

时代教育·国外高校优秀教材精选

Sears and Zemansky's

University Physics with Modern Physics

西尔斯 当代大学物理

英文版 原书第12版

(美) 休 D. 杨 (Hugh D. Young) 著
罗杰 A. 弗里德曼 (Roger A. Freedman)

下册



机械工业出版社
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APPENDIX A

THE INTERNATIONAL SYSTEM OF UNITS

The *Système International d'Unités*, abbreviated SI, is the system developed by the General Conference on Weights and Measures and adopted by nearly all the industrial nations of the world. The following material is adapted from B. N. Taylor, ed., National Institute of Standards and Technology Spec. Pub. 811 (U.S. Govt. Printing Office, Washington, DC, 1995). See also <http://physics.nist.gov/cuu>

Quantity	Name of unit	Symbol	
SI base units			
length	meter	m	
mass	kilogram	kg	
time	second	s	
electric current	ampere	A	
thermodynamic temperature	kelvin	K	
amount of substance	mole	mol	
luminous intensity	candela	cd	
SI derived units			Equivalent units
area	square meter	m ²	
volume	cubic meter	m ³	
frequency	hertz	Hz	s ⁻¹
mass density (density)	kilogram per cubic meter	kg/m ³	
speed, velocity	meter per second	m/s	
angular velocity	radian per second	rad/s	
acceleration	meter per second squared	m/s ²	
angular acceleration	radian per second squared	rad/s ²	
force	newton	N	kg · m/s ²
pressure (mechanical stress)	pascal	Pa	N/m ²
kinematic viscosity	square meter per second	m ² /s	
dynamic viscosity	newton-second per square meter	N · s/m ²	
work, energy, quantity of heat	joule	J	N · m
power	watt	W	J/s
quantity of electricity	coulomb	C	A · s
potential difference, electromotive force	volt	V	J/C, W/A
electric field strength	volt per meter	V/m	N/C
electric resistance	ohm	Ω	V/A
capacitance	farad	F	A · s/V
magnetic flux	weber	Wb	V · s
inductance	henry	H	V · s/A
magnetic flux density	tesla	T	Wb/m ²
magnetic field strength	ampere per meter	A/m	
magnetomotive force	ampere	A	
luminous flux	lumen	lm	cd · sr
luminance	candela per square meter	cd/m ²	
illuminance	lux	lx	lm/m ²
wave number	1 per meter	m ⁻¹	
entropy	joule per kelvin	J/K	
specific heat capacity	joule per kilogram-kelvin	J/kg · K	
thermal conductivity	watt per meter-kelvin	W/m · K	

Quantity	Name of unit	Symbol	Equivalent units
radiant intensity	watt per steradian	W/sr	
activity (of a radioactive source)	becquerel	Bq	s ⁻¹
radiation dose	gray	Gy	J/kg
radiation dose equivalent	sievert	Sv	J/kg
SI supplementary units			
plane angle	radian	rad	
solid angle	steradian	sr	

Definitions of SI Units

meter (m) The *meter* is the length equal to the distance traveled by light, in vacuum, in a time of 1/299,792,458 second.

kilogram (kg) The *kilogram* is the unit of mass; it is equal to the mass of the international prototype of the kilogram. (The international prototype of the kilogram is a particular cylinder of platinum-iridium alloy that is preserved in a vault at Sévres, France, by the International Bureau of Weights and Measures.)

second (s) The *second* is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

ampere (A) The *ampere* is that constant current that, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per meter of length.

kelvin (K) The *kelvin*, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

ohm (Ω) The *ohm* is the electric resistance between two points of a conductor when a constant difference of potential of 1 volt, applied between these two points, produces in this conductor a current of 1 ampere, this conductor not being the source of any electromotive force.

coulomb (C) The *coulomb* is the quantity of electricity transported in 1 second by a current of 1 ampere.

candela (cd) The *candela* is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

mole (mol) The *mole* is the amount of substance of a system that contains as many elementary entities as there are carbon atoms in 0.012 kg of carbon 12. The elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

newton (N) The *newton* is that force that gives to a mass of 1 kilogram an acceleration of 1 meter per second per second.

joule (J) The *joule* is the work done when the point of application of a constant force of 1 newton is displaced a distance of 1 meter in the direction of the force.

watt (W) The *watt* is the power that gives rise to the production of energy at the rate of 1 joule per second.

volt (V) The *volt* is the difference of electric potential between two points of a conducting wire carrying a constant current of 1 ampere, when the power dissipated between these points is equal to 1 watt.

weber (Wb) The *weber* is the magnetic flux that, linking a circuit of one turn, produces in it an electromotive force of 1 volt as it is reduced to zero at a uniform rate in 1 second.

lumen (lm) The *lumen* is the luminous flux emitted in a solid angle of 1 steradian by a uniform point source having an intensity of 1 candela.

farad (F) The *farad* is the capacitance of a capacitor between the plates of which there appears a difference of potential of 1 volt when it is charged by a quantity of electricity equal to 1 coulomb.

henry (H) The *henry* is the inductance of a closed circuit in which an electromotive force of 1 volt is produced when the electric current in the circuit varies uniformly at a rate of 1 ampere per second.

radian (rad) The *radian* is the plane angle between two radii of a circle that cut off on the circumference an arc equal in length to the radius.

steradian (sr) The *steradian* is the solid angle that, having its vertex in the center of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

SI Prefixes The names of multiples and submultiples of SI units may be formed by application of the prefixes listed in Appendix F.

APPENDIX B

USEFUL MATHEMATICAL RELATIONS

Algebra

$$a^{-x} = \frac{1}{a^x} \quad a^{(x+y)} = a^x a^y \quad a^{(x-y)} = \frac{a^x}{a^y}$$

Logarithms: If $\log a = x$, then $a = 10^x$. $\log a + \log b = \log(ab)$ $\log a - \log b = \log(a/b)$ $\log(a^n) = n \log a$
 If $\ln a = x$, then $a = e^x$. $\ln a + \ln b = \ln(ab)$ $\ln a - \ln b = \ln(a/b)$ $\ln(a^n) = n \ln a$

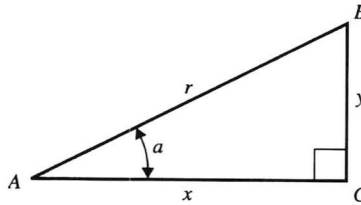
Quadratic formula: If $ax^2 + bx + c = 0$, $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$.

Binomial Theorem

$$(a + b)^n = a^n + na^{n-1}b + \frac{n(n-1)a^{n-2}b^2}{2!} + \frac{n(n-1)(n-2)a^{n-3}b^3}{3!} + \dots$$

Trigonometry

In the right triangle ABC , $x^2 + y^2 = r^2$.



Definitions of the trigonometric functions: $\sin a = y/r$ $\cos a = x/r$ $\tan a = y/x$

Identities:

$\sin^2 a + \cos^2 a = 1$	$\tan a = \frac{\sin a}{\cos a}$
$\sin 2a = 2 \sin a \cos a$	$\cos 2a = \cos^2 a - \sin^2 a = 2 \cos^2 a - 1$ $= 1 - 2 \sin^2 a$
$\sin \frac{1}{2} a = \sqrt{\frac{1 - \cos a}{2}}$	$\cos \frac{1}{2} a = \sqrt{\frac{1 + \cos a}{2}}$
$\sin(-a) = -\sin a$	$\sin(a \pm b) = \sin a \cos b \pm \cos a \sin b$
$\cos(-a) = \cos a$	$\cos(a \pm b) = \cos a \cos b \mp \sin a \sin b$
$\sin(a \pm \pi/2) = \pm \cos a$	$\sin a + \sin b = 2 \sin \frac{1}{2}(a+b) \cos \frac{1}{2}(a-b)$
$\cos(a \pm \pi/2) = \mp \sin a$	$\cos a + \cos b = 2 \cos \frac{1}{2}(a+b) \cos \frac{1}{2}(a-b)$

Geometry

Circumference of circle of radius r :	$C = 2\pi r$
Area of circle of radius r :	$A = \pi r^2$
Volume of sphere of radius r :	$V = \frac{4\pi r^3}{3}$
Surface area of sphere of radius r :	$A = 4\pi r^2$
Volume of cylinder of radius r and height h :	$V = \pi r^2 h$

Calculus

Derivatives:

$$\frac{d}{dx}x^n = nx^{n-1}$$

$$\frac{d}{dx}\sin ax = a\cos ax$$

$$\frac{d}{dx}\cos ax = -a\sin ax$$

$$\frac{d}{dx}e^{ax} = ae^{ax}$$

$$\frac{d}{dx}\ln ax = \frac{1}{x}$$

$$\int \frac{dx}{\sqrt{a^2 - x^2}} = \arcsin \frac{x}{a}$$

$$\int \frac{dx}{\sqrt{x^2 + a^2}} = \ln(x + \sqrt{x^2 + a^2})$$

$$\int \frac{dx}{x^2 + a^2} = \frac{1}{a} \arctan \frac{x}{a}$$

$$\int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{1}{a^2} \frac{x}{\sqrt{x^2 + a^2}}$$

$$\int \frac{x dx}{(x^2 + a^2)^{3/2}} = -\frac{1}{\sqrt{x^2 + a^2}}$$

Power series (convergent for range of x shown):

$$(1+x)^n = 1 + nx + \frac{n(n-1)x^2}{2!} + \frac{n(n-1)(n-2)}{3!}x^3 + \dots \quad (|x| < 1)$$

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \dots \quad (\text{all } x)$$

$$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \dots \quad (\text{all } x)$$

$$\tan x = x + \frac{x^3}{3} + \frac{2x^5}{15} + \frac{17x^7}{315} + \dots \quad (|x| < \pi/2)$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots \quad (\text{all } x)$$

$$\ln(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \dots \quad (|x| < 1)$$

Integrals:

$$\int x^n dx = \frac{x^{n+1}}{n+1} \quad (n \neq -1)$$

$$\int \frac{dx}{x} = \ln x$$

$$\int \sin ax dx = -\frac{1}{a} \cos ax$$

$$\int \cos ax dx = \frac{1}{a}$$

$$\int e^{ax} dx = \frac{1}{a} e^{ax}$$

APPENDIX C

THE GREEK ALPHABET

Name	Capital	Lowercase	Name	Capital	Lowercase
Alpha	A	α	Nu	N	ν
Beta	B	β	Xi	Ξ	ξ
Gamma	Γ	γ	Omicron	O	o
Delta	Δ	δ	Pi	Π	π
Epsilon	E	ϵ	Rho	P	ρ
Zeta	Z	ζ	Sigma	Σ	σ
Eta	H	η	Tau	T	τ
Theta	Θ	θ	Upsilon	Y	υ
Iota	I	ι	Phi	Φ	ϕ
Kappa	K	κ	Chi	X	χ
Lambda	Λ	λ	Psi	Ψ	ψ
Mu	M	μ	Omega	Ω	ω

APPENDIX D

PERIODIC TABLE OF THE ELEMENTS

Group 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
 Period

1																	2	
1	H 1.008																	He 4.003
2	Li 6.941	Be 9.012											B 10.811	C 12.011	N 14.007	O 15.999	F 18.998	Ne 20.180
3	Na 22.990	Mg 24.305											Al 26.982	Si 28.086	P 30.974	S 32.065	Cl 35.453	Ar 39.948
4	K 39.098	Ca 40.078	Sc 44.956	Ti 47.867	V 50.942	Cr 51.996	Mn 54.938	Fe 55.845	Co 58.933	Ni 58.693	Cu 63.546	Zn 65.409	Ga 69.723	Ge 72.64	As 74.922	Se 78.96	Br 79.904	Kr 83.798
5	Rb 85.468	Sr 87.62	Y 88.906	Zr 91.224	Nb 92.906	Mo 95.94	Tc (98)	Ru 101.07	Rh 102.906	Pd 106.42	Ag 107.868	Cd 112.411	In 114.818	Sn 118.710	Sb 121.760	Te 127.60	I 126.904	Xe 131.293
6	Cs 132.905	Ba 137.327	Lu 174.967	Hf 178.49	Ta 180.948	W 183.84	Re 186.207	Os 190.23	Ir 192.217	Pt 195.078	Au 196.967	Hg 200.59	Tl 204.383	Pb 207.2	Bi 208.980	Po (209)	At (210)	Rn (222)
7	Fr (223)	Ra (226)	Lr (262)	Rf (261)	Db (262)	Sg (266)	Bh (264)	Hs (269)	Mt (268)	Ds (271)	Rg (272)	Uub (285)	Uut (284)	Uuq (289)	Uup (288)	Uuh (292)	Uus	Uuo

Lanthanoids	57 La 138.905	58 Ce 140.116	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.925	66 Dy 162.500	67 Ho 164.930	68 Er 167.259	69 Tm 168.934	70 Yb 173.04
Actinoids	89 Ac (227)	90 Th (232)	91 Pa (231)	92 U (238)	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)

For each element the average atomic mass of the mixture of isotopes occurring in nature is shown. For elements having no stable isotope, the approximate atomic mass of the longest-lived isotope is shown in parentheses. For elements that have been predicted but not yet detected, no atomic mass is given. All atomic masses are expressed in atomic mass units ($1 \text{ u} = 1.66053886(28) \times 10^{-27} \text{ kg}$), equivalent to grams per mole (g/mol).

APPENDIX E

UNIT CONVERSION FACTORS

Length

$$1 \text{ m} = 100 \text{ cm} = 1000 \text{ mm} = 10^6 \mu\text{m} = 10^9 \text{ nm}$$

$$1 \text{ km} = 1000 \text{ m} = 0.6214 \text{ mi}$$

$$1 \text{ m} = 3.281 \text{ ft} = 39.37 \text{ in.}$$

$$1 \text{ cm} = 0.3937 \text{ in.}$$

$$1 \text{ in.} = 2.540 \text{ cm}$$

$$1 \text{ ft} = 30.48 \text{ cm}$$

$$1 \text{ yd} = 91.44 \text{ cm}$$

$$1 \text{ mi} = 5280 \text{ ft} = 1.609 \text{ km}$$

$$1 \text{ \AA} = 10^{-10} \text{ m} = 10^{-8} \text{ cm} = 10^{-1} \text{ nm}$$

$$1 \text{ nautical mile} = 6080 \text{ ft}$$

$$1 \text{ light year} = 9.461 \times 10^{15} \text{ m}$$

Area

$$1 \text{ cm}^2 = 0.155 \text{ in.}^2$$

$$1 \text{ m}^2 = 10^4 \text{ cm}^2 = 10.76 \text{ ft}^2$$

$$1 \text{ in.}^2 = 6.452 \text{ cm}^2$$

$$1 \text{ ft} = 144 \text{ in.}^2 = 0.0929 \text{ m}^2$$

Volume

$$1 \text{ liter} = 1000 \text{ cm}^3 = 10^{-3} \text{ m}^3 = 0.03531 \text{ ft}^3 = 61.02 \text{ in.}^3$$

$$1 \text{ ft}^3 = 0.02832 \text{ m}^3 = 28.32 \text{ liters} = 7.477 \text{ gallons}$$

$$1 \text{ gallon} = 3.788 \text{ liters}$$

Time

$$1 \text{ min} = 60 \text{ s}$$

$$1 \text{ h} = 3600 \text{ s}$$

$$1 \text{ d} = 86,400 \text{ s}$$

$$1 \text{ y} = 365.24 \text{ d} = 3.156 \times 10^7 \text{ s}$$

Angle

$$1 \text{ rad} = 57.30^\circ = 180^\circ/\pi$$

$$1^\circ = 0.01745 \text{ rad} = \pi/180 \text{ rad}$$

$$1 \text{ revolution} = 360^\circ = 2\pi \text{ rad}$$

$$1 \text{ rev/min (rpm)} = 0.1047 \text{ rad/s}$$

Speed

$$1 \text{ m/s} = 3.281 \text{ ft/s}$$

$$1 \text{ ft/s} = 0.3048 \text{ m/s}$$

$$1 \text{ mi/min} = 60 \text{ mi/h} = 88 \text{ ft/s}$$

$$1 \text{ km/h} = 0.2778 \text{ m/s} = 0.6214 \text{ mi/h}$$

$$1 \text{ mi/h} = 1.466 \text{ ft/s} = 0.4470 \text{ m/s} = 1.609 \text{ km/h}$$

$$1 \text{ furlong/fortnight} = 1.662 \times 10^{-4} \text{ m/s}$$

Acceleration

$$1 \text{ m/s}^2 = 100 \text{ cm/s}^2 = 3.281 \text{ ft/s}^2$$

$$1 \text{ cm/s}^2 = 0.01 \text{ m/s}^2 = 0.03281 \text{ ft/s}^2$$

$$1 \text{ ft/s}^2 = 0.3048 \text{ m/s}^2 = 30.48 \text{ cm/s}^2$$

$$1 \text{ mi/h} \cdot \text{s} = 1.467 \text{ ft/s}^2$$

Mass

$$1 \text{ kg} = 10^3 \text{ g} = 0.0685 \text{ slug}$$

$$1 \text{ g} = 6.85 \times 10^{-5} \text{ slug}$$

$$1 \text{ slug} = 14.59 \text{ kg}$$

$$1 \text{ u} = 1.661 \times 10^{-27} \text{ kg}$$

$$1 \text{ kg has a weight of } 2.205 \text{ lb when } g = 9.80 \text{ m/s}^2$$

Force

$$1 \text{ N} = 10^5 \text{ dyn} = 0.2248 \text{ lb}$$

$$1 \text{ lb} = 4.448 \text{ N} = 4.448 \times 10^5 \text{ dyn}$$

Pressure

$$1 \text{ Pa} = 1 \text{ N/m}^2 = 1.450 \times 10^{-4} \text{ lb/in.}^2 = 0.209 \text{ lb/ft}^2$$

$$1 \text{ bar} = 10^5 \text{ Pa}$$

$$1 \text{ lb/in.}^2 = 6895 \text{ Pa}$$

$$1 \text{ lb/ft}^2 = 47.88 \text{ Pa}$$

$$1 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 1.013 \text{ bar}$$

$$= 14.7 \text{ lb/in.}^2 = 2117 \text{ lb/ft}^2$$

$$1 \text{ mm Hg} = 1 \text{ torr} = 133.3 \text{ Pa}$$

Energy

$$1 \text{ J} = 10^7 \text{ ergs} = 0.239 \text{ cal}$$

$$1 \text{ cal} = 4.186 \text{ J (based on } 15^\circ \text{ calorie)}$$

$$1 \text{ ft} \cdot \text{lb} = 1.356 \text{ J}$$

$$1 \text{ Btu} = 1055 \text{ J} = 252 \text{ cal} = 778 \text{ ft} \cdot \text{lb}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

$$1 \text{ kWh} = 3.600 \times 10^6 \text{ J}$$

Mass–Energy Equivalence

$$1 \text{ kg} \leftrightarrow 8.988 \times 10^{16} \text{ J}$$

$$1 \text{ u} \leftrightarrow 931.5 \text{ MeV}$$

$$1 \text{ eV} \leftrightarrow 1.074 \times 10^{-9} \text{ u}$$

Power

$$1 \text{ W} = 1 \text{ J/s}$$

$$1 \text{ hp} = 746 \text{ W} = 550 \text{ ft} \cdot \text{lb/s}$$

$$1 \text{ Btu/h} = 0.293 \text{ W}$$

APPENDIX F

NUMERICAL CONSTANTS

Fundamental Physical Constants*

Name	Symbol	Value
Speed of light	c	2.99792458×10^8 m/s
Magnitude of charge of electron	e	$1.60217653(14) \times 10^{-19}$ C
Gravitational constant	G	$6.6742(10) \times 10^{-11}$ N·m ² /kg ²
Planck's constant	h	$6.6260693(11) \times 10^{-34}$ J·s
Boltzmann constant	k	$1.3806505(24) \times 10^{-23}$ J/K
Avogadro's number	N_A	$6.0221415(10) \times 10^{23}$ molecules/mol
Gas constant	R	8.314472(15) J/mol·K
Mass of electron	m_e	$9.1093826(16) \times 10^{-31}$ kg
Mass of proton	m_p	$1.67262171(29) \times 10^{-27}$ kg
Mass of neutron	m_n	$1.67492728(29) \times 10^{-27}$ kg
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ Wb/A·m
Permittivity of free space	$\epsilon_0 = 1/\mu_0 c^2$	$8.854187817 \dots \times 10^{-12}$ C ² /N·m ²
	$1/4\pi\epsilon_0$	$8.987551787 \dots \times 10^9$ N·m ² /C ²

Other Useful Constants*

Mechanical equivalent of heat		4.186 J/cal (15° calorie)
Standard atmospheric pressure	1 atm	1.01325×10^5 Pa
Absolute zero	0 K	-273.15°C
Electron volt	1 eV	$1.60217653(14) \times 10^{-19}$ J
Atomic mass unit	1 u	$1.66053886(28) \times 10^{-27}$ kg
Electron rest energy	$m_e c^2$	0.510998918(44) MeV
Volume of ideal gas (0°C and 1 atm)		22.413996(39) liter/mol
Acceleration due to gravity (standard)	g	9.80665 m/s ²

*Source: National Institute of Standards and Technology (<http://physics.nist.gov/cuu>). Numbers in parentheses show the uncertainty in the final digits of the main number; for example, the number 1.6454(21) means 1.6454 ± 0.0021 . Values shown without uncertainties are exact.

Astronomical Data[†]

Body	Mass (kg)	Radius (m)	Orbit radius (m)	Orbit period
Sun	1.99×10^{30}	6.96×10^8	—	—
Moon	7.35×10^{22}	1.74×10^6	3.84×10^8	27.3 d
Mercury	3.30×10^{23}	2.44×10^6	5.79×10^{10}	88.0 d
Venus	4.87×10^{24}	6.05×10^6	1.08×10^{11}	224.7 d
Earth	5.97×10^{24}	6.38×10^6	1.50×10^{11}	365.3 d
Mars	6.42×10^{23}	3.40×10^6	2.28×10^{11}	687.0 d
Jupiter	1.90×10^{27}	6.91×10^7	7.78×10^{11}	11.86 y
Saturn	5.68×10^{26}	6.03×10^7	1.43×10^{12}	29.45 y
Uranus	8.68×10^{25}	2.56×10^7	2.87×10^{12}	84.02 y
Neptune	1.02×10^{26}	2.48×10^7	4.50×10^{12}	164.8 y
Pluto [‡]	1.31×10^{22}	1.15×10^6	5.91×10^{12}	247.9 y

[†]Source: NASA Jet Propulsion Laboratory Solar System Dynamics Group (<http://ssd.jpl.nasa.gov>), and P. Kenneth Seidelmann, ed., *Explanatory Supplement to the Astronomical Almanac* (University Science Books, Mill Valley, CA, 1992), pp. 704–706. For each body, “radius” is its radius at its equator and “orbit radius” is its average distance from the sun (for the planets) or from the earth (for the moon).

[‡]In August 2006, the International Astronomical Union reclassified Pluto and other small objects that orbit the sun as “dwarf planets.”

Prefixes for Powers of 10

Power of ten	Prefix	Abbreviation	Pronunciation
10^{-24}	yocto-	y	<i>yoc-toe</i>
10^{-21}	zepto-	z	<i>zep-toe</i>
10^{-18}	atto-	a	<i>at-toe</i>
10^{-15}	femto-	f	<i>fem-toe</i>
10^{-12}	pico-	p	<i>pee-koe</i>
10^{-9}	nano-	n	<i>nan-oe</i>
10^{-6}	micro-	μ	<i>my-crow</i>
10^{-3}	milli-	m	<i>mil-i</i>
10^{-2}	centi-	c	<i>cen-ti</i>
10^3	kilo-	k	<i>kil-oe</i>
10^6	mega-	M	<i>meg-a</i>
10^9	giga-	G	<i>jig-a</i> or <i>gig-a</i>
10^{12}	tera-	T	<i>ter-a</i>
10^{15}	peta-	P	<i>pet-a</i>
10^{18}	exa-	E	<i>ex-a</i>
10^{21}	zetta-	Z	<i>zet-a</i>
10^{24}	yotta-	Y	<i>yot-a</i>

Examples:

1 femtometer = 1 fm = 10^{-15} m

1 picosecond = 1 ps = 10^{-12} s

1 nanocoulomb = 1 nC = 10^{-9} C

1 microkelvin = 1 μ K = 10^{-6} K

1 millivolt = 1 mV = 10^{-3} V

1 kilopascal = 1 kPa = 10^3 Pa

1 megawatt = 1 MW = 10^6 W

1 gigahertz = 1 GHz = 10^9 Hz

ANSWERS TO ODD-NUMBERED PROBLEMS

Chapter 1

- 1.1 a) 1.61 km b) 3.28×10^3 ft
 1.3 1.02 ns
 1.5 5.36 L
 1.7 31.7 y
 1.9 a) 23.4 km/L b) 1.42 tanks
 1.11 9.0 cm
 1.13 a) $1.1 \times 10^{-3}\%$ b) no
 1.15 a) 0.1% b) 0.008% c) 0.03%
 1.17 a) $28 \pm 0.3 \text{ cm}^3$ b) 170 ± 20
 1.19 a) no b) no c) no d) no e) no
 1.21 10^6
 1.23 10^9
 1.25 \$70 million
 1.29 $\$9 \times 10^{14}$; about $\$3 \times 10^6$
 1.31 7.8 km, 38° north of east
 1.33 144 m, 41° south of west
 1.35 $A_x = 0$, $A_y = -8.00$ m; $B_x = 7.50$ m,
 $B_y = 13.0$ m; $C_x = -10.9$ m, $C_y = -5.07$ m;
 $D_x = -7.99$ m, $D_y = 6.02$ m
 1.37 1190 N; 13.4° above forward direction
 1.39 a) 9.01 m, 33.7° b) 9.01 m, 33.7°
 c) 22.3 m, 250.3° d) 22.3 m, 70.3°
 1.41 5.06 km, 20.2° north of west
 1.43 a) 2.48 cm, 18.3° b) 4.10 cm, 83.7°
 c) 4.10 cm, 263.7°
 1.45 781 N, 166°
 1.47 $\vec{A} = -(8.00 \text{ m})\hat{j}$; $\vec{B} = (7.50 \text{ m})\hat{i} + (13.0 \text{ m})\hat{j}$;
 $\vec{C} = -(10.9 \text{ m})\hat{i} + (-5.07 \text{ m})\hat{j}$;
 $\vec{D} = (-7.99 \text{ m})\hat{i} + (6.02 \text{ m})\hat{j}$
 1.49 a) $\vec{A} = (1.23 \text{ m})\hat{i} + (3.38 \text{ m})\hat{j}$;
 $\vec{B} = (-2.08 \text{ m})\hat{i} + (-1.20 \text{ m})\hat{j}$
 b) $\vec{C} = (12.01 \text{ m})\hat{i} + (14.94 \text{ m})\hat{j}$
 c) 19.17 m; 51.2°
 1.51 a) no b) no; yes c) ± 0.20
 1.53 a) -104 m^2 b) -148 m^2 c) 40.6 m^2
 1.55 a) 165° b) 28° c) 90°
 1.57 a) 63.9 m; $-\hat{k}$ b) 63.9 m; $+\hat{k}$
 1.59 a) 4.61 cm^2 ; $-z$ b) 4.61 cm^2 ; $+z$
 1.61 a) $1.65 \times 10^4 \text{ km}$ b) 2.6 earth radii
 1.63 10^{28}
 1.65 a) 2.94 cm b) 1.82 cm
 1.67 a) 10^{50} b) 10^{27} c) 10^{79}
 1.69 149 N; 32.2° north of east
 1.71 b) $A_x = 3.03$ cm, $A_y = 8.10$ cm c) 8.65 cm;
 69.5° from the $+x$ -axis toward the $+y$ -axis
 1.73 144 m, 41° south of west
 1.75 a) 46 N, 139°
 1.77 a) (87, 258) b) 136 pixels, 25° below
 straight left
 1.79 380 km, 28.8° south of east
 1.81 160 N, 13° below horizontal
 1.83 a) 911 m; 8.9° west of south
 1.87 b) 90°
 1.89 a) $A = 5.39$, $B = 4.36$
 b) $-5.00\hat{i} + 2.00\hat{j} + 7.00\hat{k}$ c) 8.83; yes
 1.93 a) 54.7° b) 35.3°
 1.95 $C_x = 8.0$, $C_y = 6.1$
 1.97 b) 72.2
 1.99 38.5 yd, 24.6° to right of downfield
 1.101 a) 76 ly b) 129°

Chapter 2

- 2.1 a) 197 m/s b) 169 m/s
 2.3 1 h 10 min
 2.5 a) 17.1 s b) faster: 106 m; slower: 94 m
 2.7 250 km
 2.9 a) 12.0 m/s b) 0 m/s, 15.0 m/s, 12.0 m/s
 c) 13.3 s
 2.11 a) 2.3 m/s, 2.3 m/s b) 2.3 m/s, 0.33 m/s
 2.13 a) no b) (i) 12.8 m/s^2 (ii) 3.5 m/s^2
 (iii) 0.72 m/s^2 ; yes
 2.15 a) 2.00 cm/s, 50.0 cm, -0.125 cm/s^2
 b) 16.0 s c) 32.0 s d) 6.20 s, 1.22 cm/s ;
 25.8 s , -1.22 cm/s ; 36.4 s , -2.55 cm/s

- 2.17 a) 3 m/s^2 b) 10 m/s^2 c) depends on
 positive coordinate direction
 2.21 a) 5.0 m/s b) 1.43 m/s^2
 2.23 a) 675 m/s^2 b) 0.067 s
 2.25 1.70
 2.27 a) (i) 5.59 m/s^2 (ii) 7.74 m/s^2
 b) (i) 179 m (ii) 12,800 m
 2.29 a) $+2.7 \text{ cm/s}$, -1.3 cm/s b) -1.3 cm/s^2
 c) 22.5 cm; 25.5 cm
 2.31 a) 0, 6.3 m/s², -11.2 m/s^2
 b) 100 m, 230 m, 320 m
 2.33 a) $1.80 \times 10^4 \text{ m/s}$ b) 0.957
 c) 6 h 11 min
 2.35 b) 1 s, 3 s d) 2 s e) 3 s f) 1 s
 2.37 a) A: 20.5 m/s^2 ; B: 3.8 m/s^2 ; C: 53 m/s^2
 b) 721 km
 2.39 a) 2.94 m/s b) 0.599 s
 2.41 a) $t = \sqrt{2d/g}$ b) 0.190 s
 2.43 a) 646 m b) 16.4 s, 112 m/s
 2.45 a) 25.6 m/s b) 31.6 m c) 15.2 m/s
 2.47 a) 249 m/s^2 b) 25.4 c) 101 m d) no
 2.49 0.0868 m/s^2
 2.51 a) $x(t) = (0.250 \text{ m/s}^3)t^3 - (0.0100 \text{ m/s}^4)t^4$;
 $v_x(t) = (0.750 \text{ m/s}^3)t^2 - (0.0400 \text{ m/s}^4)t^3$;
 b) 39.1 m/s
 2.53 a) 30.0 cm/s
 2.55 b) 0.627 s, 1.60 s c) negative at 0.627 s,
 positive at 1.60 s d) 1.11 s e) 2.45 m
 f) 2.00 s, 0 s
 2.57 a) 82 km/h b) 31 km/h
 2.59 a) 3.5 m/s^2 b) 0 c) 1.5 m/s^2
 2.61 a) 92.0 m b) 92.0 m
 2.63 a) 464 m/s b) $2.99 \times 10^4 \text{ m/s}$ c) 7.48
 2.65 50.0 m
 2.67 4.6 m/s^2
 2.69 a) 6.17 s b) 24.8 m
 c) $v_{\text{truck}} = 13.0 \text{ m/s}$, $v_{\text{auto}} = 21.0 \text{ m/s}$
 2.71 a) 7.85 cm/s b) 5.00 cm/s, horizontal from
 the initial to final position
 2.73 a) 15.9 s b) 393 m c) 29.5 m/s
 2.75 a) -4.00 m/s b) 12.0 m/s
 2.77 a) 2.64H b) 2.64T
 2.79 a) no b) yes; 14.4 m/s; not physically
 attainable
 2.81 a) $6.79 \times 10^4 \text{ g}$ b) 1.45 m/s c) $H/4$
 2.83 a) 7.59 m/s b) 5.14 m c) 1.60 s
 2.85 a) 7.7 m/s b) 0.78 s c) 0.59 s d) 1.3 m
 2.87 270 m
 2.89 a) 20.5 m/s b) yes
 2.91 a) 947 m b) 393 m
 2.93 a) A b) 2.27 s, 5.73 s c) 1.00 s, 4.33 s
 d) 2.67 s
 2.95 a) 9.55 s, 4.78 m b) 1.62 m/s d) 8.38 m/s
 e) no f) 3.69 m/s, 21.7 s, 80.0 m
 2.97 a) 8.18 m/s b) (i) 0.411 m (ii) 1.15 km
 c) 9.80 m/s d) 4.90 m/s
- 3.19 a) 0.682 s, 2.99 s b) 24.0 m/s, 11.3 m/s;
 24.0 m/s, -11.3 m/s c) 30.0 m/s, -36.9°
 3.21 a) 1.5 m b) -0.89 m/s
 3.23 a) 13.6 m b) 34.6 m/s c) 103 m
 3.25 a) 296 m b) 176 m c) 198 m
 d) horizontal: 15 m/s; vertical: 58.8 m/s
 e) horizontal: 15 m/s; vertical: 78.8 m/s
 3.27 795 m
 3.29 a) 0.034 m/s^2 , 0.0034 g b) 1.4h
 3.31 a) 3.07 s b) 1.68 s
 3.33 a) 3.50 m/s^2 , upward b) 3.50 m/s^2 ,
 downward c) 12.6 s
 3.35 a) 32.9 m/s b) 27.7 m/s^2 c) 35.5 rpm
 3.37 a) 14 s b) 70 s
 3.39 0.36 m/s , 38° west of south
 3.41 a) 4.7 m/s, 25° south of east b) 190 s
 c) 380 m
 3.43 b) -7.1 m/s , -42 m/s c) 43 m/s, 9.5° west
 of south
 3.45 a) $A = 0$, $B = 2.00 \text{ m/s}^2$, $C = 50.0 \text{ m}$,
 $D = 0.50 \text{ m/s}^3$ b) $\vec{a} = (4.00 \text{ m/s}^2)\hat{i}$, $v = 0$
 c) $v_x = 40.0 \text{ m/s}$, $v_y = 150 \text{ m/s}$, $v = 155 \text{ m/s}$
 c) $\vec{r} = (200 \text{ m})\hat{i} + (550 \text{ m})\hat{j}$
 3.47 a) 124 m b) 280 m
 3.49 22 m/s
 3.51 40 m/s
 3.53 274 m
 3.55 a) 42.8 m/s b) 42.0 m
 3.57 a) $\sqrt{2gh}$ b) 30.0° c) 6.93h
 3.59 c) less than 45°
 3.61 b) 15° , 75°
 3.63 a) 17.8 m/s b) in river, 28.4 m from the near
 bank
 3.65 a) 81.6 m b) in cart c) 245 m d) 53.1°
 3.67 a) 49 m/s b) 50 m
 3.69 a) 2000 m b) 2180 m
 3.71 a) 38.5 m/s b) (i) 25.0 m/s, 0
 (ii) 25.0 m/s, 38.5 m/s c) (i) 0°
 (ii) 57.0° d) 499 m
 3.73 $\pm 25.4^\circ$
 3.77 $v_x = R\omega(1 - \cos\omega t)$, $v_y = R\omega \sin\omega t$,
 $a_x = R\omega^2 \sin\omega t$, $a_y = R\omega^2 \cos\omega t$ c) $t = 0$,
 $2\pi/\omega$, $4\pi/\omega$, ...; $x = 0$, $2\pi R$, $4\pi R$, ...;
 $y = 0$; $a = R\omega^2$ in the $+y$ direction d) no
 3.79 a) 2.50g b) 0.614n
 3.81 a) 44.7 km/h, 26.6° west of south
 b) 10.5° north of west
 3.83 a) 0.659 s b) (i) 9.10 m/s (ii) 6.46 m/s
 c) 3.00 m, 2.13 m
 3.85 7.39 m/s, 12.4° north of east
 3.87 a) 80 m b) 1.6×10^{-3} c) overall effect is
 to reduce radius
 3.89 a) $\left(\frac{2v_0^2}{g}\right) [\tan(\theta + \phi) - \tan\theta] \frac{\cos^2(\theta + \phi)}{\cos\theta}$
 b) $\frac{\pi}{4} - \frac{\theta}{2}$

Chapter 3

- 3.1 a) $v_{\text{av-x}} = 1.4 \text{ m/s}$, $v_{\text{av-y}} = -1.3 \text{ m/s}$
 b) 1.9 m/s, -43°
 3.3 a) 7.1 cm/s, 45° b) 5.0 cm/s, 90° ; 7.1 cm/s;
 45° ; 11 cm/s, 27°
 3.5 b) $a_{\text{av-x}} = -8.67 \text{ m/s}^2$, $a_{\text{av-y}} = -2.33 \text{ m/s}^2$
 c) 8.98 m/s^2 , 195°
 3.7 b) $\vec{v} = \alpha\hat{a} + (-2\beta)\hat{j}$; $\vec{a} = -2\beta\hat{j}$
 c) $v = 5.4 \text{ m/s}$, -63° ; $a = 2.4 \text{ m/s}^2$, -90°
 d) speeding up and turning right
 3.9 b) 0.600 m b) 0.385 m c) $v_x = 1.10 \text{ m/s}$,
 $v_y = -3.43 \text{ m/s}$; $v = 3.60 \text{ m/s}$, 72.2° below
 the horizontal
 3.11 3.32 m
 3.13 a) 30.6 m/s b) 36.3 m/s
 3.15 1.29 m/s²
 3.17 a) 40.0 m/s, 69.3 m/s b) 7.07 s c) 245 m
 d) 565 m e) $\alpha_x = 0$, $\alpha_y = -9.80 \text{ m/s}^2$;
 $v_x = 40.0 \text{ m/s}$, $v_y = 0$

Chapter 4

- 4.1 a) 0° b) 90° c) 180°
 4.3 7.1 N to the right, 7.1 N downward
 4.5 494 N, 31.7°
 4.7 2.2 m/s^2
 4.9 16.0 kg
 4.11 a) 3.13 m, 3.13 m/s b) 21.9 m, 6.25 m/s
 4.13 a) 45.0 N; $t = 2$ s to 4 s b) 2 s to 4 s
 c) 0, 6 s
 4.15 a) $A = 100 \text{ N}$, $B = 12.5 \text{ N/s}^2$ b) (i) 21.6 N,
 2.70 m/s^2 (ii) 134 N, 16.8 m/s^2
 c) 26.6 m/s^2
 4.17 $2.94 \times 10^3 \text{ N}$
 4.19 a) 4.49 kg b) 4.49 kg, 8.13 N
 4.21 825 N, blocks

- 4.23 a) gravity exerted by earth on bottle; force of air on bottle b) gravity exerted by bottle on earth; force of bottle on air
 4.25 $7.4 \times 10^{-23} \text{ m/s}^2$
 4.27 b) yes
 4.29 yes, in part (a)
 4.31 b) 142 N
 4.33 c) force exerted by the ground on the truck
 4.35 1840 N, 135°
 4.37 a) 17 N, 90° clockwise from +x-direction
 b) 840 N
 4.39 a) 4.8 m/s b) 16 m/s² c) 2360 N
 4.41 b) 5.83 m/s^2
 4.43 a) 2.50 m/s^2 b) 10.0 N c) to the right; F
 d) 25.0 N
 4.45 a) 2.93 m/s^2 b) 11.1 m/s^2
 4.47 b) 79.6 N
 4.49 a) mg b) mg c) $m(g + |\vec{a}|)$
 d) $m(g - |\vec{a}|)$
 4.51 a) 7.80 m/s² b) 50.6 m/s²
 c) 4532 N, 6.16mg
 4.53 a) w b) 0 c) $w/2$
 4.55 b) 1390 N
 4.57 b) (i) 3.5 m/s^2 (ii) 8.0 N
 4.59 $-6mBt$

Chapter 5

- 5.1 a) 25.0 N b) 50.0 N
 5.3 a) 990 N, 735 N b) 926 N
 5.5 48°
 5.7 $4.10 \times 10^3 \text{ N}$
 5.9 a) A: 0.732w; B: 0.897w; C: w b) A: 2.73w; B: 3.35w; C: w
 5.11 a) 337 N b) 343 N
 5.13 a) 470 N b) 163 N
 5.15 b) 1.22mg c) 0.70mg
 5.17 a) 4610 m/s^2 , 470g b) $9.70 \times 10^5 \text{ N}$, 471w
 c) 18.7 ms
 5.19 b) 2.96 m/s^2 c) 191 N; more than the bricks, less than the counterweight
 5.21 b) 2.50 m/s^2 c) 1.37 kg d) $T = 0.745w$
 5.23 a) 0.832 m/s^2 b) 17.3 s
 5.25 1.38°
 5.29 a) 22 N b) 3.1 m
 5.31 a) 0.710, 0.472 b) 258 N c) (i) 51.8 N (ii) 4.97 m/s^2
 5.33 a) 57.1 N b) 146 N, up the ramp
 5.35 11 times farther
 5.37 a) $\mu_k(m_A + m_B)g$ b) $\mu_k m_A g$
 5.39 3.82 m/s^2
 5.41 a) 0.218 m/s b) 11.7 N
 5.43 a) $\mu_k mg / (\cos\theta - \mu_k \sin\theta)$ b) $1/\tan\theta = \mu_k$
 5.45 b) 8.75 N c) 30.8 m d) 1.54 m/s^2
 5.47 a) 0.44 kg/m b) 42 m/s
 5.49 a) 3.61 m/s b) bottom c) 3.33 m/s
 5.51 a) 21.0° ; no b) car: $1.18 \times 10^4 \text{ N}$; truck: $2.36 \times 10^4 \text{ N}$
 5.53 upper cable: 1410 N; horizontal cable: 8360 N
 5.55 a) 1.49 rev/min b) 0.918 rev/min
 5.57 a) 138 km/h b) 3580 N
 5.59 2.43 m/s
 5.61 a) rope making 60° angle b) 6400 N
 5.63 a) $Mg/(2\sin\theta)$ b) $Mg/(2\tan\theta)$ c) $T \rightarrow \infty$
 5.65 a) $m_1(\sin\alpha + \mu_k \cos\alpha)$
 b) $m_1(\sin\alpha - \mu_k \cos\alpha)$
 c) $m_1(\sin\alpha - \mu_k \cos\alpha) < m_2 < m_1(\sin\alpha + \mu_k \cos\alpha)$
 5.67 a) 1.44 N b) 1.80 N
 5.69 a) $1.3 \times 10^{-4} \text{ N}$; 62.5w b) $2.9 \times 10^{-4} \text{ N}$ at 1.2 ms c) 1.2 m/s
 5.71 1040 N
 5.73 a) 11 m/s b) 7.5 m/s
 5.75 0.40
 5.77 a) $g \left(\frac{m_B + m_{\text{rope}} d/L}{m_A + m_B + m_{\text{rope}}} \right)$; increases b) 0.63 m
 c) will not work for any value of d
 5.79 a) 66 N, northward b) 59 N, southward
 5.81 a) 294 N, 152 N, 152 N b) 40.0 N
 5.83 2.52 N
 5.85 a) 12.9 kg b) 47.2 N in left-hand cord, 101 N in right-hand cord

- 5.87 $a_1 = 2m_2g/(4m_1 + m_2)$;
 $a_2 = 2m_2g/(4m_1 + m_2)$
 5.89 1.46 m above the floor
 5.91 g/μ_s
 5.93 b) 0.450
 5.95 0.34
 5.97 a) 170 m b) 18 m/s, 41 mi/h
 c) 25 m/s, 56 mi/h
 5.99 a) move up b) remains constant
 c) remains constant d) stop
 5.101 a) 6.00 m/s^2 b) 0.380 m/s^2 c) 7.36 m/s
 d) 8.18 m/s e) 7.78 m, 6.29 m/s, 1.38 m/s²
 f) 3.14 s
 5.103 $1/3$
 5.105 a) $v_y(t) = v_i + (v_0 - v_i)e^{-kt/m}$
 b) $v_y(t) = v_i(\sin\beta - 0.015\cos\beta)^{1/2}$
 5.107 a) 0.015; 0.036 N · s²/m² b) 29 m/s
 c) ratio is $(\sin\beta - 0.015\cos\beta)^{1/2}$
 5.109 a) 120 N b) 3.79 m/s
 5.111 b) 0.28 c) no
 5.113 a) right b) 120 m
 5.115 a) 81.1° b) no c) bead rides at bottom of hoop ($\beta = 0$)
 5.119 $T_{\text{max}} = 2\pi\sqrt{\left(\frac{h \tan\beta}{g}\right)\left(\frac{\sin\beta + \mu_s \cos\beta}{\cos\beta - \mu_s \sin\beta}\right)}$;
 $T_{\text{min}} = 2\pi\sqrt{\left(\frac{h \tan\beta}{g}\right)\left(\frac{\sin\beta - \mu_s \cos\beta}{\cos\beta + \mu_s \sin\beta}\right)}$
 5.121 $(M + m)g \tan\alpha$
 5.123 a) $F = \frac{\mu_k w}{\cos\theta + \mu_k \sin\theta}$
 b) $\theta = \tan^{-1}(\mu_k) = 14.0^\circ$
 5.125 a) $a_3 = g \left(\frac{-4m_1 m_2 + m_2 m_3 + m_3 m_1}{4m_1 m_2 + m_2 m_3 + m_3 m_1} \right)$
 b) $a_B = -a_3$
 c) $a_1 = g \left(\frac{4m_1 m_2 - 3m_2 m_3 + m_3 m_1}{4m_1 m_2 + m_2 m_3 + m_3 m_1} \right)$
 d) $a_2 = g \left(\frac{4m_1 m_2 + m_2 m_3 - 3m_3 m_1}{4m_1 m_2 + m_2 m_3 + m_3 m_1} \right)$
 e) $T_A = \frac{1}{2}T_C$
 f) $T_C = \frac{8gm_1 m_2 m_3}{4m_1 m_2 + m_2 m_3 + m_3 m_1}$
 g) $a_1 = a_2 = a_3 = a_B = 0$, $T_C = 2m_2 g$, $T_A = m_2 g$; yes
 5.127 $\cos^2\beta$

Chapter 6

- 6.1 a) 3.60 J b) -0.900 J c) 2.70 J
 6.3 a) 74 N b) 330 J c) -330 J d) zero; zero
 e) zero
 6.5 a) -1750 J b) no
 6.7 a) (i) 9.00 J (ii) -9.00 J b) (i) 0 (ii) 9.00 J (iii) -9.00 J (iv) 0
 c) zero for each block
 6.9 a) (i) zero (ii) zero b) (i) zero (ii) -25.1 J
 6.11 a) $1.0 \times 10^{16} \text{ J}$ b) about 2 times greater
 6.13 a) 42.85V b) 1836K
 6.15 a) 43.2 m/s b) 101 m/s c) 5.80 m
 d) 3.53 m/s e) 7.35 m
 6.17 $(2gh[1 + \mu_k/\tan\alpha])^{1/2}$
 6.19 a) 9D b) D/3
 6.21 32.0 N
 6.23 a) 4.48 m/s b) 3.61 m/s
 6.25 a) 4.96 m/s b) $a = 1.43 \text{ m/s}^2$; $v = 4.96 \text{ m/s}$; same
 6.27 a) $v_0^2/2\mu_k g$ b) 1/2 c) 4 d) 2
 6.29 a) 48.0 N, 64.0 N b) 0.360 J, 0.640 J
 6.31 a) 2.8 m/s b) 3.5 m/s
 6.33 8.5 cm
 6.35 a) 1.76 b) 0.67 m/s
 6.37 a) 4.0 J b) zero c) -1.0 J d) 3.0 J e) -1.0 J
 6.39 a) 2.83 m/s b) 2.40 m/s
 6.41 a) 5.65 cm b) no; 0.57 J
 6.43 $3.6 \times 10^5 \text{ J}$; 100 m/s
 6.45 $4.0 \times 10^{15} \text{ P}$
 6.47 743 W, 0.995 hp
 6.49 a) 1.4 b) 0.38
 6.51 a) $5.4 \times 10^9 \text{ J}$ b) 0.72 MW

- 6.53 $2.96 \times 10^4 \text{ W}$
 6.55 877 J
 6.57 a) 532 J b) -315 J c) zero d) -203 J
 e) 14.7 J f) 1.21 m/s
 6.59 a) $1/\sin\alpha$ b) $W_{\text{in}} = W_{\text{out}}$
 6.61 a) $2.59 \times 10^{12} \text{ J}$ b) 4800 J
 6.63 b) $k_{\text{eff}} = k_1 + k_2 + \dots + k_N$
 6.65 a) $k \left(\frac{1}{x_2} - \frac{1}{x_1} \right)$; negative b) $k \left(\frac{1}{x_1} - \frac{1}{x_2} \right)$;
 positive c) same magnitude and opposite sign, since net work is zero
 6.67 a) 5.11 m b) 0.304 c) 10.3 m
 6.69 a) 0.15 N b) 9.4 N c) 0.44 J
 6.71 a) 2.56 m/s b) 5.28 N c) 19.7 J
 6.73 a) -910 J b) $3.17 \times 10^3 \text{ J}$
 6.75 $1.0 \times 10^5 \text{ N/m}$
 6.77 1.1 m from where spring is released
 6.79 a) $1.02 \times 10^4 \text{ N/m}$, 8.16 m
 6.81 a) 0.600 m b) 1.50 m/s
 6.83 0.786
 6.85 1.5 m
 6.87 a) $1.10 \times 10^5 \text{ J}$ b) $1.30 \times 10^5 \text{ J}$
 c) 3.99 kW
 6.89 3.6 h
 6.91 $1.30 \times 10^3 \text{ m}^3/\text{s}$
 6.93 a) $1.26 \times 10^5 \text{ J}$ b) 1.46 W
 6.95 a) 2.4 MW b) 61 MW c) 6.0 MW
 6.97 a) 513 W b) 355 W c) 52.1 W
 6.99 a) 358 N b) 47.2 hp c) 4.06 hp d) 2.03%
 6.101 a) $\frac{1}{2}MV^2$ b) 6.1 m/s c) 3.9 m/s
 d) $K_{\text{ball}} = 0.40 J$, $K_{\text{spring}} = 0.60 J$
 6.103 a) $2.0 \times 10^5 \text{ J}$ b) $2.8 \times 10^5 \text{ J}$
 c) $2.8 \times 10^5 \text{ J}$ d) 5 km/h

Chapter 7

- 7.1 a) $6.6 \times 10^5 \text{ J}$ b) $-7.7 \times 10^5 \text{ J}$
 7.3 a) 820 N b) (i) zero (ii) 740 J
 7.5 a) 24.0 m/s b) 24.0 m/s c) part (b)
 7.7 2.5 m/s
 7.9 a) (i) zero (ii) 0.98 J b) 2.8 m/s
 c) constant: gravity; not constant: normal, friction d) 5.0 N
 7.11 -5400 J
 7.13 a) 880 J b) -157 J c) 471 J d) 253 J
 e) $a = 3.16 \text{ m/s}^2$; $v = 7.11 \text{ m/s}$; $\Delta K = 253 \text{ J}$; same
 7.15 a) 80.0 J b) 5.00 J
 7.17 a) (i) $4U_0$ (ii) $U_0/4$ b) (i) $x_0\sqrt{2}$ (ii) $x_0/\sqrt{2}$
 7.19 a) 6.32 cm b) 12 cm
 7.21 $\pm 0.092 \text{ m}$
 7.23 a) 3.03 m/s; as mass leaves spring
 b) 95.9 m/s^2 ; just after mass is released
 7.25 a) $4.46 \times 10^5 \text{ N/m}$ b) 0.128 m
 7.27 a) -308 J b) -616 J c) nonconservative
 7.29 a) -3.6 J b) -3.6 J c) -7.2 J
 d) nonconservative
 7.31 a) $\frac{1}{2}k(x_1^2 - x_2^2)$ b) $-\frac{1}{2}k(x_1^2 - x_2^2)$; zero
 c) $-\frac{1}{2}k(x_3^2 - x_1^2)$; $-\frac{1}{2}k(x_2^2 - x_3^2)$;
 $-\frac{1}{2}k(x_2^2 - x_1^2)$; same
 7.33 2.46 N, +x-direction
 7.35 c) attracts
 7.37 a) $F(r) = (12a/r^{13}) - (6b/r^7)$
 b) $(2a/b)^{1/6}$; stable c) $b^2/4a$
 d) $a = 6.68 \times 10^{-138} \text{ J} \cdot \text{m}^{12}$,
 $b = 6.41 \times 10^{-78} \text{ J} \cdot \text{m}^6$
 e) zero, 637 N b) 2.99 m/s
 7.41 a) no b) yes, \$150
 7.43 0.41
 7.45 a) 15.9 J b) 4.0 J c) 3.0 J
 7.47 a) 20.0 m from left-hand edge of horizontal section b) -78.4 J
 7.49 a) 22.2 m/s b) 16.4 m c) no
 7.51 0.602 m
 7.53 15.5 m/s
 7.55 4.4 m/s
 7.57 a) $x_0\sqrt{k/m}$ b) kx_0/m c) $x = 0$, $x = -x_0$
 d) x_0 e) system oscillates and never stops
 7.59 a) 7.00 m/s b) 2.94 N
 7.61 a) $mg(1 - h/d)$ b) 440 N