A Conversion Factors

Table A.1 Length

	m	cm	km	in.	ft	mi
1 meter	1	10^2	10^{-3}	39.37	3.281	6.214×10^{-4}
1 centimeter	10^{-2}	1	10^{-5}	0.3937	3.281×10^{-2}	6.214×10^{-6}
1 kilometer	10^3	10^5	1	3.937×10^4	3.281×10^3	0.621 4
1 inch	2.540×10^{-2}	2.540	2.540×10^{-5}	1	8.333×10^{-2}	1.578×10^{-5}
1 foot	0.304 8	30.48	3.048×10^{-4}	12	1	1.894×10^{-4}
1 mile	1 609	1.609×10^5	1.609	6.336×10^4	5280	1

Table A.2 Time

	s	min	h	day	year
1 second	1	1.667×10^{-2}	2.778×10^{-4}	1.157×10^{-5}	3.169×10^{-8}
1 minute	60	1	1.667×10^{-2}	6.994×10^{-4}	1.901×10^{-6}
1 hour	3 600	60	1	4.167×10^{-2}	1.141×10^{-4}
1 day	8.640×10^4	1440	24	1	2.738×10^{-5}
1 year	3.156×10^7	5.259×10^5	8.766×10^3	365.2	1

Table A.3 Area

	m^2	cm^2	ft^2	$in.^2$
1 square meter	1	10^4	10.76	1550
1 square centimeter	10^{-4}	1	1.076×10^{-3}	0.1550
1 square foot	9.290×10^{-2}	929.0	1	144
1 square inch	6.452×10^{-4}	6.452	6.944×10^{-3}	1

Note 1 square kilometer = 247.108 acres

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Table A.4 Volume

	m^3	cm^3	L	ft^3	$in.^3$
1 cubic meter	1	10^6	1000	35.51	6.102×10^4
1 cubic centimeter	10^{-6}	1	1.000×10^{-3}	3.531×10^{-5}	6.102×10^{-2}
1 liter	1.000×10^{-3}	1000	1	3.531×10^{-2}	61.02
1 cubic foot	2.832×10^{-4}	1	28.32	1	1728
1 cubic inch	1.639×10^{-4}	16.39	1.639×10^{-2}	5.787×10^{-4}	1

Note 1 U.S. fluid gallon = 3.786 L

Table A.5 Speed

	m/s	cm/s	ft/s	mi/h	km/h
1 meter per second	1	10^2	3.281	2.237	3.6
1 centimeter per second	10^{-2}	1	3.281×10^{-2}	2.237×10^{-2}	3.6×10^{-2}
1 foot per second	0.304 8	30.48	1	0.681 8	1.097
1 mile per hour	0.447 0	44.70	1.467	1	1.609
1 kilometer per hour	0.277 8	27.78	0.9113	0.6214	1

Table A.6 Mass

	kg	g	slug	u
1 kilogram	1	10^3	6.852×10^{-2}	6.024×10^{26}
1 gram	10^{-3}	1	6.852×10^{-5}	6.024×10^{23}
1 slug	14.59	1.459×10^4	1	8.789×10^{27}
1 atomic mass unit	1.660×10^{-27}	1.660×10^{-24}	1.137×10^{-28}	1

Note 1 metric ton = 1000 kg

Table A.7 Force

	N	lb
1 newton	1	0.224 8
1 pound	4.448	1

Table A.8 Work, energy, and heat

	J	ft.lb	eV
1 joule	1	0.737 6	6.242×10^{18}
1 foot-pound	1.356	1	8.464×10^{18}
1 electron volt	1.602×10^{-19}	1.182×10^{-19}	1
1 calorie	4.186	3.087	2.613×10^{19}
1 British thermal unit	1.055×10^3	7.779×10^2	6.585×10^{21}
1 kilowatt hour	3.600×10^6	2.655×10^6	2.247×10^{25}

Table A.8 Continued

	cal	Btu	kWh
1 joule	0.2389	9.481×10^{-4}	2.778×10^{-7}
1 foot-pound	0.3239	1.285×10^{-3}	3.766×10^{-7}
1 electron volt	3.827×10^{-20}	1.519×10^{-22}	4.450×10^{-26}
1 calorie	1	3.968×10^{-3}	1.163×10^{-6}
1 British thermal unit	2.520×10^{2}	1	2.930×10^{-4}
1 kilowatt hour	8.601×10^{5}	3.413×10^{2}	1

Table A.9 Pressure

	Pa	atm	cm Hg	lb/in.^{2}	lb/ft^2
1 pascal	1	9.869×10^{-6}	7.501×10^{-4}	1.450×10^{-4}	2.089×10^{-2}
1 atmosphere	1.013×10^{5}	1	76	14.70	2.116×10^{3}
1 centimeter mercury[a]	1.333×10^{3}	1.316×10^{-2}	1	0.194 3	27.85
1 pound per square inch	6.895×10^{3}	6.805×10^{-2}	5.171	1	144
1 pound per square foot	47.88	4.725×10^{-4}	3.591×10^{-2}	6.944×10^{-3}	1

[a] At 0°C and at a location where the free-fall acceleration has its "standard" value, 9.806 65 m/s^2

Basic Rules and Formulas

B

Scientific Notation

When numbers in powers of 10 are expressed in scientific notation are being multiplied or divided, the following rules are very useful:

$$10^m \times 10^n = 10^{m+n}$$
$$\frac{10^m}{10^n} = 10^{m-n} \qquad \text{(B.1)}$$

When powers of a given quantity x are multiplied or divided, the following rules hold:

$$x^m \times x^n = x^{m+n}$$
$$\frac{x^m}{x^n} = x^{m-n} \qquad \text{(B.2)}$$

The Distance Between Two Points

In Fig. B.1, $P(x_1, y_1)$ and $Q(x_2, y_2)$ are two different points in the (x, y) plane. As we move from point P to point Q, the coordinates x and y change by amounts that we denote by Δx and Δy (read "delta x" and "delta y"). Thus:

$$\text{The change in } x = \Delta x = x_2 - x_1$$
$$\text{The change in } y = \Delta y = y_2 - y_1 \qquad \text{(B.3)}$$

One can calculate the distance between the two points P and Q from the theorem of Pythagoras in geometry such that:

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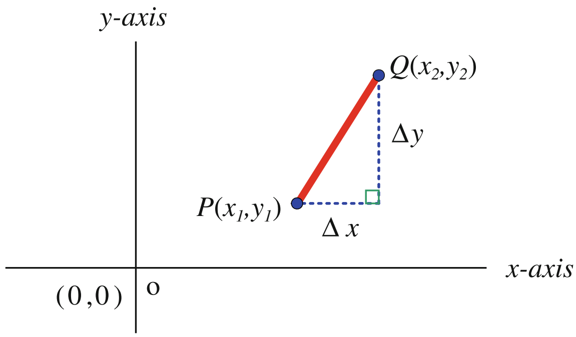
$$\text{The distance PQ} = \sqrt{(\Delta x)^2 + (\Delta y)^2} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \tag{B.4}$$

Fig. B.1

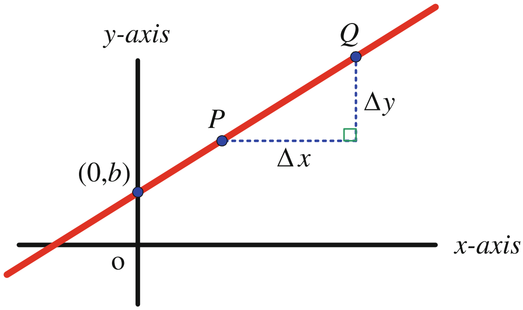


Slope and the Equation of a Straight Line

The slope of a line (usually given the symbol m) on which two points P and Q lie, is defined as the ratio $\Delta y/\Delta x$, see Fig. B.2. Thus:

$$\text{slope} \equiv m = \frac{\Delta y}{\Delta x} \tag{B.5}$$

Fig. B.2



Using this basic geometric property, we can find the equation of a straight line in terms of a general point (x, y), and the y intercept b of the line with the y-axis and the slope m of the line, as follows:

$$y = mx + b \tag{B.6}$$

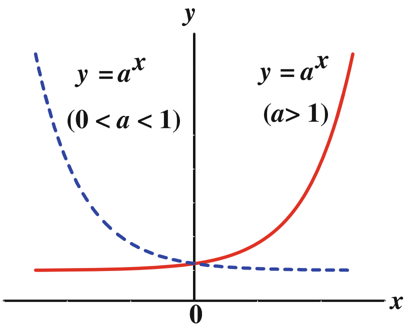
Exponential and Logarithmic Functions

An *exponential function with base a* has the following forms:

$$y = a^x \qquad (a > 0, a \neq 1) \tag{B.7}$$

where x is a variable and a is a constant, i.e., the exponential function is a constant raised to a variable power. Exponential functions are continuous on the interval $(-\infty, \infty)$ with a range $[0, \infty]$ and have one of the basic two shapes shown in Fig. B.3.

Fig. B.3



Moreover, some algebraic properties of exponential functions are:

$$\begin{aligned}
&1.\ a^x \times a^y = a^{x+y}\\
&2.\ (a\,b)^x = a^x \times b^x\\
&3.\ (a^x)^y = a^{x\,y}\\
&4.\ \frac{a^x}{a^y} = a^{x-y}\\
&5.\ a^{x/q} = \sqrt[q]{a^x} = (\sqrt[q]{a})^x,\ (q \text{ integer and } q > 0)\\
&6.\ a^0 = 1,\ (\text{for every positive real number } a)
\end{aligned} \tag{B.8}$$

The logarithmic function to the base a of x is introduced as the inverse of the exponential function $x = a^y$. That is, $y = \log_a x$ is the power (or exponent) to which a must be raised to produce x, so that:

$$y = \log_a x \quad (\text{is equivalent to}) \quad x = a^y \tag{B.9}$$

Additionally, some algebraic properties of logarithmic functions for any base a are as follows:

$$\begin{array}{lll} 1.\ \log_a(xy) = \log_a(x) + \log_a(y) & \text{Product property} \\ 2.\ \log_a(x/y) = \log_a(x) - \log_a(y) & \text{Quotient property} \\ 3.\ \log_a(x^r) = r\log_a(x) & \text{Power property} \\ 4.\ \log_a(1/x) = -\log_a(x) & \text{Reciprocal property} \end{array} \quad \text{(B.10)}$$

Historically, the first logarithmic base was 10, called the *common logarithm*. For such logarithms it is usual to suppress explicit reference to the base and write $\log x$ rather than $\log_{10} x$. However, the most widely used logarithms in applications are the *natural logarithms*, which have an irrational base denoted by the letter e in honor of L. Euler, who first suggested its application to logarithms. This constant's value to six decimal places is:

$$e \approx 2.718282 \quad \text{(B.11)}$$

This number arises as the horizontal asymptote of the graph of the equation $y = (1 + 1/x)^x$. Therefore, as $x \to \pm\infty$ this allows us to express e as a limit and e^x as an infinite sum such that:

$$e = \lim_{x\to\pm\infty}\left(1 + \frac{1}{x}\right)^x = \lim_{x\to 0}(1+x)^{\frac{1}{x}} \quad \text{(B.12)}$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots = \sum_{n=0}^{\infty}\frac{x^n}{n!} \quad \text{(B.13)}$$

where the symbol $n!$ is read as "n factorial" and by definition $1! = 1$, $0! = 1$, and $n!$ are given by:

$$n! = n \times (n-1) \times (n-2) \ldots \times 3 \times 2 \times 1 \quad \text{(B.14)}$$

Both expressions (B.11) and (B.12) are sometimes taken to be the definition of the number e. Thus, $\log_e x$ is the natural logarithm to the base e of x, and it is usually denoted by $\ln x$, so that:

$$\ln x \equiv \log_e x \quad \text{(B.15)}$$

and thus:

$$y = e^x \quad \text{(is equivalent to)} \quad \ln y = x \tag{B.16}$$

The exponential function $f(x) = e^x$ is called the *natural exponential function*. To simplify the typography, this function is sometimes written as $\exp(x)$, that is $\exp(x) \equiv e^x$. As an example, Table B.1 displays some special cases of the last relation.

Table B.1 Some exponential and logarithmic functions

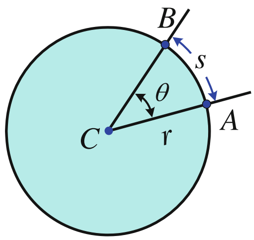
$y = e^x$	$1 = e^0$	$e = e^1$	$1/e = e^{-1}$	$e^x = e^x$
$\ln y = x$	$\ln\ 1 = 0$	$\ln\ e = 1$	$\ln(1/e) = -1$	$\ln\ e^x = x$

Radian Measures

The arc length s of a circular arc, see Fig. B.4, which is part of a circle of radius r is related to the radian measure θ of the angle ACB (measured in radians) by the relation:

$$\frac{s}{r} = \theta \quad \text{or} \quad s = r\theta \quad \text{(radian measure)} \tag{B.17}$$

Fig. B.4



Since the circumference of a unit circle is 2π and one complete revolution of a circle is $360°$, then the relation between revolutions, degrees, and radians is given by:

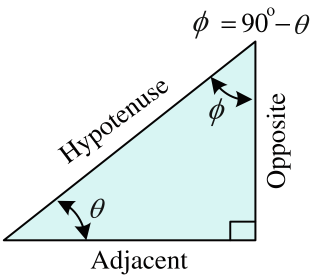
$$\begin{aligned} &1\ \text{rev} = 360° = 2\pi\ \text{rad} \quad \Rightarrow \quad \pi\ \text{rad} = 180° \\ &1° = \frac{\pi}{180}\text{rad} \approx 0.02\ \text{rad} \quad \text{and} \quad 1\ \text{rad} = \frac{180}{\pi}\text{deg} \approx 57.3° \end{aligned} \tag{B.18}$$

The Six Basic Trigonometric Functions

For an acute angle θ in a right-angled triangle, see Fig. B.5, we define the following six basic trigonometric functions:

Sine	$\sin\theta = \frac{\text{opp}}{\text{hyp}}$	Cosecant	$\csc\theta = \frac{\text{hyp}}{\text{opp}}$
Cosine	$\cos\theta = \frac{\text{adj}}{\text{hyp}}$	Secant	$\sec\theta = \frac{\text{hyp}}{\text{adj}}$
Tangent	$\tan\theta = \frac{\text{opp}}{\text{adj}}$	Cotangent	$\cot\theta = \frac{\text{adj}}{\text{opp}}$

Fig. B.5



To extend this definition to obtuse and negative angles, we place the angle in the *standard position* in a circle of radius r and define the trigonometric functions in terms of the point $P(x, y)$ where the angle's terminal ray intersects the circle, see Fig. B.6. Therefore, we get the following relations:

Sine	$\sin\theta = \frac{y}{r}$	Cosecant	$\csc\theta = \frac{r}{y} = \frac{1}{\sin\theta}$	
Cosine	$\cos\theta = \frac{x}{r}$	Secant	$\sec\theta = \frac{r}{x} = \frac{1}{\cos\theta}$	(B.19)
Tangent	$\tan\theta = \frac{y}{x} = \frac{\sin\theta}{\cos\theta}$	Cotangent	$\cot\theta = \frac{x}{y} = \frac{\cos\theta}{\sin\theta}$	

We see that $\tan\theta$ and $\sec\theta$ are not defined if $x = 0$. This means that they are not defined if θ is $\pm\pi/2, \pm3\pi/2, \ldots$ Similarly, $\cot\theta$ and $\csc\theta$ are not defined if $y = 0$, namely $\theta = 0, \pm\pi, \pm2\pi, \ldots$

Some properties of the trigonometric functions are:

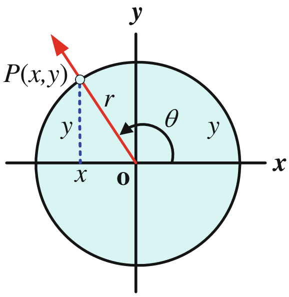


Fig. B.6

$$\begin{aligned}\sin(-\theta) &= -\sin(\theta)\\ \cos(-\theta) &= \cos(\theta)\\ \tan(-\theta) &= -\tan(\theta)\end{aligned} \tag{B.20}$$

From the right triangle of Fig. B.5, we can find the following:

$$\begin{aligned}\sin\theta &= \cos(90^\circ-\theta)\\ \cos\theta &= \sin(90^\circ-\theta)\\ \cot\theta &= \tan(90^\circ-\theta)\end{aligned} \tag{B.21}$$

Moreover, we list here the following trigonometric identities:

$$\begin{gathered}\cos^2\theta+\sin^2\theta=1\\ 1+\cot^2\theta=\csc^2\theta \qquad 1+\tan^2\theta=\sec^2\theta\\ \sin 2\theta = 2\sin\theta\ \cos\theta \qquad \cos 2\theta=\cos^2\theta-\sin^2\theta\\ \tan 2\theta=\frac{2\tan\theta}{1-\tan^2\theta} \qquad \tan\frac{\theta}{2}=\sqrt{\frac{1-\cos\theta}{1+\cos\theta}}\\ \sin^2\frac{\theta}{2}=\frac{1}{2}(1-\cos\theta) \qquad \cos^2\frac{\theta}{2}=\frac{1}{2}(1+\cos\theta)\\ \sin(\alpha\pm\beta)=\sin\alpha\ \cos\beta\pm\cos\alpha\ \sin\beta\\ \cos(\alpha\pm\beta)=\cos\alpha\ \cos\beta\mp\sin\alpha\ \sin\beta\\ \sin\alpha\pm\sin\beta=2\sin[(\alpha\pm\beta)/2]\cos[(\alpha\mp\beta)/2]\end{gathered} \tag{B.22}$$

Table B.2 The results of differentiating several functions and their corresponding integrations

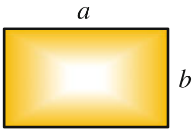
Differentiation formula	Integration formula
$\frac{d}{dx}[x] = 1$	$\int dx = x + C$
$\frac{d}{dx}\left[\frac{x^{n+1}}{n+1}\right] = x^n,\ (n \neq -1)$	$\int x^n dx = \frac{x^{n+1}}{n+1} + C, \quad (n \neq -1)$
$\frac{d}{dx}[\sin x] = \cos x$	$\int \cos x\ dx = \sin x + C$
$\frac{d}{dx}[\cos x] = -\sin x$	$\int \sin x\ dx = -\cos x + C$
$\frac{d}{dx}[\tan x] = \sec^2 x$	$\int \sec^2 x\ dx = \tan x + C$
$\frac{d}{dx}[\csc x] = -\csc x\ \cot x$	$\int \csc x\ \cot x\, dx = -\csc x + C$
$d\frac{d}{dx}[\sec x] = \sec x\ \tan x$	$\int \sec x\ \tan x\, dx = \sec x + C$
$\frac{d}{dx}[\cot x] = -\csc^2 x$	$\int \csc^2 x\ dx = -\cot x + C$
$\frac{d}{dx}[e^x] = e^x$	$\int e^x\ dx = e^x + C$
$\frac{d}{dx}[\ln x] = \frac{1}{x}$	$\int \frac{1}{x}\ dx = \ln x + C$

Table B.3 Some complicated indefinite integrals (an arbitrary constant should be added to each of these integrals)

$\int \frac{dx}{a+bx} = \frac{1}{b}\ln(a+bx)$	$\int \frac{x\,dx}{\sqrt{a^2-x^2}} = -\sqrt{a^2-x^2}$
$\int \frac{x\,dx}{a+bx} = \frac{x}{b} - \frac{a}{b^2}\ln(a+bx)$	$\int \frac{x\,dx}{\sqrt{x^2 \pm a^2}} = \sqrt{x^2 \pm a^2}$
$\int \frac{dx}{x\,(x+a)} = -\frac{1}{a}\ln\frac{x+a}{x}$	$\int x\sqrt{a^2-x^2}\,dx = -\frac{1}{3}(a^2-x^2)^{3/2}$
$\int \frac{dx}{(a+bx)^2} = -\frac{1}{b(a+bx)}$	$\int x\sqrt{x^2 \pm a^2}\,dx = \frac{1}{3}(x^2 \pm a^2)^{3/2}$
$\int \frac{dx}{x^2+a^2} = \frac{1}{a}\tan^{-1}\frac{x}{a}$	$\int e^{ax}\,dx = \frac{1}{a}e^{ax}$
$\int \frac{dx}{a^2-x^2} = \frac{1}{2a}\ln\frac{a+x}{a-x},\ (a^2-x^2>0)$	$\int x\,e^{ax}\,dx = \frac{1}{a^2}(ax-1)\,e^{ax}$
$\int \frac{dx}{x^2-a^2} = \frac{1}{2a}\ln\frac{x-a}{x+a},\ (x^2-a^2>0)$	$\int \frac{dx}{a+b\,e^{cx}} = \frac{x}{a} - \frac{1}{ac}\ln(a+b\,e^{cx})$
$\int \frac{x\,dx}{a^2 \pm x^2} = \pm\frac{1}{2}\ln(a^2 \pm x^2)$	$\int \ln(ax)\,dx = x\ln(ax) - x$
$\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2\sqrt{x^2+a^2}}$	$\int \cos^2(ax)dx = \frac{x}{2} + \frac{\sin 2ax}{4a}$
$\int \frac{x\,dx}{(x^2+a^2)^{3/2}} = -\frac{x}{\sqrt{x^2+a^2}}$	$\int \sin^2(ax)\,dx = \frac{x}{2} - \frac{\sin 2ax}{4a}$
$\int \frac{dx}{\sqrt{a^2-x^2}} = \sin^{-1}\frac{x}{a},\ (a^2-x^2>0)$	$\int \tan^2(ax)\,dx = \frac{1}{a}\tan(ax) - x$
$\int \frac{dx}{\sqrt{x^2 \pm a^2}} = \ln(x+\sqrt{x^2 \pm a^2})$	$\int \cot^2(ax)\,dx = -\frac{1}{a}\cot(ax) - x$

Useful Information for Geometry

Rectangle



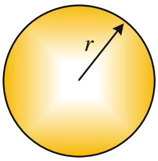
Area $= a\,b$

Sphere

Surface area $= 4\,\pi r^2$

Volume $= \frac{4}{3}\pi r^3$

Circle



Area $= \pi r^2$

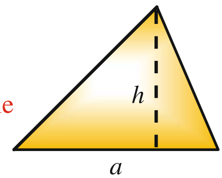
Circumference $= 2\pi r$

Cylinder

Lateral surface area $= 2\pi r h$

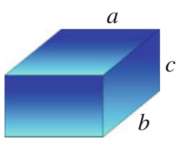
Volume $= \pi r^2 h$

Triangle



Area $= \frac{1}{2} a h$

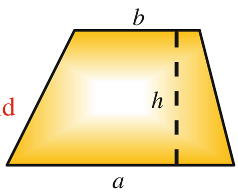
Rectangular box



Surface area $= 2(ab+ac+bc)$

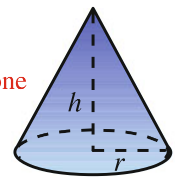
Volume $= abc$

Triapezoid



Area $= \frac{1}{2}(a+b)h$

Cone

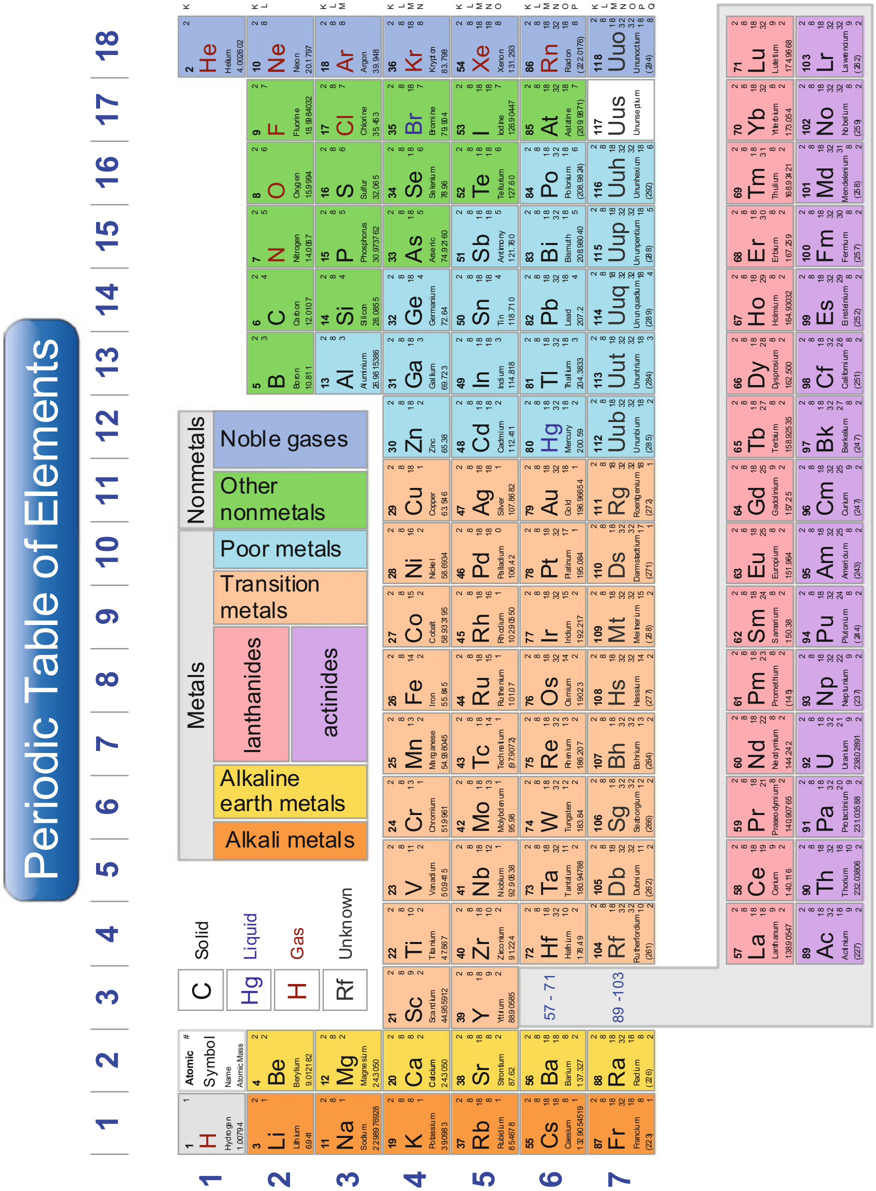


Curved surface area $= \pi\, r\sqrt{r^2+h^2}$

Volume $= \frac{1}{3}\pi\, r^2 h$

The Periodic Table of Elements

C



Notes: Elements with atomic weights between brackets have no stable isotopes.

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Answers to All Exercises

Chapter 1

(1) (a) kilo lambs, (b) mega bytes, (c) giga cars, (d) tera stars, (e) deci kelvin, (f) centi meter, (g) milli ampere, (h) micro newton, (i) nano kilogram, (j) femto second

(2) (a) 4×10^7 m, (b) 6.366×10^6 m, (c) 2.486×10^4 mi, 3.956×10^4 mi, (d) 4.02×10^6 mi which is very close to the answer of part a

(3) 2.362×10^5 mi, 3.8×10^8 m, 3.8×10^{10} cm, 3.8×10^{11} mm

(4) $0.02(\text{km})^3$

(5) (a) AU $= 1.5 \times 10^{11}$ m $= 1.5$ Gm, (b) ly $= 9.461 \times 10^{15}$ m $= 9.461$ Pm, (c) pc $= 3.084 \times 10^{16}$ m $= 30.84$ Pm, (d) Mpc $= 3.084 \times 10^{22}$ m $= 30.84$ Zm

(6) (a) 400, (b) $400^3 = 6.4 \times 10^7$, (c) 4.815×10^6 m

(7) (a) 6.3699×10^{11} m, (b) Estimated/Actual $= 1.7 \times 10^3$

(8) (a) 1.16×10^{34} days, (b) 5.78×10^{12} days, (c) 1.51×10^{12} days, (d) 1.83×10^4 days

(9) (a) 1 microyear = 0.526 of a 1-minute TV commercial, (b) 1 microcentury = 0.877 of a 60-minute TV commercial

(10) (a) 0.03 mi/h, (b) 1.243 mi/h, (c) 22.99 mi/h, (d) 136.73 mi/h, (e) 621.5 mi/h

(11) 48 months = 1440 dy (if the clock doesn't show am/pm) or 96 months = 2880 dy (if the clock shows am/pm)

(12) Atomic clock precession is about 1 part in 2×10^{15}, or about 5×10^{-16} s. So, the error for a 19-year interval is 2.9×10^{-7} s. Therefore, it is sufficiently

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precise to determine your age within 10^{-6} s, but certainly much more precise with 10^{-3} s.

(13) (a) After ten centuries, the day is longer by 0.01 s. The average day duration difference for these 10 centuries is 0.005 s, (b) The total cumulative effect is: (the average day duration difference for these 10 centuries) × (the number of days) = 1826.25 s = 0.5073 h

(14) 285714.3 mg/day, 11904.8 mg/h, 198.4 mg/min, 3.3 mg/s

(15) 5.95×10^{24} kg

(16) (a) 5.01×10^{25} atoms/(1 kg), (b) 6.022×10^{26} atoms/(12 kg)

(17) (a) $(2.988\,897\,2 \pm 0.000\,001\,7) \times 10^{-26}$ kg, (b) 5.01×10^{46} molecules

(18) (a) $1.178 \times 10^{-26}\ \text{m}^3$, (b) 2.28×10^{-9} m

(19) $T = 2\pi\sqrt{L/g} \Rightarrow \mathrm{T} = \sqrt{\mathrm{L}/(\mathrm{L}/\mathrm{T}^2)} = \mathrm{T}$. Thus, the expression is dimensionally correct.

(20) $s = ka^m t^n \Rightarrow \mathrm{L} = \left(\mathrm{L}/\mathrm{T}^2\right)^m \times \mathrm{T}^n = \mathrm{L}^m \times \mathrm{T}^{n-2m} \Rightarrow m = 1,\ n - 2m = 0$. Therefore $m = 1$ and $n = 2$.

(21) (a) $v^2 = v_\circ^2 + 2as \Rightarrow (\mathrm{L}/\mathrm{T})^2 = (\mathrm{L}/\mathrm{T})^2 + (\mathrm{L}/\mathrm{T}^2) \times \mathrm{L} = (\mathrm{L}/\mathrm{T})^2$. Thus, the equation is dimensionally correct., (b) $s = s_\circ + v_\circ t + \frac{1}{2}at^2 \Rightarrow \mathrm{L} = \mathrm{L} + (\mathrm{L}/\mathrm{T}) \times \mathrm{T} + (\mathrm{L}/\mathrm{T}^2) \times \mathrm{T}^2 = \mathrm{L}$. Thus, the equation is dimensionally correct., (c) $s = s_\circ \cos kt \Rightarrow \mathrm{L} = \mathrm{L} \times \cos(\mathrm{T}^{-1} \times \mathrm{T}) = \mathrm{L} \times \cos(\text{number}) = \mathrm{L}$. Thus, the equation is dimensionally correct.

(22) $F \propto ma \Rightarrow F \propto \text{kg} \times \mathrm{L}/\mathrm{T}^2 \Rightarrow F$ has the units kg m/s^{2}in the SI units

(23) $G = Fr^2/m_1m_2 = (\text{kg m/s}^2)(\text{m}^2)/(\text{kg})^2 = \text{m}^3/(\text{kg s}^2)$

Chapter 2

(1) 11.18 km, 26.6° W of N

(2) 5.29 km, 40.9° N of E

(3) (a) 8.66 units at 90°, (b) 13.23 units at 40.9°

(4) (a) 20 m, 10π m, (b) 0, 20π m

(5) −2 cm along the x-axis and 2 cm along the y-axis

(6) (a) 10.96 units along the x-axis and 5 units along the y-axis, (b) 12.1 units at −24.5°

(7) (a) 104 km/h, (b) No, because the radar unit measures only the component of the car's velocity along the radar beam. If the angle between the beam and the car's velocity is 90°, then the radar unit will measure zero velocity since the car is not moving perpendicularly to the highway.

(8) 15.62 km
(9) $\vec{R} = 3\vec{i} + 5\vec{j} + 5\vec{k}$ and $R = 7.68$
(12) 5 at 306.9°
(13) (a) 6 at 0°, (b) 6.3 at 108.4°
(14) (a) $\vec{A} + \vec{B} = 2\vec{i} - 3\vec{j} + 5\vec{k}$, (b) $\vec{A} - \vec{B} = -4\vec{i} + 5\vec{j} + 3\vec{k}$, (c) $\vec{C} = -2\vec{i} + 3\vec{j} - 5\vec{k}$
(15) (a) $\vec{A} \bullet \vec{B} = AB\cos\theta = -15.59$, (b) $\vec{A} \bullet \vec{B} = A_x B_x + A_y B_y = -15.59$
(18) (a) $\vec{A} \bullet \vec{B} = 0$, (b) $\vec{A} \bullet \vec{C} = -9$, (c) $\vec{B} \bullet \vec{C} = -16$, (d) $\vec{A} \times \vec{B} = 12\vec{k}$, (e) $\vec{A} \times \vec{C} = -12\vec{k}$, (f) $\vec{B} \times \vec{C} = 12\vec{k}$
(19) (b) $A^2 B \sin\theta$
(22) (b) $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$, $\tan^{-1}[(y_2 - y_1)/(x_2 - x_1)]$
(23) $\vec{F} = 1.6 \times 10^{-14}(1.5\vec{i} - \vec{j})$ N
(24) $\vec{S} = -0.44\vec{i} - 0.4\vec{j} + 1.12\vec{k}$

Chapter 3

(1) (a) 0.25 km/min, (b) 4.17×10^{-3} km/s, (c) 15 km/h
(2) (a) 53.3 km/h, (b) 53.3 km/h
(3) (a) 24 m, (b) 12 m/s and 12 m/s
(4) 100 m
(5) (a) 6 m/s, (b) 8 m/s, (c) 9 m/s
(6) (a) $\bar{v} = \Delta x/\Delta t = 4$ m/s, $\bar{s} = d/\Delta t = 4$ m/s, (b) At $t_i = 0$, we find from the equation $x = 8t - 2t^2$ that $x_i = 0$, i.e., the body is at the origin. At $t = 2$ s, we find that x is maximum and equal to 8 m. At $t = 4$ s, we find that $x = 0$ again, which means that the body returns to the origin and moves a distance of 16 m. At $t_f = 5$ s, we find that $x_f = -10$ m, which means that the body moves a total distance of 26 m. Thus, $\bar{v} = \Delta x/\Delta t = -2$ m/s and $\bar{s} = d/\Delta t = 5.2$ m/s.
(7) (a) 19.2 m, 4.8 m/s for the interval $0 \le t \le 4$ and 100.8 m, 16.8 m/s for the interval $4 \le t \le 10$, (b) 9.6 m/s, 24 m/s
(8) (a) For $t = 1, 2, 3, 4,$ and 5 s we have $x = 1, -2, -3, -2,$ and 1 m, (b) For $t = 1, 2, 3, 4,$ and 5 s we have $v = -4, -2, 0, 2,$ and 4 m/s, (c) For $t = 1, 2, 3, 4,$ and 5 s we have: motion towards decreasing x, motion towards decreasing x, momentarily no motion, motion towards increasing x, and motion towards increasing x, (d) Yes, at $t = 3$ s, (e) No
(9) Negative, zero, positive, zero, zero, and negative

(10) (a) $0 < t < 1$ s, (b) $3\text{ s} < t < 5$ s, (c) $1\text{ s} < t < 3$ s and $5\text{ s} < t < 7$ s

(11) 28 m

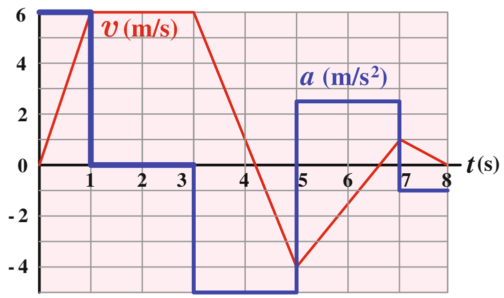
(12) -5 m/s^2

(13) (a) $v = 8 + 4t$, (b) $a = 4\text{ m/s}^2$, (c) 28 m/s, 4 m/s^2

(14) (a) 19.6 m/s^2, 15.6 m/s^2, (b) $a = 20 - 0.8t$

(15) $x = 10t^2 - 0.4t^3/3$, for $t = 0, 3,$ and 6 s we have: $x = 0, 86.4,$ and 331.3 m, $v = 0, 56.4,$ and 105.6 m/s, and $a = 20, 17.6,$ and 15.2 m/s^2

(16) (a)



(b) -0.8 m/s^2, (c) -5 m/s^2

(17) (a) 6 m/s, (b) 26 m/s, (c) $a = 4 + 6t$, 16 m/s^2, (d) $x - x_\circ = 6t + 2t^2 + t^3$

(18) 20 m/s, 50 m

(19) (a) 3 m/s^2, (b) 24 m

(20) (a) 20 m/s^2, (b) 200 m/s, (c) 4 km

(21) (a) -2 m/s^2, (b) 5 m/s, (c) 150 m

(22) (a) 31.9 m, (b) 2.55 s, (c) 26.9 m/s

(23) (a) 19.6 m, (b) 2 s, (c) 4 s, (d) −19.6 m/s

(24) (a) 49 m/s, (b) 122.5 m

(25) (a) 122.5 m, (b) 72.5 m, (c) 172.5 m

(26) (a) 36.72 m/s (downward), (b) 41.8 m

(27) (a) 9.28 m/s (upward), (b) 22.6 m

(28) (a) 5.1 s, (b) 127.6 m, (c) 10.2 s, (d) −50 m/s, (e) −53.8 m/s, (f) 10.6 s

(29) (a) 44.1 m, (b) 44.1 m for the fourth stone, 39.2 m for the third stone, 24.5 m for the second stone, 0 m for the first stone, (c) 3 s

(30) (a) $\sqrt{10}$ m/s, (d) $3\sqrt{10}/[\sqrt{2} + 1]^2$

(31) (a) 1.96 m/s, (b) 0.196 m, (c) −1.96 m/s

(33) (a) 1.5 s, (b) 11.25 m, (c) 25 m/s, 15 m/s

Chapter 4

(1) (a) $\Delta\vec{r} = (-5\vec{i} + 10\vec{j} - 5\vec{k})$m, (b) $\overline{\vec{v}} = (-\vec{i} + 2\vec{j} - \vec{k})$m/s

(2) (a) $\overline{\vec{v}} = (2\vec{i} + 4\vec{j})$m/s, (b) $\vec{v} = (2\vec{i} + 4t\vec{j})$m/s, $|\vec{v}|_{t=2s} = 8.25$ m/s at 76°, (c) $\vec{a} = (4\vec{j})$m/s^2

(3) (a) $\overline{\vec{v}} = (16\vec{i} + 6\vec{j})$m/s, (b) $\vec{v} = [(12t^2 - 12)\vec{i} + 6\vec{j}]$m/s, $|\vec{v}|_{t=1\,s} = 6$ m/s at 90°, (c) $\vec{v}|_{t=3\,s} = (96\vec{i} + 6\vec{j})$m/s, $|\vec{v}|_{t=3\,s} = 96.2$ m/s at 90°, (d) $\overline{\vec{a}} = (36\vec{i})$m/s^2, (e) $\vec{a} = (24\,t\,\vec{i})$m/s^2, $a_{t=2\,s} = 48$ m/s^2 at 0°, (f) At $t = 1$ s, x is minimum

(4) (a) $r = \sqrt{9t^2 + 4t^4 + 4}$(m), $r|_{t=2\,s} = 10.2$ m, (b) $\vec{v} = (3\vec{i} - 4t\vec{j})$m/s, $|\vec{v}|_{t=2\,s} \equiv v|_{t=2\,s} = 8.54$ m/s at 291°, (c) $\vec{a} = (-4\vec{j})$m/s^2, $a = 4$ m/s^2 at 270°

(5) $\vec{r} = (5\vec{i} - 1.25\vec{j})$(m), $\vec{v} = (10\vec{i} - 5\vec{j})$m/s

(6) (a) 13 m/s, (b) 32.7 m/s at 66.6° below the horizontal line

(7) (a) 6.708 m/s, (b) 1.265 s

(8) (a) 11.18 m/s, (b) 1.265 s

(9) (a) 18 m/s and 24 m/s, (b) $\vec{r} = 36\vec{i} + 28\vec{j}$, $\vec{v} = 18\vec{i} + 4\vec{j}$ ($v = 18.5$ m/s and $\theta = 13.7°$), (c) 28.8 m, 2.4 s, (d) 2.4 s, 86.4 m

(10) (a) 2 m/s, 6 m/s, (b) 1.2 s, 7.2 m, 7.2 m, (c) 2.4 s, 14.4 m

(11) (a) 48.2 m, (b) 60 m, (c) 25.24 m/s, (d) 100 m

(12) (a) 27.39 m/s = 98.59 km/h, (b) 17.83 m/s = 64.19 km/h

(13) (a) $v_\circ = 254.5$ m/s, (b) 50 s, (c) In the presence of air resistance, $v_\circ$ should increase so that the rock can reach the point $x = 9$ km

(14) (a) 7.45 s, (b) 438.2 m

(15) 63.44°

(17) $\theta_\circ = \frac{1}{2}\tan^{-1}(-1/\tan\phi)$

(18) $R = (v_0 \cos\theta_0/g)\left[v_0 \sin\theta_0 + \sqrt{v_0^2 \sin^2\theta_0 - 2gh}\right]$

(19) $R = (v_0 \cos\theta_0/g)\left[v_0 \sin\theta_0 + \sqrt{v_0^2 \sin^2\theta_0 + 2gh}\right]$

(20) 200 m/s

(21) 2.47 m/s^2

(22) (a) 1025 m/s, (b) 2.73×10^{-3} m/s^2

(23) (a) 30 m/s, downwards, (b) 60 m/s^2

(24) (a) 9×10^{22} m/s^2, (b) 1.52×10^{-16} s

(25) 0.029 m/s^2

(26) 1.64×10^6 m/s^2 = 167000 g

(27) 1.9 km

(28) (a) $2\,\text{m/s}^2$, (b) $5.66\,\text{m/s}^2$, (c) $5.05\,\text{m/s}$

(29) (a) $8.66\,\text{m/s}^2,\ 5\,\text{m/s}^2$, (b) $4.16\,\text{m/s}$

(30) (a) $7839\,\text{m/s},\ 9.38\,\text{m/s}^2$, (b) $26.7\,\text{m/s}^2$ at $\theta = 20.6°$

Chapter 5

(1) $1.25 \times 10^4\,\text{N}$

(2) (a) 5 s, (b) 25 m

(3) (a) $\vec{F} = 3\vec{i} - 4\vec{j}$, 5 N at 323.1°, (b) $2.5\,\text{m/s}^2$ at 323.1°

(4) (a) $5.25\vec{i} + 1.5\vec{j}$, (b) $5.46\,\text{m/s}^2$ at 15.9°

(5) (a) 30°, (b) Yes, this angle is independent of W

(6) $T_1 = 100\,\text{N},\ T_2 = 118.3\,\text{N}$

(7) $T_1 = 200\,\text{N},\ T_2 = 190.8\,\text{N},\ T_3 = 101.5\,\text{N}$

(8) (a) $-16\,\text{m/s}^2$, (b) $-16000\,\text{N}$, (c) $\mu_s = 1.6$ (In some cases μ_s can exceed 1 as in this case)

(9) (a) 8.7°, (b) 0°

(10) 14.3°

(11) (a) $0.75\,\text{m/s}^2$, (b) 9 N

(12) (a) $0.75\,\text{m/s}^2$, (b) 3 N

(13) (a) $0.25\,\text{m/s}^2$, (b) 0.03 N

(14) 0.25

(15) (a) $a_P/s_B = 1/2$, (b) $12\,\text{N},\ 2\,\text{m/s}^2$, (c) $12\,\text{N},\ 1\,\text{m/s}^2$

(16) (a) $T_1 = 60\,\text{N},\ T_2 = 100\,\text{N}$, (b) $T_1 = 72\,\text{N},\ T_2 = 120\,\text{N}$

(17) $a_2 = 0.5\,\text{m/s}^2,\ T_2 = 0.01\,\text{N}$

(18) (a) 500 N, (b) 560 N, (c) 300 N, 336 N

(19) 20 N

(20) 90 N

(21) (a) For m_1, $a = 4\,\text{m/s}^2$ up the plane and for m_2, $a = 4\,\text{m/s}^2$ downwards. (b) The magnitude of the tension in both cords is 36 N, (c) For $m_1,\ a = 1\,\text{m/s}^2$ up the plane and for $m_2,\ a = 1\,\text{m/s}^2$ downwards. The magnitude of the tension in both cords is also 36 N

(22) For m_1, $2\,\text{m/s}^2$ downwards and for m_2, $2\,\text{m/s}^2$ upwards, 48 N

(23) 3 m/s

(24) $a = (m_2 - m_1)g/(m_1 + m_2),\ T_1 = T_2 = T_3 = 2m_1 m_2 g/(m_1 + m_2)$

(25) (a) 0.5, 30 N

(26) $6\,\text{m/s}^2$, $12\,\text{N}$

(27) $3\,\text{m/s}^2$, $12\,\text{N}$

(28) $T_1 = \frac{3}{4}F$, $T_2 = \frac{2}{4}F$, $T_3 = \frac{1}{4}F$, when the number of the locomotive engine plus the cars is n, we get $T_i = \frac{n-1}{n}F$, $i = 1, 2, \ldots, (n-1)$

(29) (a) 0.58, (b) 0.36

(30) (a) 1154.7 N, (b) 2309.4 N

(31) 603.9 N

(32) $1.68\,\text{m/s}^2$, 4.62 N

(33) Block m_2 has $a_2 = 1.103\,\text{m/s}^2$, block m_1 has $a_1 = 2.835\,\text{m/s}^2$, and the tension is zero

(34) From 0 to $2.5\,\text{m/s}^2$

(35) (a) 491 N, 49.1 kg, (b) $2.04\,\text{m/s}^2$

(36) The same answers as exercise 35, but the maximum/minimum readings will be during the stopping/starting period of the elevator's descending motion

(37) 13.8 m/s

(38) (a) 7.97 m/s, when we take $g = 10\,\text{m/s}^2$ (b) 140 m/s (≈50 km/h) (about 18 times the speed of the drop when the resistive drag force exists)

(40) $\theta = 0$

Chapter 6

(1) (a) 200 N, (b) 100 m, (c) −20 000 J, (d) 400 N, 50 m, −20 000 J

(2) (a) −39.2 J, (b) +39.2 J, (c) +19.6 J, −19.6 J

(3) (a) $W_g(\text{A} \to \text{B}) = -mgh$, (b) $W_g(\text{B} \to \text{A}) = +mgh$, (c) $W_g(\text{A} \to \text{B} \to C) = -mgh$, (d) $W_g(\text{A} \to \text{C}) = -mgh$, (e) $W_g(\text{A} \to \text{B} \to C \to A) = 0$

(4) −1.715 J

(5) (a) Fd, $-\mu_k mgd$, 0, 0, (b) 100 J, −49 J, 0, 0

(6) 60 J, 0, 69.3 J

(7) (a) −2 J, (b) −8 J, (c) −2 J, (d) 9 J, (e) −3 J

(8) (a) 32 J, (b) 32 J

(9) (a) 5.89 J, (b) -1.57×10^{-2} J

(10) (a) 0.54 J, (b) 0.3 J

(12) $-\frac{1}{5}kd^5$

(13) $2\pi RF\cos\theta$

(14) 3.86×10^5 J

(15) 1.5 J

(16) 4.06×10^5 J

(17) 420 J

(18) 40 J

(19) (a) 25 J, (b) −25 J, (c) 9 J, (d) −9 J, (e) 0

(20) (a) 2.5 J, (b) 7.5 J, (c) 11.875 J

(21) 0.21 m

(22) 187.5 J

(23) (a) 98 J, (b) 6.26 m/s

(24) (a) 7.35 J, (b) 5.78 m/s

(25) (a) 9.8 J, (b) 6.26 m/s, (c) 4.43 m/s

(26) (a) 4.43 m/s, (b) 0.25

(28) (a) $v = \pm\sqrt{3Fd/4m}$, (b) $v = \pm\sqrt{Fd/m}$

(29) 2.86 m/s

(30) 14 m

(31) $\theta = \cos^{-1}(2/3) = 48.2°$

(32) 20 m/s

(33) (a) 7.67 m/s, (b) −845 J (more energy loss than Ex. 6.8, but the percentage loss of energy by friction with respect to original potential energy of the boy is the same; about 58%)

(34) (a) −98 J, (b) The block will never reach point C if the track is more rough and might stop somewhere on the track once it goes past point A. The block will pass point C if the track is smoother

(35) −14.5 J, No, because its energy (stored in the spring) will be less than its potential energy at the edge of the rough surface

(36) (a) 29 N, (b) 8.57 cm

(37) 36750 J, 147 N

(38) (a) −25 J, (b) 25 J, (c) 125 N

(39) 0.327 kW = 0.438 hp

(40) 223.8 piasters

(41) (a) −62400 W, (b) $(-18900\,t)$W

(42) 500 W

(43) 537.1 N opposite the velocity

(44) 7.234×10^4 W $\simeq$ 97 hp opposite the velocity

(45) (a) $ma + mg\sin\theta + \alpha + \beta\, v^2$, (c) 40 000 W, 50 728.5 W, 4 000 W, 4 000 W, 98 728.5 W

Chapter 7

(1) 2.71×10^{-22} kg.m/s
(2) (a) 160 000 kg.m/s, (b) 80 m/s, (c) 40 m/s
(3) -3.2 kg.m/s
(4) (a) -16 kg.m/s, -16 kg.m/s (b) -8000 N
(5) (a) -3 m/s (b) 15 N
(6) (a) 16 kg.m/s, -12 kg.m/s (b) 20 kg.m/s, 323.1°
(7) $(16\,\vec{i} - 8\,\vec{j})$ kg.m/s
(8) 300 N
(9) (a) 40 kg.m/s, (b) 20 N, (c) 30 N
(10) $m\sqrt{2gh}$
(11) (a) 2.4 kg.m/s upward, (b) 75%
(12) (a) 1.25×10^{-3} s, (b) 0.48 N.s (in the direction of penetration), (c) -384 N (opposite to the direction of penetration)
(13) (a) 5×10^{-5} meters every second, (b) 0.1 kg, (c) 0.6 N (downwards)
(14) (a) -86.6 kg.m/s (opposite to the x-axis), (b) -8660.3 N (opposite to the x-axis)
(15) The smallest value is for $\theta = 0$, where $\Delta p = 0$ and $\overline{F} = 0$. The largest value is for $\theta = 90°$, where $\Delta p = -100$ kg.m/s and $\overline{F} = -10000$ N
(16) (a) 0.8 m/s, (b) 4.8×10^4 J, (c) $-4/3$ m/s (in opposite direction)
(17) $m_1/m_2 = 0.5$
(18) -6.47×10^2 m/s (The negative sign indicates that the recoiling nucleus is moving in the opposite direction to the alpha particle)
(19) 0.125 m/s
(20) (a) $V = -(m/M)\ v$ (The negative sign indicates that the car is moving in the opposite direction to the man's motion), (b) $v_{rel} = v + |V| = [(m+M)/M]v$
(21) (a) 0.5 m/s, (b) 200 J, (c) 199.75 J
(22) 594 m/s
(23) 2.8 m/s, 3.8 m/s
(24) -1.67 m/s, 3.33 m/s
(25) $m_2 = 3\ m_1$
(26) (a) 1.5 kg, (b) $v_1' = -0.2\,v_1$ (The negative sign indicates that the first ball will move in the opposite direction to its original motion), (c) 0.96
(27) (a) 1, (b) 0.89, (c) 0.296, (d) 0.019

(28) (a) Yes, the collision is elastic because all involved forces are conservative forces, (b) 0.4 cm

(29) (a) Yes, as in Exercise 28, (b) 2 m/s, (c) 0.25 m, (d) $v_1' = -4$ m/s, $v_2' = 4$ m/s

(30) (a) Yes, as in Exercise 29, (b) 6 m/s, (c) 0.25 m (same compression as Exercise 29), (d) $v_1' = +4$ m/s, $v_2' = 12$ m/s

(31) $v_1' = v_1/\sqrt{3} = 10\sqrt{3/2}$ m/s, $v_2' = v_1/\sqrt{6} = 10/\sqrt{2}$ m/s, $\cos\theta = \sqrt{2/3}$, $K_{\text{target}}/K_{\text{projectile}} = 0.5$

(32) $v_1' = \sqrt{3}\, v_1/2 = 15\sqrt{3}$ m/s, $v_2' = v_1/2 = 15$ m/s

(33) $v_1' = v_2' = v_1/\sqrt{2} = 30/\sqrt{2}$ m/s

(35) Two times

(36) $-M/(m+M)$, -0.98. Thus, 98% of the energy is lost.

(37) (a) 10 m/s, (b) -0.923. Thus, 92.3% of the energy is lost.

(38) (a) 19 m/s, (b) -0.687. Thus, 68.7% of the energy is lost

(39) (a) The heavier nucleus will move with half the speed of the lighter nucleus, but in an opposite direction, (b) 4×10^{-17} J for the lighter nucleus and 2×10^{-17} J for the heavier one

(40) (a) $\vec{v}'_2 = (2\vec{i} + 3\vec{j})$ (m/s), (b) 50 J are lost

(41) $|\vec{p}'_3| = 1.3 \times 10^{-22}$ kg.m/s, $\vec{p}'_3$ is 157.4° from the vector $\vec{p}'_2$ and 112.6° from the vector $\vec{p}'_1$

(42) (a) $v_2' = 2.506$ (m/s), $\theta = 60.8°$ (b) 22.14 J

(43) (b) 18.47 m/s, $\phi = 22.5°$, -0.146. Thus 14.6% of the energy is lost

(44) 0.048 nm

(45) $x_{\text{CM}} = 0.286$ m, $y_{\text{CM}} = 0.571$ m (this answer does not depend on the value of m because it appears as a common factor in both the numerator and denominator)

(47) $z_{\text{CM}} = 0.03$ nm

(48) $\vec{r}_{\text{CM}} = 2.8\vec{i} + 3.8\vec{j}$

(49) $x_{\text{CM}} = L/2$, $y_{\text{CM}} = L/2$ (from the center of the left rod)

(50) $x_{\text{CM}} = (3/4)h$

(51) $z_{\text{CM}} = H/4$, 34.7 m

(52) $\vec{v}_{\text{CM}} = (2.8\vec{i} + 0.2\vec{j})$ (m/s)

(53) (a) -7.8 m/s, 11.2 m/s, (b) 3.6 m/s

(54) (a) 0, (b) 1.2 m, (c) 1.2 m/s, 0.8 m/s

(55) (a) 7.5 m from the man, 5 m/s, (b) 4.5 m/s, (c) 10 s, 45 m/s

(56) 120 m

(57) (a) 49 N (b) 171.5 W, (c) 85.75 W

(58) 50 m/s^2

(59) -1000 m/s, 1.5×10^5 N

(60) (a) 3.75×10^6 N, (b) 6056.5 m/s

Chapter 8

(1) $\pi/6 = 0.52$ rad, $\pi/4 = 0.79$ rad, $\pi/3 = 1.05$ rad, $\pi/2 = 1.57$ rad, $\pi = 3.14$ rad, $3\pi/2 = 4.71$ rad, $\pi = 6.28$ rad

(2) 1.327×10^3 km

(3) (a) 0.75 rad = 42.97°, (b) 2.4 m

(4) 636.6 rev

(5) 930.8 rad/s^2

(6) -188.5 rad/s^2

(7) 1.2 rev

(8) (a) $\omega = 8t - 14$, $\alpha = 8$ rad/s^2, (b) $\theta = 0$ at $t = 0.5$ s and $t = 3$ s, $\omega = 0$ at $t = 1.75$ s

(9) $\omega = \omega_\circ - 2\,bt + 3\,at^2$, $\theta = \theta_\circ + \omega_\circ\, t - bt^2 + at^3$

(10) (a) 2.4 m/s, (b) No, but may be the best location is somewhere close to the rim of the wheel if the spokes and the dart are not very thin

(11) 9.425×10^3 rad $= 1.5 \times 10^3$rev $= 3 \times 10^3\pi$ rad $= 5.4 \times 10^5$ degrees, 2.356×10^3 rad $= 3.75 \times 10^2$rev $= 7.5 \times 10^2\pi$ rad $= 1.35 \times 10^5$ degrees

(12) (a) $-10\,\pi$ rad/s$^2 = -31.42$ rad/s^2, (b) 4 s

(13) (a) $-50\,\pi$ rad/s$^2 = -1.571 \times 10^2$ rad/s^2, (b) 116.7 rev

(14) (a) 23.56 s, (b) 167.7 rev

(15) $-30\,\pi$ rad/s$^2 = -188.5$ rad/s^2

(16) (a) $3\,\vec{i}$ rad/s, $4\,\vec{k}$ rad/s, (b) 5 rad/s and at angle 53.13° above the x-axis, (c) $\vec{\alpha}_1(t) = 12[-\sin 4t\,\vec{i} + \cos 4t\,\vec{j}\,]$ (rad/s^2), $\vec{\alpha}_1(0) = 12\vec{j}$ (rad/s^2)

(17) (a) $12\,\pi$ rad/s $= 37.699$ rad/s, (b) $2.4\,\pi$ m/s $= 7.539$ m/s, $a_t = 0$, $a_r = 28.8\,\pi^2$ m/s$^2 = 284.24$ m/s^2

(18) (a) $\pi/30$ rad/s $= 1.05 \times 10^{-1}$ rad/s, (b) $\pi/1800$ rad/s $= 1.75 \times 10^{-3}$ rad/s, (c) $\pi/21600$ rad/s $= 1.45 \times 10^{-4}$ rad/s, (d) zero

(19) 20.9 mm/s, 0.26 mm/s, 0.015 mm/s

(20) (a) 12.57 m/s, (b) $a_t = 0$, $a_r = 16\,\pi^2/3$ m/s$^2 = 52.64$ m/s^2 towards the center

(21) (a) 7.272×10^{-5} rad/s, (b) 403 m/s, $a_t = 0$, $a_r = 0.029$ m/s^2 (perpendicular to the Earth's axis), (c) 465.4 m/s

(22) 5.373 rad/s if we take $g = 10$ m/s^2

(23) (a) 2.5 rad/s^2, (b) 500 rad = 79.58 rev

(24) 102.9 m.N

(25) 2.05 m.N, clockwise

(26) (a) 2, (b) 7.84×10^{-2} m·N, counterclockwise

(27) $(m_A + m_B)L^2/3$

(28) (a) $I = \frac{2}{5}MR^2 + M(L+R)^2$, (b) $I_{\text{app}} = M(L+R)^2$, (c) 1.1%

(29) 0.12π m.N $= 0.377$ m·N

(30) 4 m/s^2, 20 rad/s^2, 18 N

(31) (a) $\alpha = 3g\cos\theta/2L - 3\tau_f/ML^2$, $\alpha_{\text{max}} = 60$ rad/s^2, (b) 29.9°

(32) (a) 0.095 kg·m^2, (b) It is greater than the value 0.05 kg·m^2 obtained from $I = MR^2/2$. This is because the pulley with the wrapped cord has more mass concentrated around its edge

(33) $\tau = mgL\sin\theta$, $\alpha = g\sin\theta/L$

(34) $\alpha = g\sin\theta[mL + 2M(L+R)]/[\frac{2}{3}mL^2 + M(3R^2 + 4RL + 2L^2)]$

(35) 1.67 m/s^2, $T_2 = 50$ N, $T_1 = 46.67$ N

(36) 616.9 J

(37) (a) 432 J, $F_M = 384$ N, $F_m = 192$ N, (b) 384 J, $F_M = F_m = 256$ N

(38) $v = \sqrt{54ga/7} = 8.695\sqrt{a}$

(39) 0.792 kg.m^2

(40) (a) 398.4 W, (b) −6.56 m·N

(41) (a) 16 rad/s, (b) 1.6 m/s, $a_t = 0$, $a_r = 12.8$ m/s^2, 1.6 m/s, (c) 3.84 J

(42) (a) To the right, (b) 10 m/s^2, (c) 10 N

Chapter 9

(1) $34\,\vec{k}$ (kg.m^2/s or J.s)

(2) $-1.5 \times 10^5\,\vec{k}$ (kg.m^2/s) for the clockwise motion, $1.5 \times 10^5\,\vec{k}$ (kg.m^2/s) for the counterclockwise motion

(3) $-24\,t^2\,\vec{k}$ (kg.m^2/s)

(4) $\vec{L}_i = mvd$ (into the page for $i = 1, 2, 3$), $\vec{L}_i = mvd$, (out the page for $i = 5, 6, 7$), $\vec{L}_i = 0$ (for $i = 4, 8$)

(5) (a) 15 kg.m^2/s (into the page), (b) 25.46 m.N (out of the page)

(9) 11.27 kg.m^2/s (out of the page)

(10) (a) 0.1047 rad/s, (b) 3.421×10^{-6} kg.m^2/s (into of the page)

(11) (a) 7.1 kg.m^2, (b) 14.22 kg.m^2/s (out of the page)

(12) (a) $(0.24\,\vec{i} + 0.16\vec{j})$kg·m^2/s, (b) $3.2 \times 10^{-2}\,\vec{j}$ (kg·m^2/s), (c) 0°

(13) (a) $I = \frac{17}{6} m R^2$, $L = \frac{17}{3} \pi m R^2 / T$ along z-axis, (b) 1.417×10^{-2} kg.m^2, 4.451×10^{-2} kg.m^2/s

(14) (a) $m_2 g R$ clockwise, (b) $[m_2 + m_1 + \frac{1}{2} M] R v$ clockwise, (c) $m_2 g / [m_2 + m_1 + \frac{1}{2} M]$, 3 m/s^2

(15) (a) $\alpha = 24\ t$ (rad/s), $L = 24\ t^2$ (J·s), $\alpha = 48$ rad/s, $L = 96$ (J·s), (b) $\sum \tau_{\text{ext}} = I\alpha = 48\ t$ (m·N), $\sum \tau_{\text{ext}} = dL/dt = 48\ t$ (m·N), $\sum \tau_{\text{ext}} = 96$ m·N

(16) 0.7 kg.m^2/s along z-axis

(17) 3.848×10^3 kg.m^2/s upwards

(18) (a) 4, 1/4, (b) 256, 16

(20) $I_a R_a R_b \omega_a / (I_a R_b^2 + I_b R_a^2)$

(21) (b) 1.5 m/s^2, $T_1 = 10$ N, $T_2 = 17.5$ N, (c) $0.75\ t$ (kg.m^2/s)

(22) (a) 7.149×10^{33} kg.m^2/s, (b) 2.69×10^{40} kg.m^2/s

(23) (a) $\sum \tau_{\text{ext},1} = m_1 g R$ clockwise, $\sum \tau_{\text{ext},2} = -m_2 g R$ counterclockwise, $\sum \tau_{\text{ext,sys}} = (m_1 - m_2) g R$ clockwise, (b) $L_1 = R m_1 v + M R v/2$ clockwise, $L_2 = R m_2 v + M R v/2$ clockwise, $L_{\text{sys}} = (m_1 + m_2 + M) R v$ clockwise, (c) $a = (m_2 - m_1) g / (m_1 + m_2 + M)$, $T_1 = (2 m_2 + M) m_1 g / (m_1 + m_2 + M)$, $T_2 = (2 m_1 + M) m_2 g / (m_1 + m_2 + M)$

(24) 100 %

(25) 1.8 kg.m^2, by pulling her arms to the center of her body

(26) 0.41 rev/s

(27) $\omega_i / (1 + 6 m/M)$

(28) 5.45 rev/min

(29) 0.316 rev/s

(30) 0.2 rev/s (same as before)

(31) −0.8 rad/s

(32) (a) 0.643 rad/s, (b) 1080 J, 463 J

(33) 1.2 rev/s

(34) (a) 2 rev/s = 4π rad/s, (b) 66.67% decrease

(35) $-3.7 \times 10^{-15}\%$

(36) $-2.6 \times 10^{-15}\%$

(37) (a) $\omega_f = 2m v / [(4M/3 + m)d]$, (b) $H = m^2 v^2 / [(M + m)(4M/3 + m)g]$

(38) (a) $\omega_f = 2m v / [(M/3 + m)d]$, (b) $-(1 + 3m/M)^{-1}$

(39) (a) $\omega_f = 5$ rad/s, (b) −74.8%

(40) $v_{\text{CM}} = mv/(M + m)$, ω(about CM) $= [12m/(7m + 4M)](v/d)$

(41) (a) 3 rev/s, (b) $K_i = 3$ J, $K_f = 18$ J, the increase in the rotational kinetic energy came from the work that the student did in pulling his arms with the dumbbells

(42) 1.974 J
(43) 2.34 rad/s = 22.34 rev/min
(44) 3.466 rad/s = 33.1 rev/min
(45) (a) 5.516×10^{-4} kg.m^2, (b) 3.313×10^{-2} m.N

Chapter 10

(1) 4×10^4 kg/m^3, 40
(2) 9549.3 kg/m^3, 9.55
(3) 11.36 kg, 111.328 N
(4) 6.24×10^7 N/m^2
(5) 1.96×10^{11} N/m^2
(6) 2.352×10^{11} N/m^2
(7) 8.04×10^{-3} m, -5.03×10^{-6} m
(8) 6.57×10^{-4} m
(9) (a) 2.5 N/m^2, (b) 0.025, (c) 100 N/m^2
(10) 2×10^{-7} m, $(4.6 \times 10^{-5})^\circ$
(11) 3.82×10^{-4} rad = 2.19×10^{-2} deg
(12) 6.67×10^{-7}
(13) -1.024×10^{-5} m^3
(14) 84 000 N/m^2
(15) 3.92×10^7 N/m^2
(16) 345000 N/m^2 = 3.45 P_a, 245000 N/m^2 = 2.45 P_a [$P_a = 10^5$ N/m$^2 \equiv 10^5$ Pa]
(17) 117 268 N/m$^2 \equiv$ 117 268 Pa
(18) 28.57 m
(19) 0.8×10^3 kg/m^3
(20) 113 328 Pa
(21) (a) 10.31 m, (b) 13.05 m, (Both values are not practical)
(22) 498 N
(23) (a) 3.27 N, (b) 0.817 N
(24) 3800 kg/m^3
(25) (a) 2.205×10^{-3} N, (b) 533.3 kg/m^3
(26) (a) $v_2 = 25\, v_1$, (b) No effect, because the continuity equation does not depend on altitude
(27) (a) 400 Pa, (b) 5400 Pa
(28) (a) 8.854 m/s, (b) 5.657 m

(30) (a) $v_C = \sqrt{2\,g\,h}$, (b) $P_B = P_a - \rho\, g\,(h+H)$, (c) $H_{max} = P_a/\rho\, g - h$, (d) 7.67 m/s, 52 kPa, 7.3 m

(31) 1.5×10^{-3} N

(32) 5×10^{-3} m/s

(33) 4.36×10^{-4} m/s

(35) 2.64×10^{3} Pa ≡ 19.9 mm Hg

Chapter 11

(1) −30 °C ≡ 243.15 K ≡ −22 °F, 10 °C ≡ 283.15 K ≡ 50 °F, 50 °C ≡ 323.15 K ≡ 122 °F

(2) 37 °C ≡ 98.6 °F ≡ 310.15 K, 6 000 °C ≡ 10 832 °F ≡ 6 273.15 K

(3) −40 °C ≡ −40 °F ≡ 233.15 K, $\Delta T = 10\,°\text{C} - (-40\,°\text{C}) = 50\,\text{C}°$ ≡ 90 F°

(4) (a) 1064.5 °C ≡ 1948.1 °F ≡ 1337.65 K, 2660 °C ≡ 4820 °F ≡ 2933.15 K, (b) $\Delta T = 1595.5$ C°, (c) $\Delta T = 1595.5$ K

(5) $T = 5$ °C

(6) 0.12 m

(7) 2.72×10^{-3} m

(8) 3.6 mm

(9) 100.1 m

(10) 2.88×10^{-4} m^2

(11) 0.048 %

(12) 8.95 cm

(13) (b) 0.5 m, 0.3 m

(14) $(b-a)_T \to (b-a)_{T+\Delta T} = \alpha\,(b-a)\Delta T$, i.e., $a_T \to a_{T+\Delta T} = a(1+\alpha\,\Delta T)$ and $b_T \to b_{T+\Delta T} = b(1+\alpha\,\Delta T)$. Thus, $b_T/a_T = b_{T+\Delta T}/a_{T+\Delta T}$

(15) −113.16 °C

(16) 8.395×10^{7} N/m^2

(17) $r = [2 + (\alpha_2 + \alpha_1)\,\Delta T]\,d/[2(\alpha_2 - \alpha_1)\,\Delta T] \approx d/[(\alpha_2 - \alpha_1)\,\Delta T]$

(18) 1.13×10^{-5} m^3

(19) 50.0135 cm^3

(20) 3.64×10^{7} N/m^2

(21) 2.688 cm^3

(22) 1.25 kg/m^3, 1.43 kg/m^3

(23) (a) 3×10^{4} N/m^2, (b) 3×10^{5} N/m^2

(24) 1.59 atm

(25) 4.15%

(26) 31.18 atm

(27) 3.214

(28) 2.42×10^{22} molecules

(29) 1.14 atm

(30) 1.155×10^{-3} kg

(31) 500 K

(32) (a) 1.270 kg, (b) 0.726 kg, (c) $0.566\ m^3 = 566$ L

(33) 1.43 times the original volume

(34) 0.588 kg/m^3. The difference in density between 0.588 kg/m^3 and the value 0.598 kg/m^3 arises from the fact that water vapor is very "near" to the state phase change. Therefore, we would not expect the steam to act like an ideal gas, because water vapor molecules will have other interactions besides purely elastic collisions. This is evident from the fact that steam can form droplets, indicating an attractive force between the molecules.

Chapter 12

(1) 2.592×10^6 J

(2) 1526 m

(3) 16.5 °C

(4) 3×10^5 J, 71.66 kcal

(5) 8561.9 cal

(6) 6.279×10^6 J

(7) (a) 4500 J/C°, (b) 45000 J

(8) 450 J/kg.C°

(9) 4 °C

(10) 91.8 °C

(11) 4867 J/kg.C°

(12) 754.9 J/kg.C°

(13) 1.45×10^7 J

(14) 0.285 kg

(15) 152695 J

(16) 0.0329 kg = 32.9 g

(17) 8.09 °C

(18) 26.45 g

(19) 6.1 g
(20) (a) 1.2×10^6 J, (b) -3×10^5 J
(21) (a) 300 J, 225 J, 150 J, (b) −300 J, −225 J, −150 J
(22) (a) 3.174×10^6 J, (b) -3.174×10^6 J
(23) 2.5×10^5 J
(24) −100 J, −418.6 J, −318.6 J
(25) (a) 1.65×10^{-3} J, (b) 17 550 J, (c) 17 549.995 J
(26) (a) 538.85 K, 44.8 m^3, 269.43 K, (b) 8.65×10^5 J
(27) (a) 0.289 K, (b) 2.27×10^{-3} m^3
(28) (a) 3.2×10^3 kJ, (b) 0, (c) -1.6×10^3 kJ, (d) 1.6×10^3 kJ
(29) (a) 164.6 kJ, (b) 2200 kJ, (c) 2035.4 kJ
(30) (a) 6 000 J, (b) 3 500 J, (c) 627 °C
(31) (a) 28 J, (b) 62 J, (c) −68 J, (d) −96 J
(32) (a) 1000 J, (b) 1000 Pa, (c) 6907.7 J, (d) 6907.7 J
(33) (a) 3×10^{-3} cal/cm.C°.s = 1.256 W/m.C°, 3×10^{-3} cal/cm.C°.s = 0.075 Btu/ft.F°.h., (b) 7.963×10^{-3} m^2.C°/W
(34) 4.32×10^6 J
(35) 1656 W
(36) 45°C, $H = 45\ k_F\, A/L$
(37) 350.4 W
(38) (a) 4825 W, (b) 0.24 cm
(40) 0.018 W/m.C°

Chapter 13

(1) 26.5×10^4 N/m^2
(2) (a) 5.65×10^{-21} J, (b) 6813 J
(3) 1200 K = 927 °C
(4) (a) 1.368×10^4 m/s, (b) 10 times faster
(5) (a) 240.6 K, (b) 4.98×10^{-21} J
(6) (a) 6.642×10^{-27} kg, (b) 2.415×10^{21} atoms, (c) 1368 m/s
(7) (a) 6.21×10^{-21} J, (b) 7480 J
(8) (a) 7.721×10^{-21} J, (b) 1525 m/s, 483 m/s
(9) (a) 498.8 J, (b) Yes, because the monatomic gas model does not include the energy associated with the internal motions of the gas, such as vibrational and rotational motions of molecules.
(10) (a) 3.73×10^{-26} m^3/molecule, (b) 3.34×10^{-9} m

(11) $v_{rms} = \sqrt{3P/\rho}$

(12) (a) 493.1 m/s, (b) 5.269×10^{-3} s, (c) 94.9 round/s

(13) (a) 3.7413×10^6 J, (b) 6.2355×10^6 J, 2.4942×10^6 J, 3.7413×10^6 J

(14) (a) 2×10^5 J, (b) 43 °C

(15) 131.293 kg/kmol, Xenon gas

(16) 22.7 C°

(17) (a) 1247.1 J, (b) 831.4 J, (c) 2078.5 J

(18) 28284.2 J

(20) 4.65×10^{-21} J

(21) (a) $C_P = 29.09$ J/mol.K, $C_V = 20.79$ J/mol.K (b) $\Delta T = 85.94$ K, (c) $\Delta E_{int} = 3.5726 \times 10^3$ J, (b) $V_f = 7.72 \times 10^{-3}$ m^3

(23) (a) 483 m/s, (b) 445 m/s, (c) 395 m/s

(24) 1.5

(25) 1900, 60

Chapter 14

(1) (a) 2 s, (b) 0.5 Hz, (c) π rad/s

(2) (a) 0.25 s, 4 Hz, 8π rad/s, (b) $x(t) = A \cos(8\pi t)$

(3) (a) 1.5 m, 1 Hz, 1 s, (b) $v = -(3\pi \text{ m/s}) \sin(2\pi t - \pi/4)$, $a = -(6\pi^2 \text{ m/s}^2) \times \cos(2\pi t - \pi/4)$, (c) 3π m/s, $6\pi^2$ m/s^2, (d) zero

(4) The new amplitude is $\sqrt{2}$ times the old one

(5) (a) 39 N/m, (b) 1.42 kg

(6) (a) 0.5 s, 2 Hz, 4π rad/s, (b) $8\pi^2$N/m, 1.4π m/s, $2.8\pi^2$N

(7) (a) $k_{eff} = k_1 + k_2$, (b) $k_{eff} = k_1 + k_2$, (c) $1/k_{eff} = 1/k_1 + 1/k_2$

(8) (a) $f = \sqrt{2k/m}/2\pi$, (b) $f = \sqrt{2k/m}/2\pi$, (c) $f = \sqrt{k/2m}/2\pi$

(9) (a) 6×10^4 N/m, (b) 2.52 Hz

(11) 4 J

(12) (a) 6.25×10^{-3} J, (b) 0.25 m/s, (c) $v = \pm 2.291 \times 10^{-1}$ m/s, $K = 5.25 \times 10^{-3}$ J, $U = 10^{-3}$ J

(13) (a) $T = \pi/2$ s, $f = 2/\pi$ Hz, $\omega = 4$ rad/s, (b) $E = \frac{1}{2} m v_i^2 + \frac{1}{2} k x_i^2 = 0.004$ J, $A = \sqrt{2}/10$ m, $\phi = -\pi/4$ rad, $v_{max} = 0.4\sqrt{2}$ m/s, $a_{max} = 1.6\sqrt{2}$ m/s^2, (c) $x = (0.1\sqrt{2}\text{ m}) \cos(4t - \pi/4)$, $v = -(0.4\sqrt{2}\text{ m}) \sin(4t - \pi/4)$, $a = -(1.6\sqrt{2}\text{ m}) \cos(4t - \pi/4)$, $x = +0.1$ m, $v = -0.4$ m/s, $a = -1.6$ m/s^2

(14) (a) 196.2 m/s, (b) 1.03 s, 0.97 Hz

(15) (a) 0.3408 s, (b) 5%, (c) 5 s

(16) (c) 2.3×10^{-3} kg/s, 6.67×10^{-6} (about 7 parts per million)

(17) 0.2 m, 0.5 π m, $4/\pi$ Hz, 2 m/s
(18) (a) 0.25 m, 3 rad/m, 40 rad/s, 13.3 m/s, (b) 20.9 m, 0.157 s, 6.37 Hz
(19) 519.6 m/s, No
(20) $y = (0.05\ \text{m})\ \sin(5\pi x - 100\pi t)$, 0.08 N
(21) 55.1 Hz
(22) (a) 16 m/s, 628.3 rad/s, (b) 157.9 W, (c) 1.6 cm
(23) (a) 20 m/s, π m, 6.4 Hz, (b) 75 W
(26) 60 m/s
(27) (a) 0.02 m, (b) 36 m/s, (c) 64.8 N
(28) (a) 40 Hz, (b) 80 Hz, 120 Hz, 160 Hz
(29) 1 m, π m, $10/\pi$ Hz, 10 m/s
(30) (a) 2.3 cm, (b) $n(\frac{\pi}{2.3})$ cm, ($n = 0, 1, 2, \ldots$), $(n + \frac{1}{2})(\frac{\pi}{2.3})$ cm, ($n = 0,1,2,\ldots$), (c) 4 cm
(31) 3.7 cm
(32) 437 Hz
(33) (a) 25 Hz, (b) $25/\sqrt{2}$ Hz, (c) $25\sqrt{2}$ Hz
(36) (a) 40 Hz, (b) 400 kg
(37) (a) 6 loops, (b) 1.67 Hz
(38) (a) $\mu_1/\mu_2 = 4$, (b) $\mu_1/\mu_2 = 2.25$
(39) 2 loops in string 1 and 5 loops in string 2, 395.2 Hz
(40) 8 nodes positioned at 0.32 m, 0.64 m, 0.8 m, 0.96 m, 01.12 m, 1.28 m, and 1.44 m from the left end of string 1

Chapter 15

(1) 351.6 m/s
(2) 422.3 m/s
(3) 5064 m/s
(4) 0.272 s
(6) 1321 m/s
(7) (a) 8.746×10^{-3} s = 8.8 ms, (b) 2.915×10^{-2} s = 29.2 ms
(8) 1170 m
(9) 1400 m
(10) (a) 2 Pa, (b) 1 m, 343 Hz, (c) 343 m/s
(11) (a) 4 μm, 0.314 m, 1091.8 Hz, 343 m/s, (b) 1.766 μm, (c) 2.74 cm/s
(13) 5.81 m
(14) 22.9 W

(15) (a) 2 W/m^2, (b) 1.125 W/m^2
(16) 1.77 μW
(17) (a) $\lambda_w = 4.51\,\lambda_a$, (b) $(s_{max})_a = 59.13\,(s_{max})_w$, (c) $(\Delta P_{max})_w = 59.13\,(\Delta P_{max})_a$, (d) $\lambda_a = 0.331$ m, $\lambda_w = 1.49$ m, $(s_{max})_a = 1.09 \times 10^{-8}$ m, $(s_{max})_w = 1.84 \times 10^{-10}$ m, $(\Delta P_{max})_a = 0.0292$ Pa, $(\Delta P_{max})_w = 1.73$ Pa
(18) 5×10^{-17} W, 5×10^{-5} W
(19) 120.8 dB
(20) 1000
(21) (a) 10^{-4} W/m^2, (b) 82.1 dB
(23) 1.76 dB (This would barely be perceptible)
(24) (a) 133.8 dB, (b) 132 dB, (c) 129 dB
(25) (a) increased by a factor of 5, (b) increased by 7 dB
(26) (a) 4.0×10^{-5} W/m^2, (b) 10 dB
(27) (a) about 10^9, (b) about 10^{12}
(28) from about 100 Hz to about 20000 Hz
(29) 9 Hz difference
(30) 40 kHz
(31) 36 kHz
(32) (a) 5.92 Hz, (b) 4.34 m/s
(33) 20.58 m/s
(34) (a) 313 Hz, (b) 524 Hz, (c) 480 Hz
(35) (a) 471 Hz, (b) 480 Hz, (c) 9 beats/s
(36) (a) 0.364 m, (b) 0.398 m, (c) 982 Hz, (d) 900 Hz
(37) (a) The plane has a speed which is 1.5 times the speed of sound (or Mach 1.5), (b) 41.8°
(38) (a) 42.4 km, (b) 41.5 s
(39) (a) 23.6°, (b) 17.2 s
(40) (a) 73.4°, (b) 29.4 s, (c) 33.5 km

Chapter 16

(1) 2.83 cm, zero
(2) (a) 8 rad, (b) 0.073 m
(3) (a) 5(2n+1) cm, n = 0,1,2,..., (b) 10 n cm, n = 0,1,2,...
(4) 40.4 Hz, 80.9 Hz, 121.3 Hz
(6) The listener hears three minima.

(8) (a) 2.18 cm, (b) $0.4\,n\pi$ cm $(n=0,1,2,\ldots)$, $0.4\,(n+\frac{1}{2})\,\pi$ cm $(n=0,1,2,\ldots)$, (c) 4 cm
(11) 1429 Hz, 1143 Hz, 1715 Hz
(12) 286 Hz, 1429 Hz, 858 Hz
(13) (a) 0.75 m, (b) 1.5 m
(14) (a) 120 Hz, (b) 1.43 m
(15) 850 Hz, 1133 Hz
(16) 0.85 cm (for the upper limit) to 850 cm for the lower limit
(17) 67 cm, 111.7 cm
(18) (a) 15.5 cm, (b) 119 cm, (c) 440 Hz, 78 cm
(19) (a) 66 cm, (b) 262 Hz, 132 cm, (c) 262 Hz, 132 cm (the frequency and wavelength are the same in the air, because it is the air that is resonating in the organ pipe)
(20) −1.72%
(21) 476 m/s
(22) (a) The difference between successive harmonics is 140 Hz. The difference between successive overtones for an open pipe is the fundamental frequency, and each overtone is an integer multiple of it. Since 210 Hz is not a multiple of 140 Hz, then 140 Hz cannot be the fundamental frequency, and so the pipe cannot be open at both ends. Thus, it must be a closed pipe. (b) For a closed pipe, the successive harmonics differ by twice the fundamental frequency. Thus 140 Hz must be twice the fundamental frequency, which is 70 Hz.
(23) (a) 85 Hz, (b) 340 m/s
(24) (a) 291 harmonics with $n=1, 2, 3, \ldots, 291$, (b) 291 harmonics with $n=1, 3, 5, \ldots, 583$
(25) (a) 348 m/s, (b) 125 cm
(26) 6 Hz
(27) 2%
(28) 516 Hz
(29) (a) 259 Hz or 265 Hz, (b) The frequency must have started at 265 Hz to become 266 Hz, (c) The tension should be reduced by 2.99%
(30) (a) 10.13 Hz, (b) 34.45 m

Chapter 17

(1) 1.25×10^8 m/s, 208.3 nm

(2) (a) 3×10^8 m/s, (b) 2.256×10^8 m/s, (c) 5×10^{14} Hz, (d) 451.113×10^{-9} m, (e) 5×10^{14} Hz

(3) (a) 0.1 ns, (b) 50 000

(4) 43.6°

(5) (a) 2.143×10^8 m/s, (b) 38.2°

(6) (a) 1.43, (b) 2.098×10^8 m/s

(7) 0.9 cm

(8) (a) 32.1°, (b) 25.7°, (d) 0.387 cm

(9) 24.4°

(10) (a) 61.3°, (b) 53.7°

(11) (a) 1.3, (b) 50.3°, (c) 66.8°

(12) (a) 48.8°, (b) 41.2°

(13) (a) 50.3°, (b) 33°, 387 μm, Yes $\theta = 57° > \theta_c$ fulfill the condition of total internal reflection (c) 3902 reflections

(14) 56.2°

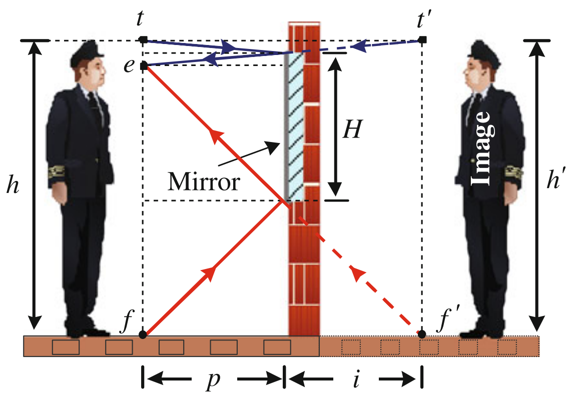
(15) 1.2 μs

(16) 58.47°

(17) 0.34°

(18) (a) 15.68°, (b) 22.84°

(19) (a) $H = 100$ cm, (b) $h' = h = 200$ cm, $i = -p$ (virtual), see the figure



(20) 0.75 m from its center

(21) $i = -0.2$ m and $M = +2$. The image is *virtual* because i is negative, *upright* because M is positive, and *twice as large as* the object ($h' = 6$ cm) because $M = 2$

(22) $i = -0.2/3$ m and $M = +2/3$. The image is *virtual* because i is negative, *upright* because M is positive, and *reduced* ($h' = 2$ cm) because M is less than unity

(23) We found that choosing $i = p$ from the condition $M = |-i/p| = 1$ satisfies the mirror equation $1/p + 1/i = 1/|f|$ and gives $p = 2|f|$, i.e. the object must be placed at a distance $2f$ from the concave mirror. Note that, choosing $i = -p$ from the condition $M = |-i/p| = 1$ cannot satisfy the mirror equation.

(24) Choosing either $i = p$ or $i = -p$ from the condition $M = |-i/p| = 1$ does not satisfy the mirror equation $1/p + 1/i = -1/|f|$. Note that the mirror equation for convex mirrors leads always to a *virtual*, *upright*, and *reduced* image for all values of p.

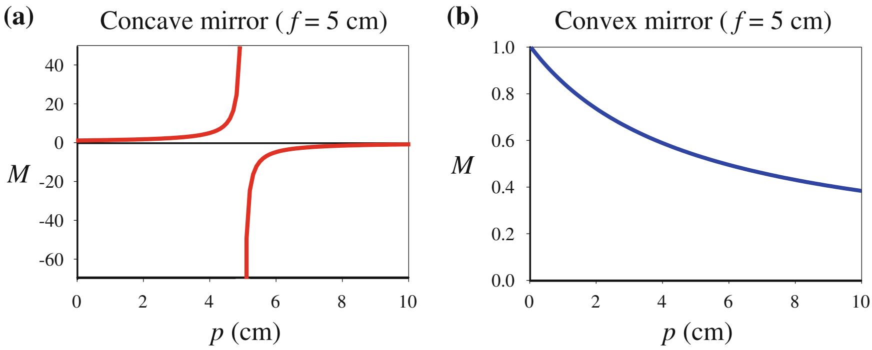
(25) (a) $f = +5$ cm for the concave mirror:

(i)	$p = \infty$,	$i = 5$ cm,	$M = 0$	(real, focus, reduced)
(ii)	$p = 15$ cm,	$i = 7.5$ cm,	$M = -0.5$	(real, inverted, reduced)
(iii)	$p = 10$ cm,	$i = 10$ cm,	$M = -1$	(real, inverted, equal)
(iv)	$p = 7.5$ cm,	$i = 15$ cm,	$M = -2$	(real, inverted, enlarged)
(v)	$p = 5$ cm,	$i = \infty$ cm,	$M = -\infty$	(real, inverted, enlarged)
(vi)	$p = 2.5$ cm,	$i = -5$ cm,	$M = +2$	(virt., upright, enlarged)

(b) $f = -5$ cm for the convex mirror:

(i)	$p = \infty$,	$i = -5$ cm,	$M = 0$	(virt., focus, reduced)
(ii)	$p = 15$ cm,	$i = -3.75$ cm,	$M = +0.25$	(virt., upright, reduced)
(iii)	$p = 10$ cm,	$i = -3.3$ cm,	$M = +0.33$	(virt., upright, reduced)
(iv)	$p = 7.5$ cm,	$i = -3$ cm,	$M = +0.4$	(virt., upright, reduced)
(v)	$p = 5$ cm,	$i = -2.5$ cm,	$M = +0.5$	(virt., upright, reduced)
(vi)	$p = 2.5$ cm,	$i = -1.67$ cm,	$M = +0.67$	(virt., upright, reduced)

(26)



(27) (a) $i = 18$ cm and $M = -2$. The image is *real* because i is positive, *inverted* because M is negative, and *enlarged* ($h' = -0.4$ cm) because $|M|$ is greater than unity. (b) $i = -6$ cm and $M = 2$. The image is *virtual* because i is negative, *upright* because M is positive, and *enlarged* ($h' = 0.4$ cm) because M is greater than unity

(28) $i = -22.5$ cm (both the object and image are in *front* of the spherical surface in water) and $M = 1.5$. The image is *virtual* because i is negative, *upright* because M is positive, and *enlarged* because M is greater than unity

(29) (a) $i = 15$ cm and $M = -0.5$. The image is *real* because i is positive, *inverted* because M is negative, and *reduced* because M is less than unity, (b) $i = -10$ cm and $M = 2$. The image is *virtual* because i is negative, *upright* because M is positive, and *enlarged* because M is greater than unity

(30) (a) $i = -7.5$ cm and $M = 0.25$. The image is *virtual* because i is negative, *upright* because M is positive, and *reduced* because M is less than unity, (b) $i = -3.3$ cm and $M = 0.67$. The image is *virtual* because i is negative, *upright* because M is positive, and *reduced* because M is less than unity

(32) (a) $i = -5$ cm and $f = -20/3$ cm. The image is *virtual* and the lens is a diverging lens. (b) $R = 18$ cm

(33) $f_2 = -37.5$ cm

(34) $i = -1.75$ cm. The image is *virtual* and 1.75 cm in front the diverging lens

(35) $i = +9.6$ cm. The image is *real* and 9.6 cm behind the diverging lens

(36) $i = +40$ cm. The image is *real* and 40 cm behind the second lens, *reduced* because $M = 0.5$, and *upright* because M is positive

(37) $i = +4$ cm. The image is *real* and 4 cm behind the second lens, *reduced* because $M = -0.4$, and *inverted* because M is negative

(38) $f_1 = -5$ cm

(39) $f_1 = -5$ cm as in Exercise 38

(40) $di/dt = f^2/(p-f)^2\, v,\ p = 2f$

Chapter 18

(1) $\Delta y = 2.52$ mm

(2) 500 nm (in the range of green light)

(3) $\lambda_V = 400$ nm, $\lambda_R = 700$ nm

(4) 600 nm, 5×10^{14} Hz

(5) 4.5×10^{-6} m
(6) 2.9°, 8.6°, 14.5°, 20.5°, and 26.7°, (corresponding to the order $m = 1, 2, \ldots, 5$ for dark fringes)
(7) After the central fringe, the 12th blue fringe will overlap with the 10th yellow fringe to produce a green fringe
(8) (a) 58, (b) 80.4°
(9) 8.8 cm
(10) 0.019 mm
(11) 1355 rad
(12) (a) 0.75 $I_\circ$, (b) 94.5 nm
(13) 0.864
(16) (a) $d = 100$ nm, (b) Yes, with $m = 2$
(17) 686.4 nm
(18) $d = 1473$ nm
(19) (a) 21 dark bands and 20 bright bands between them, (b) 0.5 cm
(20) (a) 168.6 nm, (b) If the thickness were much less than one wavelength, then there would be a very little phase change introduced by an additional path length, and so the two reflected waves would have about π rad phase difference. This would produce destructive interference.
(21) 102 nm
(22) (a) 74.2 nm, 541.7 nm (b) A light ray reflected from the air-oil interface undergoes a phase shift $\phi_1 = \pi$. A ray reflected at the oil-water interface undergoes no phase shift. When the oil thickness is negligible compared to the wavelength of the light, then there is no significant shift in phase due to a path distance traveled by a ray in the oil, i.e., $\phi_2 \approx 0$. Thus, the light reflected from the two surfaces will destructively interfere for all visible wavelengths and the oil will appear black.
(23) (a) 675 nm, (b) 2.8 mm
(26) 12.33 m, 23.71 m
(27) (a) $\lambda = 632.9$ nm, (b) $I_3/I_{\text{max}} = 8.3 \times 10^{-3} \equiv 0.83\%$
(28) 114 cm
(29) 0.26 mm
(30) (a) $a = \lambda$, (a) $a = 400$ nm
(31) (a) 25 cm, (a) 51.5%
(33) 625 nm
(34) 17.3°

(35) (a) $d = 2.5 \times 10^3$ nm, (b) $m = 0, 1, 2, 3$, (c) $R = 732.5$, (d) $N' = 366$ slits

(36) For $\lambda = 700$ nm, $m_{\text{max}} = 3.2$. Three full spectral orders can be observed on each side of the central maximum as well as a portion of the fourth order. For $\lambda = 400$ nm, $m_{\text{max}} = 5.6$. Five full spectral orders can be observed on each side of the central maximum as well as a portion of the six order.

(37) 16.6 cm for $\lambda = 700$ nm and 9.1 cm for $\lambda = 400$ nm

(38) The wavelengths 600–700 nm of the second order overlap with the wavelengths 400–467 nm of the third order.

(39) (a) 3, (b) The resolution is best for the third order, since it is more spread out than the second and first order, (c) 0.028 nm

(40) 63.4°

(41) 0.125 $I_\circ$

(42) 45°

(43) 0.5625 $I_\circ$ (56.25%)

(44) 65.53°

(45) (a) $I_1/I_\circ = \frac{1}{2}$, $I_2/I_1 = \frac{3}{4}$, and $I_2/I_\circ = \frac{3}{8}$, (b) 63.4°

Chapter 19

(1) A neutral atom has the same number of electrons orbiting a nucleus having the same number of protons. A negatively charged atom has an excess of one or more electrons, while a positively charged atom has one or more missing electrons.

(2) The rubber rod will be negatively charged while the fur will be positively charged. It is not possible to transfer positive charges from rubber to fur or vice versa, because positively charged nuclei (or protons) are massive and immobile, unlike electrons.

(3) Negative charged copper rod.

(4) When the comb is near the bits of paper, molecules in the paper are polarized with an opposite charge facing the comb, and the paper is attracted. During contact, charge from the comb is transferred to the paper by conduction. Then the paper may be neutralized and fall off. It may even become equally charged as the comb, and then get repelled.

(5) Wearing rubber-soled shoes allows for an accumulation of charge by friction with the floor. Upon discharging, a spark may result, and if the area is enriched with oxygen, then it would result in an explosion.

(6) No. Molecules in the wall are polarized with an opposite charge facing the balloon, and the balloon is attracted to the wall. During contact, ionization of the air between the balloon and the wall provide ions so the excess electrons in the balloon can be transferred to the ions, reducing the charge on the balloon and eventually causing the attractive force to be insufficient to support the weight of the balloon.

(7) We first allow the two uncharged metallic spheres to touch. The charged rubber rod is then brought near one of the spheres. The positive charge on the rubber rod will repel the electrons in the nearby sphere and cause them to move to the far end of the second sphere (this is known as charging by induction). If the spheres are now separated, one of them will retain a negative charge while the other will retain an equal amount of positive charge. Finally, we take away the charged rubber rod.

(8) 6.24×10^{18} electrons, 5.68×10^{-12} kg

(9) (a) 9×10^{13} N, (b) 9×10^{9} N, (c) 9000 N, Yes, Yes

(10) 2.3×10^{-8} N

(11) 2.1×10^{-4} N

(12) 2.1×10^{11} electrons

(13) (a) 2.62×10^{24} electrons, (b) 2.39 electrons per billion (10^9)

(14) (a) 57.6 N, (b) Larger by 1.24×10^{36} times

(15) $q/m = 8.61 \times 10^{-11}$ C/kg

(16) $q = \pm 1.4 \times 10^{-9}$ C, No, both positive and negative charges repel each other.

(17) (a) 35 μC and 5 μC, (b) 45 μC and -5 μC or -45 μC and 5 μC

(18) 14.4 N away from q_2

(19) 0.02 N on q_1 and directed to the left, zero force on q_2, and 0.02 N on q_3 and directed to the left.

(20) 0.25 N, No, only the direction will be reversed

(21) 8.9 N at 204° or $\vec{F} = (-8.1\,\vec{i} - 3.6\,\vec{j}\,)$ N

(23) 0.97 N at 135° or $\vec{F} = (-0.69\,\vec{i} + 0.69\,\vec{j}\,)$ N

(24) (a) 0.018 N at 45° or $\vec{F} = (0.013\,\vec{i} + 0.013\,\vec{j}\,)$ N, (b) 3.1×10^{-2} N at 225° or $\vec{F} = (-2.2 \times 10^{-2}\,\vec{i} - 2.2 \times 10^{-2}\,\vec{j}\,)$ N

(25) (a) $2\,k\,q\,q_\circ/a^2$, negative x-direction, (b) $2\,k\,q\,q_\circ/(a^2 + y^2)^{3/2}$, negative x-direction

(26) (a) 82.3×10^{-9} N, (b) 9.04×10^{22} m/s^2, (c) 2.19×10^{6} m/s

(27) (a) zero, (b) 1.9×10^{9} N

(28) $q_1 = q_2 = Q/2$

(29) (a) $T = 2\pi\sqrt{\pi\epsilon_\circ m a^3/q q'}$, (b) 6.63×10^{-13} s $\simeq 0.7$ ps

(30) (b) 7.318×10^{-9} C

(31) (a) $x = k q Q L/2 W h^2$, $P = W - 3 k q Q/h^2$, (b) $h = \sqrt{3 k q Q/W}$

(32) (a) $\theta_1/\theta_2 = 3$, (b) $r = (8 k L q^2/3 m g)^{1/3}$

Chapter 20

(1) (a) 9×10^7 N/C, (b) 9×10^3 N/C, (c) 9×10^{-3} N/C

(2) (a) 1.1×10^{-14} C, (b) 1.1×10^{-10} C, (c) 1.1×10^{-4} C

(3) (a) 5.6×10^{-11} N/C, down, (b) 1.0×10^{-7} N/C, up, very small values

(4) (a) 5×10^5 N/C, negative x-direction, (b) 8.8×10^{16} m/s^2

(5) (a) 1.8×10^3 N/C, 243.4°, (b) 3.6×10^4 N/C, 36.9°

(6) At 20 cm to the right of the $-4\ \mu$C charge

(7) 7.2×10^7 N/C directed toward q_2

(8) (a) zero, (b) zero, (c) $1.3 \times 10^7 \vec{i}$ (N/C)

(9) 5.4×10^5 N/C to the left

(10) (a) $+5.88 \times 10^8$N/C, $+1.28 \times 10^{11}$N/C, -6.41×10^{11}N/C, -6.41×10^{11}N/C, $+1.28 \times 10^{11}$N/C, $+5.88 \times 10^8$N/C, (b) about 98%

(11) (a) $-2.84 \times 10^8 \vec{i}$ (N/C), $-2.58 \times 10^{10} \vec{i}$ (N/C), $-2.06 \times 10^{11} \vec{i}$ (N/C), $-2.06 \times 10^{11} \vec{i}$ (N/C), $-2.58 \times 10^{10} \vec{i}$ (N/C), $-2.84 \times 10^8 \vec{i}$ (N/C), (b) about 102%

(12) (a) $\lambda = -Q/L$, (d) 3.2×10^6 N/C directed toward the rod

(13) (a) $E = k\lambda/a$ to the left, (a) $E = k\lambda_\circ/2a$ to the left

(14) (a) zero, (b) 1.32×10^6 N/C, (c) 7.68×10^6 N/C, (d) 4.35×10^5 N/C, (e) The electric field is zero at the center of the ring, then increases as a increases, and finally starts to decrease as a increases

(15) 1182 N/C to the right

(16) $E = 4 k Q/\pi R^2$ to the left, where Q is the magnitude of the charge on each quarter circle, i.e. with $|\lambda| = 2|Q|/(\pi R)$

(17) $E = 4 k Q/\pi R^2$ to the left, the same formula as in Exercise 16, but Q here is the magnitude of the charge on each half circle, i.e. with $|\lambda| = |Q|/(\pi R)$

(20) (a) $q_1/q_2 = 3/5^{3/2} \simeq 0.3$, (b) Yes, to the left of C_1

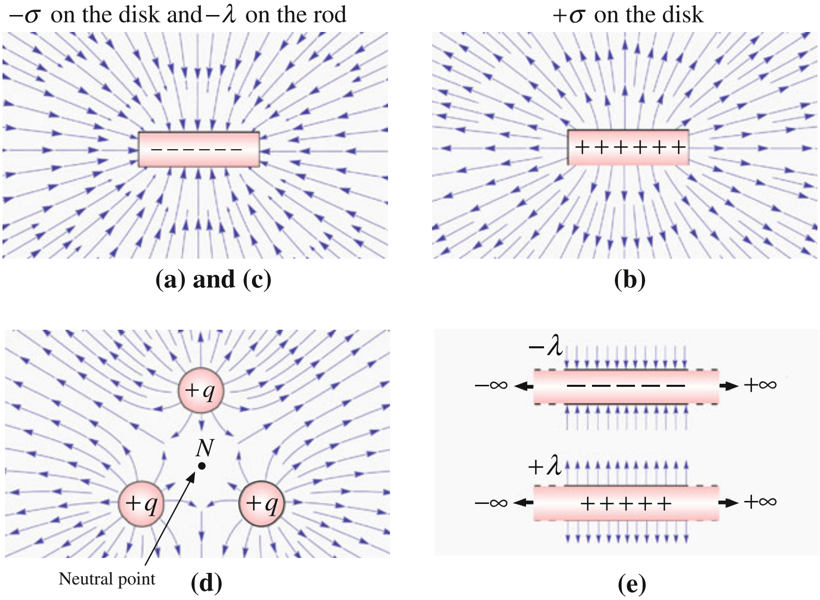
(21) (a) 3.32×10^5 N/C, (b) 2.72×10^5 N/C, (c) 3.58×10^4 N/C, (d) 4.23×10^2 N/C

(23) The near-field approximation matches the 1 mm location and the point charge approximation matches the 100 cm location.

(24) $z = R/\sqrt{3}$

(25) $E = \sigma/\epsilon_{\circ}$

(27) (a) 8.78×10^{8} m/s, 3.51×10^{-13} J, (b) 4.79×10^{5} m/s, 1.92×10^{-16} J



(28) (a) 4.52×10^{5} N/C, (b) 7.23×10^{-14} N to the left, (c) 7.95×10^{16} m/s^{2} to the left, (d) 6.14×10^{-10} s, (e) 4.88×10^{7} m/s and 1.08×10^{-15} J

(29) (a) 7.95×10^{16} m/s^{2} to the left, (b) 4.88×10^{7} m/s, (c) 4.61×10^{-10} s

(30) The electron will hit the upper plate at $x = 2.386 \times 10^{-2}$ m $\simeq 2.4$ cm

(31) The proton will never hit the lower plate and at $y = -d/2$, the x-coordinate of the proton will be $x \simeq 102$ cm

(32) (a) 1.76×10^{13} m/s^{2}, (b) 1.5×10^{-8} s, (c) 1.98×10^{-3} m $= 0.198$ cm, (d) 4.15×10^{-2} m $= 4.15$ cm

(33) (a) 9.581×10^{9} m/s^{2}, (b) 1.5×10^{-8} s, (c) 1.078×10^{-6} m (almost no deflection), (d) 2.263×10^{-5} m (little deflection)

Chapter 21

(1) (a) 10^{5} N.m^{2}/C, (b) -10^{5} N.m^{2}/C, (c) zero, (d) zero, (e) 5×10^{4} N.m^{2}/C

(2) 2.5×10^{6} N/C

(3) (a) zero, (b) $-\pi \times 10^{3}$ N.m^{2}/C, (c) $\pi \times 10^{3}$ N.m^{2}/C

(4) (a) $a^{3}\beta$ N.m^{2}/C, (b) 0.04 N.m^{2}/C, zero

(5) (a) zero, (b) βA, (c) αA

(6) (a) 2.8 N.m^2/C, (b) -2.8 N.m^2/C

(7) (a) $-E\ r\ h$, (b) $+E\ r\ h$, (c) zero

(8) (a) $q/\epsilon_\circ$, (b) $(q + 2\,\pi\,R\,\lambda)/\epsilon_\circ$

(9) (a) $q/\epsilon_\circ$, zero, $2\,q/\epsilon_\circ$, and zero, (b) No, (c) Because the number of electric field lines that enter any surface will emerge from it and hence do not contribution to the electric flux.

(10) (a) 2.856×10^4 N.m^2/C, (b) 1.414×10^6 N.m^2/C, Yes

(11) (a) 10^3 N.m^2/C, (b) zero

(12) 4.425×10^{-3} C/m^3

(13) (a) zero, (b) 126.3 N.m^2/C

(14) (a) $q/2\epsilon_\circ$, (b) $-q/2\epsilon_\circ$

(15) 5×10^5 N/C upwards

(16) 5×10^9 N/C away from the wall. The field is uniform as long as the distance from the wall is much less than the wall's dimensions.

(17) (a) zero, (b) $\sigma/\epsilon_\circ$ to the right, (c) zero

(18) (i) (a) $\sigma/\epsilon_\circ$ to the left, (b) zero, (c) $\sigma/\epsilon_\circ$ to the right (ii) (a) $\sigma/\epsilon_\circ$ to the right, (b) zero, (c) $\sigma/\epsilon_\circ$ to the left

(19) (a) 3.9×10^{-9} C/m^2, (b) (441.4 N/C) $\vec{\mathrm{k}}$, (c) $-$(441.4 N/C) $\vec{\mathrm{k}}$

(20) (a) 14.4 MN/C inwards, directed to the filament, (b) 7.2 MN/C inwards, directed to the filament, (c) 1.44 MN/C inwards, directed to the filament

(21) (a) 6×10^5 N/C, (b) 7.54×10^3 N.m^2/C

(22) (a) 1.1×10^{-6} C, (b) zero

(23) $\rho\,r/2\epsilon_\circ$ radially outward if ρ is positive

(24) (a) zero, (b) 6.75×10^6 N/C

(25) (a) zero, (b) $E = k\,Q/r^2$, (c) zero

(26) 5.94×10^5 m/s

(27) (a) 9×10^{-7} C, (b) 7.5×10^{-6} C

(28) (a) zero, (b) 3.38×10^6 N/C, (c) 6.75×10^6 N/C, (d) 3.0×10^6 N/C, (e) 7.5×10^5 N/C

(29) 8.34×10^{-9} C

(30) $E = \alpha\,r^2/4\epsilon_\circ$ for $r \leq R$ radially outward, and $E = \alpha\,R^4/4\epsilon_\circ\,r^2$ for $r \geq R$ radially outward

(31) $E_{C_1} = -\rho R/6\epsilon_\circ$ downwards, $E_{C_1} = 17\rho R/54\epsilon_\circ$ upwards

(32) (a) $E = (kQ/R^3)\,r$, (b) $E = kQ/r^2$, (c) zero, (d) zero, (e) inner charge is $-Q$, outer charge is 0

(33) (a) $\sigma_{\text{Copper}} = Q/2A$, $\sigma_{\text{Glass}} = Q/A$, (b) $E_{\text{Copper}} = \sigma_{\text{Copper}}/\epsilon_\circ = Q/2A\,\epsilon_\circ$, $E_{\text{Glass}} = \sigma_{\text{Glass}}/\epsilon_\circ = Q/2A\,\epsilon_\circ$, the magnitude of the two fields are the same, and both are perpendicular to the plates

(34) (a) $\lambda_{\text{inner}} = -\lambda$, $\lambda_{\text{outer}} = 4\,\lambda$, (b) $E = 2\,k\,\lambda/r$ (radius of the wire $< r < R_1$), $E = 0$, $(R_1 < r < R_2)$, $E = 8\,k\,\lambda/r (r > R_2)$

(35) $E = k(q_1 + q_2)/r^2$, directed outward if $(q_1 + q_2) > 0$ and inwards if $(q_1 + q_2) < 0$

Chapter 22

(1) (a) Zero, (b) 10^{-3} J, (c) -1.56×10^{-3} J
(2) (a) Zero, (b) -10^{-3} J, (c) $+1.56 \times 10^{-3}$ J
(3) (a) Zero, (b) 10^{-3} J, (c) -1.56×10^{-3} J
(4) 1.35×10^6 J, 6.02×10^{23} electrons, Avogadro's number
(5) 3.7×10^5 N/C
(6) (a) 1200 V, (b) 2.05×10^7 m/s
(7) (a) 135.6 N/C, (b) 7.38 cm
(8) (a) 240 V, (b) 240 V
(9) (a) 2 m/s, (b) The same
(10) (a) 1.44×10^{-7} V, 7.2×10^{-8} V, (b) -7.2×10^{-8} V
(11) (a) -1.44×10^{-7} V, -7.2×10^{-8} V, (b) 7.2×10^{-8} V
(12) (a) 0.9 m, (b) 3.6×10^{-9} C
(13) 3 cm
(14) (a) $-1.44 \times 10^7 \vec{i}$ (V), (b) Zero, -0.36 J, (c) Zero
(15) 4639 V
(16) -7.2×10^3 V
(19) $16.3\,\mu$ V
(20) (a) $k\,Q \ln(1.8)/L$, (b) Zero
(21) $-2\,\pi\,k\,\lambda/3$
(22) $k\,\lambda(\pi + 2\ln 2)$
(23) (a) -3.02×10^6 V, (b) -1.51×10^6 V
(24) $z = \pm\sqrt{3}\,R$
(25) $V = 2\,\pi\,\sigma\,k\left(\sqrt{R_2^2 + a^2} - \sqrt{R_1^2 + a^2}\right)$
(26) 2331 V

(28) $V = \pi\,\alpha\,k\left(R\sqrt{R^2+a^2} + a^2\ln\left[a/\left\{R+\sqrt{R^2+a^2}\right\}\right]\right)$
(29) (a) $r = \sqrt{3/2}\,R$, (b) $V_R - V_0 = -kQ/2R$
(30) (a) $V_r = (\alpha R^3/12\,\epsilon_\circ)(4 - r^3/R^3)$ for $0 \le r \le R$, (b) $V_r = \alpha R^4/(4\,\epsilon_\circ r)$ for $r \ge R$
(31) (a) 1.8×10^6 V, (b) 1.8×10^6 V, (c) 1.8×10^6 V, (d) 1.2×10^6 V
(32) (a) 4.2×10^{14} electrons, (b) 1.33×10^{-4} C/m^2
(33) 150 V
(35) (a) $q_a = Q\,a/(a+b)$, $q_b = Q\,b/(a+b)$, (b) $V = k\,Q/(a+b)$
(36) 109.86 V
(37) (a) $E_x = (-6\,x - 6\,y^2 + 4\,z)$ V/m, $E_y = (-3\,x^2 - 12\,y^2 + 4\,z)$ V/m, $E_z = (-3\,x^2 - 6\,y^2 + 4)$ V/m, (b) $E_x = -4$ V/m, $E_y = -28$ V/m, $E_z = -32$ V/m
(38) $E_r = \pm\,2\,k\,p/r^3$ (+ when $\theta = 0$ and − when $\theta = \pi$)
(39) (a) 900 kV, (b) 3×10^{-5} C = 30 μC, (c) 135 kV, 67.5 kV/m
(40) 10.7 hp

Chapter 23

(1) 150 μ C
(2) 80 000 V
(3) 3×10^{-5} C
(4) 3.54 n m
(5) (a) 177 pF, (b) 3.54 n C, 8.85×10^{-8} C/m^2 (c) 10 kV
(6) 79.65 n C
(7) 3.475 n C
(11) (a) 227 pF, (b) 353 V
(12) 40 pF
(13) (a) 2×10^{-10} F, (b) 10 nC
(14) 708 μ F
(15) 4.41 f F
(16) (a) 53.1 pF, (b) 376.6 V
(17) (a) 750 μ C, (b) 33 μ C, 22.7 V
(18) (a) 10.6 n C, (b) 210 n C
(19) 1.000 578
(20) (a) 1.77 nF, 21.24 n C, 7.97 nF, 95.58 n C, (b) 30.98 n C/m^2, 3500 N/C
(21) (a) 5 μ F, (b) $Q_1 = 18$ μ C, $Q_2 = 27$ μ C, (c) $\Delta V_1 = \Delta V_2 = 9$ V
(22) (a) 1.2 μ F, (b) $Q_1 = Q_2 = 10.8$ μ C, (c) $\Delta V_1 = 5.4$ V, $\Delta V_2 = 3.6$ V

(23) (a) 2.2 μ F, (b) $Q_1 = 6\ \mu$ C, $Q_2 = Q_3 = 7.2\ \mu$ C, (c) $\Delta V_1 = 6$ V, $\Delta V_2 = 3.6$ V, $\Delta V_3 = 2.4$ V
(24) (a) 484 μ C, (b) 198 μ C, (c) 96 μ C, (d) 44 μ C
(25) (a) $Q_1 = 50\ \mu$ C, $Q_3 = 40\ \mu$ C, (b) $\Delta V = 35$ V
(26) (a) 6 μ F, (b) $\Delta V = 35$ V
(27) (a) 2 C/5, (b) C, (c) 5 C/3, (d) 11 C/6
(28) (a) 9.6 μ C, (b) 24 μ C, (c) 40 μ C, (d) 44 μ C
(29) (a) 65 μ F, (b) 750 μ C, (c) 11.54 V, (d) $Q_{1\text{f}} = 28.85\ \mu$ C, $Q_{2\text{f}} = 46.13\ \mu$ C
(33) 44.25 n J
(34) (a) $U_1 = 200\ \mu$ J, $U_2 = 300\ \mu$ J, (b) Yes, $U_{\text{eq}} = U_1 + U_2$
(35) (a) $\Delta V_f = 5$ V, $Q_{1\text{f}} = Q_{2\text{f}} = 25\ \mu$ C, (b) $U_{\text{i}} = 250\ \mu$ J, $U_{\text{f}} = 125\ \mu$ J, $U_{\text{i}} > U_{\text{f}}$
(36) 9.5%
(37) 50 kV/m, 0.011 J/m^3, 8.69×10^{-8} J
(38) 0.02 J
(39) (a) 40 V, (b) 800 J

Chapter 24

(1) 10^{19} elecrons/s
(2) (a) 600 C, (b) 3.75×10^{21} electrons
(3) (a) 9632 C, (b) 5.35 A
(4) (a) 5×10^{18} electrons per second, (b) 0.8 A
(5) (a) 60 C, (b) 30 A
(6) (a) $I = 2(1 + t)$, 6 A, (b) $J = 2 \times 10^4(1 + t)$, 60 kA/m^2
(7) (a) 2387.3 A/m^2, (b) 596.8 A/m^2
(8) (a) $I_{\text{Iron}} = 8$ A, $J_{\text{Iron}} = 4.07 \times 10^5$ A/m^2, (b) $J_{\text{Copper}} = 2.55 \times 10^8$ A/m^2
(9) 1.04×10^{-3} m/s $\simeq 1$ mm/s
(10) 7.32×10^{-1} V/m
(11) (a) 1.59×10^6 A/m^2, (b) 50 V/m, (c) $3.14 \times 10^{-5}\ \Omega$.m, $3.18 \times 10^4\ (\Omega\text{.m})^{-1}$
(12) 3.975 Ω
(13) (a) 3.9×10^5 A/m^2, (b) 6.357×10^{-3} V/m, (c) 3.184×10^{-3} V, (d) $6.366 \times 10^{-4}\ \Omega$, (e) 23.91°C
(14) (a) 18.85 A, (b) $5.3 \times 10^{-6}\ \Omega$, 10^{-4} V
(15) (a) 1.776×10^{-2} m, (b) $9.57 \times 10^{-7}\ \Omega$, (c) 10.45 A, 2.45 μm/s
(16) 78%

(17) 27.8 Ω

(18) 5.25×10^{-3} Ω

(19) (a) 1.892×10^{-8} Ω.m, (b) 1.06×10^{7} A/m^2, (c) 8.33 A, (d) 0.012 Ω, (e) 1.13 mm/s, (f) 1 V

(20) $R_{\circ n} = 4$ Ω, $R_{\circ c} = 5$ Ω

(21) (a) 0.25 A, (b) 960 Ω, (c) 0.42 A, 576 Ω

(22) (a) 88 Ω, (b) 2.5 A, (c) 163.6 W

(23) (a) 2.4 Ω, (b) 10 A, (c) 102 mm

(24) (a) 0.02 A, (b) 20 V

(25) (a) 0.9 kW. h, (b) 31.5 piaster

(26) (a) 31.83 A/m^2, (b) 6.25×10^{14} electrons/s, (c) 0.5 W, (d) 4.19×10^{7} m/s, (e) 4.75×10^{12} electrons/m^3

(27) 231.25 Ω

(28) (a) 2 A, (b) 10 V

(29) (a) 0.5 Ω, (b) 8.25 V

(30) (a) 0.05 Ω, (b) 0.15 Ω

(31) (a) 29 Ω, (b) 3.3%, (c) 0.1 A, No

(32) (a) 2.8 Ω, (b) 14 V

(33) (a) 6 Ω, (b) 14 V

(34) (a) $5\,R/2$, (b) R, (c) $3\,R/5$, (d) $6R/11$

(35) (a) 2.4 A, 1.2 A, 1.2 A, 2.4 A, (b) 3 A, 3 A, 3 A, 3 A, (c) 4 A, 6 A, 2 A, 2 A, (d) 2 A, 3 A, 6 A

(36) (a) 1.5 MΩ, (b) 0.7 MΩ

(37) (a) 960 Ω, (b) 0.2 A, (c) 192 V, (d) 38.4 W

(38) (a) 6 Ω, (b) 2 A, (c) $I_3 = 1.5$ A, $I_4 = 0.5$ A, (d) $P_1 = 4$ W, $P_2 = 9$ W, $P_3 = 9$ W, $P_4 = 3$ W

(39) $I_1 = -1$ A, $I_2 = 1$ A, $I_3 = 2$ A

(40) $I_1 = -14/11$ A, $I_2 = -18/11$ A, $I_3 = -32/11$ A

(41) $I_1 = 2$ A, $I_2 = 2$ A, $I_3 = -4$ A

(42) $\varepsilon_1 = 9$ V, $I_2 = -2.5$ A, $I_3 = -2$ A

(43) $I_1 = 0.5$ A, $I_2 = -1$ A, $I_3 = -0.5$ A, $I_4 = 0$

(46) 39. 7%

(47) (a) 2 s, 24 μC, 12 μA, (b) 1.39 s

(49) (a) 1.1 mC, 4.4 mA, (b) 0.15 mC, 0.6 μA

(50) $\tau_{\text{Before}} = 2$ s, $\tau_{\text{After}} = 0.75$ s, $I_{\text{Switch}} = 0.6 \text{ mA} + (0.2 \text{ mA})e^{-t/0.75}$

Chapter 25

(1) (a) down, (b) to the left, (c) in the plane of the page and perpendicular to $\vec{v}$ and $\vec{B}$, (d) up, (e) no force, (f) into the page, (g) into the page, (h) out of the page

(2) (a) to the left, (b) no deflection, (c) out of the page, (d) to the right

(3) 24.6° or 155.4°

(4) $-1.82 \times 10^{-13}\,\vec{k}$ (N), along the negative z-axis

(5) 6.4×10^{-17} N, downwards

(6) 3.845×10^{-26} kg, Sodium ion

(7) (a) 0.167 m, (b) 131 μs, (c) 6.4×10^{-11}N

(8) (a) 1.548×10^{7} m/s, (b) 7.43×10^{-12} N, (c) 0.215 m, (d) 1.1×10^{15} m/s^2

(9) (a) 1.708×10^{-3} m, (b) 3.577 ns, (c) 0.014 m

(10) (a) 60°, 62.625 cm, (b) 39.7°, 14.44 cm, (c) 21.2°

(11) 3.75×10^{4} m/s

(12) 20.5 mT

(13) (a) and (b) The magnetic field is out of page, the left plate is at a higher electric potential for the left pair, and the right plate is at a higher electric potential for the right pair. Note that, these polarities are reversed when the magnetic field is into the page in the case of a clockwise path, (c) 8.54 cm

(14) (a) 7.5×10^{4} m/s, (b) 40.56 cm

(15) (a) 2.4×10^{5} m/s, (b) 9.96 mm

(16) (a) 7.38×10^{-11} m^3/C, (b) 5.53 μV, (c) 1.11×10^{-3} V/m

(17) (a) 5.85×10^{28} electrons/m^3, (b) 5.86×10^{28} atoms/m^3, the number of charge carriers in silver is almost one electron per atom, (c) 1.424×10^{-4} V/m

(18) (a) 6.67×10^{-5} m/s, (b) 5.854×10^{28} electrons/m^3, (c) point b is at higher potential

(19) 0.525 N

(20) (a) 1.875×10^{-1} N, 323.1° from the x-axis in the xy plane

(21) $F_{ab} = 0$, $F_{bc} = 0.5\,I\,LB$, into the page, $F_{cd} = 0.5\,I\,LB$ out of the page, $\sum F = 0$ as must be for a closed loop

(22) 0.625 A (when $g = 10$ m/s^2)

(23) $F_{ab} = 0$, $F_{bc} = 0.1$ N, $F_{cd} = 0.05$ N, $F_{de} = 0.1$ N, $F_{ef} = 0$

(24) $F = 2\pi R\,I\,B \sin\theta$, to the right

(25) (a) 0.628 A·m^2, (b) 6.283×10^{-2} A·m

(26) (a) $\mu = 0.2171\,I\,L^2$ out of the page, (b) $\tau = 0.2171\,I\,L^2 B$ up

(27) 9.425×10^{-3} N·m

(28) (a) $B = mg/\pi I R$, (b) The same $B = mg/\pi IR$ for $0° \leq \theta \leq 90°$

(29) 1.35 N·m, counterclockwise

(30) (a) 21 A·m^2, (b) 53°, (c) 13.42 N·m, the coil will rotate so that $\vec{\mu}$ aligns with $\vec{B}$. Looking down along the y-axis, the loop will rotate in a clockwise direction

(31) (a) $\mu = 1.473 \times 10^{-3}$ A·m^2, (b) $\vec{\mu} = 1.473 \times 10^{-3}\vec{\text{k}}$ (A·m^2), (c) $\vec{\tau} = [2.946 \times 10^{-4}\,\vec{\text{j}} - 4.419 \times 10^{-4}\vec{\text{i}}\,]$ (N·m), only the component of torque along y-axis cause a torque about this axis, while the one along the negative x-axis has no effect on the loop. Looking down along the y-axis, the loop will rotate in a counterclockwise direction

(32) 1.4 rad = 80.2°

(33) (a) 1.3×10^8 m/s, 0.31 s, (b) 5.2 km, no

Chapter 26

(1) (a) $-7.8 \times 10^{-9}\,\vec{\text{k}}\,(T)$, (b) $-4 \times 10^{-9}\,\vec{\text{k}}\,(T)$

(2) 13.7 T

(3) υ^2/c^2

(4) At P, 33.3 μT out of the page and at Q, 33.3 μT out the page

(5) At P, 66.7 μT out of the page and at Q, 66.7 μT into the page

(6) 69.3 μT to the left

(7) (a) Zero, (b) 11.3 μT to the left, (c) Zero

(8) Zero for the two wires that point extends along their length, 2 μT (into the page) for the two vertical wires that they have a 5 cm length, 4 μT (into the page) for the horizontal wire that has a 10 cm length, $B_{\text{tot}} = 8\,\mu$T

(9) 31.42 μT, 22.48 μT, 1.11 μT, 1.16 μT

(10) 7.63 cm, 18.13 cm, 39.79 cm

(11) 21.14 μT out of the page

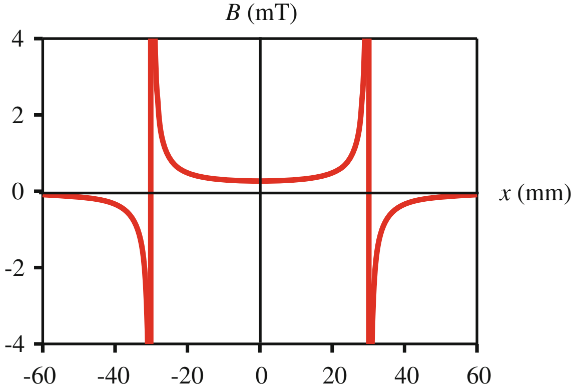
(12) 17.65 μT out of the page

(13) (a) 0.021 T

(14) (a) 16 μC, (b) 64 μN repulsive force

(15) (a) $B(x) = \mu_\circ Ia/\pi(a^2 + x^2)$

(b)



(16) (a) $F_{(2)} = 30\,\mu$T to the right, $F_{(4)} = 90\,\mu$T to the left, (b) $F_{(3)}$ is up, $F_{(1)}$ is down, (c) 60 μT to the left

(17) (a) $B = 0$ (for $r < R$) and $B = \mu_\circ I/2\pi r$ (for $r \geq R$)

(18) $\oint_{C_1} \vec{B} \bullet d\vec{s} = 10\mu_\circ$, $\oint_{C_3} \vec{B} \bullet d\vec{s} = -10\mu_\circ$, $\oint_{C_3} \vec{B} \bullet d\vec{s} = 0$, No one

(19) $B_a = 100\,\mu$T toward top of page, $B_b = 50\,\mu$T toward bottom of page

(20) 250 μT, 500 μT, 250 μT

(21) $B_{r<a} = 0$, $B_{a<r<b} = [\mu_\circ I/2\pi r][(r^2 - a^2)/(b^2 - a^2)]$, $B_{r>b} = \mu_\circ I/2\pi r$

(22) $B = \mu_\circ nI$

(23) $B = 0.503$ T

(24) (a) 400 turns per layer, (b) 3.0 T

(25) 60.3 μT

(26) (a) 5 layers, (b) 47.43 m

(27) $B(r) = \mu_\circ NI/2\pi r$

(28) 2×10^{-3} T

(29) 0.024 T, 0.022 T

(30) (b) $B = \frac{1}{2}\mu_\circ \lambda$

(31) $\vec{B}_a = -\mu_\circ \lambda \vec{i}$, $\vec{B}_b = 0$, $\vec{B}_c = +\mu_\circ \lambda \vec{i}$

(32) (a) 0.2 A, (b) 22.6×10^9 V·m/s, (c) 0.5 μT

(33) (a) 1.079×10^{12} V/m.s, (b) 3×10^{-7} T

(34) 2.57×10^{-34} J·s, 0, -9.27×10^{-24} J/T, 1.85×10^{-23} J/T

(35) (a) For $m_\ell = 0$ we get $L_z = 0$, $\mu_{\ell,z} = 0$, (b) For $m_\ell = 0$ we get $U_\ell = 0$, (c) For $m_\ell = -2$ we get $L_z = 2.1 \times 10^{-34}$ J·s, $\mu_{\ell,z} = 1.85 \times 10^{-23}$ J/T, $U_\ell = -7.42 \times 10^{-24}$ J

(36) $U_s = \pm 4.635 \times 10^{-24}$ J, $\Delta U_s = 9.27 \times 10^{-24}$ J

(37) 6.489×10^{-22} J = 4.056×10^{-3} eV

(38) 1.105×10^{2} A/m along the disk axis, 1.192×10^{27} atoms

(39) (a) $\vec{\mu}_{\text{Before}} = 0$, $\vec{\mu}_{\text{After}}$ is out of page, (b) Counterclockwise, (c) Into of the page

(40) -5×10^{-5}

(41) (a) 1.8×10^{3} A/m, 2.2619467 mT, 0.452 389 34 μWb, (b) 3.6×10^{-3} A/m, 2.2619422 mT, 0.452 388 44 μWb

(42) (a) 4×10^{3} A/m, 5.026548 m T (b) 9.2×10^{-2} A/m, 5.026663 m T,

(43) 2.72×10^{-1} A/m, 5.026890 mT

(44) 5.58×10^{5} A/m, 0.7 T

(45) (a) 1.6×10^{6} A/m, (b) 15.98 A.m^2, (c) 8 m.N

(46) 2.64 T

(47) 2×10^{-4} T.m/A = 159.2 $\mu_\circ$

Chapter 27

(1) (a) 0.06 Wb, (b) 64.6°

(2) 0.12 V, 0.08 A

(3) As the south pole of the magnet is pushed into the loop, the magnetic flux *increases out* of the right face of the loop. To oppose this increase, the flux produced by the induced current must be *into* the right face of the loop, so the induced current must be from *right* to *left* in the resistor

(4) As the north pole of the magnet recedes from the loop, the magnetic flux *decreases into* the left face of the loop. To oppose this decrease, the flux produced by the induced current must be *into* the left face of the loop, so the induced current must be from *left* to *right* in the resistor

(5) −200 V

(6) Clockwise for the inside loop and Counterclockwise for the outside loop

(7) 1.57×10^{-2} V

(8) 0.005 V

(9) (a) $(0.8 - 10^{-3}t)$ (T), (b) $\pi \times 10^{-5}$ V

(10) (a) Clockwise, (b) counterclockwise, (c) counterclockwise, (d) clockwise, (e) counterclockwise, (f) clockwise, (g) clockwise when Φ_B decreases and counterclockwise when Φ_B increases, (h) no induced current

(11) (a) Clockwise, (b) 4.91×10^{-2} V, (c) 2.5×10^{-2} A

(12) (a) Clockwise, (b) 3.47×10^{-1} V, (c) 2.31×10^{-1} A

(13) (a) Clockwise, (b) 0.94 mV, (c) 0.38 mA

(14) (a) Opposite to the solenoid's current, (b) 0.2 mV, (c) 51 μA, (d) Opposite to the solenoid's new current, 0.2 V, 51 mA

(15) (a) 5.89 mV, (b) 23.1 mJ, (c) 8.97×10^{-3} °C

(16) (a) 8.011×10^{-3} V, (b) $4.48 \times 10^{-2}\ \Omega$, (c) 178.8 mA, (d) 1.43×10^{-3} W

(17) (a) 235.6 mV, (b) 1.04×10^{-4} J,

(18) (a) $\Phi_B = \mu_\circ I\, b\, \mathrm{In}(1 + x/a)/2\pi$, (b) $\varepsilon = \mu_\circ I\, b\, v/[2\pi(x+a)]$, $F = \{\mu_\circ I\, b\, v/[2\pi(x+a)]\}^2/(Rv)$

(19) 0.18 V

(20) 0.5 T

(21) 0.6 V

(22) (a) 3.75 V, (b) 140.6 mN, (c) 1.406 W

(23) (a) $I = BLvA_{\mathrm{rod}}/[2(vt + L)\rho]$, (b) $P = B^2L^2v^2A_{\mathrm{rod}}/[2(vt + L)\rho]$

(24) $v_t = m\, g\, R/B^2L^2 = 0.33$ m/s

(25) (a) $B\, L\, g\ \sin\theta \cos\theta\, t$, (b) The near side has a higher potential

(26) $v = (\varepsilon_\circ/BL)[1 - e^{-(B^2L^2/mR)t}]$, $v_t = \varepsilon_\circ/BL$

(27) 30 V

(28) 311 V

(29) 198 turns

(30) 4.4 rev/s

(31) 0.156 A

(32) 3.536 A, 5 A

(33) (a) 302.5 Ω, (b) 806.7 Ω for the 60-W bulb and 484 Ω for the 100-W bulb

(34) 110 V

(35) 155.6 V, 14.14 A

(36) (a) 2200 W, (b) 0 and 4400 W

(37) (a) Step-down, (b) 0.12, 8.3

(38) 46

(39) (a) Step-down, (b) 2.7

(40) $R_{\mathrm{eq}} = (N_P/N_S)^2\ R$

(41) (a) 55.6 kV, (b) 88.96 MW, 10.1%

(42) 5×10^{-9} N down

(43) 10^{-9} N up

(44) 6.283×10^{-6} N/C

(45) (a) $\pi r^2 dB/dt$, $r < R$, (b) $\frac{1}{2} r dB/dt$, $r < R$, (c) $\frac{1}{2}(R^2/r) dB/dt$, $r < R$, (d) $\pi r^2 dB/dt$, $r < R$, (e) $\pi R^2 dB/dt$, $r = R$, $\pi R^2 dB/dt$, $r > R$

Chapter 28

(1) 1.5 V
(2) 1 H
(3) 25 mH
(4) 12.57 mH
(5) 892 turns
(6) 23 turns
(7) (a) 157.1 mH, (b) 10.2 V
(8) (a) 10 V, (b) 8 mH, (C) 0.1 J
(9) (a) 63.33 cm, (b) 795.8 m, (c) 68.1 Ω
(10) (a) (3/10) H (when in series), (b) (2/30) H (when in parallel)
(11) 2.5 mH
(12) 1.2 V
(13) 20 mH
(14) (a) 105.6 mH, (b) 26.39 V
(15) (a) 17.5 mH, (b) 1 mH, (c) −0.25 V
(16) $L_{\text{eq}} = L_1 + L_2 + M_{\text{s}}$, $L_{\text{eq}} = (L_1 L_2 - M_{\text{p}})/(L_1 + L_2 - 2M_{\text{p}})$
(17) (a) 1.592×10^4 J/m^3, (b) 318 mJ
(18) 112.5 mJ
(19) 9.43 μ J
(20) (a) $u_B \simeq 1.6 \times 10^6$ J/m^3, $u_E \simeq 4.4 \times 10^{-4}$ J/m^3, (b) $E = 6 \times 10^8$ N/C =200 $E_{\text{breakdown}}$
(21) 320 V
(22) 174.5 μ J
(24) (a) 2.25 H, (b) 180 mJ, (c) 1.2 T, (d) 3819 A/m, (e) 573 kJ/m^3
(25) (a) 0.11 τ, (b) 0.69 τ, (c) 2.3 τ
(26) (a) 2.15 s, (b) 4 A
(27) 20 μs, (b) 92.1 μs, (c) 6 mA
(28) (a) 2.49 s, (b) 20.1 Ω
(29) (a) 300, (b) 16 Ω, 80 mH
(30) (a) $\varepsilon_L(t) = -\varepsilon \exp(-t/\tau)$, (b) $P_{\text{output}}(t) = (\varepsilon^2/R)[1 - \exp(-t/\tau)]$, (c) $P_{\text{diss}}(t) = (\varepsilon^2/R)[1 - \exp(-t/\tau)]^2$, (d) $dU_B(t)/dt = (\varepsilon^2/R)[1 - \exp(-t/\tau)]\exp(-t/\tau)$, (e) $-0.368\,\varepsilon$, $0.632\,(\varepsilon^2/R)$, $0.3996\,(\varepsilon^2/R)$, $0.2326\,(\varepsilon^2/R)$
(31) (a) $I_1 = I_2 = 1.2$A, $I_3 = 0$, (b) $I_1 = 2$ A, $I_2 = 2/3$ A, $I_3 = 4/3$ A, (c) $I_1 = 0$, $I_2 = -2.25$A, $I_3 = -2.25$A, (d) $I_1 = I_2 = I_3 = 0$

(32) (a) $\varepsilon_L(t) = +(9V)\exp(-[10^{-5}\,\mathrm{s}^{-1}]t)$, (b) 9 V, 0

(33) 12.7 μH

(34) (a) 79.6 Hz, (b) 0.2A, (c) (0.2 A) $\sin[(500\,\mathrm{s}^{-1})t]$ (d) 10^{-2} J

(35) 1.59 mH, 15.92 μF

(36) (a) 0.35 nF, (b) 75.1 μH

(37) 0.5 A

(38) Yes, the circuit oscillates with frequency 2236 Hz

(39) (a) $R_c = 2\,\Omega$, and the circuit will oscillate since $R < R_c$, (b) 95.5 Hz (c) 5.236 ms, 1.5 %, (d) 1.73 Ω

(40) $8.163 \times 10^{-3}\,\Omega$

(41) 0.248 H, 25.6 nF

(42) (a) 311 V, (b) $v = (311\,\mathrm{V})\sin(100\,\pi t)$

(43) (a) 110 V, (b) 5.5 A, (c) 50 cycle/s

(44) (a) 110 A, (b) 0.58 A

(45) (a) zero, (b) 82.9 mA

(46) 10 Ω, 22 A

(47) 2.21 kHz

(48) (a) 4.375 kΩ, (b) 5.029×10^{-2} A, (c) $-46.7°$ (The current leads the source voltage by 46.7°), (d) 7.587 W, (e) 150.9 V, 160.08 V

(49) (a) 50 Hz, (b) The voltages across the resistor and across the capacitor are not in phase, the rms voltage across the source will not be the sum of their rms voltages

(50) (a) 10 Ω, (b) 11 A, (c) 88 V, 99 V, 33 V

(51) (a) 23.9 mH, 884 μF, (b) 0.8, (c) 968 W

(52) (a) 37.7 Ω, 4.1 Ω, 48.5 Ω, (b) 2.267 A, 3.206 A, (c) 112.2 V, 120.9 V, 13.1 V, $v_R = (112.2\,\mathrm{V})\sin(377\,t)$, $v_L = (120.9\,\mathrm{V})\sin(377\,t + \pi/2)$, $v_C = (13.1\,\mathrm{V})\sin(377\,t - \pi/2)$, 79.3 V, 85.5 V, 9.3V, (d) 43.8°, 179.9 W

(54) (a) 2.639 nF, (b) 37.5 mA

(55) (a) 1508 Ω, 1508 Ω, (b) 5.63 W

(56) (a) 456.4 rad/s, (b) 73.03 Ω, 73.03 Ω, 20 Ω (c) 0, 12.5 A, (d) 250 V, 913 V, 913 V

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