ANSWERS TO EVEN-NUMBERED PROBLEMS

P1.2 2.15×10^4 kg/m^3

P1.4 (a) 2.3×10^{17} kg/m^3; (b) 1.0×10^{13} times the density of osmium

P1.6 $\dfrac{4\pi\rho(r_2^3 - r_1^3)}{3}$

P1.8 (a) $8.42\times10^{22}\ \dfrac{\text{Cu-atom}}{\text{cm}^3}$; (b) 1.19×10^{-23} cm^3/Cu-atom; (c) 2.28×10^{-8} cm

P1.10 (a) and (f); (b) and (d); (c) and (e)

P1.12 $\dfrac{\text{m}^3}{\text{kg}\cdot\text{s}^2}$

P1.14 (a) [A] = L/T^3 and [B] = L/T; (b) L/T

P1.16 667 lb/s

P1.18 9.19 nm/s

P1.20 2.57×10^6 m^3

P1.22 (a) $7.14\times10^{-2}\ \dfrac{\text{gal}}{\text{s}}$; (b) $2.70\times10^{-4}\ \dfrac{\text{m}^3}{\text{s}}$; (c) 1.03 h

P1.24 290 m^3, 2.9×10^8 cm^3

P1.26 $r_{Fe}(1.43)$

P1.28 (a) 3.39×10^5 ft^3; (b) 2.54×10^4 lb

P1.30 (a) 2.07 mm; (b) 8.62×10^{13} times as large

P1.32 (a) $\sim 10^2$ kg; (b) $\sim 10^3$ kg

P1.34 10^7 rev

P1.36 (a) 3; (b) 4; (c) 3; (d) 2

P1.38 (a) 796; (b) 1.1; (c) 17.66

P1.40 9 bars / year

P1.42 1.66×10^3 kg/m^3

P1.44 288°; 108°

P1.46 See P1.46 for complete description.

P1.48 1.38×10^3 m

P1.50 (a) nine times smaller; (b) Δt is inversely proportional to the square of d; (c) Plot Δt on the vertical axis and $1/d^2$ on the horizontal axis; (d) $4QL/k\pi(T_h - T_c)$

P1.52 1.61×10^3 kg/m^3, 0.166×10^3 kg/m^3, $(1.61\pm0.17)\times10^3$ kg/m^3

P1.54 3.64 cents; the cost is negligible compared to $4.98.

P1.56 (a) 10^{14} bacteria; (b) beneficial

P1.58 The scenario has the contestants succeeding on the whole. But the calculation shows that is impossible. It just takes too long!

P1.60 $h = r\tan\phi = (\tan\theta)C/2\pi$

P1.62 10^{11} stars

P1.64 (a) m = 346 g – (14.5 g/cm^3)a^3; (b) a = 0; (c) 346 g; (d) yes; (e) no change

P1.66 (a) 478 cm^3/s; (b) 0.225 cm/s; (c) When the balloon radius is twice as large, its surface area is four times larger. The new volume added in one second in the inflation process is equal to this larger area times an extra radial thickness that is one-fourth as large as it was when the balloon was smaller.

P1.68 31.0°

P1.70 (a-b) see ANS. FIG. P1.70(a) and P1.70(b); (c) $y = x\tan 12.0°$ and $y = (x - 1.00\text{ km})\tan 14.0°$; (d) $y = 1.44$ km

P1.72 $\dfrac{d\tan\phi\tan\theta}{\tan\phi - \tan\theta}$

ANSWERS TO EVEN-NUMBERED PROBLEMS

P2.2 0.02 s

P2.4 (a) 50.0 m/s; (b) 41.0 m/s

P2.6 (a) 27.0 m; (b) 27.0 m + (18.0 m/s) Δt + (3.00 m/s^2)(Δt^2); (c) 18.0 m/s

P2.8 (a) $+L/t_1$; (b) $-L/t_2$; (c) 0; (d) $2L/t_1 + t_2$

P2.10 1.9×10^8 years

P2.12 (a) 20 mi/h; (b) 0; (c) 30 mi/h

P2.14 1.34×10^4 m/s^2

P2.16 See graphs in P2.16.

P2.18 (a) See ANS. FIG. P2.18; (b) 23 m/s, 18 m/s, 14 m/s, and 9.0 m/s; (c) 4.6 m/s^2; (d) zero

P2.20 (a) 13.0 m/s; (b) 10.0 m/s, 16.0 m/s; (c) 6.00 m/s^2; (d) 6.00 m/s^2; (e) 0.333 s

P2.22 (a–e) See graphs in P2.22; (f) with less regularity

P2.24 160 ft.

P2.26 4.53 s

P2.28 (a) 6.61 m/s; (b) −0.448 m/s^2

P2.30 (a) 20.0 s; (b) No; (c) The plane would overshoot the runway.

P2.32 31 s

P2.34 The accelerations do not match.

P2.36 (a) $x_f - x_i = v_{xf}t - \frac{1}{2}a_x t^2$; (b) 3.10 m/s

P2.38 (a) 2.56 m; (b) −3.00 m/s

P2.40 19.7 cm/s; (b) 4.70 cm/s^2; (c) The length of the glider is used to find the average velocity during a known time interval.

P2.42 (a) 3.75 s; (b) 5.50 cm/s; (c) 0.604 s; (d) 13.3 cm, 47.9 cm; (e) See P2.42 part (e) for full explanation.

P2.44 (a) 8.20 s; (b) 134 m

P2.46 (a and b) The rock does not reach the top of the wall with $v_f = 3.69$ m/s; (c) 2.39 m/s; (d) does not agree; (e) The average speed of the upward-moving rock is smaller than the downward moving rock.

P2.48 (a) 29.4 m/s; (b) 44.1 m

P2.50 7.96 s

P2.52 0.60 s

P2.54 (a) $\frac{h}{t} + \frac{gt}{2}$; (b) $\frac{h}{t} - \frac{gt}{2}$

P2.56 (a) $(v_i + gt)$; (b) $\frac{1}{2}gt^2$; (c) $|v_i - gt|$; (d) $\frac{1}{2}gt^2$

P2.58 (a) See graphs in P2.58; (b) See graph in P2.58; (c) −4 m/s^2; (d) 32 m; (e) 28 m

P2.60 (a) 5.25 m/s^2; (b) 168 m; (c) 52.5 m/s

P2.62 (a) 0; (b) 6.0 m/s^2; (c) −3.6 m/s^2; (d) at t = 6 s and at 18 s; (e and f) t = 18 s; (g) 204 m

P2.64 (a) $A = v_{xi}t + \frac{1}{2}a_x t^2$; (b) The displacement is the same result for the total area.

P2.66 (a) 96.0 ft/s; (b) 3.07×10^3 ft/s^2 upward; (c) 3.13×10^{-2} s

P2.68 The trains do collide.

P2.70 (a) +4.8 m/s^2; (b) 7.27 m/s^2

P2.72 (a) 41.0 s; (b) 1.73 km; (c) −184 m/s

P2.74 (a) Ball 1: $y_1 = h - v_0 t - \frac{1}{2}gt^2$, Ball 2: $y_2 = h + v_0 t - \frac{1}{2}gt^2, \frac{2v_0}{g}$; (b) Ball 1: $-\sqrt{v_0^2 + 2gh}$, Ball 2: $-\sqrt{v_0^2 + 2gh}$; (c) $2v_0 t$

P2.76 (a and b) See TABLE P2.76; (c) 1.63 m/s^2 downward and see graph in P2.76

P2.78 155 s

P2.80 ~10^3 m/s^2

P2.82 (a) 3.45 s; (b) 10.0 ft.

P2.84 (a) The red bead falls through a greater distance with a downward acceleration of g. The blue bead travels a shorter distance, but with acceleration of $g\sin\theta$. A first guess would be that the blue bead "wins," but not by much. (b) $\sqrt{\frac{2D}{g}}$; (c) $\sqrt{\frac{2L}{g\sin\theta}}$; (d) the beads arrive at point Ⓒ simultaneously; (e) Once we recognize that the two rods form one side and the hypotenuse of a right triangle with θ as its smallest angle, then the result becomes obvious.

ANSWERS TO EVEN-NUMBERED PROBLEMS

P3.2 (a) 2.31; (b) 1.15

P3.4 (a) (2.17, 1.25) m, (–1.90, 3.29) m; (b) 4.55m

P3.6 (a) r, $180° - \theta$; (b) $180° + \theta$; (c) $-\theta$

P3.8 $\vec{B}$ is 43 units in the negative y direction

P3.10 9.5 N, 57° above the x axis

P3.12 (a) See ANS. FIG. P3.12; (b) The sum of a set of vectors is not affected by the order in which the vectors are added.

P3.14 310 km at 57° S of W

P3.16 $A_x = 28.7$ units, $A_y = -20.1$ units

P3.18 1.31 km north and 2.81 km east

P3.20 (a) 5.00 blocks at 53.1° N of E; (b) 13.00 blocks

P3.22 $\left(2.60\hat{i} + 4.50\hat{j}\right)$ m

P3.24 788 miles at 48.0° northeast of Dallas

P3.26 (a) See ANS. FIG. P3.24; (b) $5.00\hat{i} + 4.00\hat{j}, -1.00\hat{i} + 8.00\hat{j}$; (c) 6.40 at 38.7°, 8.06 at 97.2°

P3.28 (a) Its component parallel to the surface is (1.50 m) cos 141° = –1.17 m, or 1.17 m toward the top of the hill; (b) Its component perpendicular to the surface is (1.50 m) sin 141° = 0.944 m, or 0.944 m away from the snow.

P3.30 42.7 yards

P3.32 $C_x = 7.30$ cm; $C_y = -7.20$ cm

P3.34 59.2° with the x axis, 39.8° with the y axis, 67.4° with the z axis

P3.36 (a) $5.00\hat{i} - 1.00\hat{j} - 3.00\hat{k}$, 5.92 m; (b) $(4.00\hat{i} - 11.0\hat{j} + 15.0\hat{k})$ m, 19.0) m

P3.38 (a) $49.5\hat{i} + 27.1\hat{j}$; (b) 56.4, 28.7°

P3.40 magnitude: 170.1 cm, direction: 57.2° above $+x$ axis (first quadrant); magnitude: 145.7 cm, direction: 58.6° above $+x$ axis (first quadrant)

P3.42 (a) $\left(3.12\hat{i} + 5.02\hat{j} - 2.20\hat{k}\right)$km; (b) 6.31 km

P3.44 Impossible because 12.4 m is greater than 5.00 m

P3.46 (a) $(5 = 11f)\hat{i} + (3 + 9f)\hat{j}$ meters; (b) $(5 + 0)\hat{i} + (3 + 0)\hat{j}$ meters; (c) This is reasonable because it is the location of the starting point, $5\hat{i} + 3\hat{j}$ meters. (d) $16\hat{i} + 12\hat{j}$ meters; (e) This is reasonable because we have completed the trip, and this is the position vector of the endpoint.

P3.48 2.24 m, 26.6°

P3.50 390 mi/h at 7.37° N of E

P3.52 86.6 m, –50.0 m

P3.54 2.29 km

P3.56 (a) The perimeter measures $2(H + W) = 11.24$ m; (b) magnitude: 12.9 m, direction: 36.4° above $+x$ axis (first quadrant)

P3.58 (a) 7.17 km; (b) 6.15 km

P3.60 $\theta = 2\tan^{-1}\left(\frac{1}{n}\right)$

P3.62 $0.456\hat{i}$ m $- 0.708\hat{j}$ m

P3.64 (a) 496 m, 65.1° N of W; (b) The arguments are justified because the distances involved are small relative to the radius of the Earth.

P3.66 $\phi = 2\theta = 106°$

ANSWERS TO EVEN-NUMBERED PROBLEMS

P4.2 2.50 m/s

P4.4 (a) $-5.00\omega\ \hat{\mathbf{i}}$ m/s; (b) $-5.00\omega^2\ \hat{\mathbf{j}}$ m/s;
(c) $(4.00\text{ m})\hat{\mathbf{j}} + (5.00\text{ m})\left(-\sin\omega t\hat{\mathbf{i}} - \cos\omega t\hat{\mathbf{j}}\right)$,
$(5.00\text{ m})\omega\left[-\cos\omega\hat{\mathbf{i}} + \sin\omega t\hat{\mathbf{j}}\right]$, $(5.00\text{ m})\omega^2\left[\sin\omega t\hat{\mathbf{i}} + \cos\omega\hat{\mathbf{j}}\right]$; (d) a circle of radius 5.00 m centered at (0, 4.00 m)

P4.6 (a) $5.00t\hat{\mathbf{i}} + 1.50t^2\hat{\mathbf{j}}$; (b) $5.00\hat{\mathbf{i}} + 3.00t\ \hat{\mathbf{j}}$; (c) 10.0 m, 6.00 m; (d) 7.81 m/s

P4.8 (a) $\left(10.0\ \hat{\mathbf{i}} + 0.241\ \hat{\mathbf{j}}\right)$ mm; (b) $\left(1.84\times10^7\text{ m/s}\right)\hat{\mathbf{i}} + \left(8.78\times10^5\text{ m/s}\right)\hat{\mathbf{j}}$;
(c) 1.85×10^7 m/s; (d) 2.73°

P4.10 (a) $\vec{\mathbf{v}}_f = (3.45 - 1.79t)\hat{\mathbf{i}} + (2.89 - 0.650t)\hat{\mathbf{j}}$;
(b) $\vec{\mathbf{r}}_f = (-25.3 + 3.45t - 0.893t^2)\hat{\mathbf{i}} + \left(28.9 + 2.89t - 0.325t^2\right)\hat{\mathbf{j}}$

P4.12 0.600 m/s²

P4.14 (a) $v_{xi} = d\sqrt{\dfrac{g}{2h}}$, (b) The direction of the mug's velocity is $\tan^{-1}(2h/d)$ below the horizontal.

P4.16 $x = 7.23\times10^3$ m, $y = 1.68\times10^3$ m

P4.18 (a) 76.0°, (b) $R_{max} = 2.13R$, (c) the same on every planet

P4.20 (a) 22.6 m; (b) 52.3 m; (c) 1.18 s

P4.22 (a) there is; (b) 0.491 m/s

P4.24 (a) 0.852 s; (b) 3.29 m/s; (c) 4.03 m/s; (d) 50.8°; (e) $t = 1.12$ s

P4.26 (a) (0, 0.840 m); (b) 11.2 m/s at 18.5°; (c) 8.94 m

P4.28 (a) $t = v_i\sin\theta/g$; (b) $h_{max} = h + \dfrac{(v_i\sin\theta)^2}{2g}$

P4.30 (a) 28.2 m/s; (b) 4.07 s; (c) the required initial velocity will increase, the total time of flight will increase

P4.32 (a) 41.7 m/s; (b) 3.81 s; (c) $v_x = 34.1$ m/s, $v_y = -13.4$ m/s, $v = 36.7$ m/s

P4.24 0.033 7 m/s² directed toward the center of Earth

P4.36 10.5 m/s, 219 m/s² inward

P4.38 (a) 6.00 rev/s; (b) 1.52×10^3 m/s²; (c) 1.28×10^3 m/s²

P4.40 (a) 13.0 m/s²; (b) 5.70 m/s; (c) 7.50 m/s²

P4.42 (a) See ANS. FIG. P4.42; (b) 29.7 m/s²; (c) 6.67 m/s tangent to the circle

P4.44 153 km/h at 11.3° north of west

P4.46 (a) $\Delta t_{woman} = \dfrac{L}{v_1}$; (b) $\Delta t_{man} = \dfrac{L}{v_1 + v_2}$; (c) $\Delta t_{man} = \dfrac{L}{v_1 + 2v_2}$

P4.48 (a) 57.7 km/h at 60.0° west of vertical; (b) 28.9 km/h downward

P4.50 (a) 2.02×10^3 s; (b) 1.67×10^3 s; (c) Swimming with the current does not compensate for the time lost swimming against the current.

P4.52 27.7° E of N

P4.54 (a) straight up, at 0° to the vertical; (b) 8.25 m/s; (c) a straight up and down line; (d) a symmetric parabola opening downward; (e) 12.6 m/s north at $\tan^{-1}(8.25/9.5) = 41.0°$ above the horizontal

P4.56 (a) $2\sqrt{\dfrac{R}{3g}}$; (b) $\dfrac{1}{2}\sqrt{3gR}$; (c) $\sqrt{\dfrac{gR}{3}}$; (d) $\sqrt{\dfrac{13gR}{12}}$; (e) 33.7°; (f) $\dfrac{13}{24}R$;
(g) $\dfrac{13}{12}R$

P4.58 (a) $5\hat{\mathbf{i}} + 4t^{3/2}\hat{\mathbf{j}}$; (b) $5t\hat{\mathbf{i}} + 1.6t^{5/2}\hat{\mathbf{j}}$

P4.60 (a) 9.80 m/s², downward; (b) 10.7 m/s

P4.62 (a) $t = \sqrt{\dfrac{2h}{g}}$; (b) $v_{xi} = d\sqrt{\dfrac{g}{2h}}$; (c) $v_f = \sqrt{v_{xf}^{\ 2} + v_{yf}^{\ 2}} = \sqrt{\left(\dfrac{d^2g}{2h}\right) + (2gh)}$;
(d) $\theta_f = \tan^{-1}\left(\dfrac{2h}{d}\right)$

P4.64 68.8 km/h

P4.66 22.4° or 89.4°

P4.68 $2v_it\cos\theta_i$

P4.70 (a) 25.0 m/s²; (b) 9.80 m/s²; (c) See ANS. FIG. P4.70; (d) 26.8 m/s², 21.4°

P4.72 (a) See table in P4.72(a); (b) From the table, it looks like the magnitude of r is largest at a bit less than 6 s; (c) 138 m; (d) We can require $dr^2/dt = 0 = (d/dt)[(12t)^2 + (49t - 4.9t^2)^2]$, which results in the solution.

P4.74 (a) $\theta = 26.6°$; (b) 0.949

P4.76 18.8 m, −17.3 m

P4.78 (a) 22.9 m/s and 3.06 s; (b) 360 m; (c) 114 m/s, −44.3 m/s

ANSWERS TO EVEN-NUMBERED PROBLEMS

P5.2 2.38 kN

P5.4 8.71 N

P5.6 (a) -4.47×10^{15} m/s²; (b) $+2.09 \times 10^{-10}$ N

P5.8 (a) zero; (b) zero

P5.10 (a) $\frac{1}{2}vt$; (b) magnitude: $m\sqrt{(v/t)^2 + g^2}$, direction: $\tan^{-1}\left(\frac{gt}{v}\right)$

P5.12 $(16.3\hat{\mathrm{i}} + 14.6\hat{\mathrm{j}})$ N

P5.14 (a–c) See free-body diagrams and corresponding forces in P5.14.

P5.16 1.59 m/s² at 65.2° N of E

P5.18 (a) $\frac{1}{3}$; (b) 0.750 m/s²

P5.20 (a) $\sim 10^{-22}$ m/s²; (b) $\Delta x \sim 10^{-23}$ m

P5.22 (a) $\hat{a}$ is at 181°; (b) 11.2 kg; (c) 37.5 m/s; (d) $(-37.5\hat{\mathrm{i}} - 0.893\hat{\mathrm{j}})$ m/s

P5.24 $\sum\vec{F} = -km\vec{v}$

P5.26 (a) See ANS. FIG. P5.26; (b) 1.03 N; (c) 0.805 N to the right

P5.28 (a) 49.0 N; (b) 49.0 N; (c) 98.0 N; (d) 24.5 N

P5.30 (a) See ANS. FIG. P5.30(a); (b) −2.54 m/s²; (c) 3.19 m/s

P5.32 112 N

P5.34 See P5.33 for complete derivation.

P5.36 (a) $T_1 = 31.5$ N, $T_2 = 37.5$ N, $T_3 = 49.0$ N; (b) $T_1 = 113$ N, $T_2 = 56.6$ N, $T_3 = 98.0$ N

P5.38 (a) 78.4 N; (b) 105 N

P5.40 $a = 6.30$ m/s² and $T = 31.5$ N

P5.42 (a) See ANS FIG P5.42; (b) 3.57 m/s²; (c) 26.7 N; (d) 7.14 m/s

P5.44 (a) $2m(g + a)$; (b) $T_1 = 2T_2$, so the upper string breaks first; (c) 0, 0

P5.46 (a) $a_2 = 2a_1$; (b) $T_1 = \frac{m_1 m_2}{2m_2 + \frac{1}{2}m_1}g$ and $T_2 = \frac{m_1 m_2}{m_2 + \frac{1}{4}m_1}g$; (c) $\frac{m_1 g}{2m_2 + \frac{1}{2}m_1}$ and $\frac{m_1 g}{4m_2 + m_1}$

P5.48 $B = 3.37 \times 10^3$ N, $A = 3.83 \times 10^3$ N, B is in tension and A is in compression.

P5.50 (a) 0.529 m below its initial level; (b) 7.40 m/s upward

P5.52 (a) 14.7 m; (b) neither mass is necessary

P5.54 (a) 256 m; (b) 42.7 m

P5.56 The situation is impossible because maximum static friction cannot provide the acceleration necessary to keep the book stationary on the seat.

P5.58 (a) 4.18; (b) Time would increase, as the wheels would skid and only kinetic friction would act; or perhaps the car would flip over.

P5.60 (a) See ANS. FIG. P5.60; (b) $\theta = 55.2°$; (c) $n = 167$ N

P5.62 (a) 0.404; (b) 45.8 lb

P5.64 (a) See ANS. FIG. P5.64; (b) 2.31 m/s², down for m_1, left for m_2, and up for m_3; (c) $T_{12} = 30.0$ N and $T_{23} = 24.2$ N; (d) T_{12} decreases and T_{23} increases

P5.66 (a) 48.6 N, 31.7 N; (b) If $P > 48.6$ N, the block slides up the wall. If $P < 31.7$ N, the block slides down the wall; (c) 62.7 N, $P \geq 62.7$ N, the block cannot slide up the wall. If $P < 62.7$ N, the block slides down the wall

P5.68 834 N

P5.70 (a) See P5.70 for complete solution; (b) 9.80 N, 0.580 m/s²

P5.72 (a) 3.43 m/s² toward the scrap iron; (b) 3.43 m/s² toward the scrap iron; (c) −6.86 m/s² toward the magnet

P5.74 The situation is impossible because these forces on the book cannot produce the acceleration described.

P4.76 (a) and (b) See P5.76 for complete derivation; (c) 3.56 N

P5.78 (a) See ANS. FIG. P5.78(a); (b) $a=\dfrac{F}{m_b+m_r}$; (c) $T=\left(\dfrac{m_b}{m_b+m_r}\right)F$; (d) the tension in a cord of negligible mass is constant along its length

P5.80 (a) At any instant they have the same velocity and at all instants they have the same acceleration; (b) 1.61×10^4 N; (c) 2.95×10^4 N

P5.82 (a) Nick and the seat, with total weight 480 N, will accelerate down and the child, with smaller weight 440 N, will accelerate up; (b) In P5.81, a rope tension of 250 N does not make the rope break. In part (a), the rope is strong enough to support tension 459 N. But now the tension everywhere in the rope is 480 N, so it can exceed the breaking strength of the rope.

P5.84 (a) The system will not start to move when released; (b and c) no answer; (d) $f=m_2 g\sin\theta=29.4$ N

P5.86 (a) $T=\dfrac{f}{2\sin\theta}$; (b) 410 N

P5.88 (a) $M=3m\sin\theta$; (b) $T_1=2mg\sin\theta$, $T_2=3mg\sin\theta$; (c) $a=\dfrac{g\sin\theta}{1+2\sin\theta}$;

(d) $T_1=4mg\sin\theta\left(\dfrac{1+\sin\theta}{1+2\sin\theta}\right)$, $T_2=6mg\sin\theta\left(\dfrac{1+\sin\theta}{1+2\sin\theta}\right)$;

(e) $M_{max}=3m(\sin\theta+\mu_s\cos\theta)$; (f) $M_{min}=3m(\sin\theta-\mu_s\cos\theta)$;

(g) $T_{2,max}-T_{2,min}=M_{max}g-M_{min}g=6\mu_s mg\cos\theta$

P5.90 See table in P5.90 and ANS. FIG P5.90; (b) 0.143 m/s^2; (c) The acceleration values agree.

P5.92 (a) $a_1=2a_2$; (b) $a_2=12.7\text{ N}\,(1.30\text{ kg}+4m_1)^{-1}$ down; (c) 9.80 m/s^2 down; (d) a_2 approaches zero; (e) $T=6.37$ N; (f) yes

P5.94 (a) $n=(8.23\text{ N})\cos\theta$; (b) $a=(9.80\text{ m/s}^2)\sin\theta$; (c) See ANS. FIG P5.94; (d) At 0°, the normal force is the full weight, and the acceleration is zero. At 90° the mass is in free fall next to the vertical incline.

P5.96 (a) 3.00 s; (b) 20.1 m; (c) $(18.0\text{m})\hat{i}-(9.00\text{m})\hat{j}$

P5.98 (a) $m_2 g\left[\dfrac{m_1 M}{m_2 M+m_1(m_2+M)}\right]$; (b) $\left[\dfrac{gm_1(m_2+M)}{m_2 M+m_1(m_2+M)}\right]$;

(c) $\left[\dfrac{m_1 m_2 g}{m_2 M+m_1(m_2+M)}\right]$; (d) $\left[\dfrac{m_1 Mg}{m_2 M+m_1(m_2+M)}\right]$

P5.100 The situation is impossible because at the angle of minimum tension, the tension exceeds 4.00 N

P5.102 $\vec{R}=mg\cos\theta\sin\theta$ to the right $+(M+m\cos^2\theta)g$ upward

P5.104 (a) $T_1=\dfrac{2mg}{\sin\theta_1}$, $\dfrac{2mg}{\tan\theta_1}=T_3$; (b) $\theta_2=\tan^{-1}\left(\dfrac{\tan\theta_1}{2}\right)$,

$T_2=\dfrac{mg}{\sin\left[\tan^{-1}\left(\frac{1}{2}\tan\theta_1\right)\right]}$; (c) See P5.104 for complete explanation.

ANSWERS TO EVEN-NUMBERED PROBLEMS

P6.2 (a) 1.65×10^3 m/s; (b) 6.84×10^3 s

P6.4 215 N, horizontally inward

P6.6 (a) $(-0.233\hat{i}+0.163\hat{j})$ m/s^2; (b) 6.53 m/s, $(-0.181\hat{i}+0.181\hat{j})$ m/s^2

P6.8 (a) $(68.6\text{ N})\hat{i}+(784\text{ N})\hat{j}$; (b) $a = 0.857$ m/s^2

P6.10 The situation is impossible because the speed of the object is too small, requiring that the lower string act like a rod and push rather than like a string and pull.

P6.12 (a) the gravitational force and the contact force exerted on the water by the pail; (b) contact force exerted by the pail; (c) 3.13 m/s; (d) the water would follow the parabolic path of a projectile

P6.14 (a) 4.81 m/s; (b) 700 N

P6.16 (a) 2.49×10^4 N; (b) 12.1 m/s

P6.18 (a) 20.6 N; (b) 32.0 m/s^2 inward, 3.35 m/s^2 downward tangent to the circle; (c) 32.2 m/s^2 inward and below the cord at 5.98°; (d) no change; (e) acceleration is regardless of the direction of swing

P6.20 (a) 3.60 m/s^2; (b) $T = 0$; (c) noninertial observer in the car claims that the forces on the mass along x are T and a fictitious force $(-Ma)$; (d) inertial observer outside the car claims that T is the only force on M in the x direction

P6.22 93.8 N

P6.24 $\dfrac{2(vt-L)}{(g+a)t^2}$

P6.26 (a) 53.8 m/s; (b) 148 m

P6.28 (a) 6.27 m/s^2 downward; (b) 784 N directed up; (c) 283 N upward

P6.30 (a) 32.7 s^{-1}; (b) 9.80 m/s^2 down; (c) 4.90 m/s^2 down

P6.32 36.5 m/s

P6.34 (a) 2.03 N down; (b) 3.18 m/s^2 down; (c) 0.205 m/s down

P6.36 10^1 N

P6.38 1.2×10^3 N

P6.40 (a) 1.15×10^4 N up; (b) 14.1 m/s

P6.42 See Problem 6.42 for full derivation.

P6.44 (a) 217 N; (b) 283 N; (c) $T_2 > T_1$ always, so string 2 will break first

P6.46 The situation is impossible because the speed of the child given in the problem is too large: static friction could not keep the child in place on the incline

P6.48 0.835 rev/s

P6.50 (a) $v = \sqrt{Rg\tan 35.0°} = \sqrt{(6.86\text{ m/s}^2)R}$; (b) the mass is unnecessary; (c) increasing the radius will make the required speed increase; (d) when the radius increases, the period increases; (e) the time interval required is proportional to $R/\sqrt{R} = \sqrt{R}$

P6.52 (a) 1 975 lb; (b) −647 lb; (c) When $F_g' = 0$, then $mg = \dfrac{mv^2}{R}$.

P6.54 (a) $m_2 g$; (b) $m_2 g$; (c) $\sqrt{\left(\dfrac{m_2}{m_1}\right)gR}$; (d) The puck will spiral inward, gaining speed as it does so; (e) The puck will spiral outward, slowing down as it does so

P6.56 (a) $a = +kv$; (b) $\sum\vec{F} = km\vec{v}$; (c) some feedback mechanism could be used to impose such a force on an object; (d) think of a duck landing on a lake, where the water exerts a resistive force on the duck proportional to its speed

P6.58 (a) $\sqrt{\pi Rg}$; (b) $m\pi g$

P6.60 (a) See table in P6.60 (a); (b) See graph in P6.60 (b); (c) 53.0 m/s

P6.62 84.7°

P6.64 (a) 2.63 m/s^2; (b) 201 m; (c) 17.7 m/s

P6.66 (a) $x = \dfrac{1}{k}\ln(1+v_i kt)$; (b) $v = v_i e^{-kx}$

P6.68 (a) $\theta = 70.4°$ and $\theta = 0°$; (b) $\theta = 0°$; (c) the period is too large; (d) Zero is always a solution for the angle; (e) there are never more than two solutions

P6.70 0.092 8°

ANSWERS TO EVEN-NUMBERED PROBLEMS

P7.2 (a) 3.28×10^{-2} J; (b) -3.28×10^{-2} J

P7.4 1.56×10^{4} J

P7.6 method one: -4.70×10^{3} J; method two: −4.70 kJ

P7.8 28.9

P7.10 5.33 J

P7.12 (a) 11.3°; (b) 156°; (c) 82.3°

P7.14 (a) 24.0 J; (b) −3.00 J; (c) 21.0 J

P7.16 7.37 N/m

P7.18 (a) 1.13 kN/m; (b) 0.518 m = 51.8 cm

P7.20 (a) 2.04×10^{-2} m; (b) 720 N/m

P7.22 kg/s^2

P7.24 (a) −1.23 m/s^2, 0.616 m/s^2; (b) −0.252 m/s^2 if the force of static friction is not too large, zero; (c) 0

P7.26 (a) See ANS FIG P7.26; (b) −12.0 J

P7.28 (a) 9.00 kJ; (b) 11.7 kJ; (c) The work is greater by 29.6%

P7.30 (a) 0.600 J; (b) −0.600 J; (c) 1.50 J

P7.32 (a) 29.2 N; (b) speed would increase; (c) crate would slow down and come to rest.

P7.34 (a) 1.94 m/s; (b) 3.35 m/s; (c) 3.87 m/s

P7.36 (a) 3.78×10^{-16} J; (b) 1.35×10^{-14} N; (c) $1.48 \times 10^{+16}$ m/s^2; (d) 1.94×10^{-9} s

P7.38 (a) $F_{avg} = 2.34 \times 10^4$ N, opposite to the direction of motion; (b) 1.91×10^{-4} s

P7.40 (a) $U_B = 0$, 2.59×10^5 J; (b) $U_A = 0$, -2.59×10^5 J, -2.59×10^5 J

P7.42 (a) 800 J; (b) 107 J; (c) $U_g = 0$

P7.44 (a) $\vec{F} \cdot (\vec{r}_f - \vec{r}_i)$, which depends only on end points, and not on the path; (b) 35.0 J

P7.46 (a) 30.0 J; (b) 51.2 J; (c) 42.4 J; (d) Friction is a nonconservative force

P7.48 The book hits the ground with 20.0 J of kinetic energy. The book-Earth now has zero gravitational potential energy, for a total energy of 20.0 J, which is the energy put into the system by the librarian.

P7.50 (a) $\frac{Ax^2}{2} - \frac{Bx^3}{3}$; (b) $\Delta U = (4.5A - 9B) - (2A - 2.67B) = 2.5A - 6.33B$;

(c) $\Delta K = -\Delta U = -2.5A + 6.33B$

P7.52 (a) F_x is zero at points A, C, and E; F_x is positive at point B and negative at point D; (b) A and E are unstable, and C is stable; (c) See ANS FIG P7.52

P7.54 (a) $(3x^2 - 4x - 3)\hat{i}$; (b) 1.87 and −0.535; (c) See ANS. FIG. P7.54

P7.56 0.799 N · m

P7.58 $k_1 \frac{x_{max}^2}{2} + k_2 \frac{x_{max}^3}{3}$

P7.60 The ball will simply stop momentarily and roll back to the spring.

P7.62 (a) $b = 1.80$, $a = 4.01 \times 10^4$ N/m$^{1.8}$; (b) 295 J

P7.64 $x = \dfrac{g\sin\theta \sqrt{(g\sin\theta)^2 + \left(\frac{k}{m}\right)\left[v^2 + 2(g\sin\theta)d\right]}}{k/m}$

P7.66 (a) $-2kx\left(1 - \frac{L}{\sqrt{x^2 + L^2}}\right)\hat{i}$; (b) $kx^2 + 2kL\left(L - \sqrt{x^2 + L^2}\right)$; (c) See ANS. FIG. P7.66(c), $x = 0$; (d) $v = 0.823$ m/s

ANSWERS TO EVEN-NUMBERED PROBLEMS

P8.2 (a) $\Delta K + \Delta U = 0$, $v = \sqrt{2gh}$; (b) $v = \sqrt{2gh}$

P8.4 (a) 1.85×10^4 m, 5.10×10^4 m; (b) 1.00×10^7 J

P8.6 (a) 5.94 m/s, 7.67 m/s; (b) 147 J

P8.8 (a) $\sqrt{\frac{2(m_1 - m_2)gh}{m_1 + m_2}}$; (b) $\frac{2m_1 h}{m_1 + m_2}$

P8.10 (a) 1.11×10^9 J; (b) 0.2

P8.12 2.04 m

P8.14 (a) −168 J; (b) 184 J; (c) 500 J; (d) 148 J; (e) 5.65 m/s

P8.16 (a) 650 J; (b) 588 J; (c) 0; (d) 0; (e) 62.0 J; (f) 1.76 m/s

P8.18 (a) 22.0 J, $E = K + U = 30.0\text{ J} + 10.0\text{ J} = 40.0\text{ J}$; (b) Yes; (c) The total mechanical energy has decreased, so a nonconservative force must have acted.

P8.20 (a) $v_B = 1.65\text{ m/s}^2$; (b) green bead, see P8.20 for full explanation

P8.22 3.74 m/s

P8.24 (a) 0.381 m; (b) 0.371 m; (c) 0.143 m

P8.26 (a) 24.5 m/s; (b) Yes. This is too fast for safety; (c) 206 m; (d) see P8.26(d) for full explanation

P8.28 (a) 1.24×10^3 W; (b) 0.209

P8.30 (a) 8.01 W; (b) see P8.30(b) for full explanation

P8.32 2.03×10^8 s, 5.64×10^4 h

P8.34 194 m

P8.36 The power of the sports car is four times that of the older-model car.

P8.38 (a) 5.91×10^3 W; (b) 1.11×10^4 W

P8.40 (a) 854; (b) 0.182 hp; (c) This method is impractical compared to limiting food intake.

P8.42 $\sim 10^2$ W

P8.44 (a) 0.225 J; (b) −0.363 J; (c) no; (d) It is possible to find an effective coefficient of friction but not the actual value of μ since n and f vary with position.

P8.46 (a) 2.49 m/s; (b) 5.45 m/s; (c) 1.23 m; (d) no; (e) Some of the kinetic energy of m_2 is transferred away as sound and to internal energy in m_1 and the floor.

P8.48 We find that her arms would need to be 1.36 m long to perform this task. This is significantly longer than the human arm.

P8.50 (a) 0.403 m or −0.357 m (b) From a perch at a height of 2.80 m above the top of a pile of mattresses, a 46.0-kg child jumps upward at 2.40 m/s. The mattresses behave as a linear spring with force constant 19.4 kN/m. Find the maximum amount by which they are compressed when the child lands on them; (c) 0.023 2 m; (d) This result is the distance by which the mattresses compress if the child just stands on them. It is the location of the equilibrium position of the oscillator.

P8.52 (a) $\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$; (b) $-mgh - \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2\right)$; (c) $\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh$

P8.54 $\frac{\rho A v^3}{2}$; $F = \frac{\rho A v^2}{2}$; see P8.54 for full explanation

P8.56 (a) 16.5 m; (b) See ANS. FIG. P8.56

P8.58 Unrestrained passengers will fall out of the cars

P8.60 (a) See P8.60(a) for full explanation; (b) see P8.60(b) for full explanation

P8.62 (a) 0.378 m; (b) 2.30 m/s; (c) 1.08 m

P8.64 1.24 m/s

P8.66 48.2°

P8.68 $\frac{3L}{5}$

P8.70 The tension at the bottom is greater than the performer can withstand.

P8.72 (a) 5R/2; (b) $6mg$

P8.74 (a) No, mechanical energy is not conserved in this case; (b) 77.0 m/s

P8.76 25.2 km/h and 27.0 km/h

P8.78 (a) 21.0 m/s; (b) 16.1 m/s

P8.80 (a) (627 N)y; (b) $U_s = 0$, $\frac{1}{2}(81\text{ N/m})(39.2\text{m} - y)^2$; (c) (627 N)$y$, (40.5 N/m) y^2 − (2 550 N)y + 62 200 J; (d) See ANS. FIG. P7.78(d); (e) 10.0 m; (f) stable equilibrium, 31.5 m; (g) 24.1 m/s

P8.82 (a) $\frac{1.60\text{ m}}{1 + 8.64\text{ N}^2/\text{F}^2}$; (b) 0.166 m; (c) 1.47 m; (d) $H \rightarrow 0$ as is reasonable; (e) H → 1.60 m; (f) $(0.800\text{ m})\left(1 - \frac{1}{\sqrt{1 + F^2/8.64\text{ N}^2}}\right)$; (g) 0.574 m; (h) 0.800 m

P8.84 (a) 3.00λ; (b) 7.42 m/s