knock someone out, it is generally much more effective to hit the person in the head than in the torso.

13. ***Professional Application*** *A 75.0-kg person is riding in a car moving at 20.0 m/s when the car runs into a bridge abutment. (a) Calculate the average force on the person if he is stopped by a padded dashboard that compresses an average of 1.00 cm. (b) Calculate the average force on the person if he is stopped by an air bag that compresses an average of 15.0 cm.*

Solution

(a) $\text{net } F = ma$, and $v^2 = v_0^2 + 2a\Delta x$, so $a = \frac{v^2 - v_0^2}{2\Delta x} = \frac{0 - (20.0\text{ m/s})^2}{2(0.0100\text{ m})} = -2.00 \times 10^4\text{ m/s}^2$.

Thus, $\text{net } F = ma = (75.0\text{ kg})(-2.00 \times 10^4\text{ m/s}^2) = \underline{-1.50 \times 10^6\text{ N}}$

$$a = \frac{v^2 - v_0^2}{2\Delta x} = \frac{0 - (20.0\text{ m/s})^2}{2(0.0150\text{ m})} = -1.33 \times 10^3\text{ m/s}^2.\text{ Or}$$

(b) $\text{net } F = (75.0\text{ kg})(-1.33 \times 10^3\text{ m/s}^2) = \underline{-1.00 \times 10^5\text{ N}}$

24. *Suppose a clay model of a koala bear has a mass of 0.200 kg and slides on ice at a speed of 0.750 m/s. It runs into another clay model, which is initially motionless and has a mass of 0.350 kg. Both being soft clay, they naturally stick together. What is their final velocity?*

Solution This is a perfectly inelastic collision, therefore:

$$m_1v_1 + m_2v_2 = (0.200\text{ kg})(0.750\text{ m/s}) + 0 = (0.550\text{ kg})v_{\text{f}} \text{ so } v_{\text{f}} = \underline{0.272\text{ m/s}}$$