(b) 0.83 m/s²; (c) 0 **63.** (a) 0.74 m/s²; (b) 7.3 m/s² **65.** (a) 3.5 N; (b) west; (c) 2.7 N; (d) 22° west of due south **67.** 16 N **69.** (a) rope breaks; (b) 1.6 m/s² **71.** 12 N **73.** (a) 4.6 m/s²; (b) 2.6 m/s² **75.** 4.6 N **77.** (a) 2.6 N; (b) 17° **79.** (b) 313 N; (c) 0 N; (d) no; (e) yes **81.** (a) 11 N; (b) 2.2 kg; (c) 0; (d) 2.2 kg **83.** (a) 1.8×10^2 N; (b) 6.4×10^2 N **85.** (a) 620 N; (b) 580 N **87.** (a) $(5.0 \text{ m/s})\hat{i} + (4.3 \text{ m/s})\hat{j}$; (b) $(15 \text{ m})\hat{i} + (6.4 \text{ m})\hat{j}$ **89.** (a) $\cos\theta$; (b) $(\cos\theta)^{0.5}$ **91.** (a) 4.9×10^5 N; (b) 1.5×10^6 N **93.** (a) 4.1 m/s²; (b) 836 N **95.** (a) $(1.0\hat{i} - 2.0\hat{j})$ N; (b) 2.2 N; (c) −63°; (d) 2.2 m/s²; (e) −63° **97.** (a) 1.1×10^{-15} N; (b) 8.9×10^{-30} N **99.** (a) 44 N; (b) 78 N; (c) 54 N; (d) 152 N **101.** (a) 2.8 N, due west; (b) 2.2 N, 22° west of due south

chapter 6

CP 1. (a) zero (because there is no attempt at sliding); (b) 5 N; (c) no; (d) yes; (e) 8 N **2.** (a) same (10 N); (b) decreases; (c) decreases (because N decreases) **3.** greater (from Sample Problem 6-5, v_t depends on $\sqrt{R}$) **4.** ($\vec{a}$ is directed toward center of circular path) (a) $\vec{a}$ downward, $\vec{N}$ upward; (b) $\vec{a}$ and $\vec{N}$ upward **5.** (a) same (must still match the gravitational force on the rider); (b) increases ($N = mv^2/R$); (c) increases ($f_{s,\max} = \mu_s N$) **6.** (a) $4R_1$; (b) $4R_1$ **Q 1.** (a) F_1, F_2, F_3; (b) all tie **3.** (a) upward; (b) horizontal, toward you; (c) no change; (d) increases; (e) increases **5.** (a) decrease; (b) decrease; (c) decrease; (d) decrease; (e) decrease **7.** At first, $\vec{f}_s$ is directed up the ramp and its magnitude increases from $mg \sin\theta$ until it reaches $f_{s,\max}$. Thereafter the force is kinetic friction directed up the ramp, with magnitude f_k (a constant value smaller than $f_{s,\max}$). **9.** (a) 5 m/s² to 10 m/s²; (b) 0 to 5 m/s² **11.** (a) all tie; (b) all tie; (c) 2, 3, 1 **P 1.** 2° **3.** (a) 2.0×10^2 N; (b) 1.2×10^2 N **5.** (a) 1.9×10^2 N; (b) 0.56 m/s² **7.** (a) 11 N; (b) 0.14 m/s² **9.** 0.58 **11.** (a) 1.3×10^2 N; (b) no; (c) 1.1×10^2 N; (d) 46 N; (e) 17 N **13.** (a) 3.0×10^2 N; (b) 1.3 m/s² **15.** (a) no; (b) $(-12 \text{ N})\hat{i} + (5.0 \text{ N})\hat{j}$ **17.** (a) 19°; (b) 3.3 kN **19.** (a) $(17 \text{ N})\hat{i}$; (b) $(20 \text{ N})\hat{i}$; (c) $(15 \text{ N})\hat{i}$ **21.** 1.0×10^2 N **23.** 0.37 **25.** (a) 3.5 m/s²; (b) 0.21 N **27.** (a) 0; (b) $(-3.9 \text{ m/s}^2)\hat{i}$; (c) $(-1.0 \text{ m/s}^2)\hat{i}$ **29.** 4.9×10^2 N **31.** 9.9 s **33.** 2.3 **35.** (a) 3.2×10^2 km/h; (b) 6.5×10^2 km/h; (c) no **37.** 21 m **39.** 0.60 **41.** 1.37×10^3 N **43.** (a) 10 s; (b) 4.9×10^2 N; (c) 1.1×10^3 N **45.** (a) light; (b) 778 N; (c) 223 N; (d) 1.11 kN **47.** 2.2 km **49.** 1.81 m/s **51.** (a) 8.74 N; (b) 37.9 N; (c) 6.45 m/s; (d) radially inward **53.** (a) 69 km/h; (b) 139 km/h; (c) yes **55.** (a) 222 N; (b) 334 N; (c) 311 N; (d) 311 N; (e) c, d **57.** (a) 7.5 m/s²; (b) down; (c) 9.5 m/s²; (d) down **59.** (a) $\mu_k mg/(\sin\theta - \mu_k \cos\theta)$; (b) $\theta_0 = \tan^{-1}\mu_s$ **61.** (a) 27 N; (b) 3.0 m/s² **63.** (a) 35.3 N; (b) 39.7 N; (c) 320 N **65.** (a) 3.0 N; (b) 3.0 N; (c) 1.6 N; (d) 4.4 N; (e) 1.0 N; (f) e **67.** $g(\sin\theta - 2^{0.5}\mu_k \cos\theta)$ **69.** (a) 13 N; (b) 1.6 m/s² **71.** 118 N **73.** (a) $v_0^2/(4g \sin\theta)$; (b) no **75.** 0.76 **77.** (a) 30 cm/s; (b) 180 cm/s²; (c) inward; (d) 3.6×10^{-3} N; (e) inward; (f) 0.37 **79.** 4.6 N **81.** 20° **83.** (a) 0.11 m/s²; (b) 0.23 m/s²; (c) 0.041; (d) 0.029 **85.** (a) 0.34; (b) 0.24 **87.** (a) 3.21×10^3 N; (b) 3.75×10^3 N **89.** 178 km/h **91.** 0.18 **93.** (a) 100 N; (b) 245 N; (c) 86.6 N; (d) 195 N; (e) 50.0 N; (f) 158 N; (g) at rest; (h) slides; (i) at rest **95.** 0.56 **97.** (a) 2.1 m/s²; (b) down the plane; (c) 3.9 m; (d) it stays there **99.** (a) 275 N; (b) 877 N **101.** 874 N **103.** (a) 84.2 N; (b) 52.8 N; (c) 1.87 m/s² **105.** (a) 74 N; (b) (76 N)/(cos θ + 0.42 sin θ); (c) 23°; (d) 70 N **107.** (a) bottom of circle; (b) 9.5 m/s

chapter 7

CP 1. (a) decrease; (b) same; (c) negative, zero **2.** d, c, b, a **3.** (a) same; (b) smaller **4.** (a) positive; (b) negative; (c) zero **5.** zero **Q 1.** all tie **3.** c, b, a **5.** all tie **7.** (a) A, $\vec{F}_2$; B, $\vec{F}_1$; C, $\vec{F}_3$; D, $\vec{F}_4$; (b) E, A, and D; F, B, and C; G and H meaningless because K cannot have negative values **9.** e through h **P 1.** 1.8×10^{13} J **3.** (a) 2.9×10^7 m/s; (b) 2.1×10^{-13} J **5.** (a) 2.4 m/s; (b) 4.8 m/s **7.** 6.8 J **9.** 0.96 J **11.** (a) 1.7×10^2 N; (b) 3.4×10^2 m; (c) -5.8×10^4 J; (d) 3.4×10^2 N; (e) 1.7×10^2 m; (f) -5.8×10^4 J **13.** (a) 1.50 J; (b) increases **15.** (a) 62.3°; (b) 118° **17.** (a) 12 kJ; (b) −11 kJ; (c) 1.1 kJ; (d) 5.4 m/s **19.** (a) $-3Mgd/4$; (b) Mgd; (c) $Mgd/4$; (d) $(gd/2)^{0.5}$ **21.** 25 J **23.** (a) 25.9 kJ; (b) 2.45 N **25.** (a) $x = -4.9$ cm and $x = +4.9$ cm **27.** (a) 16 J; (b) 16 J; (c) 0; (d) −14 J **29.** (a) 6.6 m/s; (b) 4.7 m **31.** 8.0×10^2 J **33.** (a) 0; (b) 0 **35.** 5.3×10^2 J **37.** (a) 42 J; (b) 30 J; (c) 12 J; (d) 6.5 m/s, $+x$ axis; (e) 5.5 m/s, $+x$ axis; (f) 3.5 m/s, $+x$ axis **39.** +41.7 J **41.** 4.9×10^2 W **43.** (a) 0.83 J; (b) 2.5 J; (c) 4.2 J; (d) 5.0 W **45.** 7.4×10^2 W **47.** (a) 1.0×10^2 J; (b) 8.4 W **49.** (a) 12 J; (b) 4.0 m; (c) 18 J **51.** (a) 2.7×10^2 N; (b) -4.0×10^2 J; (c) 4.0×10^2 J; (d) 0; (e) 0 **53.** (a) 11 J; (b) −21 J **55.** (a) 0.6 J; (b) 0; (c) −0.6 J **57.** (a) 1.20 J; (b) 1.10 m/s **59.** (a) 314 J; (b) −155 J; (c) 0; (d) 158 J **61.** (a) 8.0 N; (b) 8.0 N/m **63.** (a) 98 N; (b) 4.0 cm; (c) 3.9 J; (d) −3.9 J **65.** −6 J **67.** (a) 1.7 W; (b) 0; (c) −1.7 W **69.** (a) 2.1×10^2 J; (b) 2.1×10^2 J **71.** (a) 23 mm; (b) 45 N **73.** 235 kW **75.** (b) $x = 3.00$ m; (c) 13.5 J; (d) $x = 4.50$ m; (e) $x = 4.50$ m **77.** (a) 1.8×10^5 ft · lb; (b) 0.55 hp **79.** (a) 1×10^5 megatons TNT; (b) 1×10^7 bombs

chapter 8

CP 1. no (consider round trip on the small loop) **2.** 3, 1, 2 (see Eq. 8-6) **3.** (a) all tie; (b) all tie **4.** (a) CD, AB, BC (0) (check slope magnitudes); (b) positive direction of x **5.** all tie **Q 1.** (a) 12 J; (b) −2 J **3.** (a) 4; (b) returns to its starting point and repeats the trip; (c) 1; (d) 1 **5.** (a) AB, CD, then BC and DE tie (zero force); (b) 5 J; (c) 5 J; (d) 6 J; (e) FG; (f) DE **7.** +30 J **9.** (a) increasing; (b) decreasing; (c) decreasing; (d) constant in AB and BC, decreasing in CD **P 1.** 89 N/cm **3.** (a) 4.31 mJ; (b) −4.31 mJ; (c) 4.31 mJ; (d) −4.31 mJ; (e) all increase **5.** (a) 0; (b) 170 kJ; (c) 340 kJ; (d) 170 kJ; (e) 340 kJ; (f) increase **7.** (a) 0.15 J; (b) 0.11 J; (c) 0.19 J; (d) 38 mJ; (e) 75 mJ; (f) all the same **9.** (a) 2.08 m/s; (b) 2.08 m/s; (c) increase **11.** (a) 17.0 m/s; (b) 26.5 m/s; (c) 33.4 m/s; (d) 56.7 m; (e) all the same **13.** (a) 2.6×10^2 m; (b) same; (c) decrease **15.** (a) 3.0 m; (b) 0.81 m; (c) 11 m/s; (d) 6.3 m/s; (f) 0.51 m **17.** (a) 0.98 J; (b) −0.98 J; (c) 3.1 N/cm **19.** (a) $U = 27 + 12x - 3x^2$; (b) 39 J; (c) −1.6 m; (d) 5.6 m **21.** (a) 2.5 N; (b) 0.31 N; (c) 30 cm **23.** (a) 4.85 m/s; (b) 2.42 m/s **25.** (a) 4.4 m; (b) same **27.** (a) 5.0 m/s; (b) 79°; (c) 64 J **29.** (a) 35 cm; (b) 1.7 m/s **31.** (a) 39.2 J; (b) 39.2 J; (c) 4.00 m **33.** (a) 2.8 m/s; (b) 2.7 m/s **35.** −18 mJ **37.** (a) 2.1 m/s; (b) 10 N; (c) $+x$ direction; (d) 5.7 m; (e) 30 N; (f) $-x$ direction **39.** (a) −3.7 J;

(c) 1.3 m; (d) 9.1 m; (e) 2.2 J; (f) 4.0 m; (g) $(4 - x)e^{-x/4}$; (h) 4.0 m **41.** (a) 5.6×10^2 J; (b) 5.6×10^2 J **43.** (a) 30.1 J; (b) 30.1 J; (c) 0.225 **45.** (a) −2.9 kJ; (b) 3.9×10^2 J; (c) 2.1×10^2 N **47.** 20 ft · lb **49.** 75 J **51.** (a) 67 J; (b) 67 J; (c) 46 cm **53.** (a) 0.292 m; (b) 14.2 J **53.** (a) 1.5×10^2 J; (b) 5.5 m/s **57.** (a) −0.90 J; (b) 0.46 J; (c) 1.0 m/s **59.** 20 cm **61.** 3.5 m/s **63.** (a) 39.6 cm; (b) 3.64 cm **65.** (a) 10 m; (b) 49 N; (c) 4.1 m; (d) 1.2×10^2 N **67.** 4.33 m/s **69.** (a) 4.9 m/s; (b) 4.5 N; (c) 71°; (d) same **71.** (a) 4.8 N; (b) $+x$ direction; (c) 1.5 m; (d) 13.5 m; (e) 3.5 m/s **73.** (a) 5.5 m/s; (b) 5.4 m; (c) same **75.** 69 hp **77.** (a) 13 m/s; (b) 11 m/s; (c) no, 9.3 m **79.** (a) 109 J; (b) 60.3 J; (c) 68.2 J; (d) 41.0 J **81.** (a) 0.950 m/s; (b) 11.0 m **83.** (a) 24 kJ; (b) 4.7×10^2 N **85.** (a) 2.1×10^6 kg; (b) $(100 + 1.5t)^{0.5}$ m/s; (c) $(1.5 \times 10^6)/(100 + 1.5t)^{0.5}$ N; (d) 6.7 km **87.** (a) 6.75 J; (b) −6.75 J; (c)–(d) 6.75 J; (e) −6.75 J; (f) 0.459 m **89.** 3.7 J **91.** 5.4 kJ **93.** (a) 2.2 kJ; (b) 7.7×10^2 J **95.** (a) 2.7 J; (b) 1.8 J; (c) 0.39 m **97.** 80 mJ **99.** (a) 7.0 J; (b) 22 J **101.** (a) 94 J; (b) 94 J; (c) 7.7 m/s **103.** 5.5×10^6 N **105.** 25 J **107.** 24 W **109.** (a) 2.35×10^3 J; (b) 352 J **111.** −12 J **113.** (a) 8.8 m/s; (b) 2.6 kJ; (c) 1.6 kW **115.** (a) 3.7 J; (b) 4.3 J; (c) 4.3 J **117.** (a) 3.0 mm; (b) 1.1 J; (d) yes; (e) ≈ 40 J; (f) no **119.** (a) 6.0 kJ; (b) 6.0×10^2 W; (c) 3.0×10^2 W; (d) 9.0×10^2 W **121.** 3.1×10^{11} W **123.** (a) 0.75 J; (b) −1.0 J; (c) 0.25 J; (d) 1.0 J; (e) −2.0 J; (f) 1.0 J; (g) 0.75 J; (h) −3.0 J; (i) 2.3 J (j) 0 J; (k) −4.0 J; (l) 4.0 J **125.** 880 MW **127.** (a) 1.2 J; (b) 11 m/s; (c) no; (d) no **129.** (a) $v_0 = (2gL)^{0.5}$; (b) $5mg$; (c) $-mgL$; (d) $-2mgL$ **131.** (a) 2.7×10^9 J; (b) 2.7×10^9 W; (c) 2.4×10^8 **133.** (a) turning point on left, none on right, molecule breaks apart; (b) turning points on both left and right, molecule does not break apart; (c) -1.1×10^{-19} J; (d) 2.1×10^{-19} J; (e) ≈ 1×10^{-9} N on each, directed toward the other; (f) $r < 0.2$ nm; (g) $r > 0.2$ nm; (h) $r = 0.2$ nm **135.** (a) $U(x) = -Gm_1m_2/x$; (b) $Gm_1m_2d/x_1(x_1 + d)$

chapter 9

CP 1. (a) origin; (b) fourth quadrant; (c) on y axis below origin; (d) origin; (e) third quadrant; (f) origin **2.** (a)–(c) at the center of mass, still at the origin (their forces are internal to the system and cannot move the center of mass) **3.** (Consider slopes and Eq. 9-23.) (a) 1, 3, and then 2 and 4 tie (zero force); (b) 3 **4.** (a) unchanged; (b) unchanged (see Eq. 9-32); (c) decrease (see Eq. 9-35) **5.** (a) zero; (b) positive (initial p_y down y; final p_y up y); (c) positive direction of y **6.** (No net external force; $\vec{P}$ conserved.) (a) 0; (b) no; (c) $-x$ **7.** (a) 500 km/h; (b) 2600 km/h; (c) 1600 km/h **8.** (a) yes; (b) no (because of net force along y) **9.** (a) 10 kg · m/s; (b) 14 kg · m/s; (c) 6 kg · m/s **10.** (a) 4 kg · m/s; (b) 8 kg · m/s; (c) 3 J **11.** (a) 2 kg · m/s (conserve momentum along x); (b) 3 kg · m/s (conserve momentum along y) **Q 1.** (a) ac, cd, bc; (b) bc; (c) bd, ad **3.** d, c, a, b (zero) **5.** all tie **7.** a, c, e, f: the sum of the momenta after explosion does not equal the momentum before explosion. **9.** (a) positive; (b) positive; (c) 2 and 3 **11.** (a) forward; (b) stationary; (c) backward **P 1.** (a) 1.1 m; (b) 1.3 m; (c) toward **3.** (a) 11 cm; (b) −4.4 cm **5.** (a) 0; (b) 3.13×10^{-11} m **7.** (a) 20 cm; (b) 20 cm; (c) 16 cm **9.** (a) 28 cm; (b) 2.3 m/s **11.** (a) 22 m; (b) 9.3 m/s **13.** (a) $(2.35\hat{i} - 1.57\hat{j})$ m/s^2; (b) $(2.35\hat{i} - 1.57\hat{j})t$ m/s, with t in seconds; (d) straight, at downward angle 34° **15.** 53 m **17.** 4.2 m **19.** (a) 7.5×10^4 J; (b) 3.8×10^4 kg · m/s; (c) 39° south of due east **21.** 48° **23.** (a) 67 m/s; (b) $-x$; (c) 1.2 kN; (d) $-x$ **25.** (a) 1.1 m; (b) 4.8×10^3 kg · m/s **27.** 5 N **29.** (a) 5.86 kg · m/s; (b) 59.8°; (c) 2.93 kN; (d) 59.8° **31.** (a) 1.00 N · s; (b) 100 N; (c) 20 N **33.** (a) $(1.8\text{ N} \cdot \text{s})\hat{j}$; (b) $(-180\text{ N})\hat{j}$ **35.** 3.0 mm/s **37.** 4.4×10^3 km/h **39.** 3.5 m/s **41.** (a) 14 m/s; (b) −45° **43.** (a) $(1.00\hat{i} - 0.167\hat{j})$ km/s; (b) 3.23 MJ **45.** (a) 1.81 m/s; (b) 4.96 m/s **47.** (a) $(2.67\text{ m/s})\hat{i} + (-3.00\text{ m/s})\hat{j}$; (b) 4.01 m/s; (c) 48.4° **49.** (a) 721 m/s; (b) 937 m/s **51.** (a) +2.0 m/s; (b) −1.3 J; (c) +40 J; (d) system got energy from some source, such as a small explosion **53.** 25 cm **55.** (a) 99 g; (b) 1.9 m/s; (c) 0.93 m/s **57.** (a) 100 g; (b) 1.0 m/s **59.** (a) 1.2 kg; (b) 2.5 m/s **61.** (a) 3.00 m/s; (b) 6.00 m/s **63.** (a) 0.21 kg; (b) 7.2 m **65.** (a) 4.15×10^5 m/s; (b) 4.84×10^5 m/s **67.** (a) 433 m/s; (b) 250 m/s **69.** 120° **71.** (a) 1.57×10^6 N; (b) 1.35×10^5 kg; (c) 2.08 km/s **73.** (a) 46 N; (b) none **75.** (a) 7.11 m/s; (b) greater; (c) less; (d) less **77.** (a) 1.92 m; (b) 0.640 m **79.** 28.8 N **81.** (a) 25 mm; (b) 26 mm; (c) down; (d) 1.6×10^{-2} m/s^2 **83.** (a) 11.4 m/s; (b) 95.1° **85.** (a) 7290 m/s; (b) 8200 m/s; (c) 1.271×10^{10} J; (d) 1.275×10^{10} J **87.** (a) $(-4.0 \times 10^4\text{ kg} \cdot \text{m/s})\hat{i}$; (b) due west; (c) 0 **89.** (a) down; (b) 0.50 m/s; (c) 0 **91.** (a) 0; (b) 0; (c) 0 **93.** (a) 0; (b) 4.0 m/s **95.** (a) 0.745 mm; (b) 153°; (c) 1.67 mJ **97.** (a) 0.841 m/s; (b) 0.975 m/s **99.** (a) 1.0 kg · m/s; (b) 2.5×10^2 J; (c) 10 N; (d) 1.7 kN; (e) answer for (c) includes time between pellet collisions **101.** (a) $(7.4 \times 10^3\text{ N} \cdot \text{s})\hat{i} - (7.4 \times 10^3\text{ N} \cdot \text{s})\hat{j}$; (b) $(-7.4 \times 10^3\text{ N} \cdot \text{s})\hat{i}$; (c) 2.3×10^3 N; (d) 2.1×10^4 N; (e) −45° **103.** (a) 3.7 m/s; (b) 1.3 N · s; (c) 1.8×10^2 N **105.** (a) 9.0 kg · m/s; (b) 3.0 kN; (c) 4.5 kN; (d) 20 m/s **107.** 1.18×10^4 kg **109.** (a) 4.4 m/s; (b) 0.80 **111.** 0.22% **113.** 2.2 kg **115.** 61.2 kJ **117.** (a) $(1.3\text{ m/s})\hat{i} + (1.3\text{ m/s})\hat{j}$; (b) 1.9 m/s; (c) 45° **119.** (a) 2.18 kg · m/s; (b) 575 N **121.** 5.0 kg **123.** (a) $(24.0\text{ kg} \cdot \text{m/s})\hat{i} - (180\text{ kg} \cdot \text{m/s})\hat{j} + (30.0\text{ kg} \cdot \text{m/s})\hat{k}$; (b) 4.23 kJ; (c) 4.30 kJ **125.** 190 m/s **127.** (a) 0.54 m/s; (b) 0; (c) 1.1 m/s **129.** (a) $5mg$; (b) $7mg$; (c) 5 m **131.** (a) 1.9 m/s; (b) −30°; (c) elastic **133.** (a) 4.6×10^3 km; (b) 73% **135.** (a) 50 kg/s; (b) 1.6×10^2 kg/s **137.** (a) 1.26 m/s; (b) 2.25 kJ; (c) 1.61 m/s; (d) 1.00 m/s **139.** (a) 8.1 m/s; (b) 38° south of due east

chapter 10

CP 1. (b) and (c) **2.** (a) and (d) ($\alpha = d^2\theta/dt^2$ must be a constant) **3.** (a) yes; (b) no; (c) yes; (d) yes **4.** all tie **5.** 1, 2, 4, 3 (see Eq. 10-36) **6.** (see Eq. 10-40) 1 and 3 tie, 4, then 2 and 5 tie (zero) **7.** (a) downward in the figure ($\tau_{net} = 0$); (b) less (consider moment arms) **Q 1.** (a) positive; (b) zero; (c) negative; (d) negative **3.** (a) 1: counterclockwise (positive); 2: counterclockwise (positive); 3: at $\theta = 0$; (b) 1: before; 2: at $t = 0$; 3: after; (c) 1: positive; 2: negative; 3: positive **5.** larger **7.** $\vec{F}_5$, $\vec{F}_4$, $\vec{F}_2$, $\vec{F}_1$, $\vec{F}_3$ (zero) **9.** (a) 1 and 2 tie, then 3; (b) 1 and 3 tie, then 2; (c) 2, 1, 3 **P 1.** (a) 0.105 rad/s; (b) 1.75×10^{-3} rad/s; (c) 1.45×10^{-4} rad/s **3.** (a) 12:00; (b) 12:00; (c) 3:00; (d) 6:00; (e) 9:00; (f) 12:00; (g) 2:24; (h) 4:48; (i) 7:12; (j) 9:36; (k) 12:00 **5.** 11 rad/s **7.** (a) 4.0 m/s; (b) no **9.** (a) 9.0×10^3 rev/min^2; (b) 4.2×10^2 rev **11.** (a) 2.0 rad/s^2; (b) 5.0 rad/s; (c) 10 rad/s; (d) 75 rad **13.** 8.0 s

15. (a) 3.4×10^2 s; (b) -4.5×10^{-3} rad/s^2; (c) 98 s **17.** (a) 44 rad; (b) 5.5 s, (c) 32 s; (d) -2.1 s, (e) 40 s **19.** 6.9×10^{-13} rad/s **21.** (a) 20.9 rad/s; (b) 12.5 m/s; (c) 800 rev/min^2; (d) 600 rev **23.** (a) 2.50×10^{-3} rad/s; (b) 20.2 m/s^2; (c) 0 **25.** (a) 6.4 cm/s^2; (b) 2.6 cm/s^2 **27.** (a) 7.3×10^{-5} rad/s; (b) 3.5×10^2 m/s; (c) 7.3×10^{-5} rad/s; (d) 4.6×10^2 m/s **29.** (a) 3.8×10^3 rad/s; (b) 1.9×10^2 m/s **31.** (a) 73 cm/s^2; (b) 0.075; (c) 0.11 **33.** 12.3 kg · m^2 **35.** (a) 1.1 kJ; (b) 9.7 kJ **37.** 0.097 kg · m^2 **39.** (a) 0.023 kg · m^2; (b) 11 mJ **41.** 4.7×10^{-4} kg · m^2 **43.** (a) 1.3×10^3 g · cm^2; (b) 5.5×10^2 g · cm^2; (c) 1.9×10^3 g · cm^2; (d) $A + B$ **45.** 4.6 N · m **47.** -3.85 N · m **49.** (a) 28.2 rad/s^2; (b) 338 N · m **51.** 0.140 N **53.** (a) 9.7 rad/s^2; (b) counterclockwise **55.** (a) 6.00 cm/s^2; (b) 4.87 N; (c) 4.54 N; (d) 1.20 rad/s^2; (e) 0.0138 kg · m^2 **57.** (a) 4.2×10^2 rad/s^2; (b) 5.0×10^2 rad/s **59.** (a) 1.4 m/s; (b) 1.4 m/s **61.** (a) 0.63 J; (b) 0.15 m **63.** 5.42 m/s **65.** 9.82 rad/s **67.** 1.4 m/s **69.** (a) 314 rad/s^2; (b) 7.54 m/s^2; (c) 14.0 N; (d) 4.36 N **71.** 6.16×10^{-5} kg · m^2 **73.** (a) 5.1 h; (b) 8.1 h **75.** (a) 0.32 rad/s; (b) 1.0×10^2 km/h **77.** (a) 3.3 J; (b) 2.9 J **79.** (a) -7.66 rad/s^2; (b) -11.7 N · m; (c) 4.59×10^4 J; (d) 624 rev; (e) 4.59×10^4 J **81.** (a) 1.5×10^2 cm/s; (b) 15 rad/s; (c) 15 rad/s; (d) 75 cm/s; (e) 3.0 rad/s **83.** 4.6 rad/s^2 **87.** (a) 0.689 N · m; (b) 3.05 N; (c) 9.84 N · m; (d) 11.5 N **89.** 3.1 rad/s **91.** (a) -1.25 rad/s^2; (b) 250 rad; (c) 39.8 rev **93.** (a) 0.791 kg · m^2; (b) 1.79×10^{-2} N · m **95.** 1.5×10^3 rad **97.** (a) 2.8 rad; (b) 0.42 m/s^2 **99.** (a) 0.27 kg · m^2; (b) 0.22 kg · m^2; (c) 0.10 kg · m^2 **101.** (a) 10 J; (b) 0.27 m **103.** (a) 11 rad/s **105.** (a) 5.00 rad/s; (b) 1.67 rad/s^2; (c) 2.50 rad **107.** (a) -67 rev/min^2; (b) 8.3 rev **109.** (a) $\omega_0 + at^4 - bt^3$; (b) $\theta_0 + \omega_0 t + at^5/5 - bt^4/4$ **111.** 17 **113.** 1.4×10^2 N · m **115.** 5.6 rad/s^2 **117.** (a) 1.94 m/s^2; (b) 75.1° **119.** 200 rev/min **121.** (a) 3.5 rad/s; (b) 52 cm/s; (c) 26 cm/s **123.** 6.75×10^{12} rad/s **125.** (a) 9.71×10^{37} kg · m^2; (b) 2.57×10^{29} J; (c) 1.6×10^9 y

chapter 11

CP 1. (a) same; (b) less **2.** less (consider the transfer of energy from rotational kinetic energy to gravitational potential energy) **3.** (draw the vectors, use right-hand rule) (a) $\pm z$; (b) $+y$; (c) $-x$ **4.** (see Eq. 11-21) (a) 1 and 3 tie, then 2 and 4 tie, then 5 (zero); (b) 2 and 3 **5.** (see Eqs. 11-23 and 11-16) (a) 3, 1; then 2 and 4 tie (zero); (b) 3 **6.** (a) all tie (same τ, same t, thus same ΔL); (b) sphere, disk, hoop (reverse order of I) **7.** (a) decreases; (b) same ($\tau_{net} = 0$, so L conserved); (c) increases **Q 1.** (a) 0 or 180°; (b) 90° **3.** (a) 5 and 6; (b) 1 and 4 tie, then the rest tie **5.** b, then c and d tie, then a and e tie (zero) **7.** (a) 3; (b) 1; (c) 2; (d) 4 **9.** (a) 4, 6, 7, 1, then 2, 3, and 5 tie (zero); (b) 1, 4, and 7 **P 1.** (a) 59.3 rad/s; (b) 9.31 rad/s^2; (c) 70.7 m **3.** -3.15 J **5.** 0.020 **7.** (a) 63 rad/s; (b) 4.0 m **9.** 4.8 m **11.** (a) 2.0 m; (b) 7.3 m/s **13.** 0.50 **15.** (a) 13 cm/s^2; (b) 4.4 s; (c) 55 cm/s; (d) 18 mJ; (e) 1.4 J; (f) 27 rev/s **17.** (a) $(24 \text{ N} \cdot \text{m})\hat{j}$; (b) $(-24 \text{ N} \cdot \text{m})\hat{j}$; (c) $(12 \text{ N} \cdot \text{m})\hat{j}$; (d) $(-12 \text{ N} \cdot \text{m})\hat{j}$ **19.** $(-2.0 \text{ N} \cdot \text{m})\hat{i}$ **21.** (a) $(50 \text{ N} \cdot \text{m})\hat{k}$; (b) 90° **23.** -5.00 N **25.** (a) 9.8 kg · m^2/s; (b) $+z$ direction **27.** (a) 0; (b) $(8.0 \text{ N} \cdot \text{m})\hat{i} + (8.0 \text{ N} \cdot \text{m})\hat{k}$ **29.** (a) $(3.00 \text{ m/s}^2)\hat{i} - (4.00 \text{ m/s}^2)\hat{j} + (2.00 \text{ m/s}^2)\hat{k}$; (b) $(42.0 \text{ kg} \cdot \text{m}^2/\text{s})\hat{i} + (24.0 \text{ kg} \cdot \text{m}^2/\text{s})\hat{j} + (60.0 \text{ kg} \cdot \text{m}^2/\text{s})\hat{k}$; (c) $(-8.00 \text{ N} \cdot \text{m})\hat{i} - (26.0 \text{ N} \cdot \text{m})\hat{j} - (40.0 \text{ N} \cdot \text{m})\hat{k}$; (d) 127° **31.** (a) $(-1.7 \times 10^2 \text{ kg} \cdot \text{m}^2/\text{s})\hat{k}$; (b) $(+56 \text{ N} \cdot \text{m})\hat{k}$; (c) $(+56 \text{ kg} \cdot \text{m}^2/\text{s}^2)\hat{k}$ **33.** (a) $48t\hat{k}$ N · m; (b) increasing **35.** (a) 1.47 N · m; (b) 20.4 rad; (c) -29.9 J; (d) 19.9 W **37.** (a) 4.6×10^{-3} kg · m^2; (b) 1.1×10^{-3} kg · m^2/s; (c) 3.9×10^{-3} kg · m^2/s **39.** (a) 1.6 kg · m^2; (b) 4.0 kg · m^2/s **41.** (a) 3.6 rev/s; (b) 3.0; (c) forces on the bricks from the man transferred energy from the man's internal energy to kinetic energy **43.** (a) 267 rev/min; (b) 0.667 **45.** 0.17 rad/s **47.** (a) 1.5 m; (b) 0.93 rad/s; (c) 98 J; (d) 8.4 rad/s; (e) 8.8×10^2 J; (f) internal energy of the skaters **49.** 3.4 rad/s **51.** 1.3×10^3 m/s **53.** 11.0 m/s **55.** (a) 18 rad/s; (b) 0.92 **57.** 1.5 rad/s **59.** (a) 0.148 rad/s; (b) 0.0123; (c) 181° **61.** (a) 0.33 rev/s; (b) clockwise **63.** $(5.55 \text{ kg} \cdot \text{m}^2/\text{s})\hat{k}$ **65.** 0.62 J **67.** (a) 6.65×10^{-5} kg · m^2/s; (b) no; (c) 0; (d) yes **69.** 0.47 kg · m^2/s **71.** (a) $(-24t^2 \text{ kg} \cdot \text{m}^2/\text{s})\hat{k}$; (b) $(-48t \text{ N} \cdot \text{m})\hat{k}$; (c) $(12t^2 \text{ kg} \cdot \text{m}^2/\text{s})\hat{k}$; (d) $(24t \text{ N} \cdot \text{m})\hat{k}$ **73.** 12 s **75.** (a) 0; (b) 0; (c) $-30t^3\hat{k}$ kg · m^2/s; (d) $-90t^2\hat{k}$ N · m; (e) $30t^3\hat{k}$ kg · m^2/s; (f) $90t^2\hat{k}$ N · m **77.** (a) $mvR/(I + MR^2)$; (b) $mvR^2/(I + MR^2)$ **79.** $7.4\hat{k}$ kg · m^2/s **81.** (a) $mR^2/2$; (b) a solid circular cylinder **83.** (a) 58.8 J; (b) 39.2 J **85.** (a) 1.6 m/s^2; (b) 16 rad/s^2; (c) $(4.0 \text{ N})\hat{i}$ **87.** (a) 12.7 rad/s; (b) clockwise **89.** (a) 0.89 s; (b) 9.4 J; (c) 1.4 m/s; (d) 0.12 J; (e) 4.4×10^2 rad/s; (f) 9.2 J **91.** (a) 2.9×10^4 kg · m^2/s; (b) 1.2×10^6 N · m **93.** (a) 3.14×10^{43} kg · m^2/s; (b) 0.614 **95.** (a) 149 kg · m^2; (b) 158 kg · m^2/s; (c) 0.744 rad/s **97.** 2.5×10^{11} kg · m^2/s