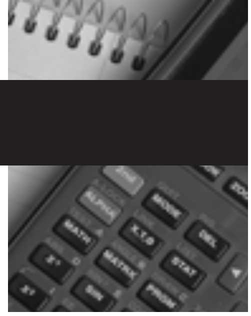

Student Edition Solutions

Momentum and Collisions

I

Momentum and Collisions, Practice A

Givens — *Solutions*

1. $m = 146$ kg

$\mathbf{v} = 17$ m/s south

$\mathbf{p} = m\mathbf{v} = (146 \text{ kg})(17 \text{ m/s south})$

$\mathbf{p} = \boxed{2.5 \times 10^3 \text{ kg•m/s to the south}}$

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2. $m_1 = 21$ kg

$m_2 = 5.9$ kg

$\mathbf{v} = 4.5$ m/s to the northwest

a. $\mathbf{p_{tot}} = m_{tot}\mathbf{v} = (m_1 + m_2)\mathbf{v} = (21 \text{ kg} + 5.9 \text{ kg})(4.5 \text{ m/s})$

$\mathbf{p_{tot}} = (27 \text{ kg})(4.5 \text{ m/s}) = \boxed{1.2 \times 10^2 \text{ kg•m/s to the northwest}}$

b. $\mathbf{p_1} = m_1\mathbf{v} = (21 \text{ kg})(4.5 \text{ m/s}) = \boxed{94 \text{ kg•m/s to the northwest}}$

c. $\mathbf{p_2} = m_2\mathbf{v} = (5.9 \text{ kg})(4.5 \text{ m/s}) = \boxed{27 \text{ kg•m/s to the northwest}}$

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3. $m = 1210$ kg

$\mathbf{p} = 5.6 \times 10^4$ kg•m/s to the east

$$\mathbf{v} = \frac{\mathbf{p}}{m} = \frac{5.6 \times 10^4 \text{ kg•m/s}}{1210 \text{ kg}} = \boxed{46 \text{ m/s to the east}}$$

Momentum and Collisions, Practice B

1. $m = 0.50$ kg

$\mathbf{v_i} = 15$ m/s to the right

$\Delta t = 0.020$ s

$\mathbf{v_f} = 0$ m/s

$$\mathbf{F} = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\Delta t} = \frac{(0.50 \text{ kg})(0 \text{ m/s}) - (0.50 \text{ kg})(15 \text{ m/s})}{0.020 \text{ s}} \text{ to the right}$$

$\mathbf{F} = -3.8 \times 10^2$ N to the right

$\mathbf{F} = \boxed{3.8 \times 10^2 \text{ N to the left}}$

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2. $m = 82$ kg

$\Delta y = -3.0$ m

$\Delta t = 0.55$ s

$\mathbf{v_i} = 0$ m/s

$a = -9.81 \text{ m/s}^2$

$$v_f = \pm\sqrt{2a\Delta y} = \pm\sqrt{(2)(-9.81 \text{ m/s}^2)(-3.0 \text{ m})} = \pm 7.7 \text{ m/s} = -7.7 \text{ m/s}$$

For the time the man is in the water,

$\mathbf{v_i} = 7.7$ m/s downward $= -7.7$ m/s $\quad \mathbf{v_f} = 0$ m/s

$$\mathbf{F} = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\Delta t} = \frac{(82 \text{ kg})(0 \text{ m/s}) - (82 \text{ kg})(-7.7 \text{ m/s})}{0.55 \text{ s}} = 1.1 \times 10^3 \text{ N}$$

$\mathbf{F} = \boxed{1.1 \times 10^3 \text{ N upward}}$

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3. $m = 0.40$ kg

$\mathbf{v_i} = 18$ m/s to the north $= +18$ m/s

$\mathbf{v_f} = 22$ m/s to the south $= -22$ m/s

$\Delta\mathbf{p} = m\mathbf{v_f} - m\mathbf{v_i} = (0.40 \text{ kg})(-22 \text{ m/s}) - (0.40 \text{ kg})(18 \text{ m/s})$

$\Delta\mathbf{p} = -8.8 \text{ kg•m/s} - 7.2 \text{ kg•m/s} = -16.0 \text{ kg•m/s}$

$\Delta\mathbf{p} = \boxed{16 \text{ kg•m/s to the south}}$

Givens	Solutions

Givens — *Solutions*

4. $m = 0.50$ kg

$\mathbf{F_1} = 3.00$ N to the right

$\Delta t_1 = 1.50$ s

$\mathbf{v_{i,1}} = 0$ m/s

$\mathbf{F_2} = 4.00$ N to the left $= -4.00$ N

$\Delta t_2 = 3.00$ s

$\mathbf{v_{i,2}} = 9.0$ m/s to the right

a. $$\mathbf{v_{f,1}} = \frac{\mathbf{F_1}\Delta t_1 + m\mathbf{v_{i,1}}}{m} = \frac{(3.00 \text{ N})(1.50 \text{ s}) + (0.50 \text{ kg})(0 \text{ m/s})}{0.50 \text{ kg}}$$

$$\mathbf{v_{f,1}} = 9.0 \text{ m/s} = \boxed{9.0 \text{ m/s to the right}}$$

b. $$\mathbf{v_{f,2}} = \frac{\mathbf{F_2}\Delta t_2 + m\mathbf{v_{i,2}}}{m} = \frac{(-4.00 \text{ N})(3.00 \text{ s}) + (0.50 \text{ kg})(9.0 \text{ m/s})}{0.50 \text{ kg}}$$

$$\mathbf{v_{f,2}} = \frac{-12.0 \text{ kg}\bullet\text{m/s} + 4.5 \text{ kg}\bullet\text{m/s}}{0.50 \text{ kg}} = \frac{-7.5 \text{ kg}\bullet\text{m/s}}{0.50 \text{ kg}} = -15 \text{ m/s}$$

$$\mathbf{v_{f,2}} = \boxed{15 \text{ m/s to the left}}$$

Momentum and Collisions, Practice C

1. $m = 2240$ kg

$\mathbf{v_i} = 20.0$ m/s to the west, $v_i = -20.0$ m/s

$\mathbf{v_f} = 0$

$\mathbf{F} = 8410$ N to the east, $F = +8410$ N

a. $$\Delta t = \frac{\Delta \mathbf{p}}{\mathbf{F}} = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\mathbf{F}}$$

$$\Delta t = \frac{(2240 \text{ kg})(0) - (2240 \text{ kg})(-20.0 \text{ m/s})}{(8410 \text{ N})} = \frac{44\,800 \text{ kg}\bullet\text{m/s}}{8410 \text{ kg}\bullet\text{m/s}^2}$$

$$\Delta t = \boxed{5.33 \text{ s}}$$

b. $$\Delta x = \tfrac{1}{2}(v_i + v_f)\Delta t$$

$$\Delta x = \tfrac{1}{2}(-20.0 \text{ m/s} - 0)(5.33 \text{ s})$$

$$\Delta x = \boxed{-53.3 \text{ m or } 53.3 \text{ m to the west}}$$

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2. $m = 2500$ kg

$\mathbf{v_i} = 20.0$ m/s to the north $= +20.0$ m/s

$\mathbf{F} = 6250$ N to the south $= -6250$ N

$\Delta t = 2.50$ s

a. $$\mathbf{v_f} = \frac{\mathbf{F}\Delta t + m\mathbf{v_i}}{m} = \frac{(-6250 \text{ N})(2.50 \text{ s}) + (2500 \text{ kg})(20.0 \text{ m/s})}{2500 \text{ kg}}$$

$$\mathbf{v_f} = \frac{(-1.56 \times 10^4 \text{ kg}\bullet\text{m/s}) + (5.0 \times 10^4 \text{ kg}\bullet\text{m/s})}{2500 \text{ kg}} = \frac{3.4 \times 10^4 \text{ kg}\bullet\text{m/s}}{2500 \text{ kg}}$$

$$\mathbf{v_f} = 14 \text{ m/s} = \boxed{14 \text{ m/s to the north}}$$

b. $$\Delta\mathbf{x} = \tfrac{1}{2}(\mathbf{v_i} + \mathbf{v_f})(\Delta t) = \tfrac{1}{2}(20.0 \text{ m/s} + 14 \text{ m/s})(2.50 \text{ s})$$

$$\Delta\mathbf{x} = \tfrac{1}{2}(34 \text{ m/s})(2.50 \text{ s}) = \boxed{42 \text{ m to the north}}$$

$\mathbf{v_f} = 0$ m/s

c. $$\Delta t = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\mathbf{F}} = \frac{(2500 \text{ kg})(0 \text{ m/s}) - (2500 \text{ kg})(20.0 \text{ m/s})}{-6250 \text{ N}} = \boxed{8.0 \text{ s}}$$

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3. $m = 3250$ kg

$\mathbf{v_i} = 20.0$ m/s to the west $= -20.0$ m/s

$\mathbf{v_f} = 0$ m/s

$\Delta t = 5.33$ s

a. $$\mathbf{F} = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\Delta t} = \frac{(3250 \text{ kg})(0 \text{ m/s}) - (3250 \text{ kg})(-20.0 \text{ m/s})}{5.33 \text{ s}}$$

$$\mathbf{F} = 1.22 \times 10^4 \text{ N} = \boxed{1.22 \times 10^4 \text{ N to the east}}$$

b. $$\Delta\mathbf{x} = \tfrac{1}{2}(\mathbf{v_i} + \mathbf{v_f})(\Delta t) = \tfrac{1}{2}(-20.0 \text{ m/s} + 0 \text{ m/s})(5.33 \text{ s}) = -53.3 \text{ m}$$

$$\Delta\mathbf{x} = \boxed{53.3 \text{ m to the west}}$$

Momentum and Collisions, Section 1 Review

Givens | *Solutions*

2. $m_1 = 0.145$ kg

$m_2 = 3.00$ g

$v_2 = 1.50 \times 10^3$ m/s

a. $m_1v_1 = m_2v_2$

$$v_1 = \frac{m_2v_2}{m_1} = \frac{(3.00 \times 10^{-3}\text{ kg})(1.50 \times 10^3\text{ m/s})}{(0.145\text{ kg})} = \boxed{31.0\text{ m/s}}$$

b. $KE_1 = \frac{1}{2}m_1v_1^2 = \frac{1}{2}(0.145\text{ kg})(31.0\text{ m/s})^2 = 69.7\text{ J}$

$KE_2 = \frac{1}{2}m_2v_2^2 = \frac{1}{2}(3.00 \times 10^{-3}\text{ kg})(1.50 \times 10^3\text{ m/s})^2 = 3380\text{ J}$

$\boxed{KE_2 > KE_1}$ The bullet has greater kinetic energy.

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3. $m = 0.42$ kg

$\mathbf{v_i} = 12$ m/s downfield

$\mathbf{v_f} = 18$ m/s downfield

$\Delta t = 0.020$ s

a. $\Delta\mathbf{p} = m\mathbf{v_f} - m\mathbf{v_i} = (0.42\text{ kg})(18\text{ m/s}) - (0.42\text{ kg})(12\text{ m/s})$

$\Delta\mathbf{p} = 7.6\text{ kg}\bullet\text{m/s} - 5.0\text{ kg}\bullet\text{m/s} = \boxed{2.6\text{ kg}\bullet\text{m/s downfield}}$

b. $$\mathbf{F} = \frac{\Delta\mathbf{p}}{\Delta t} = \frac{2.6\text{ kg}\bullet\text{m/s}}{0.020\text{ s}} = \boxed{1.3 \times 10^2\text{ N downfield}}$$

Momentum and Collisions, Practice D

1. $m_1 = 63.0$ kg

$m_2 = 10.0$ kg

$v_{2,i} = 0$ m/s

$v_{2,f} = 12.0$ m/s

$v_{1,i} = 0$ m/s

$$v_{1,f} = \frac{m_1v_{1,i} + m_2v_{2,i} - m_2v_{2,f}}{m_1}$$

$$v_{1,f} = \frac{(63.0\text{ kg})(0\text{ m/s}) + (10.0\text{ kg})(0\text{ m/s}) - (10.0\text{ kg})(12.0\text{ m/s})}{63.0\text{ kg}} = -1.90\text{ m/s}$$

astronaut speed = $\boxed{1.90\text{ m/s}}$

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2. $m_1 = 85.0$ kg

$m_2 = 135.0$ kg

$\mathbf{v_{1,i}} = 4.30$ m/s to the west $= -4.30$ m/s

$\mathbf{v_{2,i}} = 0$ m/s

$$\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2} = \frac{(85.0\text{ kg})(-4.30\text{ m/s}) + (135.0\text{ kg})(0\text{ m/s})}{85.0\text{ kg} + 135.0\text{ kg}}$$

$$\mathbf{v_f} = \frac{(85.0\text{ kg})(-4.30\text{ m/s})}{220.0\text{ kg}} = -1.66\text{ m/s} = \boxed{1.66\text{ m/s to the west}}$$

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3. $m_1 = 0.50$ kg

$v_{1,i} = 12.0$ m/s

$v_{2,i} = 0$ m/s

$m_2 = 0.50$ kg

$v_{1,f} = 0$ m/s

$v_{1,f} = 2.4$ m/s

a. $$v_{2,f} = \frac{m_1v_{1,i} + m_2v_{2,i} - m_1v_{1,f}}{m_2}$$

$m_1 = m_2$

$v_{2,f} = v_{1,i} + v_{2,i} - v_{1,f} = 12.0\text{ m/s} + 0\text{ m/s} - 0\text{ m/s} = \boxed{12.0\text{ m/s}}$

b. $v_{2,f} = v_{1,i} + v_{2,i} - v_{1,f} = 12.0\text{ m/s} + 0\text{ m/s} - 2.4\text{ m/s} = \boxed{9.6\text{ m/s}}$

Givens	Solutions
4. $m_1 = 2.0 \text{ kg} + m_b$ $m_2 = 8.0$ kg $v_{2,i} = 0$ m/s $v_{2,f} = 3.0$ m/s $v_{1,i} = 0$ m/s $v_{1,f} = -0.60$ m/s	$m_i v_{1,i} + m_2 v_{2,i} = m_1 v_{1,f} + m_2 v_{2,f}$ $(2.0 \text{ kg} + m_b)(0 \text{ m/s}) + (8.0 \text{ kg})(0 \text{ m/s}) = (2.0 \text{ kg} + m_b)(-0.60 \text{ m/s}) + (8.0 \text{ kg})(3.0 \text{ m/s})$ $(2.0 \text{ kg} + m_b)(0.60 \text{ m/s}) = (8.0 \text{ kg})(3.0 \text{ m/s})$ $m_b = \frac{24 \text{ kg} \bullet \text{m/s} - 1.2 \text{ kg} \bullet \text{m/s}}{0.60 \text{ m/s}} = \frac{23 \text{ kg} \bullet \text{m/s}}{0.60 \text{ m/s}}$ $m_b = \boxed{38 \text{ kg}}$

I

Momentum and Collisions, Section 2 Review

1. $m_1 = 44$ kg $m_2 = 22$ kg $\mathbf{v_{1,i}} = 0$ m/s $\mathbf{v_{2,i}} = 0$ m/s $\mathbf{v_{1,f}} = 3.5$ m/s backward $= -3.5$ m/s	**a.** $\mathbf{v_{2,f}} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_1\mathbf{v_{1,f}}}{m_2}$ $\mathbf{v_{2,f}} = \frac{(44 \text{ kg})(0 \text{ m/s}) + (22 \text{ kg})(0 \text{ m/s}) - (44 \text{ kg})(-3.5 \text{ m/s})}{22 \text{ kg}} = \boxed{7.0 \text{ m/s forward}}$
$\mathbf{v_{1,i}} = 0$ m/s $\mathbf{v_{2,i}} = 4.6$ m/s to the right $= +4.6$ m/s	**c.** $\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2} = \frac{(44 \text{ kg})(0 \text{ m/s}) + (22 \text{ kg})(4.6 \text{ m/s})}{44 \text{ kg} + 22 \text{ kg}}$ $\mathbf{v_f} = \frac{(22 \text{ kg})(4.6 \text{ m/s})}{66 \text{ kg}} = \boxed{1.5 \text{ m/s to the right}}$
3. $m_1 = 215$ g $v_{1,i} = 55.0$ m/s $v_{2,i} = 0$ m/s $m_2 = 46$ g $v_{1,f} = 42.0$ m/s	$v_{2,f} = \frac{m_1 v_{1,i} + m_2 v_{2,i} - m_1 v_{1,f}}{m_2}$ $v_{2,f} = \frac{(0.215 \text{ kg})(55.0 \text{ m/s}) + (0.046 \text{ kg})(0 \text{ m/s}) - (0.215 \text{ kg})(42.0 \text{ m/s})}{0.046 \text{ kg}}$ $v_{2,f} = \frac{11.8 \text{ kg}\bullet\text{m/s} - 9.03 \text{ kg}\bullet\text{m/s}}{0.046 \text{ kg}} = \frac{2.8 \text{ kg}\bullet\text{m/s}}{0.046 \text{ kg}} = \boxed{61 \text{ m/s}}$

Momentum and Collisions, Practice E

1. $m_1 = 1500$ kg $\mathbf{v_{1,i}} = 15.0$ m/s to the south $= -15.0$ m/s $m_2 = 4500$ kg $\mathbf{v_{2,i}} = 0$ m/s	$\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2} = \frac{(1500 \text{ kg})(-15.0 \text{ m/s}) + (4500 \text{ kg})(0 \text{ m/s})}{1500 \text{ kg} + 4500 \text{ kg}}$ $\mathbf{v_f} = \frac{(1500 \text{ kg})(-15.0 \text{ m/s})}{6.0 \times 10^3 \text{ kg}} = -3.8 \text{ m/s} = \boxed{3.8 \text{ m/s to the south}}$
2. $m_1 = 9.0$ kg $m_2 = 18.0$ kg $v_{2,i} = 0$ m/s $v_{1,i} = 5.5$ m/s	$v_f = \frac{m_1 v_{1,i} + m_2 v_{2,i}}{m_1 + m_2} = \frac{(9.0 \text{ kg})(5.5 \text{ m/s}) + (18.0 \text{ kg})(0 \text{ m/s})}{9.0 \text{ kg} + 18.0 \text{ kg}}$ $v_f = \frac{(9.0 \text{ kg})(5.5 \text{ m/s})}{27.0 \text{ kg}} = \boxed{1.8 \text{ m/s}}$
3. $m_1 = 1.50 \times 10^4$ kg $\mathbf{v_{1,i}} = 7.00$ m/s north $m_2 = m_1 = m$ $\mathbf{v_{2,i}} = 1.50$ m/s north	$\mathbf{v_f} = \frac{(m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}})}{m_1 + m_2} = \frac{m(\mathbf{v_{1,i}} + \mathbf{v_{2,i}})}{2m} = \frac{1}{2}(\mathbf{v_{1,i}} + \mathbf{v_{2,i}})$ $\mathbf{v_f} = \frac{1}{2}(7.00 \text{ m/s north} + 1.50 \text{ m/s north})$ $\mathbf{v_f} = \boxed{4.25 \text{ m/s to the north}}$

Givens	Solutions
4. $m_1 = 22$ kg $m_2 = 9.0$ kg $\mathbf{v_{2,i}} = 0$ m/s $\mathbf{v_f} = 3.0$ m/s to the right	$\mathbf{v_{1,i}} = \frac{(m_1 + m_2)\mathbf{v_f} - m_2\mathbf{v_{2,i}}}{m_1} = \frac{(22\text{ kg} + 9.0\text{ kg})(3.0\text{ m/s}) - (9.0\text{ kg})(0\text{ m/s})}{22\text{ kg}}$ $\mathbf{v_{1,i}} = \frac{(31\text{ kg})(3.0\text{ m/s})}{22\text{ kg}} = \boxed{4.2\text{ m/s to the right}}$
5. $m_1 = 47.4$ kg $v_{1,i} = 4.20$ m/s $v_{2,i} = 0$ m/s $v_f = 3.95$ m/s	**a.** $m_2 = \frac{m_1 v_f - m_1 v_{1,i}}{v_{2,i} - v_f} = \frac{(47.4\text{ kg})(3.95\text{ m/s}) - (47.4\text{ kg})(4.20\text{ m/s})}{0\text{ m/s} - 3.95\text{ m/s}}$ $m_2 = \frac{187\text{ kg•m/s} - 199\text{ kg•m/s}}{-3.95\text{ m/s}} = \frac{-12\text{ kg•m/s}}{-3.95\text{ m/s}} = \boxed{3.0\text{ kg}}$
$v_f = 5.00$ m/s	**b.** $v_{1,i} = \frac{(m_1 + m_2)v_f - m_2 v_{2,i}}{m_1} = \frac{(47.4\text{ kg} + 3.0\text{ kg})(5.00\text{ m/s}) - (3.0\text{ kg})(0\text{ m/s})}{47.4\text{ kg}}$ $v_{1,i} = \frac{(50.4\text{ kg})(5.00\text{ m/s})}{47.4\text{ kg}} = \boxed{5.32\text{ m/s}}$

Momentum and Collisions, Practice F

1. $m_1 = 0.25$ kg $\mathbf{v_{1,i}} = 12$ m/s to the west $= -12$ m/s $m_2 = 6.8$ kg $\mathbf{v_{2,i}} = 0$ m/s	**a.** $\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2} = \frac{(0.25\text{ kg})(-12\text{ m/s}) + (6.8\text{ kg})(0\text{ m/s})}{0.25\text{ kg} + 6.8\text{ kg}}$ $\mathbf{v_f} = \frac{(0.25\text{ kg})(-12\text{ m/s})}{7.0\text{ kg}} = -0.43\text{ m/s} = \boxed{0.43\text{ m/s to the west}}$ **b.** $\Delta KE = KE_f - KE_i$ $KE_i = \frac{1}{2}m_1 v_{1,i}^2 + \frac{1}{2}m_2 v_{2,i}^2 = \frac{1}{2}(0.25\text{ kg})(-12\text{ m/s})^2 + \frac{1}{2}(6.8\text{ kg})(0\text{ m/s})^2$ $KE_i = 18\text{ J} + 0\text{ J} = 18\text{ J}$ $KE_f = \frac{1}{2}(m_1 + m_2)v_f^2 = \frac{1}{2}(0.25\text{ kg} + 6.8\text{ kg})(-0.43\text{ m/s})^2$ $KE_f = \frac{1}{2}(7.0\text{ kg})(-0.43\text{ m/s})^2 = 0.65\text{ J}$ $\Delta KE = KE_f - KE_i = 0.65\text{ J} - 18\text{ J} = -17\text{ J}$ The kinetic energy decreases by $\boxed{17\text{ J}}$.
2. $m_1 = 0.40$ kg $\mathbf{v_{1,i}} = 8.5$ m/s to the south $= -8.5$ m/s $m_2 = 0.15$ kg $\mathbf{v_{2,i}} = 0$ m/s	**a.** $\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2} = \frac{(0.40\text{ kg})(-8.5\text{ m/s}) + (0.15\text{ kg})(0\text{ m/s})}{0.40\text{ kg} + 0.15\text{ kg}}$ $\mathbf{v_f} = \frac{(0.40\text{ kg})(-8.5\text{ m/s})}{0.55\text{ kg}} = -6.2\text{ m/s} = \boxed{6.2\text{ m/s to the south}}$ **b.** $\Delta KE = KE_f - KE_i$ $KE_i = \frac{1}{2}m_1 v_{1,i}^2 + \frac{1}{2}m_2 v_{2,i}^2 = \frac{1}{2}(0.40\text{ kg})(-8.5\text{ m/s})^2 + \frac{1}{2}(0.15\text{ kg})(0\text{ m/s})^2$ $KE_i = 14\text{ J} + 0\text{ J} = 14\text{ J}$ $KE_f = \frac{1}{2}(m_1 + m_2)v_f^2 = \frac{1}{2}(0.40\text{ kg} + 0.15\text{ kg})(-6.2\text{ m/s})^2$ $KE_f = \frac{1}{2}(0.55\text{ kg})(-6.2\text{ m/s})^2 = 11\text{ J}$ $\Delta KE = KE_f - KE_i = 11\text{ J} - 14\text{ J} = -3\text{ J}$ The kinetic energy decreases by $\boxed{3\text{ J}}$.

Givens | *Solutions*

3. $m_1 = 56$ kg

$\mathbf{v_{1,i}}$ = 4.0 m/s to the north = +4.0 m/s

$m_2 = 65$ kg

$\mathbf{v_{2,i}}$ = 12.0 m/s to the south = −12.0 m/s

a. $$\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2} = \frac{(56 \text{ kg})(4.0 \text{ m/s}) + (65 \text{ kg})(-12.0 \text{ m/s})}{56 \text{ kg} + 65 \text{ kg}}$$

$$\mathbf{v_f} = \frac{220 \text{ kg•m/s} - 780 \text{ kg•m/s}}{121 \text{ kg}} = \frac{-560 \text{ kg•m/s}}{121 \text{ kg}} = -4.6 \text{ m/s}$$

$$\mathbf{v_f} = \boxed{\text{4.6 m/s to the south}}$$

b. $\Delta KE = KE_f - KE_i$

$KE_i = \frac{1}{2}m_1v_{1,i}^2 + \frac{1}{2}m_2v_{2,i}^2 = \frac{1}{2}(56 \text{ kg})(4.0 \text{ m/s})^2 + \frac{1}{2}(65 \text{ kg})(-12.0 \text{ m/s})^2$

$KE_i = 450 \text{ J} + 4700 \text{ J} = 5200 \text{ J}$

$KE_f = \frac{1}{2}(m_1 + m_2)v_f^2 = \frac{1}{2}(56 \text{ kg} + 65 \text{ kg})(-4.6 \text{ m/s})^2$

$KE_f = \frac{1}{2}(121 \text{ kg})(-4.6 \text{ m/s})^2 = 1300 \text{ J}$

$\Delta KE = KE_f - KE_i = 1300 \text{ J} - 5200 \text{ J} = -3900 \text{ J}$

The kinetic energy decreases by $\boxed{3.9 \times 10^3 \text{ J}}$.

Momentum and Collisions, Practice G

1. $m_1 = 0.015$ kg

$\mathbf{v_{1,i}}$ = 22.5 cm/s to the right = +22.5 cm/s

$m_2 = 0.015$ kg

$\mathbf{v_{2,i}}$ = 18.0 cm/s to the left = −18.0 cm/s

$\mathbf{v_{1,f}}$ = 18.0 cm/s to the left = −18.0 cm/s

a. $$\mathbf{v_{2,f}} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_1\mathbf{v_{1,f}}}{m_2}$$

$m_1 = m_2$

$\mathbf{v_{2,f}} = \mathbf{v_{1,i}} + \mathbf{v_{2,i}} - \mathbf{v_{1,f}} = 22.5 \text{ cm/s} + (-18.0 \text{ cm/s}) - (-18.0 \text{ cm/s})$

$\mathbf{v_{2,f}} = 22.5 \text{ cm/s} = \boxed{\text{22.5 cm/s to the right}}$

b. $KE_i = \frac{1}{2}m_1v_{1,i}^2 + \frac{1}{2}m_2v_{2,i}^2$

$KE_i = \frac{1}{2}(0.015 \text{ kg})(0.225 \text{ m/s})^2 + \frac{1}{2}(0.015 \text{ kg})(-0.180 \text{ m/s})^2$

$KE_i = 3.8 \times 10^{-4} \text{ J} + 2.4 \times 10^{-4} \text{ J} = \boxed{6.2 \times 10^{-4} \text{ J}}$

$KE_f = \frac{1}{2}m_1v_{1,f}^2 + \frac{1}{2}m_2v_{2,f}^2$

$KE_f = \frac{1}{2}(0.015 \text{ kg})(-0.180 \text{ m/s})^2 + \frac{1}{2}(0.015 \text{ kg})(0.225 \text{ m/s})^2$

$KE_f = 2.4 \times 10^{-4} \text{ J} + 3.8 \times 10^{-4} \text{ J} = \boxed{6.2 \times 10^{-4} \text{ J}}$

---

2. $m_1 = 16.0$ kg

$\mathbf{v_{1,i}}$ = 12.5 m/s to the left, $v_{1,i} = -12.5$ m/s

$m_2 = 14.0$ kg

$\mathbf{v_{2,i}}$ = 16.0 m/s to the right, $v_{2,i} = 16.0$ m/s

$\mathbf{v_{2,f}}$ = 14.4 m/s to the left, $v_{1,f} = -14.4$ m/s

a. $$\mathbf{v_{1,f}} = \frac{(m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_2\mathbf{v_{2,f}})}{m_1}$$

$$v_{1,f} = \frac{(16.0 \text{ kg})(-12.5 \text{ m/s}) + (14.0 \text{ kg})(16.0 \text{ m/s}) - (14.0 \text{ kg})(-14.4 \text{ m/s})}{16.0 \text{ kg}}$$

$$v_{1,f} = \frac{-200 \text{ kg•m/s} + 224 \text{ kg•m/s} + 202 \text{ kg•m/s}}{16.0 \text{ kg}} = 14.1 \text{ m/s}$$

$$v_{1,f} = \boxed{\text{14.1 m/s to the right}}$$

Givens	Solutions

b. $KE_i = \frac{1}{2}m_1v_{1,i}^2 + \frac{1}{2}m_2v_{2,i}^2$

$KE_i = \frac{1}{2}(16.0\ \text{kg})(-12.5\ \text{m/s})^2 + \frac{1}{2}(14.0\ \text{kg})(16.0\ \text{m/s})^2$

$KE_i = 1.25 \times 10^3\ \text{J} + 1.79 \times 10^3\ \text{J} = \boxed{3.04 \times 10^3\ \text{J}}$

$KE_f = \frac{1}{2}m_1v_{1,f}^2 + \frac{1}{2}m_2v_{2,f}^2$

$KE_f = \frac{1}{2}(16.0\ \text{kg})(14.1\ \text{m/s})^2 + \frac{1}{2}(14.0\ \text{kg})(-14.4\ \text{m/s})^2$

$KE_f = 1.59 \times 10^3\ \text{J} + 1.45 \times 10^3\ \text{J} = \boxed{3.04 \times 10^3\ \text{J}}$

---

3. $m_1 = 4.0$ kg

$\mathbf{v_{1,i}} = 8.0$ m/s to the right

$m_2 = 4.0$ kg

$\mathbf{v_{2,i}} = 0$ m/s

$\mathbf{v_{1,f}} = 0$ m/s

a. $\mathbf{v_{2,f}} = \dfrac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_1\mathbf{v_{1,f}}}{m_2}$

$m_1 = m_2$

$\mathbf{v_{2,f}} = \mathbf{v_{1,i}} + \mathbf{v_{2,i}} - \mathbf{v_{1,f}} = 8.0\ \text{m/s} + 0\ \text{m/s} - 0\ \text{m/s}$

$\mathbf{v_{2,f}} = 8.0\ \text{m/s} = \boxed{8.0\ \text{m/s to the right}}$

b. $KE_i = \frac{1}{2}m_1v_{1,i}^2 + \frac{1}{2}m_2v_{2,i}^2$

$KE_i = \frac{1}{2}(4.0\ \text{kg})(8.0\ \text{m/s})^2 + \frac{1}{2}(4.0\ \text{kg})(0\ \text{m/s})^2$

$KE_i = 130\ \text{J} + 0\ \text{J} = \boxed{1.3 \times 10^2\ \text{J}}$

$KE_f = \frac{1}{2}m_1v_{1,f}^2 + \frac{1}{2}m_2v_{2,f}^2$

$KE_f = \frac{1}{2}(4.0\ \text{kg})(0\ \text{m/s})^2 + \frac{1}{2}(4.0\ \text{kg})(8.0\ \text{m/s})^2$

$KE_f = 0\ \text{J} + 130\ \text{J} = \boxed{1.3 \times 10^2\ \text{J}}$

---

4. $m_1 = 25.0$ kg

$\mathbf{v_{1,i}} = 5.00$ m/s to the right

$m_2 = 35.0$ kg

$\mathbf{v_{1,f}} = 1.50$ m/s to the right

$\mathbf{v_{2,f}} = 4.50$ m/s to the right

a. $\mathbf{v_{2,i}} = \dfrac{m_i\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}} - m_1\mathbf{v_{1,i}}}{m_2}$

$\mathbf{v_{2,i}} = \dfrac{(25.0\ \text{kg})(1.50\ \text{m/s}) + (35.0\ \text{kg})(4.50\ \text{m/s}) - (25.0\ \text{kg})(5.00\ \text{m/s})}{35.0\ \text{kg}}$

$\mathbf{v_{2,i}} = \dfrac{37.5\ \text{kg•m/s} + 158\ \text{kg•m/s} - 125\ \text{kg•m/s}}{35.0\ \text{kg}} = \dfrac{7.0 \times 10^1\ \text{kg•m/s}}{35.0\ \text{kg}}$

$\mathbf{v_{2,i}} = 2.0\ \text{m/s} = \boxed{2.0\ \text{m/s to the right}}$

b. $KE_i = \frac{1}{2}m_iv_{1,i}^2 + \frac{1}{2}m_2v_{2,i}^2$

$KE_i = \frac{1}{2}(25.0\ \text{kg})(5.00\ \text{m/s})^2 + \frac{1}{2}(35.0\ \text{kg})(2.0\ \text{m/s})^2$

$KE_i = 312\ \text{J} + 7.0 \times 10^1\ \text{J} = \boxed{382\ \text{J}}$

$KE_f = \frac{1}{2}m_1v_{1,f}^2 + \frac{1}{2}m_2v_{2,f}^2$

$KE_f = \frac{1}{2}(25.0\ \text{kg})(1.50\ \text{m/s})^2 + \frac{1}{2}(35.0\ \text{kg})(4.50\ \text{m/s})^2$

$KE_f = 28.1\ \text{J} + 354\ \text{J} = \boxed{382\ \text{J}}$

Momentum and Collisions, Section 3 Review

Givens | *Solutions*

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2. $m_1 = 95.0$ kg

$\mathbf{v_{1,i}} = 5.0$ m/s to the south, $v_{1,i} = -5.0$ m/s

$m_2 = 90.0$ kg

$\mathbf{v_{2,i}} = 3.0$ m/s to the north, $v_{2,i} = 3.0$ m/s

a. $\mathbf{v_f} = \dfrac{(m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}})}{m_1 + m_2}$

$v_f = \dfrac{(95.0\text{ kg})(-5.0\text{ m/s}) + (90.0\text{ kg})(3.0\text{ m/s})}{95.0\text{ kg} + 90.0\text{ kg}}$

$v_f = \dfrac{-480\text{ kg•m/s} + 270\text{ kg•m/s}}{185\text{ kg}} = \dfrac{-210\text{ kg•m/s}}{185\text{ kg}} = -1.1\text{ m/s}$

$v_f = \boxed{1.1\text{ m/s to the south}}$

b. $\Delta KE = KE_f - KE_i$

$KE_i = \frac{1}{2}m_1 v_{1,i}{}^2 + \frac{1}{2}m_2 v_{2,i}{}^2 = \frac{1}{2}(95.0\text{ kg})(-5.0\text{ m/s})^2 + \frac{1}{2}(90.0\text{ kg})(3.0\text{ m/s})^2$

$KE_i = 1200\text{ J} + 400\text{ J} = 1600\text{ J}$

$KE_f = \frac{1}{2}m_f v_{1,f}{}^2 = \frac{1}{2}(m_1 + m_2)v_{1,f}{}^2 = \frac{1}{2}(95.0\text{ kg} + 90.0\text{ kg})(1.1\text{ m/s})^2$

$KE_f = \frac{1}{2}(185\text{ kg})(1.2\text{ m}^2/\text{s}^2) = 220\text{ J}$

$\Delta KE = KE_f - KE_i = 220\text{ J} - 1600\text{ J} = -1400\text{ J}$

$\boxed{\text{The kinetic energy decreases by } 1.4 \times 10^3\text{ J.}}$

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3. $m_1 = m_2 = 0.40$ kg

$v_{1,i} = 0$ m/s

$v_{2,i} = 3.5$ m/s

$v_{2,f} = 0$ m/s

a. $v_{1,f} = \dfrac{m_1 v_{1,i} + m_2 v_{2,i} - m_2 v_{2,f}}{m_1}$

$m_1 = m_2$

$v_{1,f} = v_{1,i} + v_{2,i} - v_{2,f} = 0\text{ m/s} + 3.5\text{ m/s} - 0\text{ m/s} = \boxed{3.5\text{ m/s}}$

b. $KE_{1,i} = \frac{1}{2}m_1 v_{1,i}{}^2 = \frac{1}{2}(0.40\text{ kg})(0\text{ m/s})^2 = \boxed{0\text{ J}}$

c. $KE_{2,f} = \frac{1}{2}m_2 v_{2,f}{}^2 = \frac{1}{2}(0.40\text{ kg})(0\text{ m/s})^2 = \boxed{0\text{ J}}$

Momentum and Collisions, Chapter Review

11. $m = 1.67 \times 10^{-27}$ kg

$\mathbf{v} = 5.00 \times 10^6$ m/s straight up

a. $\mathbf{p} = m\mathbf{v} = (1.67 \times 10^{-27}\text{ kg})(5.00 \times 10^6\text{ m/s}) = \boxed{8.35 \times 10^{-21}\text{ kg•m/s upward}}$

$m = 15.0$ g

$\mathbf{v} = 325$ m/s to the right

b. $\mathbf{p} = m\mathbf{v} = (15.0 \times 10^{-3}\text{ kg})(325\text{ m/s}) = \boxed{4.88\text{ kg•m/s to the right}}$

$m = 75.0$ kg

$\mathbf{v} = 10.0$ m/s southwest

c. $\mathbf{p} = m\mathbf{v} = (75.0\text{ kg})(10.0\text{ m/s}) = \boxed{7.50 \times 10^2\text{ kg•m/s to the southwest}}$

$m = 5.98 \times 10^{24}$ kg

$\mathbf{v} = 2.98 \times 10^4$ m/s forward

d. $\mathbf{p} = m\mathbf{v} = (5.98 \times 10^{24}\text{ kg})(2.98 \times 10^4\text{ m/s}) = \boxed{1.78 \times 10^{29}\text{ kg•m/s forward}}$

Givens	*Solutions*

12. $m_1 = 2.5$ kg

$\mathbf{v_i} = 8.5$ m/s to the left $= -8.5$ m/s

$\mathbf{v_f} = 7.5$ m/s to the right $= +7.5$ m/s

$\Delta t = 0.25$ s

$$\mathbf{F} = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\Delta t} = \frac{(2.5\text{ kg})(7.5\text{ m/s}) - (2.5\text{ kg})(-8.5\text{ m/s})}{0.25\text{ s}}$$

$$\mathbf{F} = \frac{19\text{ kg•m/s} + 21\text{ kg•m/s}}{0.25\text{ s}} = \frac{4.0 \times 10^1\text{ kg•m/s}}{0.25\text{ s}} = \boxed{160\text{ N to the right}}$$

---

13. $m = 0.55$ kg

$v_i = 0$ m/s

$v_f = 8.0$ m/s

$\Delta t = 0.25$ s

$$F = \frac{mv_f - mv_i}{\Delta t} = \frac{(0.55\text{ kg})(8.0\text{ m/s}) - (0.55\text{ kg})(0\text{ m/s})}{0.25\text{ s}} = \frac{4.4\text{ kg•m/s}}{0.25\text{ s}}$$

$$F = \boxed{18\text{ N}}$$

---

14. $m = 0.15$ kg

$v_i = 26$ m/s

$v_f = 0$ m/s

$F = -390$ N

$$\Delta t = \frac{mv_f - mv_i}{F} = \frac{(0.15\text{ kg})(0\text{ m/s}) - (0.15\text{ kg})(26\text{ m/s})}{-390\text{ N}}$$

$$\Delta t = \frac{-(0.15\text{ kg})(26\text{ m/s})}{-390\text{ N}} = \boxed{0.010\text{ s}}$$

$$\Delta x = \tfrac{1}{2}(v_i + v_f)\Delta t = \tfrac{1}{2}(26.0\text{ m/s} + 0\text{ m/s})(0.010\text{ s}) = \boxed{0.13\text{ m}}$$

---

22. $m_1 = 65.0$ kg

$\mathbf{v_{1,i}} = 2.50$ m/s forward

$m_2 = 0.150$ kg

$\mathbf{v_{2,i}} = 2.50$ m/s forward

$\mathbf{v_{2,f}} = 32.0$ m/s forward

a. $$\mathbf{v_{1,f}} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_2\mathbf{v_{2,f}}}{m_1}$$

$$\mathbf{v_{1,f}} = \frac{(65.0\text{ kg})(2.50\text{ m/s}) + (0.150\text{ kg})(2.50\text{ m/s}) - (0.150\text{ kg})(32.0\text{ m/s})}{65.0\text{ kg}}$$

$$\mathbf{v_{1,f}} = \frac{162\text{ kg•m/s} + 0.375\text{ kg•m/s} - 4.80\text{ kg•m/s}}{65.0\text{ kg}} = \frac{162\text{ kg•m/s} - 4.42\text{ kg•m/s}}{65.0\text{ kg}}$$

$$\mathbf{v_{1,f}} = \frac{158\text{ kg•m/s}}{65.0\text{ kg}} = \boxed{2.43\text{ m/s forward}}$$

$m_1 = 60.0$ kg

$\mathbf{v_{1,i}} = 0$ m/s

$m_2 = 0.150$ kg

$\mathbf{v_{2,i}} = 32.0$ m/s forward

b. $$\mathbf{v_f} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}}}{m_1 + m_2} = \frac{(60.0\text{ kg})(0\text{ m/s}) + (0.150\text{ kg})(32.0\text{ m/s})}{60.0\text{ kg} + 0.150\text{ kg}}$$

$$\mathbf{v_f} = \frac{(0.150\text{ kg})(32.0\text{ m/s})}{60.2\text{ kg}} = \boxed{7.97 \times 10^{-2}\text{ m/s forward}}$$

---

23. $m_1 = 55$ kg

$m_2 = 0.057$ kg

$\mathbf{v_{2,i}} = 0$ m/s

$\mathbf{v_{1,i}} = 0$ m/s

$\mathbf{v_{2,f}} = 36$ m/s to the north

Because the initial momentum is zero,

$$m_1\mathbf{v_{1,f}} = -m_2\mathbf{v_{2,f}}$$

$$\mathbf{v_{1,f}} = \frac{-m_2\mathbf{v_{2,f}}}{m_1} = \frac{-(0.057\text{ kg})(36\text{ m/s})}{55\text{ kg}} = -0.037\text{ m/s}$$

$$\mathbf{v_{1,f}} = \boxed{0.037\text{ m/s to the south}}$$

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Givens	*Solutions*

28. $m_1 = 4.0$ kg

$m_2 = 3.0$ kg

$v_{1,i} = 5.0$ m/s

$v_{2,i} = -4.0$ m/s

$$v_f = \frac{m_1 v_{1,i} + m_2 v_{2,i}}{m_1 + m_2} = \frac{(4.0\text{ kg})(5.0\text{ m/s}) + (3.0\text{ kg})(-4.0\text{ m/s})}{4.0\text{ kg} + 3.0\text{ kg}}$$

$$v_f = \frac{2.0 \times 10^1\text{ kg•m/s} + (-12\text{ kg•m/s})}{7.0\text{ kg}} = \frac{8\text{ kg•m/s}}{7.0\text{ kg}} = \boxed{1\text{ m/s}}$$

29. $m_1 = 1.20$ kg

$v_{1,i} = 5.00$ m/s

$m_2 = 0.800$ kg

$v_{2,i} = 0$ m/s

$$v_f = \frac{m_1 v_{1,i} + m_2 v_{2,i}}{m_1 + m_2} = \frac{(1.20\text{ kg})(5.00\text{ m/s}) + (0.800\text{ kg})(0\text{ m/s})}{1.20\text{ kg} + 0.800\text{ kg}}$$

$$v_f = \frac{(1.20\text{ kg})(5.00\text{ m/s})}{2.00\text{ kg}} = \boxed{3.00\text{ m/s}}$$

30. $m_1 = 2.00 \times 10^4$ kg

$v_{1,i} = 3.00$ m/s

$m_2 = 2m_1$

$v_{2,i} = 1.20$ m/s

a. $$v_f = \frac{m_1 v_{1,i} + m_2 v_{2,i}}{m_1 + m_2} = \frac{(2.00 \times 10^4\text{ kg})(3.00\text{ m/s}) + (2)(2.00 \times 10^4\text{ kg})(1.20\text{ m/s})}{(2.00 \times 10^4\text{ kg}) + (2)(2.00 \times 10^4\text{ kg})}$$

$$v_f = \frac{6.00 \times 10^4\text{ kg•m/s} + 4.80 \times 10^4\text{ kg•m/s}}{6.00 \times 10^4\text{ kg}}$$

$$v_f = \frac{10.80 \times 10^4\text{ kg•m/s}}{6.00 \times 10^4\text{ kg}} = \boxed{1.80\text{ m/s}}$$

b. $\Delta KE = KE_f - KE_i$

$KE_i = \frac{1}{2}m_1 v_{1,i}^2 + \frac{1}{2}m_2 v_{2,i}^2 = \frac{1}{2}(2.00 \times 10^4\text{ kg})(3.00\text{ m/s})^2 + \frac{1}{2}(2)(2.00 \times 10^4\text{ kg})(1.20\text{ m/s})^2$

$KE_i = 9.00 \times 10^4\text{ J} + 2.88 \times 10^4\text{ J} = 11.88 \times 10^4\text{ J}$

$KE_f = \frac{1}{2}(m_1 + m_2)v_f^2 = \frac{1}{2}(2.00 \times 10^4\text{ kg} + 4.00 \times 10^4\text{ kg})(1.80\text{ m/s})^2 = 9.72 \times 10^4\text{ J}$

$\Delta KE = KE_f - KE_i = 9.72 \times 10^4\text{ J} - 11.88 \times 10^4\text{ J} = -2.16 \times 10^4\text{ J}$

The kinetic energy decreases by $\boxed{2.16 \times 10^4\text{ J}}$.

31. $m_1 = 88$ kg

$\mathbf{v_{1,i}} = 5.0$ m/s to the east
$= +5.0$ m/s

$m_2 = 97$ kg

$\mathbf{v_{2,i}} = 3.0$ m/s to the west
$= -3.0$ m/s

a. $$\mathbf{v_f} = \frac{m_1 \mathbf{v_{1,i}} + m_2 \mathbf{v_{2,i}}}{m_1 + m_2} = \frac{(88\text{ kg})(5.0\text{ m/s}) + (97\text{ kg})(-3.0\text{ m/s})}{88\text{ kg} + 97\text{ kg}}$$

$$\mathbf{v_f} = \frac{440\text{ kg•m/s} - 290\text{ kg•m/s}}{185\text{ kg}} = \frac{150\text{ kg•m/s}}{185\text{ kg}} = \boxed{0.81\text{ m/s to the east}}$$

b. $\Delta KE = KE_f - KE_i$

$KE_i = \frac{1}{2}m_1 v_{1,i}^2 + \frac{1}{2}m_2 v_{2,i}^2 = \frac{1}{2}(88\text{ kg})(5.0\text{ m/s})^2 + \frac{1}{2}(97\text{ kg})(-3.0\text{ m/s})^2$

$KE_i = 1100\text{ J} + 440\text{ J} = 1.5 \times 10^3\text{ J}$

$KE_f = \frac{1}{2}(m_1 + m_2)v_f^2 = \frac{1}{2}(88\text{ kg} + 97\text{ kg})(0.81\text{ m/s})^2 = \frac{1}{2}(185\text{ kg})(0.81\text{ m/s})^2 = 61\text{ J}$

$\Delta KE = KE_f - KE_i = 61\text{ J} - 1.5 \times 10^3\text{ J} = -1.4 \times 10^3\text{ J}$

The kinetic energy decreases by $\boxed{1.4 \times 10^3\text{ J}}$.

Givens | *Solutions*

32. $m_1 = 5.0$ g

$\mathbf{v_{1,i}} = 25.0$ cm/s to the right $= +25.0$ cm/s

$m_2 = 15.0$ g

$\mathbf{v_{2,i}} = 0$ m/s

$\mathbf{v_{1,f}} = 12.5$ cm/s to the left $= -12.5$ cm/s

a. $$\mathbf{v_{2,f}} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_1\mathbf{v_{1,f}}}{m_2}$$

$$\mathbf{v_{2,f}} = \frac{(5.0\text{ g})(25.0\text{ cm/s}) + (15.0\text{ g})(0\text{ m/s}) - (5.0\text{ g})(-12.5\text{ cm/s})}{15.0\text{ g}}$$

$$\mathbf{v_{2,f}} = \frac{120\text{ g}\bullet\text{cm/s} + 62\text{ g}\bullet\text{cm/s}}{15.0\text{ g}} = \frac{180\text{ g}\bullet\text{cm/s}}{15.0\text{ g}} = 12\text{ cm/s}$$

$$\mathbf{v_{2,f}} = \boxed{12\text{ cm/s to the right}}$$

b. $$\Delta KE_2 = KE_{2,f} - KE_{2,i} = \tfrac{1}{2}m_2 v_{2,f}^{\,2} - \tfrac{1}{2}m_2 v_{2,i}^{\,2}$$

$$\Delta KE_2 = \tfrac{1}{2}(15.0 \times 10^{-3}\text{ kg})(0.12\text{ m/s})^2 - \tfrac{1}{2}(15.0 \times 10^{-3}\text{ kg})(0\text{ m/s})^2$$

$$\Delta KE_2 = \boxed{1.1 \times 10^{-4}\text{ J}}$$

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33. $v_{1,i} = 4.0$ m/s

$v_{2,i} = 0$ m/s

$m_1 = m_2$

$v_{1,f} = 0$ m/s

$$v_{2,f} = \frac{m_1 v_{1,i} + m_2 v_{2,i} - m_1 v_{1,f}}{m_2}$$

$$m_1 = m_2$$

$$v_{2,f} = v_{1,i} + v_{2,i} - v_{1,f} = 4.0\text{ m/s} + 0\text{ m/s} - 0\text{ m/s} = \boxed{4.0\text{ m/s}}$$

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34. $m_1 = 25.0$ g

$\mathbf{v_{1,i}} = 20.0$ cm/s to the right

$m_2 = 10.0$ g

$\mathbf{v_{2,i}} = 15.0$ cm/s to the right

$\mathbf{v_{2,f}} = 22.1$ cm/s to the right

$$\mathbf{v_{1,f}} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_2\mathbf{v_{2,f}}}{m_1}$$

$$\mathbf{v_{1,f}} = \frac{(25.0\text{ g})(20.0\text{ cm/s}) + (10.0\text{ g})(15.0\text{ cm/s}) - (10.0\text{ g})(22.1\text{ cm/s})}{25.0\text{ g}}$$

$$\mathbf{v_{1,f}} = \frac{5.00 \times 10^2\text{ g}\bullet\text{cm/s} + 1.50 \times 10^2\text{ g}\bullet\text{cm/s} - 2.21 \times 10^2\text{ g}\bullet\text{cm/s}}{25.0\text{ g}}$$

$$\mathbf{v_{1,f}} = \frac{429\text{ g}\bullet\text{cm/s}}{25.0\text{ g}} = \boxed{17.2\text{ cm/s to the right}}$$

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35. $m = 0.147$ kg

$\mathbf{p} = 6.17$ kg•m/s toward second base

$$\mathbf{v} = \frac{\mathbf{p}}{m} = \frac{6.17\text{ kg}\bullet\text{m/s}}{0.147\text{ kg}} = \boxed{42.0\text{ m/s toward second base}}$$

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36. $KE = 150$ J

$p = 30.0$ kg•m/s

$$KE = \tfrac{1}{2}mv^2$$

$$m = \frac{p}{v}$$

$$KE = \frac{1}{2}\left(\frac{p}{v}\right)v^2 = \frac{pv}{2}$$

$$v = \frac{2KE}{p} = \frac{(2)(150\text{ J})}{30.0\text{ kg}\bullet\text{m/s}} = \boxed{1.0 \times 10^1\text{ m/s}}$$

$$m = \frac{p}{v} = \frac{30.0\text{ kg}\bullet\text{m/s}}{1.0 \times 10^1\text{ m/s}} = \boxed{3.0\text{ kg}}$$

Givens	Solutions

37. $m = 0.10$ kg

$\mathbf{v_i} = 15.0$ m/s straight up

$a = -9.81$ m/s^2

a. At its maximum height, $\mathbf{v} = 0$ m/s.

$\mathbf{p} = m\mathbf{v} = (0.10 \text{ kg})(0 \text{ m/s}) = \boxed{0.0 \text{ kg•m/s}}$

b. Halfway to its maximum height (where $v_f = 0$ m/s),

$$\Delta y = \left(\frac{1}{2}\right)\left(\frac{v_f^2 - v_i^2}{2a}\right) = \frac{(0 \text{ m/s})^2 - (15.0 \text{ m/s})^2}{(4)(-9.81 \text{ m/s}^2)} = 5.73 \text{ m}$$

Now let $\mathbf{v_f}$ represent the velocity at $\Delta y = 5.73$ m.

$$v_f = \pm\sqrt{v_i^2 + 2a\Delta x} = \pm\sqrt{(15.0 \text{ m/s})^2 + (2)(-9.81 \text{ m/s}^2)(5.73 \text{ m})}$$

$$v_f = \pm\sqrt{225 \text{ m}^2/\text{s}^2 - 112 \text{ m}^2/\text{s}^2} = \pm\sqrt{113 \text{ m}^2/\text{s}^2} = \pm 10.6 \text{ m/s}$$

$\mathbf{v_f} = 10.6$ m/s upward

$\mathbf{p} = m\mathbf{v_f} = (0.10 \text{ kg})(10.6 \text{ m/s}) = \boxed{1.1 \text{ kg•m/s upward}}$

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38. $m_1 = 3.00$ kg

$v_{2,i} = 0$ m/s

$v_f = \frac{1}{3}v_{1,i}$, or $v_{1,i} = 3v_f$

$$m_1v_{1,i} + m_2v_{2,i} = m_1v_f + m_2v_f$$

$$m_2(v_{2,i} - v_f) = m_1v_f - m_1v_{1,i}$$

$$m_2 = \frac{m_1v_f - m_1v_{1,i}}{v_{2,i} - v_f}, \text{ where } v_{2,i} = 0 \text{ m/s}$$

$$m_2 = \frac{m_1v_f - m_1(3v_f)}{-v_f} = -(m_1 - 3m_1) = -m_1 + 3m_1$$

$$m_2 = 2m_1 = (2)(3.00 \text{ kg}) = \boxed{6.00 \text{ kg}}$$

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39. $m_1 = 5.5$ g

$m_2 = 22.6$ g

$v_{2,i} = 0$ m/s

$\Delta y = -1.5$ m

$\Delta x = 2.5$ m

$a = -9.81$ m/s^2

For an initial downward speed of zero,

$$\Delta y = \tfrac{1}{2}a\Delta t^2$$

$$\Delta t = \sqrt{\frac{2\Delta y}{a}}$$

$$v_f = \frac{\Delta x}{\Delta t} = \frac{\Delta x}{\sqrt{\frac{2\Delta y}{a}}} = \Delta x\sqrt{\frac{a}{2\Delta y}}$$

$$v_f = (2.5 \text{ m})\sqrt{\frac{-9.81 \text{ m/s}^2}{(2)(-1.5 \text{ m})}} = 4.5 \text{ m/s}$$

$$v_{1,i} = \frac{(m_1 + m_2)v_f - m_2v_{2,i}}{m_1}$$

$$v_{1,i} = \frac{(5.5 \text{ g} + 22.6 \text{ g})(1 \text{ kg}/10^3 \text{ g})(4.5 \text{ m/s}) - (22.6 \times 10^{-3} \text{ kg})(0 \text{ m/s})}{5.5 \times 10^{-3} \text{ kg}}$$

$$v_{1,i} = \frac{(28.1 \times 10^{-3} \text{ kg})(4.5 \text{ m/s})}{5.5 \times 10^{-3} \text{ kg}} = \boxed{23 \text{ m/s}}$$

Givens	*Solutions*
40. $m_1 = \frac{730\text{ N}}{9.81\text{m/s}^2}$ $R = 5.0$ m $m_2 = 2.6$ kg $\mathbf{v_{1,i}} = 0$ m/s $\mathbf{v_{2,i}} = 0$ m/s $\mathbf{v_{2,f}} = 5.0$ m/s to the north	Because the initial momentum is zero, $\mathbf{v_{1,f}} = \frac{-m_2\mathbf{v_{2,f}}}{m_1} = \frac{-(2.6\text{ kg})(5.0\text{ m/s})}{\left(\frac{730\text{ N}}{9.81\text{ m/s}^2}\right)} = -0.17\text{ m/s} = 0.17\text{ m/s to the south}$ $\Delta t = \frac{\Delta\mathbf{x}}{\mathbf{v_{1,f}}} = \frac{-R}{v_{1,f}} = \frac{-5.0\text{ m}}{-0.17\text{ m/s}} = \boxed{29\text{ s}}$
41. $m = 0.025$ kg $v_i = 18.0$ m/s $\Delta t = 5.0 \times 10^{-4}$ s $v_f = 10.0$ m/s	$F = \frac{mv_f - mv_i}{\Delta t} = \frac{(0.025\text{ kg})(10.0\text{ m/s}) - (0.025\text{ kg})(18.0\text{ m/s})}{5.0 \times 10^{-4}\text{ s}}$ $F = \frac{0.25\text{ kg•m/s} - 0.45\text{ kg•m/s}}{5.0 \times 10^{-4}\text{ s}} = \frac{-0.20\text{ kg•m/s}}{5.0 \times 10^{-4}\text{ s}} = -4.0 \times 10^2\text{ N}$ magnitude of the force = $\boxed{4.0 \times 10^2\text{ N}}$
42. $m_1 = 1550$ kg $\mathbf{v_{1,i}} = 10.0$ m/s to the south $= -10.0$ m/s $m_2 = 2550$ kg $\mathbf{v_f} = 5.22$ m/s to the north $= +5.22$ m/s	$\mathbf{v_{2,i}} = \frac{(m_1 + m_2)\mathbf{v_f} - m_1\mathbf{v_{1,i}}}{m_2} = \frac{(1550\text{ kg} + 2550\text{ kg})(5.22\text{ m/s}) - (1550\text{ kg})(-10.0\text{ m/s})}{2550\text{ kg}}$ $\mathbf{v_{2,i}} = \frac{(4.10 \times 10^3\text{ kg})(5.22\text{ m/s}) - (1550\text{ kg})(-10.0\text{ m/s})}{2550\text{ kg}}$ $\mathbf{v_{2,i}} = \frac{2.14 \times 10^4\text{ kg•m/s} + 1.55 \times 10^4\text{ kg•m/s}}{2550\text{ kg}} = \frac{3.69 \times 10^4\text{ kg•m/s}}{2550\text{ kg}}$ $\mathbf{v_{2,i}} = 14.5\text{ m/s} = \boxed{14.5\text{ m/s to the north}}$
43. $m_1 = 52.0$ g $m_2 = 153$ g $v_{1,i} = 0$ m/s $v_{2,i} = 0$ m/s $v_{1,f} = 2.00$ m/s $g = 9.81$ m/s^2	Because the initial momentum is zero, $v_{2,f} = \frac{-m_1v_{1,f}}{m_2} = \frac{-(52.0\text{ g})(2.00\text{ m/s})}{153\text{ g}} = -0.680\text{ m/s}$ $KE_i = PE_f$ $\frac{1}{2}mv_{2,f}^2 = mgh$ $h = \frac{v_{2,f}^2}{2g} = \frac{(-0.680\text{ m/s})^2}{(2)(9.81\text{ m/s}^2)} = \boxed{2.36 \times 10^{-2}\text{ m} = 2.36\text{ cm}}$
44. $m_1 = 85.0$ kg $m_2 = 0.500$ kg $\mathbf{v_{1,i}} = 0$ m/s $\mathbf{v_{2,i}} = 0$ m/s $\mathbf{v_{2,f}} = 20.0$ m/s away from ship $= -20.0$ m/s $\Delta x = 30.0$ m	Because the initial momentum is zero, $\mathbf{v_{1,f}} = \frac{-m_2\mathbf{v_{2,f}}}{m_1} = \frac{-(0.500\text{ kg})(-20.0\text{ m/s})}{85.0\text{ kg}} = 0.118\text{ m/s toward the ship}$ $\Delta t = \frac{\Delta x}{v_{1,f}} = \frac{30.0\text{ m}}{0.118\text{ m/s}} = \boxed{254\text{ s}}$

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Givens	Solutions

45. $m_1 = 2250$ kg, $v_{1,i} = 10.0$ m/s, $m_2 = 2750$ kg, $v_{2,i} = 0$ m/s, $d = 2.50$ m, $\theta = 180°$, $g = 9.81$ m/s^2

$$v_f = \frac{m_1 v_{1,i} + m_2 v_{2,i}}{m_1 + m_2} = \frac{(2250\text{ kg})(10.0\text{ m/s}) + (2750\text{ kg})(0\text{ m/s})}{2250\text{ kg} + 2750\text{ kg}}$$

$$v_f = \frac{(2250\text{ kg})(10.0\text{ m/s})}{5.00 \times 10^3\text{ kg}} = 4.50\text{ m/s}$$

From the work-kinetic energy theorem,

$$W_{net} = \Delta KE = KE_f - KE_i = \tfrac{1}{2}(m_1 + m_2)(v_f')^2 - \tfrac{1}{2}(m_1 + m_2)(v_i')^2$$

where

$v_i' = 4.50$ m/s $v_f' = 0$ m/s

$$W_{net} = W_{friction} = F_k d(\cos\theta) = (m_1 + m_2) g \mu_k d(\cos\theta)$$

$$(m_1 + m_2) g \mu_k d(\cos\theta) = \tfrac{1}{2}(m_1 + m_2)[(v_f')^2 - (v_i')^2]$$

$$\mu_k = \frac{(v_f')^2 - (v_i')^2}{2\,gd(\cos\theta)} = \frac{(0\text{ m/s})^2 - (4.50\text{ m/s})^2}{(2)(9.81\text{ m/s}^2)(2.50\text{ m})(\cos 180°)} = \frac{-(4.50\text{ m/s})^2}{-(2)(9.81\text{ m/s}^2)(2.50\text{ m})}$$

$$\mu_k = \boxed{0.413}$$

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46. $\mathbf{F} = 2.5$ N to the right, $m = 1.5$ kg, $\Delta t = 0.50$ s, $\mathbf{v_i} = 0$ m/s

a. $$\mathbf{v_f} = \frac{\mathbf{F}\Delta t + m\mathbf{v_i}}{m} = \frac{(2.5\text{ N})(0.50\text{ s}) + (1.5\text{ kg})(0\text{ m/s})}{1.5\text{ kg}}$$

$\mathbf{v_f} = 0.83$ m/s $\boxed{0.83\text{ m/s to the right}}$

$\mathbf{v_i} = 2.0$ m/s to the left $= -2.0$ m/s

b. $$\mathbf{v_f} = \frac{\mathbf{F}\Delta t + m\mathbf{v_i}}{m} = \frac{(2.5\text{ N})(0.50\text{ s}) + (1.5\text{ kg})(-2.0\text{ m/s})}{1.5\text{ kg}}$$

$$\mathbf{v_f} = \frac{1.2\text{ N}\bullet\text{s} + (-3.0\text{ kg}\bullet\text{m/s})}{1.5\text{ kg}} = \frac{-1.8\text{ kg}\bullet\text{m/s}}{1.5\text{ kg}} = -1.2\text{ m/s}$$

$\mathbf{v_f} = \boxed{1.2\text{ m/s to the left}}$

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47. $m_1 = m_2$, $v_{1,i} = 22$ cm/s, $v_{2,i} = -22$ cm/s

Because $m_1 = m_2$, $v_{2,f} = v_{1,i} + v_{2,i} - v_{1,f}$.

Because kinetic energy is conserved and the two masses are equal,

$$\tfrac{1}{2}v_{1,i}^2 + \tfrac{1}{2}v_{2,i}^2 = \tfrac{1}{2}v_{1,f}^2 + \tfrac{1}{2}v_{2,f}^2$$

$$v_{1,i}^2 + v_{2,i}^2 = v_{1,f}^2 + v_{2,f}^2$$

$$v_{1,i}^2 + v_{2,i}^2 = v_{1,f}^2 + (v_{1,i} + v_{2,i} - v_{1,f})^2$$

$$(22\text{ cm/s})^2 + (-22\text{ cm/s})^2 = v_{1,f}^2 + (22\text{ cm/s} - 22\text{ cm/s} - v_{1,f})^2$$

$$480\text{ cm}^2/\text{s}^2 + 480\text{ cm}^2/\text{s}^2 = 2v_{1,f}^2$$

$$v_{1,f} = \pm\sqrt{480\text{ cm}^2/\text{s}^2} = \pm 22\text{ cm/s}$$

Because m_1 cannot pass through m_2, it follows that $v_{1,f}$ is opposite $v_{1,i}$.

$v_{1,f} = \boxed{-22\text{ cm/s}}$

$$v_{2,f} = v_{1,i} + v_{2,i} - v_{1,f}$$

$v_{2,f} = 22\text{ cm/s} + (-22\text{ cm/s}) - (-22\text{ cm/s}) = \boxed{22\text{ cm/s}}$

Givens	Solutions
48. $m_1 = 7.50$ kg $\Delta y = -3.00$ m $m_2 = 5.98 \times 10^{24}$ kg $v_{1,i} = 0$ m/s $v_{2,i} = 0$ m/s $a = -9.81$ m/s^2	**a.** $v_{1,f} = \pm\sqrt{2a\Delta y} = \pm\sqrt{(2)(-9.81 \text{ m/s}^2)(-3.00 \text{ m})} = \pm 7.67 \text{ m/s} = -7.67 \text{ m/s}$ Because the initial momentum is zero, $m_1 v_{1,f} = -m_2 v_{2,f}$ $v_{2,f} = \frac{-m_1 v_{1,f}}{m_2} = \frac{-(7.50 \text{ kg})(-7.67 \text{ m/s})}{5.98 \times 10^{24} \text{ kg}} = \boxed{9.62 \times 10^{-24} \text{ m/s}}$
49. $m = 55$ kg $\Delta y = -5.0$ m $\Delta t = 0.30$ s $\mathbf{v_i} = 0$ m/s $a = -9.81$ m/s^2 $\mathbf{v_i} = 9.9$ m/s downward $= -9.9$ m/s $\mathbf{v_f} = 0$ m/s	**a.** $v_f = \pm\sqrt{2a\Delta y} = \pm\sqrt{(2)(-9.81 \text{ m/s}^2)(-5.0 \text{ m})} = \pm 9.9 \text{ m/s}$ $\mathbf{v_f} = -9.9 \text{ m/s} = \boxed{9.9 \text{ m/s downward}}$ **b.** $\mathbf{F} = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\Delta t} = \frac{(55 \text{ kg})(0 \text{ m/s}) - (55 \text{ kg})(-9.9 \text{ m/s})}{0.30 \text{ s}}$ $\mathbf{F} = 1.8 \times 10^3 \text{ N} = \boxed{1.8 \times 10^3 \text{ N upward}}$
50. $m_{nuc} = 17.0 \times 10^{-27}$ kg $m_1 = 5.0 \times 10^{-27}$ kg $m_2 = 8.4 \times 10^{-27}$ kg $\mathbf{v_{nuc,i}} = 0$ m/s $\mathbf{v_{1,f}} = 6.0 \times 10^6$ m/s along the positive y-axis $\mathbf{v_{2,f}} = 4.0 \times 10^6$ m/s along the positive x-axis	$m_3 = m_{nuc} - (m_1 + m_2) = (17.0 \times 10^{-27} \text{ kg}) - [(5.0 \times 10^{-27} \text{ kg}) + (8.4 \times 10^{-27} \text{ kg})]$ $m_3 = 3.6 \times 10^{-27}$ kg $p_1 = m_1 v_{1,f} = (5.0 \times 10^{-27} \text{ kg})(6.0 \times 10^6 \text{ m/s}) = 3.0 \times 10^{-20} \text{ kg•m/s}$ $p_2 = m_2 v_{2,f} = (8.4 \times 10^{-27} \text{ kg})(4.0 \times 10^6 \text{ m/s}) = 3.4 \times 10^{-20} \text{ kg•m/s}$ Because the initial momentum is zero, the final momentum must also equal zero. $\mathbf{p_1} + \mathbf{p_2} + \mathbf{p_3} = 0$ kg•m/s $\mathbf{p_3} = -(\mathbf{p_1} + \mathbf{p_2})$ Because $\mathbf{p_1}$ and $\mathbf{p_2}$ are along the y-axis and the x-axis, respectively, the magnitude of $\mathbf{p_3}$ can be found by using the Pythagorean theorem. $p_3 = \sqrt{{p_1}^2 + {p_2}^2} = \sqrt{(3.0 \times 10^{-20} \text{ kg•m/s})^2 + (3.4 \times 10^{-20} \text{ kg•m/s})^2}$ $p_3 = \sqrt{(9.0 \times 10^{-40} \text{ kg}^2\text{•m}^2/\text{s}^2) + (1.2 \times 10^{-39} \text{ kg}^2\text{•m}^2/\text{s}^2)}$ $p_3 = \sqrt{(21 \times 10^{-40} \text{ kg}^2\text{•m}^2/\text{s}^2)} = 4.6 \times 10^{-20} \text{ kg•m/s}$ $v_{3,f} = \frac{p_3}{m_3} = \frac{4.6 \times 10^{-20} \text{ kg•m/s}}{3.6 \times 10^{-27} \text{ kg}} = \boxed{1.3 \times 10^7 \text{ m/s}}$ Because $\mathbf{p_{1,2}}$ is between the positive x-axis and the positive y-axis and because $\mathbf{p_3} = -\mathbf{p_{1,2}}$, $\mathbf{p_3}$ must be between the negative x-axis and the negative y-axis. $\tan\theta = \frac{p_1}{p_2}$ $\theta = \tan^{-1}\left(\frac{p_1}{p_2}\right) = \tan^{-1}\left(\frac{3.0}{3.4}\right) = \boxed{41° \text{ below the negative } x\text{-axis}}$

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Momentum and Collisions, Standardized Test Prep

Givens	Solutions
3. $m = 0.148$ kg $\mathbf{v} = 35$ m/s toward home plate	$\mathbf{p} = m\mathbf{v} = (0.148 \text{ kg})(35 \text{ m/s}) = \boxed{5.2 \text{ kg•m/s toward home plate}}$
4. $m_1 = 1.5$ kg $\mathbf{v_{1,i}} = 3.0$ m/s to the right $m_2 = 1.5$ kg $\mathbf{v_{2,i}} = 0$ m/s $\mathbf{v_{1,f}} = 0.5$ m/s to the right	**a.** $\mathbf{v_{2,f}} = \dfrac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_1\mathbf{v_{1,f}}}{m_2}$ $m_1 = m_2$ $\mathbf{v_{2,f}} = \mathbf{v_{1,i}} + \mathbf{v_{2,i}} - \mathbf{v_{1,f}}$ $\mathbf{v_{2,f}} = 3.0 \text{ m/s} + 0 \text{ m/s} - 0.5 \text{ m/s} = \boxed{2.5 \text{ m/s to the right}}$
5. $\mathbf{v_{1,f}} = 0$ m/s	$\mathbf{v_{2,f}} = \mathbf{v_{1,i}} + \mathbf{v_{2,i}} - \mathbf{v_{1,f}} = 3.0 \text{ m/s} + 0 \text{ m/s} - 0 \text{ m/s} = \boxed{3.0 \text{ m/s to the right}}$
8. $m_1 = m_2$ $\mathbf{v_{1,i}} = 0$ m/s $\mathbf{v_{2,i}} = 5.00$ m/s to the right $\mathbf{v_{2,f}} = 0$ m/s	$\mathbf{v_{1,f}} = \dfrac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_2\mathbf{v_{2,f}}}{m_1}$ $m_1 = m_2$ $\mathbf{v_{1,f}} = \mathbf{v_{1,i}} + \mathbf{v_{2,i}} - \mathbf{v_{2,f}} = 0 \text{ m/s} + 5.00 \text{ m/s} - 0 \text{ m/s}$ $\mathbf{v_{1,f}} = \boxed{5.00 \text{ m/s to the right}}$
9. $m_1 = 0.400$ kg $\mathbf{v_{1,i}} = 3.50$ cm/s right, $v_{1,i} = 3.50$ cm/s $m_2 = 0.600$ kg $\mathbf{v_{2,i}} = 0$ $\mathbf{v_{1,f}} = 0.07$ cm/s left, $v_{1,f} = -0.70$ cm/s	$\mathbf{v_{2,f}} = \dfrac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_1\mathbf{v_{1,f}}}{m_2}$ $v_{2,f} = \dfrac{(0.400 \text{ kg})(3.50 \text{ cm/s}) + (0.600 \text{ kg})(0) - (0.400 \text{ kg})(-0.70 \text{ cm/s})}{0.600 \text{ kg}}$ $v_{2,f} = \dfrac{1.40 \text{ kg•cm/s} + 0.28 \text{ kg•cm/s}}{0.600 \text{ kg}} = \dfrac{1.68 \text{ kg•cm/s}}{0.600 \text{ kg}} = 2.80 \text{ cm/s}$ $\mathbf{v_{2,f}} = \boxed{2.80 \text{ cm/s to the right}}$
10. $m_1 = 0.400$ kg $v_{1,f} = -0.70 \times 10^{-2}$ m/s $m_2 = 0.600$ kg $v_{2,f} = 2.80 \times 10^{-2}$ m/s	$KE_f = \frac{1}{2}m_1 v_{1,f}{}^2 + \frac{1}{2}m_2 v_{2,f}{}^2$ $KE_f = \frac{1}{2}(0.400 \text{ kg})(-0.70 \times 10^{-2} \text{ m/s})^2 + \frac{1}{2}(0.600 \text{ kg})(2.80 \times 10^{-2} \text{ m/s})^2$ $KE_f = 9.8 \times 10^{-6} \text{ kg•m}^2\text{/s}^2 + 2.35 \times 10^{-4} \text{ kg•m}^2\text{/s}^2$ $KE_f = \boxed{2.45 \times 10^{-4} \text{ J}}$
13. $m_1 = 8.0$ g $m_2 = 2.5$ kg $v_{2,i} = 0$ m/s $h = 6.0$ cm $g = 9.81$ m/s^2	$KE_i = PE_f$ $\frac{1}{2}mv_f{}^2 = mgh$ $v_f = \sqrt{2gh} = \sqrt{(2)(9.81 \text{ m/s}^2)(0.060 \text{ m})} = 1.1 \text{ m/s}$ $v_{1,i} = \dfrac{(m_1 + m_2)v_f - m_2 v_{2,i}}{m_1} = \dfrac{(0.0080 \text{ kg} + 2.5 \text{ kg})(1.1 \text{ m/s}) - (2.5 \text{ kg})(0 \text{ m/s})}{0.0080 \text{ kg}}$ $v_{1,i} = \dfrac{(2.5 \text{ kg})(1.1 \text{ m/s})}{0.0080 \text{ kg}} = \boxed{340 \text{ m/s}}$

Givens	*Solutions*
14. $m_1 = 8.0\ \text{g} = 0.0080\ \text{kg}$	$KE_{lowest} = KE_i = PE_f = mgh$
$m_2 = 2.5\ \text{kg}$	$KE_{lowest} = (m_1 + m_2)gh$
$g = 9.81\ \text{m/s}^2$	$KE_{lowest} = (0.0080\ \text{kg} + 2.5\ \text{kg})(9.81\ \text{m/s}^2)(0.060\text{m})$
$h = 6.0\ \text{cm} = 0.060\ \text{m}$	$KE_{lowest} = \boxed{1.5\ \text{J}}$

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