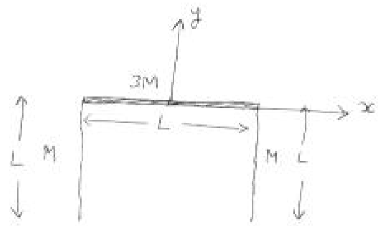
Chapter 9

Pb # 4.



3M (0, 0)

M left $(-\frac{L}{2}, -\frac{L}{2})$

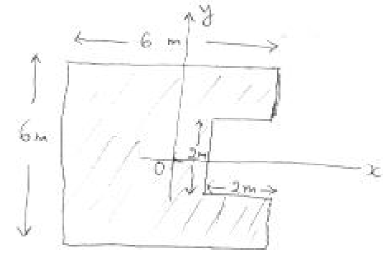
M right $(\frac{L}{2}, \frac{L}{2})$

$$X_{cm} = \frac{0 \times 3M + (-\frac{L}{2} \times M) + (\frac{L}{2} \times M)}{5M} = 0$$

$$Y_{cm} = \frac{0 \times 3M + (-\frac{L}{2} \times M) + (-\frac{L}{2} \times M)}{5M} = -\frac{L}{4}$$

Coordinates of the center of mass are $(0, -\frac{L}{4})$

Pb # 5.



Consider two pieces

① one which is a square of dimensions $6 \times 6\ m^2$ and mass M

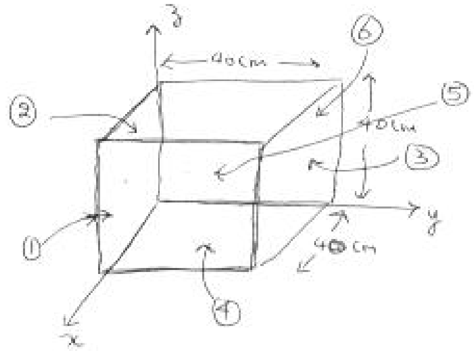
② one which is a square of dimensions $2 \times 2\ m^2$ and mass m.

notice that $\frac{M}{m} = \frac{36}{4} = 9 \Rightarrow M = 9m$

$$\Rightarrow \quad X_{cm} = \frac{0 \times M + 2 \times (-m)}{9m + (-m)} = \frac{-2m}{8m} = -\frac{1}{4} = \boxed{-0.25m}$$

$$Y_{cm} = \frac{0 \times M + 0 \times (-m)}{9m + (-m)} = \boxed{0}$$

Pb#8.



face #1 $M(20, 0, 20)$

#2 removed

#3 $M(20, 40, 20)$

#4 $M(20, 20, 0)$

#5 $M(40, 20, 20)$

#6 $M(0, 20, 20)$

$$x_{cm} = \frac{\cancel{M} \times (20 \times 3 + 40)}{5\cancel{M}} = \frac{40+60}{5} = \frac{100}{5} = 20\,cm$$

$$y_{cm} = \frac{\cancel{M} \times (20 \times 3 + 40)}{5\cancel{M}} = \frac{100}{5} = 20\,cm$$

$$z_{cm} = \frac{\cancel{M} \times (20 \times 4)}{5\cancel{M}} = \frac{80}{5} = 16\,cm$$

Cm $(20, 20, 16)$ cm

Pb#11.

$$v_{cm} = \frac{\sum m_i v_i}{\sum m_i} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2} = \frac{2400 \times 80 + 1600 \times 60}{2400 + 1600}$$

$$= 72\ Km/h$$

Pb#13. $t_1 = 300 \times 10^{-3}\,s$ $\quad y_1 = \frac{1}{2} g t_1^2 = 0.44\,m$

$t_2 = 200 \times 10^{-3}\,s$ $\quad y_2 = \frac{1}{2} g t_2^2 = 0.20\,m$

$$y_{cm} = \frac{\sum m_i y_i}{\sum m_i} = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2} = \boxed{0.28\,m}$$

b) $v_1 = g t_1 = 2.94 m/s$

$v_2 = g t_2 = 1.96 m/s$

$$v_{cm} = \frac{\sum m_i v_i}{\sum m_i} = \boxed{2.29 m/s}$$

Pb# 14.

$m_1 = 1000 Kg \qquad a_1 = 4 m/s^2$

$m_2 = 2000 Kg \qquad v_2 = 8 m/s$

$t = 3 sec \qquad v_1 = a_1 t = 12 m/s$

$x_1 = \frac{1}{2} a_1 t_1^2 = 18 m$

$x_2 = \frac{1}{2} \cancel{a_2 t^2} + vt = 24 m$

$$x_{cm} = \frac{\sum x_i m_i}{\sum m_i} = \frac{x_1 m_1 + x_2 m_2}{m_1 + m_2} = \boxed{22 m}$$

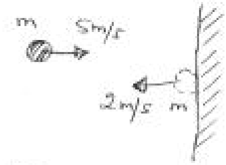
$$V_{cm} = \frac{v_1 m_1 + v_2 m_2}{m_1 + m_2} = \frac{12 \times 1000 + 8 \times 2000}{3000}$$

$$= \boxed{9.3 m/s}$$

$$a_{cm} = \frac{a_1 m_1 + \cancel{a_2 m_2}}{m_1 + m_2} = \frac{4 \times 1000}{3000}$$

$$= \frac{4}{3} = \boxed{1.33 m/s^2}$$

Pb # 22.



$p_i = m_i v_i = 0.7 \times 5$

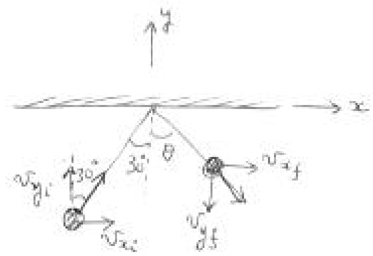
$= 3.5 \ Kg \frac{m}{s}$

$p_f = m_f v_f = 0.7 \times (-2) = -1.4 \ Kg \frac{m}{s}$

$\Delta \vec{p} = \vec{p}_f - \vec{p}_i = -1.4\hat{i} - 3.5\hat{i} = -4.9\hat{i} \ Kg \frac{m}{s}$

$\boxed{|\Delta \vec{p}| = 4.9 \ Kg.\frac{m}{s}}$

Pb # 24.



a) Since $p_{xi} = p_{xf}$

$\Rightarrow m v_i \sin 30° = m v_f \sin\theta$ but $v_i = v_f = 2 \ m/s$

$\Rightarrow \theta = 30°$

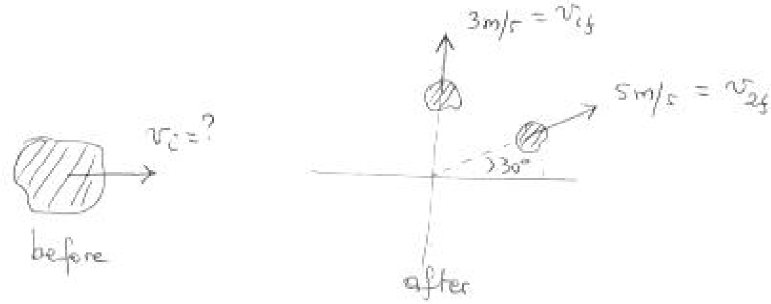
b) $\Delta p_x = m v_{xf} - m v_{xi} = m v \sin 30° - m v \sin 30° = 0$

$\Delta p_y = m v_{yf} - m v_{yi} = -m v \cos 30° - (+m v \cos 30°)$

$= -2 m v \cos 30° = -0.57 \ Kg.\frac{m}{s}$

$\boxed{\Delta \vec{p} = 0\hat{i} - 0.57\hat{j}} \ Kg.\frac{m}{s}$

Pb # 34.



$$\vec{p_i} = \vec{p_f} \Rightarrow P_{x_i} = P_{x_f}$$
$$P_{y_i} = P_{y_f}$$

$$M\, v_{ix} = 0 + m\, v_{2f} \cos 30° \quad \text{— (1)}$$

$$M\, v_{iy} = m v_{1f} + m\, v_{2f} \sin 30° \quad \text{— (2)}$$

$$(1) \Rightarrow \quad 4\, v_{ix} = 2 \times 5 \times \cos 30° \Rightarrow v_{ix} = 2.16 \text{ m/s}$$

$$(2) \Rightarrow \quad 4\, v_{iy} = 2 \times 3 + 2 \times 5 \times \sin 30° \Rightarrow v_{iy} = 2.75 \text{ m/s}$$

velocity $\vec{v_i} = 2.16\,\hat{i} + 2.75\,\hat{j}$ m/s

speed $\Rightarrow$ $\boxed{|\vec{v_i}| = 3.5 \text{ m/s}}$

14P. Figure 10-29 shows an approximate plot of force magnitude versus time during the collision of a 58 g Superball with a wall. The initial velocity of the ball is 34 m/s perpendicular to the wall; it rebounds directly back with approximately the same speed, also perpendicular to the wall. What is F_{max}, the maximum magnitude of the force on the ball from the wall during the collision?

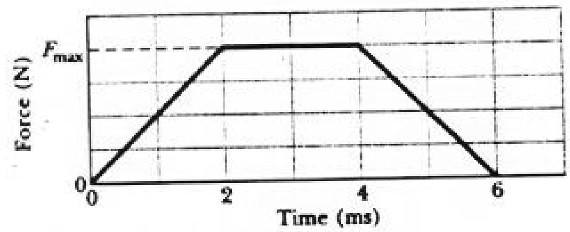
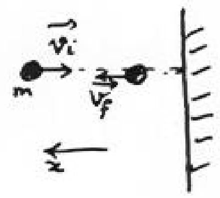


Fig. 10-29 Problem 14.



$$\text{Impulse} = \underbrace{\int \vec{F} \cdot dt}_{\text{area under the curve}} = \Delta \vec{p}$$

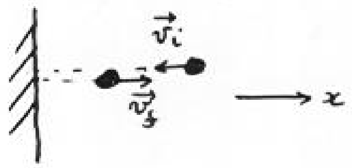
$$\text{Area} = \frac{1}{2}\left(F_{max} \times 2\times10^{-3}\right) + F_{max} \times 2\times10^{-3} + \frac{1}{2}\left(F_{max} \times 2\times10^{-3}\right)$$

$$= 4\,F_{max} \times 10^{-3}$$

$$\Delta p = p_f - p_i = 58\times10^{-3}\left(34 - (-34)\right) = 3944 \times 10^{-3}$$

$$\Rightarrow 4\,F_{max} = 3944 \Rightarrow \boxed{F_{max} = 986\ \text{N}}$$

16P. A ball having a mass of 150 g strikes a wall with a speed of 5.2 m/s and rebounds with only 50% of its initial kinetic energy. (a) What is the speed of the ball immediately after rebounding? (b) What is the magnitude of the impulse on the wall from the ball? (c) If the ball was in contact with the wall for 7.6 ms, what was the magnitude of the average force on the ball from the wall during this time interval?



a) $K_f = \frac{1}{2} K_i$

$v_i = 5.2\ m/s$

$K_i = \frac{1}{2} m v_i^2 = 2.028\ J$

$K_f = 1.014\ J = \frac{1}{2} m v_f^2 \Rightarrow \boxed{v_f = 3.7\ m/s}$

b) $J = \Delta p = p_f - p_i = m(v_f - v_i)$

$= 0.15 \times (3.7 - (-5.2)) = 1.3\ Kg \cdot \frac{m}{s}$

c) $J = \bar{F} \Delta t \Rightarrow \bar{F} = \frac{J}{\Delta t} = \frac{1.3}{7.6 \times 10^{-3}} = \boxed{17[illegible]\ N}$

35E. The blocks in Fig. 10-37 slide without friction. (a) What is the velocity $\vec{v}$ of the 1.6 kg block after the collision? (b) Is the collision elastic? (c) Suppose the initial velocity of the 2.4 kg block is the reverse of what is shown. Can the velocity $\vec{v}$ of the 1.6 kg block after the collision be in the direction shown? ssm

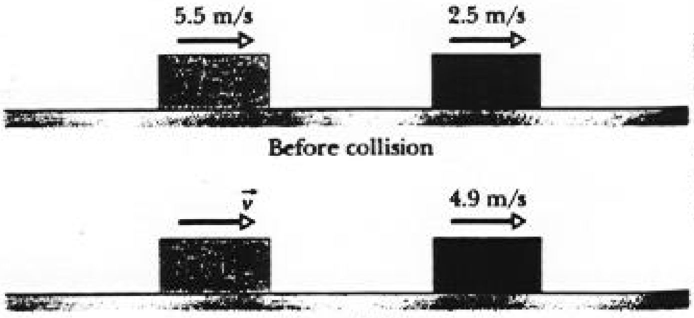


Fig. 10-37 Exercise 35.

a) Conservation of momentum

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

$$v_{1f} = \frac{1.6 \times 5.5 + 2.5 \times 2.4 - 2.4 \times 4.9}{1.6} = \boxed{1.9 \text{ m/s}}$$

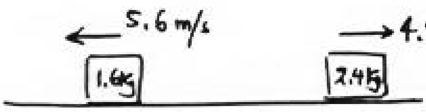
b) $K_i = \frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2 = 31.7 \text{ J}$

$K_f = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2 = 31.7 \text{ J}$

Since $K_i = K_f \Rightarrow$ the collision is <u>elastic</u>.

c) $v_{2i} = -2.5$ m/s

$$v_{1f} = \frac{1.6 \times 5.5 + (2.4)(-2.5) - 2.4 \times 4.9}{1.6} = -5.6 \text{ m/s}$$



after collision

46E. Two 2.0 kg bodies, A and B, collide. The velocities before the collision are $\vec{v}_A = 15\hat{i} + 30\hat{j}$ and $\vec{v}_B = -10\hat{i} + 5.0\hat{j}$. After the collision, $\vec{v}'_A = -5.0\hat{i} + 20\hat{j}$. All speeds are given in meters per second. (a) What is the final velocity of B? (b) How much kinetic energy is gained or lost in the collision?

a) Conservation of momentum (two dimensions)

$$\vec{P}_i = \vec{P}_f$$

$$m_A \vec{v}_{Ai} + m_B \vec{v}_{Bi} = m_A \vec{v}_{Af} + m_B \vec{v}_{Bf}$$

Since $m_A = m_B \Rightarrow \vec{v}_{Bf} = \vec{v}_{Ai} + \vec{v}_{Bi} - \vec{v}_{Af}$

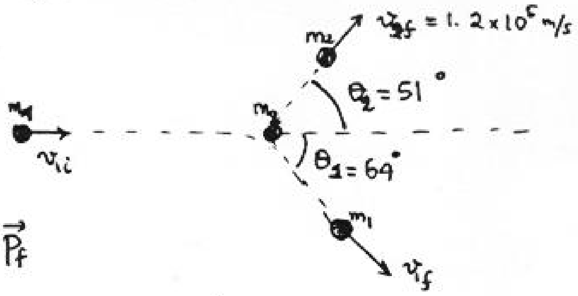
$$\boxed{\vec{v}_{Bf} = 10\hat{i} + 15\hat{j}} \quad m/s$$

b) $K_i = \frac{1}{2} m v_{Ai}^2 + \frac{1}{2} m v_{Bi}^2 = \frac{1}{2}(2)\left[1125 + 125\right] = 1250\,J$

$K_f = \frac{1}{2} m v_{Af}^2 + \frac{1}{2} m v_{Bf}^2 = \frac{1}{2}(2)\left[425 + 325\right] = 750\,J$

$\Delta K = K_f - K_i = \boxed{-500\,J}$ kinetic energy lost

47E. An alpha particle collides with an oxygen nucleus that is initially at rest. The alpha particle is scattered at an angle of 64.0° from its initial direction of motion, and the oxygen nucleus recoils at an angle of 51.0° on the opposite side of that initial direction. The final speed of the nucleus is 1.20×10^5 m/s. Find (a) the final speed and (b) the initial speed of the alpha particle. (In atomic mass units, the mass of an alpha particle is 4.0 u, and the mass of an oxygen nucleus is 16 u.) ILW



a) $\vec{P_i} = \vec{P_f}$

$$P_{xi} = P_{xf} \Rightarrow m_1 v_{1i} = m_1 v_{1f}\cos\theta_1 + m_2 v_{2f}\cos\theta_2 \quad -(1)$$

$$P_{yi} = P_{yf} \Rightarrow 0 = -m_1 v_{1f}\sin\theta_1 + m_2 v_{2f}\sin\theta_2 \quad -(2)$$

$$(2) \Rightarrow v_{1f} = \frac{m_2 v_{2f}\sin\theta_2}{m_1 \sin\theta_1} = \frac{16u \times 1.2\times10^5 \times \sin 51}{4u \times \sin 64} = \boxed{4.2\times10^5 \text{ m/s}}$$

(b)

$$(1) \Rightarrow v_{1i} = \frac{m_1 v_{1f}\cos\theta_1 + m_2 v_{2f}\cos\theta_2}{m_1}$$

$$= \frac{4u \times 4.2\times10^5 \times \cos 64° + 16u \times 1.2\times10^5 \cos 51°}{4u}$$

$$= \boxed{4.86\times10^5 \text{ m/s}}$$