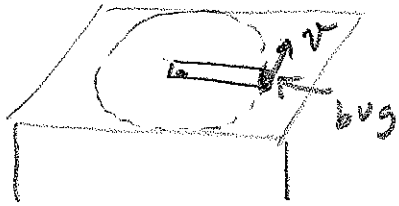
10.45)



$m_{bug} = 10g = .01 kg$

thin uniform bar initially at rest.

$m_{bar} = 50g = 0.05 kg$

$\ell = 100cm = 1m$

$v = 20 \frac{cm}{s} = 0.2 m/s$

a.) Angular speed of bar after bug leaps?

$$L_i^{net} = L_f^{net}$$

$$L_i^{net} = L_i^{bug} + L_i^{bar} = 0 \quad \text{(at rest)}$$

$$L_f^{net} = L_f^{bug} + L_f^{bar} = rmv + I_{bar}\omega$$

$$I_{bar} = \frac{1}{12}m\ell^2 + m\left(\frac{\ell}{4}\right)^2 = \frac{m\ell^2}{3}$$

Conservation of Angular Momentum: $L_i^{net} = L_f^{net}$

$$0 = (1)(.01)(0.2) + \frac{(.05)(1)^2}{3}\omega$$

$$0 = 0.002 + 0.0167\omega \Rightarrow \omega = -\frac{0.002}{0.0167} = \boxed{-0.12 \frac{rad}{s}}$$

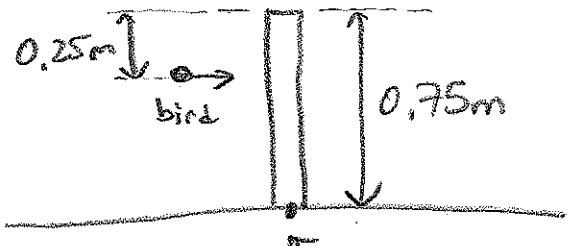
b.) $K_f^{net} = K_f^{bug} + K_f^{bar} = \frac{1}{2}m_b v^2 + \frac{1}{2}I_{bar}\omega^2$

$$K_f^{net} = \frac{1}{2}(0.01)(0.2)^2 + \frac{1}{2}\underbrace{\left[\frac{1}{3}(0.05)(1)^2\right]}_{1/3\, m\ell^2}(-0.12)^2$$

$$K_f^{net} = 0.002 + 0.0012 = \boxed{0.00312 J}$$

c) The bug pushes against the bar to jump and thus it does work on the system, hence ↑ in KE.

10.91.)



$m_b = 500g = 0.5\,kg$

$v = 2.25\ m/s$

$m_{bar} = 1.5\,kg$

bird drops to ground upon impact. Bar rotates upon impact.

a) ω of bar = ? (after impact)

$\Sigma\tau = 0 \Rightarrow$ Conservation of Angular Momentum

$L_i^{net} = L_f^{net}$ $\quad L_i^{net} = L_i^{bird} + L_i^{bar} = rmv + 0$ ← not rotating

r ← distance from bird to axis

$L_i^{net} = (0.75 - 0.25)(0.5)(2.25) = 0.5625\ J_s$ ← units of Angular Momentum can be Joule-sec.

$L_f^{net} = L_f^{bird} + L_f^{bar} = 0 + I_{bar}\omega$

↑ drops to ground

$I_{bar} = \frac{1}{12}ml^2 + m\left(\frac{l}{2}\right)^2 = \frac{ml^2}{3}$

$\Rightarrow L_f^{net} = \frac{(1.5)(0.75)^2}{3}\omega = 0.28125\,\omega$

$L_i^{net} = L_f^{net} \Rightarrow 0.5625 = 0.28125\,\omega \Rightarrow \boxed{\omega = 2.00\ \frac{rad}{s}}$

b.) ω of bar just as it reaches ground

Use $U_1 + K_1 + W_{other} = U_2 + K_2$ (for bar) bird is gone from scene!

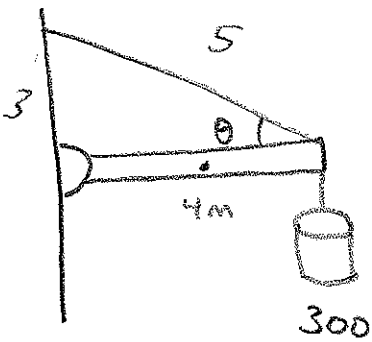
$U_1 = m_{bar} g \left(\frac{0.75}{2}\right)$ ← y_{cm} $\quad K_1 = \frac{1}{2}I_{bar}\omega^2 = \frac{1}{2}\cdot\frac{1}{3}m_{bar}(0.75)^2(2)^2$

$U_2 = 0$ (ground) $\quad K_2 = \frac{1}{2}I_{bar}\omega_f^2 = \frac{1}{2}\cdot\frac{1}{3}m_{bar}(0.75)^2\omega_f^2$

$m_{bar} g\left(\frac{0.75}{2}\right) + 0.375\,m_{bar} = 0.09375\,m_{bar}\omega_f^2$

$\Rightarrow \boxed{\omega_f = 6.57\ rad/s}$

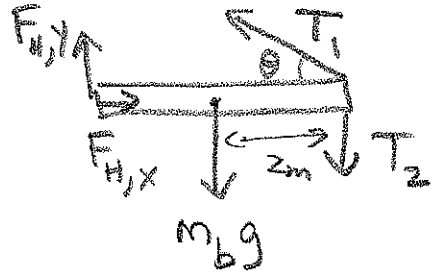
11.14)

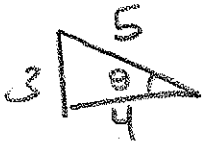


$m_{beam}g = m_b g = 150N$

Tension in cable = ?

① FBD for BEAM





$\sin\theta = 3/5$

$\cos\theta = 4/5$

② Axes: ↑ y, → x ccw = + cw = −

③ $\Sigma F_x = -T_1\cos\theta + F_{H,x} = 0$ $\Sigma F_y = T_1\sin\theta + F_{H,y} - m_b g - T_2 = 0$

④ $\Sigma \tau_{\text{about hinge}} = F_{H,y}(0) + F_{H,x}(0) - m_b g(2) + (T_1\sin\theta)4 - T_2(4) = 0$

($m_b g$ = 150N; $F_{H,y}(0)$ → 0; $F_{H,x}(0)$ → 0; $(T_1\sin\theta)4$: 4 → x)

From FBD for suspended weight (T_2 ↑, $m_b g$ ↓)

$\Sigma F_y = T_2 - 300 = 0$

$\boxed{T_2 = 300\ N}$

Substitute T_2 in $\Sigma\tau$: $-300 + T_1 \cdot \frac{3}{5} \cdot 4 - 300(4) = 0$

$-300 + \frac{12}{5}T_1 - 600 = 0 \Rightarrow \frac{12}{5}T_1 = 1500 \Rightarrow T_1 = 1500\cdot\left(\frac{5}{12}\right)$

$\boxed{T_1 = 625\ N}$

b.) Horizontal and vertical components wall exerts on beam!

$\vec{F}_{wall} = F_{H,x}\,\hat{i} + F_{H,y}\,\hat{j}$

From ΣF_x, $F_{H,x} = T_1\cos\theta$

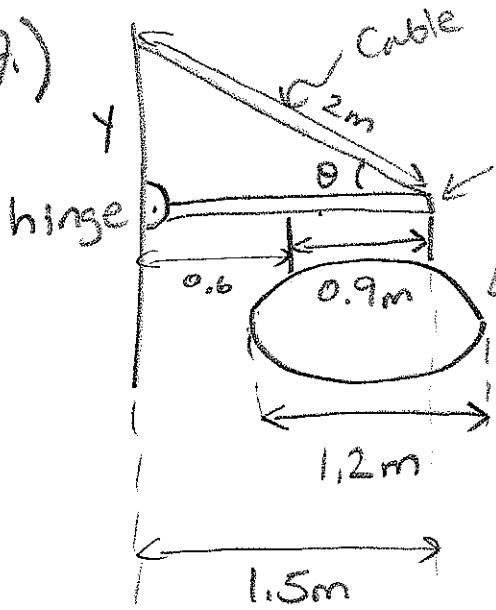
$F_{H,x} = 625(4/5) = 500N$

From ΣF_y: $F_{H,y} = m_b g + T_2 - T_1\sin\theta = 150N + 300 - 625\left(\frac{3}{5}\right)$

$F_{H,y} = 450 - 375 = 75N$

$\therefore \boxed{\vec{F}_{wall} = 500N\,\hat{i} + 75N\,\hat{j}}$

11.47)

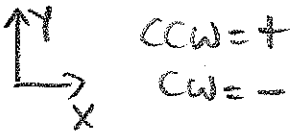


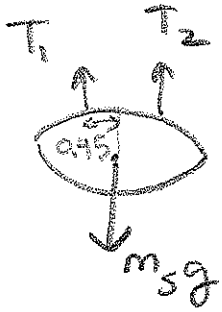
$Y^2 + (1.5)^2 = 2^2$

$Y = \sqrt{4 - (9/4)} = 1.32m$

Tension in cable = ?

① FBD for Sign





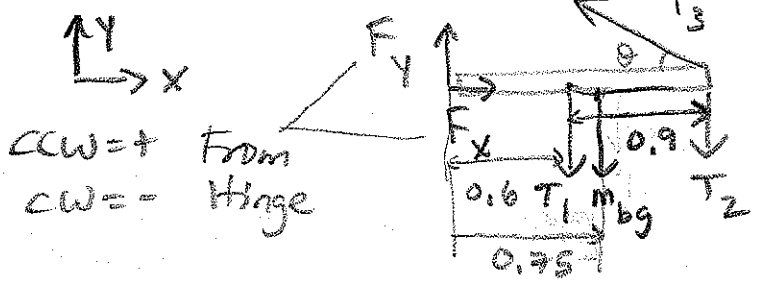
$\Sigma F_y = T_1 + T_2 - m_s g = 0$

$\Sigma \tau_{center} = -T_1(0.45) + T_2(0.45) = 0$

$\Rightarrow T_1 = T_2$

So $\Sigma F_y \Rightarrow 2T_1 = m_s g \Rightarrow T_1 = \frac{m_s g}{2}$

② FBD for Beam



$\Sigma F_y = T_3 \sin\theta + F_y - m_b g - T_1 - T_2 = 0$

$T_3 \sin\theta + F_y - m_b g - \frac{m_s g}{2} - \frac{m_s g}{2} = 0$

$T_3 \sin\theta + F_y - m_b g - m_s g = 0$

$\Sigma F_x = F_x - T_3 \cos\theta = 0 \Rightarrow F_x = T_3 \cos\theta$

$\Sigma \tau_{\text{about hinge}} = F_y(0) + F_x(0) - m_b g(0.75) - 0.6T_1 - 1.5T_2 + T_3 \sin\theta(1.5) = 0$

$-0.75 m_b g - 0.6\left(\frac{m_s g}{2}\right) - 1.5\left(\frac{m_s g}{2}\right) + T_3 \sin\theta(1.5) = 0$

$-13.5g - \frac{2.1}{2}(m_s g) + T_3 \sin\theta(1.5) = 0$

$\sin\theta = \frac{Y}{2}$

$Y = 1.32m$

$\sin\theta = 0.66$

$-13.5g - 1.05(28)g + T_3(0.66)(1.5) = 0$

$0.99 T_3 = 13.5g + 1.05(28)g = 420.42$

$\boxed{T_3 = 425\,N}$

11.47 cont.) b) $F_y = ?$

From ΣF_y for beam: $T_3 \sin\theta + F_y - m_b g - m_s g = 0$

$F_y = m_b g + m_s g - T_3 \sin\theta$

$Y = 1.32$

$\sin\theta = \frac{1.32}{2} = 0.66$

$F_y = 18g + 28g - 425(0.66)$

$F_y = 46g - 280.5 = \boxed{170\ N}$

c) $\sqrt{2gh(1 - y/d)}$
7.63 48.2°
7.65 a) 0.392 b) −0.832 J
7.67 a) $U(x) = (30.0\ \text{N/m})x^2 + (6.00\ \text{N/m}^2)x^3$ b) 7.85 m/s
7.69 7.01 m/s
7.71 a) $m(g + a)^2/2gh$ b) $2gh/(g + a)$
7.73 119 J
7.75 a) 3.87 m/s b) 0.10 m
7.77 a) $F_x = -m\omega_0^2 x$, $F_y = -m\omega_0^2 x$, b) $\frac{1}{2}m\omega_0^2(x^2 + y^2)$ c) (i) $\frac{1}{2}m\omega_0^2(x_0^2 + y_0^2)$ (ii) $\frac{1}{2}m\omega_0^2(x_0^2 + y_0^2)$
7.79 a) 4.4×10^{12} J b) 2.7×10^3 m³; 0.90 mm
7.81 c) attracts
7.83 a) −50.6 J b) −67.5 J c) nonconservative
7.85 a) no b) $x_0 = F/k$ d) no e) $3F/k$, $-F/k$ f) $v_{max} = 2F/\sqrt{mk}$ at $x = x_0 = F/k$
7.87 b) $v(x) = \left[\frac{2\alpha}{mx_0^2}\left(\frac{x_0}{x} - \left[\frac{x_0}{x}\right]^2\right)\right]^{1/2}$
c) $x = 2x_0$, $v = \sqrt{\alpha/2mx_0^2}$ d) zero
e) $v(x) = \left[\frac{2\alpha}{mx_0^2}\left(\frac{x_0}{x} - \left[\frac{x_0}{x}\right]^2 - \frac{2}{9}\right)\right]^{1/2}$
f) first case: x_0, ∞; second case: $3x_0/2$, $3x_0$

Chapter 8

8.1 a) 1.20×10^5 kg · m/s b) i) 60.0 m/s ii) 26.8 m/s
8.3 b) baseball, 0.525 c) woman, 0.643
8.5 a) 22.5 kg · m/s, to the left b) 838 J
8.7 562 N, no
8.9 a) 10.8 m/s, to the right b) 0.75 m/s, to the left
8.11 a) 500 N/s² b) 5810 kg · m/s c) 2.70 m/s
8.13 a) 2.50 N · s b) i) +6.25 m/s, to the right b) ii) 3.75 m/s, to the right
8.15 a) 6.79 m/s b) 55.2 J
8.17 a) 0.790 m/s b) −0.0023 J
8.19 0.866 kg · m/s
8.21 a) 0.0559 m/s b) 0.0313 m/s
8.23 3.65×10^5 m/s
8.25 a) 7.20 m/s b) −680 J
8.27 3.56 m/s
8.29 a) 0.846 m/s b) 2.10 J
8.31 a) 1.4×10^{-6} km/h, which is not noticeable. b) 6.7×10^{-8} km/h, which is not noticeable.
8.33 5.9 m/s at 32° east of north
8.35 a) Both cars have the same change in momentum, but the smaller car has a greater velocity change. b) $2.5\,\Delta v$ c) Those in the smaller car
8.37 19.5 m/s (car), 21.9 m/s (truck)
8.39 a) 2.93 cm b) 866 J c) 1.73 J
8.41 a) 0.333 m/s, 3.33 J b) −1.33 m/s (*A*), +0.67 m/s (*B*)
8.43 a) −0.100 m/s (*A*), 0.500 m/s (*B*) b) 0.009 kg · m/s for both c) -4.5×10^{-4} J (*A*), 4.5×10^{-4} J (*B*), same magnitudes because the collision is elastic
8.45 a) 1/3 b) 1/9 c) 10
8.47 $x_{cm} = 0.044$ m, $y_{cm} = 0.056$ m
8.49 2520 km from the center of Pluto
8.51 0.700 m upward and 0.700 m to the right
8.53 0.47 m/s
8.55 $F_x = (-1.50\ \text{N/s})t$, $F_y = 0.25$ N, $F_z = 0$
8.57 a) 53 g b) 5.22 N
8.59 2.4 km/s
8.61 45.1
8.63 a) 0.47 N · s b) 237 N
8.65 a) $J_x = -1.14$ N · s, $J_y = 0.33$ N · s b) $v_{2x} = 0.0500$ m/s, $v_{2y} = 1.78$ m/s
8.67 2.67 m/s (convertible), 3.46 m/s (SUV)
8.69 a) $v_{Cx} = 1.75$ m/s, $v_{Cy} = 0.26$ m/s b) −0.092 J
8.71 15.0 m/s
8.73 36.4 N
8.75 a) 2.60 m/s b) 325 m/s
8.77 a) 5.28 m/s b) 5.7 m
8.79 68.8°
8.81 102 N
8.83 a) 0.222 b) −291 J c) 0.784 J
8.85 b) $M = m$ c) zero
8.87 a) 9.35 m/s b) 3.29 m/s
8.89 b) $\frac{1}{2}Mv_{cm}^2$
8.91 a) 3.56 m/s b) 5.22 m/s c) 4.67 m/s
8.93 0.00544%
8.95 1.61×10^{-22} kg · m/s, to the left
8.97 *A*: 13.6 m/s; *B*: 6.34 m/s, 65.0°
8.99 a) $(L/2)\cos(\alpha/2)$, along axis from apex b) $(L/3)$, along bisector from bottom c) $L/\sqrt{8}$ along bisector d) $L/\sqrt{12}$ from each side
8.101 0.400 m/s
8.103 a) 1.40 kg: 14.3 m/s; 0.28 kg: 71.6 m/s b) 347 m
8.105 222 m/s, 1.01×10^3 m/s; $v_{Kr} = 1.5v_{Ba}$
8.107 a) zero b) 1 d) 0.87 m f) 0.089 m
8.109 a) yes b) no; kinetic energy decreases by 4.8×10^3 J
8.111 a) $1.37v_{ex}$ b) $1.18v_{ex}$ c) $2.38v_{ex}$ d) 2.94 km/s
8.113 b) $2L/3$
8.115 a) $l^2\lambda g/32$ b) $l^2\lambda g/32$

Chapter 9

9.1 a) 34.4° b) 6.27 cm c) 1.05 m
9.3 a) *A*: rad/s; *B*: rad/s³ b) (i) 0 (ii) 15.0 rad/s² c) 9.50 rad
9.5 a) $\omega_z(t) = (0.400\ \text{rad/s}) + (0.0360\ \text{rad/s}^3)t^2$ b) 0.400 rad/s c) $\omega_z = 1.30$ rad/s; $\omega_{av-z} = 0.700$ rad/s
9.7 a) $a = \pi/4$ rad, $b = 2.00$ rad/s, $c = -0.139$ rad/s³ b) zero c) 19.5 rad; 9.35 rad/s
9.9 a) 2.25 rad/s b) 4.69 rad
9.11 a) 24.0 s b) 68.8 rev
9.13 10.5 rad/s
9.15 a) 300 rpm b) 75.0 s; 312 rev
9.17 9.00 rev
9.19 a) 540 rad b) 12.3 s c) −8.17 rad/s²
9.21 a) 1.99×10^{-7} rad/s b) 7.27×10^{-5} rad/s c) 2.99×10^4 m/s d) 464 m/s e) 0.0337 m/s²; zero
9.23 a) 15.1 m/s² b) 15.1 m/s²
9.25 a) 0.180 m/s²; 0; 0.180 m/s² b) 0.180 m/s²; 0.377 m/s²; 0.418 m/s² c) 0.180 m/s²; 0.754 m/s²; 0.775 m/s²
9.27 10.7 cm; no
9.29 a) 0.831 m/s b) 109 m/s²
9.31 a) 2.29 b) 1.51 c) 15.7 m/s, 108*g*
9.33 2.99 cm
9.35 a) (i) 0.469 kg · m² (ii) 0.117 kg · m² (iii) zero b) (i) 0.0433 kg · m² (ii) 0.0722 kg · m² c) (i) 0.0288 kg · m² (ii) 0.0144 kg · m²
9.37 a) 0.0640 kg · m² b) 0.0320 kg · m² c) 0.0320 kg · m²
9.39 0.193 kg · m²
9.41 8.52 kg · m²
9.43 a) 3.15×10^{23} J b) 158 y; no
9.45 0.600 kg · m²
9.47 7.35×10^4 J
9.49 a) 67.3 cm b) 45.5%
9.51 a) f^5 b) 6.37×10^8 J
9.53 −88.2 J
9.55 on an axis parallel to a diameter and $(2/\sqrt{15})R$ from the center of the sphere
9.57 $\frac{1}{3}M(a^2 + b^2)$
9.59 a) $ML^2/12$ b) $ML^2/12$
9.61 $MR^2/2$
9.63 a) $\gamma L^2/2$ b) $ML^2/2$; larger c) $ML^2/6$; one-third result of (b)
9.65 in 128 d
9.67 a) 0.600 m/s³ b) $\alpha = (2.40\ \text{rad/s}^3)t$ c) 3.54 s d) 17.7 rad
9.69 a) 0.050 rad/s² b) 0.300 rad/s c) 5.40 m/s² e) 6.18 m/s²; 7.66×10^3 N f) 60.9°
9.71 a) 1.70 m/s b) 84.8 rad/s
9.73 b) 2.00 m/s² d) 0.208 kg · m²
9.77 a) 7.36 m b) 327 m/s²
9.79 a) 2.14×10^{29} J b) 2.66×10^{33} J
9.81 a) $Mb^2/6$ b) 182 J
9.83 a) −0.784 J b) 5.42 rad/s c) 5.42 rad/s d) particle speed = 4.43 m/s
9.85 $\sqrt{(2gd)(m_B - \mu_k m_A)/(m_A + m_B + I/R^2)}$
9.87 $\sqrt{(g/R)(1 - \cos\beta)}$
9.89 a) 2.25×10^{-3} kg · m² b) 3.40 m/s c) 4.95 m/s
9.91 7.23 m
9.93 a) $(247/512)MR^2$ b) $(383/512)MR^2$
9.95 b) $\frac{1}{4}M(R_1^2 + R_2^2)$
9.97 a) $\frac{3}{5}MR^2$ b) larger
9.99 b) 5.97×10^{24} kg c) $0.334MR^2$
9.101 a) $s = r_0\theta + \beta\theta^2/2$ b) $\theta = (1/\beta)[\sqrt{r_0^2 + 2\beta vt} - r_0]$ c) $\omega_z = \dfrac{v}{\sqrt{r_0^2 + 2\beta vt}}$, $\alpha_z = \dfrac{\beta v^2}{(r_0^2 + 2\beta vt)^{3/2}}$; no d) $r_0 = 2.50$ cm, $\beta = 0.247$ μm/rad; 2.13×10^4 rev

Chapter 10

10.1 a) 40.0 N · m, out of the page b) 34.6 N, out of the page c) 20.0 N · m, out of the page d) 17.3 N · m, into the page e) zero f) zero
10.3 2.50 N · m, counterclockwise
10.5 b) into page c) $(-1.05\ \text{N} \cdot \text{m})\hat{k}$
10.7 13.1 N · m
10.9 a) 14.8 rad/s² b) 1.52 s
10.11 7.47 N
10.13 0.482
10.15 a) 7.5 N in horizontal part, 18.2 N in hanging part b) 0.0160 kg · m²
10.17 a) 2.65 rad/s² b) no c) 3.31 m/s²; no
10.19 a) 1.80 m/s b) 7.13 J c) (i) 3.60 m/s, to the right (ii) 0 (iii) 2.55 m/s, 45° below horizontal d) (i) 1.80 m/s, to the right (ii) 1.80 m/s, to the left (iii) 1.80 m/s, downward
10.21 a) 1/3 b) 2/7 c) 2/5 d) 5/13
10.23 a) 0.613 b) no, requires $\mu_s = 0.858$ c) no slipping
10.25 11.7 m
10.27 a) 0.309 rad/s b) 100 J c) 6.67 W
10.29 a) 0.38 N · m b) 160 rad c) 59 J d) 59 J
10.31 b) 65.6 N
10.33 a) 358 N · m b) 1.79×10^3 N c) 83.8 m/s
10.35 a) 115 kg · m²/s, into the page b) 125 kg · m²/s², out of the page
10.37 4.71×10^{-6} kg · m²/s
10.39 4.6×10^3 rad/s
10.41 1.14 rev/s
10.43 0.60 rev
10.45 a) 0.120 rad/s b) 3.20×10^{-4} J; work done by bug
10.47 a) 5.88 rad/s
10.49 a) 1.62 N b) 1.80×10^3 rev/min
10.51 a) halved b) doubled c) halved d) doubled e) unchanged
10.53 a) 67.6 N b) 62.9 N c) 3.27 s
10.55 a) 840 rpm b) 75 mph c) 60 mph
10.57 a) 16.3 rad/s² b) no; decreases c) 5.70 rad/s
10.59 a) at $x = l$ b) at $x = l$ c) at $x = (l/2)(1 + [2h/l]^2)$ for $l > 2h$; at $x = l$ for $l < 2h$
10.61 a) FR b) FR; yes c) $\sqrt{4F/MR}$ d) $2F/M$ e) $4F/M$
10.63 a) 266 N b) 4.71 rad/s²
10.65 a) 2.88 m/s² b) 6.13 m/s²; greater in case (b)
10.67 239 N
10.69 $a = \dfrac{2g}{2 + (R/b)^2}$; $\alpha = \dfrac{2g}{2b + R^2/b}$; $T = \dfrac{2mg}{2(b/R)^2 + 1}$
10.71 clockwise; clockwise; clockwise
10.73 a) 1.41 s; 70.5 m/s b) t larger, v smaller
10.75 29.0 m/s
10.77 a) 26.0 m/s b) unchanged
10.79 a) $\sqrt{20hy/7}$ b) no c) rolling friction d) $\sqrt{8hy/3}$

10.81 b) R = radius of wheel, T = period of wheel's rotation
c) $v_x = \frac{2\pi R}{T}\left[1 - \cos\left(\frac{2\pi t}{T}\right)\right]$, $v_y = \frac{2\pi R}{T}\sin\left(\frac{2\pi t}{T}\right)$; $a_x = \left(\frac{2\pi R}{T}\right)^2 R\sin\left(\frac{2\pi t}{T}\right)$, $a_y = \left(\frac{2\pi R}{T}\right)^2 R\cos\left(\frac{2\pi t}{T}\right)$
d) $t = 0, T, 2T, \ldots$; $a_x = 0$, $a_y = \frac{4\pi^2 R}{T^2}$
e) $\frac{4\pi^2 R}{T^2}$, independent of time
10.83 $g/3$
10.85 1.87 m
10.87 a) $6v/19L$ b) $3/19$
10.89 a) 5.46 rad/s b) 3.17 cm
c) 1.01×10^3 m/s
10.91 a) 2.00 rad/s b) 6.57 rad/s
10.93 0.30 rad/s, clockwise
10.97 -4.2×10^{-16} rad/s per year; decreasing
10.101 a) $a = +\mu_k g$, $\alpha = -2\mu_k g/R$
b) $\omega_0^2 R^2/18\mu_k g$ c) $-M\omega_0^2 R^2/6$
10.103 a) $mv_1^2 r_1^2/r^3$ b) $(mv_1^2/2)[(r_1/r_2)^2 - 1]$
c) same

Chapter 11

11.1 29.8 cm
11.3 20.0 kg
11.5 5450 N
11.7 a) 1000 N, 1.20 m from end where 400-N force is applied b) 800 N, 1.25 m from end where 400-N force is applied
11.9 a) 550 N b) 0.614 m from A
11.11 a) 1920 N b) 1140 N
11.13 a) $T = 2.60w$; $F_{\text{pivot}} = 3.28w$ at 37.6°
b) $T = 4.10w$; $F_{\text{pivot}} = 5.38w$ at 48.8°
11.15 140 N by each hinge
11.17 246 N; 0.34 m behind front feet
11.19 $T_{\text{left}} = 270$ N, $T_{\text{right}} = 304$ N, $\theta = 40°$
11.21 a) 0.800 m b) clockwise c) 0.800 m, clockwise
11.23 1.4 mm
11.25 2.00×10^{11} Pa
11.27 a) upper: 3.1×10^{-3}; lower: 2.0×10^{-3}
b) upper: 1.6 mm; lower: 0.98 mm
11.29 9.1×10^6 N
11.31 a) 3.33×10^6 Pa b) 1.33×10^5 Pa
11.33 a) 4.8×10^9 Pa; 2.1×10^{-10} Pa^{-1}
11.35 b) 6.60×10^5 N c) 1.8 mm
11.37 3.41×10^7 Pa
11.39 10.2 m/s^2
11.41 a) 525 N b) 222 N, 328 N c) 1.48
11.43 wing force: 7300 N upward; tail force: 600 N downward
11.45 a) 140 N b) 6 cm to the right
11.47 a) 424 N b) 170 N
11.49 120 N to the right, 160 N upward
11.53 b) $(Mg/2)\sin\theta$
11.55 a) $V = mg + w$, $H = T = (w + mg/4)\cot\theta$
b) 950 N c) 4.00°
11.57 7600 N
11.59 a) 2700 N b) 19
11.61 a) 4.90 m b) 60 N
11.63 a) $\theta = \arctan(h/d)$; $T = (Wd/2)\sqrt{h^2 + d^2}$
b) $\frac{Whd}{2(h^2 + d^2)}$; $W\frac{2h^2 + d^2}{2(h^2 + d^2)}$
11.65 a) 1150 N b) 1940 N c) 918 N d) 0.473
11.67 person above: 590 N; person below: 1370 N; above
11.69 a) $w_{\max} = T_{\max} hD/(L\sqrt{h^2 + D^2})$
11.71 a) 7140 N; tall walls b) 7900 N
11.73 a) 268 N b) 232 N c) 366 N
11.75 a) A: 0.424 N; B: 1.47 N; C 0.424 N
b) 0.848 N
11.77 a) tips at 27°, slips at 31°; the bale tips before it slips b) tips at 27° slips at 22° the bale slips before it tips
11.79 a) $F_A = 80$ N, $F_B = 870$ N b) 1.92 m
11.81 a) 3.7 kN, 2.0 kN vertically upward
11.83 a) $0.012w$ b) less c) 25.0°; tips
11.85 a) 5.4 mm b) 4.2 mm
11.87 a) 0.70 m from wire A b) 0.45 m from wire B
11.89 a) 1.63 m b) brass: 2.00×10^8 Pa; nickel: 4.00×10^8 Pa c) brass: 2.2×10^{-3}; nickel: 1.9×10^{-3}
11.91 a) 0.36 mm b) 0.045 mm c) 0.33 mm
11.93 a) $(F\cos^2\theta)/A$ b) $(F\sin 2\theta)/2A$ c) 0
d) 45°
11.95 a) 600 N b) 13.5 kN
c) slide: $\mu_s w/(\sin\theta - \mu_s\cos\theta)$; tip: $w/[(\frac{1}{2})\cos\theta + 2\sin\theta]$; 66°
11.97 the lesser of $h^2/L + L/2$ and L
11.99 $[(A^2x/F) - k_O V_O]/V_S$
11.101 a) 0.662 mm b) 2.20×10^{-2} J
c) 8.33×10^{-3} J d) -3.04×10^{-2} J
e) 3.04×10^{-2} J

Chapter 12

12.1 2.18
12.3 0.026 mm
12.5 a) 2.59×10^8 m b) no
12.7 a) 2.40×10^{-3} N b) 3.6×10^{-6}
12.9 a) 6.30×10^{20} N, toward sun
b) 4.77×10^{20} N, 24.6° toward earth from sun
c) 2.37×10^{20} N, toward sun
12.11 a) 0.366 m from mass m b) (i) unstable (ii) stable
12.13 2.1×10^{-9} m/s^2, down
12.15 1.38×10^7 m
12.17 a) 0.37 m/s^2 b) 1700 kg/m^3
12.19 610 N; 83% of weight at surface
12.21 5.98×10^{24} kg
12.23 0.83 m/s; yes
12.25 a) 5.02×10^3 m/s b) 6.06×10^4 m/s
12.27 a) 7.46×10^3 m/s b) 1.68 h
12.29 2.01×10^{30} kg
12.31 a) 4.7 m/s; yes b) 2.2 h
12.33 a) 8.3×10^4 m/s b) 1.3×10^6 s
12.35 a) 4.45×10^{12} m, 4.55×10^{12} m b) 248 y
12.39 a) (i) 5.31×10^{-9} N (ii) 2.67×10^{-9} N
12.41 a) $-GMm/\sqrt{a^2 + x^2}$
c) $GMmx/(a^2 + x^2)^{3/2}$ toward center of ring
e) $-GMm/a$, zero
12.43 a) 53 N b) 52 N
12.45 1.39×10^{-9}
12.47 a) 4.3×10^{37} kg, $2.1 \times 10^7 M_{\text{sun}}$ b) no
c) 6.3×10^{10} m; yes
12.49 a) 9.67×10^{-12} N, midway between x and y axes b) 3.02×10^{-5} m/s
12.51 b) 5.39×10^{-13} N · m, clockwise
12.53 b) (i) 1.63×10^{-5} m/s, 4.08×10^{-6} m/s
(ii) 2.04×10^{-5} m/s c) 31.9 m
12.55 a) 3.58×10^7 m
12.57 1.8×10^2 m/s
12.59 a) 1.39×10^7 m b) 3.59×10^7 m
12.61 $0.01R_E = 64$ km
12.63 0.28%
12.65 6.06×10^3 km/h
12.67 $\sqrt{2Gm_E h/(R_E^2 + hR_E)}$
12.69 a) 13.7 km/s b) 13.3 km/s c) 13.2 km/s
12.71 a) (i) 2.8 y (ii) 6.1 y b) 4.90×10^8 km
c) 4.22×10^8 km
12.73 a) $GM^2/4R^2$ b) $\sqrt{GM/4R}$, $4\pi\sqrt{R^3/GM}$
c) $GM^2/4R$
12.75 6.8×10^4 m/s
12.77 a) 7.91×10^3 s b) 1.53
c) 8.43×10^3 m/s, 5.51×10^3 m/s
d) 2.41×10^3 m/s, 3.26×10^3; perigee
12.79 3.22×10^9 J
12.81 9.36 m/s^2
12.83 $\frac{GmM}{x(x + L)}$
12.85 a) $U(r) = \frac{Gm_E m}{2R_E^3}r^2$ b) 7.90×10^3 m/s
12.87 a) against the direction of motion in all cases
b) 2.24×10^7 s c) 44.1°
12.89 $F = \frac{2GMm}{a^2}\left[1 - \frac{x}{\sqrt{a^2 + x^2}}\right]$, toward the center of the disk

Chapter 13

13.1 a) 4.54×10^{-3} s, 1.38×10^3 rad/s
b) 2.27×10^{-3} s, 2.76×10^3 rad/s
13.3 5.53×10^3 rad/s, 1.14×10^{-3} s
13.5 0.0500 s
13.7 a) 0.167 s b) 37.7 rad/s c) 8.44×10^{-2} kg
13.9 a) 0.375 s b) 2.66 Hz c) 16.7 rad/s
13.11 a) 0.98 m b) $\pi/2$ rad
c) $x(t) = (-0.98\text{ m})\sin([12.2\text{ rad/s}]t)$
13.13 a) -2.71 m/s^2
b) $x(t) = (1.46\text{ cm})\cos([15.7\text{ rad/s}]t + 0.715\text{ rad})$,
$v_x(t) = (-22.9\text{ cm/s})\sin([15.7\text{ rad/s}]t + 0.715\text{ rad})$,
$a_x(t) = (-359\text{ cm/s}^2)\cos([15.7\text{ rad/s}]t + 0.715\text{ rad})$
13.15 120 kg
13.17 a) 0.253 kg b) 1.22 cm c) 3.05 N
13.19 a) 1.51 s b) 26.0 N/m c) 0.308 m/s
d) 1.92 N e) -0.0125 m; 0.303 m/s; 0.216 m/s^2
13.21 a) 1.48 m/s b) 2.96×10^{-5} J
13.23 a) 1.20 m/s b) 1.11 m/s c) 36 m/s^2
d) 13.5 m/s^2 e) 0.36 J
13.25 $m = 3M$; $\frac{3}{4}$
13.27 0.240 m
13.29 a) 0.0778 m b) 1.28 Hz c) 0.624 m/s
13.31 a) 4.06 cm b) 1.21 m/s c) 29.8 rad/s
13.33 b) 23.9 cm; 1.45 Hz
13.35 a) 2.7×10^{-8} kg · m^2
b) 4.3×10^{-6} N · m/rad
13.37 5.12×10^{-2} kg · m^2
13.41 a) 0.25 s b) 0.25 s
13.43 0.407 swings/s
13.45 2.00 m
13.47 10.7 m/s^2
13.49 0.129 kg · m^2
13.53 A: $2\pi\sqrt{L/g}$; B: $(4\pi\sqrt{2}/3)\sqrt{L/g} = 0.943T_A$; pendulum A
13.55 A: $2\pi\sqrt{L/g}$; B: $2\pi\sqrt{\frac{11L}{10g}} = 1.05T_A$; pendulum B
13.57 a) 0.393 Hz b) 1.73 kg/s
13.59 a) A b) magnitude = $bA/2m$, in $-x$-direction; slope is negative
c) $a_x(0) = A\left(\frac{b^2}{2m^2} - \frac{k}{m}\right)$; if $b < \sqrt{2mk}$, $a(0) < 0$; if $b = \sqrt{2mk}$, $a(0) = 0$; if $b > \sqrt{2mk}$, $a(0) > 0$
13.61 a) kg/s b) (i) $5.0F_{\max}/k$ (ii) $2.5F_{\max}/k$
13.63 a) 6.72×10^3 m/s^2 b) 3.02 kN
c) 18.3 m/s, 75.6 J d) 17.6 kW e) 12.1 kN, 36.7 m/s, 302 J, 141 kW
13.65 a) all unchanged b) 1/4 as large c) halved
d) $1/\sqrt{5}$ as great e) U: unchanged; K: 1/5 as large
13.67 a) 24.4 cm b) 0.220 s c) 1.19 m/s
13.69 a) 0.318 Hz, 0.500 m, 3.14 s b) 1.57 s
13.71 $\frac{1}{2\pi}\sqrt{\frac{3\sqrt{2}}{5}}\sqrt{\frac{g}{L}} = 0.921\left(\frac{1}{2\pi}\sqrt{\frac{g}{L}}\right)$
13.73 a) 1.49 s b) -2.12×10^{-4} s per s; shorter
c) 0.795 s
13.75 a) 0.150 m/s b) 0.112 m/s^2, downward
c) 0.700 s d) 4.38 m
13.77 a) 2.6 m/s b) 0.21 m c) 0.49 s
13.79 9.08×10^{24} kg
13.81 1.17 s
13.83 a) yes c) 2.40×10^3 s d) no
13.87 c) -7.57×10^{-19} J e) 8.39×10^{14} Hz
13.89 0.705 Hz; 14.5°
13.91 $2\pi\sqrt{M/3k}$
13.93 $\frac{1}{4\pi}\sqrt{\frac{3g}{\sqrt{2}L}}$
13.95 c) 0.430 m
13.97 a) $k_{\text{eff}} = k_1 + k_2$ b) $k_{\text{eff}} = k_1 + k_2$
c) $k_{\text{eff}} = \frac{k_1 k_2}{k_1 + k_2}$ d) $\sqrt{2}$