(h) **Solve:** $8m - (2m - 3) = 3(m - 4)$

$8m - 2m + 3 = 3(m - 4)$ — Change signs to remove parentheses on the left.

$8m - 2m + 3 = 3m - 12$ — Multiply by 3 to remove parentheses on the right.

$6m + 3 = 3m - 12$ — Combine like terms.

$6m + 3 - 3m = 3m - 12 - 3m$ — Subtract $3m$ from both sides.

$3m + 3 = -12$

$3m + 3 - 3 = -12 - 3$ — Subtract 3 from both sides.

$3m = -15$

$\frac{3m}{3} = \frac{-15}{3}$ — Divide by 3.

$m = -5$ Solution

Check the solution.

(i) **Solve:** $3 - (5x - 8) = 6x + 22$ — Remove parentheses by changing the signs of both terms.

$3 - 5x + 8 = 6x + 22$

$11 - 5x = 6x + 22$ — Combine terms.

$11 - 5x - 6x = 6x + 22 - 6x$ — Subtract $6x$ from both sides.

$11 - 11x = 22$ — Combine terms.

$11 - 11x - 11 = 22 - 11$ — Subtract 11 from both sides.

$-11x = 11$ — Divide by -11.

$x = -1$ Solution

Check it.

(j) **Solve:** $-2(3x - 5) = 7 - 5(2x + 3)$ — Remove parentheses. Multiply each term inside parentheses on the left by -2. Multiply each term inside parentheses on the right by -5 (leave the 7 alone!).

$-6x + 10 = 7 - 10x - 15$

$-6x + 10 = -8 - 10x$ — Combine terms.

$-6x + 10 + 10x = -8 - 10x + 10x$ — Add $10x$ to both sides.

$4x + 10 = -8$ — Combine terms.

$4x + 10 - 10 = -8 - 10$ — Subtract 10 from both sides.

$4x = -18$ — Divide by 4.

$x = -4.5$ Solution

Check it.

Remember:

1. Do only legal operations: add or subtract the same quantity from both sides of the equation; multiply or divide both sides of the equation by the same nonzero quantity.

Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition*, Pearson, 2005.

2. Remove all parentheses carefully.
3. Combine like terms when they are on the same side of the equation.
4. Use legal operations to change the equation so that you have only x by itself on one side of the equation and a number on the other side of the equation.
5. Always check your answer.

Solving Formulas

To *solve a formula* for some letter means to rewrite the formula as an equivalent formula with that letter isolated on the left of the equals sign.

For example, the area of a triangle is given by the formula

$A = \frac{BH}{2}$ where A is the area, B is the length of the base, and H is the height.

Solving for the base B gives the equivalent formula

$$B = \frac{2A}{H}$$

Solving for the height H gives the equivalent formula

$$H = \frac{2A}{B}$$

Solving formulas is a very important practical application of algebra. Very often a formula is not written in the form that is most useful. To use it you may need to rewrite the formula, solving it for the letter whose value you need to calculate.

To solve a formula, use the same balancing operations that you used to solve equations. You may add or subtract the same quantity on both sides of the formula and you may multiply or divide both sides of the formula by the same nonzero quantity.

EXAMPLE

To solve the formula

$S = \frac{R+P}{2}$ for R

First, multiply both sides of the equation by 2.

$$2 \cdot S = 2 \cdot \left(\frac{R+P}{2}\right)$$

$$2S = R + P$$

Second, subtract P from both sides of the equation.

$$2S - P = R + \underbrace{P - P}_{0}$$

$$2S - P = R$$

This formula can be reversed to read

$R = 2S - P$ We have solved the formula for R.

Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition*, Pearson, 2005.

YOUR TURN

Solve the following formulas for the variable indicated.

(a) $V = \frac{3K}{T}$ for K

(b) $Q = 1 - R + T$ for R

(c) $V = \pi R^2 H - AB$ for H

(d) $P = \frac{T}{A - B}$ for A

SOLUTIONS

(a) $V = \frac{3K}{T}$

First, multiply both sides by T to get $VT = 3K$

Second, divide both sides by 3 to get $\frac{VT}{3} = K$

Solved for K, the formula is $K = \frac{VT}{3}$

(b) $Q = 1 - R + T$

First, subtract T from both sides to get $Q - T = 1 - R$

Second, subtract 1 from both sides to get $Q - T - 1 = -R$

This is equivalent to $-R = Q - T - 1$

or $R = -Q + T + 1$

We have multiplied *all terms by* −1.

or $R = 1 - Q + T$

(c) $V = \pi R^2 H - AB$

First, add AB to both sides to get $V + AB = \pi R^2 H$

Second, divide both sides by πR^2 to get $\frac{V + AB}{\pi R^2} = H$

Notice that we divide *all* of the left side by πR^2

Solved for H, the formula is $H = \frac{V + AB}{\pi R^2}$

(d) $P = \frac{T}{A - B}$

First, multiply each side by $A - B$ to get $P(A - B) = T$

Second, multiply to remove the parentheses $PA - PB = T$

Next, add PB to each side $PA = T + PB$

Finally, divide each side by P $A = \frac{T + PB}{P}$

Solved for A, the formula is $A = \frac{T + PB}{P}$

Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition,* Pearson, 2005.

Careful ▶ Remember, when using the multiplication/division rule, you must multiply or divide *all* of both sides of the formula by the same quantity. ◀

PROBLEMS

Practice solving formulas with the following problems.

Solve:

(a) $P = 2A + 3B$ for A

(b) $E = MC^2$ for M

(c) $S = \dfrac{A - RT}{1 - R}$ for A

(d) $S = \dfrac{1}{2}gt^2$ for g

(e) $P = i^2R$ for R

(f) $I = \dfrac{V}{R + a}$ for R

(g) $A = \dfrac{2V - W}{R}$ for V

(h) $F = \dfrac{9C}{5} + 32$ for C

(i) $A = \dfrac{\pi R^2 S}{360}$ for S

(j) $P = \dfrac{t^2 dN}{3.78}$ for d

(k) $C = \dfrac{AD}{A + 12}$ for D

(l) $V = \dfrac{\pi LT^2}{6} + 2$ for L

ANSWERS

(a) $A = \dfrac{P - 3B}{2}$

(b) $M = \dfrac{E}{C^2}$

(c) $A = S - SR + RT$

(d) $g = \dfrac{2S}{t^2}$

(e) $R = \dfrac{P}{i^2}$

(f) $R = \dfrac{V - aI}{I}$

(g) $V = \dfrac{AR + W}{2}$

(h) $C = \dfrac{5F - 160}{9}$

(i) $S = \dfrac{360A}{\pi R^2}$

(j) $d = \dfrac{3.78P}{t^2 N}$

(k) $D = \dfrac{CA + 12C}{A}$

(l) $L = \dfrac{6V - 12}{\pi T^2}$

USING SQUARE ROOTS IN SOLVING EQUATIONS

The equations you learned to solve in this chapter are all *linear* equations. The variable appears only to the first power—no x^2 or x^3 terms appear in the equations. You will learn how to solve more difficult algebraic equations later, but equations that look like

$x^2 = a$ where a is some positive number

can be solved easily.

Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition*, Pearson, 2005.

To solve such an equation, simply take the square root of each side of the equation. The solution can be either

$x = \sqrt{a}$ or $x = -\sqrt{a}$

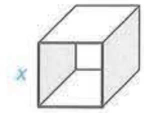
Example: Solve $x^2 = 36$.

Taking square roots, we have $x = +6$ or $x = -6$.
There are two possible solutions, one negative and one positive. Be careful, one of them, usually the negative one, may not be a reasonable answer to a practical problem.

Example: If the cross-sectional area of a square heating duct is 75 sq in., what must be the width of the duct?

Solve $x^2 = 75$.

Taking the square root of each side, we obtain the positive solution



$x = \sqrt{75}$

$x \approx 8.7$ in. rounded

75 $\boxed{\sqrt{}}$ → 8.660254038

If you need to review the concept of square roots, return to Section 6-4 on page 315.

We will look at more problems like this in a later chapter.

Now turn to Exercises 7-5 for a set of practice problems on solving equations and formulas.

Exercises 7-5

Solving More Equations and Formulas

A. Solve the following equations.

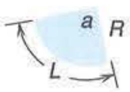
1. $5(x - 3) = 30$
2. $22 = -2(y + 6)$
3. $3(2n + 4) = 41$
4. $-6(3a - 7) = 21$
5. $2 - (x - 5) = 14$
6. $24 = 5 - (3 - 2m)$
7. $6 + 2(y - 4) = 13$
8. $7 - 11(2z + 3) = 18$
9. $8 = 5 - 3(3x - 4)$
10. $7 + 9(2w + 3) = 25$
11. $6c - (c - 4) = 29$
12. $9 = 4y - (y - 2)$
13. $5x - 3(2x - 8) = 31$
14. $6a + 2(a + 7) = 8$
15. $9t - 3 = 4t - 2$
16. $7y + 5 = 3y + 11$
17. $12x = 4x - 16$
18. $22n = 16n - 18$
19. $8y - 25 = 13 - 11y$
20. $6 - 2p = 14 - 4p$
21. $9x = 30 - 6x$
22. $12 - y = y$
23. $2(3t - 4) = 10t + 7$
24. $5A = 4(2 - A)$
25. $2 - (3x - 20) = 4(x - 2)$
26. $2(2x - 5) = 6x - (5 - x)$
27. $8 + 3(6 - 5x) = 11 - 10x$
28. $2(x - 5) - 3(2x - 8) = 16 - 6(4x - 3)$

Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition*, Pearson, 2005.

B. Solve the following formulas for the variable shown.

1. $S = LW$ for L
2. $A = \frac{1}{2}BH$ for B
3. $V = IR$ for I
4. $H = \frac{D - R}{2}$ for D
5. $S = \frac{W}{2}(A + T)$ for T
6. $V = \pi R^2 H$ for H
7. $P = 2A + 2B$ for B
8. $H = \frac{R}{2} + 0.05$ for R
9. $T = \frac{RP}{R + 2}$ for P
10. $I = \frac{E + V}{R}$ for V

C. Practical Problems



Problem 1

1. **Sheet-Metal Technology** The length of arc of a sector of a circle is given by the formula

$$L = \frac{2\pi Ra}{360}$$

R is the radius of the circle and a is the central angle in degrees.

(a) Solve for a. (b) Solve for R.

(c) Find L when $R = 250$ mm and $a = 30°$. Use $\pi \approx 3.14$.

2. **Sheet-Metal Technology** The area of the sector shown in problem 1 is $A = \pi R^2 a/360$.

(a) Solve this formula for a.

(b) Find A if $R = 305$ mm, $a = 45°$, $\pi \approx 3.14$. Round to three significant digits.

3. **Electronics** When two resistors R_1 and R_2 are put in series with a battery giving V volts, the current through the resistors is

$$i = \frac{V}{R_1 + R_2}$$

(a) Solve for R_1.

(b) Find R_2 if $V = 100$ V, $i = 0.4$ A, $R_1 = 200$ ohms.

4. **Machine Technology** Machinists use a formula known as Pomeroy's formula to determine roughly the power required by a metal punch machine.

$$P \approx \frac{t^2 dN}{3.78}$$

where P = power needed, in horsepower
t = thickness of the metal being punched
d = diameter of the hole being punched
N = number of holes to be punched at one time

(a) Solve this formula for N.

Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition*, Pearson, 2005.

(b) Find the power needed to punch six 2-in.-diameter holes in a sheet $\frac{1}{8}$ in. thick. Round to one significant digit.

5. **Marine Technology** When a gas is kept at constant temperature and the pressure on it is changed, its volume changes in accord with the pressure–volume relationship known as Boyle's law:

$$\frac{V_1}{V_2} = \frac{P_2}{P_1}$$

where P_1 and V_1 are the beginning volume and pressure, and P_2 and V_2 are the final volume and pressure.

(a) Solve for V_1. (b) Solve for V_2.

(c) Solve for P_1. (d) Solve for P_2.

(e) Find P_1 when $V_1 = 10$ L, $V_2 = 25$ L, and $P_2 = 120$ kPa.

6. The volume of a football is roughly $V = \pi LT^2/6$, where L is its length and T is its thickness.

(a) Solve for L.

(b) Solve for T^2.

7. **Medical Technology** Nurses use a formula known as Young's rule to determine the amount of medicine to give a child under 12 years of age when the adult dosage is known.

$$C = \frac{AD}{A + 12}$$

C is the child's dose; A is the age of the child in years; D is the adult dose.

(a) Work backward and find the adult dose in terms of the child's dose. Solve for D.

(b) Find D if $C = 0.05$ g and $A = 7$.

8. **Carpentry** The projection or width P of a protective overhang of a roof is determined by the height T of the window, the height H of the header above the window, and a factor F that depends on the latitude of the construction site.

$$P = \frac{T + H}{F}$$ Solve this equation for the header height H.

9. **Electronics** For a current transformer, $\frac{i_L}{i_S} = \frac{T_P}{T_S}$

where i_L = line current
i_S = secondary current
T_P = number of turns of wire in the primary coil
T_S = number of turns of wire in the secondary coil

(a) Solve for i_L.

(b) Solve for i_S.

(c) Find i_L when $i_S = 1.5$ A, $T_P = 1500$, $T_S = 100$.

10. **Electronics** The electrical power P dissipated in a circuit is equal to the product of the current I and the voltage V, where P is in watts, I is in amperes, and V is in volts.

(a) Write an equation giving P in terms of I and V.

Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition*, Pearson, 2005.

(b) Solve for I.

(c) Find V when $P = 15{,}750$ W, $I = 42$ A.

11. **Electronics** The inductance L in microhenrys of a coil constructed by a ham radio operator is given by the formula

$$L = \frac{R^2N^2}{9R + 10D}$$

where R = radius of the coil
D = length of the coil
N = number of turns of wire in the coil

Find L if $R = 3$ in., $D = 6$ in., $N = 200$.

12. **Sheet-Metal Technology** A sheet metal technician uses the following formula for calculating bend allowance, BA:

$$BA = N(0.01743R + 0.0078T)$$

where N = number of degrees in the bend
R = inside radius of the bend
T = thickness of the metal

Find BA for each of the following situations. (You'll want to use a calculator on this one.)

	N	R	T
(a)	50°	$1\frac{1}{4}$ in.	0.050 in.
(b)	65°	22 mm	0.4 mm
(c)	40°	26 mm	0.9 mm

13. **Machinist** Suppose that, on the average, 3% of the parts produced by a particular machine have proven to be defective. Then the formula

$$N - 0.03N = P$$

will give the number of parts N that must be produced in order to manufacture a total of P nondefective ones. How many parts should be produced by this machine in order to end up with 7500 nondefective ones?

14. **Office Services** The formula

$$A = P(1 + rt)$$

is used to find the total amount A of money in an account when an original amount or principal P is invested at a rate of simple interest r for t years. How long would it take \$8000 to grow to \$10,000 at 8% simple interest?

15. **Civil Engineer** The formula

$$I = 0.000014L(T - t)$$

gives the expansion I of a particular highway of length L at a temperature of T degrees Fahrenheit. The variable t stands for the temperature at which the highway was built. If a 2-mile stretch of highway was built at an average temperature of 60°F, what is the maximum temperature it can withstand if expansion joints allow for 7.5 ft of expansion? (*Hint:* The units of L must be the same as the units of I.)

Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition*, Pearson, 2005.

We can solve a formula for a particular symbol just as we solve any equation. That is,
NOTE ▸ we *isolate the required symbol by using algebraic operations on literal numbers.*

EXAMPLE 1 Solving for symbol in formula

In Einstein's formula $E = mc^2$, solve for m.

$$\frac{E}{c^2} = m \quad \text{divide both sides by } c^2$$

$$m = \frac{E}{c^2} \quad \text{switch sides to place } m \text{ at left}$$

The required symbol is usually placed on the left, as shown. ■

EXAMPLE 2 Symbol with subscript in formula

A formula relating acceleration a, velocity v, initial velocity v_0, and time is $v = v_0 + at$. Solve for t.

■ The subscript $_0$ makes v_0 a different literal symbol from v. (We have used subscripts in a few of the earlier exercises.)

$$v - v_0 = at \quad v_0 \text{ subtracted from both sides}$$

$$t = \frac{v - v_0}{a} \quad \text{both sides divided by } a \text{ and then sides switched}$$ ■

EXAMPLE 3 Symbol in capital and in lower case

In the study of the forces on a certain beam, the equation $W = \dfrac{L(wL + 2P)}{8}$ is used. Solve for P.

■ Be careful! Just as subscripts can indicate different literal numbers, a capital letter and the same letter in lowercase are different literal numbers. In this example, W and w are different. This is shown in several of the exercises for this section.

$$8W = \frac{8L(wL + 2P)}{8} \quad \text{multiply both sides by 8}$$

$$8W = L(wL + 2P) \quad \text{simplify right side}$$

$$8W = wL^2 + 2LP \quad \text{remove parentheses}$$

$$8W - wL^2 = 2LP \quad \text{subtract } wL^2 \text{ from both sides}$$

$$P = \frac{8W - wL^2}{2L} \quad \text{divide both sides by } 2L \text{ and switch sides}$$ ■

EXAMPLE 4 Formula with groupings

The effect of temperature upon measurements is important when measurements must be made with great accuracy. The volume V of a special precision container at temperature T in terms of the volume V_0 at temperature T_0 is given by $V = V_0[1 + b(T - T_0)]$, where b depends on the material of which the container is made. Solve for T.

Since we are to solve for T, we must isolate the term containing T. This can be done by first removing the grouping symbols.

$$V = V_0[1 + b(T - T_0)] \quad \text{original equation}$$

$$V = V_0[1 + bT - bT_0] \quad \text{remove parentheses}$$

$$V = V_0 + bTV_0 - bT_0V_0 \quad \text{remove brackets}$$

$$V - V_0 + bT_0V_0 = bTV_0 \quad \text{subtract } V_0 \text{ and add } bT_0V_0 \text{ to both sides}$$

$$T = \frac{V - V_0 + bT_0V_0}{bV_0} \quad \text{divide both sides by } bV_0 \text{ and switch sides}$$ ■

Practice Exercises

Solve for the indicated letter. Each comes from the indicated area of study.

1. $\theta = kA + \lambda$, for λ (robotics)
2. $P = n(p - c)$, for p (economics)

To determine the values of any literal number in an expression for which we know
NOTE ▸ values of the other literal numbers, we should *first solve for the required symbol and then evaluate.*

Allyn Washington, *Basic Technical Mathematics*, Pearson, 2009.

EXAMPLE 5 Solve for symbol before substituting

The electric resistance R (in Ω) of a resistor changes with the temperature T (in °C) according to $R = R_0 + R_0\alpha T$, where R_0 is the resistance at 0°C. For a given resistor, $R_0 = 712\ \Omega$ and $\alpha = 0.00455/°\text{C}$. Find the value of T for $R = 825\ \Omega$.

We first solve for T and then substitute the given values.

$$R = R_0 + R_0\alpha T$$
$$R - R_0 = R_0\alpha T$$
$$T = \frac{R - R_0}{\alpha R_0}$$

Now substituting, we have

$$T = \frac{825 - 712}{(0.00455)(712)}$$
$$= 34.9°\text{C} \quad \text{rounded off}$$

estimation: $\frac{800 - 700}{0.005(700)} = \frac{1}{0.035} = 30$

■

EXERCISES 1.11

In Exercises 1–4, solve for the given letter from the indicated example of this section.

1. For the formula in Example 2, solve for a.
2. For the formula in Example 3, solve for w.
3. For the formula in Example 4, solve for T_0.
4. For the formula in Example 5, solve for α. (Do not evaluate.)

In Exercises 5–40, each of the given formulas arises in the technical or scientific area of study shown. Solve for the indicated letter.

5. $E = IR$, for R (electricity)
6. $PV = nRT$, for T (chemistry)
7. $rL = g_2 - g_1$, for g_1 (surveying)
8. $W = S_dT - Q$, for Q (air conditioning)
9. $Q = SLd^2$, for L (machine design)
10. $P = 2\pi Tf$, for T (mechanics)
11. $p = p_a + dgh$, for h (hydrodynamics)
12. $2Q = 2I + A + S$, for I (nuclear physics)
13. $A = \frac{Rt}{PV}$, for t (jet engine design)
14. $u = -\frac{eL}{2m}$, for L (spectroscopy)
15. $ct^2 = 0.3t - ac$, for a (medical technology)
16. $2p + dv^2 = 2d(C - W)$, for C (fluid flow)
17. $T = \frac{c + d}{v}$, for d (traffic flow)
18. $L = \frac{N\Phi}{i}$, for Φ (electricity)
19. $\frac{K_1}{K_2} = \frac{m_1 + m_2}{m_1}$, for m_2 (kinetic energy)
20. $f = \frac{F}{d - F}$, for d (photography)
21. $a = \frac{2mg}{M + 2m}$, for M (pulleys)
22. $v = \frac{V(m + M)}{m}$, for M (ballistics)
23. $C_0^2 = C_1^2(1 + 2V)$, for V (electronics)
24. $A_1 = A(M + 1)$, for M (photography)
25. $N = r(A - s)$, for s (engineering)
26. $T = 3(T_2 - T_1)$, for T_1 (oil drilling)
27. $T_2 = T_1 - \frac{h}{100}$, for h (air temperature)
28. $p_2 = p_1 + rp_1(1 - p_1)$, for r (population growth)
29. $Q_1 = P(Q_2 - Q_1)$, for Q_2 (refrigeration)
30. $p - p_a = dg(y_2 - y_1)$, for y_2 (pressure gauges)
31. $N = N_1T - N_2(1 - T)$, for N_1 (machine design)
32. $t_a = t_c + (1 - h)t_m$, for h (computer access time)
33. $L = \pi(r_1 + r_2) + 2x_1 + x_2$, for r_1 (pulleys)
34. $I = \frac{VR_2 + VR_1(1 + \mu)}{R_1R_2}$, for μ (electronics)
35. $P = \frac{V_1(V_2 - V_1)}{gJ}$, for V_2 (jet engine power)
36. $W = T(S_1 - S_2) - Q$, for S_2 (refrigeration)
37. $C = \frac{2eAk_1k_2}{d(k_1 + k_2)}$, for e (electronics)

Allyn Washington, *Basic Technical Mathematics*, Pearson, 2009.

ANSWERS TO ODD-NUMBERED EXERCISES

Since statements will vary for writing exercises (W), answers here are in abbreviated form. Answers are not included for end-of-chapter writing exercises.

Exercises 1.1, page 5

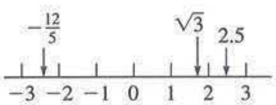
1. Change $\frac{5}{1}$ to $\frac{-3}{1}$ and $\frac{-19}{1}$ to $\frac{14}{1}$. **3.** Change $2 > -4$, 2 is to the right of -4, to $-6 < -4$, -6 is to the left of -4. Also the figure must be changed to show -6 to left of -4.

5. 3: integer, rational, real; $\sqrt{-4}$: imag.; $-\frac{\pi}{6}$: irrational, real

7. $3, 4, \frac{\pi}{2}$ **9.** $6 < 8$ **11.** $\pi > -3.2$ **13.** $-4 < -|-3|$

15. $-\frac{1}{3} > -\frac{1}{2}$ **17.** $\frac{1}{3}, -\frac{\sqrt{3}}{4}, \frac{b}{y}$

19.



21. No, $|0| = 0$

23. The number itself **25.** $\frac{3}{22}$ or $\frac{3}{23}$

27. $-3.1, -|-3|, -1, \sqrt{5}, \pi, |-8|, 9$

29. (a) Positive integer (b) Negative integer (c) Positive rational number less than 1

31. (a) Yes (b) Yes **33.** (a) To right of origin (b) To left of -4

35. Between 0 and 1 **37.** $a =$ any real number; $b = 0$

39. 0.0008 F **41.** $N = 1000an$

43. Yes; -20 is to right of -30

Exercises 1.2, page 10

1. 22 **3.** -4 **5.** 4 **7.** 6 **9.** -3 **11.** -24

13. 35 **15.** 20 **17.** 40 **19.** -1 **21.** -17

23. Undefined **25.** 20 **27.** 16 **29.** -9 **31.** 24

33. -6 **35.** 3 **37.** Commutative law of multiplication

39. Distributive law **41.** Associative law of addition

43. Associative law of multiplication **45.** d **47.** b

49. (a) Positive (b) Negative

51. Correct. (For $x > 0$, x is positive; for $x < 0$, $-x$ is positive.)

53. (a) Negative reciprocals of each other (b) They may not be equal.

55. -2.4 kW·h **57.** 2°C **59.** 10 V

61. 100 m + 200 m = 200 m + 100 m; commutative law of addition

63. 4(8 min + 6 min); distributive law

Exercises 1.3, page 15

1. 0.390 has 3 sig. digits; the zero is not needed for proper location of the decimal point.

3. 75.7 **5.** 8 is exact; 55 is approx. **7.** 24 and 1440 are exact

9. 3, 4 **11.** 3, 3 **13.** 1, 5 **15.** (a) 0.01 (b) 30.8

17. (a) Same (b) 78.0 **19.** (a) 0.004 (b) Same

21. (a) 4.94 (b) 4.9 **23.** (a) 50,900 (b) 51,000

25. (a) 9550 (b) 9500 **27.** (a) 0.945 (b) 0.94

29. (a) 12 (b) 12.20 **31.** (a) 0.015 (b) 0.0114

33. (a) 0.1 (b) 0.1356 **35.** (a) 6.5 (b) 6.086

37. 15.8788 **39.** 204.2 **41.** 2.745 MHz, 2.755 MHz

43. Too many sig. digits; time has only 2 sig. digits

45. (a) 19.3 (b) 27 **47.** (a) 2 (b) 2 (c) -2 (d) 0 (e) Undefined

49. Example: $(456789 - 987654) \div 9 = -58985$; integer

51. (a) $3.1416 > \pi$; (b) $22/7 > \pi$

53. (a) $\frac{1}{3} = 0.33333333\ldots$ (b) $\frac{5}{11} = 0.4545454545\ldots$ (c) $\frac{2}{5} = 0.400000000$ (0 repeats)

55. 95.3 MJ **57.** 262,144 bytes **59.** 59.14%

Exercises 1.4, page 20

1. x^6 **3.** $\frac{a^6x^2}{b^4t^2}$ **5.** x^7 **7.** $2b^6$ **9.** m^2 **11.** $\frac{1}{7n^4}$

13. P^8 **15.** $8\pi^3$ **17.** $a^{30}T^{60}$ **19.** $\frac{8}{b^3}$ **21.** $\frac{x^8}{16}$

23. 1 **25.** -3 **27.** $\frac{1}{6}$ **29.** R^2 **31.** $-t^{14}$

33. $\frac{1}{64v^{12}}$ **35.** $-L^2$ **37.** $\frac{1}{8}$ **39.** 1 **41.** $\frac{a}{x^2}$

43. $\frac{64s^6}{g^2}$ **45.** $\frac{x^3}{64a^3}$ **47.** $\frac{5n^3}{T}$ **49.** -53 **51.** 253

53. -0.421 **55.** 9990 **57.** Yes **59.** 625 **61.** 1

63. $\frac{G^2k^5T^5}{h}$ **65.** $\frac{r}{6}$ **67.** \$3212.27

Exercises 1.5, page 23

1. 8060 **3.** 45,000 **5.** 0.00201 **7.** 3.23

9. 18.6 **11.** 4×10^3 **13.** 8.7×10^{-3} **15.** 6.09×10^0

17. 6.3×10^{-2} **19.** 1×10^0 **21.** 5.6×10^{13}

23. 2.2×10^8 **25.** 3.2×10^{-34} **27.** 1.728×10^{87}

29. 4.85×10^{10} **31.** 1.59×10^7 **33.** 9.965×10^{-3}

35. 3.38×10^{16} **37.** 6.5×10^6 kW **39.** 3×10^{-6} W

41. 2×10^9 Hz **43.** 0.0000000000016 W

45. (a) 2.3×10^3 (b) 230×10^{-3} (c) 23×10^0

47. (a) 1×10^{100} (b) $10^{10^{100}}$ **49.** 4.2×10^{-8} s

51. 2.46×10^{-1} s **53.** 3.32×10^{-18} kg **55.** 3.433 Ω

Exercises 1.6, page 25

1. -4 **3.** 12 **5.** 9 **7.** -11 **9.** -7 **11.** 0.3

13. 5 **15.** -6 **17.** 5 **19.** 47 **21.** 53 **23.** $20\sqrt{3}$

25. $4\sqrt{21}$ **27.** $2\sqrt{5}$ **29.** 4 **31.** 7 **33.** 10

35. $3\sqrt{10}$ **37.** 9.24 **39.** 0.6877 **41.** (a) 60 (b) 84

43. (a) 0.0388 (b) 0.0246 **45.** 60 mi/h **47.** 1450 m/s

Allyn Washington, *Basic Technical Mathematics*, Pearson, 2009.

49. 42.0 in. **51.** no, not true if $a < 0$
53. (a) 12.9 (b) −0.598 **55.** (a) Imag. (b) Real

Exercises 1.7, page 29

1. $3x - 3y$ **3.** $4ax + 5s$ **5.** $8x$ **7.** $y + 4x$
9. $5F - 3T - 2$ **11.** $-a^2b - a^2b^2$ **13.** $3s - 4$
15. $5x - v - 4$ **17.** $5a - 5$ **19.** $-5a + 2$
21. $-2t + 5u$ **23.** $7r + 8s$ **25.** $-50 + 19j$
27. $-9 + 3n$ **29.** $18 - 2t^2$ **31.** $6a$ **33.** $2aZ + 1$
35. $4c - 6$ **37.** $8p - 5q$ **39.** $-4x^2 + 22$ **41.** $7V^2 - 3$
43. $-6t + 13$ **45.** $4Z - 24R$ **47.** $2D + d$
49. $3B - 2\alpha$ **51.** $40x + 250$
53. (a) $x^2 + 2y + 2a - b$ (b) $3x^2 - 4y + 2a + b$
55. Yes; $|a - b| = |-(b - a)| = |b - a|$

Exercises 1.8, page 31

1. $-8s^8t^{13}$ **3.** $x^2 - 5x + 6$ **5.** a^3x **7.** $-a^2c^3x^3$
9. $-8a^3x^5$ **11.** $i^2R + 2i^2r$ **13.** $-3s^3 + 15st$
15. $5m^3n + 15m^2n$ **17.** $-3M^2 - 3MN + 6M$
19. $acx^4 + acx^3y^3$ **21.** $x^2 + 2x - 15$ **23.** $2x^2 + 9x - 5$
25. $6a^2 - 7ab + 2b^2$ **27.** $6s^2 + 11st - 35t^2$
29. $2x^3 + 5x^2 - 2x - 5$ **31.** $x^2 - 4xy + 4y^2 - 16$
33. $2a^2 - 16a - 18$ **35.** $18T^2 - 15T - 18$
37. $-2L^3 + 6L^2 + 8L$ **39.** $4x^2 - 20x + 25$
41. $x_1^2 + 6x_1x_2 + 9x_2^2$ **43.** $x^2y^2z^2 - 4xyz + 4$
45. $2x^2 + 32x + 128$ **47.** $-x^3 + 2x^2 + 5x - 6$
49. $6T^3 + 9T^2 - 6T$ **51.** (a) $49 \neq 9 + 16$ (b) $1 \neq 9 - 16$
53. $n^2 - 1 = (n - 1)(n + 1)$ for any n
55. $(x + y)^3 = x^3 + 3x^2y + 3xy^2 + y^3$
57. $P + 0.02Pr + 0.0001Pr^2$ **59.** $3R^2 - 4RX$
61. $n^2 + 200n + 10{,}000$ **63.** $R_1^2 - R_2^2$

Exercises 1.9, page 34

1. $\frac{3}{y^3}$ **3.** $3x - 2$ **5.** $-4x^2y$ **7.** $\frac{4t^4}{r^2}$ **9.** $4x^2$
11. $-6a$ **13.** $a^2 + 2y$ **15.** $t - 2rt^2$ **17.** $q + 2p - 4q^3$
19. $\frac{2L}{R} - R$ **21.** $\frac{1}{3a} - \frac{2b}{3a} + 1$ **23.** $3y^n - 2ay$
25. $2x + 1$ **27.** $x - 1$ **29.** $4x^2 - x - 1, R = -3$
31. $Z - 2 - \frac{1}{4Z + 3}$ **33.** $x^2 + x - 6$ **35.** $2a^2 + 8$
37. $x^2 - 2x + 4$ **39.** $x - y$ **41.** $x - y + z$ **43.** -5
45. $\frac{x^4 + 1}{x + 1} = x^3 - x^2 + x - 1 + \frac{2}{x + 1}$
47. $A + \frac{\mu^2E^2}{2A} - \frac{\mu^4E^4}{8A^3}$ **49.** $\frac{GMm}{R}$
51. $s^2 + 2s + 6 + \frac{16s + 16}{s^2 - 2s - 2}$

Exercises 1.10, page 38

1. −9, −15, −36, −4 **3.** $\frac{1}{8}$ **5.** 9 **7.** −1 **9.** −10
11. −5 **13.** −3 **15.** 4 **17.** $-\frac{7}{2}$ **19.** 8
21. $\frac{10}{3}$ **23.** 2 **25.** −2.5 **27.** 0 **29.** 8
31. 9 or −9 **33.** 9.5 **35.** −2.1 **37.** 5.7 **39.** 0.85
41. (a) Identity (b) Conditional equation **43.** $x = 3.75$
45. 55 mi/h **47.** 120°C **49.** 750 gal **51.** 460 mi

Exercises 1.11, page 40

1. $\frac{v - v_0}{t}$ **3.** $\frac{V_0 + bTV_0 - V}{bV_0}$ **5.** $\frac{E}{I}$ **7.** $g_2 - rL$
9. $\frac{Q}{Sd^2}$ **11.** $\frac{p - p_a}{dg}$ **13.** $\frac{APV}{R}$ **15.** $\frac{0.3t - ct^2}{c}$
17. $Tv - c$ **19.** $\frac{K_1m_1 - K_2m_1}{K_2}$ **21.** $\frac{2mg - 2am}{a}$
23. $\frac{C_0^2 - C_1^2}{2C_1^2}$ **25.** $\frac{rA - N}{r}$ **27.** $100T_1 - 100T_2$
29. $\frac{Q_1 + PQ_1}{P}$ **31.** $\frac{N + N_2 - N_2T}{T}$
33. $\frac{L - \pi r_2 - 2x_1 - x_2}{\pi}$ **35.** $\frac{gJP + V_1^2}{V_1}$
37. $\frac{Cd(k_1 + k_2)}{2Ak_1k_2}$ **39.** $\frac{CN - NV}{C}$ **41.** 1040 K
43. 32.3°C **45.** 3.22 Ω **47.** $\frac{d - 4v_2 - 2v_1}{v_1}$

Exercises 1.12, page 44

1. 29 1.5-Ω resistors, 5 2.5-Ω resistors **3.** 3.000 h
5. \$22,000, \$27,000
7. 1.9 million the first year, 2.6 million the second year
9. 50 acres at \$200/acre, 90 acres at \$300/acre
11. 60 ppm/h **13.** 20 girders
15. −2.3 μA, −4.6 μA, 6.9 μA **17.** 6.9 km, 9.5 km
19. 32 CDs, 22 DVDs **21.** 900 m
23. 84.2 km/h, 92.2 km/h **25.** 390 s, first car
27. 64 mi from A **29.** 4 L **31.** 79 km/h

Review Exercises for Chapter 1, page 46

1. −10 **3.** −20 **5.** −22 **7.** −25 **9.** −4
11. 5 **13.** $4r^2t^4$ **15.** $-\frac{24t}{m^2n}$ **17.** $\frac{8T^3}{N}$ **19.** $3\sqrt{5}$
21. (a) 3 (b) 8800 **23.** (a) 4 (b) 9.0 **25.** 18.0
27. 1.3×10^{-4} **29.** $-a - 2ab$ **31.** $7LC - 3$
33. $2x^2 + 9x - 5$ **35.** $x^2 + 16x + 64$ **37.** $hk - 3h^2k^4$
39. $7R - 6r$ **41.** $13xy - 10z$ **43.** $2x^3 - x^2 - 7x - 3$
45. $-3x^2y + 24xy^2 - 48y^3$ **47.** $-9p^2 + 3pq + 18p^2q$
49. $\frac{6q}{p} - 2 + \frac{3q^4}{p^3}$ **51.** $2x - 5$ **53.** $x^2 - 2x + 3$

Allyn Washington, *Basic Technical Mathematics*, Pearson, 2009.

23. $V = 8580\ \text{mm}^3$ 24. $T = 39.3$ min
25. (a) $506.7087\ \text{mm}^2$ (b) 0.6013 sq in. (c) 13.3803 sq in. (d) $3.3345\ \text{cm}^2$
26. 79.84 ft 27. $6.5\ \text{m}^3$
28. (a) −8.5°C (b) −18.1°C or −0.6°F

Exercises 7–2, page 346

A.

1. $9y$	2. $9x^2y$	3. $6E$
4. $-4ax$	5. $7B$	6. 0
7. $-2x^2$	8. $10x + 16y$	9. $2R^2 + 5R$
10. $1.45A - 0.8A^2$	11. $\frac{1}{8}x$	12. $-2x$
13. $1\frac{1}{2} - 3.1W$	14. $q - 2\frac{1}{2}p$	15. $3x + 6xy$
16. $4ab$	17. $5x^2 + x^2y + 3x$	18. $4.6p + 0.3pq$

B.

1. $3x^2 + 2x - 5$	2. $6 - 3a + 8b$
3. $4m^2 + 10m$	4. $11x - 5x^2$
5. $2 - x - 5y$	6. $7x - 4 - 2y$
7. $3a - 8 + 6b$	8. $5 - w + 6z$
9. $-10x^2 - 3x$	10. $8m - 6n$
11. $23 - 3x$	12. $-3 - 5y$
13. $x + 8y$	14. $8 - 9m$
15. $-14 - 7w + 3z$	16. $-14x - 4y + 8$
17. $9x - 12y$	18. $20a + 24b$
19. $-56m - 48$	20. $-12x + 6$
21. $-9x - 15$	22. $-2y - 16$
23. $23m - 42$	24. $-19w + 15$
25. $3 - 8x - 12y$	26. $6 - 6a + 10b$
27. $28 - 6w$	28. $-75 - 55a$
29. $6x + 8y - 24x^2 + 20y^2$	30. $-20a + 24b + 14ab - 28b^2$
31. $4x + 10y$	32. $18w - 31z$
33. $3x + 9y$	34. $33x^2 + 6x$
35. $-2x^2 - 42x + 62$	36. $-10a - 18b + 44ab$

Exercises 7–3, page 354

A.

1. $x = 9$	2. $A = 17$	3. $x = -24$	4. $z = 47$
5. $a = 8\frac{1}{2}$	6. $x = -62$	7. $y = 24.66$	8. $R = 7.9$
9. $x = -13$	10. $y = -13$	11. $a = 0.006$	12. $x = 21$
13. $z = 0.65$	14. $N = \frac{3}{4}$	15. $m = -12$	16. $x = -27$
17. $y = 6.5$	18. $a = -36$	19. $T = -18$	20. $y = 36$
21. $Q = 0.7$	22. $Z = 10$	23. $x = 25$	24. $y = 24$
25. $K = 4.24$	26. $z = -0.3$		

B.

1. 360 V	2. 5.64 h or 5 h 38 min	3. 28.8 parts per million	4. 12.8 ft
5. 1.715 m	6. 18 psi	7. 21 windings	8. 2900 rpm

Exercises 7–4, page 362

A.

1. $x = 10$	2. $x = -1$	3. $x = 35$	4. $y = -2.5$
5. $m = 2.5$	6. $x = \frac{1}{6}$	7. $n = 10$	8. $a = 5$
9. $z = -6$	10. $q = 10$	11. $x = 48$	12. $m = -5.5$
13. $n = -9$	14. $y = 25$	15. $x = \frac{1}{4}$	16. $x = 10$
17. $a = 7$	18. $x = 14$	19. $z = -5\frac{1}{2}$	20. $x = -3$
21. $x = \frac{2}{5}$	22. $x = -24$	23. $P = 3$	24. $x = 8$
25. $x = 10$	26. $x = 6$	27. $x = 5\frac{1}{3}$	28. $x = -7$

 Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition*, Pearson, 2005.

B.	1.	4.5 hr	2.	22,000 ft	3.	32.5 years	4.	10%
	5.	5 mm	6.	6.5 mm	7.	31.75 h	8.	472 mm

Exercises 7–5, page 377

A.	1.	$x = 9$	2.	$y = -17$	3.	$n = 4\frac{5}{6}$	4.	$a = 1\frac{1}{6}$
	5.	$x = -7$	6.	$m = 11$	7.	$y = 7\frac{1}{2}$	8.	$z = -2$
	9.	$x = 1$	10.	$w = -\frac{1}{2}$	11.	$c = 5$	12.	$y = 2\frac{1}{3}$
	13.	$x = -7$	14.	$a = -\frac{3}{4}$	15.	$t = \frac{1}{5}$	16.	$y = 1\frac{1}{2}$
	17.	$x = -2$	18.	$n = -3$	19.	$y = 2$	20.	$p = 4$
	21.	$x = 2$	22.	$y = 6$	23.	$t = -3\frac{3}{4}$	24.	$A = \frac{8}{9}$
	25.	$x = 4\frac{2}{7}$	26.	$x = -1\frac{2}{3}$	27.	$x = 3$	28.	$x = 1$

B. 1. $L = \frac{S}{W}$ 2. $B = \frac{2A}{H}$ 3. $I = \frac{V}{R}$

4. $D = 2H + R$

5. $T = \frac{2S - WA}{W}$ 6. $H = \frac{V}{\pi R^2}$ 7. $B = \frac{P - 2A}{2}$

8. $R = 2H - 0.1$ 9. $P = \frac{T(R + 2)}{R}$ 10. $V = IR - E$

C. 1. (a) $a = \frac{360L}{2\pi R}$ (b) $R = \frac{360L}{2\pi a}$ (c) $L = 130.83$ mm

2. (a) $a = \frac{360A}{\pi R^2}$ (b) $A = 3650\text{ mm}^2$

3. (a) $R_1 = \frac{V - R_2 i}{i}$ (b) $R_2 = 50$ ohms

4. (a) $N = \frac{3.78P}{t^2 d}$ (b) $P = 0.05$ hp

5. (a) $V_1 = \frac{V_2 P_2}{P_1}$ (b) $V_2 = \frac{V_1 P_1}{P_2}$ (c) $P_1 = \frac{V_2 P_2}{V_1}$

(d) $P_2 = \frac{V_1 P_1}{V_2}$ (e) $P_1 = 300$ kPa

6. (a) $L = \frac{6V}{\pi T^2}$ (b) $T^2 = \frac{6V}{\pi L}$

7. (a) $D = \frac{CA + 12C}{A}$ (b) 0.14 g

8. $H = PF - T$

9. (a) $i_L = \frac{i_s T_p}{T_s}$ (b) $i_s = \frac{i_L T_s}{T_p}$ (c) $i_L = 22.5$ A

10. (a) $P = IV$ (b) $I = \frac{P}{V}$ (c) $V = 375$ V

11. $L = 4138$ microhenrys

12. (a) 1.11 in. (b) 25.13 mm (c) 18.41 mm

13. 7732 parts 14. 3.125 years 15. 110.7°F

Exercises 7–6, page 389

A. 1. $H = 1.4\,W$ 2. $W_1 + W_2 = 167$ 3. $V = \frac{1}{4} h\pi d^2$

4. $K = 0.454\,P$ 5. $V = AL$ 6. $V = \frac{1}{3}\pi hr^2$

7. $D = \frac{N}{P}$ 8. $T = \frac{L}{FR}$ 9. $W = 0.7854\,hDd^2$

10. $V = iR$

Carman, R., Saunders, H. & Mills, T., *Mathematics for the Trades Canadian Edition*, Pearson, 2005.