Serway & Vuille
Chapter 6 Homework

1. $p = mv$

a) $p = (1.67 \times 10^{-27} \text{ kg})(5.00 \times 10^{6} \text{ m/s}) = 8.35 \times 10^{-21} \text{ kg}\cdot\text{m/s}$

b) $p = (.015 \text{ kg})(300 \text{ m/s}) = 4.50 \text{ kg}\cdot\text{m/s}$

c) $p = (75.0 \text{ kg})(10.0 \text{ m/s}) = 750 \text{ kg}\cdot\text{m/s}$

d) $p = (5.98 \times 10^{24} \text{ kg})(2.98 \times 10^{4} \text{ m/s}) = 1.78 \times 10^{29} \text{ kg}\cdot\text{m/s}$

4. $m = 0.10 \text{ kg}$ a) maximum height $\Rightarrow v_y = 0 \therefore p = 0$

$V_0 = 15 \text{ m/s}$ b) At midpoint $h = (\frac{1}{2}) h_{max}$

50% KE and 50% PE

$$KE' = \frac{1}{2} m v'^2 = \frac{1}{2}\left[KE_{max}\right] = \frac{1}{2}\left[\frac{1}{2} m v_0^2\right]$$

$$\therefore \quad v'^2 = \frac{1}{2} v_0^2 = \frac{1}{2}(15 \text{ m/s})^2 = 112.5 \text{ m}^2/\text{s}^2$$

$$v' = 10.6 \text{ m/s} \approx 11 \text{ m/s} \quad \Rightarrow p' = mv' = (.10 \text{ kg})(11 \text{ m/s})$$

$$= 1.1 \text{ kg}\cdot\text{m/s up}$$

6. $KE = \frac{1}{2} m v^2$ 1) From 2) $\Rightarrow v = p/m$

$p = mv$ 2) Substitute into equation 1)

$$KE = \frac{1}{2} m \left[\frac{p}{m}\right]^2$$

$$= \frac{1}{2} m \left[\frac{p^2}{m^2}\right]$$

$$= \frac{p^2}{2m}$$

13. $V_0 = 0$ $\quad$ impulse $= \Delta p = m[V_f - V_0] = mV_f$

$V_f = 5.20\ m/s$

$t = 0.832\ s$ $\quad$ I = impulse $= (70.0\ kg)(5.20\ m/s) = 364\ kg \cdot m/s$

$m = 70.0\ kg$ $\quad$ $I = \bar{F}t \quad \therefore \quad \bar{F} = \dfrac{364\ kg \cdot m/s}{0.832\ s} = 438\ N$

15. See graph on p. 184, $m = 1.5\ kg$

a) impulse = area under the curve

$= (2N)(3s) + \frac{1}{2}(2s)(2N) = 8.0\ N \cdot s$

b) $V_0 = 0$ $\quad$ $8.0\ N \cdot s = (1.5\ kg)\, V_f \quad \therefore \quad V_f = 5.3\ m/s$

c) $V_0 = -2.0\ m/s$ $\quad$ $8.0\ N \cdot s = (1.5\ kg)V_f - (1.5\ kg)(-2.0\ m/s)$

$\therefore \quad V_f = 3.3\ m/s$

20. $m = 0.15\ kg$ $\quad$ a) Impulse $= \Delta p = mV_2 - mV_1 = m(V_2 - V_1)$

$V_1 = 20\ m/s$ $\quad$ $I = (.15\ kg)(-22\ m/s - 20\ m/s)$

$V_2 = -22\ m/s$ $\quad$ $= -6.3\ kg \cdot m/s$

towards the pitcher

Choose (+) direction to be from pitcher towards home plate

b) $t = 2.0 \times 10^{-3}\ s$

$\bar{F}\Delta t$ = impulse

$\bar{F}(2.0 \times 10^{-3}\ s) = -6.3\ kg \cdot m/s$

$\therefore \quad \bar{F} = -3.2 \times 10^{3}\ N$

towards the pitcher

24. $W = 730N \quad \therefore \quad m = W/g = 74.5\ Kg$

$X = 5.0m$

$m_b = 1.2\ Kg$

$V_b = 5.0\ m/s$ North

Conservation of $\vec{p}$:

$0 = mv + m_b V_b$

$0 = (74.5kg)v + (1.2kg)(5.0\ m/s)$

$V = -.081\ m/s$

south

$\therefore \quad t = \dfrac{5.0m}{.081\ m/s} = 62s$

22. $W_r = 30N \quad \therefore \quad m_r = 30N / 9.8\ m/s^2 = 3.06\ kg$

$m_b = 5.0g = 5.0 \times 10^{-3}\ kg$

$V_b = 300\ m/s$

a) Conservation of $\vec{p}$:

$0 = m_r V_r + m_b V_b$

$0 = (3.06\ kg) V_r + (5.0 \times 10^{-3}\ kg)(300\ m/s)$

$V_r = -.49\ m/s$

recoils in the opposite direction

b) $W_m = 700N \quad \therefore \quad m_m = 700N / 9.80\ m/s^2 = 71.4\ Kg$

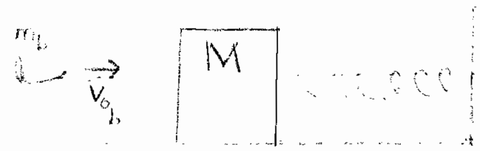
$0 = (m_r + m_m) V_{r+m} + m_b V_b$

$0 = (74.46\ Kg) V_{r+m} + (5.0 \times 10^{-3}\ Kg)(300\ m/s)$

$V_{r+m} = -2.0 \times 10^{-2}\ m/s$

opposite direction

41.



$m_b = 12.0\,g = 1.20 \times 10^{-2}\,kg$

$M = 100\,g = .100\,kg$

$V_{o_{block}} = 0$ and $V_{o_b} = ?$

$K = 150\,N/m$

$x = 80.0\,cm = .800\,m$

frictionless surface ∴ energy is conserved after collision

The final (after collision) $KE_{\text{bullet + block}}$ is converted into PE_{spring}.

$$\frac{1}{2}(m_b + M)V_f^2 = \frac{1}{2}Kx^2 \quad ①$$

$\vec{P}$ is conserved during the collision $P_{before} = P_{after}$

$$m_b V_{o_b} + 0 = (m_b + M)V_f$$

$$\therefore V_f = \frac{m_b V_{ob}}{(m_b + M)} \quad ②$$

substitute ② into ①

$$(m_b + M)\left[\frac{m_b V_{ob}}{(m_b + M)}\right]^2 = Kx^2$$

$$\frac{m_b^2 V_{ob}^2}{(m_b + M)} = Kx^2$$

$$V_{o_b}^2 = \frac{Kx^2(m_b + M)}{m_b^2}$$

$$V_{o_b} = \frac{x}{m_b}\sqrt{K(m_b + M)}$$

$$= \frac{(.800\,m)}{(.0120\,kg)}\sqrt{(150\,N/m)(.1120\,kg)}$$

$$= 273\,m/s$$

43. $m_1 \rightarrow V_{1_i} = 20.0\ \text{cm/s}$ $\quad$ m_2 $\quad V_{2_i} = 0$ $\quad$ Elastic Head-on Collision

$5.00\,g$ $\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad$ $10.0\,g$

a) Find V_{1_f} and V_{2_f}. Use equations 6.10 + 6.11. See the derivation on pages 161 + 162 in your textbook.

$$m_1 V_{1_i} = m_1 V_{1_f} + m_2 V_{2_f} \Rightarrow m_1 V_{1_i} - m_1 V_{1_f} = m_2 V_{2_f} \quad ①$$

$$V_{1_i} = V_{2_f} - V_{1_f} \Rightarrow V_{2_f} = V_{1_i} + V_{1_f} \quad ②$$

Substitute eqn ② into ①:

$$m_1 V_{1_i} - m_1 V_{1_f} = m_2 \left[V_{1_i} + V_{1_f} \right]$$

$$(5.00g)(20.0\ \text{cm/s}) - (5.00g)(V_{1_f}) = (10.0g)(20.0\ \text{cm/s} + V_{1_f})$$

$$\therefore V_{1_f} = -6.67\ \text{cm/s}$$

Sub. into ② $\Rightarrow$

$$V_{2_f} = 13.3\ \text{cm/s}$$

b) $KE_i = \frac{1}{2} m_1 V_{1_i}^2 = (.5)(.00500\ \text{kg})(.200\ \text{m/s})^2$
$= 10^{-4}\ \text{J}$

$KE_{2_f} = \frac{1}{2} m_2 V_{2_f}^2 = (.5)(.0100\ \text{kg})(.133\ \text{m/s})^2 = 8.84 \times 10^{-5}\ \text{J}$

$\therefore$ fraction of energy transferred $= \dfrac{8.84 \times 10^{-5}\ \text{J}}{10^{-4}\ \text{J}}$

$= .884$

49. $m_1 \rightarrow V_1 = 10.0\ \text{m/s}$ $\quad\quad$ $\uparrow V_2 = ?$ $\quad\quad$ $\nearrow V_f$, θ

$2000\ \text{kg}$ $\quad\quad$ $m_2 = 3000\ \text{kg}$ $\quad\quad$ $m_1 + m_2$

before $\quad\quad$ $\theta = 40.0°$

$V_f = 5.$[illegible] m/s

Momentum must be conserved in both the x and y direction.

For the x axis:

$$m_1 V_1 + 0 = (m_1 + m_2) V_{f_x} = (m_1 + m_2) V_f \cos 40.0°$$

You can solve both sides ⇒ shows 20,000 kg m/s is the original x momentum + final x momentum. This is not needed to solve for V_2, but it does prove P_y is conserved.

For the y axis:

$$0 + m_2 V_2 = (m_1 + m_2) V_{f_y} = (m_1 + m_2) V_f \sin 40.0^\circ$$

$$(3000\ \text{kg}) V_2 = (5000\ \text{kg})([illegible]\ \text{m/s})(.643)$$

$$V_2 = 5.59\ \text{m/s}$$

58. $m_1 = .400\ \text{kg}$ $\quad m_2 = [illegible]\ \text{kg}$ $\quad V_{2_i} = 0$

$V_{A_i} = 0$ $\quad$ elastic Head on collision ∴ eqn. will

$h_A = 1.50\ \text{m}$ $\quad$ is valid

since the wire is frictionless, the PE_A of m_1 = KE_B

$$m_1 g h_A = \frac{1}{2} m_1 V_B^2$$

$$\sqrt{(9.8\ \text{m/s}^2)(1.50\ \text{m})(2)} = V_B = 5.42\ \text{m/s} = V_{1_i}$$

Use Conservation of $\vec{p}$ and KE to find the velocity of m_2 after the collision (V_{2_f}):

$$\therefore\ m_1 V_{1_i} = m_1 V_{1_f} + m_2 V_{2_f} \qquad ② \quad V_{1_f} = V_{2_f} - V_{1_i}$$

$$(.400)(5.42) = (.400)\left[V_{2_f} - 5.42\right] + ([illegible]) V_{2_f}$$

$$2.17 = .400 V_{2_f} - [illegible] + [illegible] V_{2_f}$$

$V_{2_f} = 4.3[illegible]\ \text{m/s}$ $\quad$ The KE of bead ② is converted into PE of bead ② ⇒

$$m_2 g h = \frac{1}{2} m_2 V_{2_f}^2$$

$$h = [illegible](4.3[illegible]\ \text{m/s})^2 / 9.8\ \text{m/s}^2 = .960\ \text{m}$$

48. $m_A = m_B = 55.0\,kg$ Two different events, use Conservation of $\vec{p}$ for each

$m_{pack} = 12.0\,kg$

$V_{pack} = 3.00\,m/s$

Twin A throws pack:

$$p_{before} = p_{After}$$

$$0 = m_A V_A + m_p V_p$$

$$V_A = -\frac{m_p V_p}{m_A}$$

$$V_A = -\frac{(12.0\,kg)(3.00\,m/s)}{55.0\,kg}$$

$$= -.655\,m/s$$

opposite direction

Twin B and pack:

$$p_{before} = p_{After}$$

$$m_p V_p = (m_p + m_B)\,V_{p+B}$$

$$(12.0\,kg)(3.00\,m/s) = (67.0\,kg)\,V_{p+B}$$

$$V_{p+B} = .537\,m/s$$