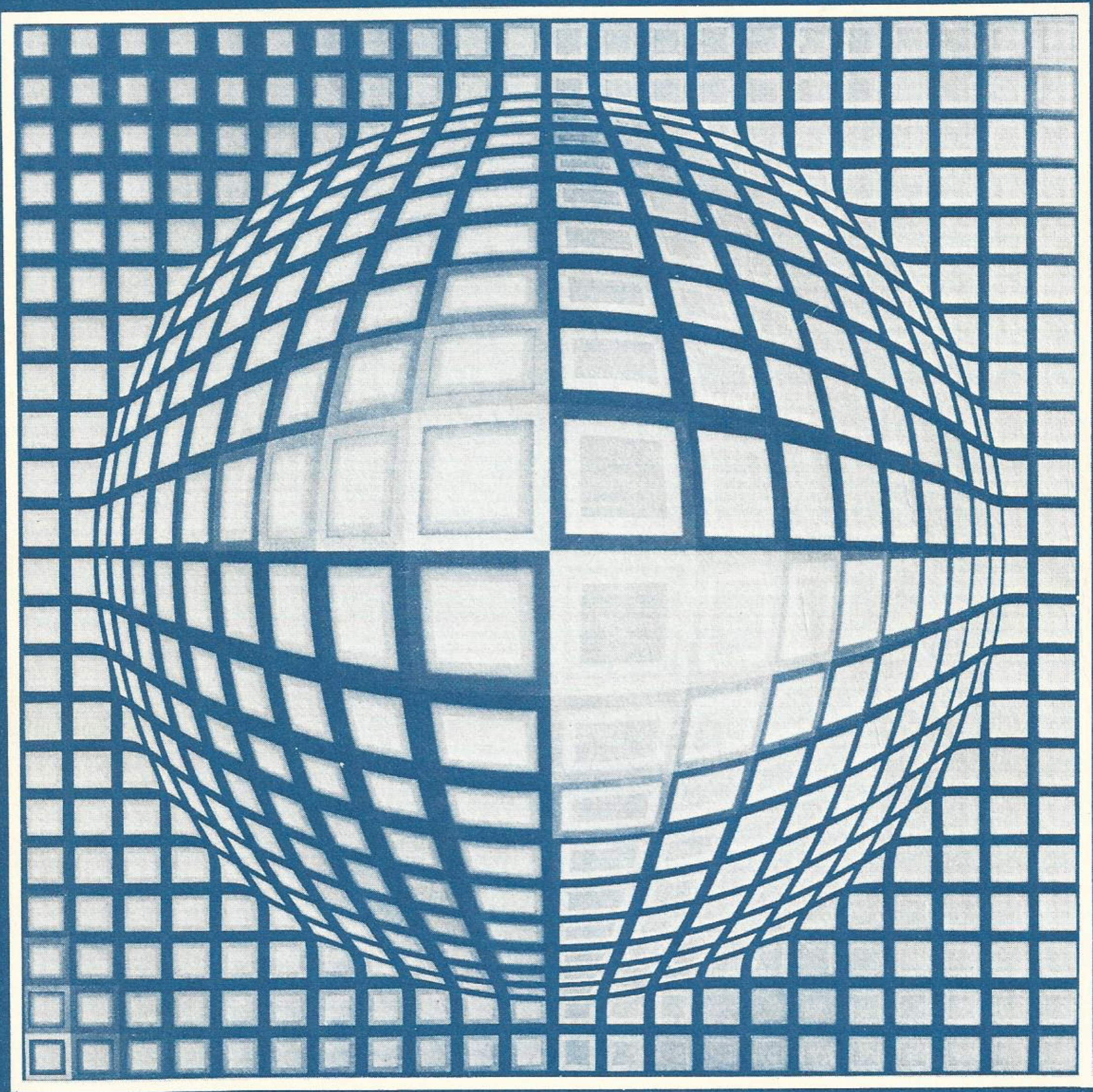
Solutions Manual to Accompany

Eisberg/Lerner: PHYSICS Foundations and Applications *volume* I



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Solutions Manual to Accompany
Eisberg/Lerner:

PHYSICS
Foundations and Applications

volume I

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PREFACE

Volume I (Chapters 1 - 15) of the text Physics: Foundations and Applications contains 636 exercises. Among those, this manual contains solutions to all 348 of the more challenging "non-numerical" exercises (225 in Group B and 123 in Group C), as well as solutions to 33 selected Group A exercises. (This manual does not include solutions to any of the exercises in the Numerical group.) For all even-numbered exercises (Groups A - C) possessing short answers, these are given in a brief section at the front of the manual.

In preparing this manual, we have attempted to write solutions which are full enough to be useful not only for reference by instructors, but also for direct display to students. For many of the exercises, outlines of solutions were available to us, but in almost every such case we have considerably revised or extended them.

We have given most final answers to three significant figures, but have abandoned this convention wherever that appeared appropiate, based on the problem statement or on the numerical details. In most places, g, (the effective value of) the terrestrial acceleration due to gravity, has been assigned the value 9.80 m/s^2.

We have placed a high priority on accuracy, both in the method and in the presentation, but we recognize that some errors must be present. We will be grateful to individuals who notify us or the authors of the text when errors are encountered.

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ANSWERS TO EVEN-NUMBERED EXERCISES

CHAPTER TWO

2-2 (a) 3.3×10^{-4} s; (b) 1.2×10^{-1} s; (c) 1.3 s; (d) 1.3×10^{3} s

2-6 9.33×10^{3} s = 2.6 hr

2-8 (a) 10 m/s; (b) -10 m/s; (c) 20 m/s

2-10 $3ct_i^2$; 6 m/s, 24 m/s

2-12 (a) 1.96×10^{4} m/s^2 up; (b) 6.39×10^{-4} s

2-14 (a), (d), and (e)

2-16 (a) 9.8 m/s = 3.27×10^{-8}c, 4.9 m, 4.9 m/s = 1.63×10^{-8}c; (b) 588 m/s = 1.96×10^{-6}c, 1.76×10^{4} m, 294 m/s = 9.8×10^{-7}c; (c) 3.53×10^{4} m/s = 1.18×10^{-4}c, 6.35×10^{7} m, 1.76×10^{4} m/s = 5.88×10^{-5}c; (d) 8.47×10^{5} m/s = 2.82×10^{-3}c, 3.66×10^{10} m, 4.23×10^{5} m/s = 1.41×10^{-3}c; (e) 2.54×10^{7} m/s = 8.47×10^{-2}c, 3.29×10^{13} m = 3.47×10^{-3} lt-yr 1.27×10^{7} m/s = 4.23×10^{-2}c

2-18 Est: (a) 20 mi/hr; (b) 5000; (c) 1.1 hr, 6.8%

2-20 59.5 m

2-22 (a) 7.35 m/s; (b) 2.76 m

2-24 (a) 1.18×10^{3} m/s; (b) 3.53×10^{4} m; (c) 7.06×10^{4} m; (d) 2 more minutes; (e) 147 s; (f) 1.44×10^{3} m/s

2-30 5

2-34 (a) 6.25 km; (b) 4:52:30 p.m.; (c) 7.14 km/hr; (d) no

2-36 (a) 23.1 m; (b) 13.3 s, 326 m; (c) 24.1 s, 596 m;

(d) 1.35 km

2-38 (a) 1.89 s, 3.19 s; (b) 8.58 s, 84.1 m/s; (c) 354 m/s^2 = 36.1g

CHAPTER THREE

3-2 (a) $v\sqrt{2h/g}$; (b) $\tan^{-1}(v\sqrt{2/gh})$; (c) 3.71 x 10^3 m, 51.1°; (d) directly over point of impact

3-4 (a) 1:2:3; (b) $\sqrt{3}:2:\sqrt{3}$

3-6 (a) 1.92 m/s; (b) 0.391 s

3-8 magnitude 6, direction same (The resultant vector is identical to $\vec{A}$.)

3-10 Taking N to be up and E to the right: (a) $\sqrt{2}$, 45° N of E; (b) 0; (c) $\sqrt{2}$, 45° S of E; (d) $\sqrt{2}$, 45° S of E; (e) 2, E; (f) $\sqrt{2}$, 45° N of E; (g) 0; (h) $2\sqrt{2}$, 45° N of E; (i) $\sqrt{5}$, 63.4° N of E

3-12 (b) (x_1,y_1) = (0,1 m), (x_2,y_2) = (1 m, 1.73 m), (x_3,y_3) = (2.60 m, 1.50 m), $(x_4,y_4$ = (4.00 m, 0), (x_5,y_5) = (3.54 m, -3.54 m). The resultant vector has (x,y) = (11.14 m, 0.69 m).; (c) magnitude 11.2 m, direction 3.5° north of east (or 86.5° east of north)

3-14 (b) The maximum height is twice the height obtained when throwing for maximum range.

3-16 $\tan^{-1}(4)$ = 76.0°

3-18 (a) 7.9 x 10^6 m/s^2; (b) 8.1 x 10^5

3-20 26.9 knots (13.9 m/s) from 21.8° S of W

3-22 (a) $v = L\sqrt{g/2d}$; (b) 582 m/s; (c) 343 m from firing point

3-24 (a) 39.2 km; (b) 5.5 km (ignoring the earth's curvature)

3-26 (a) 12.7 m/s; (b) 15.5 m/s; (c) Difference is 2.8 m/s or 20% of the average, while the average is 7.9 m/s or 36% slower than 22 m/s.; (d) Gravity would appear too strong.

3-28 (a) 12.9°, 77.1°; (b) 4.60 s, 1.37 s

3-30 (a) $\tan\theta = v^2/rg$; (b) 20.2°

3-32 speed = 164 km/hr, compass reading = 14.1° E of N, elevation angle = $-3.1^\circ = 3.1^\circ$ below horizontal

3-34 $\theta_{max} = 45^\circ - \beta/2$

3-36 (a) 45.6° upstream of perpendicular to bank, 0.49 m/s, 102 s; (b) perpendicular to bank, 0.7 m/s, 71.4 s, 35.7 m

CHAPTER FOUR

4-2 back in the funnel

4-4 (a) 2.24 m/s; (b) 214 rev/min

4-8 15.7 N

4-14 447 m/s

4-16 4 kg

4-18 638 N

4-20 (a) 7.07 N northwest; (b) 22.4 kgm/s, 26.6° W of N

4-22 (b) 42.5 m; (c) 3.4 s

4-24 Using Eq. (4-28), which neglects buoyancy, the terminal speed is 3.5×10^{-4} m/s. Allowing for buoyancy, the terminal speed is 3.0×10^{-4} m/s. (The density of glycerin is 1.26×10^3 kg/m^3.)

4-26 (a) 2.55×10^4 N; (b) 2.55×10^4 N

4-28 (a) $v = \sqrt{2gh}$; (b) $F_{net} = m\sqrt{2gh}/\Delta t$,

$F_{floor} = m[g + (\sqrt{2gh}/\Delta t)]$, $(F_{net}/mg) = \sqrt{2h/g}/\Delta t$,

$(F_{floor}/mg) = 1 + (\sqrt{2h/g}/\Delta t)$; (c) $F_{net} = 1960$ N = 2.86mg,

$F_{floor} = 2650$ N = 3.86mg

4-30 (b) $\vec{v}_{1f} = 0$, $\vec{v}_{2f} = \vec{v}_{1i}$; (c) The two directions are opposite.; (d) $\vec{v}_{1f} \simeq -\vec{v}_{1i}$, $\vec{v}_{2f} \simeq (2m_1/m_2)\vec{v}_{1i}$; (e) All three vectors have the same direction.

4-32 (b) $m_2/m_1 = 0.67$; (c) inelastic

4-34 $m_C/m_D = 1/2$

4-36 $k' = k_1k_2/(k_1 + k_2)$

4-38 (a) $\theta = \tan^{-1}\mu_s$; (b) 16.7°

4-40 Ignoring buoyancy, $v_T = \sqrt{\frac{2mg}{\rho_f A\delta}}$. (If buoyancy is included, $v_T = [2mg(1 - \frac{\rho_f}{\rho})/\rho_f A\delta]^{1/2}$, where ρ is the density of the falling object.)

4-42 (a) $P = W\tan\theta$, directed toward the right

4-44 (a) 2/3 m/s; (b) 0; (c) 2 m/s; (d) 2 s; (e) 4 m; (f) 0; (g) 0

4-46 1.01 u, a proton

4-48 (a) $\sqrt{2h/g}$; (b) $c\sqrt{2h/g}$; (c) $c\sqrt{2gh}$; (d) $\sqrt{2gh}$; (e) $c\sqrt{2gh}$ (f) $c\sqrt{2gh}$ down; (h) Vessel descends.

4-50 (a) $a = g(\sin\alpha - \mu_k\cos\alpha)$, $t_1 = \sqrt{2\ell/a}$, $v_1 = \sqrt{2a\ell}$;

(b) $v_{ji} = \sqrt{2(j-1)a\ell}$, $v_{jf} = \sqrt{2ja\ell}$, $T = \sqrt{2n\ell/a}$;

(c) $T' = \sqrt{2[n\ell + (n-1)d]/a} > T$,

$v' = \sqrt{2na\ell\{1 + [(n-1)d/n\ell]\}} > v_{nf}$;

(d) $(v''_{ji})^2 = 2a\ell[(j-1)(2j-1)/6j]$,

$(v''_{jf})^2 = 2a\ell[(j + 1)(2j + 1)/6j]$,

$$T'' = \sqrt{\frac{2\ell}{a}} \sum_{j=1}^{n} \left[\sqrt{\frac{(j + 1)(2j + 1)}{6j}} - \sqrt{\frac{(j - 1)(2j - 1)}{6j}} \right]$$

(e) $T'' > T$, but T'' may be greater than or less than T', depending on the value of d/ℓ. $v''_{nf} < v_{nf} < v'$.

CHAPTER FIVE

5-2 2 kg

5-4 7.8×10^3 N

5-6 5.86°

5-8 62.6 m/s

5-10 (a) v^2/Rg; (b) static

5-12 (a) no; (b) no

5-14 (a) v_o^2/R; (b) $m(g + v_o^2/R)$, $F/W = 1 + v_o^2/Rg$;
(c) 32.3 m/s^2, 2.94×10^3 N, F/W = 4.29

5-16 (a) 6×10^4 N; (b) 4×10^4 N; (c) 2×10^4 N

5-18 (a) 39.2 N; (b) 29.4 N

5-20 $(m + M)g \sin\theta/M$, downward along the plane

5-22 (a) 1.63 m/s^2; (b) no; (c) yes, 0.817 m/s^2

5-26 0.25

5-28 (a) $\sqrt{gR/\mu_s}$; (b) 7.38 m/s

5-30 (a) $|a| = v_o^2/2d$; (b) $F/W = v_o^2/2gd$; (c) F/W = 13.8;
(d) Est: 13.8 x (15 lbs.) $\simeq$ 210 lbs $\simeq$ 940 N

5-32 (a) 4.83 m/s^2; (b) 0.523 N

5-34 (d) $m_1 m_2 g \sec\theta/(m_2 \sec^2\theta + m_1 \tan^2\theta)$;
(e) $m_2(m_1 + m_2)g \sec^2\theta/(m_2 \sec^2\theta + m_1 \tan^2\theta)$

5-36 (a) $d_2 = 2d_1$; (b) $a_1 = 2.98\ m/s^2$ up, $a_2 = 5.96\ m/s^2$ down;

(c) 1.92 N

5-38 (a) $T_s = 2\pi[mr/(M + \mu_s m)g]^{1/2}$, $T_\ell = 2\pi[mr/(M - \mu_s m)g]^{1/2}$

(b) $T_\ell / T_s = 1.29$

5-40 (a) It inclines toward the upper end of the ramp with respect to the vertical.

CHAPTER SIX

6-4 (a) $T = 2\pi\sqrt{\ell/g}$

6-6 Both (a) and (b): $T = 2\pi\sqrt{m/2k}$

6-8 (a) $x = 2.00 \sin(6.00\pi t)$ cm $= 2.00 \cos(6.00\pi t + 3\pi/2)$ cm,

$v = 12.0\pi \cos(6.00\pi t)$ cm/s $= -12.0\pi \sin(6.00\pi t + 3\pi/2)$ cm/s,

$a = -72.0\pi^2 \sin(6.00\pi t)\ cm/s^2$

$= -72.0\pi^2 \cos(6.00\pi t + 3\pi/2)\ cm/s^2$; (b) $x = 1.62$ cm,

$v = 22.2$ cm/s, $a = -575\ cm/s^2$

6-10 (a) yes; (b) yes

6-14 3T/4

6-16 (b) $N = N_o e^{-Rt}$

6-18 (a) kA/m; (b) mg/k; (c) 9.8 cm

6-20 (a) $x = 5.00 \sin t$ m; (b) $x = 5.006e^{-0.05t} \sin(.9987t)$ m,

$x = 5.774e^{-0.5t} \sin(.8660t)$ m; (c) $x = 5.00te^{-t}$ m;

(d) $x = 2.236[e^{-0.38197t} - e^{-2.61803t}]$ m,

$x = 0.5103[e^{-0.10102t} - e^{-9.89898t}]$ m; (e) $(x_{max}\sqrt{\alpha}/v_o)$

= 1, 0.927, 0.546, 0.368, 0.275, 0.096

6-22 (a) $2\pi\sqrt{(1 + \alpha)M_1/k}$; (b) $(1 + \alpha)M_1 g\mu_s/k$; (c) 3.14 s,

0.98 m

6-26 (a) $m/\rho A$; (b) net upward force is $A\rho g(d - m/\rho A)$;
(d) $\frac{1}{2\pi}\sqrt{\rho Ag/m}$

CHAPTER SEVEN

7-2 Est: (a) 7.0 m/s; (b) 1.7×10^3 J

7-4 (a) 8.85 m/s

7-6 (a) 150 J; (b) 125 J; (c) 2.24 m/s

7-8 (a) 10 m/s; (b) 14.1 m/s; (c) 26.9 m/s; (d) 41.2 m/s

7-10 (a) 1.96×10^3 J; (b) 8.23×10^3 J

7-12 (a) mgh; (b) mg/2; (c) 2h; (d) mgh

7-14 (a) 1200 J, -1120 J, 80 J; (b) constant acceleration

7-16 (a) 1.15mg; (b) 0.577mg; (c) $0.518\sqrt{g\ell}$; (d) 1.27mg;
(e) 0.866mg

7-18 $\frac{1}{2}Mv_i^2$

7-20 3.13 m/s

7-22 $\sqrt{g\ell/3}$

7-24 42.2 J

7-26 (a) $v_o^2/2\mu_s g$; (b) 91.8 m

7-28 (a) 1000 J; (b) 1450 J; (c) 145 N; (d) 0.342;
(e) 5.97 m

7-30 0.831 m/s

7-32 (a) 5.48 m/s; (b) 5.30 m/s

7-34 (a) $mg + mv_o^2/R$; (b) $\sqrt{v_o^2 - 4gR}$; (c) $(mv_o^2/R) - 5mg$;
(d) 6mg (e) rod is under compression; (f) $\sqrt{4gR}$

7-36 (a) $s_B = s_A/2$; (b) $v_A = 2v_B$; (c) $\sqrt{8gD/\left(1 + \frac{4m_A}{m_B}\right)}$;
(d) 5.60 m/s

7-42 (a) $\omega(t) = \sqrt{k/M(t)} = \sqrt{k/(M_i + t\frac{dM}{dt})}$;

(b) $\frac{\pi}{2}\left|\frac{dM}{dt}\right| \omega(t)A^2(t)$; (c) $\frac{A(t)}{A_i} = \left[\frac{M(t)}{M_i}\right]^{1/4}$;

(d) $\omega_f = \omega_i(M_f/M_i)^{-1/2}$, $A_f = A_i(M_f/M_i)^{1/4}$, $E_f = E_i(M_f/M_i)^{1/2}$;

(e) $\omega_f = 3.16\,\omega_i$; $A_f = 0.562A_i$, $E_f = 0.316E_i$

CHAPTER EIGHT

8-2 1.41×10^6 kW

8-4 (a) 2.22 N; (b) 2.22×10^{-2} N/m^2; (c) 2.19×10^{-7} atm

8-6 345 W = 0.462 hp

8-8 R/r

8-10 (a) 3; (b) 2

8-12 $\cot\theta$

8-14 (a) $2\pi R/p$; (b) 628

8-16 $\vec{v}_{2f} = \vec{v}_{1i}$, $\vec{v}_{1f} = \vec{0}$

8-18 (a) 1.13 kg·m/s; (b) 6.00×10^{-3} s; (c) 188 N

8-22 4.12×10^3 kW

8-26 $v_{1max} = \sqrt{6}\,v_o$, $v_{2max} = \sqrt{3}\,v_o$, $v_{3max} = \sqrt{2}\,v_o$

8-28 (a) $\sqrt{h_f/h_i}$; (b) 0.894; (c) $h_1(1 + \epsilon^2)/(1 - \epsilon^2)$;

(d) 270 cm

8-30 (a) $mv_i(1 + \epsilon)\sin\theta_i$ perpendicular to surface;

(b) $\tan^{-1}(\epsilon\tan\theta_i)$; (c) $v_i\sqrt{1 - (1 - \epsilon^2)\sin^2\theta_i}$;

(d) $1 - (1 - \epsilon^2)\sin^2\theta_i$

8-32 (a) 224 kg·m/s at 116.6° with $\vec{v}_i$; (b) 4.47 s, point rocket 63.4° with $\vec{v}_i$; (c) 6.00 s, 34% more fuel

8-36 (a) 44.4°; (b) $K_{Hgf} = 3.92 \times 10^{-2} K_{\alpha i} = 1.18 \times 10^5$ eV

8-38 (c) If $\theta_i < \tan^{-1}(1/2\mu_k)$, then K_f/K_i $= 1 - 4\mu_k \sin\theta_i \cos\theta_i + 4\mu_k^2 \sin^2\theta_i$. If $\theta_i \geq \tan^{-1}(1/2\mu_k)$, then $K_f/K_i = \sin^2\theta_i$.

8-40 (a) $-f|v| \simeq -f\omega A|\sin(\omega t + \delta)|$; (d) $Q(t) = (\pi m\omega^2/4f)A(t)$; (e) Q decreases; (f) $A(t) >> 4f/\pi m\omega^2$

CHAPTER NINE

9-2 5.28 m/s^2 at an angle of 4.16° with inward radius, 5.28 m/s^2 at an angle of -4.16° with inward radius

9-4 (a) 8.38 rad/s^2; (b) 2.51 m/s^2

9-6 (a) 18.8 m/s; (b) 3.55×10^3 m/s^2

9-10 (a) and (b) 1.88 rad/s

9-12 (a) and (b) Fd clockwise

9-14 $[(4\hat{x}/3) + \hat{y}]$ m

9-16 245 J

9-18 (a) 10^{-3} rad; (b) 0.2 mm

9-24 (a) to the right; (b) to the left; (c) to the left; (d) no motion

9-26 (a) $(\vec{a} + \vec{b} + \vec{c})/3$

9-30 3/4

9-32 (a) Both are mgb/2(h - 2d); (b) mg

9-34 (a) 882 N; (b) and (c) 970 N

9-36 70.7 N

9-38 (a) 30°; (b) F_B = 490 N, F_{BH} = 424 N, F_{BV} = 245 N; (c) 490 N

9-40 (a) $\frac{4M_i r}{3\pi(M_t + M_i)}$ below center; (b) $\frac{4M_i gr(1 - \cos\theta)}{3\pi(M_t + M_i)}$

9-44 3MR/8m

9-46 7.96 cm

9-50 (a) $\vec{N}_B = -\vec{N}_A$; (b) $\vec{f}_B = \vec{f}_A$; (c) $\vec{f}_B = \vec{f}_A = -\vec{F}/2$;

(d) $\mu_s \geq \ell/d$; (e) no

9-52 (a) $m^2(2\ell_2 + \ell_3)/m_A\ell_1$; (b) 2 grams

9-54 (a) $F_E = Mgb/(a + b)$, $F_F = Mga/(a + b)$;

(b) $F_H = \frac{Mga}{(a + b)n}$; (d) $M = 100m$; (e) $d_H = nd$, $d_F = d$

9-56 (b) a distance $4R/3\pi$ directly above the midpoint of the flat edge

9-58 (a) $Mg(R + L)/\sqrt{2RL + L^2}$; (b) $MgR/\sqrt{2RL + L^2}$;

(c) 0.155, 1.73Mg; (d) For $L \ll R$, $S \simeq Mg\sqrt{R/2L}$ and $N \simeq Mg\sqrt{R/2L}$. For $L \gg R$, $S \simeq Mg[1 + R^2/2L^2]$ and $N \simeq MgR/L$.

CHAPTER TEN

10-2 (a) $M(B^2/12 + A^2/3)$; (b) $M(A^2 + B^2)/3$

10-4 (a) $7Mv_c^2/10$; (b) 175 J

10-6 ω_p increases by a factor of 4

10-8 32.9 N·m about axle

10-10 (a) $dI_z = dI_x + dI_y$; (b) $I_z = I_x + I_y$; (c) $I_x = I_y$;

(d) $I_x = I_y = MR^2/2$, $I_z = MR^2$; (e) $3MR^2/2$

10-14 $I_{dia} = \frac{1}{2} I_{central\ axis}$

10-16 0.165

10-18 (a) 5.00 rad/s^2; (b) 2.00 kg m^2; (c) 4.54 rad/s^2;

(e) 100 kg

10-24 (b) $T_i = 2\pi\sqrt{\frac{G_o^2 + D_i^2}{D_i g}}$ for i = 1,2; (e) Using a sufficiently massive bob that the pendulum is quite asymmetrical, adjust the bob's position so that $T_1 = T_2$ even though $D_1 \neq D_2$.

10-26 (a) Mg; (b) 2g/R; (c) 2g

10-28 (a) 0.500 m/s; (b) 2/3 m from struck end

10-30 (a) 2/3 m rightward; (b) 1 m/s^2 rightward; (c) 1/2 m rightward; (d) 1 m rightward; (e) 1/3 m rightward; (f) 2/3 m/s^2 rightward; (g) 2/3 m/s^2 rightward.

10-32 Letting I_o represent the moment of inertia of lecturer plus stool, $\omega_2 = [(I_o + 2mR_1^2)/(I_o + 2mR_2^2)]\,\omega_1$,

$K_1 = \frac{1}{2}(I_o + 2mR_1^2)\omega_1^2$ and $K_2 = [(I_o + 2mR_1^2)/(I_o + 2mR_2^2)]K_1$.

Work is done in pulling in the weights.

10-34 $\sqrt{8g/3R}$

10-36 (a) $\omega_o = 0$, $v_o = \sqrt{2gh}$, $K_o = mgh$;

(b) $\omega_1 = \frac{\sqrt{2gh}}{R[1 + (M/2m)]}$, $v_1 = \frac{\sqrt{2gh}}{[1 + (M/2m)]}$,

$K_1 = \frac{mgh}{[1 + (M/2m)]}$; (d) 1/3

10-38 5.48×10^7 J, 56.0 km

10-40 (b) $dM = (M/2)\sin\theta d\theta$; (c) $dI = (MR^2/2)\sin^3\theta d\theta$;

(d) $0 \leq \theta \leq \pi$

10-42 (d) $L_{//} = \frac{1}{2} m\omega d^2 \sin^2\gamma$, $L_\perp = \frac{1}{2} m\omega d^2 \sin\gamma \cos\gamma$;

(e) $d\vec{L}_\perp/dt = \frac{1}{2} m\omega^2 d^2 \sin\gamma \cos\gamma$ into the page;

(f) $\vec{F}_A = (m\omega^2 d^2/2h)\sin\gamma \cos\gamma$ toward top of diagram;

$\vec{F}_B = -\vec{F}_A$

10-44 (a) cylindrical shell: $\theta_M = \tan^{-1}(2\mu_s)$, solid cylinder: $\theta_M = \tan^{-1}(3\mu_s)$, spherical shell: $\theta_M = \tan^{-1}(5\mu_s/2)$, solid sphere: $\theta_M = \tan^{-1}(7\mu_s/2)$; (b) cylindrical shell: $a = (g/2)\sin\theta$, solid cylinder: $a = (2g/3)\sin\theta$, spherical shell: $a = (3g/5)\sin\theta$, solid sphere: $a = (5g/7)\sin\theta$; (c) All exhibit the same acceleration: $a = g(\sin\theta - \mu_k\cos\theta)$; (d) Cylindrical shell and spherical shell arrive together, then solid sphere, and finally solid cylinder.

10-46 The precessional angular speed ω_p depends upon the angle γ between the spin axis and the upward vertical. With the given numerical values, ω_p is real-valued only for $\gamma > 58.9^\circ$. For values of γ ranging from 60° to 165°, ω_p ranges from 18.6 rad/s to 8.1 rad/s. For comparison, Eq. (10-36) predicts $\omega_p = 10.89$ rad/s for any value of γ.

10-48 (a) $L_{sB} = \lambda^5 L_{sA}$; (b) $K_{sB} = \lambda^5 K_{sA}$;
(c) $\omega_{pB} = \omega_{pA}/\lambda$; (d) $\omega_{pB}/\omega_{sB} = (1/\lambda)\cdot(\omega_{pA}/\omega_{sA})$;
(e) yes, yes

10-50 (c) Assuming that $\omega_p << \omega_s$, $\omega_p = (5gh/2R^2\omega_s)$;
(d) The formula of part (c) gives $\omega_p = 4.48$ rad/s, but $(4d^2/G^2)(\omega_p/\omega_s)$ is <u>not</u> much less than unity, which invalidates the expressions that are correct in the limit $(\omega_p/\omega_s) \rightarrow 0$; (e) If Eq. (10-36) were strictly applicable, the precessional angular speed would be 4.48 rad/s for all α; the exact solution indicates that $\omega_p \simeq 5.38$ rad/s for the angle $\alpha \simeq 25^\circ$ shown in Fig. 10E-50.

10-52 (d) $\frac{1}{(\pi/2 + \theta)} \ln \left[\frac{7 + 4 \sin\theta}{3(1 + 2 \sin\theta)}\right]$

CHAPTER ELEVEN

11-2 8 years

11-4 (a) 2.46 m/s^2; (b) 238 min; (c) force of attraction is 172 N; (d) 70 kg

11-6 (a) 29.4 m/s, 44.1 m; (b) 44.1 (g/g') m, 6(g/g') s; (c) (i) 117 m, 15.9 s; (ii) 265 m, 36.1 s

11-8 3.35

11-10 (b) 2.72

11-12 (a) 4.19×10^{14} kg - $7.00 \times 10^{-11} M_e$; (b) 1.12×10^{-3} m/s^2 = $1.14 \times 10^{-4} g_e$; (c) 3.34 m/s = $2.99 \times 10^{-4} v_e$

11-14 (a) no; (c) 1856 km from center, 118 km from surface 739 s = 12.3 min. (Note: The answers for part (c) are all actually slightly too small since the altitude is several percent as large as the lunar radius.)

11-16 (a) 3.14×10^{-6}; (b) 3.14

11-18 (a) $T_o = 2.68T_i$; (b) 5.85×10^{26} kg = $97.7M_e$

11-20 (a) $2\pi r^{3/2}/\sqrt{GM}$; (b) $\sqrt{3\pi/G\langle\rho\rangle}$

11-22 (a) $k(m_1 + m_2)/m_2$; (b) $2\pi\sqrt{m_1 m_2/[k(m_1 + m_2)]}$; (c) $k(m_1 + m_2)/m_1$, $2\pi\sqrt{m_1 m_2/[k(m_1 + m_2)]}$

11-26 (a) $-k/R$; (b) $k/2R$, $-k/2R$; (c) $R = \ell^2/mk$, $E = -mk^2/2\ell^2$; (d) 4, 1/4

11-28 (b) Using the formula given in the first printing of text: $R_r = (12/\pi)^{1/3}(M_e/\rho_s)^{1/3} = 18.88 \times 10^3$ km = $2.96R_e$.

Assuming circular lunar orbit and neglecting lunar spin:

$R_r = (3/2\pi)^{1/3}(M_e/\rho_s)^{1/3} = 9.44 \times 10^3$ km $= 1.48R_e$

Assuming circular orbit with synchronous rotation:

$R_r = (9/4\pi)^{1/3}(M_e/\rho_s)^{1/3} = 10.8 \times 10^3$ km $= 1.70R_e$;

(c) in Saturn's ring system

11-30 (a) 1.87×10^4 km; (b) 2.50×10^4 km

11-32 (a) $mv'(\gamma - c) = mv(\gamma + c)$; (b) $E' = \frac{1}{2}m(v')^2$ $- GMm/(\gamma - c)$, $E = \frac{1}{2}mv^2 - GMm/(\gamma + c)$, $E' = E$

11-34 984 s = 16.4 min (for an observer at the equator)

CHAPTER TWELVE

12-4 (a) 90 s; (b) 1.24×10^3 s = 20.6 min

12-6 $y = 0.10 \text{ m} \cos\left[2\pi\left(\frac{x}{2.0} + \frac{t}{0.50}\right)\right] = 0.10 \text{ m} \cos(\pi x + 4\pi t)$

12-8 (a) positive, 5.00×10^{-3} m, 0.200 m, 4.00 m/s;

(b) 0, 5.00×10^{-3} m, -5.00×10^{-3} m;

(c) 0, 5.00×10^{-3} m, -5.00×10^{-3} m

12-10 4

12-12 152 m/s

12-14 (a) 0.531 W/m; (b) 0.265 W/m; (c) $A_2 = A_1/\sqrt{2}$

12-16 200 Hz

12-26 29.5 m/s, 200 Hz

12-28 (a) 1.63 m, 209 Hz; (b) 228 Hz; (c) 1.36 m, 250 Hz;

(d) 261 Hz

12-30 $\nu' = \nu$

12-36 (a) $\rho_E = FA^2/\ell^2$ if $|x - vt| < \ell$; otherwise $\rho_E = 0$;

(c) $S = FA^2v/\ell^2 = (F^{3/2}A^2)/(\mu^{1/2}\ell^2)$ if $|x - vt| < \ell$;

otherwise S = 0.

12-38 ρ_E = 1 J/m and S = 42.6 W for $|x - vt| < 0.1$ m;

ρ_E and S are both zero otherwise; E = 0.20 J

12-42 (c) $\alpha = \sin^{-1}(1/M)$

CHAPTER THIRTEEN

13-2 (a) 3.5×10^3 Hz; (b) 336 m/s

13-4 (a) 0.25 m; (b) 0.5 m; (c) 400 Hz; (d) 200 m/s;

(e) 0.02 m

13-6 (a) 100 m/s; (b) 200 Hz; (c) $y = A \sin 4\pi x \cos 400\pi t$,

with x in m and t in s.

13-10 (a) 74.6 Hz, 172 Hz, 269 Hz; (b) 1.14 m, 0.496 m,

0.316 m

13-12 (a) 2.83 m; (b) 60 Hz

13-14 $L_o = 4L_c/3$

13-16 2%

13-18 (a) ν_n = 5n Hz; (b) $(9.93 \times 10^{-3}/n^2)$ m

13-20 (a) 2A; (b) The magnitude of the energy flow can be up

to four times as much, depending on the relative directions

of S_1 and S_2, as seen from O; (c) 6.02 dB

13-22 680 Hz

13-24 0, 60, 200, 260, 400, 460, and 520 Hz

13-26 (a) 25 cm; (b) 1.25 s; (c) 762 vibrations

13-28 (a) The wires must remain joined at all times; (d) For

$\mu_1 < \mu_2$, the reflected and incident waves are 180° out

of phase: $\delta_r = 180°$; (e) For $\mu_1 > \mu_2$, $\delta_r = 0°$.

CHAPTER FOURTEEN

14-2 0.866c

14-4 (a) 3.33×10^{-8} s; (b) 1.11×10^{-8} s

14-6 $v/c \simeq 1 - 2.5 \times 10^{-7}$ (assuming a 70-year lifespan)

14-8 0.976c

14-12 (a) $u'_x = c/2$, $u'_y = c\sqrt{3}/2$; (b) $u_x = -c/2$, $u_y = c\sqrt{3}/2$;

(c) 120°, which is larger (by nearly 50°) than the angle made by the meter stick.

14-20 (a) c; (b) c; (c) $\gamma = 1/\sqrt{1 - V^2/c^2}$;

(d) $t' = \gamma\left(t - \frac{Vx}{c^2}\right)$

14-24 (b) $e = \frac{|V|}{c}$: (1) 0.010, (2) 0.10, (3) 0.50, (4) 0.90

(5) 0.999

14-26 0.438c away from the earth (assuming purely radial motion)

14-32 (a) $\theta = \cos^{-1}[1/(1 + \sqrt{1 - V^2/c^2})]$, $\theta' = 180^\circ - \theta$;

(b) (1) 59.9°, 120.1°, (2) 59.2°, 120.8°, (3) 45.9°, 134.1°,

(4) 28.8°, 151.2°

14-34 $v' \equiv \sqrt{(v'_x)^2 + (v'_y)^2 + (v'_z)^2} = c$

CHAPTER FIFTEEN

15-2 (a) 0.115; (b) 0.99995

15-4 (b) $\sqrt{3}/2$

15-6 3.72×10^{-12}

15-8 (b) equal but opposite momenta, 8.2×10^{-14} J

15-10 1.13×10^{-12} J/nucleon

15-12 35.2°

15-14 $2.883 \times 10^{-3} uc^2 = 4.31 \times 10^{-13}$ J

15-18 (a) $m_o\left[2 + \frac{2}{\sqrt{1 - v_i^2/c^2}}\right]^{1/2}$; (b) The fraction of the kinetic energy that is changed into rest-mass energy is

$$\frac{\left[\left(2 + \frac{2}{\sqrt{1 - v_i^2/c^2}}\right)^{1/2} - 2\right]}{\left(\frac{1}{\sqrt{1 - v_i^2/c^2}} - 1\right)}$$

(c) The rest of the initial kinetic energy becomes the kinetic energy of the composite particle.

(d) $v_f = v_i/(1 + \sqrt{1 - v_i^2/c^2})$

15-20 $K_\mu = 2.43 \times 10^{-11}$ J, $K_\nu = E_\nu = 3.76 \times 10^{-11}$ J

15-22 4.75×10^{-12} J

15-24 (a) 4.95×10^{-13} J; (b) 13% underestimate.

15-26 3.30×10^{-13} J

15-28 1.64×10^{-13} J

15-32 (a) $p_1 + p_2 - p_3 - p_4 = 0$

$= [p_1' + p_2' - p_3' - p_4' + \frac{V}{c^2}(E_1' + E_2' - E_3' - E_4')]$;

(b) conservation of energy

15-36 (a) $4m_oc^2$, $2m_oc^2$; (b) and (c) $c\sqrt{3}/2 = 0.866c$;

(d) $4c\sqrt{3}/7 = 0.990c$; (e) $7m_oc^2$, $6m_oc^2$; (f) It remains in the form of kinetic energy of the four particles (in the lab frame).