Answers, Even-Numbered Problems, Chapter 8

8.4

he horizontal component of the initial momentum is $83.9\ \mathrm{kg\cdot m/s}$.

The vertical component of the initial momentum is $70.4\ \mathrm{kg\cdot m/s}$

8.6

(a) $P_x = -3.50\times 10^4\ \mathrm{kg\cdot m/s}$ $P_y = 3.45\times 10^4\ \mathrm{kg\cdot m/s}$

(b) $4.91\times 10^4\ \mathrm{kg\cdot m/s}$. $\theta = 45.4°$. ($45.4°$ west of north.)

8.8

(a) Both the change in momentum and the impulse have magnitude $14.5\ \mathrm{kg\cdot m/s}$.
(b) $7250\ \mathrm{N}$.

8.10

(a) $1.04\times 10^5\ \mathrm{N\cdot s}$.
(b) $\Delta p_y = J_y = 1.04\times 10^5\ \mathrm{kg\cdot m/s}$.
(c) $\Delta p_y = m\Delta v_y$. $1.09\ \mathrm{m/s}$.
(d) The initial velocity of the shuttle isn't known. The change in kinetic energy is $\Delta K = K_2 - K_1 = \frac{1}{2}m(v_2^2 - v_1^2)$. It depends on the initial and final speeds and isn't determined solely by the change in speed.
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8.12

(a) $J_x = -15.4\ \mathrm{kg\cdot m/s}$. $J_y = 4.71\ \mathrm{kg\cdot m/s}$
The horizontal component is $15.4\ \mathrm{kg\cdot m/s}$, to the left and the vertical component is $4.71\ \mathrm{kg\cdot m/s}$, upward.
(b) $F_{\text{av-}x} = -8800\ \mathrm{N}$. $F_{\text{av-}y} = 2690\ \mathrm{N}$.
The horizontal component is 8800 N, to the left, and the vertical component is 2690 N, upward.

8.14

0.105 m/s opposite to the direction in which she throws the tool.

8.16

(a) $0.0568\ \mathrm{m/s}$.
(b) $0.103\ \mathrm{m/s}$.

8.18

(a) $0.409\ \mathrm{m/s}$.After the collision the lighter car is moving to the right with a speed of 0.409 m/s.

(b). $-2670\ \text{J}$.

8.20

(a) $-3.60\ \text{m/s}$

(b) $8.64\ \text{J}$

8.22

(a). $v_B = \left(\frac{m_A}{m_B}\right) v_A$.

(b) $\frac{K_A}{K_B} = \frac{m_B}{m_A}$.

8.24

$2.11\ \text{m/s}$

8.26

81.8 kg

8.28

(a) $v_{Af} = 29.3\ \text{m/sec}$**,** v_{Bf}=20.7 m/s.

(b). $\frac{\Delta K}{K_1} = -0.196$.

19.6% of the original kinetic energy is dissipated during the collision.

8.30

(a).. $-0.226\ \text{m/s}$.

(b) 197 J of mechanical energy is dissipated.

8.32

(a). $6.44\ \text{m/s}$, eastward.

(b) 2.50 m/s.

(c) part (a): $-2.81 \times 10^5\ \text{J}$

part (b): $-1.38 \times 10^5\ \text{J}$. The change in kinetic energy has the greater magnitude in part (a).

8.34

$-0.167\ \text{m/s}$. (The two skaters move to the left at 0.167 m/s.)

8.36

(a) $48°$.

8.38 $229\ \text{m/s}$

8.40

(a) $2.26\ \text{m/s}$.

(b) $\Delta K = -639\ \text{J}$.

8.42

The 0.150 kg glider (*A*) is moving to the left at 3.20 m/s and the 0.300 kg glider (*B*) is moving to the left at 0.20 m/s.

8.46

(a) $9.00m$.

(b) Eq. 8.25: $3.00 \times 10^{6}\ \text{m/s}$.

8.48 $7.42 \times 10^{8}\ \text{m}$

The sun's radius is $6.96 \times 10^{8}\ \text{m}$ so the center of mass lies just outside the sun.

8.50

(a) $24.0\ \text{m}$.

The center of mass is between the two cars, 24.0 m to the right of the station wagon and 16.0 m behind the lead car.

(b) $5.04 \times 10^{4}\ \text{kg} \cdot \text{m/s}$.

(c) $16.8\ \text{m/s}$.

(d) same as in part (b).

8.52. **(a)** $m_1 = 0.30\ \text{kg}$.

(b) $\left(2.0\ \text{kg} \cdot \text{m/s}\right)\hat{\text{i}}$.

(c) $\left(6.7\ \text{m/s}\right)\hat{\text{i}}$.

8.54 **(a)** $m_1 + m_2 = 1.25\ \text{kg}$ and $m_1 = 0.75\ \text{kg}$.

(b) $\vec{\text{a}}_{\text{cm}} = \dfrac{d\vec{\text{v}}_{\text{cm}}}{dt} = \left(1.5\ \text{m/s}^3\right)t\hat{\text{i}}$. where *t* is the time.

(c) $\left(5.6\ \text{N}\right)\hat{\text{i}}$.

8.56

(a) $80.0\ \text{N}$.

(b) The absence of atmosphere would not prevent the rocket from operating. The rocket could be steered by ejecting the gas in a direction with a component perpendicular to the rocket's velocity and braked by ejecting it in a direction parallel (as opposed to antiparallel) to the rocket's velocity.

8.58

in 1 s the rocket must eject 75.0 kg of gas.

8.60

(a) $F_{\text{av}} \,/\, F_{\text{max}} = 0.442$.

(b) 800 m/s.

(c) 530 m/s.

8.62

(a) 7.2×10^{-66}.

(b) 0.223.

8.64

The other fragment lands 91.3 m directly south of the point of explosion.

8.66 15.

8.68

One puck moves in a direction 60° north of east and the other puck moves in a direction 60° south of east.

8.70

(a) The final velocity of the car is $5.00 \text{ m/s},$ east (unchanged).

(b) The final velocity of the car is $5.71 \text{ m/s},$ east.

(c) The final velocity of the car is $3.78 \text{ m/s},$ east.

8.72

(a) $\dfrac{K_{\text{N}}}{K_{\text{P}}} = 1.68$.

(b) The Packard has the greater magnitude of momentum and $\dfrac{p_{\text{N}}}{p_{\text{P}}} = 0.933$.

(c) $\dfrac{F_{\text{N}}}{F_{\text{P}}} = \dfrac{p_{\text{N}}}{p_{\text{P}}} = 0.933$.

(d) $\dfrac{F_{\text{N}}}{F_{\text{P}}} = \dfrac{K_{\text{N}}}{K_{\text{P}}} = 1.68$.

8.74 $0.232 \text{ m}.$

EVALUATE: The collision is inelastic and mechanical energy is lost. Thus the decrease in gravitational potential

8.76

(a) 25.8 m/s. at $\theta = 35.5^\circ$

(b). $\Delta K = -147 \text{ J}$. the collision is *not* elastic.

8.78

$R / 4$

8.80 $65.5\ \text{m/s}$.

8.82 The floor exerts an upward impulse of $2.76m\sqrt{gh}$ to the ball.

8.84 $391\ \text{m/s}$.

8.86

(a) $\dfrac{K_{A2}}{K_1} = \left(\dfrac{m_A - m_B}{m_A + m_B}\right)^2$.

$\dfrac{K_{B2}}{K_1} = \dfrac{4m_A m_B}{(m_A + m_B)^2}$.

(b) (i) For $m_A = m_B$, $\dfrac{K_{A2}}{K_1} = 0$ and $\dfrac{K_{B2}}{K_1} = 1$. (ii) For $m_A = 5m_B$, $\dfrac{K_{A2}}{K_1} = \dfrac{4}{9}$ and $\dfrac{K_{B2}}{K_1} = \dfrac{5}{9}$.

(c) $\dfrac{m_A}{m_B} = 5.83$ or $\dfrac{m_A}{m_B} = 0.172$. We can also verify that these values give $\dfrac{K_{B2}}{K_1} = \dfrac{1}{2}$.

8.88

(a) $0.250\ \text{m/s}$.

(b) $0.024\ \text{kg}$.

8.90

(a) The small ball moves upward with speed 3*v* after the collision.

(b) The ball's rebound distance is nine times the distance it fell.

8.92

$$K_A = \frac{Q}{1 + m_A / m_B} = \left(\frac{m_B}{m_A + m_B}\right)Q.$$

$$K_B = Q - K_A = Q\left(1 - \frac{m_B}{m_A + m_B}\right) = \left(\frac{m_A}{m_A + m_B}\right)Q.$$

(b) The lighter fragment gets 80% of the energy that is released.

8.94

$K_A = 6.43 \times 10^{-13}\ \text{J}$ and $K_B = 0.11 \times 10^{-13}\ \text{J}$.

8.96

(a) $P_{1x} = P_{2x}$ gives $m_A v_{A1} = m_A v_{A2} \cos\alpha + m_B v_{B2} \cos\beta$.
$P_{1y} = P_{2y}$ gives $0 = m_A v_{A2} \sin\alpha - m_B v_{B2} \sin\beta$.

(b) $m_A^2 v_{A1}^2 = m_A^2 v_{A2}^2 \cos^2\alpha + m_B^2 v_{B2}^2 \cos^2\beta + 2m_A m_B v_{A2} v_{B2} \cos\alpha\cos\beta$ and $0 = m_A^2 v_{A2}^2 \sin^2\alpha + m_B^2 v_{B2}^2 \sin^2\beta - 2m_A m_B v_{A2} v_{B2} \sin\alpha\sin\beta$. Adding these two equations and using the trig identities in the SET UP step gives
$m_A^2 v_{A1}^2 = m_A^2 v_{A2}^2 + m_B^2 v_{B2}^2 + 2m_A m_B v_{A2} v_{B2} \cos(\alpha+\beta)$.

(c) $K_1 = K_2$ says $\frac{1}{2} m_A v_{A1}^2 = \frac{1}{2} m_A v_{A2}^2 + \frac{1}{2} m_B v_{B2}^2$. The result in part (b) agrees with this expression only if $\cos(\alpha+\beta) = 0$. This requires that $\alpha + \beta = 90° = \frac{\pi}{2}\ \text{rad}$.

8.98

$-0.105\ \text{m/s}$. (The sleigh's velocity is 0.105 m/s, to the left.)

8.100

The canoe moves 1.29 m to the left.

8.102

(a) The second fragment lands $283\ \text{m} + 566\ \text{m} = 849\ \text{m}$ from the firing point.
(b) The energy released in the explosion is $1.60 \times 10^4\ \text{J}$.

8.104

the lighter fragment travels a horizontal distance $7546\ \text{m}$ from the point of explosion and $8624\ \text{m}$ from the launch point. The energy released in the explosion is $5.33 \times 10^5\ \text{J}$.

8.106

(a) $v_{\text{cm-}x} = \dfrac{m_A v_{A1}}{m_A + m_B}$.

(b) The center of mass moves with constant speed so this coordinate system is an inertial frame.

(c) $u_{A1x} = \dfrac{m_B v_{A1}}{m_A + m_B}$. $u_{B1x} = -\dfrac{m_A v_{A1}}{m_A + m_B}$. In this frame $P_{1x} = m_A u_{A1x} + m_B u_{B1x} = 0$.

(d) In the center of mass frame the momentum and hence the velocity of each puck keeps the same magnitude and reverses direction.

(e) $v_{\text{cm-}x} = \left(\dfrac{0.400\ \text{kg}}{0.600\ \text{kg}}\right)(6.00\ \text{m/s}) = 4.00\ \text{m/s}$.
$u_{A1x} = 6.00\ \text{m/s} - 4.00\ \text{m/s} = 2.00\ \text{m/s}$. $u_{B1x} = 0 - 4.00\ \text{m/s} = -4.00\ \text{m/s}$.
$u_{A2x} = -2.00\ \text{m/s}$ and $u_{B2x} = +4.00\ \text{m/s}$.

$v_{A2x} = u_{A2x} + v_{\text{cm-}x} = -2.00 \text{ m/s} + 4.00 \text{ m/s} = 2.00 \text{ m/s}$.
$v_{B2x} = u_{B2x} + v_{\text{cm-}x} = 4.00 \text{ m/s} + 4.00 \text{ m/s} = 8.00 \text{ m/s}$.
Eq. 8.24 says $v_{A2x} = \left(\dfrac{0.400 \text{ kg} - 0.200 \text{ kg}}{0.400 \text{ kg} + 0.200 \text{ kg}}\right)(6.00 \text{ m/s}) = 2.00 \text{ m/s}$. Eq. 8.25 says $v_{A2x} = \left(\dfrac{2[0.400 \text{ kg}]}{0.400 \text{ kg} + 0.200 \text{ kg}}\right)(6.00 \text{ m/s}) = 8.00 \text{ m/s}$. Our result agrees with Eqs. 8.24 and 8.25.

8.108

(b) $V = 1.20 \times 10^4 \text{ m/s}$ and $v_3 = 2.40 \times 10^4 \text{ m/s}$.

8.110

(a) $m\dfrac{dv}{dt} = -v_{\text{ex}}\dfrac{dm}{dt} - mg$.

(b) $a = \dfrac{dv}{dt} = -\dfrac{v_{\text{ex}}}{m}\dfrac{dm}{dt} - g$.

(c) 10.2 m/s^2.

(d) 2445 m/s.

8.112

(a) For $t \le 0$, $v = 0$. For $0 \le t \le 90 \text{ s}$, Eq. 8.40 says $v = (2400 \text{ m/s})\ln 4 = 3327 \text{ m/s}$. For $t > 90 \text{ s}$, *v* has the constant value 3327 m/s. The graph of $v(t)$ is given in Fig. 8.112a.

(b) For $0 \le t \le 90 \text{ s}$, Eq. 8.39 gives

$$a = -\frac{v_{\text{ex}}}{m}\frac{dm}{dt} = -\frac{2400 \text{ m/s}}{m_0(1 - t/[120 \text{ s}])}\left(-\frac{m_0}{120 \text{ s}}\right) = \frac{20 \text{ m/s}^2}{1 - t/[120 \text{ s}]}.$$

$a = 20 \text{ m/s}^2$ at $t = 0$ (as in Example 8.15) and $a = 80 \text{ m/s}^2$ at $t = 90 \text{ s}$. For $t > 90 \text{ s}$, $a = 0$. The graph of $a(t)$ is given in Fig. 8.112b.

(c) The astronaut has the same acceleration as the rocket. This is maximum at $t = 90 \text{ s}$ and $F_{\text{max}} = m_{\text{astronaut}}a_{\text{max}} = (75 \text{ kg})(80 \text{ m/s}^2) = 6.0 \times 10^3 \text{ N}$. This is 8.2 times her weight on earth, since a_{max} is 8.2 times *g*.

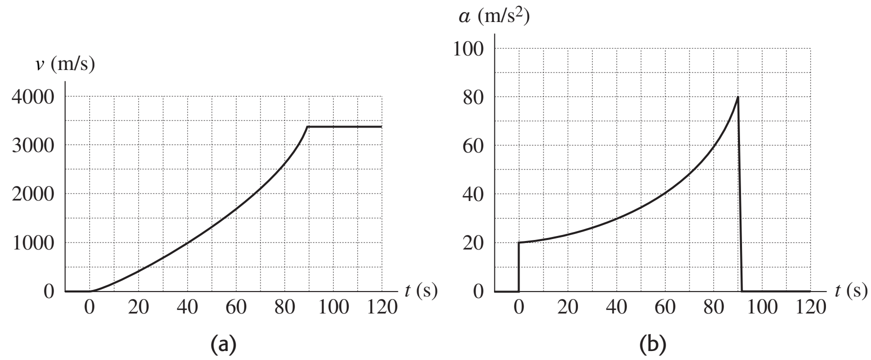

Figure 8.112

8.114

SET UP: To find x_{cm}, divide the plate into thin strips parallel to the *y*-axis, as shown in Fig. 8.114a. To find y_{cm}, divide the plate into thin strips parallel to the *x*-axis as shown in Fig. 8.114b. The plate has volume one-half that of a circular disk, so $V = \frac{1}{2}\pi a^2 t$ and $M = \frac{1}{2}\rho\pi a^2 t.$

EXECUTE: In Fig.114a each strip has length $y = \sqrt{a^2 - x^2}.$ $x_{cm} = \frac{1}{M}\int x dm,$ where $dm = \rho t y dx = \rho t\sqrt{a^2 - x^2}dx.$ $x_{cm} = \frac{\rho t}{M}\int_{-a}^{a} x\sqrt{a^2 - x^2}dx = 0,$ since the integrand is an odd function of *x*. $x_{cm} = 0$ because of symmetry. In Fig.114b each strip has length $2x = 2\sqrt{a^2 - y^2}.$ $y_{cm} = \frac{1}{M}\int y dm,$ where $dm = 2\rho t x dy = 2\rho t\sqrt{a^2 - y^2}dy.$

$y_{cm} = \frac{2\rho t}{M}\int_0^a y\sqrt{a^2 - y^2}dy$. The integral can be evaluated using $u = a^2 - y^2$, $du = -2y dy$. This substitution gives

$$y_{cm} = \frac{2\rho t}{M}\left(-\frac{1}{2}\right)\int_{a^2}^{0} u^{1/2}du = \frac{2\rho t a^3}{3M} = \left(\frac{2\rho t a^3}{3}\right)\left(\frac{2}{\rho\pi a^2 t}\right) = \frac{4a}{3\pi}.$$

EVALUATE: $\frac{4}{3\pi} = 0.424.$ y_{cm} is less than $a/2,$ as expected, since the plate becomes wider as *y* decreases.

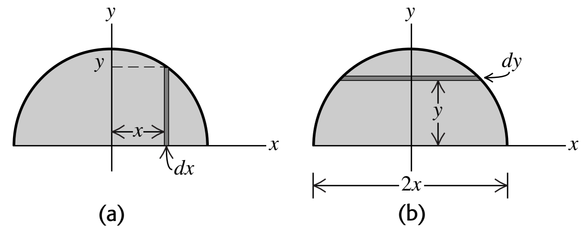

Figure 8.114

8.116

(a) $a = g\,/\,3$.

(b) $14.7\ \mathrm{m}$.

(c) $29.4\ \mathrm{g}$.